Data Recovery Investigations: Murvaul Creek Site (41PN175), Panola County, Texas

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Cite this Record
McKee, Arlo; Frederick, Charles D.; Perttula, Timothy K.; Selden, Robert Z. Jr.; Bush, Leslie L.; Kemp, Leonard; Gregory, Britney; Yost, Chad; Cummings, Linda Scott; Ferguson, Jeffrey R.; Glascock, Michael D.; Tomka, Steve; Cecil, Leslie G.; Masiello, Caroline; Gao, Xiaodong; Goodmaster, Christopher; and Beasley, Virgil III (2015) "Data Recovery Investigations: Murvaul Creek Site (41PN175), Panola County, Texas," Index of Texas Archaeology: Open Access Gray Literature from the Lone Star State: Vol. 2015, Article 5. https://doi.org/10.21112/ita.2015.1.5
ISSN: 2475-9333
Available at: https://scholarworks.sfasu.edu/ita/vol2015/iss1/5

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Data Recovery Investigations: Murvaul Creek Site (41PN175), Panola County, Texas
(CSJ 1222-01-014, Atlanta District)
VOLUME I

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Texas Department of Transportation, Environmental Affairs Division
Archaeological Studies Program Report Number 165

Texas Antiquities Permit Number 5879

May 2015
EXECUTIVE SUMMARY

In early 2011, Geo-Marine, Inc., conducted data recovery investigations at the prehistoric Caddo site 41PN175 in Panola County, Texas. Because of its location near Murvaul Creek, the site was named the Murvaul Creek site. This work was conducted under Texas Antiquities Permit 5879 as mitigative efforts in advance of the Texas Department of Transportation (TxDOT) planned widening of Farm-to-Market Road 10 (CSJ:1222-01-014). The data recovery excavations consisted of the removal of 47.66 cubic meters of fill from a combination of 56 small 50-x-50-centimeter units and 71 test units measuring 1-x-1 meter. These excavations resulted in the recovery of more than 15,000 prehistoric artifacts. Additionally, roughly 400 grams of ecofacts (charred vegetal material, animal bone, and mussel shell) were recovered from 76 features. Multiple artifactual and geoarchaeological analyses conducted on materials from the site contributed to the interpretation that the site was a small Middle Caddo to Late Caddo occupation that was likely occupied by a single nuclear family for a generation. Radiocarbon dates indicate that the site was primarily occupied during the periods between A.D. 1457 and 1513 as well as A.D. 1610 and 1618, although the site had been intermittently in use since at least the Early Archaic period. The majority of the documented site existed within the TxDOT right-of-way, though evidence indicated that the site continued for an unknown distance beyond the project boundary. The investigated portion of the site is interpreted as consisting largely of an outdoor work area adjacent to a refuse midden. The topics addressed by the investigations presented in this report focused on site chronology and site formation processes, paleoenvironmental reconstruction, subsistence, technology, and settlement systems.
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ACKNOWLEDGMENTS

The successful completion of the data recovery work at the Murvaul Creek site would not have been possible without the opportunity and guidance provided by numerous people at the Texas Department of Transportation Environmental Affairs Division. We especially thank Dr. Jim Abbott and Mr. Waldo Troell who provided expert guidance on many aspects of the project.

Numerous people associated with Geo-Marine served ably in the field, braving poison ivy infections and occasional snowy and icy conditions. The field crew consisted of Bethany Oliver, Jeremiah Hull, Cat Cael, Dawn Schauer, Anne Gibson, Olga Torres, Brett Lang, Shawn Marceau, and Barry Dwiggens. The field leadership consisted of Arlo McKee as Project Archeologist and Chris Kugler as Crew Chief. Missi Green and Tom Middlebrook additionally assisted in field excavations because of their personal interest in the site. Geoarchaeological fieldwork was performed by Dr. Charles Frederick and Brittney Gregory. David Taylor mechanically excavated the site following the controlled excavations. Finally, Principal Investigator Duane Peter guided all phases of the work at the Murvaul Creek site.

In the Geo-Marine laboratory, Steve Hunt, Lindsey Skelton, and Bethany Oliver processed and recorded the excavated materials. As the author list indicates, numerous experts in their respective fields contributed analysis and text for the document. These contributors include Dr. Timothy K. Perttula, Robert (Zac) Z. Selden, Jr., Dr. Charles Frederick, Dr. Leslie Bush, Leonard Kemp, Brittney Gregory, Chad Yost, Dr. Linda Scott Cummings, Dr. Jeffrey Ferguson, Dr. Michael Glascock, Dr. Steve Tomka, Dr. Leslie Cecil, Dr. Caroline Masiello, Dr. Xiaodong Gao, Christopher Goodmaster, and Dr. Virgil (Duke) Beasley. Sharlene Allday provided her expertise with editing the text. The majority of the maps and many figures were produced by Erin King and Lance Trask. Formatting and document production were performed by Denise Pemberton. Without the efforts of all the above, including any of those that we may have inadvertently omitted, this project could not have been completed.
SECTION I: DATA RECOVERY
Chapter 1: Introduction
by Arlo McKee

This report summarizes the archeological findings of the 2011 data recovery investigations at the Murvaul Creek site, 41PN175, in far northeastern Texas in Panola County. The site is located along Farm-to-Market Road (FM) 10 approximately 1 mile north of Gary, Texas (Figure 1). Geo-Marine, Inc. (GMI), performed this work under contract to the Texas Department of Transportation, Environmental Affairs Division (TxDOT ENV) under the Texas Antiquities Permit Number 5879 (Work Authorization [WA] 579 06 SA005; WA 590 08 SA005; CSJ:1222-01-014; Geo-Marine project numbers 22005.00.06 and 22005.00.09). The fieldwork for this project was conducted in advance of the planned widening of FM 10 that was to replace three bridges and a culvert over Murvaul Creek with a larger structure and shift the road approximately 26 meters (m; 85 feet [ft]) to the east. Since the planned improvements of FM 10 would result in the loss of information at the Murvaul Creek site—a site that was recommended eligible for inclusion in the National Register of Historic Places (NRHP) and for designation as a State Antiquities Landmark (SAL; formerly State Archeological Landmark)—the current data recovery investigations were initiated.

The data recovery investigations were conducted between February 7, 2011, and April 3, 2011. During this period, the fieldwork was conducted in several stages: site clearing, geophysical survey, 50-x-50-centimeter (cm) excavations, block excavations, and mechanical site scraping. With the exception of the site clearing stage, the results of each of the fieldwork stages are reviewed individually in this report. The investigations resulted in the documentation of numerous features that appeared to have been the remains of a small Middle-to-Late Caddo settlement or farmstead situated on the edge of an interfluve south of the Murvaul Creek floodplain. Additionally, materials pertaining to the Archaic period were documented across the site. Although the site has been intensively studied within the TxDOT right-of-way (ROW), both the current investigations and previous work were limited to the ROW (cf. Cliff and Perttula 2002). Hence, the site is very likely larger than has been adequately documented.

Previous Investigations

Site Identification
The Murvaul Creek site (41PN175) was initially discovered by Prewitt & Associates, Inc. in 2000 as part of the initial survey in preparation for the expansion of FM 10 (Gadus 2000). As part of that original survey, 48 shovel tests were excavated along FM 10, which resulted in the discovery of two sites above the floodplain on both the northern and southern sides of Murvaul Creek. Site 41PN175 was identified on an upland interfluve on the southern side of the creek within dense second-growth mixed hardwood forest. Site 41PN176 was recorded on the distal edge of the northern floodplain of the creek within a cleared...
Figure 1. Location of Murvaul Creek site 41PN175.
agricultural field. Diagnostic Caddo artifacts were recovered from both sites; however, only site 41PN175 was recommended for additional investigations.

The initial cultural material collection recovered from site 41PN175 consisted of 49 artifacts, among which were 28 ceramic sherds and 13 lithic debitage fragments, suggesting a Caddo occupation. The material was collected from within the nine positive shovel tests excavated on the site. These results indicated that the site contained an artifact density of 1.6 artifacts per 20-cm shovel test level. Additionally, one burned feature, consisting of fire-hardened sediment, was identified in a shovel test. Although the burned feature was identified, only one flake was recovered from the shovel test containing the feature and no charcoal, ash, or fire-cracked rock (FCR) was discovered in association with the feature. This feature, along with the additional artifacts, including burned rock and nutshell, suggested subsistence activities had been taking place on site. The ceramic collection contained a high proportion (17.8 percent) of brushed sherds, which led Gadus (2000) to suggest that the occupation at site 41PN175 likely pertained to a Middle-to-Late Caddo affiliation.

In contrast, only 14 artifacts, including six ceramic sherds and one lithic debitage fragment, were recovered from the two positive shovel tests excavated at nearby site 41PN176. As a result, site 41PN175 was interpreted as a small Caddo camp or farmstead that retained potential for intact features and artifact patterning, whereas 41PN176 was interpreted as a Caddo site area that had been significantly disturbed by agricultural activities and natural erosion. No further work was considered necessary for site 41PN176 since the site was recommended not eligible for either National Register inclusion or SAL designation. Conversely, site 41PN175 was consequently recommended potentially eligible for National Register inclusion or SAL designation and further investigations were recommended to confirm this recommendation. Additionally, the plans to widen FM 10 were revised after these recommendations to lessen the impact to the two sites. The revised plans narrowed the ROW to half its original width in the area of 41PN175 and the length of the project was shortened to eliminate impacts to 41PN176.

**National Register of Historic Places Eligibility Testing**

Subsequent site testing of 41PN175 was completed by PBS&J in 2001 (Cliff and Perttula 2002). That site testing was conducted through both the excavation of 18 shovel tests and three excavation blocks, which were composed of 13 1-x-1-m units and one 1-x-0.5-m unit. Those excavations resulted in the recovery of 1,862 prehistoric artifacts and the discovery of five prehistoric features. The prehistoric collection consisted primarily of 1,375 ceramic artifacts and 487 chipped stone artifacts. Additionally, the prehistoric collection included 12 burned rock fragments, more than 10 kilograms (kg) of burned earth, 1 burned nutshell, 113 charcoal fragments, and an additional 72 grams (g) of bulk charcoal. Limited recent or modern disturbance was documented through two historic glass fragments, four fragments of recently burned wood, and a linear feature that was created by a water line trench that
had been excavated through the central portion of the site. The results of those investigations suggested that the site retained overall good contextual integrity and was likely primarily a single-component Middle-to-Late Caddo hamlet or farmstead.

PBS&J test excavations yielded a repeatable site stratigraphy that suggested the majority of the artifacts and features were contained within a buried soil situated approximately 30–50 cm below surface (cmbs). The actual depth, color, and thickness of the buried soil varied across the site. At the northern portion of the site, the buried soil was generally deeper (70 cm) and darker in color than in the central site area. Cliff and Perttula (2002) noted that the paleosol was charcoal flecked and small fragments of daub or burned soil were present. Cliff and Perttula (2002:29) suggested that the buried soil could be interpreted as a midden, but they were hesitant with this interpretation due to “the lack of preserved bone or shell.” To the south and east of the northern portion of the site, the buried soil was very faint or absent in the profile altogether.

The sediments overlying the buried soil also varied in color across the site. In general, a weakly developed soil had developed within the sandy loam sediments across the site. The colors were generally yellowish brown in hue (10YR Munsell page) in most places. However, in the central portion of the site, the colors of the overlying sediment were anomalously red (7.5YR to 2.5YR Munsell pages). The interpretation for the upper sediments at the site was that the soil was represented by an A-E horizonation. The reddened zone in the central site area was located within the E-horizon, which should have been leached in iron. Given that this reddened zone was encountered only in a limited area, its occurrence was interpreted as a culturally burned zone.

Six features were identified within the excavation blocks (Cliff and Perttula 2002). Among these features, Feature 1 was confirmed as a linear disturbance from the emplacement of a rural water line. The remaining five features were interpreted as cooking pits or reused trash pits (n=2) and postholes or small pits (n=3). The two features identified as cooking or reused trash pits were located in the Central and Northern blocks on the site. These two features contained both a combination of burned materials and artifacts that were recovered in abundances not seen in the features identified as likely postholes. The features identified as possible postholes or pits were identified in each of the excavation blocks. The largest of the pit features, which was identified in the Central Block, contained abundant debitage and ceramic artifacts that Cliff and Perttula (2002:55) suggested was likely originally used for food preparation but later reused as a trash pit. The presence of multiple subsistence and refuse features on the site suggested that one or more Caddo houses would have been present. Two of the features on the site were radiocarbon dated. Feature 6, located in the Central Block, was dated to the Middle–Late Caddo period (360 ± 40 14C years before present [yr B.P.] [A.D. 1440–A.D. 1640]), which was expected for the site. Nonetheless, an anomalously early date of 2,990 ± 40 yr B.P. (1320 B.C.–1060 B.C.) was
obtained from Feature 5, located within the Southern Block. The date from Feature 5 suggested an additional Late Archaic presence on the site that was not well documented through the artifactual remains recovered from the excavations.

As previously mentioned, a total of 1,375 ceramic artifacts was recovered from the PBS&J test excavations. The sherds were recovered in a variable density from across the site, with a mean of roughly 71 sherds per unit across the site. The highest sherd density was found in the North Block (153.3 per unit), whereas the South Block yielded only 68 per unit. Though a variation in ceramic density was noted across the site, the predominance of brushed sherds (between 47 and 55 percent) and the abundance of bone temper (between 71 to 83 percent) suggested that the ceramic collection was likely from a single occupation. Further, Cliff and Perttula (2002) suggested that the site may have stylistic similarities to other Caddo sites in the Toledo Bend Reservoir area to the south. Given this similarity, they argued that the site could provide insight on the local cultural-historical sequence in the Middle Sabine River Basin, which is an area that has received comparatively few large-scale data recovery efforts.

Based on the test excavations at the Murvaul Creek site in 2001, Cliff and Perttula (2002) argued that the site retained contextual integrity, an isolable Middle Caddo component, and spatial patterning that suggested the site would yield significant information pertaining to both the region and the specific time period. As such, they recommended that, under 36 CFR § 60.4, Criterion D, of the National Historic Preservation Act (NHPA) of 1966, as amended through 2000, the site was eligible for inclusion in the NRHP, and also recommended the site eligible for designation as an SAL under 13 TAC 26.8 of the Texas Antiquities Code. Additional data recovery excavations were therefore recommended should the site be impacted by the proposed development of FM 10.

**Report Outline**
This report is divided into two sections. The remaining chapters in Section I are organized into discussions regarding the environmental setting, the cultural setting, the analytical research design and field and laboratory methods, and the results of each stage of the data recovery fieldwork, followed by the results of the ceramic and lithic analyses. Section II presents the results of specialized analyses of radiocarbon dates, geoarchaeological investigations, ceramic artifact laser scanning, stable isotopes related to maize agriculture, phytolith examination, regional drought history, ceramic petrography, and ceramic neutron activation analysis. References cited in the report and appendices follow Section II.

**Curation**
All materials and records generated as part of this project will be curated at the Center for Archaeological Studies (CAS) at Texas State University, San Marcos, Texas.
Chapter 2: Environmental Setting
by Arlo McKee

Physiography and Hydrology
The Murvaul Creek site is located in southcentral Panola County immediately south of Murvaul Creek, which is a major tributary to the Sabine River, at an elevation between 70 and 76 m (230 and 250 ft) above mean sea level (amsl). This area is within the Western Gulf Coastal Plain section of the Gulf Coastal Plain physiographic province. Fenneman (1938) places the eastern boundary of the Western Gulf Coastal Plain at the western bluff of the Mississippi. The section is bounded on the north by the Ouachita and Arbuckle mountains. The western and southwestern boundaries are placed loosely at the Western Cross Timbers and the Balcones Escarpment (Fenneman 1938:100–102).

The Western Gulf Coastal Plain generally dips toward the Gulf of Mexico because it is an element of a receding coastline that is part of the Mesozoic-Cenozoic geosyncline (Murray 1960). The sedimentary rock formations form a series of cuestas with four prominent escarpments comprising the boundaries of numerous subsections. Fenneman (1938) places Panola County within the Wilcox Forest Belt between the White Rock Escarpment and the Nacogdoches Cuesta. The region is characterized by rolling or hummocky plains underlain by the stratified shales and sandstones of the Eocene Wilcox Formation (Bureau of Economic Geology 1974). The landscape within the county consists of gently rolling plains with broad creek valleys, of which bottomlands comprise over one-quarter of the county (Dolezel 1975). The elevation ranges between 60 m amsl in the southeast corner of the county to approximately 180 m amsl in the northwest corner (200–450 ft).

This landscape position of site 41PN175 is on the edge of an upland terrace south of Murvaul Creek, which is a major tributary to the Sabine River. The Sabine River drainage covers an area of more than 25,000 square kilometers (km²; 9,756 square miles [mi²]), of which more than 19,000 km² (7426 mi²) are in Texas and the remainder are in Louisiana (Long 2013). The Sabine River is formed from the confluence of three main branches: Crowleech Fork, Caddo Fork, and South Fork. Each of these branches meet in Hunt County at what is now Lake Tawakoni. The Sabine River is supplied by a network of perennial, seasonal, and ephemeral drainages; Murvaul Creek is but one of 10 perennial tributaries in Panola County. Murvaul Creek flows northeast from 4 miles east of Minden in eastern Rusk County for 26 miles to its confluence with the Sabine River (Handbook of Texas Online 2013). Given that the creek traverses generally flat terrain with clay and sandy loams, the broad floodplain is frequently inundated and is referred to as a bayou. Approximately 4.4 km (2.8 mi) upstream (west) of site 41PN175, Murvaul Creek has been dammed to form Lake Murvaul. Although the damming of the creek almost certainly impacted the stream flow, the floodplain near the site area remains seasonally saturated.
**Geology**

Panola County is underlain primarily by the Eocene-aged Wilcox group and Quaternary-aged alluvial units (Bureau of Economic Geology 1975). The Wilcox group consists of beds of siliceous clay, silt, sand, and gravel that were deposited by the Mt. Pleasant Fluvial system, which consisted of a wide set of meandering streams that flowed over the relatively flat region (Fisher and McGowen 1967). The lowland areas between the stream systems supported Eocene-aged marshes and swamps that formed peat deposits that eventually became buried, lithified, and then became the lignite formations that are economically important to the region today. Within the valley of Murvaul Creek, the area is mapped as containing alluvial deposits of both Pleistocene and Holocene age (Bureau of Economic Geology 1975). Although alluvial materials are prominent in the area, no evidence exists that they have been deposited over the Murvaul Creek Site area. The recent geomorphological setting is discussed in greater detail in Chapter 10.

**Climate**

The climate of the project area is humid and subtropical (Dolezel 1975). The weather typically consists of hot summers with high humidity and short winters because of the influence of the Gulf of Mexico. Average annual precipitation measures approximately 112 cm (44 in), primarily as rainfall distributed uniformly throughout the year. The average summer temperature recorded in nearby Carthage, Texas, is around 27 degrees Celsius (°C; 80° Fahrenheit [F]), and the average winter temperature is 8°C (47°F), with temperatures seldom dropping below 0°C (32°F).

**Flora and Fauna**

The Murvaul Creek site is located within the Austro riparian biotic province (Blair 1950; Dice 1943) and supports a variety of flora and fauna. The environs encompassing the project area contain an array of subtropical terrestrial communities. These ecosystems support a diverse range of fauna, including several endangered or threatened species. The Sabine and Angelina rivers support a diverse biotic community, characterized by hydrophilic vegetation and numerous aquatic vertebrates and invertebrates that include 32 varieties of mussel (Unionidae) and 104 species of freshwater fish (Dahm et al. 2005). Mammal species in the area, either presently or historically, include deer (*Odocoileus virginianus*), cougar (*Puma concolor*), feral hogs (*Sus scrofa*), black bear (*Ursus americanus*), squirrel (*Sciurus* spp.), rabbit (*Sylvilagus* spp.), opossum (*Didelphis virginiana*), and raccoon (*Procyon lotor*).

Once blanketed by oak-hickory-pine forests, the area now supports loblolly and shortleaf pine and is locally referred to as the Pineywoods (Gould et al. 1960). As the name implies, coniferous forest ecosystems dominate much of the region, although variations in soil types, topography, and drainage allow for areas of native hardwoods such as oaks (*Quercus* sp.), elms (*Ulmus* sp.), hickories (*Carya* sp.), pecan (*C. illinoinensis*), black walnut (*Juglans nigra*), tupelo (*Nyssa* sp.), sweetgum (*Liquidambar* sp.), and others. Shortleaf (*Pinus echinata*),
longleaf (*P. palustris*), and loblolly pine (*P. taeda*) are the three native species of southern yellow pine. Uplands may harbor certain hardwoods, such as post oak (*Q. stellata*) and blackjack oak (*Q. marilandica*). Bottomlands near rivers and other major drainages are most often dominated by native bottomland hardwoods such as water oak (*Q. nigra*), cherrybark oak (*Q. pagoda*), Nuttall oak (*Q. nuttallii*), black hickory (*C. texana*), bitternut hickory (*C. cordiformis*), black tupelo (*N. sylvatica*), and sweetgum. Dense understory growth may often be found in forest areas in the form of woody shrubs and small trees such as yaupon (*Ilex vomitoria*), wax myrtle (*Myrica cerifera*), American hornbeam (*Carpinus caroliniana*), rusty blackhaw viburnum (*Viburnum rufidulum*), and other species. In recent years, invasive species such as Chinese tallow (*Triadica sebifera*), Japanese climbing fern (*Lygodium japonicum*), and soda apple (*Solanum viarum*) have become well established throughout the Pineywoods as well. Much of the general area is managed coniferous timberlands.
Chapter 3: Cultural Context
by Arlo McKee

This chapter presents a brief synopsis, based on regional archeology, of Native American cultural chronology and Euro-American history of Northeast Texas and the Sabine River valley. Given the size of the region and the depth and breadth of cultural complexity that has developed in the area, this chapter must necessarily be limited in scope. References are provided to supplement the information summarized here.

Native American Cultural Chronology

Table 1: Generalized Native American Cultural Sequences for Northeast Texas

<table>
<thead>
<tr>
<th>Years B.P.</th>
<th>Great Bend-Neches/Angelina Areas</th>
<th>Western Cypress Creek Basin</th>
</tr>
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<tbody>
<tr>
<td>90</td>
<td>Historic Caddo</td>
<td>Historic Caddo</td>
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<tr>
<td>150</td>
<td>Late Caddo</td>
<td>Late Caddo</td>
</tr>
<tr>
<td>270</td>
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<td>350</td>
<td>Middle Caddo</td>
<td>Whelan Phase</td>
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<td>450</td>
<td>Early Caddo</td>
<td>Period 2</td>
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<td>550</td>
<td>Formative Caddo</td>
<td>Period 1</td>
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<td>650</td>
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<td>Early Ceramic</td>
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<tr>
<td>6,000</td>
<td>Early Archaic</td>
<td>Early Archaic</td>
</tr>
<tr>
<td>9,000</td>
<td>Paleoindian</td>
<td>Paleoindian</td>
</tr>
<tr>
<td>11,500</td>
<td></td>
<td>9500 B.C.</td>
</tr>
</tbody>
</table>

1 After Kenmotsu and Perttula (1993)
2 After Thurmond (1990)
Paleoindian (±10,000–7000 B.C.)
Evidence suggests human migration by groups known as Paleoindians into the northeast Texas region by approximately 10,000–9500 B.C., although the exact timing and nature of the arrival is the subject of some dispute. In Northeast Texas, numerous diagnostic projectile points, such as Clovis, Plainview, Dalton, Scottsbluff, and San Patrice, have been recovered as isolated surface finds or excavated in later contexts (Carley n.d.; Perttula 1988:17). Unfortunately, few Paleoindian sites in good stratigraphic context have been found outside of the Northeast Texas Region (Perttula 1988:17; Preston 1972, 1974), and those that have received any sort of systematic excavation are scarce. One possible example of a horizontally stratified site with early Paleoindian deposits is the Forrest Murphey site (41MR62), located at Lake O’ The Pines. Both Perttula (1998:17) and Story (1990:184–185) noted that the Forrest Murphey site may have contained early Paleoindian deposits, but the site was destroyed by dam construction before being excavated.

Despite the lack of good data relating to the early Paleoindian period in Northeast Texas, some attempts have been made to generalize settlement mobility and intensity of site occupation, drawing on the limited data that are known and on assumptions based on comparisons with other areas. The people of this period are often characterized as living in small bands of highly mobile hunter-gatherers, specializing in the hunting of now-extinct Pleistocene megafauna. For instance, a number of researchers have seen evidence for a high degree of group mobility in the broad distribution of Paleoindian artifacts over the landscape and in the variety of presumably nonlocal lithic raw materials from which they were made (Meltzer and Smith 1986; Shafer 1977; Story 1990:177). Likewise, the well-documented exploitation of large megafauna by Paleoindians in the western United States, coupled with the known presence of similar species in Northeast Texas between 11,000 and 9,000 years ago (see Hemmings 1983; Slaughter and Hoover 1963), has resulted in the popular conclusion that “big game hunting” was part of the Paleoindian subsistence strategy in Northeast Texas. Although a possible association between a Clovis point and mastodon remains at the Murphey site (Story 1990:185) does support this likelihood, increasing evidence from sites to the west (such as the Aubrey site) suggests that Paleoindian groups were less dependent upon “big game hunting” than has been assumed in the past. A more accurate view of Paleoindian life likely includes use of a much wider array of resources (Ferring 1989).

The late Paleoindian period in Northeast Texas appears to be distinguished by the divergence of the earlier, widespread fluted point tradition into several distinct subtraditions. The first of these includes Scottsbluff, Plainview, and similar lanceolate points that appear to be part of a more western or “plains-derived” subtradition in terms of origin and style; the second includes Dalton and Dalton-related projectile points that have a wide distribution throughout the wooded southeastern and midwestern United States. Some researchers have suggested that this Dalton horizon represents an adaptation to the changing environment at the end of the Pleistocene (Goodyear 1982:389–391), a view that has found some support in the addition of the Dalton adze, a presumed “heavy, woodworking
tool,” to what otherwise is viewed as a Paleoindian tool kit (Kelley et al. 1988:21). San Patrice, an important complex that may be related to Dalton, is found in eastern Texas, southeastern Oklahoma, northern Louisiana, and southern Arkansas and is characterized by San Patrice points, Keithville points, and Albany scrapers (Ensor 1987; Schambach 1979; Webb et al. 1971).

**Archaic (±7000–200 B.C.)**

With the end of Pleistocene glaciation, the prehistoric residents of the region began to develop into populations of efficient hunter-gatherers exploiting localized resource bases. This period, and the subsistence pattern that characterizes it, has become termed the “Archaic” period. Representing a significant period of time (approximately 6,800 years), this period is characterized by gradual changes in subsistence patterns, lithic technology, and projectile point styles. Archaic populations are usually portrayed as generalized hunters and gatherers with more limited geographic ranges than the preceding Paleoindian peoples. At the present time, there is no evidence for the development of local cultigens during the Archaic period in Texas, although this is not the case for the Ozark Highlands and other parts of the eastern United States.

The Archaic period in Northeast Texas is tentatively dated between 7000 and 200 B.C. As is true for many areas, a threefold division of the Archaic period, consisting of early, middle, and late subperiods, has been applied in Northeast Texas. Although reliable dating for the Archaic period in this area of Texas is virtually nonexistent, these divisions have been given tentative dates on the basis of cross-correlation with more confidently dated and stratified sites in surrounding areas. Thus, the Early Archaic has been dated from 7000 to 4000 B.C., the Middle Archaic from 4000 to 2000 B.C., and the Late Archaic from 2000 to 200 B.C. (for overviews that cover the Archaic in this portion of Texas, see Fields and Tomka 1993; Peter et al. 1991:Appendix I; and Story 1985, 1990). Archaic remains are usually found in upland settings and are frequently mixed with later material (Campbell et al. 1983; Story 1981). General trends have been proposed that characterize the Archaic period in Northeast Texas as (1) increasing development of complex settlement system, (2) increasing population size and density, (3) increasing sedentism, and (4) development of distinct group territories (Perttula 1988:17; Story 1985:52). Despite these changes, however, no evidence of any level of horticulture has been reported from any Northeast Texas Archaic site (Perttula 1988:17; Story 1990:Table 56), in spite of the fact that definite steps toward food production were being taken elsewhere in the eastern United States (Ford 1985:347–349; Watson 1988).

**Early Ceramic/Woodland (200 B.C.–A.D. 800)**

The Early Ceramic period (200 B.C.–A.D. 800) is defined by changes in technology (ceramics, ground stone), subsistence, and settlement pattern. As Ellis and Smith (2013:23-24) have noted, the archeological evidence indicates that Woodland period sites in East Texas share a shift to more intensive occupations and decreased residential mobility with obvious
interaction with the Lower Mississippi River valley as evidenced by the low frequency of Tchefuncte and Marksville ceramics. These similarities are found throughout southeastern Oklahoma, southwestern Arkansas, northwestern Louisiana, and southeast Texas. Three major Woodland traditions have been identified in East Texas (Perttula and Nelson 2004; Rogers et al. 2001; Schambach 2002; Story 1990). The Fourche Maline cultural tradition (Schambach 1998, 2002) is recognized north and east of the Red River while the Mossy Grove Tradition is recognized in southwest Louisiana and coastal Texas, and inland into the southern portion of the Piney Woods (Aten 1983; Aten and Bollich 2011; Moore 1995; Story 1990). The third tradition, the Mill Creek culture, which has been defined by Perttula and Nelson (2004) and Story (1990:279), occurs in central East Texas to the west and south of the Red River and its tributary, the Sulphur River.

Although the Woodland components do not usually exhibit evidence of intensive long-term occupation and they often appear intermixed with later period components. Ellis and Smith (2013:29-32) provide overviews of six sites (Resch [41HS16](Webb et al. 1969), Folly [41RK16](Jarvis 1972), Herman Bellew [41RK222](Rogers et al. 2001), Broadway [41SM273](Perttula and Nelson 2004), and Haddens Bend [16DS203](Bryan 1984; Jensen 1968)). These sites contain ceramic assemblages that are more varied than those found within the Fourche Maline and Mossy Grove traditions. Grog-tempered and bone tempered plain wares with a sandy paste and untempered sandy pastes are present. Decorative elements, such as punctations and broad u-shaped curved lines, are similar to those on Lower Mississippi River valley ceramics. Burned rock and potential earth ovens have been noted on some of the sites, but whether these features are a product of the Woodland period occupation is not always clear. According to Perttula and Nelson (2004), Mill Creek middens, when they exist, are smaller than their Fourche Maline counterparts and lack evidence of structures and cemeteries. Mill Creek settlement patterns indicate some degree of occupational redundancy, with groups tethered to certain locations or territories and a consistent, repeated use of those locations. Manos and nutting stones are usually present and Gary and Kent dart points are replaced by expanding stemmed arrow points near the end of the period.

Formative (A.D. 800–1000) and Early Caddo (A.D. 1000–1200)
The Formative (A.D. 800–1000) and Early Caddo (A.D. 1000–1200) periods in the Great Bend-Neches/Angelina regions are not well defined. Conversely, in the Cypress Creek region, Caddo occupation of the area is well documented from ca. A.D. 800 to the period of historic contact. For detailed cultural and chronological information, consult Thurmond’s (1990) treatise on the archeology of the Cypress Creek Basin.

The Formative and Early Caddo periods are characterized by what may best be termed the Alto complex or Alto sphere, a widespread manifestation related to the Alto phase, originally defined at the George C. Davis site in Cherokee County, Texas, south of the Great Bend area (Newell and Krieger 1949). The Alto complex shows strong influence from the Coles Creek
culture to the east and appears to partially overlap it in time. It also, however, shows a number of new characteristics (Neuman 1970), including new projectile point types (i.e., Hayes and Homan arrow points), new ceramic vessel forms (i.e., the carinated bowl and the bottle), and a new mode of vessel decoration (i.e., fine engraving with red pigment filler).

Perttula (1988:18) has suggested that these and other cultural innovations, including the introduction of the bow and arrow ca. A.D. 800 and increased food production based on maize, led to increases in population and sociopolitical complexity during these periods. The settlement system became increasingly complex, apparently involving sedentary villages and farmsteads, special function sites (what Binford [1980] has called logistical camps), and mound centers that were presumably ritual or ceremonial in function (see Perttula 1988:18–19). A number of mound centers attributed to the Formative and Early Caddo periods occur in Northeast Texas, including the T. M. Coles or Mustang Creek Mound (Jackson 1931) on a tributary of the Sulphur River to the west of Wright Patman Lake, and several mounds at the lake itself (Stephenson 1950). Many more mound sites occur along the Red River and its immediate tributaries to the north (Banks 1983; Miller 1986; Taylor 1949). To the south, the Bivins-Flanagan mound (also known as Hudnall-Pirtle, site 41RK4) on the middle Sabine River is a major multiple mound site with six to eight mounds, a plaza, and a habitation area (Kenmotsu and Perttula 1993:129). The George C. Davis site in Cherokee County on the Neches River may be the best representative of the mound center-village site type, another characteristic of the Alto focus. The Early Caddo component of this site likely indicates an immigrant group from the middle Sabine River area, possibly the Bivins-Flanagan area, arriving prior to ca. A.D. 900 (Story 1990:325).

Middle Caddo (A.D. 1200–1400)
The Middle Caddo period (A.D. 1200–1400) in the Great Bend region includes what is known as the Haley phase, the definition of which is based generally on mortuary data largely from C. B. Moore’s excavations at the Haley site (3MI1) in Arkansas (Moore 1912). The Haley phase appears to represent a development of the earlier Alto complex, and among the continuities from the earlier period is the use of shaft grave burials for some members of the society, who were accompanied by relatively rich grave offerings (Kelley et al. 1988:26). This phase was centered in the Great Bend area in Arkansas, but northwestern Louisiana and northeastern Texas also fall within its peripheral influence. A Haley phase component is reported at the C. D. Marsh site (41HS269; Jones 1968), located approximately 3.9 km (2.4 mi) west of the proposed project area. Haley phase components are also recognized at the Hatchel site in Bowie County (Davis 1970:44). Other Haley components, including the Cabe Mounds site (Perttula et al. 1995) and the Mitchell site (Cliff et al. 1997), are known in the area. Coker Mound (41CS1) also apparently has a Haley phase component, based on radiocarbon dates and a reported Haley Engraved bottle in a mortuary feature (Perttula et al. 1997:17–20). Despite its presence in Texas, however, the Haley phase was apparently most fully elaborated in the Arkansas portion of the Great Bend.
In the Sabine River area, the Oak Hill Village site (41RK214) in Rusk County (Perttula and Rogers 2007), Washington Square (41NA49) in Nacogdoches County, and Tyson (41SY92) in the Attoyac River basin in Shelby County are among the major mound centers dating to the Early–Middle Caddo period (Perttula 2000a:24–25). Data from these sites suggest a horticultural lifestyle based on maize and squash, supplemented by wild seeds, nuts, and tubers, along with fishing and continued hunting of deer and other game. Mounds were used both as temple and burial sites, and the larger centers were important civic-ceremonial areas. Many of the large mound centers contained structures and plazas along with storage/granary structures and pits. The distribution of the mound centers suggests an integrated society of rather complex socio-political extent. The Washington Square mound, securely dated to the late A.D. 1200s, was built at the crossroads between aboriginal trails (later known as the east–west Caddo Trace and the north–south Camino Real) and may have been primarily a ceremonial center since little indication of permanent habitation has been documented. Radiocarbon dates also suggest the possibility that Washington Square was the successor to the George C. Davis site, which was essentially abandoned by the early fourteenth century (Perttula 2000a:24–29).

**Late Caddo (A.D. 1400–1680)**

The Late Caddo period (A.D. 1400–1680) spans the conclusion of the prehistoric period and the initial years of European contact (for an overview of this period and the subsequent Historic Caddo period, see Perttula 1992). The survivors of the Hernando de Soto Spanish entrada may have entered Northeast Texas ca. 1542, and the latter part of this period appears to have overlapped with the initial movements of seventeenth-century European explorers and traders into northeastern Texas. Numerous archeological complexes whose spheres of influence extend into the Sabine River drainage have been defined for the Late Caddo period. The Bossier phase, though centered on the Great Bend region of Arkansas, has been identified in the Sabine River valley (Dieste et al. 1985:2–20; Gadus and Howard 1988:31). The Titus phase appears to be centered between the Sabine and Sulphur rivers in the Northeast Texas Pineywoods and post-oak savanna. The Bossier, Titus, and Texarkana phases appear to be characterized by small hamlets or farmsteads that were probably occupied by small family groups of shifting agriculturalists. These farmsteads are apparently characterized by a limited number of structures and a small family cemetery (see Brewington and Dockall 1991; Brewington et al. 1995; Jelks 1961; Perttula 1988; and Wormser 1988). They presumably were associated with larger, more permanent suprahousehold sites, including both mound centers and nonmound cemeteries, which served to integrate the scattered households into a unified social group.

**Historic Native American Period (A.D. 1680–1860)**

The Historic Caddo period (A.D. 1680–1860) in Northeast Texas began with the founding by René Robert Cavelier, Sieur de La Salle, of a short-lived French colony on the Texas coast and ended with the expulsion of the Caddo from Texas in 1859. During the closing decades of the seventeenth century, French explorers, such as Henri de Tonti, Jean Baptiste Le
Moyne de Bienville, and Louis Juchereau de St. Denis, traveled through the upper Red River valley and made contact with the Native Americans residing in the area. The primary Native American groups inhabiting the Great Bend–Neches/Angelina region at that time were Caddoan speakers, presumably descendants of groups that had inhabited the area at least as far back as A.D. 800. These Caddoan-speaking populations were divided very generally into the Kadohadacho in the Great Bend area north of the Sulphur River, and the Hasinai in the Neches/Angelina River region south of the Sabine River.

The groups in the northern area comprised the Kadohadacho Confederacy (Swanton 1946:141). The confederacy was originally composed of five groups—the Kadohadacho, the Petit Caddo, the Upper Natchitoche, the Upper Nasoni, and the Nanatsoho. According to Williams (1974:286), the Upper Yatasi and the Cahinnio joined the confederacy at a later time, possibly in the early eighteenth century in the case of the Cahinnio and in the 1760s in the case of the Yatasi. The confederacy apparently controlled the entire Texas portion of the Great Bend region. Don Domingo Terán de los Rios, who in 1692 visited one of the Kadohadacho villages located just above the Great Bend of the Red River near present-day Texarkana (Swanton 1946:57), noted that their power extended as far south as Big Cypress Bayou (Hackney 1966:3). The origin of the confederacy is unknown at present, but it may have arisen as a result of what was probably a severe demographic impact resulting from the earlier Hernando de Soto entrada (cf. Smith 1989).

The Hasinai south of the Sabine River were organized in a loose confederacy composed primarily of the Hainai, Nabedache, Nacogdoche, Nasoni, Nadaco, Neche, Nacono, Nechaui, and Nacao, but membership apparently was fluid and fluctuating (Story 1990:322). An intertribal organization pertaining especially to religious beliefs was the basis of this confederacy. At the top of a relatively weak social and political hierarchy was the grand xinesi, along with the subordinate chiefs of each tribe and their lesser officials (Bolton 1987; Story 1982:21). Although males inherited these offices, females often held powerful positions and descent was likely through the female line.

René Robert Cavelier, Sieur de La Salle, established Fort Saint Louis on the Gulf coast in 1685 (John 1975:182). By 1686, he had traveled northward to Caddo country. By the late 1600s, a regular European presence/settlement into Caddo territory had begun. In 1690, the Spanish established Hasinai area missions—San Francisco de los Tejas and Santísimo Nombre de María—but abandoned them in 1693 when the local population refused to comply with Spanish attempts to convert and control them (Swanton 1942:46–49). In response to St. Denis’s 1714 French trading post at Natchitoches, three more Spanish missions were established in 1716—a second Mission San Francisco de los Tejas just east of the Neches River, and two in the main villages of the Hasinai (Nuestra Señora de la Purísima Concepción, likely on the Angelina River) and the Nacogdoche (Nuestra Señora de Guadalupe, likely on Bayou La Naña) (Swanton 1942:46–49). In 1779, a group of Euro-
American settlers from the Trinity River moved into the Nacogdoche area, and a rancher set up operations on Bayou Loco near or on the Deshazo site. These moves, as well as intruding Indian groups, forced the Hasinai to emigrate westward to the prairie or to withdraw into smaller villages. The French briefly regained control of Louisiana, only to lose it again in 1803 when President Thomas Jefferson bought the Louisiana Purchase. The area was now open for American immigration, which effectively forced the remaining Hasinai to move to a reservation on the Brazos in 1845, and then final removal to Indian Territory in Oklahoma in 1859 (Newcomb 1961:289; Swanton 1942:71–88).

Historic Euro-American Era
The period of European exploration and settlement and the subsequent Euro-American and African-American development of Northeastern Texas are briefly covered in the remaining portions of this chapter. For more extensive treatments of this period in North Texas, see Peter and Cliff (1990:Chapters 3 and 7) and Peter et al. (1991:Appendix J).

Spanish and French Colonization (A.D. 1542–1803)
The initial European penetration into the general area of North Texas was first made by the Spanish and then the French in the middle of the sixteenth century (ca. 1542) when the survivors of the Hernando de Soto entrada, led by Luís de Moscoso de Alvarado after de Soto’s death, entered Texas in their attempt to reach New Spain by land (Bruseth and Kenmotsu 1991; Weddle 1985). Although Moscoso’s exact route is unknown, archeological studies of the available historic accounts and correlation with known archaeological sites in the region suggested to Bruseth and Kenmotsu (1993) that he likely traversed the Red River valley somewhere near Texarkana, Texas, north of Clarksville, Texas. Although, Bruseth and Kenmotsu (1993) admit that there were multiple routes possible, they suggest that the most likely route was south from Texarkana through present day East Texas. With this route, Moscoso would have encountered both Texarkana Phase and Titus Phase Caddo groups. The survivors then journeyed through Texas, perhaps as far as the Guadalupe River, before becoming so thoroughly lost that they retraced their route out of Texas and returned to the Mississippi River to travel to the Gulf of Mexico (Bruseth and Kenmotsu 1993).

In the late 1600s, the Spanish introduced the first of their missions into East Texas. The goal of these missions was to eradicate the indigenous religions and to Christianize the native populations. The Spanish established missions—San Francisco de los Tejas and Santísimo Nombre de María—in the Hasinai area in 1690, but abandoned them in 1693 when failing to convert and control the local population (Swanton 1942:46–49).

The French, led by René Robert Cavelier, Sieur de La Salle, first ventured into eastern Texas after establishing Fort Saint Louis in 1685 along the central Texas coast in present-day Victoria County (Davis and Bruseth 2000; Fort St. Louis 2009; John 1975:182). Subsequently, in 1714, Louis Juchereau de St. Denis set up a trading post at Natchitoches, in present-day Louisiana. Spanish fear of an increased French presence in Texas led to the
decision in 1716 to try again to establish a series of missions and presidios in present-day East Texas—this time a second Mission San Francisco de los Tejas near the Neches River, Nuestra Señora de la Purísima Concepción (later removed to the San Antonio area in 1731) on the Angelina River, the Nuestra Señora de Guadalupe at present-day Nacogdoches, San Jose de los Nazonis in present-day northwestern Nacogdoches County, and Nuestra Señora de los Ais; as well as San Miguel de Linares de los Adaes in present-day Louisiana—as a buffer against further French encroachment into that region (Cooper et al. 2003; Pool 1975:28; Swanton 1942:46–49). When France and Spain went to war, the French at Natchitoches attacked the Spanish settlement of Los Adaes, forcing the Spanish to abandon the area once again (Newcomb 1961:288). After the truce in 1721, Spanish representative Marques de Aguayo persuaded the French to withdraw from Texas. He reestablished the missions and set Los Adaes as the capital of the Province of Texas.

In the Red River area, the French established Le Poste des Cadodaquious in present-day Bowie County in 1719, and explored what is now Franklin County (Harper 2002). Bénard de la Harpe’s 1719 trading post (which became known as the Nassonite Post) on the Red River north of present-day Texarkana was the first European settlement in the Great Bend (Cooper et al. 2003; Kelley and Coxe 1996:21). Another effort by Spain to curb French influence occurred in 1760, when Fray Jose Francisco de Calahorra y Saenz led an expedition to present-day Rains County to make peace with the Native American tribes in Northcentral Texas. These trading posts eventually served as illicit trading centers between the two European colonies; modern-day archeological investigations have yielded artifacts of both Spanish and French origin that would suggest that the different cultures interacted at the trading sites. Story (1990:Table 85) reviews numerous sites where European artifacts have been recovered in the area displaying this interaction. This list includes several sites in nearby Harrison and Rusk counties, such as Susie Slade (41HS13) and Millsey Williamson (41RK3), which both contained numerous burials with European trade goods, and Taylor (41RK36), which contained numerous European gunflints of French, Dutch, and English origin. After briefly regaining control of the area, the French sold it as part of the Louisiana Purchase in 1803.

**American Immigration (A.D. 1806–1830)**

Following the sale of Louisiana to the United States in 1803, Anglo-American immigration into North Texas intensified, although for a number of years it was not clear who actually owned the area south of the Red River. The United States considered it (and indeed, most of Texas) to be part of the Louisiana Purchase and encouraged settlement of the area (Chandler and Howe 1939). Spain (and later Mexico), on the other hand, was violently opposed to this view, and at several times during the first few decades of the nineteenth century the dispute nearly led to war (Smith 1991). The first official Anglo-American penetration of the region was by the Freeman-Custis Expedition of 1806, which was turned back at Spanish Bluffs, along the Red River, by a Spanish military force (Flores 1984).
Despite Spain’s claim, North Texas was too close to the United States not to fall into the Anglo-American sphere of influence, and settlement continued. The earliest settlements were confined to the areas immediately adjacent to the Red River, but after 1818, settlement pushed into the prairies along river tributaries and early roads such as Dayton’s Road and Trammel’s Trace, the present western boundary of Panola County (LaGrone 2008). Trammel’s Trace, a popular immigrant route into Texas after 1813, crossed the Sulphur River at Epperson’s Ferry and continued southwestward through Cass County to Hughes Springs, founded in 1839, and then south to cross Cypress Creek 2 miles west of modern Jefferson (Webb and Carroll 1952:2:793–794). Dayton’s Road was a major east-west overland route that ran along the divide between the Sulphur and Red rivers.

The original Anglo-American settlers in Texas were largely subsistence farmers residing on small holdings, with an economy based on grain and livestock production (Peter and Cliff 1990:36). The commercial production of cotton apparently was not introduced until the 1830s (Fehrenbach 1968), a shift that was accompanied by increasing numbers of slaves into the region.

**Texas Independence (A.D. 1836–1846)**

As settlers began to move into Texas, they remained initially under Spanish and later under Mexican control until the struggle for Texas independence in 1836. For the most part, North Texas was beyond the direct sphere of the conflict associated with the fight for Texas independence: that conflict played out primarily in South and Central Texas in 1835 and 1836. The most significant change thereafter involved decrees by President Mirabeau Lamar, the second president of Texas, to make the settlers of the Texas Republic safe from marauding Native Americans by adopting an Indian removal or extermination program. Active efforts to drive off or exterminate the Native Americans in North Texas had been under way for some time. In one instance in 1837, a group of Texas Rangers under the command of Lt. A. B. Van Benthuyzen camped on Turtle Creek after conducting raids on Indians to the north (Maxwell 2002). Subsequently, many native groups who used the Trinity River basin relocated north of the Red River.

**Early Texas Statehood (A.D. 1846–1861)**

Texas traded its independence for U.S. statehood on December 29, 1845, entering the Union as the twenty-eighth state. Panola County was created from Shelby and Harrison counties in 1846. The original county seat at Pulaski was relocated to Carthage within two years. In 1850 (Mayfield 1998), Panola County had a population of 3,871 (2,676 Anglo-Americans, 1,193 slaves, and two former slaves). Farms in Panola County encompassed more than 116,000 acres; however, only 13,000 acres were classified as “improved,” with corn being the most important crop, followed by cotton and various other produce. By 1860, the local economy had grown to encompass 237,000 acres of farmland, of which 49,000 acres were considered “improved,” and the census (Mayfield 2000) reported a county population of 10,119 (6,392 whites and 3,727 slaves); there were no free African-
Americans. According to the census, 445 slaveholders lived in Panola County, and though 75 of these owned 10 or more slaves and 25 owned 20 or more slaves, only two owned 50 or more slaves, and the remaining 343 slaveholders owned fewer than five slaves. Agricultural production increased, with corn yields tripling those of only a decade earlier and cotton production substantially improving (LaGrone 2008).

Texas, however, did not remain part of the United States for long. Sectarian politics were raised to a fever pitch during that period, and after the presidential election of 1860, Texas began to consider secession. The sympathies of most of the Anglo-American residents of North Texas lay with the secessionist southerners; after all, a majority of them had immigrated from the South, the region as a whole had a substantial slave population, and the cash economy of the area was built on slave-based agriculture even though most of the individual farmers could not afford to own slaves. In most of Northeast and Northcentral Texas, anti-Union feelings ran high (Webb and Carroll 1952:1:306), and nearly all the counties in the area voted to secede—though some, like Delta County, did support Sam Houston’s Unionist forces during the early part of the war (Hervey 1951). On February 1, 1861, Texas became part of the Confederate States of America.

Civil War (A.D. 1861–1865)
Although the fighting never reached North Texas, the Civil War still inflicted hardships on the region (Works Projects Administration [WPA] 1992:55–58). Because most able-bodied men were away fighting for the Confederacy, most small towns and villages were left unprotected from and fearful of Native American raids (Denton County History Page 2001). The result was an eastward retreat of the frontier. Simultaneously, the region also experienced considerable immigration by Southerners who were moving west to escape the warfare that ravaged the Deep South. The region gradually became impoverished as the war progressed, and food and other commodities became expensive and difficult to obtain (WPA 1992:55–58).

Northeastern Texas escaped serious, direct effects from the Civil War, being too far west of the centers of fighting to the east and south to be affected by Union forces, and too far east of the frontier to be affected by the resurgence of Native American problems that accompanied the withdrawal of U.S. and Texas military forces (Pool 1975:110–113). The defeat of the Confederacy in 1865 brought with it the end of slavery in Texas, the breakdown of the old slave-based plantation system, and the presence of a Union army of occupation.

Postbellum Texas (A.D. 1865–1920)
The end of slavery brought many changes in the economy of rural Northeast Texas. Lacking the cheap and dependable labor resources provided by slavery, the large plantations of the prewar period ceased to be economically feasible and many were broken up and partially sold off. Most of the land put on the market found its way into the hands of speculators and
investors, with the result that a new system of sharecropping or tenant farming replaced the old plantation system. Productive land was now often held by absentee landlords, with the labor supplied by African-American or poor Anglo-American sharecroppers or tenants. Agriculture continued to be the basis of the Panola County economy, with cotton and corn as the primary crops (LaGrone 2008). Although this system failed to improve the lot of the sharecroppers and tenants, it was a successful replacement for the prewar system, and by the beginning of the twentieth century, the bulk of the rural farms in Northeast Texas were operated by sharecroppers or tenants. The town of Jefferson, on Cypress Creek, was a major cotton market, and postbellum planters throughout the region undoubtedly sent their cotton there for sale (Peter and Cliff 1990:39). Other major industries established about the same time included tan yards and syrup mills, and after 1857, railroad construction had progressed westward (Webb and Carroll 1952:1:198, 2:59).

After 1870, the population of North Texas began to increase, and the region began to recover from the worst effects of the war and the subsequent recession. One of the most important factors in this recovery was the increasing role of the railroad in the regional economy. A small amount of railroad construction had occurred prior to the outbreak of the war, when more than 50 miles of track had been laid westward from Texarkana in 1857 by the Memphis, El Paso, and Pacific Railroad. Following the end of the war, construction did not resume for four more years. When it finally did, it continued at a relatively steady rate. In 1871 and 1872, the Texas and Pacific Railroad went through the southern corner of Upshur County and the eastern portion of Cass and Marion counties. In 1876, the East Line and Red River Railroad (later part of the Louisiana and Arkansas), building west from Jefferson, crossed western Marion County and the southwestern portion of Cass County. In the Pineywoods of northeastern Texas, the Houston, East and West Texas Railway from Houston to Shreveport was completed in 1882, quickly followed by the Kansas and Gulf Short Line; the Texas Southeastern; the Groveton, Lufkin and Northern; the Texas and New Orleans; and the Angelina and Neches River railroads. With the completion of a local railroad line from Longview into the county in 1885, the already important logging industry intensified, and continued to do so as the rail line was upgraded and extended to Carthage in 1888 and eventually became part of the Gulf, Colorado, and Santa Fe Railway (LaGrone 2008).

New towns emerged along these railroad routes and developed as important shipping centers (Webb and Carroll 1952:1:306). The continuing expansion of the railroads after 1870, and the improved communications they brought, spurred the development of other local industries as well. During this period, lumbering assumed its place as an important industry in many areas of the Pineywoods of northeastern Texas (Chandler 1937). The Houston, East and West Texas Railway and the Gulf, Beaumont, and Great Northern Railroad allowed transportation of lumber from timber-rich Polk, Angelina, San Augustine, San Jacinto, Shelby, Trinity, and Nacogdoches counties. Sawmills to process this lumber also sprang up throughout these Northeast Texas counties, especially in Lufkin and Angelina.
County, which led to innovations for lumber and paper production and provided another major source of employment (Webb and Carroll 1952:2:824). All of these mills helped supply raw material to factories located in Texarkana and in other large towns (Webb and Carroll 1952:1:198).

Through connecting the area to national markets, the railroads also encouraged the development of mineral resources in Panola County. As early as 1889, a geological survey discovered rich deposits of lignite in the county, and before the turn of the twentieth century, a limited mining operation began in the Martin Creek area, though it was soon abandoned because of the plentiful supply of wood for fuel (LaGrone 2008). In spite of the steady growth in nonagricultural industries during these years, farming continued to be important in Northeast Texas, with the small, owner-operated farm still prominent. Despite the inequities of the sharecropper and tenant systems, the participants were not locked into the system as had been the case under slavery, and in the last three decades of the nineteenth century increasing numbers of African-Americans achieved the status of small landowners. Regardless of their status, they often settled in dispersed rural communities separate from those of their white neighbors.

Modern Texas (A.D. 1920–Present)
Between about 1920 and 1935, the rural population generally declined as the farming population relocated to urban centers (Webb and Carroll 1952). Some factors that may have influenced this demographic shift were the continued growth of urban industries, the declining agricultural productivity of the land, and the depressed regional and national economy. The discovery of oil in many North Texas counties in the 1930s led to the development of new industries and increased employment opportunities (Webb and Carroll 1952:1:306, 2:144, 2:783).

The period following the end of World War II has been one of general prosperity and urbanization for the entire region. Demographic changes within this area have been dominated by the growth of medium-sized urban areas, such as Tyler. Commercial patterns in the region have benefited from the construction of Interstate Highways 20 and 30 that have served to link the area to major manufacturing centers to both the east and the west. The improved infrastructure, as well as the construction of several lakes in the area, has brought increased prosperity in the form of tourism and the recreation enterprises.

Although oil was first discovered in Panola County in 1917, followed by gas in 1936, significant production of the area’s energy resources did not begin until 1944 when the Jordan well was drilled west of Carthage (LaGrone 2008). Today, Panola County derives a substantial portion of its income from the extraction of energy resources (oil, coal, and natural gas). Nearly 2 million barrels of oil and a quarter of a billion cubic feet of gas were produced in the county during 2004, bringing Panola County’s cumulative oil production to over 92 million barrels since the discovery of the resource in 1917 (LaGrone 2008). Other modern industries include sawmills, poultry and egg processing, and the manufacture of plastic products.
Chapter 4: Research Methods
by Arlo McKee, Charles Frederick, Ph.D., and Virgil Beasley, III, Ph.D.

Research Design for Artifact Analysis
Archeological data recovery excavations at Murvaul Creek site 41PN175 were carried out according to field protocols approved by the Texas Historical Commission (THC) and TxDOT ENV under Texas Antiquities Permit Number 5879. Following the fieldwork conducted in early 2011, an analytical research design was prepared by Geo-Marine and was approved by TxDOT ENV. This research design was used to guide both the laboratory analysis and reporting within this document. The text that follows was derived from the research design and provides a summary of the basic laboratory techniques that were applied to the artifact collection. Additional specialized laboratory methods are provided in subsequent chapters for analyses that are outside of the scope of the basic treatment of all artifacts in the collection.

Two historic contexts from Kenmotsu and Perttula (1993) are applicable for framing the analysis of the materials from 41PN175. These contexts are: Quaternary Environments and Archeology in Northeast Texas and the Development of Agriculture in Northeast Texas before A.D 1600. Concepts that Kenmotsu and Perttula outline led to expanding five research domains for this study:

- Research Domain 1: Site Chronology and Site Integrity
- Research Domain 2: Environmental Conditions
- Research Domain 3: Subsistence and Seasonality
- Research Domain 4: Technology: Typology, Change, and Implementation
- Research Domain 5: Settlement Systems and Intra-site Structure

Each research domain, associated issues, and specific investigative strategies are presented below.

Research Domain 1: Site Chronology and Site Integrity
One of the primary reasons given by Cliff and Perttula (2002:89–90) for considering 41PN175 potentially eligible for NRHP inclusion and SAL designation was the possibility of an isolable Middle (A.D. 1300–1400)/Late (A.D. 1400–1600) Caddo component at the site. This was based largely on the composition of the ceramic assemblage. A radiocarbon date obtained from a Caddo context excavated during the testing phase of site excavations (cal. A.D. 1440–1680) suggested that if there was an isolated Caddo component, it trended toward the Late period (Cliff and Perttula 2002:89). However, it was noted that this single date should not have been taken as fully representative of the Caddo component, or of the site as a whole. An additional Late Archaic radiocarbon date (ca. 1360 B.C. [1320–1060 B.C.]) from a pit feature was obtained during the testing phase of 41PN175. Although Cliff and Perttula (2002:89) interpreted this date as a minor Late Archaic component at the site,
a significant proportion of the projectile points recovered during the mitigation excavations were dart points assumed to be manufactured during Archaic times. Additionally, a San Patrice point, which is associated with Late Paleoindian–Early Archaic period, was also recovered during the mitigation excavations.

Given the limited number of dates that were previously obtained from the site and the fact that the artifact assemblage appeared to cover a broader range of time than previously suspected, researchers considered it critical to site understanding to obtain a significant volume of dates from the site. It was proposed that these data would be obtained with the primary focus of refining the site chronology and establishing a confidence of the integrity of the studied proveniences. Below are two research questions that address the chronology and integrity of the site.

Research Question: What is the chronology of the site and history of the site stratigraphy?

Given that the site was found to contain components of Late Archaic and Middle-to-Late Caddo occupations, it was necessary to extensively date both feature contexts and associated soils. The feasibility of radiocarbon dating features was demonstrated during site testing, and the feasibility of dating the associated soils was demonstrated by optically stimulated luminescence (OSL) dating of three samples recovered during the mitigation excavations. Combining these two dating techniques with radiocarbon dating carbon found within pottery sherds and thermoluminescence dating of those same materials with further analysis of the soil column samples will provide a very robust site chronology.

Investigative Strategy: Radiocarbon-Dating Features and Thermoluminescence/Radiocarbon-Dating Pottery

Radiocarbon dating of samples recovered from features was done in order to gain a clearer understanding of the extent of the Archaic presence at the site as well as to provide a reference for the Caddo occupation at the site. Fifteen radiocarbon samples were submitted from secure feature contexts for accelerator mass spectrometry (AMS) analysis to contribute to a database of absolute dates from 41PN175. The two radiocarbon dates from the site testing represent two disparate time frames and provide little clarity to the relationship of the site stratigraphy to the cultural material and temporal placement. The mitigation excavations further revealed that a larger sample of Archaic materials was present in a mixed context with the Caddo materials. It seemed likely at the close of fieldwork that that numerous features identified at the site would have pertained to the Archaic use of the site rather than the later occupation. Although this was the working hypothesis, the results of this study, presented in Chapters 6 and 8, show that the chronology of the site was much more homogenous that initially thought.
In addition to feature contexts, four samples of pottery were sent to the University of Washington for thermoluminescence dating (TL). Directly dating the pottery from the site is of utility because it was thought that successful results would refine the regional ceramic typology. The four TL samples were used as a control group for checking the validity of using direct AMS radiocarbon dates from typed ceramic sherds. In order to contribute to a database of absolute dates from typed ceramics, 10 additional samples were submitted for AMS dates. Of these AMS dates, four were the same sherds that were submitted for TL analysis, and the remaining six sherds were submitted based on the recommendations from the ceramic typological/stylistic analysis. These results are reviewed in Chapter 6.

With a large enough sample database of radiometric and luminescence dates, it was thought to be advantageous to approach interpretation of the site chronology through statistical methods, such as Bayesian analysis. It is likely that the submission of numerous samples from a narrow temporal range will yield overlapping probability spectrums, so outliers in the data may not be apparent from a straightforward comparison of the probability ranges. Bayesian and Monte Carlo statistical procedures may beneficially provide a best-fit range of chronometric years for the assemblage (Aitken 1990; Ramsey 2009). The results of this analysis with a comparison to other similarly aged sites are presented in Chapter 8.

**Investigative Strategy: Chronology of Occupational and Erosional Events**

Cliff and Perttula (2002:94) recommended further testing of the buried soil at the site to gain an understanding of its context and character. The timing of the burial of the portion of the site containing the buried soil was important. The results of the micromorphological pilot study suggested that the paleosol was buried by colluvium that represented an inverted soil profile. The colluvium appeared to contain two portions (upper and lower) of sediment that were composed largely of sediment derived from the erosion of the solum upslope from the main site area. The lower portion of the colluvium appeared to be derived from the A- and E-horizons, whereas the upper colluvium contained Bt-horizon sediment. However, it was not entirely clear at the close of testing fieldwork to what effect this erosional event had on the Caddo occupation at the site.

In order to examine this issue, three samples from the mitigation phase of excavations at 41PN175 were submitted to the Sheffield Centre for International Drylands Research (SCIDR) luminescence laboratory in Sheffield, England, for OSL analysis. The OSL dates recovered from two samples above the buried soil indicated that erosion of the adjacent upland slope, and redeposition of the upper portion of the site, occurred by approximately A.D. 1650. This period of partial landscape instability continued to bury the site until later than ca. A.D. 1860. Although this is early for erosion associated with European farming in the region, the date does appear to be contemporaneous with the early historic period in Northeast Texas. With this in mind, it is important to note that no Historic-period Caddo
artifacts have been identified at the site, which seems to support the interpretation that the site was abandoned prior to the erosional event that deposited the colluvium.

In preparation for the completion of the analytical research design, a microartifact pilot study was conducted for one profile at the site, and numerous charcoal fragments were recovered from both the upper and lower colluvium. Since OSL and radiocarbon processes date different aspects, the age expectations for the colluvium differ according to the dating method. The OSL ages should date the period the sand was transported, whereas the radiocarbon ages of charcoal within this deposit will date the death of the organism dated and, if this charcoal from within the deposit is derived from occupation debris upslope, the dates should match the age of the occupation. For the paleosol and overlying colluvium, these two dating methods have two distinctly different implications. Within the paleosol, it is expected that the two ages will be similar or the OSL date will be slightly older given that it would take some amount of time for artifacts to be incorporated into the profile. In the colluvium, however, if the cultural material in this deposit are artifacts that were eroded from the paleosol upslope and then deposited on top of it downslope, the age expectations are slightly different. The OSL dates should be in correct order, whereas radiocarbon dates should exhibit age reversals, with older ages obtained from shallower depths. As many as four AMS samples from the colluvium were proposed for analysis and comparison with the OSL samples.

**Investigative Strategy: Microartifact Analysis of the Early Occupation**

A feasibility study was performed in order to determine if the separation of microartifacts from a 20-x-20-x-5-cm sample column would produce enough material for analysis, and if so, whether such an analysis would meaningfully complement the macroartifact distributions at the site. The results of this work indicated that, in general, there is a good correlation with the macroartifacts, but there are some differences as well. First, the macroartifact distributions are clearly unimodal. This shape of profile is common in East Texas sandy mantle sites and is often thought to be an artifact of pedoturbation. However, in this particular case, a major unconformity is in the middle of this mode. The microartifact distributions respect this unconformity and exhibit the major modes above the unconformity in the lower colluvium, with a secondary mode in the paleosol below the unconformity. Hence, the depth distribution of the microartifacts is more discrete than macroartifacts (with almost no artifacts below 40 cm) and the modes are slightly skewed from the macroartifact distributions.

An examination of the depth distribution of microcharcoal from the pilot study showed a distribution follows the lithic and ceramic artifacts; however, the microcharcoal then increases toward the bottom of the profile where macro- and microartifacts are virtually nonexistent. It was unclear from the pilot study whether this increase of microcharcoal at depth was reflecting the older occupations at the site or whether it simply was caused locally by bioturbation. If this increase in charcoal were shown to be present at other locations
across the site, then this could provide a reliable measure for the pre-Caddo occupation. Therefore, the proposal was that the two other microartifact columns collected through the buried soil be analyzed and compared with the artifact distributions across the site. Additional samples of microcharcoal (>2-millimeter [mm] diameter) were to be submitted for AMS dates should this trend be repeated across the site. These results are reviewed in Chapter 12.

**Research Question: What processes are responsible for site formation?**

**Investigative Strategy: Physical and Chemical Analyses of the Buried Soil**

One of the main questions at the close of the testing excavations was whether or not the buried soil at the northern end of the site is a midden (Cliff and Perttula 2002:94). The paleosol across the site exhibits a wide range of apparent organic matter content as is inferred from its color. Where it was darkest, this deposit was inferred to be a midden, but this was not the case where the buried A-horizon exhibited a lower Munsell hue and chroma. Spatial variations in the appearance of the paleosol are most likely indicative of edaphic or anthropogenic, or both, factors and distinguishing which would be useful in terms of understanding Caddo land use at the site.

Middens are widely recorded archeological phenomena but the study of their formation varies considerably in the archeological literature. Some, such as burned rock middens in Texas, have been the subject of archeological investigation for over a century, with progressive refinements in the understanding of their origins following more detailed and focused analytical inquiries. Conversely, middens lacking rock, which typically manifest as dark-colored soil with artifacts, are often identified in Texas but are rarely studied closely (cf. Frederick and Bateman 2011 for one example). Research over the last two decades on organic-rich soils in the tropics (aka. Amazonian Dark Earths or ADEs), terras pretas and terras mulatas (Arroyo-Kalin 2012; Knicker 2011; Lehmann et al. 2004; Lehmann et al. 2003; Major et al. 2010), primarily focusing on understanding how to recreate these soils for purposes of carbon sequestration (often under the guise of biochar), has opened a new door into the creation of such prehistoric anthropogenic soils. The terras pretas (dark earths) are classic middens in that they always contain ceramic sherds and other artifacts, whereas the terras mulatas (or brown earths) are organically enriched soils thought to have been the site of agricultural fields and generally surround the terras pretas, although some consider these to merely be end members of a continuum of anthropogenically altered soils (cf. Fraser et al. 2011). Analytical work on these soils has found that they are typically enriched in carbon, phosphorus, nitrogen, calcium, magnesium, manganese, and zinc, as well as having elevated cation-exchange capacity and pH (Fraser et al. 2011; Woods et al. 2008).

Given the variation in appearance of the paleosol at the site, this issue proposes to explore the properties of the paleosol/midden in order to assess whether the more apparently organic-rich parts exhibit significantly different chemical attributes, as might be expected.
from anthropogenic enrichment of a ground surface by the discard of organic refuse. If the
darker parts of the midden correlate with spatial variations in artifacts and exhibit
compositional variations consistent with anthropogenic activity, then it is an artifact of Caddo
land use rather than a product of a natural soil forming process.

In order to better understand whether the paleosol is a midden, researchers proposed
examining a suite of soil samples that first characterize the chemical composition of several
soil profiles collected from the site. It was proposed that these samples would be compared
with the composition of soil samples from the paleosol where the organic carbon content is
greatest. A suite of 61 soil samples was collected from test unit profiles across the site.
These samples were used to examine the spatial variation in carbon content, and then to
compare this with the spatial variation in artifacts, to understand whether or not they were
correlated. Then, it was proposed to chemically characterize the paleosol by analyzing
samples where the paleosol was weakly melanized and comparing those results to samples
where the paleosol was strongly melanized. Additionally, these paleosol samples were
compared with samples collected from the E- and Bt-horizons. An additional method of
nuclear magnetic resonance was ultimately selected because further analysis of the organic
matter constituents (e.g., assays of black carbon content vs. organic carbon content, or
other means of assessing the amount of pyrogenic organic matter) would permit delineation
of the soil enriched in pyrogenic organic matter as opposed to “normal” humus-enriched
soil.

**Investigative Strategy: 3D Laser Scanning Ceramic Roughness**
The mitigation excavations and preliminary micromorphology/microartifact study have
suggested that the northern portion of the site has been buried by colluvium. The transport
of fine-grained sands and silt by fluid action was also evident with the infilling of several pit
features at the site. The OSL dates obtained from the colluvium above the buried portion of
the site suggest that the site was buried during early historic times (see Appendix B-3);
however, no features were present within the colluvium and no Historic-period Caddo
artifacts or features were discovered at the site. Given that both macro- and microartifacts
at one portion of the site show a peak in artifact frequency immediately above the buried
soil, a likely interpretation is that the upper portion of the site has been transported from the
uplands and redeposited on the northern portion of the site. An examination of the degree
of wear on the ceramic sherds would be a direct method of addressing whether a portion of
the site has been redeposited. However, given the assumption that the transport distance
from the adjacent uplands to the site area is relatively short, the difference in sherd
roughness between the redeposited sherds with the collection in primary context would
likely be very subtle. Researchers therefore proposed the use of a three-dimensional (3D)
laser scanner as an appropriate method to collect high-resolution data for this problem.
Three-dimensional laser scanners are instruments that record precise and accurate surface data of objects in a nondestructive manner. Based on Light Detection and Ranging (LiDAR) technology and trigonometric principles, laser scanners employ a near-infrared laser to measure and record the distance to an object, typically as data points with spatial coordinates. Millions of data points can be collected in three dimensions with a high degree of precision and accuracy across the surfaces of the artifacts. This creates dense arrays of data points with Cartesian coordinates often referred to as point clouds. Given the speed of these instruments, large numbers of data points can be collected quickly and at a high sampling interval, or density, across the artifact surfaces to create highly accurate 3D digital models of the target object with a submillimeter spatial resolution. The use of this method has yet to be tested with respect to documenting ceramic abrasion; however, it has shown great utility in other ceramic studies (cf. Bouzakis et al. 2011; Karasik and Smilansky 2008), in lithic reduction studies (Clarkson and Hiscock 2011; Clarkson et al. 2006; Lin et al. 2010), and in postdepositional alteration of chipped stone tools (Grosman et al. 2011) where subtleties of research interest are often not visible to the naked eye. Studies into the effects of postdepositional processes on ceramic artifacts have been conducted with limited results in controlled settings (cf. O'Brien 1990; Skibo and Schiffer 1987); however, these studies have rarely been considered for analysis with prehistoric ceramic collections.

Researchers proposed an analysis of as much as 10 percent of the ceramic collection via the use of a 3D laser scanner to measure multiple profiles transverse to representative broken edges of each sherd. Expectations were that the gradient of the broken edge of the sherds collected from within the colluvium will be statistically lower in amplitude and broader in standard deviation than the sherds collected from within buried contexts at the site. However, the degree of this difference was not initially known. Therefore, researchers recommend combining this analysis with an experimental study of ceramic abrasion following the methods of Skibo and Schiffer (1987), whereby large sherds from the site were broken and placed in a rock tumbler with a sandy solution for varying lengths of time. After varying durations, the replica sherds were scanned and compared to the collection from 41PN175. With decent results, these data should prove useful in analyzing the collection with respect to the amount of time or distance necessary to wear the edges of the sherds. Similar theoretical applications have been applied to erosion models for earthen mounds and natural slopes regarding time (Jetten 2003; O'Neal 2005; Pierce 1986), as well as clastic roundness as a function of transport distance (Roussillon et al. 2009). With success, the study will demonstrate a new approach to a common archeological issue and provide new avenues for additional research.

**Research Domain 2: Environmental Conditions**

Evidence of an onset of arid conditions during the Middle Caddo period exists as indicated in dendrochronological analysis from Big Cypress Bayou in Northwest Louisiana (Perttula 1996:297). This topic has not been widely pursued as a research topic, but has great potential for contributing to an understanding of Middle–Late Caddo dynamics.
Furthermore, climate change is one possible explanation for the erosion of the uplands that is evident within the site. Although environmental factors will be considered in the study of the changing landscape, researchers do not go into additional detail of this theme in the sections below.

Research Question: What evidence is there regionally and locally that suggests a period of abrupt climate change during the period of site occupation?

**Investigative Strategy: Pollen and Phytolith Analysis**
The palynological evidence for northeast Texas is not abundant, but there are at least two suites of pollen cores within 75 miles of site 41PN175 (Albert 2007, 2011a). One of these is from Caddo Creek in northern Anderson County (Albert 2011a), and the other was sampled as a component of research at site 41UR77 in Upshur County (Albert 2007; Perttula and Ricklis 2005). The data have been interpreted as potentially indicative of anthropogenic fire, which may reflect drier conditions during this period (Albert 2011a). Given this nearby data and the preservation of limited pollen and phytoliths at the site, researchers proposed submitting a suite of 23 samples from a geoarchaeological column for phytolith analysis. Chad Yost and Dr. Linda Scott Cummings present these results and compare it with other Late Holocene trends in Chapter 15.

**Investigative Strategy: Review of the Effects of Environmental Pressures on Caddo Communities**
There appears to have been a fracturing of communities during the Middle Caddo period, indicated by smaller and more dispersed communities (Perttula 1996). Diasporas can be indicative of disintegrating environmental conditions as populations find it necessary to organize into smaller and more widely dispersed communities (Kennett et al. 2007). The timing and reasons for the abandonment of the Murvaul Creek site (41PN175) was unclear upon the conclusion of fieldwork. Since no definitively Historic Caddo artifacts were identified at the site, it is likely that the site was abandoned prior to this period. However, given that the landscape underwent a period of relative destabilization during the early historic period, it is also likely that this is evidence that the site was abandoned at the onset of this period. This was a period of documented widespread population decline due to disease, the lack of fertility and reproductive success, and cultural stresses (Perttula 1999b:150). Researchers proposed to review the site file records for the Middle, Late, and early Historic Caddo periods, comparing dispersion and site size as a proxy for community fracturing/cohesiveness. By comparing site frequency/size with environmental trends, it should be possible to estimate the degree to which changes in the local environment affected Caddo communities.
Research Domain 3: Subsistence and Seasonality

Research Question: What is the extent of maize use during the Caddo period at 41PN175?

The collection from site 41PN175 contains very little direct evidence concerning subsistence strategies employed by the people who occupied the site. For instance, the field records indicated that only 10 small fragments of bone and six charred nut shells were collected. However, additional macrobotanical remains were recovered in a pilot study of 10 flotation samples from features at the site. Additionally, pollen and phytolith residue analysis was performed on five residues from five ceramic sherds and four ground stone artifacts during the pilot study phase of the project. Each data set provided evidence that maize, along with several other local weedy cultigens, was present at the site. Although it was suspected that maize agriculture was practiced by the inhabitants of the site during the Middle–Late Caddo period, no direct evidence was observed prior to these studies (Cliff et al. 1999). Given the good results from the flotation samples, researchers recommend that additional samples be submitted to more fully examine the issue. Because the mitigation excavations yielded a mixed assemblage of Archaic projectile points with the Caddo materials, it is likely that numerous features will date to the Archaic period. Further analysis of subsistence remains from features will have to proceed with caution, depending on the additional dating results.

Research Question: What is the extent of maize use during the Caddo period at 41PN175?

Research Question: What is the dietary contribution of wild/native plants to the people at the site?

Research Question: Is there evidence of seasonality of site use or continuous, year-round settlement?

Investigative Strategy: Macrobotanical, Pollen and Phytolith Analysis

Researchers submitted 20 additional flotation samples for macrobotanical analysis. Ideally, additional residue samples should also have been submitted, but because of an error in sample processing, no additional unwashed sherds remained in the collection. Since maize was identified in macrobotanical remains from flotation samples and maize phytoliths were identified on select ceramic residues during the preliminary analyses, it was clear during preparation of the research design that maize agriculture was of some importance to the people at 41PN175. To what extent was not well understood, and further analysis of flotation samples was conducted to help determine if this use was widespread at the site compared with the use of wild/native plants. Additionally, the larger sample of botanical remains provided the potential for distinguishing seasonality during both the Archaic and Caddo periods.
**Investigative Strategy: Isotopic Investigation of Maize Agriculture**

Skeletal and isotopic evidence suggests that the Caddo gradually shifted from a foraging to a farming lifestyle (cf. Rose et al. 1990), and this dietary change undoubtedly affected settlement and land use practices. At the time of European contact, the Caddo economy was mixed, employing both cultivation of domesticated plants (most notably maize and beans) and foraging for a wide range of edible wild and encouraged plants. Although the historical record provides a wealth of details on these practices in the early years following European contact, several facets of Caddo agriculture are little known.

Perhaps the most glaring is the lack of understanding of the relative locations of agricultural/horticultural fields and domiciles, and the physical subdivision and layout of these activity areas, details of which are almost unknown. All published discussions of Caddo agriculture refer to the Teran map, which depicts agricultural fields and houses together in direct proximity to one another, and often surrounded by a vegetative barrier that resembles a hedge (Figure 2). Ethnographic information on Caddo fields suggests that they were typically small. For instance, Weltfish (1937:39, as paraphrased by Doolittle 2000:156) describes the fields as covering an area “half a block” by “a block and a half.” Henri Joutel (1906 [1687]:167) additionally reported that the Indians in East Texas [not specifically the Caddo] lived in “cottages . . . that are in the midst of their fields and gardens.” Although this general relationship is widely assumed, it is still unclear where Caddo fields would have been located in situations similar to the one to be examined by the mitigation of site 41PN175.

Because the vegetation in the vicinity of the site is now forest, and most likely has been generally forested since the last glacial period (cf. Bryant . and Holloway 1985; Delcourt and Delcourt 2004), it was suspected that the soil organic matter might retain isotopic evidence showing where the Caddo practiced maize agriculture. Several studies in the Maya lowlands have demonstrated that soils in that region retain geochemical evidence of prehistoric agriculture (cf. Burnett 2009; Fernández et al. 2005; Johnson, Terry, Jackson, and Golden 2007; Johnson, Wright, and Terry 2007). Given the positive results in these studies, it was thought likely that this method would prove useful for this current study. The rationale behind the use of stable isotopic ratio analysis of soil organic matter is to search for areas where maize might have been cultivated in the past. Maize (*Zea mays*), being a C$_4$ grass, may leave a carbon isotopic signature in soil organic matter that is distinctly different from the naturally occurring forest (which will impart a C$_3$ isotopic signature).
In order to determine whether geochemical evidence of maize cultivation exists at the site, researchers analyzed a suite of 200 soil samples of two types: (1) profile samples that permit examination of the depth of variation of the ratio of $^{13}$C/$^{12}$C; and (2) a spatial sample that will permit examination of how the carbon isotopes vary within various stratigraphic units in the vicinity of the site. The profile samples were submitted to explain how the carbon isotopic ratio changes with depth and which stratigraphic units may hold evidence of former maize agriculture. The spatial soil samples permit examination where organic matter from plants like maize may have been deposited, which should be former fields and refuse areas such as middens. Both vertical control samples and spatial samples were collected during the field season from within the TxDOT ROW and, with permission, from the adjacent privately owned property.

**Research Domain 4: Technology: Typology, Change, and Implementation**

**Issue 1. Types and Uses of Chipped-Stone Lithic Artifacts at 41PN175**

The lithic assemblage at 41PN175 is not extensive, particularly given the volume of soil excavated. The collection consists of 62 chipped stone tools, 2,066 debitage fragments, six cores, and five ground stone artifacts. A subset of 20 chipped-stone tools was submitted to the Center for Archaeological Research for a feasibility study of the macroscopic and microscopic evidence of use-wear. The results of this feasibility study indicated that the assemblage is dominated by local raw materials and with an apparently only a very light use...
of the chipped-stone artifact assemblage. Due to the limited results, no additional micro-usewear analysis was conducted beyond the 20 artifacts previously submitted. Furthermore, given that Late Archaic dart points, as well as a Late Paleoindian projectile point, were identified within a mixed assemblage with Middle–Late Caddo period materials, the usefulness of a detailed lithic analysis would be limited. Nevertheless, a characterization of the lithic assemblage is necessary for a discussion of the site as a whole. Analysis of the lithic assemblage will follow the protocols laid out in the TxDOT Chipped Stone Analytical Protocol and the TxDOT Protocol for Debitage Analysis.

Investigative Strategy: Chipped-Stone Tool Analysis
The entire assemblage of chipped stone tools was analyzed according to the dendritic taxonomy developed by TxDOT to record artifact modes deemed vital for contributing to the state-wide database, allowing for aerial comparisons. The analyst additionally recorded the relevant metric and nonmetric attributes of chipped stone tools as a component of the linear lithic reduction model developed by TxDOT. This strategy will be employed in an attempt to answer the following questions:

What is the taxonomic and reduction position for each recognizable chipped stone tool and core?
What range of activities is indicated by the chipped-stone tool assemblage?
Are there notable differences between the lithic artifacts identified from the deepest portions of the site (likely Archaic contexts) and those from the upper depths?
Is the raw material for stone tool production from local or nonlocal sources?

Investigative Strategy: Debitage Analysis
Of the 2,066 debitage fragments recovered from the site, only those 1152 artifacts recovered from contexts below the surface of the buried soil were analyzed. Although significant bioturbation was evident at all depths within the site, the debitage recovered from colluvial levels was interpreted as certainly from a mixed set of ages. Researchers therefore analyzed only the debitage recovered from within the buried soil as selected for further analysis. By analyzing only these artifacts, researchers attempted to minimize the likelihood of making interpretations of the collection based on a mixture of Caddo and Archaic technological strategies. For the analysis, researchers employed the TxDOT mass analysis strategy in an attempt to answer the following questions:

What reduction stages are represented?
Are there notable differences in reduction stages between artifacts collected from the Ab-horizon (likely Caddo contexts) and at depth?
What techniques are being used in the production of chipped stone tools?
Are there differences between the raw material represented in the formal tool assemblage and in the debitage assemblage?
Is the raw material being subjected to thermal alteration?
Approximately 6,115 pottery sherds were recovered during the mitigation phase of the 41PN175 excavations. Additionally, 1,057 sherds were recovered during the site testing phase (Cliff and Perttula 2002). The pottery assemblage indicates a Middle–Late Caddo timeframe. In preparation for this research design, a feasibility study included the submission of 20 sherds for petrographic analysis, 10 sherds for neutron activation analysis (NAA), and four sherds for thermoluminescence dating. Before these samples were submitted for destructive analysis, Dr. Timothy K. Perttula analyzed each sherd and developed a detailed proposal for the stylistic, technological, and taxonomic analysis of the ceramic assemblage (presented in detail in Chapter 6). These preliminary studies have proven to be effective tools for a more thorough analysis. However, the results of the NAA study have provided results that have linked the submitted samples to Caddo source regions located more than 50 miles from the site. Researchers are therefore recommending that a significant portion of the final analysis be conducted toward characterizing the provenance of the ceramic assemblage.

Research Question: How Local is the Ceramic Assemblage?

Investigative Strategy: Stylistic and Technological Analysis

Stylistic and technological analysis of the pottery was conducted by Dr. Timothy K. Perttula. The analysis conducted during the testing investigations and preliminary examination of the mitigation collection suggested that the stylistic elements (e.g., frequencies of brushed pottery sherds, engraved fine wares) were similar to other Middle Caddo occupations within the Sabine River and Angelina River basins of East Texas. What connection this small site may have had with other large villages in the area, such as Oak Hill Village (Perttula and Rogers 2007; Rogers and Perttula 2004) and the Pine Tree Mound site (Fields and Gadus 2012a, 2012b), required a more detailed study. Given that Caddo potters would have dictated the range of allowable variation possible for different vessel types, a direct study of the styles present in the collection would lend some insight into the cohesiveness of the social structure of the inhabitants of the Murvaul Creek site, both as a group and within a larger community in the Sabine River valley. It was expected that if potters were producing vessels largely independent of each other that there would be a wider variation in the styles present in the collection compared to a larger community. Additionally, a detailed stylistic analysis of the collection would potentially aid in interpreting whether temporally discrete portions of the site can be delineated.

Technological analysis was conducted by analyzing attributes such as temper, vessel form, rim and lip profiles, oxidation patterns, and vessel wall thickness. By determining the character and frequency of utility ware vessel forms, a combination of intensive dating of the collection and technological analysis was used to help determine how this assemblage was
related to, and influenced by, the intensification of maize consumption documented during the Middle Caddo period. Comparison of this collection with other sites in the region was used to help to display how changes in subsistence strategies were associated with changing food processing and storage technologies.

Researchers proposed that 10 percent of the ceramic collection be analyzed for stylistic and technological analysis. These data will be used to characterize the assemblage at the site and compare it with other sites in the region. A selection of sherds displaying characteristically local stylistic attributes and a second selection of sherds that may represent trade wares or are indicative of long use/transport lives were additionally reserved for additional provenience analysis (described below).

**Petrographic Analysis and Instrumental Neutron Activation Analysis Study of Ceramics and Raw Materials**

There is an obvious issue with the interpretation of the neutron activation analysis of the preliminary ceramic sherds submitted from the site. The principal component analysis of the individual elements (based largely on the sodium and chromium concentrations) suggested that the majority of the samples (n=6) originated in Region 4, whereas the remaining samples likely originated in Regions 6 (n=3) and Region 5 (n=1). These regions are located in the upper Sabine, Upper Cypress, and Sulphur river valleys, located approximately 50 miles from the site area. Ferguson and Glascock (see Chapter 18) conclude that the data suggest that all of the samples were likely produced locally. However, for Regions 7, 8, and 9—all of which are much closer to the 41PN175 site area—there was only a slim statistical chance that the materials originated from these areas. Ferguson and Glascock further suggest that this unexpected variation may be caused by two factors: (1) the large-scale similarity of raw clays in the region; and (2) the frequent use of grog as temper. Curiously, the results of the ceramic petrographic analysis yielded only scant evidence for grog temper in the 20 sherds that were analyzed (see Chapter 17). To address these issues, researchers suggested the following approaches for analysis.

First, researchers proposed submitting samples from the argillic Bt-horizon that were collected from within the site limit during the excavation. The samples collected from the site area did show differences in redoximorphic features, which were suspected to have caused slight variations in the chemical concentrations of the samples. An experimental suite of three clay samples collected from within the site area were submitted to the University of Missouri Research Reactor (MURR) for NAA analysis. Additionally, researchers proposed sampling clay from soils forming within the geological units mapped within 5 miles of the site area. Within this distance are four Eocene formations (Carizo Sand [Ec], Reklaw Formation [Er], Queen City Sand [Eqc], and Weches Formation [Ew]) and alluvial units of Pleistocene and Holocene age (Qt, and Qal) within the Murvaul Bayou (Bureau of Economic Geology 1975). As part of this study, researchers selected areas within TxDOT ROW to sample clay sources by means of a shovel or auger or both. In total, six clay samples along
with the three clay samples collected from the site were submitted for NAA analysis. Additional portions of the samples will be fired and submitted for petrographic analysis. It was thought that this approach would help characterize the variation of the regional clays that would have been immediately available to potters at 41PN175 and display how these variations are reflected in the NAA and petrographic data. However, as Dr. Zac Selden and Drs. Ferguson and Glascock reflected in their analyses, this approach contributed only limited information to understanding the variation of the chemical signatures of clay sources of the region.

The second approach included a carefully selected sample of additional sherds for additional petrographic and NAA analyses. Twenty-five additional samples were selected for both petrographic and neutron activation analysis. These samples were selected from the results of the stylistic and technological analysis conducted by Dr. Perttula. The initial petrographic results (Chapter 17) indicated that the sherds contained a very low percentage of grog temper; however, variations were present. The goal will be to select those sherds that exhibit negligible grog temper and select only those for further NAA analysis. The results collected from these additional samples will be integrated with the data from the pilot study and compared to both the raw material results and the wider Caddo database. Although the sodium and chromium results may indicate sources northwest of the site, researchers will additionally consider concentrations of arsenic as possibly reflecting source variations.

**Research Domain 5: Settlement Systems and Intrisite Structure**

Much of the data pertaining to settlement systems have been integrated within previously discussed investigative strategies. For instance, within the investigative strategy focused on identifying the environmental effects on Caddo community cohesiveness, researchers will discuss how site 41PN175 fits into a larger model of regional settlement systems. Within the section identifying the isotopic evidence for the locations of maize fields near the site area, researchers will discuss how the site components compare with the evidence from both historic records and other well-studied sites in the area. Additionally, within the investigation of the possible midden at the site, researchers will discuss how this feature fits in with the settlement as a whole.

Deserving specific attention are questions pertaining to the community and household organization that may be represented at the site. No observed spatial pattern of features suggests a Caddo house at the site. However, hearths, smudge pits, and potential shallow storage pits were documented at the site. A field interpretation of the internal organization of the site was that the site represented a palimpsest of multiple, short-term Middle–Late Caddo occupations in an area that had also been inhabited during Late Archaic times. Many small features were identified at the site that were interpreted as post molds; however, the number and size of structures that may have been present still needs additional research.
The size of the settlement and population represented by the site still need additional consideration.

Research Question: Are there recognizable patterns in the definitive cultural feature that suggest types and numbers of structures present, if any?

Bioturbation in the form of small insect burrows, burned tree roots, and large rodent krotovina were evident in nearly every block at the site. In many instances, the field crew examined soil stains that were later suspected to be signs of disturbance rather than cultural features. A preliminary micromorphology study of the features was conducted (Chapter 11), revealing that although many cultural features retained a matrix-defined outline, these features could not be positively distinguished from natural samples based on micromorphological characteristics. A suite of elemental analyses (e.g., grain-size, phosphorus, organic carbon content, magnetic susceptibility) was conducted on samples retained from feature fill for additional comparison. These data were used to help distinguish between those soil anomalies that are in fact posts from those anomalies that may have other natural origins (e.g., redoximorphic and/or pedoturbative origins).

Research Question: Can the abundance of ceramics at the site give indications for population size?

Within Dr. Perttula’s research plan for the site (presented in Chapter 6), he details a strategy of mass analysis for determining population size represented by a given collection of ceramic sherds. Rates of ceramic breakage for Native American farming populations have been studied by Varien’s (1999) work at Mesa Verde. According to this research, domestic contexts will accumulate between 4,000 and 8,000 g (8.8 and 13.2 pounds) of ceramics per year. Given that the entire ceramic collection will be sorted for curation purposes, researchers propose that the entire collection be minimally separated into utility and nonutility wear categories and weighed. Researchers will then calculate the total weight of utility wear sherds deposited at the site and compare this dataset with the chronology of the site to estimate the likely population inhabiting the site area. Researchers will then compare these results with additional sites in the region to complement other datasets concerning settlement sizes for the period.

Field Methods
Data recovery excavations at the Murvaul Creek site were conducted in four major stages. Prior to the initiation of data recovery, a 65-x-15-m area within the ROW, and encompassing the entire recorded boundary of the site, was first hand-cleared of all standing trees and brush. This cleared area served as the project limit for all subsequent investigations. A geophysical grid was then established covering the 65-x-15-m project area, and the first stage of investigation included the collection of both magnetic gradient and electrical conductivity data. The second stage consisted of the excavation of 50-x-50-cm small units...
in a regular 5-m grid over the project area. Based on both the geophysical and 50-x-50-cm small unit data, block excavations were then established across the site. Finally, the entire project area was mechanically stripped and all identified features were investigated.

**Geophysical Survey**
The initial stages of data recovery fieldwork operated on the working assumption that the Murvaul Creek site contained at least one isolable Middle Caddo-aged habitation area, or structure, along with an associated refuse scatter. The goal for the data recovery excavations was to determine the most likely areas of the site to investigate these differing activity areas. In order to identify likely areas and target the excavations, the 65-x-15-m project area was surveyed with both a Geonics EM-38 electrical conductivity meter and a Geometrics G-858 cesium gradiometer. The geophysical survey methods for both instruments was conducted in a similar fashion. Once the survey grid was established, two survey ropes, marked every 50 cm, were stretched between the western and eastern base lines. A third survey rope was then extended between the two base lines. This rope was moved at 50-cm increments across the survey area to serve as a guide during data collection. To minimize instrument heading error, all data were collected from west to east across the grid.

**Electrical Conductivity**
EM sensors operate by sending an AC current from a transmitter coil that induces an alternating magnetic field in the subsurface. This magnetic field is known as the primary magnetic field. Any conducting materials within this field react to the primary field and generate a secondary magnetic field. A receiver coil, located a fixed horizontal distance from the transmitter coil, records the sum of the primary and secondary magnetic fields. The resulting field is sinusoidal and can be broken down into two components: in phase and quadrature. Any material changes in electrical conductivity or magnetic permeability will be sensed by the EM instrument. The Geonics EM-38 was used for the conductivity portion of this survey. The instrument houses two noncontact transmitting and receiving coils separated by approximately 1 m that operate on a frequency of 14.6 kHz. Changes in the electrical conductivity in the ground are naturally caused by increases in clay or moisture content. Additionally, metal can appear as extreme values in the data. For the survey, five data samples were collected along each transect, for a total of 10 readings per meter.

**Magnetometry**
The Geometrics G-858 cesium gradiometer was used for the magnetometry portion of the survey. Magnetometers measure the relative strength of the earth’s magnetic field. The magnetic properties of a soil depend on the concentration of iron compounds like hematite, magnetite, and maghaemite (Weymouth 1986). Undisturbed earth will yield a uniform magnetic field, whereas cultural features (e.g., buried ditches, etc.), will tend to be more or less magnetic than the surrounding matrix. Magnetometers are generally most sensitive to metals and fired materials. Metals will appear in magnetic data as a dipolar anomaly of
paired strong positive and negative values, whereas archeological features such as hearths or earth ovens that have been fired beyond the Curie point often contain thermoremanent magnetism and will cause disturbances in the background magnetic field between 0.1 and several hundred nanotesla (nT). For this reason, burned features, such as hearths, kilns, fired bricks, and burned house floors, are readily visible in magnetic data. Typically, most anomalies range between ± 5 nT. It is not uncommon, however, for a feature to fall within 0.1 nT of the background magnetic strength.

The Geometrics G-858 sensors were mounted on a vertical shaft at a 1-m probe separation, with the lower sensor measuring the magnetic field of the soils. The upper sensor measures the background magnetic field, which ranged near 49,087 ± 77 nT. The vertical gradient was then calculated by subtracting the reading from the top sensor from the bottom sensor and dividing by the distance between the sensors. This calculation tends to cancel out the background magnetic variance not related to changing subsurface conditions observed during data collection. For this survey, the data collection was set to a 0.1 s cycle time. The transect was traversed at a near constant pace of 1 m/s and fiducial mark was placed in the every 5 m. The placement of individual data points was interpolated between each fiducial mark. This strategy resulted in approximately 10 sample readings per meter along each transect, or 20 samples per meter.

Excavation Units

*50-x-50-cm Test Unit Excavations*

The initial plan for the excavation units was to excavate 56 units in a regular 5-m grid across the 65-x-15-m site area in 10-cm vertical levels. However, once it was determined that many small units would be deeper than the initial 50-cm projection, the 10-cm vertical level-approach was quickly abandoned after consultation with TxDOT archeologists. Instead, the majority of these units were excavated in 20-cm levels. However, 10-cm levels were still used in cases where a stratigraphic break or the culturally sterile subsoil was encountered. This approach yielded a total of 8.9 cubic meters (m³) of excavated site matrix. Additionally, during this portion of the investigations, the PBS&J test excavation blocks were identified as surface depressions and were mapped accordingly. These former excavation blocks were oriented along magnetic north, and slightly askew (12.3 degrees) from the alignment of FM 10 and the geophysical grid. Given that the eventual desire for the project was to expand on the 50-x-50-cm small units, as well as the PBS&J units, all Geo-Marine units were also oriented on magnetic north.

*Block Excavations*

Based on the interpreted geophysical anomalies and artifact concentrations, seven excavation blocks were established across the project area. The size and orientation of each block varied and was generally initially based on the size of the geophysical anomaly that was being investigated. An additional excavation block was subsequently placed on the
site based on the results of the PBS&J test excavations, all of which resulted in a total of eight excavation blocks. Although the excavation blocks provided a basic analytical unit, each block was established as a collection of 1-x-1-m test units. Artifacts from each test unit were collected and separated by quadrant in order to maximize the spatial resolution of the information being gathered. In general, each test unit was excavated at 10-cm levels. However, five test units (TUs 117, 120, and 123–125) were excavated at 5-cm levels in order to aid in the interpretation of how the level thickness may have contributed to understanding artifact placement across the site.

Following the initial placement and excavation of the eight blocks, selected areas were recommended to TxDOT archeologists for expansion. As a result of these expansions, a total of 71 test units was excavated, which yielded a total of just over 38 cubic meters of site fill. The controlled excavations also yielded 44 soil stains, generally located at the base of the buried A-horizon, that were assigned and investigated as features. Each feature was numbered arbitrarily and was investigated by mapping the dimensions in plan view. The features were then bisected, and half of the feature fill was collected in bulk as a fine flotation sample. A profile was then drawn of the remaining half of the feature and a field interpretation was made concerning whether or not the stain was cultural or natural in origin. In instances where it was determined that the stain was a cultural feature, the remaining feature fill was hand excavated and screened.

A total station was used to establish both vertical and horizontal datums and to record large artifacts, such as ceramic sherds that were collected for specialized analysis. The total station was set up over the same ground surface datum each day and two back sight measurements were collected to account for small errors in data collection. With the exception of bulk soil collected from feature fill or for specialized analyses, all excavated matrix was screened onsite through 6.4-mm (0.25-inch [in]) mesh hardware cloth. Ceramic sherds, lithic tools and debitage, FCR, baked clay masses, animal bone, and mussel shell fragments were collected from the screens. Due to its fragility, charcoal was not systematically collected from the screens. Particularly large fragments (over approximately 1 cm in diameter or length) were noted and collected in situ before removal of the matrix, but smaller flecks and chunks were noted only. Field observations were documented on standard Geo-Marine forms for each test unit level and separate forms were used for each feature encountered.

All recovered materials were bagged, labeled, and delivered to the Geo-Marine laboratory (see Laboratory Procedures below). Near the end of each field day, a field sample number was assigned to each excavated context (for instance, one quadrant of a 10-cm level within a 1-x-1-m subunit, or half of a bisected feature), and all materials associated with that context were inventoried. Flotation samples were collected from all features encountered, and additional bulk samples were collected from profile walls and feature contexts.
Mechanical Stripping
A trackhoe with a bucket approximately 1 m in width was used to mechanically strip upper deposits from the project area immediately following the controlled excavation. The primary goal of this stage was to determine whether or not any human burials were present on the site. Although no burials were identified, the mechanical stripping excavations resulted in the identification of an additional 69 soil stains that were investigated as features. The mechanical excavations proceeded with the trackhoe operator performing horizontal scrapes to remove approximately 20 cm at a time from one section of the project area at a time under the supervision of Geo-Marine archeologists. Once the buried soil was encountered and the fill was excavated to a depth where features had been typically identified in the controlled excavations, the trackhoe operator temporarily ceased excavation. The archeological crew then hand shovel-skimmed the subsoil and flagged any soil stains that were present. The stains were mapped using the total station and investigated using the same procedures reviewed in the section above. Once the feature fill was removed, mechanical excavation then continued into the sterile subsoil. Following these excavations, all matrix was backfilled by the trackhoe operator and fill materials were compacted to a level grade.

Laboratory Procedures
All cultural materials collected from the data recovery investigations were returned to the Geo-Marine laboratory facilities in Plano, Texas, to be washed, weighed, counted, catalogued, and labeled in compliance with Center for Archaeological Studies (CAS) standards prior to analyses. Context and attribute data for all materials were recorded in a Microsoft ACCESS database on an IBM network system. The main categories of material recovered were animal bone, mussel shell, baked clay masses, lithics, ceramics, botanical samples (both flotation samples and opportunistically collected wood charcoal), and FCR. Lithic tools and debitage, baked clay masses, faunal materials, mussel shell fragments, and FCR were analyzed in the Geo-Marine laboratory; ceramics, geoarchaeological soil samples, and a subset of botanical remains were sent to external analysts. The following discussion describes analytical strategies and summarizes the attributes recorded during the analysis of each class of material.

Ceramics
All ceramic sherds were first washed, sorted, and labeled for curation in the Geo-Marine laboratory. Detailed analysis of the ceramic sherds from the Murvaul Creek Site was performed by Dr. Timothy K. Perttula. The analysis separated sherds based on differences in temper, sherd type (i.e., rim, body, or base), rim and lip form, decoration (if present), surface treatment (smoothing, burnishing, or polishing), and firing conditions (see Chapter 6). The general goal of the analysis was to identify the stylistic elements present in the ceramic sherd assemblage and the general time period of the Caddo occupation at the Murvaul Creek site. Additionally, a focus of the ceramic study was to understand how this assemblage of vessel sherds in the project collection represented the stylistic and
technological characteristics of the Caddo cultural group or region in which the ceramics were produced. To aid in this latter goal, 15 ceramic samples and nine clay samples collected from within 5 miles of the site, were submitted to the Archaeometry Laboratory at the Missouri Research Reactor for neutron activation analysis. The NAA results were compared to a large database of ceramics from northeastern Texas to identify clay source regions. Individual elements were also compared to regional concentrations by Dr. Robert Z. Selden, Jr.

**Botanical Remains**
Each feature encountered in the manual excavations was bisected, and half of the feature was bulk collected and floated to recover charred and uncharred plant remains. A standard oil-drum flotation apparatus with upward water flow—sometimes called a Siraf system—was employed to separate material of interest from extraneous matrix. The light fraction—charcoal fragments and other buoyant objects scooped from the water surface—was dried and then passed through 6.35-mm and 0.5-mm screens. The heavy fraction—material that sank to the bottom of the apparatus—was dried and passed through 6.35-mm and 1.6-mm screens. Heavy-fraction objects larger than 6.35 mm were sorted into material classes (FCR, lithics, bone, etc.) and integrated into the corresponding collections from the excavations. Heavy materials smaller than 6.35 mm were set aside for later discard, with the exception of bone fragments and lithics, which were integrated into the appropriate assemblages with the larger pieces.

The fine and coarse components of the light fraction material from each context were examined by Geo-Marine personnel using hand lenses and microscopes as necessary. Professional examination of the wood charcoal from a selected subset of features was undertaken by Dr. Leslie Bush, and the identifications and their implications are discussed in Chapter 9.

**Stone Tools and Debitage**
Geo-Marine personnel conducted an analysis of 100 percent of the lithic cores, tools, and ground stone. Approximately 56 percent of the unmodified lithic debitage was analyzed. All of the chipped stone artifacts were analyzed following the TxDOT Chipped Stone Analytical Protocol (version 2.4b), which is discussed further in Chapter 7. The bulk of the analysis was conducted by Geo-Marine staff; however, a subset of tools was submitted for microwear analysis to Dr. Steve Tomka. The generalized goal of the lithic analysis was to categorize the types of tools present and to identify the use of many of the informal tools. Debitage analysis focused on understanding the degree of lithic reduction that was represented by the collection and to address whether different portions of the site represent differing activities.
Baked Clay
Irregular, gravel-sized masses of hardened clay, many with evidence of oxidation, reduction, or smudging due to fire, were commonly recovered from feature fill and were occasionally recovered from test unit matrix within culture-bearing deposits. A basic analysis of these masses was performed in the Geo-Marine laboratory, where they were separated by the presence or absence of plant impressions and insect burrows. The cumulative weight and total number of baked clay masses within each class and within each context were then recorded in the project ACCESS database.

Fire-Cracked Rock
FCR was subjected to a similar basic analysis in the Geo-Marine laboratory. Fragments were first sorted based by rock material type (e.g., sandstone, limestone, quartzite), and any direct evidence of heating (e.g., fracture pattern, discoloration) noted (see Chapter 7). Within material types, the FCR was then sorted into size classes: smaller than 0.5 in (12.7 mm), 0.5–1 in (12.7–25.4 mm), 1–1.5 in (25.4–38.1 mm), 1.5–2 in (38.1–50.8 mm), 2–4 in (50.8–101.6 mm), 4–6 in (101.6–152.4 mm), and larger than 6 in (152.4 mm). No FCR fragments larger than 1.5 in were found, and thus the largest size classes were not included in the analysis. The cumulative weight and total number of FCR fragments within each class and within each archeological context were then recorded in the project ACCESS database.

Faunal Remains
Only 17.72 g (0.63 oz) of animal bone and mussel shell were recovered from the data recovery investigations at the Murvaul Creek site. Because of the limited amount of these materials recovered, the analysis was necessarily limited in scope. Similar to other material classes, basic counts and weights were recorded for the analytical categories of these materials. The bone specimens were separated by the highest identifiable taxonomic level possible. However, in most cases the highly fragmentary nature of the collection afforded only very basic classification: small terrestrial mammal (STM), medium terrestrial mammal (MTM), large terrestrial mammal (LTM), and very large terrestrial mammal (VLTM). Assessments were also made of the following characteristics: bone element, burning/butchery evidence, and weathering evidence. The extremely small and fragmentary nature of the mussel shell limited the analysis of these materials to count and weight measurements only. No umbos or other diagnostic features of shell were recovered.

Curation
Upon completion of the analyses and reporting, collected materials will be assessed for the appropriateness for long-term curation. Some classes of recovered remains, such as burned rocks, residual and bulk unprocessed soil samples, unidentifiable shell fragments, nonartifacts from the heavy and light fractions of sediment columns (e.g., coarse sand, gravel, rootlets, etc.), unburned (e.g., likely modern) macrobotanical remains, mass-produced historic period artifacts less than 50 years of age, etc., will be earmarked for discard. A list of such materials will be prepared and submitted to the THC for approval.
before disposal. Artifact inventories will be annotated to reflect the disposal of approved materials.

The remaining collections from the project will be prepared for curation according to the packaging guidelines established by CAS at Texas State University. Field and laboratory forms will be on acid-free paper; negatives and photographs will be labeled and placed in acid-free holders; cleaned and labeled artifacts will be placed in appropriate bags and boxes suitable for long-term storage. An inventory of materials submitted to curation will be prepared, and a copy will be sent with the collection to CAS for long-term storage.
Chapter 5: Data Recovery Results
by Arlo McKee

Introduction
Data recovery investigations took place between February 7 and April 3, 2011. The investigations proceeded through multiple stages. First, the 65-x-15-m project area was cleared of large trees and brush. The second two stages consisted of a geophysical survey (Figure 3) with both electrical conductivity and magnetic gradiometer instruments as well as the excavation of 50-x-50-cm small units (numbered from 1–56) in a regular 5-m grid over the site area. The goal of the geophysical and small unit surveys was to target specific areas of the site that were likely to yield in situ activity areas for block excavations. A short pause in fieldwork then occurred as the geophysical and small unit data were compiled and recommendations were made for the placement of wider block excavations. The fourth stage consisted of controlled block excavations, which were accomplished by 1-x-1-m test units numbered from 57–127, that were generally widely spaced across the project area. Finally, at the conclusion of the controlled excavations, the entire project area was mechanically stripped with a trackhoe to investigate features and eliminate the possibility that burials were present on the site but missed by the excavations.

As a result of these investigations, a total of 47.66 m$^3$ of site matrix was excavated. This included 8.9 m$^3$ excavated from the 56 small units and 38.76 m$^3$ of fill from the block excavations. From these excavations, 15,419 prehistoric artifacts and 438.9 g of ecofacts (charred vegetal materials, animal bone, and mussel shell) were recovered (Appendix A). Additionally, 113 soil stains were investigated and assigned feature numbers. Of the stains identified in the field, investigations ultimately concluded that 76 features were the result of anthropogenic origin and 37 were naturally occurring soil features (e.g., krotovina and root casts). The sections that follow detail the findings of the data recovery investigations and provide analyses of the features and radiocarbon dates obtained from these results. The full analytical tables for the artifact collection are provided in Appendix A and the laboratory dating results are presented in Appendix B.

Geophysical Survey
A detailed plan map showing the survey area ground surface conditions was created prior to conducting the geophysical survey (Figure 4). This map includes the large tree stumps resulting from tree cutting during the site clearing activities, as well as natural tree throw depressions (cradle knolls) and other ground-disturbing conditions. At the time this survey was conducted, the crew was aware that somewhere within the western one-third of the project area was the subsurface rural water line that PBS&J investigated as Feature 1 during the testing season (Cliff and Perttula 2002). As can be seen in Figure 4, numerous brush piles were on the ground surface on both sides of a two-track road on the northern end of
the project area. These brush piles each stood approximately 50 cm above the surrounding ground surface, and it was suspected that they would limit the resolution of the geophysical instruments in the area. On the southern two-thirds of the site was a fairly even distribution of extant tree stumps that had been generally cut nearly flush to the ground surface. Although these stumps likely did not have any measurable effect on the geophysical data, their presence was additionally useful for planning the block excavations. The final features of note on the ground surface were several paired depression and small mounded areas (cradle knolls) that were formed from small falling trees. The depression areas were generally 20 cm or less below ground surface, though likely these areas have filled through time and their initial ground disturbance was likely greater than that observed during fieldwork.

\[1\] Crew members conducting the geophysical survey did not wear personal protective equipment (PPE) during the geophysical survey because the metal contained in steel-toed boots and metal rivets in hard hats would have interfered with the readings of the geophysical instruments. PPE was worn by the crew during all other portions of the data recovery excavations.
Figure 4. 41PN175 site map showing excavations and ground disturbing features that may have affected the geophysical survey.
Electrical Conductivity

The electrical conductivity results generally ranged from 10 to 20 millisiemens per meter (mS/m) (Figure 5). The raw data contained only minimal horizontal striping due to variations in instrument height needed to traverse the remaining vegetation. Accordingly, only minimal data processing of a Gaussian Low-Pass filter was required for interpretation. Extreme values were only recorded along the western edge of the survey, in places where the former fence was still in place underground. Notably, these areas are plotted as high values (greater than 10 mS/m) in Figure 5 at approximately 8-9 m N and 45-50 m N along the western edge of the plot. Additionally, localized areas of extreme values are present in the data north of 60 m at approximately 7 m E and 12.5 m E. These extreme data values are interpreted as shallowly buried metal, likely in association with the two-track road present at this end of the site. Obvious discrete small anomalies attributed to prehistoric features were largely absent in the data. However, two major trends in the data were noted. First, a discrete highly conductive area was noted immediately north of the former fence line (20 m north in the data). This area was roughly circular (approximately 7–10 m in diameter), with a broad protruding arm extending to the northwest to approximately 40 m north. The second conductivity high was located between 10 and 15 m north at the extreme east portion of the survey. This area certainly extends off the survey area to the east and is similar in magnitude to the previously discussed area. During the excavation of the 50-x-50-cm small units, it was discovered that the eastern anomalous area was likely caused by the shallow depth of the clay-rich subsoil and increase in moisture in the upper soil horizons. A corresponding trend in soil conditions for the central anomalous area was not noted.

Magnetometry

The magnetic gradient data were severely affected by an abundance of metal across the site (Figure 6). These strong dipolar anomalies were noted especially in the locations of the former PBS&J excavation units, as well as along the former western fence line; most likely, the excavation crew deposited the test unit nails in the units while backfilling. This had a negative impact on the magnetic data for at least 2 m beyond the excavation unit boundaries. Accordingly, subtle anomalies relating to archeological features were not noted adjacent to any of the former test unit blocks. Finally, the utility line was also observed as a faint ground disturbance in the southern 20 m of the survey (Figure 7).

One cluster of anomalies was noted in the center of the survey block immediately north of the former E–W-oriented fence (20 m north in the data). This area is noted as Anomaly cluster 1 on Figure 7. A roughly circular pattern was observed of at least five monopolar anomalies and two dipolar anomalies ranging between approximately ±8 nT/m. This pattern overlaps with the center of the conductivity high in Figure 5. The diameter formed by this cluster of anomalies is approximately 6–7 m. This corresponds to the range of structure sizes observed at the Oak Hill Village site in Rusk County (Rogers and Perttula 2004).
Figure 5. Results of the electrical conductivity survey at 41PN175.
Figure 6. Results of the magnetic gradiometer survey at 41PN175.
Figure 7. Interpreted results of the magnetic gradiometer survey at 41PN175.
Two other discrete monopole anomalies were also observed along the eastern portion of the survey grid. Both anomalies were recorded at roughly 8 nT/m above the relative background field strength. Monopole 1 is located at the center of the two-track road that crosses through the site area, and Monopole 2 is located at the southern end of the site at approximately 9 m north. Neither anomalies appear to be associated with any other pattern or nearby anomaly cluster. Nevertheless, these could be caused by archeological features, and ground-truth excavations utilizing the block excavations were recommended.

Excavation Units

50-x-50-cm Small Units
The goal of the small unit survey was to explore the density of artifacts across the project area. In total, 56 small units were placed in regular 5-m intervals using the geophysical grid that was previously established. Although the primary focus of this stage of the excavations was not centered on studying the stratigraphy of the site, several important observations were made that helped guide the block excavations. First, the general pattern across the site showed that the sterile subsoil was encountered at a very shallow depth (<50 cm) at the southeastern quarter of the site. The shallowest depths were observed in the eastern two transects at 15 m north, where subsoil was encountered within the upper 20 cm of the ground surface. Depth to the subsoil increased to the north, which seemed to correspond with the presence of the darkened buried A-horizon (what Cliff and Perttula referred to as the darkened cultural horizon). The third observation was that the westernmost transect of small units contained a high degree of variability that was likely due to disturbance from both the terrace edge and the placement of a barbed wire fence. Although Cliff and Perttula discuss both a white sandy deposit and a reddened E-horizon near the central portion of the site, these soil features were not observed during the small unit excavations. Portions of the upper 20 cm of fill in many of the small units did contain reddened clayey aggregates, which were later shown to be redeposited portions of the Bt-horizon from farther upslope. However, these areas did not appear to have been culturally derived, as Cliff and Perttula (2002) suggested.

A total of 666 prehistoric artifacts was recovered from the dry screened samples of the 56 small units excavated across the site (Table 2). Additionally, bulk samples from a subset of small units were water screened in an attempt to use the artifacts recovered from these samples as a proxy for locations where microartifact sample collection would be advantageous. From the water screened sample, an additional 26 fragments of lithicdebitage and 34.25 g of baked clay were recovered. The horizontal spatial pattern noted in the frequency of artifacts appears to be clustered in the northern portion of the survey area. No significant difference in patterning was noted between the recovered ceramic and lithic artifacts. Given that a higher total number of ceramics was recovered, these data were used as a proxy for the distribution of artifacts across the site. Figures 8 and 9 display the quantity and weight distribution of ceramics recovered across the site. Although the
Table 2: Summary of Artifacts Recovered by Dry Screening during the Preliminary Excavations

<table>
<thead>
<tr>
<th>Artifact Class</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramics</td>
<td>571</td>
</tr>
<tr>
<td>Lithics</td>
<td>92</td>
</tr>
<tr>
<td>Baked clay</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>666</td>
</tr>
</tbody>
</table>

subsequent analysis of the collection distinguished between sherds and sherdlets (<1 cm in diameter), the preliminary recommendations made from these data did not take this distinction into account. Thus, the recommendations for block placement were based primarily on the weight of the ceramic collection. Both the quantity and weight distributions indicated that the bulk of artifacts was concentrated in the upper 40 cm of the soil profile. Occasionally, artifacts were observed deeper within the profile to 60 cm or 80 cm. Only along the western baseline were artifacts observed consistently at 80 cm or below. These soil profiles were largely disturbed due to the adjacent fence line. Although the site matrix was deeper across the majority of the northern end of the site, Figure 9 shows that the artifact density at 40–60 cm appears to be limited to the central area of the ROW.

A preliminary examination of the ceramic sherds in the Geo-Marine laboratory also indicated one additional anomalous area of the site. Within small unit 52, located at the extreme eastern portion of the study area and on the southern edge of the two-track road, several large sherds were recovered. These sherds are undecorated and have a grit temper and a coarse sandy paste. The sherds are dissimilar to the rest of the collection and were initially thought to be the remains of a Woodland-age pot. Since a large sherd remained in the western profile wall of the small unit, a small block excavation (Block 6) was placed to recover additional remains. Subsequent analysis conducted by Dr. Perttula on these ceramic materials concluded that the pot was simply not well made, but the sherds were indeed Caddo-age (Perttula 2013, personal communication).

Five soil stains were identified in the small units. Subsequent testing of each of these soil anomalies indicated that only the stain located in small unit 22 was indicative of a cultural feature. This feature (later designated Feature 10) was approximately 15 cm in diameter and filled with a dense concentration of charcoal (Figure 10). Excavation Block 4 was initially established centered on this feature. The remaining soil stains were each inspected during a preliminary consultation with TxDOT archeologists on site before proceeding to the block excavation phase. Based on this meeting, it was decided that the stains were too ephemeral to warrant additional excavation other than feature exploration.
8. Distribution of the quantity of recovered ceramics by depth. The 50-cm units that the gridded data is based on are shown on the plots as slightly rotated black squares.

At the close of the small unit excavations, four data sets were available (conductivity, gradiometer, artifact distribution, and soil stain distribution) for consideration. Based on these data sets, it was recommended that the block excavations should be conducted in two steps. First, eight excavation blocks were recommended to be established across the site (Figure 11). Blocks 1, 3, and 5 were centered on magnetic gradient anomalies that were suspected to represent cultural features. Blocks 2 and 4 were placed over small units that had soil stains that appeared in plan view to be cultural features. Block 6 was placed adjacent to the open small unit that had the large anomalous ceramic sherd remaining in the western profile wall. Finally, Blocks 7 and 8 were centered over the area that Cliff and Perttula (2002) identified as the “reddened E-horizon” and the highest density area of ceramic recovery by weight. It was recommended that the second step involve the expansion of selected blocks that yielded quality data or additional features that would need a wider area of excavation to fully explore their context. Based on these recommendations, 36 individual 1-x-1-m test units were initially established. An additional 35 test units were then placed through coordination with TxDOT archeologists (Figure 12).
Block Excavations

**Block 1: Test Units 57–60**

Block 1 was placed on the southeastern end of the site over Monopole Anomaly 2 in the magnetic gradiometer survey (see Figure 7). Very few artifacts were recovered from the small unit excavations near this block. However, the presence of the isolated anomaly warranted investigation. The block consisted of four 1-x-1-m test units arranged as a 2-x-2-m square centered on the anomaly. The block contained a thin A-horizon of very dark grayish brown (10YR 3/2) sandy loam within the upper 10 cm of the unit. Below this, the matrix lightened in color to a brown (10YR 4/3) sandy loam with abundant bioturbation and common iron/manganese nodules. This profile matched that observed in the nearby small units, where very few artifacts were recovered. One small historic iron chain link was recovered from the southeast quadrant of Test Unit 58 (Table 3). The interpretation was that this small piece of metal was the cause of the anomaly rather than any prehistoric origin. Based on the limited recovery of artifacts from the block and the presence of the sterile subsoil below 20 cm, the block was abandoned to focus on more productive areas of the site.
Block 2: Test Units 61–64 and 83–85

Block 2 was initially placed as a 2-x-2-m square centered on small unit 19, which contained a small faint soil stain at approximately 40 cmbs. The block was subsequently expanded to include three additional test units located on the northeast end of the block (Figure 13). The upper portion of the soil profile in this block was generally consistent with that observed in Block 1, consisting of a thin A-horizon of dark grayish brown (10YR 4/2) sandy loam that graded into a lighter-colored yellowish brown (10YR 5/4) sandy loam to approximately 20 cmbs. Below this zone was a thin, faint, and patchy horizon of slightly darkened brown (10YR 5/3) matrix. This darkened zone was most prominently observed in the east wall of the block (Figure 14). Unfortunately, because of the patchy and subtle nature of the buried A-horizon, artifacts were not collected separately from this horizon in Block 2. However, it was clearly noted where the matrix lightened again to a yellowish brown (10YR 5/6) sandy loam E-horizon. The artifacts recovered below 20 cmbs were all noted as occurring within the E-horizon.

Within this block was a moderate amount of disturbance. The rural water line trench was identified in Test Units 61 and 62. The trench was clearly visible beginning approximately 10 cmbs as a mottled strong brown (7.5YR 5/6), yellowish red (5YR 5/6), and gray (10YR 5/1) sandy clay loam. Upon identification, excavated matrix from within the trench was
Figure 11. Initial block excavations with gradiometer survey as a background.
Figure 12. Map showing the locations of data recovery excavations.
Table 3: Artifacts Recovered from Block 1 (Test Units 57–60)

<table>
<thead>
<tr>
<th>Depth (cmbs)</th>
<th>Historic metal</th>
<th>Prehistoric ceramic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10–20</td>
<td>1</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

Figure 13. Plan map of Block 2 showing the final layout of the block and the three soil stains investigated as features.

separated and discarded from the materials excavated from the remainder of the units. Although PBS&J test excavations assigned the trench a feature number, a number was not assigned to the utility trench during the data recovery excavations. However, three soil stains were assigned feature numbers (see Figure 13), but subsequent investigation suggested that all three were natural in origin. Features 1–3 were small brown (10YR 4/4) krotovinia identified within the E-horizon at approximately 40 cmbs. Since the stain identified as Feature 1 contained a cluster of artifacts, additional test units were added to the block to further explore the concentration. Once each of the features was bisected, their profiles revealed that each consisted of thin amorphous lenses of darkened materials originating from bioturbation. Upon this determination, the artifacts collected from within the “features” were combined with the block artifact totals presented on Table 4.
14. Block 2 east profile wall with the dashed lines marking the faint buried A-horizon in the profile.

![Image of Block 2 east profile wall with dashed lines marking the faint buried A-horizon.]

**Figure 14.** Block 2 east profile wall with the dashed lines marking the faint buried A-horizon in the profile.

<table>
<thead>
<tr>
<th>Table 4: Artifacts recovered from Block 2 (Test Units 61-64 and 83-85)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (cmbs)</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>0–10</td>
</tr>
<tr>
<td>10–20</td>
</tr>
<tr>
<td>20–30</td>
</tr>
<tr>
<td>30–40</td>
</tr>
<tr>
<td>40–50</td>
</tr>
<tr>
<td>50–60</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Similar to other areas on the site, the artifact concentration in Block 2 was primarily within the upper 40 cm of the profile (see Table 4). The greatest density of artifacts was observed in the 30–40-cmbs level. This depth approximates the area with the patchy buried A-horizon, and based on the artifact distribution, it is reasonable to interpret this zone as a buried surface. Although two fragments of historic glass were recovered from the 30–40-cmbs level, these were recovered in close association with the utility trench, and modern disturbances generally were not observed at this depth elsewhere across the site.
Block 3: Test Units 65–72

Block 3 was established as a 4-x-2-m excavation oriented N–S along several magnetic gradiometer anomalies that ranged between approximately 2.5 and 4.5 nT. The orientation of these anomalies and several others to the north and west of the block, along with their occurrence within a broad EM anomaly, led to the initial interpretation that they might be indicative of a Caddo structure. Unfortunately, no features were discovered in the block to confirm this interpretation. Instead, the excavated test units revealed a soil profile very similar to Block 2 with the exception that the buried A-horizon was nearly nonexistent. Only Test Units 65 and 69, located at the southern end of the block, contained patches of the buried soil. The remainder of the block appeared to have a simple profile consisting of a thin A-horizon overlying a lightened E-horizon that continued to 60 cmbs (Figure 15). The artifact distribution was also similar to Block 2 with concentration in the upper 30 cm (Table 5). However, although this block was slightly larger than Block 2, Block 3 contained less than half of the total number of artifacts as found in the previous block. One interesting note was that Test Unit 70 contained a San Patrice projectile point that was recovered in the 40–50-cmbs level. Although the PBS&J test excavations indicated an Archaic component at the site, the projectile point documents that the site had been used at least intermittently since the Late Paleoindian period. Since the San Patrice point was identified deep within the test unit, additional levels were excavated into the Bt subsoil, but no additional artifacts were recovered. Given the excavated depth of the unit, the profile wall was used as a geoarchaeological profile (Profile 1), discussed in Chapter 10.

Figure 15. Block 3 showing the simple profile, view facing north.
Table 5: Artifacts recovered from Block 3 (Test Units 65-72)

<table>
<thead>
<tr>
<th>Depth (cmbs)</th>
<th>Chipped Stone Tool</th>
<th>Debitage</th>
<th>FCR</th>
<th>Prehistoric Ceramic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>31</td>
<td>39</td>
</tr>
<tr>
<td>10–20</td>
<td>1</td>
<td>37</td>
<td>3</td>
<td>80</td>
<td>121</td>
</tr>
<tr>
<td>20–30</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>38</td>
<td>54</td>
</tr>
<tr>
<td>30–40</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>40–50</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>50–60</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>64</td>
<td>7</td>
<td>152</td>
<td>232</td>
</tr>
</tbody>
</table>

**Block 4: Test Units 73-78, 86-106, and 118-127**

Block 4 was initially established as a 3-x-2-m excavation (Test Units 73–78) oriented E–W and centered over small unit 22. This location was chosen because small unit 22 contained a very dark soil stain that was subsequently determined to be a smudge pit (Feature 10; see Figure 10). Based on the identification of numerous additional soil stains along the northern and eastern ends of the block, the block was then expanded to include Test Units 86–106 in the form of a 5-x-5-m block (Figure 16). Two additions to the block were also added to the north (Test Units 118–123) and east (Test Units 124–127) ends to explore soil stains identified in those areas. With these expansions, the block included the excavation of a total of 37 m² and resulted in the recovery of more than 5,000 artifacts (Table 6) and the identification of 21 features.

The recovery of artifacts within Block 4 was generally similar to both Blocks 2 and 3 with the greatest concentration of artifacts occurring within the upper 40 cm. However, within the block there was considerable variation in the depth and color of the buried A-horizon. The upper boundary of the buried soil ranged in depth from 19 cmbs to 34 cmbs with an average depth of 26 cmbs. In general, this boundary was identified slightly deeper in the units on the southern end of the block, and it was generally the shallowest in the northeast end. The color of the buried soil ranged from slightly melanized yellowish brown (10YR 5/4) to a very dark grayish brown (10YR 3/2). In general, the northern and central portions of the block contained the most pronounced melanization when compared to the southern and western ends. Based on the changing appearance of the buried soil, the field interpretation was that the buried A-horizon at the northern end of the site could represent a midden deposit. The lack of significant concentrations of bone or other kitchen refuse suggested that these materials were likely highly decomposed and leached out of the solum due to the high local pH.
Figure 16. Plan map of Block 4 showing the final layout of the block and the numerous soil stains investigated as features.
Table 6: Artifacts Recovered from Block 4 (Test Units 73–78, 86–106, and 118–127)*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>35</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>208</td>
<td>250</td>
</tr>
<tr>
<td>10–20</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>195</td>
<td>0</td>
<td>11</td>
<td>20</td>
<td>1,159</td>
<td>1,396</td>
</tr>
<tr>
<td>20–30</td>
<td>1</td>
<td>0</td>
<td>13</td>
<td>2</td>
<td>421</td>
<td>0</td>
<td>7</td>
<td>54</td>
<td>1,594</td>
<td>2,092</td>
</tr>
<tr>
<td>30–40</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>255</td>
<td>3</td>
<td>6</td>
<td>75</td>
<td>815</td>
<td>1,163</td>
</tr>
<tr>
<td>40–50</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>34</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>103</td>
<td>142</td>
</tr>
<tr>
<td>50–60</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>13</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>37</td>
<td>53</td>
</tr>
<tr>
<td>60–70</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>6</td>
<td>30</td>
<td>4</td>
<td>953</td>
<td>4</td>
<td>27</td>
<td>152</td>
<td>3,918</td>
<td>5,098</td>
</tr>
</tbody>
</table>

* artifacts recovered from features are excluded
** includes aggregated artifacts frequencies from test unit levels of varying thickness

Because of the changing relative depth of the separate soil horizons observed in Block 4, the placement of the artifacts presented in Table 6 is somewhat misleading. In the field, the changing depth to the buried A-horizon caused numerous test unit levels to be cut short of the intended 10-cm thickness. In order to accurately present which stratigraphic horizon the artifacts were concentrated within, each provenience was later attributed by soil horizon. By the time these data were being attributed, a significant portion of the site had been excavated, and an interpretation that sediments burying the dark A-horizon represented colluvium from farther upslope had been made (see Chapter 10). Accordingly, the materials from Block 4 were separated into multiple sections: Colluvium, Ab-horizon, E-horizon, and Disturbed. Table 7 shows the artifacts collected from Block 4 separated by soil horizon. Although a greater total number of artifacts was recovered from the colluvium, when accounting for the thickness of each horizon, the buried A-horizon levels had a density of roughly 124 artifacts per centimeter of matrix, whereas 103 artifacts per centimeter were collected from colluvial levels.

Table 7: Artifacts Recovered from Block 4 Separated by Profile Section

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Disturbed</td>
<td></td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>84</td>
<td>1</td>
<td>4</td>
<td>52</td>
<td>435</td>
<td>581</td>
</tr>
<tr>
<td>Colluvium</td>
<td>26</td>
<td>3</td>
<td>3</td>
<td>15</td>
<td>3</td>
<td>452</td>
<td>0</td>
<td>15</td>
<td>67</td>
<td>2,127</td>
<td>2,685</td>
</tr>
<tr>
<td>Ab</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>398</td>
<td>2</td>
<td>7</td>
<td>33</td>
<td>1,288</td>
<td>1,740</td>
</tr>
<tr>
<td>E</td>
<td>12</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>68</td>
<td>92</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>6</td>
<td>30</td>
<td>4</td>
<td>953</td>
<td>4</td>
<td>27</td>
<td>152</td>
<td>3,918</td>
<td>5,098</td>
<td></td>
</tr>
</tbody>
</table>

* in cm

An additional attempt was made to understand the placement of the artifacts within the soil profile through the excavation of five 1-x-1-m units in 5-cm levels. Within Block 4, two pairs of test units were excavated in this fashion (Figure 17). In Test Units 124 and 125, located on the eastern end of the block, there was an overall increase in both ceramics and lithics.
with depth through the Colluvium. Although this pattern was generally repeated in most other units on the site, the 5-cm levels showed that the relative increase in artifacts was not entirely uniform. Test Units 124 and 125 showed an increase in lithic frequency to the bottom of the colluvium but ceramics varied in frequency through this section. Each of the 5-cm levels clearly showed a decreasing frequency of artifacts throughout the buried A-horizon. However, Test Units 120 and 123, located on the extreme northern end of Block 4, actually show the greatest frequency at the top of this horizon instead of within the colluvium. Within the buried soil, the artifact distribution was consistent with the interpretation that the Caddo occupation represents a postdepositional occupation on a formerly stable surface (Ferring 1992:19). Given that there was considerable variation in the frequency of artifacts within the colluvium and that it appeared during the excavation that the greatest abundances of artifacts were identified near the bottom of this horizon, there was considerable question near the close of fieldwork as to whether or not the bulk of the artifact assemblage had been redeposited on top of the site. This issue is discussed more completely in Chapter 10; however, the interpretation is that should the artifacts in the colluvium represent redeposited materials, then likely their primary source was very near the present location of the site.

In addition to an abundance of artifacts, 39 soil stains were assigned feature numbers and investigated. Of the 39 investigated soil stains, 13 were shown to be cultural, eight were of questionable origin, and 18 were ultimately shown to be the result of natural origin. The statement that many of these features were of questionable origin stems from the prominence of bioturbation throughout the profile. As the excavation continued to the base of the buried A-horizon, special care was taken to trowel the interface to the E-horizon. The
E-horizon had a very mottled appearance, ranging from very pale brown (10YR 8/2), to yellowish brown (10YR 5/4), including many inclusions of strong brown (7.5YR 5/8) fine sandy loam (Figure 18). During the feature investigations, numerous concentrations of mottled areas gave roughly circular appearances in plan view and caused the initial interpretation that the concentrations represented postholes or other cultural features. However, in cross section, these faint stains often contained irregular or amorphous boundaries that suggested they were instead natural soil features. A representative sample of features was collected for micromorphological study (see Chapter 11), and many of the subtle postholes were ultimately shown in thin section to be indistinct from the natural soil profile. Of the 21 soil stains that were shown to be of cultural origin, approximately half (n=11) were indeed small postholes. The remaining cultural features consisted of eight pit features, one smudge pit, and the remains of a hearth that was initially discovered during the PBS&J test excavations.

Figure 18. Block 4 showing the interface with the E-horizon and several prominent features visible on the western end of the block, view facing west.

In general, the stains that were shown to be features were concentrated on the western half of the block. The total counts of artifacts were plotted for each soil horizon by the test unit quadrangle from which they were collected. The test units were excavated in 50-cm quadrangles in an attempt to help delineate concentrations of artifacts that might have resulted from their deposition either inside or outside a Caddo structure. Figure 19 shows that the artifact density varied considerably across the site, depending on the soil horizon.
Figure 19. Map showing the location of artifacts collected in Block 4 separated by soil horizon.
context. The central and western ends of the block generally contained higher overall concentrations of artifacts. However, a majority of the artifacts in the central portion of the block were collected from the Colluvium, which is suspected to represent translocated materials. Within the buried soil (Ab-and E-horizons), the greatest density of artifacts appeared to be along the western side of the block. This concentration was closely associated with the concentration of features in the block. Although numerous postholes were identified, there was no clear pattern confirming the location of a structure. Given the relatively high artifact density in close association with an area of high feature density, it is reasonable to conclude that this activity area was not habitually cleaned as would be suspected in a maintained dwelling. Although bioturbation certainly has removed the definitive signature of many features, especially small postholes, this area is not presently interpreted as being indicative of a Caddo dwelling. Instead, it is interpreted as an outdoor work area where postholes likely served for hide processing stands or other activities. An additional possibility is that the area served as a temporary shelter such as a ramada.

**Block 5: Test Units 79–82**

Block 5 was established as a 2-x-2-m excavation centered on a magnetic monopole anomaly that was approximately 2.2 nT above the background signature. The block was placed in the center of a two-track road used to access the property from FM-10. Along the road’s path was a subtle swale in the ground surface, and brush piles were present along both sides of the road. The stratigraphy in the block was very similar to that observed in the previous blocks, with the exception that the buried A-horizon was very strongly expressed as a dark yellowish brown (10YR 3/4) fine sandy loam that occurred between 30 cmbs and 50 cmbs. Table 8 shows that this horizon was marked with the greatest concentration in both prehistoric ceramic sherds and chipped stone debitage. Although the block was located in the two-track road, no clear damage to the archeological materials in the block was apparent. However, two sources of disturbance were noted below the buried A-horizon. Features 4 and 5 were two soil stains identified near the western and eastern ends of the block, respectively (Figure 20). In both cases, the soil stains appeared roughly circular in plan view. However, once the features were bisected, both were irregular and conical in profile. Both features were determined to be large decayed tree roots. Feature 4 did contain two prehistoric ceramic sherds, but these were likely contained in the overlying matrix that filled the feature as the root decayed. Although these two root disturbances were noted on the edges of the block, no definitive source of the magnetic anomaly was identified.

**Block 6: Test Units 107–108**

Block 6 was established as a 1-x-2-m excavation immediately adjacent to the west profile wall of small Unit 52. The block was set up immediately adjacent to the edge of the two-track road and partially over a brush pile that had been placed on the edge of the road. In small unit 52, several large plain sherds were recovered at approximately 40 cmbs.
Table 8: Artifacts Recovered from Block 5 (Test Units 79-82)

<table>
<thead>
<tr>
<th>Depth (cmbs)</th>
<th>Chipped Stone Tool</th>
<th>Debitage</th>
<th>FCR</th>
<th>Baked Clay</th>
<th>Prehistoric Ceramic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10–20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>20–30</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>58</td>
<td>63</td>
</tr>
<tr>
<td>30–40</td>
<td>0</td>
<td>16</td>
<td>2</td>
<td>1</td>
<td>101</td>
<td>120</td>
</tr>
<tr>
<td>40–50</td>
<td>3</td>
<td>10</td>
<td>0</td>
<td>1</td>
<td>67</td>
<td>81</td>
</tr>
<tr>
<td>50–60</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>60–70</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>31</td>
<td>2</td>
<td>2</td>
<td>243</td>
<td>281</td>
</tr>
</tbody>
</table>

NOTE: Material from features not included in table.

Figure 20. Plan map of Block 5 showing the locations of two soil stains ultimately determined to be noncultural root disturbances.

(Figure 21). These sherds were by far the largest in the collection from the small excavation units (approximately 7 cm in diameter) and an additional sherd appeared to still be present in the west wall of small Unit 52. Further, the sherds were thought to be somewhat anomalous at the time they were discovered because they had a gritty and rough surface treatment. Subsequent analysis by Dr. Perttula concluded that the sherds represented a Caddo pot that was poorly manufactured rather than representing ceramics from a previous time period.
Unfortunately the Block 6 excavation was of limited success in recovering additional large sherds. Given the proximity of Block 5 just to the northwest, it was not surprising that the stratigraphy between the two blocks was nearly identical. The upper 35 cm of Block 6 consisted of colluvial sediments that varied between dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4). Below this was a 10-cm-thick buried A-horizon that was a slightly darkened brown (10YR 4/3) in color. The sherd that was visible in the adjacent unit wall was encountered at 40 cmbs within the buried A-horizon. Unfortunately, the sherd was only a small fragment and it appeared that the vast majority of the representative sherds were collected previously in small Unit 52. No additional soil stains or features were encountered. Table 9 shows that the artifacts collected from this block were primarily located in the 25–35-cmbs level, which represented the lower portion of the colluvium. Only limited artifacts were present in the buried A-horizon and underlying E-horizon. Once the clay-rich Bt-horizon was encountered at 55 cm, the block was abandoned.

**Block 7: Test Units 109–112**

Block 7 was the northernmost block excavation from the data recovery investigations. The block was placed immediately adjacent to the PBS&J North Block because both that block and the small unit excavations suggested that this area had the highest artifact density on the site. Although four test units were established, two were quickly abandoned at approximately 40 cmbs because the rural water trench disturbed the majority of the units (Figure 22). The remaining two units on the east side of the block were excavated to 90 cmbs, but artifacts were only recovered to 70 cmbs. The upper portion of the block was
Table 9: Artifacts Recovered from Block 6 (Test Units 107-108)

<table>
<thead>
<tr>
<th>Depth (cmbs)</th>
<th>Debitage</th>
<th>FCR</th>
<th>Baked Clay</th>
<th>Prehistoric Ceramic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10–25*</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>25–35</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>44</td>
<td>59</td>
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<td>35–45</td>
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<td>0</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Total</td>
<td>18</td>
<td>1</td>
<td>2</td>
<td>89</td>
<td>110</td>
</tr>
</tbody>
</table>

* levels were skewed in order to match with both stratigraphy and to end a level near the depth where a large pot fragment was found in the adjacent 50-cm unit

Figure 22. Block 7 excavations showing the rural water trench disturbance on the western side of the block, view facing north.

similarly represented by colluvial sediments. However, the color ranged from strong brown (7.5YR 5/8) to light yellowish brown (10YR 6/4), depending on the location within the colluvium. In general, redder hues were observed in the upper 20 cm of the units and lighter colors were observed in greater abundance with depth. No distinction was made during the excavation between the upper and lower colluvium because although this
distinction was apparent in profile, the matrix was often so mottled between the two colors that a clear boundary between the two horizons was not observed. Below the colluvium, the buried A-horizon was very strongly expressed as a dark brown (10YR 3/3) fine sandy loam that was approximately 20 cm thick. Extensive bioturbation was present that blurred both the upper and lower boundaries of this horizon. The strong melanization of the buried A-horizon in this area suggested that considerable organic enrichment, likely from anthropogenic sources, had occurred. Below 60 cmbs was a thin E-horizon of brown (10YR 5/3) fine sandy loam that overlies the sterile Bt-horizon of strong brown (10YR 5/6) clay loam.

Table 10 presents the artifacts collected from Block 7. Although only two test units were excavated below 40 cmbs, the table does reflect the overall variability of artifacts through the profile. The greatest concentration of artifacts was observed in the lower portion of the colluvium and relatively limited artifacts were present within the buried soil. Although two fragments of historic glass were recovered from within the colluvium, both of these were collected from the units that contained the utility trench. In general, the modern disturbance appeared to be limited in the remaining portion of the block. Overall the density of artifacts was only slightly higher in Block 7 than that observed in Block 4. The density of artifacts recovered from the blocks was actually the greatest in Block 8. This contrasting artifact density between the block excavations and the small excavation units suggests a great deal of intrasite variability in the assemblage that may not have been entirely evident in the small unit survey. No soil stains or features were identified in the block.

**Table 10: Artifacts Recovered from Block 7 (Test Units 109-112)**

<table>
<thead>
<tr>
<th>Depth (cmbs)</th>
<th>Historic Glass</th>
<th>Bone</th>
<th>Chipped Stone Tool</th>
<th>Debitage</th>
<th>FCR</th>
<th>Baked Clay</th>
<th>Prehistoric Ceramic</th>
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<td>11</td>
<td>514</td>
<td>594</td>
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</table>

**Block 8: Test Units 113–117**

Block 8 was initially placed as a 2-x-2-m excavation centered over an area that PBS&J identified as a central area for the “Reddened E-Horizon” that was identified overlying the buried A-horizon. An additional test unit was later added to the north end of the block to allow greater exposure to the west profile wall of the block. The stratigraphy of Block 8 was
nearly identical to that observed in Block 7 with one notable exception (Figure 23). The boundaries of the buried A-horizon overall were less obscured by bioturbation than those observed in Block 7. Although Block 8 was located only roughly 5–6 m north of the northern extension of Block 4, the buried A-horizon was considerably darker in Block 8 than that observed in both Block 4 and the other southern blocks. This sudden increase in melanization further suggested to the field crew that the buried soil was anthropogenic in origin.

Figure 23. Block 8 north wall profile prior to expansion of the block with Test Unit 117.

Although Block 8 contained only one additional test unit compared to Blocks 5 and 7, considerably more artifacts were collected from Block 8 than were collected from either of those two blocks (Table 11). The artifact frequency generally increased with depth through the colluvium. However, the peak in both lithics and ceramics occurred in the 40–50-cmbs level, which was the first occurrence of the buried A-horizon. As can be seen in Figure 23, the upper boundary of the buried A-horizon did vary slightly across the block. In general, test unit levels were terminated at stratigraphic boundaries. As a second test of artifact distribution variation with depth, Test Unit 117 was excavated in 5-cm levels (see Figure 17). In Test Unit 117, the peak in artifact concentration was actually located immediately above the boundary for the buried A-horizon, and artifacts decreased gradually with depth below this boundary. No soil stains or cultural features were identified in Block 8. However,
### Table 11: Artifacts Recovered from Block 8 (Test Units 113-117)

<table>
<thead>
<tr>
<th>Depth (cmbs)</th>
<th>Hist.</th>
<th>Bone</th>
<th>Chipped Stone Tool</th>
<th>Chipped Stone Core</th>
<th>Debitage</th>
<th>FCR</th>
<th>Baked Clay</th>
<th>Prehistoric Ceramic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>0–10</td>
<td>0</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>49</td>
<td>58</td>
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<td>3</td>
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<td>284</td>
</tr>
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<td>1</td>
<td>2</td>
<td>60</td>
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<td>335</td>
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<td>1</td>
<td>0</td>
<td>0</td>
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<td>3</td>
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<td>371</td>
</tr>
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<td>1</td>
<td>1</td>
<td>0</td>
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<td>16</td>
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<tr>
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<td>183</td>
<td>10</td>
<td>11</td>
<td>964</td>
<td>1,177</td>
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</table>

Extensive additional geoarchaeological studies were conducted on the sediment profiles that were collected from the west wall of the block (see Chapter 10). Based on these studies, it became apparent that the “Reddened E-horizon” identified by PBS&J during the site testing excavations was likely the manifestation of the Upper Colluvium, which contained greater redeposited aggregates from the reddened Bt-horizon. No fired soil or other cultural features were identified in the block.

**Mechanical and Feature Excavations**

Following the conclusion of the controlled block excavations, the entire 65-x-15-m project area was mechanically scraped to the sterile subsoil to confirm that burials were not present. At this stage of the field excavations, the variability of the site stratigraphy was well known and the block excavations served as a guide for the trackhoe operator to expose the base of the buried A-horizon. This was the general position that the vast majority of features investigated in the excavation blocks were identified. The excavations generally proceeded from south to north across the site. After a large swath of area was exposed with the trackhoe, the excavation crew carefully shovel-skimmed the top of the exposed E-horizon and marked areas that appeared to be discrete soil stains. In total, 69 soil stains were identified and investigated as features during this stage (Figure 24). Of these investigated stains, 25 were ultimately shown to be the result of bioturbation such as large decayed roots or burrows. Twenty-nine of these stains were classified as pit features (n=11) of various sizes and likely various functions as postholes (n=12), smudge pits (n=4), and hearths (n=2). The remaining 15 stains were classified as possible pit features (n=6) and possible post features (n=9). Extensive bioturbation was present in association with all of the possible features; however, these features did retain characteristics, such as a darkened matrix and rounded bottom, which were suggestive of an anthropogenic origin. Flotation samples were collected and processed from all cultural and possibly cultural features. Table 13 presents the total counts and weights (if measured) of all artifactual materials recovered from the flotation samples.
When features from both the block and mechanical excavations were compiled, it became apparent that the spatial arrangement of the features was not randomly spread across the project area. Instead, there appeared to be at least two separate clusters of features that were positioned on the edge of the large darkened Ab-horizon that was hypothesized to be a midden (see Figure 24). Unfortunately, these clusters also occurred in proximity to the existing water utility trench that had previously disturbed the area. The first cluster, consisting of 35 features and possible features, was partially investigated by the Block 4 excavations. This cluster was in a roughly rectangular area of approximately 7.3-x-4.0 m. Fourteen postholes and probable postholes were associated with this cluster, and the majority of these were generally situated near the periphery of the cluster. A roughly linear set of pit features (n=21) was oriented southwest to northeast near the center of this cluster. Although the results of the Block 4 excavations were less than conclusive that this area represented a discrete structure, the concentration of domestic features in this cluster suggests otherwise. The arrangement of the numerous pits and smudge pits in association with postholes suggests that a structure was present, though this was likely a ramada or other outdoor work area rather than a habitation. The second cluster was more dispersed and was located to the southwest of the Block 8 excavations. This area yielded 11 features also covering approximately the same dimensions as the first area.

**Postholes**

A total of 31 postholes was identified during data recovery investigations. These included 14 identified within the area designated as Cluster 1, six within Cluster 2, and 11 additional postholes scattered across the site (Table 14). In general, the posthole features were usually circular in plan view with a dark yellowish brown to brown (10YR 4/3–4) matrix darker than the surrounding E-horizon matrix (Figure 25). The mean diameter from all investigated postholes was 17.98 ± 6.46 cm, with the total diameter range varying from 10–38 cm. Very few differences in post diameter were observed among the features from different areas on the site. Both the average diameter and range are very similar to the posts identified at the Lang Pasture site (Perttula et al. 2011), and the assemblage is well within the range of variation observed on many of the structures at the Oak Hill Village site (Rogers and Perttula 2004). At the Oak Hill Village site, the wide variation in post diameter was attributed to differences in building function, post wood availability, and the inclusion of large center posts in the feature assemblage. The wide range of post sizes at Murvaul Creek could suggest either that post diameter was not a major concern for structure construction or that the range in diameter suggests that the patterns observed were indicative of multiple structures serving different functions placed in this location at slightly different times.
Figure 24. Map showing the location of all soil stains investigated as features on site 41PN175.
Table 12: Feature Inventory from the Murvaul Creek Site

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<th>Feature</th>
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<th>Probable Function</th>
<th>AMS Dated</th>
<th>Macrobotanical Analysis</th>
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</tr>
<tr>
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</tr>
<tr>
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The average feature thickness of the postholes was $9 \pm 4.61$ cm with an observed range of 4–22 cm. The average observed thickness of only 9 cm for each feature would have accounted for an average post depth of between 19 and 29 cm based on the thickness of the overlying buried A-horizon (Figure 26). In contrast, for each of the structures at the Lang Pasture site, the average post depth was more than 55 cmbs. The thickness of the sandy E-horizon likely could have played a part in the shallow depth of the majority of the posts at the Murvaul Creek site. Similar to the Lang Pasture site, none of the post features was found to have been excavated into the underlying clay-rich Bt-horizon. The interface to this horizon is positioned just below the lowest average depth of many of the post features. The shallow post depth is similar to the average depth observed at the Pine Tree Mound site (Fields and Gadus 2012a). However, at that site, the majority of the posts did penetrate into the Bt-horizon, which would have allowed for a stable footing. Apparently, having posts deeply anchored into the soil at Murvaul Creek was not a major concern.
Table 13: Cultural Material Recovered from Features

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<th>Mussel Shell</th>
<th>Vegetal Material</th>
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<th>Baked Clay</th>
<th>Prehistoric Ceramic</th>
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<td>67 (3.48)</td>
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<td>91 (2.7)</td>
<td>4 (22.5)</td>
<td>10 (4)</td>
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<tr>
<td>7</td>
<td>3 (0.05)</td>
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<td>4 (22.5)</td>
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<tr>
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* weights in grams are reported in parentheses

In terms of distance between posts, a wide variation was observed between Clusters 1 and 2. An alignment of posts on the east side of Cluster 1 showed an average spacing between posts of 0.53 m, though the range was quite variable (0.08–0.93 m). In Cluster 2, the spacing between posts on the northeast side of the cluster was much wider. An average spacing at Cluster 2 was observed at 1.39 m with a total range of 0.98–1.88 m, though this observation is based only on the distances between five posts. The average distance
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<th>Horizontal Dimensions (cm)</th>
<th>Feature Depth (cmbs)</th>
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<td>16-x-18</td>
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Figure 25. View of the profile of Feature 60, representing a typical posthole feature, showing the discrete darkened matrix within the bleached E-horizon.

Figure 26. Schematic of posthole feature profiles.
between the Cluster 1 posts is well within the range of variation for multiple structures present at the Oak Hill Village site. However, the wide distance between features designated in Cluster 2 is much wider than what would be expected for an enclosed structure. Likely, the Cluster 2 features represent either an incomplete sample due to the loss of many features from bioturbation or excavation practices or that this area also represents an outdoor work area. The presence of a prominent smudge pit (Feature 87) on the northwestern periphery of Cluster 2 likely supports this latter interpretation.

Very few artifacts were recovered from posthole features. The flotation samples from the postholes yielded a total of 15 ceramic sherds, 32 debitage fragments, 128 small baked clay fragments (108.4 g), 20 highly fragmentary mussel shell remains (0.11 g), six small unidentifiable calcined bone fragments (0.12 g), and 30.46 g of vegetal material. With regard to ceramic and lithic artifacts, this recovered material amounts to 1.6 artifacts per feature. All fragments of baked clay appeared to be small nodular aggregates of fired soil without fiber inclusions or other tempering agents that would suggest daub. Based on the limited contents, there does not appear to have been any deliberate depositing of refuse in any of the posthole features. Instead, the contents appear to represent general site matrix that was either intentionally placed or naturally deposited in the post void.

**Pits**

Twenty-six features were categorized as pits and possible pit features during data recovery excavations (Table 15). The size and shape of the pit features were relatively diverse. In general, pit features were differentiated from postholes and hearths primarily based on the size and apparent abundance of fired clay or burned earth. Overall, pit features were more readily distinguished as dark stains with colors ranging from very dark grayish brown (10YR 3/2) to dark yellowish brown (10YR 4/4) that contrasted well with the lighter-colored E-horizon matrix that was normally yellowish brown (10YR 5/4) or lighter. The average diameter of the features classified as pits was 35.41 ± 18.28 cm with a total range of 12–129 cm. Some differences were noted among the numerous areas on the site. Cluster 1 contained 18 pit features. Several of these pit features (i.e., Features 6, 7, 9, 53, and 57) tended to be much larger in diameter than typically identified on the site. With the exclusion of the large features from Cluster 1, most pits identified on the site averaged 29.96 ± 10.92 cm in diameter. In general, the diameters of these features tended to be larger than the features identified as postholes, but they were still in the range that would have been classified as a “small pit” at either the Lang Pasture or Oak Hill Village sites (Perttula et al. 2011; Rogers and Perttula 2004). The average thickness of the pit features was 15.31 ± 10.29 cm, with a total range of 4–53 cm (Figure 27). The pit feature extending the deepest below surface on the site (Feature 75) was identified in Cluster 2. The fill from Feature 75 was more than 23 cm deeper than that of any other pit feature identified on the site. Given that very few pits of substantial size were identified on the site, it is logical to conclude that very little food storage other than caching occurred in the site area. If one were to suppose that each of the pit features was used simultaneously for storage of plant foods and were all
Table 15: Pits

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<th>Feature Depth (cmbs)</th>
<th>Volume (m³)</th>
<th>Calibrated 2-Σ ¹⁴C Date</th>
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<td>25-x-20</td>
<td>38–42</td>
<td>0.001</td>
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<td>32-x-32</td>
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<td>51</td>
<td>32-x-28</td>
<td>40–50</td>
<td>0.007</td>
<td>A.D. 1430–1490, A.D. 1600–1610 (520–460, 350–340 B.P.)</td>
</tr>
<tr>
<td>53</td>
<td>59-x-33</td>
<td>40–50</td>
<td>0.017</td>
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<td>55</td>
<td>36-x-47</td>
<td>39–46</td>
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<tr>
<td>56</td>
<td>20-x-15</td>
<td>41–59</td>
<td>0.015</td>
<td>A.D. 1480–1650 (470–300 B.P.)</td>
</tr>
<tr>
<td>57</td>
<td>77-x-65</td>
<td>39–69</td>
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<td>58</td>
<td>35-x-30</td>
<td>42–56</td>
<td>0.011</td>
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<td>59</td>
<td>21-x-36</td>
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<tr>
<td>65</td>
<td>28-x-24</td>
<td>43–67</td>
<td>0.010</td>
<td>A.D. 1300–1360, A.D. 1380–1420 (640–590, 570–530 B.P.)</td>
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<tr>
<td>68</td>
<td>30-x-30</td>
<td>42–62</td>
<td>0.012</td>
<td></td>
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<td>97</td>
<td>25-x-25</td>
<td>42–69</td>
<td>0.042</td>
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<td><strong>Cluster 2 Pits</strong></td>
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<td>73</td>
<td>38-x-37</td>
<td>45–59</td>
<td>0.016</td>
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<td>75</td>
<td>42-x-36</td>
<td>51–104</td>
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<tr>
<td>79</td>
<td>42-x-34</td>
<td>58–82</td>
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<td><strong>Other Pits</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>30-x-40</td>
<td>41–53</td>
<td>0.010</td>
<td>A.D. 1450–1640 (500–310 B.P.)</td>
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<td>89</td>
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<td>66–86</td>
<td>0.010</td>
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<tr>
<td>105</td>
<td>38-x-24</td>
<td>34–44</td>
<td>0.007</td>
<td>A.D. 1450–1640 (500–310 B.P.)</td>
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<tr>
<td>110</td>
<td>45-x-29</td>
<td>45–51</td>
<td>0.006</td>
<td>A.D. 1280–1320, A.D. 1350–1390 (670–630, 600–560 B.P.)</td>
</tr>
</tbody>
</table>

full to capacity, then the total volume of plant foods would amount to only 15.05 bushels. More than 70 percent of the storage capacity would have been available in only seven features, five of which were located in Cluster 1 and two were located in Cluster 2.
Figure 27. Pit feature profiles.
Eleven pit features were selected for radiocarbon dating. These features were chosen for dating primarily because they appeared to have large quantities of well-preserved charred remains and because the selected samples provided a wide distribution across the site. An assumption based on the preliminary results of the research design was that a high likelihood existed that many of the features identified would be related to periods other than the Caddo occupation. However, with the distribution of dated pit features, this assumption was ultimately shown to be incorrect. Of the dated pit features, only three features were outside of the A.D. 1430–1650 time period that was observed elsewhere on the site (see Table 15). Feature 30, located on the northern extension of Block 4 was the oldest observed feature date (ca. A.D. 670-850) obtained during the data recovery excavations. This date corresponds only with Feature 88, a hearth located at the northern end of the site. Feature 110 located east of Block 4, also produced a slightly older date of A.D. 1280–1390 on a corn cupule. Only Feature 65 (A.D. 1300–1420), on the western margin of Cluster 1 had a date range comparable to Feature 110. Due to the wide distribution of dates slightly older than the bulk of the dates obtained from the site, it was not possible to conclude that any one portion of the site was being used at different times. Instead, it appears that the majority of the features on the site date to the Middle–Late Caddo period, but the site was used intermittently prior to this period.

Cluster 1 Pits

Of the 18 pit features identified in Cluster 1, the majority were relatively small, thin lenses of darkened silt loam that persisted into the E-horizon. The majority of these features were very shallow basins with sloping walls, and they differed from postholes primarily based on their size and oblong or irregular shapes. Eight pit features from Cluster 1 were radiocarbon-dated. The results of these radiocarbon dates indicated that seven of the eight features dated to the period between ca. A.D. 1450 and 1640. Several notable features were identified in this area and are discussed in the section below.

Features 6 and 7 were identified initially in plan view on the western end of Block 4 as an irregularly shaped stain that was approximately 1.8-x-0.6-m. After closely troweling and mapping the stain, it was shown that the stain actually represented two shallow pit features, with a small 10-cm gap between Feature 6 to the north and Feature 7 to the south (Figure 28). When the features were profiled, they were both shown to be shallow (13–17 cm) basins that had been filled with laminated dark grayish brown to dark yellowish brown (10YR 4/2–4/4) sandy loam. The laminated sediment suggests that the features were left open after their use and allowed to fill naturally with adjacent sediment. The contents of the features are thus assumed to represent the locally abundant artifacts left as refuse rather than indicating a special purpose activity. A total of 66.5 liters (L) of feature fill was floated from these two features. The 31.5 L processed from Feature 6 yielded 21 ceramic sherds, 67 debitage fragments, five very small fragments of unidentifiable burned bone (0.06 g), and 1.64 g of charred vegetal material. The 35-L sample processed from Feature 7 was slightly more diverse, with 51 ceramic sherds, 91 debitage fragments, one Bonham
28. Features 6 and 7 after bisecting and profiling.

Figure 28. Features 6 (right) and 7 (left) after bisecting and profiling.

projectile point, four FCR, three small fragments of unidentifiable burned bone (0.05 g), 10 fragments of baked clay (4 g), and 6.79 g of charred vegetal material. The charred materials from Feature 7 were submitted for macrobotanical analysis and were shown to contain a local signature of pine, oak, and hickory wood, as well as annuals (pinecone scales, acorns, and resin) and other unidentified hardwood species. Carbonized nutshells from each feature submitted for radiocarbon analysis yielded contemporaneous dates of ca. A.D. 1450–1650.

The lack of abundant burned clay or charcoal suggests that these two features represent shallow storage pits rather than abandoned hearths. The total volume of the two features was approximately 0.081 m³, a volume, which if used to store grain would have amounted to approximately 2.31 bushels of available storage. However, it is important to note that this bushel estimate is representative of the total feature volume. Likely, the storage capacity would have been slightly less if the features were lined with grass or cane.

Feature 9 was another wide, but shallow basin-shaped pit located approximately 80 cm south of Feature 7 in Block 4. The feature was identified in plan view as an oblong stain measuring approximately 80-x-55 cm oriented roughly north–south. In profile, the feature was shown to be a shallow basin with the deepest portion on the southern end at approximately 13 cm total thickness. The feature matrix was very similar to Features 6 and
7 in that the sediment was weakly laminated with dark brown (10YR 3/3) to grayish brown (10YR 5/2) silt loam. The total of 34.5 L of fill collected for flotation yielded 31 ceramic sherds, 47 debitage fragments, five small fragments of unidentifiable burned bone (0.11 g), one FCR, seven fragments of baked clay (5.7 g), and 3.02 g of charred vegetal material. The charred materials were submitted for macrobotanical analysis, and also similar to Features 6 and 7, the contents were shown to contain a local signature of locally available hardwoods and nutshells. No cultigens were identified among the macrobotanical remains. A radiocarbon date of A.D. 1450–1630 was obtained from a nutshell recovered from the feature. The nearly contemporaneous date obtained among Features 6, 7, and 9 as well as similar form and content suggest that these features were used for the same purpose, perhaps contemporaneously. The limited recovery of burned clay and charcoal also suggests that Feature 9 was used as a storage or refuse pit. The total volume of the feature is estimated at 0.043 m³, which if the feature were used to store grain would represent 1.23 bushels of plant materials.

Feature 57, in terms of its total volume (0.114 m³), was the largest pit identified during data recovery excavations. Considering available storage capacity, this feature would still have been classified as a small pit at sites such as Oak Hill Village or Lang Pasture (Perttula et al. 2011; Rogers and Perttula 2004), but it would have represented 3.23 bushels of storage capacity. The feature was identified within a cluster of other small pit features on the southwest end of Cluster 1. Feature 57 was a generally circular stain measuring approximately 65–77 cm in diameter. In profile, the brown (10YR 4/3) feature fill contrasted abruptly with the yellowish brown (10YR 5/4) E-horizon. The feature had slightly sloping walls and a rounded bottom, with a thickness of approximately 30 cm. A total of 9.5 L of feature matrix was collected for flotation and yielded 18 ceramic sherds, 22 debitage fragments, 34 fragments of baked clay (22.5 g), and 4.22 g of charred vegetal material. Additionally, a clear bottle glass fragment was recovered from the flotation sample. The glass fragment was taken as a sign of contamination, although its position within the feature fill was unfortunately not identified. Because of the possible contamination, a radiocarbon sample was not submitted from Feature 57. However, the charred vegetal material was analyzed for macrobotanical remains. As with other pit features, the bulk of the contents were attributable to mixed hardwood (e.g., pine, oak, hickory, and ash), but several fragments of corn cupules and kernels were also identified in the fill.

Feature 65 was a small circular pit on the southwest end of Cluster 1. The feature was approximately 25 cm in diameter and it had relatively straight sides and a flat bottom. The feature fill was a dark yellowish brown (10YR 3/4) silt loam that contrasted distinctly with the yellowish brown (10YR 5/4) E-horizon into which the pit had been excavated. A 5-L flotation sample yielded very few remains: one baked clay fragment (0.6 g) and 1.57 g of charred vegetal material. The lack of remains may indicate that the feature was used as a posthole rather than a storage pit; however, the size of the feature was larger than most of
those identified as posts elsewhere on the site. One notable result from the feature was that a nutshell fragment submitted for radiocarbon analysis yielded a date range of A.D. 1300–1420. This date range is slightly earlier than observed from the majority of the other dated features, but it does partially overlap with a date obtained from a corn cupule from Feature 110.

Cluster 2 Pits

Three pit features were identified as part of the area designated Cluster 2. Features 73 and 79 were two small basin-shaped pits that were each approximately 40 cm in diameter. Both pits were similar in size and shape to many of the other small pits identified across the site. In general, they were composed of dark brown to brown (10YR 3–4/3) silt loam and were excavated into the light-colored E-horizon. Very few artifacts were recovered from the samples collected from flotation (see Table 13). However, Feature 79 is notable because the macrobotanical analysis yielded a diverse assemblage that included both a local signature of hardwood remains as well as corn kernels and waterlily (Nymphaeaceae) tuber remains. A sample was not selected from either of these features for radiocarbon analysis, but based on the results of many of the other features, the interpretation is that likely both corn and waterlily were being processed for food on the site during the main Middle–Late Caddo occupation. Chapter 9 goes into greater detail on the significance of the findings from Feature 79.

Feature 75 is the third pit feature identified in Cluster 2. This feature was in the westcentral area of the cluster. The feature was first identified as a dark yellowish brown (10YR 3/6) stain with fine charcoal flecking that was approximately 40 cm in diameter. When the feature was bisected, it was found to be more than 50 cm in thickness and excavated through the E-horizon into the top portion of the clay-rich Bt-horizon (Figure 29). In profile, the dark feature matrix persisted for only approximately 10 cm with the majority of the feature fill composed of a yellowish brown (10YR 5/4) sandy loam matrix that appeared to lighten in color with depth. The feature had generally parallel sides and a flat bottom. The artifacts recovered from the 17.75 L of flotation fill were consistent with the density of artifacts recovered from many of the other pits on the site. Fifteen ceramic sherds, 14 debitage fragments, eight small unidentifiable bone fragments (0.11 g), 18 baked clay fragments (11.4 g), and 1.02 g of charred vegetal materials were recovered. A radiocarbon date obtained from a charred nutshell yielded a date of A.D. 1450–1640, which is consistent with the date obtained from smudge pit Feature 87 within Cluster 2 and generally from elsewhere on the site.
Although Feature 75 was classified as a pit feature based on its size and contents, it could also be considered a large posthole. The large diameter and relatively flat bottom of the feature is consistent with the range of center posts identified at Oak Hill Village (Rogers and Perttula 2004:111). At that site, the majority of the center posts were 35 cm in diameter, and, subsequent to the removal of the center post at the completion of building construction, a common practice was to backfill the posthole and use the area as a central hearth. Given a relatively low density of charcoal or other burned materials at the top of the feature, however, it is doubtful that the feature was used as a hearth for a lengthy duration. If Feature 75 were a central post rather than an abandoned storage pit, then the posthole features on the periphery of Cluster 2 may mark an incomplete outline of the structure. The six posthole features are on average 2.75 ± 0.69 m away from Feature 75. Several small structures at Oak Hill Village (e.g., Structures 3, 6, 24) were recorded as a size that would be similar to the distances of the Cluster 2 postholes from Feature 75 at Murvaul Creek. However, because of the limited additional remains recovered from this area and the fact that the post alignment is highly irregular, it is difficult to interpret Cluster 2 as a Caddo house area. Instead, it is more likely that this area represents an outdoor work area, and many of the post features could represent drying racks or other activity areas.
Other Pits

Five other small pit features were identified across the site that were not associated with either of the identified feature clusters. Like most other pits, these features were dark grayish brown (10YR 4/2) stains that had been excavated into the lighter-colored E-horizon. The pit features were approximately 25–40 cm in diameter and they ranged from 6 to 20 cm in thickness. These dimensions were generally larger than the dimensions observed in the features identified as postholes. Of these widely spaced pit features, two yielded radiocarbon dates that were slightly older than the commonly observed dates obtained from the site. Feature 30, which was located on the northern extension of Block 4, was a small pit that contained only 3.7 g of charred vegetal remains and no additional artifacts in the 7.25 L of flotation fill that was collected. The macrobotanical analysis of this feature recovered only pine wood, pinecone scales, and other unidentified hardwood. One small pinecone scale was submitted for radiocarbon analysis and yielded a date of ca. A.D. 670–850. This date was the oldest obtained from any feature excavated during data recovery investigations. Although the date is anomalous, a carbonized wood sample from hearth Feature 88 in Block 7 north of Feature 30 also yielded a date comparable with Feature 30. Although these two features were not adjacent to each other, the presence of these two dates indicates that the site had been occupied, at least intermittently, throughout the Early Ceramic period in addition to the primary Middle–Late Caddo occupation.

Feature 110 is also notable because it contained the earliest date obtained from a corn cupule on the site. This feature was identified on the eastern end of the project area during mechanical scraping of the site. Only 6 cm of the feature remained, though it is likely that the trackhoe bucket removed the top of the feature from excavating too deeply in this area. The flotation sample recovered only 54 fragments of baked clay (35.2 g) and 9.03 g of charred material, and other than the identification of the corn cupule in the charcoal sample, the contents were otherwise unremarkable. The corn cupule was submitted for radiocarbon analysis primarily because dating this feature would allow a wide distribution of dates across the site. The results yielded a date range of ca. A.D. 1280–1390. This date is well within the range of maize agriculture in East Texas, but it represents the earliest Middle Caddo period date obtained from the site.

Smudge Pits

Smudge pit features were distinguished from other pit features primarily by their abundance of charcoal and their black (10YR 2/1) to very dark gray (10YR 3/1) color. The feature color was in stark contrast to the generally bleached yellowish brown (10YR 5/4–8) E-horizon matrix (Figure 30). Additional 14C NMR analysis, presented in detail in Chapter 10, suggested that the dark color of the smudge pit features was due primarily to the abundance of charcoal as opposed to dark-colored humified organic matter. These features were generally circular or oval in plan view with an average diameter of 27.38 ± 5.32 cm and a range of 21–36 cm, with one exception. The exception to this range was Feature 87, which appeared in both plan view and profile to be a double-lobed shallow pit (Figure 31). The mean excavated thickness of the features was 10.75 ± 5.05 cm, but given that four of
Figure 30. Profile of Feature 10.

Figure 31. Smudge pit profiles.
the five features were discovered during mechanical scraping, it is likely that the features were truncated by the trackhoe bucket.

Very few artifacts were recovered from the smudge pit features (Table 16). The flotation samples yielded three ceramic sherds, 10 debitage fragments, one very small unidentifiable calcined bone fragment (<0.1g), 48 fragments of baked clay (41.7 g), and 163.44 g of vegetal material. This ceramic and debitage count equates to 2.6 artifacts per feature. When the greater overall volume of feature fill is considered, the density of ceramics and lithics is comparable to that observed in the posthole features. By contrast, the quantity of charred vegetal material recovered from the five smudge pit features roughly equates to the total amount of charred material recovered from all other feature types. Based on the abundance of charred material, samples from three of the five smudge pits were submitted for additional macrobotanical analysis. The results of the macrobotanical analysis from the site are discussed in greater detail in Chapter 9, but the charred remains from the smudge pits were composed primarily of pinecone scales, varieties of hard wood (e.g., oak, hickory, sweetgum, and pine), hickory nutshells, and maize. The abundance of pinecones and corn is typical of this type of feature, and these materials were likely added to the wood fire in order to generate smoke to be used for hide processing or insect repellant (Binford 1967).

Table 16: Smudge Pits

<table>
<thead>
<tr>
<th>Feature</th>
<th>Horizontal Dimensions (cm)</th>
<th>Feature Depth (cmbs)</th>
<th>Volume (m³)</th>
<th>Calibrated 2-Σ ¹⁴C Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cluster 1 Smudge Pits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>29-x-27</td>
<td>40–45</td>
<td>0.003</td>
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<tr>
<td><strong>Cluster 2 Smudge Pits</strong></td>
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<td></td>
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<tr>
<td>87</td>
<td>67-x-77</td>
<td>56–71</td>
<td>0.026</td>
<td>A.D. 1450–1640 (500–310 B.P.)</td>
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<td><strong>Other Smudge Pits</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>94</td>
<td>28-x-33</td>
<td>23–34</td>
<td>0.007</td>
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</table>

Three radiocarbon dates were obtained from maize, pinecone, and wood identified from the flotation samples. Two dates were obtained from smudge pits located in Cluster 1 and the third sample was obtained from the smudge pit in Cluster 2. All three of the dates appeared to be contemporaneous, with dates ranging from A.D. 1440 to 1640. These dates suggest that both areas were utilized during the same period.
Hearths

Three features identified as hearths were investigated during data recovery excavations (Table 17). These features were Feature 86 located in Cluster 2, Feature 88 at the northern end of the site near Block 7, and Feature 29 on the northern extension of Block 4. In general, these features were identified as hearths primarily on the basis of abundant burned earth and other fired materials, whereas the features identified as pits appeared to contain only darkened feature matrix but an absence of substantial pyrogenic activity. Although these features were identified as hearths at Murvaul Creek, similar features identified at Oak Hill Village have led to the conclusion that many hearth and pit features likely served multiple functions such as functioning as the site of a central post during house construction, or they may simply represent short-term use features (Rogers and Perttula 2004:97–111). In the case of the features identified at Murvaul Creek, the lack of thick oxidized rim margins of all the features likely supports the interpretation that the majority were relatively short-term use features.

Table 17: Hearths

<table>
<thead>
<tr>
<th>Feature</th>
<th>Horizontal Dimensions (cm)</th>
<th>Feature Depth (cmbs)</th>
<th>Volume (m³)</th>
<th>Calibrated 2-S 14C Date</th>
</tr>
</thead>
<tbody>
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<td>Cluster 2 Hearths</td>
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</tr>
<tr>
<td>86</td>
<td>57-x-34</td>
<td>64–71</td>
<td>0.011</td>
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</tr>
<tr>
<td>Other Hearths</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>55-x-40</td>
<td>41–55</td>
<td>0.035</td>
<td>*A.D. 1440–1640 (510–310 B.P.)</td>
</tr>
<tr>
<td>88</td>
<td>85-x-85</td>
<td>64–98</td>
<td>0.066</td>
<td>A.D. 690–880 (1260–1060 B.P.)</td>
</tr>
</tbody>
</table>

* Feature 29 is the same as the PBS&J Feature 6

Feature 29 was identified in Test Unit 120 of Block 4, a unit that partially contained the eastern end of the PBS&J Central Block. During those previous test excavations, PBS&J Feature 6 was identified in the northern end of the unit that overlapped the data recovery excavations. The feature was identified as a basin-shaped small pit during the test excavations, but the apparent abundance of fired clay observed during the data recovery investigations suggested that this feature may have been used as a hearth (Figure 32). The presence of the fired clay in this feature was anomalous with many of the other pit features identified during the data recovery excavations; during current excavations the fill appeared to contain primarily a darkened matrix and a variable density of artifacts. Although this feature had been analyzed during the test excavations, an additional 20 L of feature fill was collected for flotation. The flotation recovered 32 ceramic sherds, 37 debitage fragments, two FCR, 31 baked clay fragments (40.8 g), and 4.62 g of vegetal material. The charred remains were submitted for macrobotanical analysis, which indicated that the charcoal consisted primarily of pine, oak, limited cherry wood, other unidentified hardwoods, as well as hickory nutshells, oak acorns, and limited pine resin. This feature was not radiocarbon-dated as part of the data recovery investigations because it had been previously dated to A.D. 1440–1640 (see Table 17).
Feature 86 was identified as a very thin lens (approximately 5 cm) of darkened soil on the northern end of Cluster 2. The feature was identified during mechanical scraping and likely the trackhoe bucket removed the upper portion of the feature. What remained was an oblong 57-x-34-cm lens that seemed to be the bottom of a hearth. In profile, the feature appeared to be an irregular basin shape in which the dark grayish brown (10YR 4/2) feature fill had an abrupt boundary with the surrounding light yellowish brown (10YR 6/4) E-horizon. Approximately half of the feature was collected for flotation (6 L). Recovered artifacts were 19 ceramic sherds, five debitage fragments, four baked clay fragments (2.5 g), and 0.74 g of charred vegetal material. The charred remains were submitted for macrobotanical analysis, which indicated that the charcoal consisted primarily of pine, oak, other unidentified hardwoods, hickory nutshells, and limited pinecone scales and resin. No cultigens were identified in the macrobotanical sample.

Feature 88 was identified in plan view as a wide stain measuring approximately 85 cm in diameter. The feature was immediately adjacent to Feature 89, which was identified as a possible pit (Figure 33). Both features were profiled along the same bisection line, and the profile revealed that these were distinct features (Figure 34). Both features were filled with very dark grayish brown (10YR 3/2) sandy loam, but Feature 88 was distinct because it contained numerous large fragments of yellowish red (5YR 5/8) baked clay. Unlike many of
Figure 33. Hearth profiles.

Figure 34. Features 88 (left) and 89 (right) in profile.
the other features found through scraping, the prominence of the buried A-horizon in this area permitted the trackhoe operator to remove all but a very thin lens of the buried soil above the E-horizon. Leaving matrix overlying the E-horizon allowed full retrieval of the features in the area, rather than a truncated portion. In profile, the bulk of Feature 88 revealed a wide thin lens of darkened feature fill with a 34-cm-deep pit that had parallel sides and a flat bottom. The dimensions and overall shape of the feature are consistent with the description of those features at Oak Hill Village identified as central posts that subsequently had hearths built over them (Rogers and Perttula 2004:111). However, there was no apparent break between the portion of the feature that was likely used as a hearth and the remnants of the central post. Instead, the fill of the feature was composed of mixed material throughout both the upper and lower sections.

Very few artifacts were recovered from the 33 L of Feature 88 that were processed for flotation. The recovery consisted of five ceramic sherds, two debitage fragments, one very small unidentifiable burned bone fragment (<0.1 g), 604 baked clay fragments (871.6 g), and 45.33 g of charred vegetal material. Of the five ceramic sherds identified, four were small sherds and the remaining item was a nondescript plain sherd; plain sherds cannot generally be sorted between those of Woodland age and later post-A.D. 800/900 Caddo age. The charred remains were submitted for macrobotanical analysis and were found to be composed primarily of pine and other unidentifiable hardwood. Hickory nutshells, copperleaf seeds, pinecone scales and resin, as well as a corn cupule, were also identified in the sample. A radiocarbon date obtained from a sample of carbonized wood revealed one of the earliest feature dates (A.D. 690–880) obtained during data recovery. Unfortunately, this sample was selected prior to the full macrobotanical analysis when only woody fragments had been identified from the feature. Although this sample’s age range spans the latter part of the Woodland period to the first years of the Formative Caddo period, the lack of any diagnostic materials preceding the Middle–Late Caddo period puts the date in question. A number of possibilities exist to explain the anomalously old date. First, the fragment of wood that was submitted may have represented a section of old wood. Second, the feature could have been used as either a hearth or storage pit during multiple periods, and the contents would have contained materials from mixed time periods. Third, given that one other feature, Feature 30, was dated to nearly the same time period using a pinecone scale, it is also likely that the fill of this feature incorporated materials left behind from a previous ephemeral occupation of the site.
Chapter 6: Ceramic Analysis
by Timothy K. Perttula, with contributions by Robert Z. Selden, Jr.

Ceramic Analysis Part 1: Aboriginal Ceramic Vessel and Pipe Sherds from the Murvaul Creek Site (41PN175)
by Timothy K. Perttula

Introduction
Ceramic sherds from prehistoric Caddo pottery vessels are abundant at the Murvaul Creek site (41PN175) (Figure 35). In total, 1,057 plain and decorated sherds were recovered in test excavations in 2002 (Cliff and Perttula 2002) at the site, along with another 4,928 plain and decorated sherds in the current data recovery excavations completed by Geo-Marine, Inc. As is discussed below, about 30 percent of the sherds in the two assemblages have decorative elements on them.

Analysis of the recovered ceramic sherds from the test excavations at the Murvaul Creek site suggested that they are the product of a Middle Caddo (ca. A.D. 1200–1450) occupation by a group of Caddo peoples affiliated with other Caddo groups living in the middle reaches of the Sabine River and the Angelina River basins in East Texas (see Figure 35). This conclusion was based on the common frequency of brushed pottery sherds in the assemblage; the absence of post-A.D. 1450 engraved fine wares and ridged utility wares (the latter are common after that time in the Toledo Bend Reservoir area, see Kelley 2006); moderate plain to decorated sherd ratios of 1.74–2.51 (this ratio simply compares the number of plain sherds to decorated sherds no matter what their size or their position on a vessel from which they may have originated, and has nothing to do with typological identifications); and the very common use of burned bone as a temper for both fine wares and utility wares (Cliff and Perttula 2002:76–80). The one available calibrated radiocarbon date (2 sigma) obtained from the prehistoric Caddo component at the site, however, was A.D. 1440–1640, suggesting that at least some part of the prehistoric Caddo occupation at the site took place in Late Caddo period times (ca. A.D. 1450–1680). Resolution of the chronological age of the Caddo component or components at the Murvaul Creek site depends upon the analysis of the additional radiocarbon samples from data recovery feature contexts, plus radiocarbon samples of organic materials in sherds, thermoluminescence (TL) dates from sherds, and a more detailed analysis of the stylistic and technological character of the sherd assemblage from the different parts of the site. The dating of the ceramic assemblages from the site is discussed in more detail below.
Figure 35. Middle and Late Caddo period ceramic complexes in East Texas and selected sites including the Murvaul Creek site (41PN175).

**Theoretical and Methodological Perspectives**

Studies of prehistoric ceramic assemblages provide valuable information about Native American cultural adaptations and offer a means of addressing chronology and cultural-temporal frameworks as well as technological and stylistic attributes particular to the assemblage itself. To speak to this broad range of issues for the ceramic assemblage at site 41PN175, the analysis must be comprehensive enough to capture the array of stylistic and technological diversity found in the assemblage. When sherds large enough to exhibit the overall character of design motifs are present in the assemblage, typological classifications may be possible, although this is far from guaranteed given the current state of the East Texas Caddo ceramic typology and the difficulty in identifying Caddo types with decorated body sherds. In the absence of whole vessels or vessel sections large enough to
discern typologically distinct decorative motifs, another way to distinguish subtle differences between relatively similar ceramics in an assemblage is to look at the stylistic and technological variations found on individual sherds. Recent research indicates that for Caddo potters in East Texas, variations in key technological attributes such as temper, surface treatment, firing conditions, and thickness bear a direct relationship to the desired use of a vessel (see Perttula 2004; Perttula and Ellis 2012; Rogers and Perttula 2004). Thus, sherds recovered from the Murvaul Creek site can be characterized according to a suite of key technological attributes, as well as key decorative methods, motifs, and decorative elements. Each of these attributes identified on sherds analyzed in detail provides information about the technical knowledge and the stylistic choices specific to the ceramic tradition developed by Caddo potters living at the Murvaul Creek site (and at contemporaneous sites in the middle portion of the Sabine River basin and the Angelina River basin, see Figure 35) and the raw materials components of the pottery making process. These in turn are informative about the different technical and stylistic choices made at various stages in that process. These differences provide a basis for comparing the technological and stylistic variability of this specific ceramic assemblage to the technological and stylistic variability found in what are thought to be other contemporaneous Middle Caddo period ceramic assemblages and traditions in East Texas (see Figure 35).

There is a general consensus among archeologists that stylistic expressions, and variations in that expression, in material culture, dress, body ornamentation, food practices, etc., can be a measure of social identity. However, the recognition of style in archeological materials is more than “the material correlate’ [emphasis in the original] of social affiliation” (Wobst 1999:120). Patterns of style reflect variability in both individual choices as well as social group membership, and therefore the existence and pervasiveness of styles in material culture—the concern here being the existence of local styles of ceramic decoration as expressed in the decorated sherds from the Murvaul Creek site—are clues to the strength of interaction between individuals (individual potters), the form of cultural transmission (i.e., from parent to child; from a teacher to a pupil; from older to younger members of a social group; or between unrelated individuals, see McClure 2007:Table 1), and the ability of styles to be inherited from one generation to the next (O’Brien and Lyman 2003:19). Styles “share a common developmental history and are from the same tradition” (O’Brien and Lyman 2003:19). Style in ceramics as used here simply means the characteristic patterns of pottery decoration that when applied to the rim or body or both of a vessel in certain combinations and elements result in a unique set of visually represented design motifs and attributes. The combinations may be innumerabl e, as the choice “between certain kinds of design elements on ceramics is not a functional consideration but rather is historically determined and selectively ‘neutral,’ because there is no inherent advantage between one element and the next” (Meltzer 2003:140). In actual fact, ceramic practice among Caddo potters at the Murvaul Creek site would have dictated the range of acceptable variation in stylistic choice that was maintained for generations by socially related groups of potters.
Styles are expected to change rapidly, more rapidly than functional forms of tools and pottery vessels (see Rogers and Ehrlich 2008:3418). This interpretation follows from the idea that stylistic traits have a relatively rapid turn-over because of their use in generating and reinforcing cultural identity, their selectively neutral character (i.e., stylistic elements have no differential effect on survival), and the potential high variation between individuals and groups in learning and replicating specific shared styles, particularly (in the case of ceramics) if Caddo potters were producing vessels largely independent of one another, that together comprise a ceramic tradition at any one moment in time.

Ceramic style elements defined and recognized on sherds and vessels from a Caddo site simply represent one classification, among several developed and used in Caddo archeology, of different ways of decorating a vessel by the prehistoric Caddo peoples (cf. Dowd 2011a), and there is general consensus that shared styles are “the result of direct cultural transmission once chance similarity in a context of limited possibilities is excluded” (Dunnell 1978:199). If the decorative elements are truly stylistic in character, they allow the measurement of time as well as interaction between different but contemporaneous groups of people (Lyman et al. 1997:10), along with an assessment of a potter’s place within a larger tradition of ceramic practice. Because the vast majority of the ceramics from Caddo sites are sherds rather than vessels or sherd vessel groupings, and there are no vessels from the Murvaul Creek site, the only available stylistic information from the site’s ceramic assemblage is the rim and body decorations (often different on the same vessel) as tabulated through the counts of different decorative methods and elements.

The stylistic analysis of Caddo ceramics from the Murvaul Creek site in East Texas focuses on the definition of recognizable decorative motifs and elements in the fine wares (i.e., the engraved and red-slipped vessels, including carinated bowls and bottles) and utility wares (usually cooking or storage jars and simple bowls). These wares are known to have been made and used differently, based on functional, technological, and stylistic analyses on numerous Caddo sherd assemblages in the broader East Texas region, with uses ranging from food service, cooking of foodstuffs, as containers for liquids, and for plant food/seed crop storage. The ceramic analysis is completed in conjunction with formal and technological analyses of any sherd vessel sections (from macroscopic analyses of sherd cross sections), and from the detailed analysis of a robust sample of plain and decorated rim and body sherds, emphasizing paste characteristics, non-plastic inclusions, surface treatments, and firing environments of the decorated and plain sherd assemblages as well as whole vessels, if such are recovered.

The interest is in determining not only broad trends in changing ceramic styles in East Texas Caddo sites, but also in exploring more-fine-tuned synchronic and diachronic differences in stylistic composition and diversity at the Murvaul Creek site; these more fine-tuned comparisons must rely on more than presence/absence data to produce the useful
recognition of stylistic and temporal differences and similarities between regional assemblages. Therefore, a more detailed consideration of ceramic stylistic variability and diversity will be developed that focuses on decorative elements that can be identified on rim and body sherds. These represent distinct designs or design combinations (i.e., the breakdown of individual decorations within an overall design motif, as in a hatched triangle, circle, or tick marks) that can be identified on sherds and vessel sections (even if it is only a portion of the element), as a recurrent feature of decoration within each of the major decorative methods (e.g., incising, punctating, engraving, etc.) present in the Caddo ceramic assemblage. The design elements can be defined at different levels of association, depending upon variations in the designs (e.g., the number and spacing of engraved lines on a rim), the location of the decoration (e.g., on the rim, body, the vessel interior, etc.), and the method of decoration (e.g., horizontal vs. vertical brushing).

These same stylistic analyses can be employed to answer broader questions of the social and cultural affiliation of Caddo groups, and the place of the Murvaul Creek site within a specific community of Caddo people, through stylistic and vessel morphological comparisons with collections from other broadly contemporaneous Caddo sites in the local area (see Figure 35). Another concern is also with determining the character and frequency of the utility ware vessel forms in Caddo households and components, and how their composition at the assemblage level may be related to (and influenced by) the postulated intensification of maize consumption by Caddo groups in East Texas after ca. A.D. 1300/1400 (see Perttula 2008; Wilson 2012), as well as differences in culinary and plant food storage traditions.

**Research Questions**

There are several common research questions and problems that concern the study of Caddo ceramic sherd assemblages in East Texas that are relevant to the study of the ceramics from the Murvaul Creek site. First, can ceramic sherds from the site assemblage be employed to determine and measure social relationships/broad social affiliations between prehistoric Caddo groups in East Texas from ceramic stylistic evidence?

What do ceramic stylistic similarities between East Texas sites indicate about Caddo communities?

Because these distinctive kinds of decorated pottery in Caddo contexts were circulated within or among specific cultural and historical milieus, they have a social significance, and thus pots have a “social life” (Habicht-Mauche 2006:7). The ceramic material culture of Caddo peoples has a social significance and a social history, in that there are meanings inscribed in their form and style that have been derived by people (potters included) as a result of “material transactions and performances that make up the day-to-day, rough-and-tumble of human social life” (Habicht-Mauche 2006:7). Examining that social history through a consideration of the wide range of decorative styles that was employed on fine wares and utility ware pottery at the Murvaul Creek site and other generally
contemporaneous Caddo sites (see Figure 35) ought to lead to the identification of other Caddo peoples that held similar symbolic, structural, and aesthetic beliefs about pottery and how the world works through material culture expressions. The histories of how ceramic vessels were made, shaped, and decorated are reflective of technological, functional, and stylistic practices, beliefs, and ideas shared by different groups of people within households and communities of kin-affiliated Caddo peoples.

Are there measurable stylistic variations within each region and significant differences between the regions?

These similarities and differences lie at the heart of any conclusions about the cultural and ceramic affiliations of local Caddo groups that lived at the Murvaul Creek site and other East Texas Caddo sites of Middle Caddo period age, and the synthesis of available stylistic information from the Murvaul Creek site and related assemblages (see Figure 35) should lead to a better understanding of the development of Caddo pottery styles on a regional and intraregional basis. Chronological refinements and the temporal bounding of specific material culture assemblages of ceramics from different Caddo groups in East Texas will facilitate temporal and spatial comparisons of different local sequences that together can be interpreted to have social, social learning (Eerkens and Lipo 2007), and kin-affiliated meanings.

Can the recognition of local ceramic chemical groups and manufacturing locales at the Murvaul Creek site as determined by instrumental neutron activation analysis (INAA) and petrography shed light on the existence, size, intensity, and relative amount of goods traded and/or exchanged in local Caddo economic networks?

Such complementary information about the nature of interaction with contemporaneous Caddo groups in East Texas—based on the identification via INAA and petrographic analysis of nonlocal Caddo ceramics preserved in archeological deposits—can be enlightening about social and trade relationships that the Caddo peoples living at the Murvaul Creek site had with other Caddo groups. Presumably, the Caddo peoples living in East Texas—comprising communities of kin-affiliated families—made ceramic vessels and other goods that were also traded and exchanged through social and economic relationships.

Were these ceramic vessels (as well as their contents) obtained for use as funerary objects or for other special purposes, or with the intention of meeting domestic needs and probably fulfilling economic obligations with Caddo neighbors?

The available ceramic evidence from East Texas Caddo sites does suggest that there was a flourishing and long-term sustaining economic trade network in existence in Caddo times across the region. This network was primarily based on the exchange of materials destined
for use in domestic contexts, rather than one where obtaining prestige goods served as a primary economic and social motivation for exchange and interaction by the social and political elite.

In the case of the Murvaul Creek site, 25 sherds were selected for petrographic analysis or INAA or both (Table 18) to assess the compositional character of the ceramic assemblage and make reasonable interpretations of the local vs. nonlocal origin of different ceramic vessel sherds and wares. The 25 samples include one plain bowl rim sherd, five other plain rim sherds, three sherds from fine ware carinated bowls and bottles, and 16 sherds from utility ware jars decorated with brushed, brushed-incised, brushed-punctated, incised, incised-punctated, and punctated decorative elements.

Table 18: Murvaul Creek Site (41PN175) Sherds for Petrographic and/or Instrumental Neutron Activation Analysis

<table>
<thead>
<tr>
<th>Lot No./Specimen</th>
<th>Sherd Type</th>
<th>Temper Paste</th>
<th>Firing Conditions</th>
<th>Surface Treatment</th>
<th>Thick (mm)</th>
<th>Decoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrographic Only:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>314.2</td>
<td>Body</td>
<td>Bone-hematite</td>
<td>G</td>
<td>–</td>
<td>6.1</td>
<td>Opposed brushed</td>
</tr>
<tr>
<td>323.1</td>
<td>Body</td>
<td>Bone-organics</td>
<td>H</td>
<td>ISM</td>
<td>7.6</td>
<td>Parallel brushed</td>
</tr>
<tr>
<td>337.5</td>
<td>Body</td>
<td>Grog</td>
<td>B</td>
<td>–</td>
<td>6.7</td>
<td>Straight incised line adjacent to fingernail punctated row</td>
</tr>
<tr>
<td>429.3</td>
<td>Body</td>
<td>Bone-hematite</td>
<td>C</td>
<td>ISM</td>
<td>6.7</td>
<td>Single straight engraved line</td>
</tr>
<tr>
<td>695.10</td>
<td>Body</td>
<td>Grog</td>
<td>F</td>
<td>ISM</td>
<td>6.4</td>
<td>Horizontal and diagonal incised lines</td>
</tr>
<tr>
<td>726.4</td>
<td>Body</td>
<td>Bone</td>
<td>H</td>
<td>–</td>
<td>5.6</td>
<td>Diagonal incised lines</td>
</tr>
<tr>
<td>901.5</td>
<td>Rim</td>
<td>Bone</td>
<td>F</td>
<td>–</td>
<td>6.1</td>
<td>Horizontal brushed-incised; D-FL</td>
</tr>
<tr>
<td>920.1</td>
<td>Lower rim-body</td>
<td>Bone-hematite</td>
<td>K</td>
<td>ISM</td>
<td>8.4</td>
<td>Horizontal brushed on rim and body; diagonal incised line through body brushing</td>
</tr>
<tr>
<td>993.1</td>
<td>Lower rim-body</td>
<td>Grog/SP</td>
<td>F</td>
<td>–</td>
<td>8.4</td>
<td>Diagonal incised lines</td>
</tr>
<tr>
<td>1563.3</td>
<td>Body</td>
<td>Grog</td>
<td>B</td>
<td>ISM</td>
<td>6.2</td>
<td>Parallel incised lines</td>
</tr>
<tr>
<td>Petrographic and INAA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>414.1</td>
<td>Body</td>
<td>Bone-grog</td>
<td>L</td>
<td>–</td>
<td>9.6</td>
<td>Parallel incised lines adjacent to fingernail punctated row</td>
</tr>
<tr>
<td>514.23</td>
<td>Rim</td>
<td>Bone-hematite</td>
<td>A</td>
<td>ISM</td>
<td>7.1</td>
<td>Tool punctated row under lip, diagonal brushing on rim; D-RO</td>
</tr>
<tr>
<td>647.1</td>
<td>Body</td>
<td>Grog</td>
<td>F</td>
<td>–</td>
<td>7.9</td>
<td>Tool punctated rows</td>
</tr>
<tr>
<td>836.27</td>
<td>Rim</td>
<td>Bone-grog-hematite</td>
<td>F</td>
<td>–</td>
<td>7.4</td>
<td>Diagonal brushed; D-RO:15 cm+ OD</td>
</tr>
<tr>
<td>1105.4</td>
<td>Body</td>
<td>Bone</td>
<td>H</td>
<td>–</td>
<td>6.7</td>
<td>Diagonal incised lines</td>
</tr>
<tr>
<td>1121.6</td>
<td>Body</td>
<td>Bone-hematite</td>
<td>A</td>
<td>–</td>
<td>6.9</td>
<td>Parallel brushed</td>
</tr>
</tbody>
</table>
Table 18 (continued)

<table>
<thead>
<tr>
<th>Lot No./Specimen</th>
<th>Sherd Type</th>
<th>Temper Paste</th>
<th>Firing Conditions</th>
<th>Surface Treatment</th>
<th>Thick (mm)</th>
<th>Decoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1174.14</td>
<td>Rim</td>
<td>Bone-hematite</td>
<td>G</td>
<td></td>
<td>7.4</td>
<td>Diagonal engraved lines, CB; D-RO</td>
</tr>
<tr>
<td>1191.10</td>
<td>Body</td>
<td>Grog-hematite</td>
<td>G</td>
<td></td>
<td>6.7</td>
<td>Engraved panel filled with sets of curvilinear lines; BT</td>
</tr>
<tr>
<td>1558.4</td>
<td>Rim</td>
<td>Bone</td>
<td>F</td>
<td>I/E SM</td>
<td>6.2</td>
<td>Plain bowl; D-RO</td>
</tr>
<tr>
<td>1766.9</td>
<td>Rim</td>
<td>Bone</td>
<td>H</td>
<td></td>
<td>6.0</td>
<td>Horizontal incised lines; D-RO; 17 cm OD</td>
</tr>
</tbody>
</table>

**INAA Only:**

| Bl. 2, Unit 83, 30 cmbs | Rim | Bone-hematite | A | I SM | 7.5 | Plain, D-RO, ext f |
| Bl. 3, Unit 69, 20–30 cmbs | Rim | None | F | - | 4.9 | Plain, D-RO |
| Bl. 3, Unit 70, 0–10 cmbs | Rim | Grog | A | - | 6.4 | Plain, D-RO |
| Bl. 4, Unit 99, 30–40 cmbs | Rim | Grog | A | - | 5.7 | Plain, D-RO |

Temper Paste: SP=sandy paste;
Firing Conditions: A=oxidized; C–E=incompletely oxidized; B=reduced; F–H=reduced, but cooled in open air; I–L=sooted, smudged, refired.
Surface Treatment: I=interior; E=exterior; SM=smoothed.
Decoration: Rim/Lip: D-FL, direct rim and flat lip; RO=rounded lip; CB=carinated bowl; BT=bottle; OD=orifice diameter
* Bl=Block

The INAA and petrographic analyses follow the methods and procedures detailed in Ferguson and Glascock (2012) and Cecil (2012), relying on the recognition of core chemical groups from INAA and local paste groups from the petrographic analysis of paste inclusions. In addition to the focus on core chemical group assignments of sherds as the principal means to determine the provenance of individual samples, the study also examines the quantitative character of individual rare earth minerals in each of the sherds subjected to INAA—using z-score standard deviation plottings (Figure 36) of parts per million across space—as well as other statistical procedures (see below) to also arrive at reasonable conclusions concerning their local East Texas vs. nonlocal provenance.

As an example, Figure 36 shows a plotting of z-score standard deviations for arsenic (As) in more than 1,150 sherds subjected to INAA from more than 200 Caddo sites in East Texas and Northwest Louisiana. There are at least seven distinct spatial clusters of similar z-score standard deviations apparent on Figure 36, and these likely represent different clay chemical group areas. This distinctive spatial distribution of arsenic at different concentrations in the z-scores across the sites, and similar variability in the other chemical elements detected in INAA (see Ferguson and Glascock 2012), indicate considerable compositional variability in the sherds from East Texas sites. Such patterned variability on a
Figure 36. Z-score standard deviation plottings of the abundance of arsenic in INAA-analyzed sherds in East Texas Caddo sites.
spatial scale is key in being able to determine if particular sherds from the Murvaul Creek site and other East Texas sites are from locally made or nonlocally made vessels, and if the latter, where the likely source areas are based on the z-scores in surrounding river basins.

Can Caddo iconography be identified on ceramic vessel sherds from the Murvaul Creek site and other contemporaneous East Texas Caddo sites, and if so, does the occurrence permit the identification of regional variations in ceramic symbolic expression?

The iconography present on Caddo ceramic vessels and sherds also warrants detailed consideration in the analysis of the Murvaul Creek site, if such iconographic symbols and motifs can be identified in the large decorated sherd assemblage. This iconography reflects belief systems of different Caddo groups, as well as the social relationships between different Caddo groups as well as more far-flung Mississippian groups (Gadus 2010, 2013; Hart and Perttula 2010); some iconographic symbols consistently cross spatial and temporal stylistic boundaries. Among others, there are several engraved motifs and decorative elements in East Texas Caddo ceramics that have iconographic symbolism characteristic of the post-A.D. 1300 Southeastern Ceremonial Complex. These include engraved rattlesnakes in all their stylistic diversity, swastika cross-in-circles, rayed circles, and looped squares, as well as vertical hatched and crosshatched motifs on bottles and carinated bowls that resemble the striped pole, albeit in a more simplified form than described by Lankford (2007:30). Each of these iconographic symbols appears to have cosmological meanings (see Lankford 2007).

Ceramic sherds and other domestic artifacts in prehistoric Caddo sites are relevant to the consideration of the technological and functional character of artifact assemblage on residential settlements. These remains were the means by which plant and animal resources were procured, processed, cooked, and stored.

How did the Caddo peoples at the Murvaul Creek site process and cook wild and domesticated plant foods and an assortment of animal foods, and how were ceramic vessels used in these tasks?

How do the ceramic artifacts recovered from domestic contexts on this Caddo site express the different factors that shaped the character of artifact assemblages over the length of the occupation?

The domestic artifacts found on prehistoric and early historic Caddo sites are a testament to their use in prehistoric times to cook and serve foods and liquids and to process animal and plant foods. Considerable effort was expended by these Caddo in the processing of plant foods of various sorts, including nut meats and corn kernels as well as seeds, and their use was facilitated not only by the ability to boil these food stuffs in cooking pots (everted rim
jars), but also by being able to store dry and parched plant food stuffs and liquids in ceramic containers rather than having to rely on baskets and hide containers. Comprehensive residue analysis of visible and absorbed organic residues (see Beehr and Ambrose 2007) on pottery vessels and sherds can be employed to more fully understand the functional uses of Caddo pottery vessels, as can the analysis of vessel form, size, orifice diameter, and volume.

Is there evidence in the archeological record at the Murvaul Creek site for associated or accompanying changes in food technologies and food processing using ceramic vessels during periods of maize intensification?

Given that the main prehistoric Caddo occupation at the Murvaul Creek site was thought to have taken place (prior to this ceramic analysis) sometime after ca. A.D. 1200–1400, during a time of an intensification in maize production in East Texas (Perttula 2008; Wilson 2012; Wilson and Perttula 2013), it may be possible to directly track the rapidity or tempo with which maize production may have intensified in local Caddo economies. Other than stylistic changes in the decorations of utility ware and fine ware vessels, there may be indications in the material culture record for significant functional changes in ceramic manufacture and use (e.g., a measurement as simple as wall thickness changes over time; see Hart and Brumbach 2009; Rice 1987) that would constitute evidence for changes in food technologies and food processing, such as larger volumes or different vessel forms, especially among the utility wares.

Analytical Approach

Over the years, archeological interests in the study of ceramic artifacts have centered around a few major themes: (a) classification and typology of ceramic artifacts for cultural historical purposes; (b) the measurement of time with changes in ceramic styles and functions; (c) the compositional characterization of ceramic materials; and (d) the performance of pots as tools, in conjunction with a study of the social factors that relate to the specific ways that pottery functions as tools (McClure 2007; Neff 2005:1–3). Thematically, these represent pertinent and viable ceramic research approaches today for the study of Caddo ceramic assemblages from East Texas sites.

Following the East Texas Ceramic Protocol developed for the Council of Texas Archeologists (CTA) (see Perttula 2010), in conducting detailed sherd analysis of a large assemblage of sherds in order to obtain sufficient information from that assemblage to characterize its stylistic and technological diversity and ensure that a representative sample was subjected to analysis, a 10 percent sample of the sherds in an assemblages with >5,000 sherds will obtain a sufficiently large (+600 sherds) and analytically detailed sherd assemblage. This sampling strategy for detailed analysis was followed in the Murvaul Creek site study, and the detailed analysis of plain and decorated rim sherds will be of particular emphasis.
Certainly, a principal research issue of ceramic analysis at the Murvaul Creek site includes first refining or bracketing the age and intrasite chronological relationships of the ceramics at the site, starting from available radiocarbon and luminescence/TL dates from organic materials in features or archeological deposits, or dates directly on ceramic sherds from features and archeological deposits, and investigating differences and similarities in ceramic decoration and manufacture from occupations or components that are either contemporaneous or temporally sequent. Four sherds from the Murvaul Creek site, three decorated and one plain body sherd, were selected for paired radiocarbon/TL dating (Table 19). Another six sherds, all decorated, were submitted for AMS dating of bulk organics in the paste (Table 20).

**Table 19: Sherds Selected for Paired Radiocarbon/TL Dating from the Murvaul Creek site (41PN175)**

<table>
<thead>
<tr>
<th>Provenience</th>
<th>Sherd Type</th>
<th>Decoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 4, Unit 86, lv. 5</td>
<td>Body</td>
<td>Parallel brushed, Jar, TL UW 2716</td>
</tr>
<tr>
<td>Block 4, Unit 96, lv. 3B</td>
<td>Body</td>
<td>Applied fillets and panels of incised and brushed-incised lines, Jar, TL UW2714</td>
</tr>
<tr>
<td>Block 4, Unit 105, lv. 3A</td>
<td>Body</td>
<td>Plain, Bottle, TL UW 2713</td>
</tr>
<tr>
<td>Block 8, Unit 117, lv. 6</td>
<td>Body</td>
<td>Parallel brushed, Jar, TL UW 2715</td>
</tr>
</tbody>
</table>

**Table 20: Sherds Selected for AMS Dating of Bulk Organic Pastes from the Murvaul Creek site (41PN175)**

<table>
<thead>
<tr>
<th>Provenience (cmbs)</th>
<th>Sherd Type</th>
<th>Decoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bl. 2, Unit 62, 30–40</td>
<td>Body</td>
<td>Opposed incised lines</td>
</tr>
<tr>
<td>Bl. 3, Unit 69, 20–30</td>
<td>Body</td>
<td>Zoned incised-punctated</td>
</tr>
<tr>
<td>Bl. 4, Unit 121, 22–32</td>
<td>Body</td>
<td>Appliquéd-incised</td>
</tr>
<tr>
<td>Bl. 4, Unit 125, 20–25</td>
<td>Body</td>
<td>Engraved element</td>
</tr>
<tr>
<td>Bl. 4 Feature 9, 40–53</td>
<td>Body</td>
<td>Parallel incised lines</td>
</tr>
<tr>
<td>Bl. 8, Unit 116, 41–52</td>
<td>Rim</td>
<td>Incised-punctated</td>
</tr>
</tbody>
</table>

Attributes of the ceramics can be employed to establish the occupational history of the site as reconstructed from ceramic stylistic analyses (particularly variation in decorative elements and motifs in both the utility wares and fine wares), and then determining any structure and feature relationships through time by defining temporally distinct ceramic assemblages, if such assemblages can be identified. Establishing the temporal context of the Caddo occupation at the Murvaul Creek site will permit the tracking of technological, stylistic, and compositional variability through time and across space.

Another source of analytical information that can be derived from sherds from the Murvaul Creek site is based on ceramic accumulation research (Varien 1999). This research effort derives from ethnoarchaeological research to establish artifact use-lives for cooking pots,
along with estimates for total numbers of discarded artifacts that were derived from controlled statistical excavated samples of agricultural settlements in the Mesa Verde area, and estimates of the average numbers of artifacts of a given type in use. These are employed to model the length of time it takes for given numbers of artifacts (cooking jar sherds) to accumulate. Varien’s (1999:Table 4.2) ethnographic and archeological information on the accumulation of utility ware sherds (i.e., what he calls cooking-pot sherds) in domestic contexts suggest that 4,000–8,000 g of cooking pot sherds would be accumulated through breakage and use per year on a residential site occupied by Native American farmers. The Caddo farmers maintained permanent year-round settlements as did other aboriginal farming communities in North America, and Caddo sites often contain discrete midden deposits and midden mounds where pottery vessel fragments and sherds were regularly discarded along with other trash remains.

This accumulation information can be used as one inferential means to assess the possible length of the Caddo occupation or occupations at the Murvaul Creek site. A confounding factor is the use by Caddo potters of grog temper, as this would have removed an unknown percentage of sherds from the assemblage because they were ground up as temper. Nevertheless, if it is considered that Caddo wood pole and thatch structures would probably only last at most 10–20 or so years before they began to deteriorate (see Good 1982:69), then the utility ware accumulation data from the Murvaul Creek site can be used together with feature information to suggest, with some degree of confidence, the generational length of one or more occupations by the Caddo farmers there if it is established that the site has wood residential structures. Calculating the total number of utility ware sherds depends on (1) estimates of sherd weights in grams, (2) the total number of utility ware sherds in a specific ceramic assemblage, and (3) the relative proportion of excavations (in m²) at the site compared to the known total extent of the Caddo ceramic-bearing deposits at the site. It is also assumed that the excavations constitute a representative sample of the ceramic assemblage (i.e., counts and weights) from the site.

Utility ware vessels were used for cooking, storage, and probably other culinary activities; they tend to have a coarse paste and thick or thicker body walls, have smoothed interior surfaces, and are decorated with wet-paste designs (i.e., decorations were made with tools and fingers prior to the vessel being fired, when the vessel had a wet exterior surface). Fine wares are engraved and red-slipped vessels that were used for food service and to hold liquids, as well as for other purposes (i.e., effigy vessels). They tend to have fine pastes, with finely crushed tempers, are frequently burnished on interior or exterior or both vessel surfaces (except the bottles, which were burnished on exterior surfaces only), and have relatively thin body walls compared to the utility wares. The engraved decorations are etched into the exterior vessel surface after the vessel has been fired.
When rim or body sherds large enough to exhibit overall design motifs are present in the assemblage, typological classifications may be possible. In the absence of whole vessels or vessel sections large enough to discern typologically distinct decorative motifs, another way to distinguish subtle differences between relatively similar ceramics is to look at the technological variations found on individual sherds or groups of sherds from discrete contexts; excavations at the site (see Chapter 5) have demonstrated that there are contextually intact deposits preserved here that have associated ceramic vessel sherds. Variations in key technological attributes such as temper, surface treatment, and thickness in Caddo pottery in East Texas, and across the Caddo area, bear a direct relationship to the desired use of the pot (see Perttula 2000b). Accordingly, sherds recovered from the Murvaul Creek site can be characterized according to a suite of key technological attributes, as well as key decorative methods, motifs, and decorative elements. Each of these attributes provides information about the technical knowledge and the stylistic choices specific to the ceramic tradition(s) present at the Murvaul Creek site and contemporaneous sites in the Sabine River basin and the raw materials components of the pottery making process, which in turn is informative about the different technical and stylistic choices made at various stages in that process. These differences, in turn, provide a basis for comparing the technological and stylistic variability of this specific ceramic assemblage to the technological and stylistic variability found in other contemporaneous Caddo ceramic assemblages in this part of East Texas. The sherds from these other Caddo ceramic assemblages have been analyzed in comparable stylistic and technological manners.

Following CTA Ceramic Protocol for East Texas ceramics (see Perttula 2010), the detailed analysis of the decorated and plain ceramic sherds from the Murvaul Creek site (Appendices A-1 – A-3) is based on differences in temper, type of sherd (i.e., rim, body, or base), rim and lip form (cf. Brown 1996:Figure 2-12), decoration (if present), surface treatment (smoothing, burnishing, or polishing; see Rice 1987), and firing conditions (cf. Teltser 1993:Figure 2a-h). Sherd cross sections were inspected macroscopically and with a 10X hand lens to determine the character of the paste and its inclusions. Determining the firing conditions is based on the identification of the firing core in the sherd cross sections and the identification of oxidation patterns as defined in Teltser (1993:535–536 and Figure 2a–h; also see Perttula 2005).

More specifically, the following attributes were employed in the analysis of the ceramics from the Murvaul Creek site: (a) temper, the deliberate and indeterminate materials found in the paste (Rice 1987:411), including a variety of tempers (grog or crushed sherds, burned bone, and hematite) and “particulate matters of some size”; (b) although most of the sherds are small and thus from indeterminate vessel forms, when sherds were large enough, vessel form categories that could be identified include open containers (bowls and carinated bowls) and restricted containers, including jars and bottles. Other form attributes include rim profile (outflaring or everted, direct or vertical, and inverted) and lip profile (rounded, flat, or
folded to the exterior, among others). Observations on ceramic sherd cross sections permit consideration of oxidation patterns (Teltser 1993:Figure 2a-h), namely the conditions under which a vessel was fired and then cooled after firing. Finally, wall thickness was recorded in millimeters, using a vernier caliper, along the midsection of the sherd.

With respect to interior and exterior surface treatment on the sherds, the primary methods of finishing the surface of Caddo vessels includes smoothing, burnishing, and polishing, although a few sherds may still have scraping marks from initial surface treatment work by the potter. Brushing, a popular method of roughening the surface of Middle, Late, and Historic Caddo cooking jars in the middle part of the Sabine River basin with stiff bundles of grass, is considered a decorative treatment here rather than solely a functional surface treatment (cf. Rice 1987:138). A roughened and brushed pot would certainly have been easier to pick up and carry than would an unroughened or smoothed vessel, but because the brushing was applied to be an integral part of the decoration of both rim and body vessel surface, it is de-emphasized as a surface treatment. Smoothing creates “a finer and more regular surface . . . [and] has a matte rather than a lustrous surface” (Rice 1987:138). Burnishing creates an irregular lustrous finish marked by parallel facets left by the burnishing tool (perhaps a smoothed pebble or bone). A polished surface treatment is marked by a uniform and highly lustrous surface finish, done when the vessel is dry, but without “the pronounced parallel facets produced by burnishing leather-hard clay” (Rice 1987:138).

The application of a hematite-rich clay slip, black after firing in a reducing environment, is another form of surface treatment noted in this assemblage, although it is very rare. The clay slip was typically applied to the vessel exterior or both surfaces, and then was burnished or polished after it was leather-hard or dry; when the vessel was fired, it created a thin red slip. In other instances, a kaolin-rich clay (i.e., white pigment) or a hematite-rich clay (i.e., red pigment) may be applied as a pigment to the decoration on engraved ceramic vessels. It is important to identify the locations on the vessel (i.e., rim versus body, or rim and body) where the different pigments have been applied to the vessel design.

Besides sherds with a red slip, decorative techniques present in the Murvaul Creek site ceramic sherd collections include engraving, incising, punctation, brushing, lip notching, and appliqué, and on certain sherds, combinations of decorative techniques (i.e., brushed-incised and brushed-appliquéd, or incised-punctated sherds) created the decorative elements and motifs, with one motif on the rim and another on the vessel body (Schambach’s Rule of Two). Engraving was done with a sharp tool when the vessel was either leather-hard or after it was fired, but the other decorative techniques were executed with tools or fingers (incising, punctations, and pinching with wood or bone sticks or dowels) by adding strips of clay to the wet body (appliqué), using frayed sticks or grass stems (brushing) across the vessel surface, or corrugating vessel coils when the vessel was wet or
still plastic to create a series of neck bands. Excising is considered a form of engraved decoration, where the clay is deliberately and closely marked/scraped and carved away with a sharp tool, usually to create triangular elements or crescent-shaped elements separating or defining scrolls. A red clay film or wash may be added to the surface (interior and/or exterior surfaces) of some vessels as a slip (or a coating) before they were fired.

**Murvaul Creek Site (41PN175) Ceramic Assemblage**

The ceramic sherd assemblage from the Murvaul Creek site consists of 4,928 sherds from the numerous 50-x-50-cm test units, Blocks 1–8, and features (Table 21). The largest samples of sherds are from Block 4, comprising almost 47 percent of the entire assemblage, and Block 8 (almost 16 percent of the assemblage), but the samples from the blocks range from only eight sherds in Block 1 to 2,305 in Block 4. Approximately 34 percent of the sherds have a decorated element on them, and the overall site P/DR is 1.90; P/DR values in the blocks—excluding Block 1, because there is such a small sample from this excavation—range from 1.37 (Block 3) to 2.25 (Block 4). The P/DR for the feature sherds is a low 1.04, and the P/DR for the sherds from the many test units is 1.54. These P/DR values simply represent differences in the proportions of plain to decorated sherds by excavation context: no undue reliance is placed on the precision of the P/DR for more than intra-site comparisons. The total sherd assemblage weighs 15,939.2 g, for a mean sherd weight of 3.3 g.

**Table 21: Total Ceramic Assemblage from the Data Recovery Investigations at the Murvaul Creek Site (41PN175)**

<table>
<thead>
<tr>
<th>Provenience</th>
<th>Plain Ware</th>
<th>Utility Ware</th>
<th>Fine Ware</th>
<th>Pipe Sherds</th>
<th>N</th>
<th>Sherdlets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test units*</td>
<td>293</td>
<td>183</td>
<td>13</td>
<td>2</td>
<td>491</td>
<td>80</td>
</tr>
<tr>
<td>Block* 1</td>
<td>6</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Block 2</td>
<td>208</td>
<td>111</td>
<td>6</td>
<td>–</td>
<td>325</td>
<td>58</td>
</tr>
<tr>
<td>Block 3</td>
<td>87</td>
<td>56</td>
<td>7</td>
<td>–</td>
<td>150</td>
<td>2</td>
</tr>
<tr>
<td>Block 4</td>
<td>1599†</td>
<td>662</td>
<td>43</td>
<td>1</td>
<td>2305</td>
<td>1665</td>
</tr>
<tr>
<td>Block 5</td>
<td>132</td>
<td>65</td>
<td>9</td>
<td>–</td>
<td>206</td>
<td>36</td>
</tr>
<tr>
<td>Block 6</td>
<td>49</td>
<td>29</td>
<td>1</td>
<td>–</td>
<td>79</td>
<td>10</td>
</tr>
<tr>
<td>Block 7</td>
<td>230</td>
<td>111</td>
<td>7</td>
<td>–</td>
<td>348</td>
<td>166</td>
</tr>
<tr>
<td>Block 8</td>
<td>492</td>
<td>257</td>
<td>15</td>
<td>–</td>
<td>764</td>
<td>191</td>
</tr>
<tr>
<td>Features</td>
<td>129</td>
<td>115</td>
<td>8</td>
<td>–</td>
<td>252</td>
<td>152</td>
</tr>
<tr>
<td>Totals</td>
<td>3225</td>
<td>1591</td>
<td>109</td>
<td>3</td>
<td>4928</td>
<td>2362</td>
</tr>
</tbody>
</table>

* Test units = 50-x-50 cm; Blocks = 1-x-1 m
† Includes 1 pedestal base

In addition to the sherds, there are also 2,362 sherdlets in the assemblage (see Table 21); these are less than 1.0 cm in diameter. They were tabulated and weighed, but received no further analytical attention. These sherdlets weigh 1,125.5 g.
Spatial Distribution of the Ceramic Wares

The Caddo ceramic sherds at the Murvaul Creek site are widely distributed across the excavation corridor, based on the densities of sherds from the 50-x-50-cm units and the subsequent 1-x-1-m units in contiguous block excavations. That there are several clusters of sherds suggest that there are intrasite differences in use as well as discard of ceramic vessels.

The mean density of sherds in the 50-x-50-cm units is 8.8 ± 5.4 sherds per unit, or 35.2 ± 21.6 sherds per m². Seven (12.5 percent) of the 56 50-x-50-cm units did not have any sherds, and these units are found only in the southern part of the excavation area (Figure 37). In the remaining units, the sherd density ranges from 1–30 sherds per unit. In these 50-x-50-cm units, there are three separate concentrations of sherds; that is, areas where the density of sherds is between 15–30 sherds per unit (60–120 sherds per m²). These include units 5–7, 20, and 35 in the central part of the excavation area, unit 38 in the northeastern part of the excavation area, and units 10, 13–14, 25–27, and 40 in the northwestern part of the excavation area (see Figure 37).

In the block excavations, sherd densities range from as low as 2.0 per m² (Block 1) to as high as 152.8 per m² (Block 8) (Table 22); this compares to the densities of 35.2 ± 21.6 sherds per m² in the aforementioned test units. The highest densities are in the central to northern part of the excavation area, in Blocks 4, 5, 7, and 8 (Figure 38). Blocks 7 and 8 by far have the highest sherd densities of any of the blocks. These same areas also have high sherd densities based on sherd recovery in the 50-x-50-cm units (see Figure 37).

Lower densities of sherds in Blocks 1, 2, 3, and 6 are matched by correspondingly low sherd densities in the 50-x-50-cm units (see Figures 37 and 38). Blocks 4 and 5 are in areas with only low to moderate densities of sherds in the 50-x-50-cm units (1–14 sherds per unit, or 4–56 sherds per m²), but each block area has moderate sherd densities (51.3–61.9 sherds per m²). Overall, the highest sherd densities cover an approximate 45-x-10-m area based on the 50-x-50-cm units (see Figure 37), and an approximate 40-x-15-m area based on the block excavations (see Figure 38). High sherd densities appear to continue outside of the excavation corridor to the north, east, and west.

TxDOT reviewers expressed concern regarding this spatial analysis given the presence of colluvial deposits containing artifacts; consequently, Table 23 revises the original table by separating out the sherd density by site component.
Figure 37. Density of sherds in 50-x-50-cm units at the Murvaul Creek site.
Table 22: Total Sherd Densities in Block Excavations at the Murvaul Creek Site (41PN175)

<table>
<thead>
<tr>
<th>Block</th>
<th>Excavated m²</th>
<th>No. of Sherds</th>
<th>Sherds per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>8</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>325</td>
<td>46.4</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>150</td>
<td>18.8</td>
</tr>
<tr>
<td>4</td>
<td>37</td>
<td>2305</td>
<td>62.3</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>206</td>
<td>51.5</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>79</td>
<td>39.5</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>348</td>
<td>87.0</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>764</td>
<td>152.8</td>
</tr>
</tbody>
</table>

Note: excludes features

Table 22, which disregards stratigraphic context, indicates that the highest sherd densities are located in the northern part of the excavation area, in Blocks 4, 5, 7, and 8. Blocks 7 and 8 have the highest densities found at the site. While this is correct for the total number of sherds found in each block, Pletka suggests that the discussion be limited to only the sherds found within the buried soil. Table 23 indicates that the Blocks initially identified as having the highest densities are also the same high density Blocks for sherds recovered from within the Ab-horizon, except for Block 7 which exhibits the second lowest density of sherds within the buried soil of any Block on the site.

Figure 39 provides a comparative view of sherd frequencies for all contexts. The data were additionally separated by site component and a final plot using only 50-x-50-cm sherds is presented. The data have all been normalized to unit size by joining each sherd to the test unit quadrant where it was recovered. However, it should be noted that these data still do not include sherds recovered from feature contexts. Additionally, two sherds (recovered from Units 86 and 90) are not included in the plots because they were recovered from general unit fill and could not be attributed to quadrant. Figure 39 indicates that the application of a simple inverse distance weighted interpolation to the data set demonstrates that the northern portion of the site contained the highest density of artifacts in all contexts. Concerning only the Ab-horizon, there appeared to be two locally dense areas for sherd recovery: the extreme north portion of the site near Block 7 and the western end of Block 4. Perttula notes that two of the highest concentrations on the site appeared to be west and southwest of Block 4. While this certainly does appear to be the case from both the data from all contexts and the 50-x-50-cm units, it is important to note that the high values were also interpreted from the 50-x-50-cm excavation forms as being influenced by potential movement of materials by plowing or disking adjacent to the fence line.
Figure 38. Density of sherds in the block excavations at the Murval Creek site (41PN175).
Table 23: Total Sherd Densities in Block Excavations by Stratigraphic Unit at the Murvaul Creek Site (41PN175)

<table>
<thead>
<tr>
<th>Block</th>
<th>Excavated m²</th>
<th>Colluvium</th>
<th>Ab</th>
<th>E (n)</th>
<th>Disturbed (n)</th>
<th>Total (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 1</td>
<td>4</td>
<td>- (-)*</td>
<td>- (-)</td>
<td>8 (2.0)</td>
<td>- (-)</td>
<td>8 (2.0)</td>
</tr>
<tr>
<td>Block 2</td>
<td>7</td>
<td>63 (9.0)</td>
<td>- (-)</td>
<td>161 (23.0)</td>
<td>101 (14.4)</td>
<td>325 (46.4)</td>
</tr>
<tr>
<td>Block 3</td>
<td>8</td>
<td>109 (13.6)</td>
<td>- (-)</td>
<td>41 (5.1)</td>
<td>- (-)</td>
<td>150 (18.8)</td>
</tr>
<tr>
<td>Block 4</td>
<td>37</td>
<td>1,186 (32.1)</td>
<td>781 (21.1)</td>
<td>50 (1.4)</td>
<td>289 (7.8)</td>
<td>2,306 (62.3)</td>
</tr>
<tr>
<td>Block 5</td>
<td>4</td>
<td>89 (22.3)</td>
<td>113 (28.3)</td>
<td>4 (1.0)</td>
<td>- (-)</td>
<td>206 (51.5)</td>
</tr>
<tr>
<td>Block 6</td>
<td>2</td>
<td>59 (29.5)</td>
<td>16 (8.0)</td>
<td>4 (2.0)</td>
<td>- (-)</td>
<td>79 (39.5)</td>
</tr>
<tr>
<td>Block 7</td>
<td>4</td>
<td>136 (34.0)</td>
<td>62 (15.5)</td>
<td>4 (1.0)</td>
<td>146 (36.5)</td>
<td>348 (87.0)</td>
</tr>
<tr>
<td>Block 8</td>
<td>5</td>
<td>384 (76.8)</td>
<td>228 (45.6)</td>
<td>152 (30.4)</td>
<td>- (-)</td>
<td>764 (152.8)</td>
</tr>
</tbody>
</table>

Note: excludes features
* number format: n (n/m²)

Technological Characteristics of the Vessel Sherds

The assessment of the technological character, particularly temper and firing conditions, of the Murvaul Creek site sherds is based on detailed analysis of a randomly selected sample of 600 rim, body, and base sherds (Appendix A-3). This represents approximately 12 percent of the assemblage, a slightly higher percentage than was specified in the research design.

Although surface treatment was noted when present (see Appendix A-3), the eroded and small size of most of the sherds precludes a systematic consideration of surface treatment among the plain, utility, and fine wares from the site. In East Texas Caddo sherd assemblages that are better preserved, utility wares and plain wares tend to have smoothed interior and/or exterior surfaces, when present, whereas fine wares tend to be smoothed and/or burnished on one or both vessel surfaces.

Use of Temper

There is a wide variety of temper combinations in the Murvaul Creek site Caddo ceramic sherds (Table 24): 20 combinations in the plain wares, 17 among the utility wares, and 13 among the fine wares. Approximately 0.3 percent of the sherds analyzed in detail do not have any observed temper inclusions. The wide range of temper and paste combinations in the ceramics at the site is typical of East Texas Caddo ceramics, as Caddo potters selected different combinations or paste recipes suited to the kind of vessel (i.e., their intended use, size, and decoration) being made in the community.
Figure 39. Comparative view of ceramic sherd frequencies for all contexts at the Murvaul Creek site (41PN175).

Table 24: Temper Use Identified by Detailed Analysis Among the Murvaul Creek Site (41PN175) Ceramics

<table>
<thead>
<tr>
<th>Temper</th>
<th>Units</th>
<th>Bl. 1</th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea</th>
<th>N/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Ware:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone</td>
<td>6</td>
<td>–</td>
<td>2</td>
<td>1</td>
<td>20</td>
<td>2</td>
<td>–</td>
<td>3</td>
<td>5</td>
<td>–</td>
<td>39/15.3</td>
</tr>
<tr>
<td>Bone/SP</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>7/2.8</td>
</tr>
<tr>
<td>Bone-g</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>6</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>1</td>
<td>9/3.5</td>
</tr>
<tr>
<td>Bone-g-h</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>2/0.8</td>
</tr>
<tr>
<td>Bone-g-o</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1/0.4</td>
</tr>
<tr>
<td>Bone-h</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>–</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>32/12.6</td>
</tr>
<tr>
<td>Bone-h/SP</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4/1.6</td>
</tr>
<tr>
<td>Bone-o</td>
<td>1</td>
<td>–</td>
<td>2</td>
<td>–</td>
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**Fine Ware:**

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The principal tempers used for ceramic vessel manufacture are bone, grog, and hematite, and these occur in varying combinations. A significant percentage of the sherds, most notably among the plain wares and utility wares in Block 2 (Table 25), have organics in the paste, typically pieces of charcoal. These are not considered here as temper inclusions, but as naturally occurring organics in the clay paste that were not removed during clay preparation and cleaning, or they were not fully combusted during the firing of vessels, either because of a low temperature firing, an incomplete and short firing, or both. The majority of the sherds from the site have a clay or silt paste, but a number of the sherds have a sandy paste, indicating the use by Caddo potters of a naturally sandy clay for vessel manufacture. The highest proportions of sandy paste pottery are found in the plain wares from Blocks 4 and 7 and the fine wares from Block 4 (see Table 25).

Table 24 (continued)

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b=bone; g=grog; h=hematite; o=organics; SP=sandy paste

Table 25: Summary of Temper Classification Identified by Detailed Analysis Among the Murvaul Creek Site (41PN175) Sherds

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Table 25 (continued)

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<th>% Grog</th>
<th>% Hematite</th>
<th>% Organics</th>
<th>% SP</th>
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**Fine Ware**

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<td>33</td>
<td>–</td>
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</table>

SP=sandy paste

Looking closer at the temper and paste attributes in the blocks that have reasonable sample sizes of sherds analyzed in detail, there are several notable characteristics of the wares (see Table 25).

First, although the use of bone temper is common in all three wares, it is particularly common in the utility wares, regardless of provenience. In the plain wares from all proveniences, 46–62 percent of the sherds have bone temper, compared to 70–100 percent of the utility wares. Approximately 53 percent of the fine wares have bone temper.

Second, the use of grog temper is most common in the plain wares (41–74 percent) and fine wares (56 percent), but is present in only 13–41 percent of the utility wares. The highest proportion of grog-tempered sherds in the plain wares is in Blocks 4 and 7, and in Blocks 2 and 7 in the utility wares.

Third, crushed hematite temper is common in the plain wares and utility wares, but not in the fine wares (11 percent). Between 16 and 35 percent of the plain wares have hematite temper, compared to 7–48 percent of the utility wares. Its use is most common in the plain wares in Blocks 2 and 8 (26–35 percent) and the utility wares in Blocks 5 and 8 (40–48 percent).

Fourth, sherds with organics in the paste are most common in the utility wares (7–35 percent) and plain wares (5–18 percent), but uncommon in the fine wares (4 percent). The highest proportions of these sherds are in the plain wares from Blocks 2 and 8 (15–18 percent).
percent), as is the case with the use of hematite temper among the plain wares, and from Blocks 2, 4, and 8 in the utility wares (22–35 percent).

And lastly, sandy paste sherds are most common in the plain wares (18–32 percent), particularly in Blocks 4 and 7, and relatively common in the utility wares (6–15 percent). The highest proportion of sandy paste sherds in the utility wares is in Block 2 (15 percent) and Block 4 (11 percent). Only 13 percent of the fine wares have a sandy paste, most notably in the fine ware sherds from Block 4 (29 percent), Block 7 (40 percent), and Block 8 (22 percent).

**Firing Conditions**

**Firing Condition A:** The three ceramic wares at the Murvaul Creek site were not fired in the same way. Vessels fired and cooled in an oxidizing environment (see Teltser 1993:Figure 2a) are most common in the plain wares (13.8 percent), especially the plain wares in Blocks 3 (20.0 percent), 7 (21.0 percent) and 8 (15.4 percent). In Blocks 2 and 4, only 11.1–11.8 percent of the plain ware sherds were fired in this manner (Table 26). The highest proportion of utility ware vessels fired in an oxidizing environment has been documented in Blocks 2 and 3 (18.5–20 percent), and for the fine wares in Blocks 3 (33 percent) and 4 (14 percent).

**Firing Condition B:** Reduced cooled and fired vessel sherds (see Table 26) account for between 13.6 and 23.3 percent of the sherds by ware, with the highest overall proportions in the fine wares. Plain ware, utility ware, and fine wares from Blocks 2 and 4 all have considerable numbers of reduced fired sherds (between 17.6 and 23.5 percent), along with utility wares in Block 7 (22.2 percent), fine wares in Block 8 (22.2 percent), and especially utility ware and fine ware sherds from features (34.8–66.7 percent) (see Table 25).

**Firing Conditions C–E:** Sherds from vessels that were incompletely oxidized (see Teltser 1993:Figure 2c-e) represent between 6.8–10.8 percent by ware, with the highest percentage among the utility wares (see Table 26). Sherds from vessels fired this way are most common in the utility wares from Block 8 (19.5 percent) and Block 7 (11.1 percent), and in the fine wares in Block 4 (14.3 percent).

**Firing Conditions F–H:** The most common form of vessel firing employed by the Caddo potters at the Murvaul Creek site was firing vessels in a reducing environment and cooling them in an oxidizing environment, leaving the vessel with a thin oxidized lens on the outside of either one or both vessel surfaces (see Table 26 and Teltser 1993:Figure 2f-h). Between 56.3 and 66.4 percent of the sherds in the three wares are from vessels fired and cooled in this way; the highest proportions of such sherds are in the plain wares (66.4 percent), followed by the fine wares (60.5 percent). This form of firing is particularly well represented in all three wares in Block 5 (75.0–86.7 percent), in the plain wares in Block 8 (69.2 percent), and the fine wares in Block 7 (100 percent) (see Table 26).
### Table 26: Firing Conditions Identified by Detailed Analysis Among the Murvaul Creek site (41PN175) Ceramic Sherds

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<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
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<th>N/%</th>
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</table>

* see Firing Conditions text
**Firing Conditions I–L:** Lastly, there are a few sherds that are from vessels that appear to have been sooted or smudged during firing, as the sherd cores have distinctive black lens on either one or more surfaces. The sooting and smudging is identified by the core profiles, not whether there is visible sooting or smudging on either vessel sherd surface. These sherds are from utility wares in Blocks 2–4, the test units, and features (see Table 26).

**Rim and Lip Form**

Where it could be determined (n=172 of 181 rims), most of the rims in all three wares have a direct or vertical profile. This includes 96 percent of the plain wares, 77 percent of the utility wares, and 100 percent of the fine wares (Table 27). A significant percentage of the utility wares, wide-mouthed jars, has an everted profile (23 percent), as do 2 percent of the plain wares. One plain bowl (2 percent) has an inverted rim profile.

In the case of identifiable lip form in all three wares, the preferred form is a rounded lip: 87 percent of the plain wares, 82 percent of the utility wares, and 78 percent of the fine wares (see Table 27). Another 6 percent of the plain wares, 11 percent of the utility wares, and 11 percent of the fine wares have a rounded and exterior folded lip. Flat lips are present only in the plain wares (6 percent) and utility wares (5 percent), but one fine ware rim has a flat and exterior folded lip. Two distinctive lip forms are in the assemblage: a plain ware rim with a scalloped lip, and two utility ware rims with exterior thickened lips.

**Pedestal Base Sherd**

There is a single pedestal base leg sherd to a jar in Block 4 (Unit 97, 10–20 cmbs). The diameter of the attachment is 28.9 mm, and the diameter of the leg is 21.9 mm (Figure 39).

**Vessel Orifice Diameter**

The small size of most of the rim sherds from the Murvaul Creek site prohibited determinations of rim orifice diameter (OD) in most cases. The few measurable rim sherds (n=18, less than 10 percent of the rims in the assemblage; half of the measurable rims are from Block 4) have orifice diameters that range from 13–21 cm for the plain wares, 9–23 cm for the utility wares, and 15 cm for the one fine ware rim (Table 28). Only 18 percent of the measurable rims have orifice diameters greater than 20 cm, indicating that only moderately sized vessels were in use at the site. These vessels were likely made for individual and family use rather than for multiple family and/or communal use.

**Plain Ware Sherds**

The 3,225 plain ware sherds include 100 rims, 2,915 bodies, and 210 base sherds (including the pedestal base) (Table 29); these comprise 65 percent of the sherd assemblage. The sherds are from plain jars, bowls, carinated bowls, and bottles, and from the undecorated portions of utility ware and fine ware vessels. The base sherds are flat and disk-shaped, a traditional characteristic of Caddo ceramic vessels in East Texas, and were made first and shaped separately from the rest of each vessel, and they then provided the platform upon which to construct the rest of the vessel.
Table 27: Identifiable Rim and Lip Forms in the Three Wares at the Murvaul Creek Site (41PN175)

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<th>Bl. 3</th>
<th>Bl. 4</th>
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<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
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D=direct; EV=everted; INV=inverted; -RO=rounded; FL=flat; ext f=exterior folded; ext. th=exterior thickened; scall.=scalloped
Figure 40. Two views of the pedestal leg sherd from Block 4.

Table 28: Identifiable Rim Orifice Diameters by Ware at the Murvaul Creek Site (41PN175)

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<th>Bl. 5</th>
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<th>Bl. 8</th>
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Plain Ware

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Utility Ware

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Fine Ware

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Totals 2 - 2 2 9 - - - 2 1 18
Table 29: Total Plain Ware Sherds from the Murvaul Creek Site (41PN175)
Sherd Assemblage

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Note: table does not include 3 pipe sherds
* Includes 1 pedestal base

The 100 plain rim sherds do indicate that the plain wares are an important part of the Murvaul Creek site ceramic assemblage. In fact, 55 percent of the 181 rim sherds from all three wares in the assemblage are from plain wares (bowls, jars, and bottles), 39 percent are from utility wares (almost all jars), and only 6 percent are from fine wares (carinated bowls, primarily).

**Decorated Vessel Sherds Stylistic Characteristics**

The 1,700 decorated sherds from the Murvaul Creek site include only 6.5 percent (n=110) from fine ware vessels but 93.6 percent (n=1,591) from utility ware vessels (Table 30). Almost all of the fine ware sherds are from engraved vessels, whereas the utility wares are dominated by sherds with brushed, incised, and brushed-incised decorations.

In general terms for the fine wares, engraved sherds are proportionally most abundant in Blocks 3 and 5 (11.1–12.3 percent of all the decorated sherds from those proveniences), and least abundant in Block 6 (3.3 percent). The one circular punctated sherd from a fine ware vessel, on a carinated bowl, is from Block 8, and red-slipped sherds are only present in Block 4 and one of the features (see Table 30).

There are 13 different utility ware decorative methods in the Murvaul Creek site ceramic assemblage, several with combinations of decorative methods (i.e., brushed-incised or incised-punctated) (see Table 30). Among the utility wares, appliquéed sherds are most common in Blocks 5, 6, and 8 (2.2–3.3 percent of the decorated sherds), whereas brushed sherds are most abundant in Blocks 6 and 8 and the features; the lowest proportion of
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<th>Bl. 2 N/%</th>
<th>Bl. 3 N/%</th>
<th>Bl. 4/ N/%</th>
<th>Bl. 5 N/%</th>
<th>Bl. 6/ N/%</th>
<th>Bl. 7 N/%</th>
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</table>

In the decorated sherd assemblage from the Murvaul Creek site, the decorated sherds occur in Blocks 3 and 5. Sherds with brushed-appliquéd and brushed-incised-punctated decorations are most common in the features, but sherds with brushed-incised decorations are most abundant in Blocks 2, 3, and 4. Sherds with incised decorative elements are most common in Blocks 3 and 6 (23.2–26.1 percent of the decorated sherds), but sherds with incised-punctated decorations are more common in Blocks 3 and 5 than elsewhere in the excavations. Lip notched sherds are present only in one test unit and Block 4. Sherds with punctated decorations are most abundant in Block 2 (5.2 percent), Block 5 (4.1 percent), and Block 8 (4.0 percent), especially sherds with tool punctated elements; sherds with fingernail punctated designs are most abundant in Block 2.

**Fine Wares**

**Engraved**

Fine ware sherds with engraved decorative elements are not well represented in the decorated sherd assemblages from the Murvaul Creek site. They comprise as a group approximately 6.5 percent of all the decorated sherds from the site (see Table 30).
highest proportions of engraved sherds are in Blocks 3 (11.1 percent of all the decorated sherds) and 5 (12.3 percent), and the lowest proportions occur in Block 6 (3.3 percent), Block 8 (5.1 percent), and in the features (4.9 percent).

Many of the engraved sherds from carinated bowls and bowls have basic geometric elements, including cross-hatched (Figure 41a), horizontal, opposed, opposed diagonal, parallel, and straight lines (Table 31). There are also decorative elements that are combinations of straight and opposed lines (Figure 42a), sets of opposed lines (see Figure 42f), horizontal-diagonal lines (see Figure 42i), opposed diagonal and curvilinear lines (see Figure 42p), horizontal-vertical (Figure 43a), and vertical lines (see Figure 43d).
Table 31: Engraved Decorative Elements in the Murvaul Creek Site (41PN175)
Sherd Assemblage

<table>
<thead>
<tr>
<th>Decorative Element, Rim or Body</th>
<th>Units</th>
<th>Bl. 1</th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
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<tr>
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<tr>
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</tbody>
</table>
More distinctive carinated bowl and bowl sherds in the assemblage have curvilinear or straight hatched zones (Figures 44a and 45a; see also Figures 42d, j, t–u and 43b). Others have hatched triangles as well as horizontal and diagonal elements (see Figure 42h), or nested triangles in columns or with ovals (see Figure 42g, q). There are Block 4 engraved sherds with diagonal lines and columns filled with curvilinear lines (see Figure 42m) and diagonal lines and ovals (see Figure 42n), while sherds in Blocks 2 and 5 have cross-hatched lines or cross-hatched zones (see Figure 42e, o). There are other engraved carinated bowl and bowl sherds with curvilinear lines (see Figure 43c) or combinations of straight and curvilinear lines (see Figure 42r). One unique engraved sherd from Block 4 has a combination of parallel and opposed lines and rectilinear elements (see Figure 42l).

The few rim sherds from engraved carinated bowls and bowls have horizontal lines under the vessel lip, horizontal and diagonal lines (Figure 46e; see also Figure 42s) on the rim, horizontal, vertical, and diagonal lines (see Figure 42k), diagonal, curvilinear, as well as sets of vertical lines (see Figure 43d). There are two rims from Block 4 that have sets of horizontal lines (see Table 31), and these may be from compound bowls.

Bottle sherds are equally rare in the Murvaul Creek site engraved wares. They account for only 7.7 percent of all the engraved sherds (see Table 31) and are nowhere relatively common among the fine wares in the excavations except for Block 8, where 21 percent of the engraved sherds are from the bodies of long-necked bottles (see Figures 42b–c, v–w, y; and 44b). Bottle sherds have both parallel, opposed, diagonal and straight lines (n=3);
cross-hatched and curvilinear hatched zones (see Figures 42v–w and 45b; n=2); as well as curvilinear and opposed lines (see Figure 42b), including one with a small excised triangle element (see Figure 42c).

**Punctated, Circular**

This sherd is from a carinated bowl in Block 8 (Unit 113, 10–20 cmbs). A row of small circular punctations is above the carination, and this is a form of decorative treatment seen on both Washington Square Paneled (Hart 1982) and Handy Engraved (Suhm and Jelks 1962) vessels, as well as Glassell Engraved (see Suhm and Jelks 1962:Plate 27l) vessels.
Figure 43. Block 4 decorated engraved sherds: (a) horizontal and hatched triangle elements, Unit 125, 20–25 cmbs; (b) hatched zones, Unit 93, 30–40 cmbs; (c) curvilinear engraved lines, Unit 122, 14–24 cmbs; (d) rim, vertical engraved lines, Unit 123, 15–20 cmbs.

Red-slipped

The four red-slipped sherds account for approximately 3.6 percent of the fine wares at the site, and these sherds are from Block 4 and a feature. The Block 4 sherds (Unit 120, 30–35 and 35–40 cmbs) are bone-tempered body sherds with a red slip only on the exterior surface, but not from a bottle. The other red-slipped sherds are from Feature 97 (65–92 cmbs). Both these sherds only have a red slip on their exterior surface.

Utility Wares

As mentioned above, the utility wares from the Murvaul Creek site are dominated by sherds with brushed, brushed-incised, and incised decorative elements. About 85 percent of the utility ware rims have these three decorative elements: brushed (48 percent of the utility ware rims), incised (25 percent), and brushed-incised (12 percent). However, there are other decorative elements present in the utility wares, and sherds with combinations of elements (i.e., appliqué-incised, brushed-incised-punctated, etc.) (see Table 30).
Figure 44. Block 8 decorated sherds: (a) engraved element, Unit 114, 40–42 cmbs; (b) engraved bottle sherd, Unit 113, 42–50 cmbs; (c) closely spaced parallel incised lines, Unit 116, 41–52 cmbs; (d) parallel incised lines, Unit 117, 25–30 cmbs; (e) tool punctated rows, Unit 114, 10–20 cmbs; (f) linear tool punctated rows, Unit 117, 35–40 cmbs; (g) rim, horizontal brushed with tool punctated row under the lip, Unit 116, 41–52 cmbs; (h) overlapping brushed, Unit 115, 50–60 cmbs; (i) parallel brushed, Unit 117, 40–45 cmbs; (j) straight appliquéd ridge, Unit 117, 35–40 cmbs.
Figure 45. Test Unit decorated sherds: a, hatched engraved zones, Unit 26, 20–40 cmbs; b, straight appliquéd ridge, Unit 3, lv. 7 (provenience 43); c, rim, tool punctated row below the lip, and vertical brushing on the rim, Unit 11, 20–40 cmbs; d, horizontal brushed, with tool punctated row pushed through the brushing, Unit 49, 0–20 cmbs; e, opposed brushed, Unit 41, 40–60 cmbs.

Appliquéd
The appliquéd sherds comprise just over 1 percent of the utility wares from the site (Table 32), including two rims; most of the appliquéd sherds are from Blocks 4 and 8. The rims have circular nodes on and near the vessel lip, and it is likely there were four nodes equally spaced around the rim on each vessel. One body sherd also has a single node on it.

Body sherds have straight and parallel appliquéd ridges (n=14; Figure 47h, see Figures 44j and 45b) and fillets (n=2; see Figure 47i). These appliquéd elements likely were oriented vertically on the body of jars and would have served to divide the body into a number of panels. In some cases, the panels would have been filled with brushed or incised elements (see below).
46. Feature decorated sherds: (a) parallel brushed, Feature 7, 40–53 cmbs; (b) parallel brushed-incised with tool punctated row pushed through the brushing, Feature 62, 65–70 cmbs; (c) straight to curvilinear incised lines, Feature 9, 40–53 cmbs; (d) straight appliquéd ridge and parallel brushed, Feature 97, 65–92 cmbs; (e) rim, horizontal and diagonal engraved lines, Feature 57, 60–90 cmbs.

Appliquéd-Incised
Body sherds with appliquéd-incised elements comprise 0.4 percent of the utility wares (see Table 30). They have either straight appliquéd ridges or fillets with incised lines parallel to the appliquéd element (see Figure 47g) or with the incised lines diagonally opposed to the ridge/fillet (Figure 48i, m).

Appliquéd-Incised-Brushed
This body sherd was one of the four sherds submitted for both AMS $^{14}$C dating and TL dating (see Table 19). It has a straight appliquéd fillet with panels on each side of the fillet that have either straight incised lines or straight brushed marks and incised lines.
Table 32: Appliquéd and Appliquéd-Incised Decorative Elements in the Murvaul Creek Site (41PN175) Sherd Assemblage

<table>
<thead>
<tr>
<th>Decorative Element, Rim or Body</th>
<th>Units</th>
<th>Bl. 1</th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
<th>N</th>
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</thead>
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**Brushed**

Jars with brushing marks on the rim and the body are the predominant decorative element in the utility wares at the Murvaul Creek site (see Table 30). Approximately 66.8 percent of the utility wares from the site have brushing marks (Table 33). The highest proportions of brushed sherds among the utility wares are in Block 8 (72 percent), the features (72 percent), and the test units (72 percent), and the lowest proportions are in Block 3 (57 percent), Block 5 (58 percent), and Block 7 (62 percent).

Body sherds have almost always parallel brushing marks (Figures 49d and 50e; also see Figures 44i, 46a, and 47e): 98 percent of the brushed body sherds have parallel brushing marks (see Table 33). The orientation of the brushing is uncertain, but based on documented whole vessels from East Texas Caddo sites, in most cases the brushing is most likely oriented vertically on a jar’s body. A very few body sherds have diagonal, horizontal, vertical, opposed (see Figure 45e), or overlapping (see Figure 44h) brushing marks.
Overwhelmingly, the brushed utility ware jars have horizontal brushing marks on the rim (see Figures 41d and 50b): 90 percent of the rims are horizontal brushed (see Table 33). The other brushed rims have either diagonal or vertical brushing marks.
Figure 48. Illustrations of utility ware decorative elements from site 41PN175: a–c, f–j, incised elements; d–e, l–n, incised-punctated; g, brushed-punctated; h, brushed-incised; i, m, appliquéd-incised. Provenience: (a) Unit 30, 20–40 cmbs; (b), Unit 10, 20–40 cmbs; (c) Block 2, Unit 62, 30–40 cmbs; (d) Block 3, Unit 72, 20–30 cmbs; (e) Block 3, Unit 69, 20–30 cmbs; (f), Block 3, Unit 70, 10–20 cmbs; (g) Block 4, Unit 97, 30–39 cmbs; (h) Block 4, Unit 94, 25–30 cmbs; (i) Block 4, Unit 76, lv. 4; (j) Block 4, Unit 121, 22–32 cmbs; (k) Block 4, Unit 78, 20–30 cmbs; (l) Feature 75, 55–108 cmbs; (m) Feature 47, 55–63 cmbs; (n) Block 3, Unit 66, 20–30 cmbs.

Table 33: Brushed Decorative Elements in the Murvaul Creek Site (41PN175)

<table>
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<tr>
<th>Decorative Element, Rim or Body</th>
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<th>Bl. 2</th>
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<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
<th>N</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>–</td>
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<tr>
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<td>–</td>
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<td>Overlapping brushed, body</td>
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<td>Horizontal brushed, rim</td>
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</tr>
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<td>Vertical brushed, rim</td>
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<td>69</td>
<td>183</td>
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</table>

*on a bottle sherd
49. Block 3 decorated sherds: (a) incised-punctated element, Unit 72, 20–30 cmbs; (b) incised-punctated element, Unit 69, 20–30 cmbs; (c) sets of parallel incised lines, Unit 70, 20–30 cmbs; (d) parallel brushed, Unit 71, 0–10 cmbs; (e) rim, horizontal brushed with overlapping vertical incised lines, Unit 70, 10–20 cmbs.

Brushed-Appliqué

The brushed-appliqué body sherds represent 0.3 percent of the utility wares from the Murvaul Creek site. Three of the body sherds are from Block 4, Block 7, and Block 8, respectively, and the other two are from Feature 89 and Feature 97.

Four of the sherds have parallel brushing adjacent to straight appliqué ridges (n=2, see Figure 46d) or appliqué fillets (n=2). The body sherd from Block 7 has parallel brushing marks and parallel appliqué fillets (see Figure 50a).

Brushed-Incised

Sherds with brushed-incised decorations account for 6.2 percent of the utility ware sherds at the Murvaul Creek site (see Table 30), and 12 percent of the utility ware rim sherds. Brushed-incised sherds are most common among the utility wares in Blocks 3 and 4 (8.9–9.1 percent of the utility wares in these blocks), and least common in Blocks 6 and 8 (3.4–3.5 percent) (Table 34).
Most of the brushed-incised rim sherds (especially in Block 4) have horizontal brushing marks and interspersed horizontal incised lines (see Figure 47b), but others have brushed and incised lines in various orientations. One rim has horizontal brushing marks and vertical incised lines that overlap the brushing (see Figure 49e). Other lower rim and body sherds have horizontal or vertical incised lines on the lower rim and horizontal brushed bodies (see
Table 34: Brushed-Incised Decorative Elements in the Murvaul Creek Site (41PN175) Sherd Assemblage

<table>
<thead>
<tr>
<th>Decorative Element, Rim or Body</th>
<th>Units</th>
<th>Bl. 1</th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal brushed (rim)–horizontal brushed</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>1</td>
</tr>
<tr>
<td>With diagonal lines through brushing, body</td>
<td></td>
<td></td>
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<tr>
<td>Horizontal brushed with overlapping vertical incised lines, body</td>
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<td>–</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Horizontal incised (rim)–vertical brushed (body)</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
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<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Parallel brushed marks and incised lines, body</td>
<td>1</td>
<td>–</td>
<td>5</td>
<td>3</td>
<td>45</td>
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<td>7</td>
<td>3</td>
<td>72</td>
</tr>
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<td>Parallel brushed marks and overlapping cross-hatched lines, body</td>
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<td>–</td>
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<td>–</td>
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<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Parallel brushed marks and opposed parallel lines, body</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
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<td>1</td>
</tr>
<tr>
<td>Parallel brushed marks and overlapping parallel lines, body</td>
<td>–</td>
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<td>–</td>
<td>1</td>
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<td>1</td>
</tr>
<tr>
<td>Parallel brushed marks and overlapping straight lines, body</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<td>1</td>
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<td>1</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>Parallel incised lines and opposed brushing, body</td>
<td>–</td>
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<td>2</td>
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<td>2</td>
</tr>
<tr>
<td>Straight incised line and opposed brushing, body</td>
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<tr>
<td>Vertical brushed–incised, body</td>
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<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Vertical incised (lower rim)–horizontal brushed (body), body</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
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<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Horizontal and curvilinear brushed marks and incised lines, rim</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<td>–</td>
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<td>1</td>
</tr>
<tr>
<td>Horizontal brushed marks and incised lines, rim</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>4</td>
<td>–</td>
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<td>–</td>
<td>5</td>
</tr>
<tr>
<td>Horizontal brushed and overlapping vertical incised lines, rim</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
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<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Vertical brushed marks and Incised lines, rim</td>
<td>–</td>
<td>–</td>
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<td>5</td>
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<td>1</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>97</td>
</tr>
</tbody>
</table>

Figure 47f), whereas a lower rim-body sherd from Block 4 has horizontal brushing marks on the rim, horizontal brushing on the body, and diagonal incised lines cut through the brushing (see Table 34).
The brushed-incised body sherds typically have parallel brushing marks and parallel incised lines (see Table 34). However, there are other combinations on these sherds of parallel, straight, and vertical incised lines as well as parallel, vertical, and overlapping brushing marks (see Figures 48h and 50d).

**Brushed-Incised-Punctated**
There is one body sherd with a brushed-incised-punctated decoration in the assemblage, from Feature 62 (65–70 cmbs). The sherd has parallel brushed marks and incised lines, with a row of tool punctations pushed through the brushing (see Figure 46b).

**Brushed-Punctated**
Three rim sherds and seven body sherds have brushed-punctated decorative elements (0.6 percent of the utility wares from the site). They are from test units (n=2), Block 4 (n=4), Block 7 (n=1), and Block 8 (n=3).

The rims all have a row of tool punctations under the vessel lip, with brushing on the rim below the punctates. The brushing is either oriented vertically (from a test unit), diagonally (Block 4), or horizontally (Block 8, see Figure 44g). A body sherd from Block 7 has a tool punctated row along the rim-body juncture, with diagonal brushing marks on the vessel body below. Four body sherds (a test unit, Block 8, and two sherds from Block 4), likely from Pease Brushed-Incised jars, have brushing marks (either parallel or horizontal in orientation) and a row of tool punctates pushed through the brushing (see Figure 45d). Another body sherd (from Block 8) has parallel brushing marks adjacent to a row of tool punctates, and a body sherd from Block 4 has parallel brushing marks on each side of a straight row of tool punctates (see Figure 48g). On this sherd, likely also from a Pease Brushed-Incised jar, the parallel brushing is probably oriented horizontally on each side of a single vertical row of tool punctates. The punctated rows would have made panels filled with brushing on the vessel body of a jar.

**Incised**
Sherds from incised vessels are abundant in the utility wares from the Murvaul Creek site, accounting for 20.3 percent of all the utility wares (see Table 30) and 25.4 percent of the utility ware rims. Incised utility wares are particularly abundant in Blocks 3 (25.0 percent) and 5 (28.1 percent), and are least abundant in Block 7 (19.0 percent) and Block 8 (16.7 percent).

The incised decorations on the utility wares feature simply geometric elements with little stylistic diversity. Among the rims decorated with incised lines are those with sets of diagonal lines, opposed diagonal chevrons (see Figures 41b and 48c, f), sets of horizontal lines (see Figure 47c), horizontal and diagonal lines, vertical lines, and vertical and diagonal lines (Table 35).
Table 35: Incised Decorative Elements in the Murvaul Creek Site (41PN175) Sherd Assemblage

<table>
<thead>
<tr>
<th>Decorative Element, Rim or Body</th>
<th>Units</th>
<th>Bl. 1</th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-hatched lines, body</td>
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</tr>
<tr>
<td>Curvilinear and straight lines, body</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Diagonal lines, body</td>
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</tr>
<tr>
<td>Horizontal and diagonal lines, body</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Opposed lines, body</td>
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<td>8</td>
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<tr>
<td>Opposed lines, chevron, body</td>
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<td></td>
</tr>
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<td>Opposed lines in sets, body</td>
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<td>Parallel lines in sets, body</td>
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<td>Straight line, body</td>
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<td>5</td>
<td>6</td>
<td>18</td>
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<td>10</td>
<td>13</td>
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<td>69</td>
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<tr>
<td>Vertical and opposed diagonal lines, body</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Diagonal lines, rim</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Horizontal lines, rim</td>
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<td>Horizontal line under lip, rim</td>
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<td></td>
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<tr>
<td>Horizontal and diagonal lines, rim</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Opposed lines, chevron, rim</td>
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<td></td>
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</tr>
<tr>
<td>Vertical lines, rim</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical and diagonal lines, rim</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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<td>7</td>
<td>21</td>
<td>43</td>
<td>22</td>
<td>326</td>
<td></td>
</tr>
</tbody>
</table>

The body sherds have a similar range of incised decorative elements (see Table 35), most with sets of parallel lines (see Figures 44c–d, 47d, and 49c), straight lines, opposed lines, and diagonal lines. A few others have crosshatched lines, straight to curvilinear lines (see Figures 41c and 46c), diagonal opposed lines (see Figure 48a), vertical-horizontal lines (see Figure 48b), and horizontal and diagonal lines (see Figure 48k). One incised body sherd from a Pease Brushed-Incised jar from Block 4 has a vertical incised line with sets of opposed diagonal lines (see Figure 48j; also see Suhm and Jelks 1962:Plate 60k).

**Incised-Punctated**

Sherds with incised-punctated decorative elements represent only 1.1 percent of the utility wares from the site (see Table 30). In Block 3, however, they account for almost 9 percent of the utility wares (Table 36). Almost 90 percent of the incised-punctated sherds have a combination of incised lines and tool punctates (see Figures 48d–e, l, n; and 49a–b), with the other 11 percent having incised lines and fingernail punctates.
### Table 36: Incised-Punctated Decorative Elements in the Murvaul Creek Site (41PN175) Sherd Assemblage

<table>
<thead>
<tr>
<th>Decorative Element, Rim or Body</th>
<th>Units</th>
<th>Bl. 1</th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel lines and single fingernail punctate, body</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Straight line and adjacent fingernail punctated row, body</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Curvilinear incised line and zone of tool punctates, body</td>
<td>–</td>
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<td>–</td>
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<td>–</td>
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</tr>
<tr>
<td>Diagonal incised lines and triangular zone with tool punctates, body</td>
<td>–</td>
<td>–</td>
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<tr>
<td>Horizontal and diagonal lines and triangular zones with tool punctates, body</td>
<td>–</td>
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<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Opposed diagonal lines and dividing tool punctated row, body</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Parallel lines adjacent to tool punctated row, body</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Parallel lines and zone with tool punctates, body</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Parallel lines on each side of tool punctated row, body</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Straight line and adjacent tool punctates, body</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2</td>
<td>4</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>1</td>
<td>–</td>
<td>8</td>
</tr>
<tr>
<td>Diagonal lines and tool punctated zone, rim</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>2</td>
<td>–</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>–</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>18</td>
</tr>
</tbody>
</table>

The principal elements on either the rim or the body of vessels are either parallel or diagonal lines adjacent to a row or zone of tool punctates; the zone of punctates is probably triangular-shaped (see Figure 48d). One body sherd has parallel incised lines on each side of a tool punctated row, but another—likely from a Pease Brushed-Incised jar (Suhm and Jelks 1962:119)—has a dividing row of tool punctations with diagonal opposed lines on each side of the punctated row (see Figure 48l). A third incised-punctated body sherd (from Block 3) has a curvilinear incised zone filled with tool punctations (see Figures 48e and 49b).

**Lip Notched**

There are two lip notched rim sherds in the assemblage, one from one of the test units (Unit 37, 20–40 cmbs) north of Block 4 and the other from Block 4 (Unit 99, 10–20 cmbs). They both have a series of straight notched lines across the vessel lip, and either direct or everted rims.
Both tool and fingernail punctated decorative elements are present among the utility wares at the Murvaul Creek site, but neither is common. Tool punctated rim and body sherds comprise 2.2 percent of the utility wares, and the fingernail punctated body sherds account for only 0.4 percent of the utility wares (see Table 30). Sherds from punctated vessels are proportionally most common in Blocks 2 and 5 (Table 37), but even in these areas, punctated sherds represent less than 5.5 percent of the utility wares.

**Table 37: Tool and Fingernail Punctated Decorative Elements in the Murvaul Creek Site (41PN175) Sherd Assemblage**

<table>
<thead>
<tr>
<th>Decorative element, Rim or Body</th>
<th>Units</th>
<th>Bl. 1</th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingernail punctated, crescent–shaped, body</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Fingernail punctated row, body</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Single fingernail punctate, body</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Linear tool punctated rows, body</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Single tool punctate, body</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Random tool punctates, body</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Tool punctated row or rows, body</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>6</td>
<td>3</td>
<td>-</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Tool punctated row or rows, rim</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Tool punctated row at lip, rim</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Tool punctated row under the lip, rim</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>2</td>
<td>-</td>
<td>6</td>
<td>-</td>
<td>13</td>
<td>3</td>
<td>-</td>
<td>4</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

Tool punctated and linear tool punctated rim and/or body sherds have rows of punctates (see Figures 44c, f; and 47a). Vessel rims have rows of tool punctations at and under the lip, and in evenly spaced rows on the rim itself.

**Punctated, Fingernail**

Fingernail punctated body sherds have rows of punctations that would have covered the surface of vessel bodies. Two body sherds (from Block 2 and a feature) have distinctive crescent-shaped elements that suggest they may be from Weches Fingernail Impressed jars (see Suhm and Jelks 1962:Plate 77), generally thought to have been made by East Texas Caddo potters before ca. A.D. 1300.
Sherds for Residue Analysis

Five body sherds from Block 4 excavations at the Murvaul Creek site were submitted for residue analysis. They were examined in detail by temper, firing conditions, surface treatment, thickness, and decoration (if present) (Table 38).

Table 38: Sherds Submitted for Residue Analysis from Block 4, Murvaul Creek Site (41PN175)

<table>
<thead>
<tr>
<th>Provenience (cmbs)</th>
<th>Sherd Type</th>
<th>Temper</th>
<th>Firing Condition</th>
<th>Surface Treatment</th>
<th>Thickness (mm)</th>
<th>Decoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 76 (30–40)</td>
<td>Body</td>
<td>Grog/SP</td>
<td>Reducing–cooled in open air</td>
<td>–</td>
<td>7.3</td>
<td>Plain</td>
</tr>
<tr>
<td>Unit 77 (20–30)</td>
<td>Body</td>
<td>Grog-b</td>
<td>Reducing</td>
<td>–</td>
<td>6.3</td>
<td>Plain</td>
</tr>
<tr>
<td>Unit 86 (20–30)</td>
<td>Body</td>
<td>Bone-h/SP</td>
<td>Reducing</td>
<td>–</td>
<td>8.4</td>
<td>Plain</td>
</tr>
<tr>
<td>Unit 100 (20–27)</td>
<td>Body</td>
<td>Grog</td>
<td>Reducing–cooled in open air</td>
<td>–</td>
<td>8.1</td>
<td>Plain</td>
</tr>
<tr>
<td>Unit 125 (10–15)</td>
<td>Body</td>
<td>Grog-b-h</td>
<td>Reducing–cooled in open air</td>
<td>–</td>
<td>8.4</td>
<td>Parallel brushed</td>
</tr>
</tbody>
</table>

b=bone; h=hematite; SP=sandy paste

Clay Pipe Sherds

There are only three clay pipe sherds in the Murvaul Creek site ceramic assemblage. Two are from test units (Units 8 and 23) in the central part of the excavation area, adjacent to Block 4, and the third sherd is from Block 4 (Unit 78, 20–30 cmbs). The pipe sherd from Unit 8 (20–40 cmbs) is an elbow pipe rim tempered with bone; the pipe was fired in a reducing environment; the pipe wall is 5.4 mm thick. The pipe sherd from Unit 23 (20–40 cmbs) appears to be from a long-stemmed pipe bowl. It is tempered with grog and has a 4.0-mm-thick bowl wall. The Block 4 sherd (Figure 51) is from an elbow pipe bowl with a 4-cm orifice diameter. The pipe is tempered with finely crushed bone, fired in a reducing environment, and has a 4.2-mm-thick wall.

Local and Regional Ceramic Assemblage Comparisons and Caddo Ceramic Traditions in East Texas

The first consideration in this discussion is to examine the possible age and intrasite chronological relationship of the different excavation areas at the Murvaul Creek site from the ceramic stylistic evidence. This is followed by ceramic assemblage comparisons between the Murvaul Creek site and generally contemporaneous Caddo sites in the region (Figure 52). The purpose of this section is to assess the existence of stylistic and social relationships between the Caddo peoples who lived at the Murvaul Creek site and other Caddo groups living in the Sabine and Angelina river basins. Such social relationships—as based on shared ceramic styles and decorative elements—imply “intermarriage, economic exchange, and joint participation in ceremonies and visitation” (Thurmond 1990:222).
Assessment of Assemblage Similarity at the Murvaul Creek Site

To assess the similarity in ceramic decorative methods among the different excavation areas at the Murvaul Creek site, the Brainerd-Robinson (BR) coefficient of similarity was employed (Robinson 1951; see also discussion in Peeples and Haas 2013). Frequency data on the relative proportion of decorated sherds from Blocks 2–8 (Block 1 is not included because it only has two decorated sherds, and the sherds from the test units are not included because they are from units dispersed across the site) and the features represented in the different sherd assemblages (see Table 21) are used to compute the coefficient, using the following formula:

$$BR = \frac{200 - \sum_k |P_{ak} - P_{bk}|}{200}$$

The formula takes the percentage of class \( i \) (the decorative methods listed in Table 39 for the site) in assemblage A and subtracts it from the same class in the next assemblage (i.e., assemblage B), taking the absolute value of the differences. The percentages are summed to produce a coefficient of dissimilarity, which is then subtracted from 200 to arrive at the pair-wise BR similarity coefficient. A small cumulative percentage difference between assemblages A and B will produce a high BR coefficient (i.e., close to 200), and a large difference will produce a low BR coefficient (i.e., farther from 200 and closer to 0).
and Haas (2013:237) suggest the BR scores be divided by 200 so that they “range between 0 (indicating no similarity) and 1 (indicating perfect similarity).” No assumptions are made that the assemblages have a homogeneous composition or that the sherds in the blocks derived from the same kinds of activities through time. The analysis simply relies on the only available data on sherd decorations within the site excavation areas: that is, the numbers and relative proportions of sherds of the same or different decorative methods from Blocks 2-8 and the Features.
### Table 39: Percentages of Major Decorative Methods by Assemblage for Brainerd-Robinson Coefficient of Similarity Calculations

<table>
<thead>
<tr>
<th>Decorative Method</th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
<th>Fea.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliquéd</td>
<td>–</td>
<td>–</td>
<td>1.0</td>
<td>2.7</td>
<td>3.3</td>
<td>0.8</td>
<td>1.8</td>
<td>–</td>
</tr>
<tr>
<td>Appliquéd-Incised</td>
<td>–</td>
<td>–</td>
<td>0.7</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Appliquéd-Incised</td>
<td>–</td>
<td>–</td>
<td>0.1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Brushed</td>
<td>61.5</td>
<td>50.8</td>
<td>60.4</td>
<td>52.1</td>
<td>66.7</td>
<td>63.6</td>
<td>67.3</td>
<td>67.5</td>
</tr>
<tr>
<td>Brushed-Appliquéd</td>
<td>–</td>
<td>–</td>
<td>0.1</td>
<td>–</td>
<td>–</td>
<td>0.8</td>
<td>0.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Brushed-Incised</td>
<td>6.0</td>
<td>7.9</td>
<td>8.8</td>
<td>4.1</td>
<td>3.3</td>
<td>5.9</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Brushed-Incised-Punctated</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.8</td>
</tr>
<tr>
<td>Brushed-Punctated</td>
<td>–</td>
<td>–</td>
<td>0.6</td>
<td>–</td>
<td>–</td>
<td>0.8</td>
<td>1.1</td>
<td>–</td>
</tr>
<tr>
<td>Engraved</td>
<td>5.1</td>
<td>11.1</td>
<td>6.0</td>
<td>12.3</td>
<td>3.3</td>
<td>5.9</td>
<td>5.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Incised</td>
<td>21.4</td>
<td>20.6</td>
<td>19.2</td>
<td>24.7</td>
<td>23.2</td>
<td>17.8</td>
<td>15.8</td>
<td>17.2</td>
</tr>
<tr>
<td>Incised-Punctated</td>
<td>0.8</td>
<td>9.5</td>
<td>0.8</td>
<td>1.4</td>
<td>–</td>
<td>0.8</td>
<td>0.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Lip Notched</td>
<td>–</td>
<td>–</td>
<td>0.1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Punctated, Fingernail</td>
<td>2.6</td>
<td>–</td>
<td>0.1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.8</td>
</tr>
<tr>
<td>Punctated, Circular</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.4</td>
</tr>
<tr>
<td>Punctated, Tool</td>
<td>2.6</td>
<td>–</td>
<td>1.7</td>
<td>4.1</td>
<td>–</td>
<td>3.4</td>
<td>4.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Red Slipped</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1.6</td>
</tr>
<tr>
<td>Total Decorated Shards</td>
<td>117</td>
<td>63</td>
<td>705</td>
<td>74</td>
<td>30</td>
<td>118</td>
<td>272</td>
<td>123</td>
</tr>
</tbody>
</table>

The BR similarity coefficients among the eight principal decorated sherd assemblages range between 150.9 and 189.0 (or 0.75–0.945 on a scale from 0 to 1.0) (Table 40), suggesting considerably ceramic stylistic similarity across the different excavated areas at the Murvaul Creek site. The BR values have a maximum 19 percent difference (38 BR points) between the highest (189.0, between Blocks 4 and 7) and lowest (150.9, between Blocks 3 and 8) similarity coefficients.

Nevertheless, there are consistent BR groupings among the various assemblages (see Table 40) that have defined three groups that share a high coefficient of similarity:

- **Group I**, Blocks 3 and 5, BR coefficient of 182.4 (0.912 on a scale of 0 to 1.0)
- **Group II**, Blocks 2, 4, and 7, BR coefficients between 187.0 and 189.0 (0.935–0.945 on a scale of 0 to 1)
- **Group III**, Blocks 6, 7, 8, and Features, coefficients between 179.5 and 187.3 (0.898–0.933 on a scale of 0 to 1.0)
Table 40: Brainerd-Robinson Coefficients of Similarity Among Assemblages at the Murvaul Creek Site (41PN175)

<table>
<thead>
<tr>
<th></th>
<th>Bl. 2</th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 3</td>
<td>168.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Block 4</td>
<td>187.0</td>
<td>169.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Block 5</td>
<td>169.6</td>
<td>182.4</td>
<td>167.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Block 6</td>
<td>179.1</td>
<td>159.5</td>
<td>175.9</td>
<td>166.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Block 7</td>
<td>187.6</td>
<td>165.8</td>
<td>189.0</td>
<td>166.0</td>
<td>179.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Block 8</td>
<td>177.7</td>
<td>150.9</td>
<td>178.3</td>
<td>159.7</td>
<td>181.0</td>
<td>187.3</td>
<td>-</td>
</tr>
<tr>
<td>Fea.</td>
<td>177.9</td>
<td>153.9</td>
<td>177.1</td>
<td>155.2</td>
<td>180.8</td>
<td>182.7</td>
<td>186.6</td>
</tr>
</tbody>
</table>

Dr. Scott Pletka presented the following observation regarding the use of the BR coefficient of similarity: “Given the variation in sample size among blocks, are the observed differences in the BR coefficient significant? One way to address this issue would be to conduct a simulation study.” He suggested that we conduct a random simulation study to re-assign each sherd to a random block while retaining the original block sample sizes and then recalculate the BR coefficients. This would, in theory, give the number of times that the BR coefficient ranges would be observed due to random chance. He suggested that 50 or more iterations would likely be sufficient. We took this into consideration by setting up a random simulation experiment in BR. The original data were first input into the program and the BR coefficient table was generated. Then, an iterative loop was set up to randomize the Block order within the data while retaining all other characteristics (total number of sherds, decoration, sherds recovered per block). The results of this random simulation are presented in Table 41.

Table 41: Results of Random Simulation Experiment in BR

<table>
<thead>
<tr>
<th>Run</th>
<th>Iterations</th>
<th>Number of instances greater dissimilarity than Observed</th>
<th>Proportion with greater dissimilarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>6</td>
<td>0.120</td>
</tr>
<tr>
<td>2</td>
<td>1,000</td>
<td>237</td>
<td>0.237</td>
</tr>
<tr>
<td>3</td>
<td>10,000</td>
<td>2374</td>
<td>0.237</td>
</tr>
<tr>
<td>4</td>
<td>50,000</td>
<td>11903</td>
<td>0.238</td>
</tr>
<tr>
<td>5</td>
<td>100,000</td>
<td>24001</td>
<td>0.240</td>
</tr>
</tbody>
</table>

Table 41 shows that approximately 24 percent of the time the random samples fell outside of the observed BR coefficient range. This also suggests that 76 percent of the samples fell within the variation observed due to random chance. However, it is important to note that simply randomizing the blocks where the sherds were attributed ignores the variability between the actual sherd attributes. In order to further assess which Block-pairs were contributing to the variability of the study, a frequency matrix was generated for each random run counting the number of times that an individual cell fell outside of the observed BR value. The frequency matrix observed for the 100,000 iteration run is presented in Table 42.
Table 42: Frequency Matrix of Individual Cells Falling Outside the BR Value

<table>
<thead>
<tr>
<th></th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 2</td>
<td>6,377</td>
<td>18,451</td>
<td>8,256</td>
<td>23,684</td>
<td>23,713</td>
<td>9,948</td>
</tr>
<tr>
<td>Block 3</td>
<td>-</td>
<td>4,654</td>
<td>15,805</td>
<td>13,051</td>
<td>3,496</td>
<td>224</td>
</tr>
<tr>
<td>Block 4</td>
<td>4,654</td>
<td>-</td>
<td>2,363</td>
<td>21,769</td>
<td>19,602</td>
<td>282</td>
</tr>
<tr>
<td>Block 5</td>
<td>15,805</td>
<td>2,363</td>
<td>-</td>
<td>19,465</td>
<td>5,205</td>
<td>1,335</td>
</tr>
<tr>
<td>Block 6</td>
<td>13,051</td>
<td>21,769</td>
<td>19,465</td>
<td>-</td>
<td>22,749</td>
<td>23,496</td>
</tr>
<tr>
<td>Block 7</td>
<td>3,496</td>
<td>19,602</td>
<td>5,205</td>
<td>22,749</td>
<td>-</td>
<td>19,698</td>
</tr>
<tr>
<td>Block 8</td>
<td>244</td>
<td>282</td>
<td>1,335</td>
<td>23,496</td>
<td>19,698</td>
<td>-</td>
</tr>
<tr>
<td>Fea.</td>
<td>1,068</td>
<td>3,189</td>
<td>922</td>
<td>23,433</td>
<td>16,486</td>
<td>18,660</td>
</tr>
</tbody>
</table>

It is plainly visible in Table 42 that the frequency of sherds recovered from Block 6 causes this block to be highly dissimilar to most other blocks. Given that this table represents the 24,001 instances where the BR coefficient minimum value was below that observed from the site data, it is apparent that approximately 97 percent of those minimums included minimum values in the Block 6 groupings. Blocks 7 and 2 are also consistently dissimilar to each of their pairs. However, Blocks 3 and 4 are both rarely marked as falling outside the range observed from the site data when each is compared with Block 8.

Given that there do seem to be patterns of Block-pairs that are consistently found to have greater or lesser similarity indices, the question arises as to how much of this variation is simply due to sample size. In order to address this, a second suite of random simulations was generated. Sample size was varied by doubling the sherd records and then randomizing the Block attribute while still keeping the same proportion between blocks. However, instead of the data representing 1,497 sherds, the simulation included 2,994 sherds. The BR coefficients were again compared to the original values obtained from the site data. Table 43 presents those results, which suggest that by doubling the sample size values outside of the range observed on the site occur only approximately 1.7 percent of the time. Or in other words, 98.3 percent of the time the random values would occur within the levels observed from the site data. With the doubling of the sample size, essentially the same Block-pairs were consistently similar or dissimilar to each other.

Table 43: Results of Random Simulation with Sample Size Doubled

<table>
<thead>
<tr>
<th>Run (doubled records)</th>
<th>Iterations</th>
<th>Number of instances greater dissimilarity than observed</th>
<th>Proportion with greater dissimilarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>50</td>
<td>2</td>
<td>0.040</td>
</tr>
<tr>
<td>7</td>
<td>1,000</td>
<td>16</td>
<td>0.016</td>
</tr>
<tr>
<td>8</td>
<td>10,000</td>
<td>176</td>
<td>0.018</td>
</tr>
<tr>
<td>9</td>
<td>50,000</td>
<td>844</td>
<td>0.017</td>
</tr>
<tr>
<td>10</td>
<td>100,000</td>
<td>1,684</td>
<td>0.017</td>
</tr>
</tbody>
</table>
Finally, the BR coefficients were calculated using only the sherds recovered from within the buried soil. It is important to note that this sample size includes roughly one-third of the total collection because the sherds from the Colluvium were removed. Table 44 shows the BR coefficients using only the sherds from the buried soil. The grouping between Blocks 6 and 4 appear as an extreme outlier in the data, with a BR coefficient of 17.3. This suggests that these two Blocks are highly dissimilar. It should be noted that very few sherds were attributed to the buried soil in Block 3, so it is not surprising that this block appears dissimilar to the other blocks, with values ranging from 117.8 to 130.8. However, the remaining Block-pairs are all within the range that Perttula found for BR coefficients using the sherds from all contexts. Given that the above simulations suggest that this measure is very susceptible to sample size, there is still some doubt as to how meaningful the measurement is.

Table 44: BR Coefficient of Similarity Results for Sherds within the Buried Soil at the Murvaul Creek Site (41PN175)

<table>
<thead>
<tr>
<th></th>
<th>Bl. 3</th>
<th>Bl. 4</th>
<th>Bl. 5</th>
<th>Bl. 6</th>
<th>Bl. 7</th>
<th>Bl. 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 2</td>
<td>130.2</td>
<td>178.5</td>
<td>177.8</td>
<td>184.2</td>
<td>166.1</td>
<td>177.3</td>
</tr>
<tr>
<td>Block 3</td>
<td>-</td>
<td>133.1</td>
<td>130.8</td>
<td>117.8</td>
<td>127.3</td>
<td>122.5</td>
</tr>
<tr>
<td>Block 4</td>
<td>133.1</td>
<td>-</td>
<td>178.5</td>
<td>17.3</td>
<td>170.6</td>
<td>173.8</td>
</tr>
<tr>
<td>Block 5</td>
<td>130.8</td>
<td>178.5</td>
<td>-</td>
<td>170.4</td>
<td>179.3</td>
<td>164.7</td>
</tr>
<tr>
<td>Block 6</td>
<td>117.8</td>
<td>173.3</td>
<td>170.4</td>
<td>-</td>
<td>168.1</td>
<td>163.7</td>
</tr>
<tr>
<td>Block 7</td>
<td>127.3</td>
<td>170.6</td>
<td>179.3</td>
<td>168.1</td>
<td>-</td>
<td>155.4</td>
</tr>
<tr>
<td>Block 8</td>
<td>122.5</td>
<td>173.8</td>
<td>164.7</td>
<td>163.7</td>
<td>155.4</td>
<td>-</td>
</tr>
</tbody>
</table>

Group I assemblages are situated in the southern and northeastern part of the site, along the margins of the main occupational material remains. They have the lowest proportions of brushed sherds among the different ceramic assemblages, along with high proportions of sherds with incised, engraved, and incised-punctated decorative elements (Table 45). Group III assemblages (Blocks 6–8) are in the northern and northeastern part of the site, and the features are found primarily from the central to the northern part of the site, mainly around Blocks 4, 7, and 8. These ceramic assemblages have the highest proportions of brushed sherds at the site, a higher proportion of sherds with tool punctated elements than the other groups (although still a very low percentage, at 3 percent), and the lowest proportion of engraved sherds (see Tables 39 and 45). The Group II assemblages are found from north to south in the excavation area. These ceramic assemblages are notable for the proportion of sherds with brushed-incised decorative elements, but are otherwise intermediate between Groups I and III in the relative proportion of the principal decorative methods on rim and body sherds (see Table 45). The only lip notched rim sherd is in the Group II assemblages. Sherds with appliquéd elements (either as the sole element or in combination with others) occur in similar proportions in all three groups: Group I (1.5 percent), Group II (1.7 percent), and Group III (2.4 percent).
Table 45: Proportions of Decorated Sherds in Groups I, II, and III at the Murvaul Creek Site (41PN175)

<table>
<thead>
<tr>
<th>Decorative Method</th>
<th>Group I Percentage</th>
<th>Group II Percentage</th>
<th>Group III Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliquéd</td>
<td>1.5</td>
<td>0.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Appliquéd–Incised</td>
<td>-</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Appliquéd–Incised–Brushed</td>
<td>-</td>
<td>0.1</td>
<td>–</td>
</tr>
<tr>
<td>Brushed</td>
<td>51.5</td>
<td>61.1</td>
<td>66.4</td>
</tr>
<tr>
<td>Brushed–Appliquéd</td>
<td>–</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Brushed–Incised</td>
<td>5.9</td>
<td>8.1</td>
<td>3.9</td>
</tr>
<tr>
<td>Brushed–Incised–Punctated</td>
<td>–</td>
<td>–</td>
<td>0.2</td>
</tr>
<tr>
<td>Brushed–Punctated</td>
<td>–</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Engraved</td>
<td>11.8</td>
<td>5.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Incised</td>
<td>23.5</td>
<td>19.2</td>
<td>17.0</td>
</tr>
<tr>
<td>Incised–Punctated</td>
<td>5.1</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Lip Notched</td>
<td>–</td>
<td>0.1</td>
<td>–</td>
</tr>
<tr>
<td>Punctated, Circular ‡</td>
<td>–</td>
<td>–</td>
<td>0.2</td>
</tr>
<tr>
<td>Punctated, Fingernail</td>
<td>–</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Punctated, Tool</td>
<td>1.5</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Red–slipped</td>
<td>–</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Totals</td>
<td>136</td>
<td>940*</td>
<td>542*</td>
</tr>
</tbody>
</table>

‡ from a possible Washington Square Paneled vessel
* includes Block 7 in both totals

Given that the BR coefficient of similarity has been used to chronologically order groups of assemblages, what do the differences from Group I to Groups II and III in the relative proportion of the principal ceramic ware (i.e., sherds with brushed decorations)—50.7–50.8 percent in Group I; 60.6–63.5 percent in Group II; and 63.5–67.5 percent in Group III—suggest about the temporal ordering of these groups? It has been hypothesized that the frequency of brushed pottery in East Texas ceramic assemblages tends to increase through time (see Perttula 2010). Consequently, a related hypothesis can be suggested, based solely on the proportion of brushed pottery in the various assemblages, that the Group I ceramic assemblages represent the oldest assemblages at the Murvaul Creek site, with the Groups II and III assemblages being younger in age. A full evaluation of this hypothesis requires the consistent identification of brushed sherds in East Texas Caddo ceramic assemblages along with well-dated (with AMS dates) paleobotanical assemblages of wild and cultivated plant foods from these same set of sites.

Even given this hypothetically temporal ordering of Groups I, II, and III—which is by no means certain—the differences in proportions of brushed sherds do not by themselves, at least in this part of East Texas, provide any indication of the absolute age of the groups (other than that they all must date after ca. A.D. 1250, when brushed pottery began to become more
common among the utility wares in the region), their occupational length, or the amount of
time in years, if any, that may separate them. It may be just as likely that all three groups
are contemporaneous. Thus, the differences in proportion of certain kinds of decorated
utility wares and fine wares may simply represent the different stylistic expressions of
interacting Caddo families and potters within the site itself, or a combination of both stylistic
and functional differences in the use and discard of plain wares, utility wares, and fine
wares within the community represented by the different block excavation areas.

The temporal argument is considered the more likely of the two possibilities, although the TL
and 14C dates obtained to date are not as on-point as they could be. These 14C and TL dates
from the Murvaul Creek site warrant consideration, therefore, at this point in the discussion.
Unfortunately, almost all of the dates obtained from the site to date are from Blocks 2, 4, 7,
and 8, or from features near these same blocks, namely from Groups II and III ceramic
assemblages. There is only one 14C or TL date from Group I contexts, namely one 14C date
from a sherd from Block 3. If more C14 samples could have been submitted, dates from
Block 5 contexts would have been most helpful.

There are two apparently very anomalous TL dates from Blocks 4 and 8 (UW 2713 and
UW2715) and three very anomalous 2 sigma 14C dates from Block 4 (A.D. 970–1030 on a
ceramic sherd, Beta–344079, and A.D. 670–850 from Feature 30, Beta–344085 [this date
may actually pertain to a pre-Caddo use of the site, and not be anomalous (Arlo McKee, June
2013 personal communication]) and Block 7 (A.D. 690–880 from Feature 88, Beta–
344092). They are considered chronologically very anomalous given the overall character of
the decorated ceramic sherds in the site assemblage and their considerable age divergence
from the remainder of the TL and C14 dates from the Murvaul Creek site. In general, the TL
and 14C dates from the Murvaul Creek site present a relatively temporally coherent picture,
albeit in two chronological series. The first series has seven calibrated 14C dates (including
one on corn) from Blocks 3, 4, Block 8, and features near Block 4 that at 2-sigma range
from A.D. 1260–1420. There is one 2-sigma 14C date from an incised sherd from Block 2
that ranges from A.D. 1220–1280, overlapping the earlier end of the first series of calibrated
dates. The second series of absolute dates includes the two acceptable TL dates and 14 2-
sigma calibrated 14C dates, all from Blocks 4 and 8 and features near those blocks: they
range from A.D. 1430–1650.

Using OxCal 4.1.7 (Bronk Ramsey 2012), and taking into account the association between
the context of available dates and distinctive ceramic decorative assemblages (i.e., Groups I-
III) at the site, summed probability distributions of these dates were produced through the
14C date combination process, which reduces the standard deviation of samples of
comparable age, and refined the accuracy of the calibrated age ranges (for a more detailed
discussion of the date combination process and summed probability distributions, see
Selden and Perttula 2013). This led to the creation of three temporal groups of calibrated
Putting the three ceramic groups (Groups I–III) together with the two series of TL and calibrated radiocarbon dates, the following chronological scenario for the Caddo use of the site is offered: the Murvaul Creek site was first occupied by Caddo peoples sometime between A.D. 1275–1300 and then from A.D. 1298–1370, and the best material culture evidence of this occupation is the utility ware and fine ware ceramics from Group I (Blocks 3 and 5); there are likely sherds specific to this occupation in the other blocks (certainly in Blocks 2, 4, and 8 anyway, as based on 2-sigma calibrated age ranges of A.D. 1220–1280, A.D. 1270–1390, and A.D. 1280–1390 from sherds in those blocks), but overall they are culturally submerged by the larger and more expansive sample of ceramics in Groups II and III that are best represented in Blocks 2, 4, 6–8, and decorated ceramics from features. The Groups II and III ceramic assemblages are part of a later and more extensive Caddo occupation that took place sometime between A.D. 1457 and 1513.

**Regional Ceramic Comparisons**

In this discussion, data from a series of generally contemporaneous sites in the mid-Sabine and Angelina river basins are used (see Figure 52) to make ceramic comparisons to the ceramic assemblages from the Murvaul Creek site. The sherds from these sites have been analyzed in more or less comparable fashion, and thus can provide useful information on the composition of these decorated sherd assemblages. Moreover, these sites are primarily comprised only of sherds, and thus sherds provide the only basis for comparison with the Murvaul Creek site assemblage. The purpose is to look for ceramic stylistic affiliations between the Murvaul Creek site and other well-known Caddo sites, with an eye to identifying possible social relationships that may have existed between Caddo groups in the region.

The Burnitt site is a sixteenth–seventeenth-century Caddo site in the uplands on the east side of the Sabine River basin (Kelley 2006; about 40 km east-southeast of the Murvaul Creek site; see Figure 52). The ceramics (n=3,050) from the site are tempered with grog (100 percent), but only 22 percent are tempered with bone, much less than is the case at the Murvaul Creek site; most of the sherds also have a sandy paste (83 percent). The utility wares comprise 88 percent of the decorated sherds, and fine wares (exclusively engraved sherds; there are no red-slipped sherds in the assemblage) only 12 percent, not much different from in any of the ceramic groups at the Murvaul Creek site. However, the utility wares are dominated by sherds from vessels with either brushed (41 percent) or ridged (38 percent) decorations. The ridged pottery is identified as Belcher Ridged (Kelley 2006:55), an important utility ware in the Belcher phase, found in post–A.D. 1500 Caddo settlements in the Great Bend area of the Red River in northwest Louisiana and southwest Arkansas. As will be discussed below, Belcher Ridged also occurs in varying frequencies in mid Sabine
River basin sites at Toledo Bend Reservoir (McClurkan et al. 1966; Woodall 1969). Kelley (2006:64) concludes that the Burnitt site, and other sites in the vicinity, “represent a local group whose ceramic tradition was distinct from Titus or Belcher in a number of ways. Certainly they had contact with both these regions . . . .” No ridged pottery has been identified in the utility wares at the Murvaul Creek site, and it does not appear on stylistic grounds that the Murvaul Creek site had close stylistic or social relationships with these mid-Sabine River Caddo peoples or with more far-flung Caddo peoples living below the Great Bend of the Red River in Northwest Louisiana.

Ceramics at the Salt Lick, Goode, and Bison Area B sites at Toledo Bend Reservoir are heavily bone-tempered wares, like the Murvaul Creek ceramic assemblage, but as with the aforementioned Burnitt site, the utility wares (ranging from 953 to 2,322 sherds per site, see Kelley 2006:Table 6-3) are well represented by sherds from both brushed (34–66 percent of the utility wares) and ridged (5–20 percent) vessels. Fine wares, engraved sherds only, comprise between 19–34 percent of the decorated sherds at the three sites and are much more abundant in the assemblages than they are in the ceramic groups at Murvaul Creek. The decorative styles on the engraved wares at these sites and the Burnitt site have strong links to Red River and mid Sabine River sites (see Kelley 2006:55, 57, 60–61) but not to the engraved fine wares at the Murvaul Creek site.

The Tyson site is a fourteenth to mid fifteenth-century Caddo settlement on Attoyac Bayou (Middlebrook 1993, 1994, 1997), a tributary to the Angelina River, about 30 km south of the Murvaul Creek site (see Figure 52). Here, brushed sherds comprise about 38 percent of the decorated sherds (n=1,862), and the brushing occurs as parallel and diagonal designs on bodies, and in conjunction with incised and punctated rows and panels from vessels and sherds identified as Karnack Brushed-Incised and Pease Brushed-Incised (Middlebrook 1994:26). Similar decorative treatments are noted at the Murvaul Creek site, but panels are more commonly made with appliquéd ridges and fillets, and there are no appliquéd sherds in the ceramic assemblage at Tyson. Incised-punctated sherds (mainly punctations in curvilinear incised zones) are relatively abundant at Tyson (Middlebrook 1997:39–40), but incised-punctated sherds only account for at most 5.1 percent of the decorated sherds from ceramic Group I at the Murvaul Creek (and less than 1 percent in Groups II and III), and most of these feature incised triangles filled with tool punctations.

Some of the engraved wares at Tyson have a distinctive S-shaped scroll element that has been classified as Tyson Engraved (Middlebrook 1994:Figure 3), and there are other sherds that have hatched fill zones that are similar to Nacogdoches Engraved (see Hart 1982). Other common engraved elements noted in the ceramics at the Tyson site and other contemporaneous Caddo sites in the Angelina River basin include circles, concentric circles, scrolls, circles with rays, ladders, narrow zones, and panels filled with hatching or crosshatching, and pendant triangles (Middlebrook 1997:40). Engraved zones and panels
with hatched or crosshatched elements are one of the distinctive aspects of the fine wares at the Murvaul Creek site, but circles and scroll elements are conspicuously absent in the latter’s fine ware assemblage.

The post-fifteenth century A.D. Walter Bell site at Lake Sam Rayburn (Jelks 1965) has a large decorated sherd assemblage (n=4,452). Utility wares comprise 96 percent of the decorated sherd assemblage, particularly sherds from vessels decorated with brushed (47 percent) and incised (40 percent) decorative elements (Perttula 2009:Table 18); at the Murvaul Creek site, 63 percent of the decorated sherds are brushed and only 19 percent have incised decorative elements. As at the Murvaul Creek site (6.1 percent in the site as a whole), fine wares are not common, accounting for only 4 percent of the decorated sherds at Walter Bell. Although not quantified by Jelks (1965), the sherds at the Walter Bell site were clay [grog]-tempered, but he does note that bone-tempered and sandy paste Caddo ceramics were also present in the assemblage.

At the Washington Square Mound site, a thirteenth to mid-fifteenth-century mound center on a tributary to the Angelina River and approximately 55 km southwest of the Murvaul Creek site (see Figure 52), the ceramics are both grog and bone-tempered, with 71.6 percent of the sherds having either bone or grog-bone temper, much like the Murvaul Creek ceramic assemblages. The utility wares are dominated by sherds from brushed vessels (61 percent) (Hart 1982; Perttula 2009); this is virtually identical to the proportion of brushed sherds in the Group II ceramic assemblage at the Murvaul Creek site (61.1 percent). About 16 percent of the vessels from burials are also brushed (Hart 1982; Perttula et al. 2010). There are also a few brushed-punctated (6 percent) and brushed-incised (4 percent) sherds from Reavely Brushed-Incised jars at the Washington Square Mound site, as well as incised (13 percent), incised-punctated (4 percent), and appliquéd (2 percent) decorative elements; these are similar proportions to the Groups II and III Murvaul Creek ceramic assemblages.

The rare (8 percent of the decorated sherds) fine wares at Washington Square include a few Washington Square Paneled sherds and vessels, and engraved sherds and vessels primarily from Nacogdoches Engraved; there is one possible Washington Square Paneled sherd in the Murvaul Creek fine wares. The engraved sherds have scrolls, concentric circles, and hatched and crosshatched fill elements and zones (Hart 1982:Figure 3-4; Hart and Perttula 2010:Figures 5–9), as well as hatched triangles and narrow curvilinear crosshatched zones (Perttula 2009:167, Figure 19). One of the Nacogdoches Engraved vessels from Washington Square has a canebrake rattlesnake motif (Corbin and Hart 1998:Figure 31; Hart and Perttula 2010:Figure 8). This motif is found on vessels and sherds in two clusters in East Texas, a cluster of several sites in the mid and upper Sabine River basin not far to the northwest of the Murvaul Creek site, and a larger number of sites farther away (approximately 100 km) in the Big and Little Cypress creek basins (Hart and Perttula 2010:Figure 2). No engraved sherds with rattlesnake motifs were identified at the Murvaul
Creek site, however; but as previously noted, engraved sherds are rare in the assemblage as a whole, especially in Groups II and III (see Table 45).

Both long-stemmed and elbow pipe sherds, including a distinctive L-shaped form, are in the Washington Square Mound ceramic assemblage (Perttula 2009:Figure 21). The Murvaul Creek site also has long-stemmed and elbow pipe sherds, and the elbow pipe sherds are from A.D. 1457–1513 Groups II and III ceramic assemblages (Blocks 4 and 8).

There are several Lake Naconiche sites that share stylistic and technological similarities to the Murvaul Creek site assemblage. These sites are on a tributary to the Attoyac Bayou, about 25 km to the southwest (see Figure 52). The Tallow Grove, Foggy Fork, and Beech Ridge sites date from the thirteenth century to the late fifteenth century, but the principal component at the Naconiche Creek site dates to the mid sixteenth century and after (Perttula [editor] 2008:213–220). The first three Caddo sites have ceramics that are most commonly tempered with grog (90.6–96.5 percent), but between 27.4 and 38.3 percent also have had burned bone added as a temper, along with crushed hematite (8.5–11.9 percent); between 8.5 and 18.8 percent of the sherds are from vessels with a sandy paste, indicating common use of naturally sandy clays for vessel manufacture, as is also the case at the Murvaul Creek site.

Sherds from utility wares dominate the decorated sherds (n=3,160) from the Tallow Grove, Foggy Fork, and Beech Ridge sites, particularly sherds with brushed (31.3–42.5 percent), incised (14.9–23.1 percent), punctated (7.9–21.1 percent), and incised-punctated (4.1–9.0 percent) decorative elements. Fine wares—including sherds with red-slipped, engraved-punctated (from Washington Square Paneled vessels), and engraved elements—account for only 9.3–17.8 percent of the decorative sherd assemblage, and the proportion of fine wares appears to decrease after the early fifteenth century (Perttula [editor] 2008). Many of the distinctive engraved elements in the fine wares from these Lake Naconiche sites are shared with those identified at the Murvaul Creek site, including triangles, hatched triangles, crosshatched zones, curvilinear and vertical hatched zones, and hatched and curvilinear zones (see Perttula [editor] 2008:Figure 7-66).

Both the Tallow Grove and Beech Ridge sites have long-stemmed Red River pipe sherds, along with a platform pipe (at Tallow Grove) and an L-shaped elbow pipe (Beech Ridge) (Perttula [editor] 2008:Figures 7-77 and 7-80 to 7-82). Elbow pipe sherds are present in the ceramic assemblages from both the Beech Ridge and Foggy Fork sites, probably from fifteenth-century A.D. contexts.

At the later Naconiche Creek site, 28 percent of the sherds have bone temper, another 6.7 percent have hematite temper, and 82.7 percent have grog temper, either as the sole temper or in combination with bone and/or hematite. Almost 19 percent of the sherds are
from vessels with a naturally occurring sandy paste. Almost 98 percent of the decorated sherds (n=1,060) from the site are from utility wares, and notable among them are sherds with brushing marks (70.1 percent), as well as brushed-incised (4.8 percent), brushed-punctated (1.9 percent), brushed-appliquéd (1.8 percent), appliquéd (0.4 percent), and appliquéd-incised (0.2 percent) elements, which were uncommon decorative elements before the early fifteenth century. These proportions are quite similar to the post-A.D. 1450 Group III ceramic assemblage at the Murvaul Creek site (see Table 45).

To the north of the Murvaul Creek site by roughly 20 km (see Figure 52), the ceramic assemblage from the Tom Moore site (41PN149) on Irons Bayou can be distinguished in several respects from those to the south and west, including the Murvaul Creek site. Haskins and Walters (2001:59) suggest that the site has a Middle Caddo period component, but the single radiocarbon date (on corn) has a calibrated 2-sigma \(^{14}C\) age range of A.D. 1444–1649, suggesting instead that it is generally contemporaneous with the Groups II and III ceramic assemblages at the Murvaul Creek site. Approximately 24 percent of the sherds have bone temper, but only as secondary inclusions along with grog and grit (i.e., probably crushed hematite). Brushed sherds comprise only 21 percent of the decorated sherds (n=300), and only 24 percent of the utility wares. More common utility wares are sherds with punctated (35 percent of the utility wares), incised (26 percent), and incised-punctated (13 percent) decorative elements. These proportions are much different from the Groups I–III assemblages at the Murvaul Creek site (see Table 45). Fine ware sherds comprise only 10.3 percent of the decorated sherds. The body sherds have crosshatched filled panels, opposed lines, crosshatched circles with rays, or pendant triangles, though the rims either have horizontal lines or a hatched zone or ladder element (Haskins and Walters 2001:53).

The Nawi haia ina site (41RK170) is a thirteenth to fifteenth-century Caddo settlement in the upper Angelina River basin (Perttula and Nelson 2003), roughly 40 km northwest of the Murvaul Creek site (see Figure 41). The ceramic assemblage is primarily composed of grog-tempered vessels (> 70 percent in the utility wares and fine wares); sherds from grog-bone-tempered vessels account for 6.8–19.3 percent of the utility wares and fine wares, and bone-tempered sherds represent 10.1–10.6 percent of the utility wares and fine wares. Among the rims (n=190), 48 percent are from plain ware vessels, 36 percent are from utility wares, and 16 percent are from fine wares.

Of the 651 decorated sherds in the Nawi haia ina assemblage, 22.5 percent are from fine wares, including a few red-slipped sherds (Perttula and Nelson 2003:Table 4.1). This is one of the few assemblages in the region where sherds from brushed vessels do not dominate the utility wares: only 2.8 percent of the decorated sherds and 3.5 percent of the utility wares have brushing marks; another 3.0 percent of the utility wares have brushed-punctated, brushed-incised, brushed-punctated-incised, or brushed-appliquéd decorative elements. The difference in the proportion of sherds with brushed decorative elements
between the Murvaul Creek site and the Nawi haia ina site is quite substantial (see Table 40). Instead, sherds with punctated (38 percent), incised (33 percent), and incised-punctated (20.5 percent) elements are the principal utility wares at the site, again very different from Groups I–III at the Murvaul Creek site. Lip-notched rim sherds (n=5) are present in the assemblage, like the Group II assemblage at Murvaul Creek (see Table 45). The ceramic pipe sherds from the Nawi haia ina site are from Haley variety long-stemmed Red River pipes (Perttula and Nelson 2003:Figure 4.10). This is the latest (ca. A.D. 1300–1450) of the Red River style pipes (see Hoffman 1967).

The Musgano site (41RK19) is a ca. fourteenth–fifteenth-century A.D. Caddo settlement on Martin Creek (Clark and Ivey 1974), a northward-flowing tributary to the Sabine River, and approximately 40 km northwest of the Murvaul Creek site (see Figure 52). The ceramic sherd assemblage (n=7,803) is overwhelmingly grog-tempered (92 percent), with a low percentage of bone-tempered sherds (1 percent) and sherds with a sandy paste (7 percent), very different from the Murvaul Creek ceramic assemblages.

Utility wares comprise almost 92 percent of the decorated sherds from the Musgano site, with the fine wares (engraved and red-slipped) the remainder. Among the utility wares, almost 49 percent are from vessels that have brushing marks (not including another 0.8 percent that have brushed-punctated, brushed-incised, brushed-pinched, and brushed-appliqué decorative elements), with another 20 percent with punctated decorations, 17 percent incised, and 13 percent incised-punctated (Clark and Ivey 1974:Table 1). In some respects, these proportions are similar to the Group I ceramics from the Murvaul Creek site (see Table 45).

Pipe sherds at the Musgano site are from the distinctive L-shaped elbow pipes (Clark and Ivey 1974:Figure 13o–p). This style of elbow pipe has also been recovered at several other thirteenth–fifteenth-century sites in the middle and upper reaches of the Sabine River basin, including at the Oak Hill Village (41RK214, Rogers and Perttula 2004), Redwine (Walters and Haskins 1998), 41WD244 (Perttula et al. 2007), 41HS574 (Gadus et al. 2006:Figure 4-34), and Taddlock (Bruseth and Perttula 1981) sites, and at the Beech Ridge site in the Angelina River basin.

The Oak Hill Village site is a substantial twelfth–mid-fifteenth-century Caddo settlement on Mill Creek (Rogers and Perttula 2004), a tributary stream in the Sabine River basin, about 45 km northwest of the Murvaul Creek site (see Figure 52). Its ceramic sherd assemblage is grog-tempered, although 17 percent also has bone temper and 45 percent has hematite temper; most of the sherds are also from vessels with a sandy paste (Rogers and Perttula 2004:273).
The large decorated sherd assemblage (n=3,955) is about 88 percent from utility wares, and the remainder from engraved (11 percent) and red-slipped (0.1 percent) fine wares. The principal utility wares have punctated (40.5 percent), incised (20.5 percent), brushed (15.4 percent), and incised-punctated (10.5 percent) decorative elements, very different proportions than the Groups I–III ceramic assemblages from the Murvaul Creek site. About 1.6 percent of the utility wares have appliquéd elements, including appliquéd ridges, fillets, and nodes (Perttula 2004:Table 58). There is a lip-notched rim in the assemblage, as there are at the Nawi haia ina site and in the Group II assemblage at the Murvaul Creek site. In addition to two body sherds with engraved rattlesnake motifs (Perttula 2004:Figures 91p and 92), there are a variety of other distinctive and fairly well-represented engraved elements in the Oak Hill Village fine wares, including multiple vertical engraved lines, curvilinear engraved lines with excised triangles, hatched and cross-hatched triangles, narrow zones filled with hatched or cross-hatched lines, broad hatched zones, scrolls and semicircles, and circles (Perttula 2004:Figures 90f, h, n–o and 91b–h, l–o). The broad and narrow hatched and cross-hatched zones and triangles are also seen in the Murvaul Creek site fine wares, as well as other contemporaneous sites in the region.

Finally, the Pine Tree Mound site (41HS15) is an important Caddo ceremonial and civic center on Potters Creek that was occupied from the fourteenth century A.D. to the mid-1600s (Fields and Gadus 2012a), a tributary to the Sabine River, and about 50 km north of the Murvaul Creek site (see Figure 52). It has a large assemblage of analyzed ceramic vessel sherds (n=9,874) from village areas and the core area (Gadus and Fields 2012:Table 6.15). Approximately 44 percent of the sherds are tempered solely with grog, another 40 percent are tempered with grog and bone, and the remaining 16 percent are tempered solely with bone. The use of bone as a temper is considerable (60 percent of the analyzed sherds), as has been pointed out previously in the case in a number of other sites in this East Texas region, including the Murvaul Creek site. Other generally contemporaneous sites (i.e., with calibrated radiocarbon dates that range from as early as the late twelfth century to the mid seventeenth century) in this area examined by Gadus et al. (2006), Dockall et al. (2008), and Dockall and Fields (2011) suggest that the use of bone temper increases through time, as sherds with bone temper in earlier Middle Caddo components at 41HS231, 41HS574, 41HS844, and 41HS846 account for only 10–37 percent of the vessel sherd assemblage, but this proportion increases to more than 50 percent at post-fifteenth-century sites/components at 41HS573, 41HS843, and 41RK557.

Among the decorated sherds (n=6,620) from the Pine Tree Mound site, almost 90 percent are from utility ware vessels, with fine wares (engraved and red-slipped sherds) accounting for only 10.2 percent of the sherds (Gadus and Fields 2012:Table 6.15). Most of the utility ware sherds are from vessels with brushing—84 percent of the utility wares and 76 percent of all the decorated sherds, a percentage even higher than in the contemporaneous Group III assemblage from the Murvaul Creek site—as the main decorative technique, followed by
sherds with incised (11.5 percent of the utility wares), punctated/pinched (3 percent), appliquéd (1 percent), and ridged (0.9 percent, Belcher Ridged). Secondary decorative techniques feature appliquéd (n=313), punctated (n=586), and pinched (n=14) decorations. The main decorative elements in the assemblage include rectilinear lines, horizontal brushing, vertical brushing, curvilinear lines, cross brushing, diagonal brushing, and lines of punctuations, and secondary decorative elements include hatching, lines of punctuations, and linear appliquéd fillets. In most cases, these main and secondary decorative elements in the Pine Tree Mound ceramic sherd assemblage are quite comparable to the utility wares from the Murvaul Creek site, especially with respect to the brushing elements, lines of punctuations, and linear appliquéd elements, and Pease Brushed-Incised jar sherds are common at both sites. Utility wares at other nearby sites are also dominated by sherds from Pease Brushed-Incised vessels, as well as from Bullard Brushed, Maydelle Incised, and Harleton Appliquéd vessels (Gadus et al. 2006; Dockall et al. 2008), and brushing comprises more than 50 percent of the decorated sherd assemblages. Where the Pine Tree Mound site, as well as other nearby post-1400 sites, and the Murvaul Creek site ceramic sherd assemblages are most divergent are in the fine wares. The Pine Tree Mound site fine wares are dominated by sherds from Titus phase vessels with scroll motifs, slanted scrolls, circles, pendant triangles, and SZ elements from Ripley Engraved and Wilder Engraved carinated bowls and bottles, along with sherds from Simms Engraved and Taylor Engraved vessels, none of which are present in the Murvaul Creek site fine wares.

The Pine Tree Mound site is part of a local community (covering about 2,400 km²) centered on the Sabine River and the Hasinai Trace in East Texas (Figure 53). Sites identified in the community generally date after ca. A.D. 1400 and have high percentages of brushed ceramics and a low ratio of plain to decorated sherds (Fields and Gadus 2012a:655; see also Dockall and Fields 2011; Dockall et al. 2008; Gadus et al. 2006). Several sites discussed in this section are included in this community by Fields and Gadus (2012:661)—among them, Oak Hill Village and Musgano—and the Murvaul Creek site is situated only a few miles south of this hypothesized territory (see Figure 53). It is the case that the Pine Tree Mound site and the Murvaul Creek site share a high incidence of brushed utility wares and the use of bone temper in all wares, but the stylistic diversity apparent in the Titus phase engraved fine wares—and the common manufacture and use of Ripley Engraved vessels—from the Pine Tree Mound site is not duplicated in the Murvaul Creek site fine wares.

In sum, this consideration of the Caddo ceramic technology (i.e., use of different tempers) and decorative styles documented in the ceramic vessel sherds at the Murvaul Creek site suggests that the closest affiliations of the Caddo groups that lived there from the late thirteenth century onward into the sixteenth century were with other Caddo communities living not far to the south and southwest in the Angelina and Attoyac river basins, as well as with Caddo groups living in parts of the Sabine River basin to the northwest (see Figure 52). The Murvaul Creek site lies near the northern reaches of this ceramic tradition and is not
part of the Pine Tree Mound community (see Figure 53), although it is likely that additional work on other sites will show that this broad area of East Texas probably has several distinctive and more localized Caddo ceramic traditions during this lengthy time period. By tradition, this means a single, coherent community of technological and stylistic practice specific to the peoples of a given region. This ceramic tradition is consistent with a broad unity in culture and material culture production, as well as a shared native history, one that presumably developed through centuries of intermarriage, trade, transmission of learning, and other kinds of reciprocal relationships. This same broad area of East Texas was occupied in historic times by numerous Caddo groups that were affiliated with the Hasinai Caddo (Bolton 1987; Swanton 1942), including the Nasoni, Nadaco, Hainai, and Nacogdoche.
The Caddo settlers at the Murvaul Creek site shared a common ceramic heritage with other ancestral and historic Caddo groups living in this part of East Texas. Generally speaking, sites in this area have ceramic assemblages where brushing is an especially important decorative component in the utility wares after ca. A.D. 1250, and the proportion of brushed pottery appears to increase through time. Fine wares are not common, and sherds from red-slipped vessels are exceedingly rare. Ceramics at these sites also have high proportions of burned bone temper, either as the sole temper or in combination with other tempers; naturally sandy clays were frequently used in vessel manufacture. To the west in the upper Neches River basin, north in the Big Cypress Creek basin, and northwest in the upper Sabine River basin, by contrast, grog was the preferred temper between ca. A.D. 1300 and 1700.

Summary of the Murvaul Creek Site Ceramic Analysis
The analysis of the ceramic sherds from the Murvaul Creek site has identified several notable features of the ceramic assemblage (which includes sherds from jars, bowls, carinated bowls, compound bowls, and bottles, although the latter two forms are quite rare) retrieved in the data recovery investigations: (1) a considerable reliance on burned and crushed bone as a temper for the manufacture of plain wares, utility wares, and fine wares; (2) the firing of plain wares, utility wares, and fine wares primarily in a reducing or low oxygen environment; (3) a very high proportion (>93 percent) of utility ware sherds among the decorated vessel fragments in the assemblage; and (4) the utility ware sherds dominated by those with brushed rims and bodies (62.5 percent of the 1698 decorated sherds in the assemblage), or with rim and body sherds (6.9 percent of the decorated sherds in the assemblage) with brushed marks in combination with other decorative methods (punctations, incised lines, appliqué elements). The few fine ware sherds (from carinated bowls, compound bowls, and bottles) are characterized by geometric decorative elements, as well as narrow hatched and cross-hatched zones and triangles. Overall, the Murvaul Creek site ceramic assemblage best shares stylistic and technological features (i.e., mainly the common use of bone temper in vessel manufacture) with other known and generally contemporaneous sites in the mid Sabine and Angelina river basins, especially with sites in the Angelina River basin and northward-draining tributaries to the Sabine River (see Figure 52), and thus the closest cultural affiliations of the Caddo peoples that lived at the Murvaul Creek site appears to be in these areas of East Texas.

Comparisons of the similarity between the decorated sherd assemblages from the block excavations and the features at the site led to the identification of three different ceramic groups (Groups I–III) that share among them a high coefficient of similarity (see Table 40), and different proportions of decorative methods among the three groups (see Table 45). The Group I ceramic assemblages from Blocks 3 and 5 represent one occupation at the Murvaul Creek site, likely the earliest Caddo occupation, one that occurred sometime between A.D. 1275 and 1370. However, since only 9 percent of the decorated sherds from the site as a whole come from these block excavations, this occupation is a decidedly minor one in the overall history of settlement at Murvaul Creek. The principal Caddo occupation is

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represented by the Caddo Groups II and III ceramic assemblages, comprising 91 percent of all the decorated sherds from the blocks and features, that are found in Blocks 2, 4, 6–8 (Block 1 has too small a sample of decorated sherds to be assigned to a ceramic Group) and the majority of the features in and near the block excavations. This occupation occurred sometime between A.D. 1457 and 1513.

**Research Design Issues**

As discussed above, a number of research design issues were outlined that are considered relevant to the study of the Caddo ceramics from the Murvaul Creek site and contemporaneous Caddo ceramic sherd assemblages from sites in the mid Sabine and Angelina river basins in East Texas. These issues concern the material and spatial expressions of communities of ceramic practice in the region—“a group of people regularly engaged in a common endeavor” (Mitchell 2013:41)—including both stylistic and functional aspects of the wares, as well as more specifically at one site in the mid Sabine River basin.

First, can ceramic sherds from the site assemblage be employed to determine and measure social relationships/broad social affiliations between prehistoric Caddo groups in East Texas from ceramic stylistic evidence?

The analysis of ceramic stylistic similarities and differences in decorated sherd assemblages from generally contemporaneous Caddo sites in both the mid Sabine River basin and the Angelina River basin (see Figure 52), as well as the varying uses of temper for vessel manufacture (especially the use of burned bone as a temper), has been employed to track social relationships and social affiliations. Broad similarities and differences in the character of utility ware and fine ware ceramic sherd assemblage composition among contemporaneous sites in this East Texas region is suggested to represent the spatial extent of socially distinct Caddo populations who nevertheless had considerable interaction and cultural transmission. That being said, the closest social relationships between the Caddo group(s) that lived at the Murvaul Creek site and other Caddo groups appears to be with communities in the Angelina River basin not far to the south and southwest, and slightly less so with other Caddo communities that lived on tributaries flowing north to the Sabine River that are not far to the northwest.

What do ceramic stylistic similarities between East Texas sites disclose about Caddo communities? And, are there measurable stylistic variations within each region and significant differences between the regions?

Ceramic stylistic similarities and differences have been used to identify the distinctive character of the late thirteenth to sixteenth centuries A.D. ceramics found at the Murvaul Creek site. Broader ceramic comparisons with other contemporaneous Caddo sites in the mid-Sabine and Angelina river basins indicate that ceramic assemblages can be distinguished from each other in stylistic terms (i.e., in the choices made in the decorations
of utility wares and fine wares), most clearly in (a) the differing manufacture and use of utility wares with brushed decorations or conversely with ridged decorations (i.e., Belcher Ridged), and (b) in the spatial and temporal diversity in fine ware styles, particularly in the occurrence of Titus phase fine ware engraved styles on ceramics at the Pine Tree Mound site and community in the middle reaches of the Sabine River (see Figure 53) that emphasized scrolls and circular motifs, but such stylistic motifs occurring only rarely in other sites in the region. Another clear difference within the region is the varying use of bone as a temper, from little use in some sites (with grog as the primary temper of choice) to a very considerable use in others, including the Murvaul Creek site. These ceramic stylistic and technological similarities and differences are expressions of social identity and agency, as well as the existence of ceramic traditions with different historical trajectories, and likely mark the boundaries between different but related Caddo populations or cultural lineages that shared certain levels of cultural transmission over generations.

Can the recognition of local ceramic chemical groups and manufacturing locales at the Murvaul Creek site as determined by instrumental neutron activation analysis and petrography shed light on the existence, size, intensity, and relative amount of goods traded in local Caddo economic networks?

Small samples of sherds from the Murvaul Creek site have been analyzed by INAA (n=15; nine other samples were raw clay samples from the site and in the general local region, but these are not considered further here) and petrography (n=25) from the Murvaul Creek site (see Chapters 17 and 18). These sample sizes, even under the best circumstances, are not sufficient to confidently identify the existence of economic or social networks, much less assess their size, extent, or the amount or kind of goods that may have been traded or exchanged among communities in such networks. That kind of assessment would require information on material goods (i.e., ceramic sherds and vessels, and lithics from local vs. nonlocal sources) from hundreds of sites of known age, as in the Southwest Social Networks Project database (see Mills et al. 2013). Such an archeological database has not been constructed for any part of the Caddo area. Nevertheless, the INAA and petrographic results from the study of a sample of plain ware, utility ware, and fine wares at the Murvaul Creek site, and recent findings from other East Texas Caddo sites, provide some significant hints regarding the movement of ceramic vessels, likely a product of economic and social interaction.

Ferguson and Glascock (see Chapter 18) “suggest that all of the samples [from the Murvaul Creek site] could have been produced locally, although it is not possible to confirm.” Group membership probabilities for the sherds from the site (see Chapter 18) indicate that 80 percent of them have probabilities that suggest they are from vessels made with INAA Group 7 clays (Figure 54). Group 7 is centered in the middle Sabine River basin, and the Murvaul Creek site is located in the Group 7 area.
However, three sherds (GMI-028 [Block 3], GMI-034 [Block 7], and GMI-035 [Block 7]) have group membership probabilities that suggest they may have originated from vessels made in other East Texas regions. In the case of GMI-028, an incised-punctated utility ware sherd, its highest probabilities suggest it came from a vessel made from clays in Group 9, Subgroup 2 (Group 9-2 on Figure 54), a provenance more than 20–40 km to the south and
southwest in the Sabine, Angelina, or Neches drainage basins. The other two sherds—both engraved—have group membership probabilities that suggest they may be from vessels made from INAA Group 8 clays. This group includes sites and sherd samples in the upper Angelina and upper Neches river basins more than 20–40 km to the west of the Murvaul Creek site (see Figure 54). One of the engraved sherds (GMI-034) is not stylistically distinctive (i.e., it is a rim with diagonal engraved lines), but the other (GMI-035) has a rectangular panel filled with circles and semicircles (see Figure 42y) that stylistically resembles several regional varieties of post-A.D. 1400 Poynor Engraved in the upper Neches River basin (see Perttula 2011:Figure 6-65, Var. J and Var. L), lending support to the Group 8 provenance of this Murvaul Creek engraved sherd.

On the basis of these findings, it is possible to tentatively suggest that as much as 20 percent of the sample of INAA sherds from the Murvaul Creek site are from vessels not made locally, but were made in Caddo communities more than 20–40 km to the south, southwest, and west. This is turn suggests a fairly wide-ranging and extensive post-A.D. 1400 economic and social network in this part of East Texas. It also appears to be the case that other Caddo groups in East Texas had an active intraregional trade and exchange network in pottery vessels (and their contents?). Perttula and Ellis (2012:250–251) have suggested, based on INAA and petrographic analysis, that between 13.9 and 22.2 percent of the analyzed sherds from the Hickory Hill site (41CP408)—a small fifteenth-century Middle Caddo settlement—were from nonlocal sources from other East Texas Caddo groups. In a summary of similar analyses done at the Pine Tree Mound site (41HS15)—a large Middle to Late Caddo (ca. A.D. 1300s to ca. A.D. 1650) mound center—Gadus and Fields (2012:Table 6.19) suggest that almost 22 percent of the analyzed sherds are from nonlocal ceramic vessels. Finally, Perttula (2013) concluded from a review of the INAA and petrographic data that a similar proportion of sherds from nonlocally made vessels are present at the Late Caddo Kitchen Branch site (41CP220) in the Big Cypress Creek basin, vessels likely made by Caddo potters living elsewhere in the creek basin.

The petrographic work reported by Cecil (Chapter 17) identified eight different paste groups, all with a sandy paste, among the sherds and heavily dominated by bone temper. These paste groups can be further sorted into those with a micaceous clay paste (n=13, 52 percent) and those without (n=12, 48 percent), referred to by Cecil (see Chapter 17) as a non-micaceous sandy paste. Cecil (see Chapter 17) notes that there “is no reason that any of the sherds in this analysis represent nonlocal pottery; however, a chemical analysis will better answer this question.”

The three sherds (two fine ware sherds and one utility ware sherd from Blocks 7 and 3, respectively) identified from INAA that may be from vessels not made locally occur in petrographic Paste Group 1b (sandy paste with grog, bone, biotite, and chert), Paste Group 2 (sandy paste with grog-bone), and Paste Group 3 (sandy paste with bone and biotite). These
three paste groups comprise 56 percent of the sherds in the petrographic sample from the Murvaul Creek site, which may suggest that they are probably of local manufacture. However, two of the three INAA sherds of possible non-local manufacture occur in the nonmicaceous sandy paste groups, which could support an alternative interpretation to that of local manufacture, or at least use of several different clay sources, if there were information available on the distribution of non-micaceous clay pastes in East Texas.

To continue with the examination of the provenance of the sample of ceramic sherds from the Murvaul Creek site, Selden (below) provides a different perspective based on rare earth mineral element by element distributions in space based on INAA results from numerous other Caddo sites in East Texas. These distinctive distributions can be correlated closely with each other and with Geological Groups as a means of linking provenance determinations with site and region-specific geochemical variations.

Ceramic Analysis Part 2: Using INAA to Model Site-Specific Geochemical Variation in Ceramic Sherds and Clay Samples at the Murvaul Creek Site (41PN175)  
by Robert Z. Selden, Jr.

Introduction
Over the last 18 years, archeologists working in the ancestral Caddo region have amassed a large INAA dataset (>1,290+) of sherds and clay samples, and the majority of these data have been generated through cultural resources management (CRM) endeavors. This discussion employs a subset of the larger Caddo INAA dataset to investigate the provenance of ceramic vessel sherds from another East Texas CRM project—data recovery investigations at the Murvaul Creek site—as well as a series of clay samples from the local area.

Ceramic provenance studies remain the basis of worldwide archeological research concerned with reconstructing exchange networks, tracing migrations, and providing information about local and regional ceramic economies. However, due to the vagaries of Texas geology, traditional geochemical techniques (INAA in particular) have not achieved the degree of success in Texas as they have within other regions. During a recent reanalysis of the Caddo INAA database (Selden 2013a, 2013b), it was noted that among those sites with 33 or more samples, the chemical composition was not as homogenous as had been previously thought (see Ferguson and Glascock 2012). In fact, there were three or more contributing geochemical groups within each of these sites, which may be a result of different occupational episodes, different manufacturers and use of different clay sources, different groups of manufacturers, or different manufacturing processes. Below is a discussion on the results of Caddo INAA efforts at the Murvaul Creek site, focusing on the delineation of potential geochemical groups within the sherds and clay samples.
Methods
Twenty-four INAA samples from the Murvaul Creek site were processed at the University of Missouri Research Reactor (MURR), and those geochemical data were transferred into the Caddo INAA database (see Selden 2013a). In an attempt to better illustrate the variability in geochemical signatures across the southern Caddo landscape, particularly on sites with INAA that are within a roughly 30-mile radius of the site (Figure 55), and to highlight general trends that appear within the data, the INAA results for 1,296 sherds from 167 sites (almost all in East Texas) are employed. After assembling the dataset, two tables were used—one with geochemical data and one with site data—to catalog the sample. In reviewing the database, all of the shell- and bone-tempered sherds were noted, but in lieu of applying the calcium correction to the entirety of the dataset, the calcium correction was only applied to the 4 percent (n=57) of samples known to be shell- or bone-tempered.

![Caddo Sites with INAA Samples](image)

Figure 55. Caddo sites with INAA samples in the vicinity of the Murvaul Creek site.
This analysis deviates from MURR’s current method of applying the calcium correction (see Steponaitis et al. 1996:559) to the whole of the Caddo INAA dataset (Ferguson 2010:6; Ferguson and Glascock 2006:3, 2007:3, 2009a:3, 2009b:266, 2010:93, 2012:C-3; Perttula and Ferguson 2010:11). The overall correction used by MURR is unwarranted since the number of shell- and bone-tempered sherds remains small (4 percent). The calcium correction was applied to the shell- and bone-tempered sherds in the Caddo INAA database in version 3.0.1 of R (r-project.org), after which those sherds were recombined with the other-tempered sherds, and the log-10 of each element was calculated, adding a value of one to each sherd/element in the database, effectively replacing all missing values with a zero. Subsequently, the Getis-Ord \( G^*_i G^*_j \) statistic in ArcGIS10 was employed to calculate a z-score for each log-10 value, illustrating the spatial distribution and z-score values for each site using the formula:

\[
G^*_i = \frac{\sum_{j=1}^{n} w_{ij} x_j - \bar{X} \sum_{j=1}^{n} w_{ij}}{\sqrt{n \sum_{j=1}^{n} w_{ij}^2 - (\sum_{j=1}^{n} w_{ij})^2}}
\]

where \( x_j \) is the attribute value for feature \( j \), \( w_{ij} \) is the spatial weight between feature \( i \) and \( j \), \( n \) is equal to the total number of features and:

\[
\bar{X} = \frac{\sum_{j=1}^{n} x_j}{2}
\]

\[
S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2}
\]

The \( G^*_i G^*_j \) statistic is a z-score so no further calculations are required (ESRI 2012).

Following the calculation of log-10 values for each element, these data were then used to calculate the deterministic statistic of inverse distance weighted (IDW) in ArcGIS10 for each element to better illustrate whether discrete geochemical signatures exist close to one another, or in the same location (Selden 2013b:Figures 2–34).

Although initially an issue of sample size, deletion of neodymium (Nd) and zirconium (Zr) from the dataset prior to analysis is no longer necessary. Certainly, comparisons to the original NIST sample used by Steponaitis et al. (1996) should still follow this method, when dealing with the MURR dataset, but the contribution of these elements needs to be further explored and not disregarded on the basis of their absence from only 22 sherds analyzed at NIST (see Steponaitis et al. 1996).

\[ ^2 \text{The } G^*_i G^*_j \text{ statistic is a z-score so no further calculations are required (ESRI 2012).} \]
Results

Upon reviewing the geographic distribution for each of the elements within a 25-mile radius of the Murvaul Creek site, it appears that the site may be located between an area defined by high elemental values to the northwest, and another by low elemental values to the north and south (Figure 56). Employing the Geologic Database of Texas provided by the Texas Natural Resources Information System as a proxy, these data were plotted atop several geologic maps, and it appears that the following elements (aluminum [Al], dysprosium [Dy], europium [Eu], lanthanum [La], lutetium [Lu], neodymium [Nd], scandium [Sc], samarium [Sm], terbium [Tb], and ytterbium [Yb]) correlate with the division between the Wilcox and Claiborne Groups. The Murvaul Creek site is located atop the Wilcox Formation, but also sits adjacent to (within 100 m) Quaternary alluvium (Figure 57).

The division of these data based on geologic variability makes it possible to demarcate—on a broader scale—the provenance of the sherds from the Murvaul Creek site. Three chemical groups were identified within the elemental data from the Murvaul Creek site (Figure 58 and Table 46). Group 1 (blue) is composed of four raw clay samples, probably from Claiborne Group localities just to the south of the site (see Figure 57); in any case, Group 1 clays were not used to manufacture any of the vessels sampled by INAA at the site. Groups 2 (green) and 3 (orange) appear to represent clay samples and ceramic vessel sherds from vessels made with local Wilcox Group clays (see Figure 57).

It may be the case that differing methods of clay procurement—clay being obtained from atop the Wilcox, or else in or near the stream bed—were in practice at the same time, or conversely there may have been a technological shift over time (perhaps during different occupations) where one area of raw material procurement was seen as more advantageous than another. Four of the raw material samples clustered with Group 2 (GMI045–047 and GMI049), one other raw material sample (GMI048) clustered with Group 3, and the other four (GMI043–044 and GMI050–051) clustered as Group 1.

The INAA sherd samples from Blocks 3 and 5 (GMI028, 030, 038, and 040) fall only in Group 3 samples. Blocks 3 and 5 have been identified with Ceramic Group I, possibly representing ceramics from the earliest Caddo occupation (A.D. 1275–1370, based on the summed probability distribution range of calibrated 14C dates) at the Murvaul Creek site. The Blocks 2, 4, and 7 INAA samples fall in both Group 2 (n=5) and Group 3 (n=5); the ceramics from Blocks 2, 4, and 7 are part of the later A.D. 1457–1513 Caddo occupation at the site. The INAA results summarized here suggest that two different but local clay sources were used for vessel manufacture during the latest Caddo occupation at the Murvaul Creek site.
Figure 56. Geographic distributions of Al, Dy, Eu, La, Lu, Nd, Sc, Sm, Tb, and Yb within a 25-mile radius of the Murvaul Creek site.
Figure 57. Geological groups in the vicinity of the Murvaul Creek site: brown is the Wilcox Group and orange is the Claiborne Group; triangles are Caddo sites with INAA samples.
Figure 58. Two views of a single 3D scatterplot defined by aluminum (Al), neodymium (Nd) and ytterbium (Yb) representing three of the raw material samples (blue, Group 1) and the remaining raw material and ceramic samples (green, Group 2; orange, Group 3).

Table 46: Cluster Assignments for INAA Sherds and Clay Raw Material Samples from the Murvaul Creek Site (41PN175)

<table>
<thead>
<tr>
<th>Site</th>
<th>ID No.</th>
<th>Group</th>
<th>Site</th>
<th>ID No.</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
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<td>GMI043</td>
<td>1</td>
<td>41PN175</td>
<td>GMI028</td>
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<td>GMI029</td>
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<td>41PN175</td>
<td>GMI033</td>
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<td>41PN175</td>
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<td>GMI049</td>
<td>2</td>
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</tbody>
</table>
Ceramic Analysis Part 3: Results Pertinent to Ceramic Research

Questions

Based on the above results, the analyses of the ceramic collection from the Murvaul Creek site can be applied to the following research questions.

Were these ceramic vessels (as well as their contents) obtained for use as funerary objects or for other special purposes, or with the intention of meeting domestic needs and probably fulfilling economic obligations with Caddo neighbors?

In the case of the Murvaul Creek site, based on the limited INAA and petrographic data, it appears that any ceramic vessels that were obtained from their Caddo neighbors were intended to meet domestic needs, since the sherds from these vessels (from both utility wares and fine wares) were found discarded in domestic contexts. Because it is unknown what the contents of these vessels may have been at the time of trade/exchange, or if they even had contents, it is virtually impossible to reconstruct the use life of sherds identified as coming from a nonlocal Caddo source.

Although it is likely a sampling issue, since no Caddo burials or ceramic funerary offerings were found at the Murvaul Creek site, trade vessels do occur with regularity in post-A.D. 1400 funerary contexts in the region (see Perttula 2013:Table 8-19). At Pine Tree Mound, for instance, more than 6.5 percent of the typed vessels from burials had been “brought to the site through contact with other Caddo groups” (Gadus and Fields 2012:412). Even so, the vessel could have been originally obtained for economic or social or both purposes and was only used as a funerary offering when either an individual and or a kin lineage no longer had need of it in this life, and placed it in the grave for use in a Caddo’s journey to the House of Death.

Can Caddo iconography be identified on ceramic vessel sherds from the Murvaul Creek site and other contemporaneous East Texas Caddo sites, and if so, does the occurrence permit the identification of regional variations in ceramic symbolic expression?

There are very few engraved fine ware sherds at the Murvaul Creek site, which limits the identification of any distinctive Caddo iconography. It does appear to be the case from other studies (Dowd 2011b; Fields and Gadus 2012a; Gadus 2010, 2013; Hart and Perttula 2010) that the engraved motifs crafted for fine ware vessels made by different Caddo potters in different communities were apparently intended to convey through their symbolic messages the community’s beliefs in the cosmos and the structure of the world, as well as represent through material practice the community’s distinct social identity. The contents of these vessels, although unknown, may well have also represented the relationships that
existed between a network of people, life-sustaining foods, ritual use (as in the consumption of the black drink or a peyote tea), and material things.

North of the Murvaul Creek site, in the Pine Tree Mound community (see Figure 52), the fine ware vessels made for food service in domestic contexts as well as for use as funerary offerings in burial rituals were apparently intended to convey through symbolic messages beliefs in the cosmos and the structure of the world, as well as the community’s distinct social identity. The Caddo living here in the fourteenth through mid-seventeenth centuries apparently believed in a world with multiple realms (i.e., the lower or below world realm, the middle realm of everyday life and actions, and the upper world or celestial realm), defined by sacred poles or *axis mundi* that connected the realms, and where vessel motifs were repeated four times to represent the four quarters of the world (Gadus and Fields 2012:507). The scroll motif on engraved vessels “takes on the structure of a center with four quarters” (Gadus and Fields 2012:507), with the central element of the scroll—such as a circle or a cross within a circle—representing that center of the world. Much of the action expressed in the engraved motifs on vessels, both carinated bowls, compound bowls, and bottles on these Caddo sites—as well as related Titus phase sites in the Big Cypress Creek basin—is taking place in the upper world or the middle world of everyday life, such as the suggestion that scrolls with central circle elements are “an analog for the ground line or Caddo dance ground, i.e., the path around the axis mundi” (Gadus and Fields 2012:509). Some of the engraved motifs—including pendant triangles, serpentine bars, and crosshatching—“may represent actors or actions taking place in the middle world” (Gadus and Fields 2012:514). These motifs are especially common in the Greasy Creek valley in the Big Cypress Creek basin not far to the north, where Ripley Engraved vessels with the pendant triangle motif (Ripley Engraved, var. *McKinney*) are very common.

In the mid-Sabine and Angelina river basins, one of the key iconographic motifs on ceramic vessels in Caddo sites is the representational image of engraved rattlesnakes. This motif is closely linked with the underworld realm (Hart and Perttula 2010:219–222), and is found in at least 16 different Caddo sites in both Sabine River and Big Cypress clusters that date from the thirteenth to seventeenth centuries, as well as at the thirteenth–mid fifteenth-century Washington Square Mound site in the Angelina River basin (see Hart and Perttula 2010:Figure 2); at Washington Square, this engraved motif is one of the principal motifs on Nacogdoches Engraved vessels (Corbin and Hart 1998; Hart 1982). No sherds with engraved rattlesnake motifs have been identified at the Murvaul Creek site, but the engraved decorative elements at the site (see discussion above) speak to its social affiliations and interactions with Caddo populations that made use of the engraved rattlesnake motif as well as hatched or crosshatched curvilinear and vertical ladders or narrow panels; hatched and crosshatched triangles; pendant triangles; or rectangular panels with engraved triangles. In some instances, there are engraved vessels with vertical and triangular panels filled with concentric circles. Other engraved fine ware vessels have
horizontal interlocking, slanting, and vertical scrolls as their principal motif. There are also rayed circles/sun elements associated with the Above World (see Lankford 2007:20–21) and the swastika cross-in-circle associated with the Below World or the Underwater realm (Hart and Perttula 2010).

These differences and similarities in ceramic iconography point to a shared view of a layered cosmos—Below World, Middle World, and Above World—in East Texas Caddo populations. However, different symbolic emphases and beliefs between Titus phase communities in the Big Cypress Creek and mid Sabine River basins, where scrolls and circle motifs, including the swastika cross-in-circle, have primacy, and contemporaneous Caddo sites in the mid Sabine River and Angelina River basins (see Figures 52 and 53) where scroll motifs are less common in engraved fine wares, but there are distinctive dualistic patterns apparent in colors (red and white, especially) and motifs (see Hart and Perttula 2010), and hatched and crosshatched zones and panels.

How were ceramic vessels made and used by the Caddo peoples at the Murvaul Creek site to process and cook wild and domesticated plant foods and an assortment of animal foods? Is there evidence in the archeological record at the Murvaul Creek site for associated or accompanying changes in food technologies and food processing using ceramic vessels during periods of maize intensification?

The utility ware vessel sherds at the Murvaul Creek site are almost exclusively from jars, and it is likely that these jars were used for the cooking and/or storage of foodstuffs, probably for individual family consumption based on the small to moderate size of the vessels as determined from rim orifice diameters. Measurable orifice diameters for the different wares at the Murvaul Creek site suggest that small to medium-sized plain jars and bowls were made and used, as well as plain bottles. Fine ware rims are from carinated bowls and compound bowls. Orifice diameters ranged from 13–23 cm, indicating that small to medium-sized vessels were made for individual use. Utility ware vessels at the site range from small to medium-sized jars, which presumably relate primarily to family cooking needs; the mean diameter of these jars suggests the principal use of these vessels was for family or individual household cooking needs.

Utility ware jars were well suited to the cooking and heating of foods and liquids. The much thicker utility ware vessels (with rim thicknesses greater than 9 mm and body wall thicknesses greater than 10–11 mm) would have created stronger and more stable vessels, and the larger utility ware vessels would have been well suited for use as long-term storage containers. Fine wares were probably intended for use in the serving of some foods and liquids, although their rarity in the assemblage suggests that wood bowls and plant gourds may also have been in use. Because fine wares have thinner and less porous vessel walls than the utility wares, this would have helped to maintain the temperature of served food
and liquids; thinner and lighter vessels would have also contributed to the ease with which serving vessels could be handled, used, and transported. Plain wares probably had a mixture of uses, including both food serving as well as cooking and storage. Residue studies (see Yost and Cummings 2012) suggest that both domesticated and wild plant foods were cooked and served in the utility wares.

After ca. A.D. 800–1000 in East Texas, domesticated plant foods and meats were probably prepared with a cooking technology in which foods were cooked and boiled in ceramic vessels that were set directly over or nestled in a fire. Ceramic jar sherds have charred residues and sooting on them, evidence that they came from vessels placed directly in a fire during cooking activities. Archeological evidence from Caddo sites in East Texas suggests that these botanical remains were nowhere common until after ca. A.D. 800, and in the case of beans, they were not commonly grown until after ca. A.D. 1250. These Caddo successfully grew maize and other cultigens—beans and squash, with beans apparently becoming important after ca. A.D. 1300—in varying quantities, and an important meal that surely would have been prepared in the utility ware cooking vessels, at least after ca. A.D. 1250, was hominy. This was a gruel prepared with crushed corn kernels mixed with wood ash, meat, and/or beans (Myers 2006:511). To make hominy, corn kernels were pounded with wood ashes in a mortar, next sifted through a basket to winnow away chaff and corn hulls, then mixed in a cooking jar with water and other ingredients for flavoring, and finally boiled for several hours to make a gruel or stew.

Brushed pottery in East Texas Caddo sites can be considered a proxy for increased maize consumption because brushed utility wares in many parts of East Texas began to be manufactured by Caddo potters after ca. A.D. 1200–1250 and came to dominate utility ware assemblages in this region (and in many other parts of East Texas, including Caddo sites in the middle Sabine River basin and the Neches-Angelina river basins) by the early fifteenth century A.D. Stable carbon and nitrogen isotopes obtained from studied human remains in East Texas Caddo sites indicate that that there was a considerable increase in maize and bean consumption beginning at the same time in the Middle Caddo period (ca. A.D. 1200–1250), and the consumption of these cultigens increased and intensified through time, even into the post-A.D. 1680 Historic Caddo period (see Wilson 2012:112–115; Wilson and Perttula 2013). The same trends are apparent in the manufacture and use of brushed utility ware cooking jars in many parts of East Texas, including among many of the mid-Sabine River basin Caddo populations.

The importance of cooking jars in the cooking and boiling of cultigens like maize and the virtually ubiquitous decoration of cooking jars with brushed decorations on rims, but especially on vessel bodies, suggest the co-association of increased maize use by Caddo populations and the increased manufacture and use of brushed cooking jars. It can be suggested that in addition to the distinctive stylistic characteristics of brushed jars in post-
thirteenth century A.D. Caddo sites in the mid-Sabine River basin (and elsewhere), the manufacture of these exterior textured jars represented a significant technological and performance improvement (cf. O'Brien et al. 1994; Pierce 2005) as cooking jars. With an increased emphasis on cooking practices that featured extended boiling, textured cooking jars would have made them easier to handle when hot, brushing on the body and rim would have improved control over cooking by limiting the boiling over of cooking jars, and body brushing would have reduced thermal stresses associated with cooking use, thereby increasing their durability and use-life (Pierce 2005:152–153).

In locales where brushed utility wares were made and used, their proportions continued to increase through time, such that decorated sherd assemblages are known where more than 80 percent of all the decorated sherds are from jars with brushing on the vessel body or the rim or both; at the Murvaul Creek site, more than 62 percent of the decorated sherds have brushing. Varying proportions of brushed utility ware sherds and vessels are one of the primary ways in which to distinguish different Caddo population groups and communities in East Texas (see Figure 52), which suggests that brushed utility wares track both stylistic and technological differences in ceramic vessel use.

How do the ceramic artifacts recovered from domestic contexts on this Caddo site express the different factors that shaped the character of artifact assemblages over the length of the occupation?

What is clear from the ceramic sherd data is that throughout the Caddo occupation at the Murvaul Creek site, the manufacture and use of plain ware, utility ware, and fine ware vessels were important domestic practices. Their different proportions, as determined by the frequencies of rims among the three wares as well as the proportions of decorated utility wares vs. fine wares, suggest that plain wares were most commonly used for food service when compared to the fine wares, given the rarity of the latter, and utility wares were designed to be used for cooking and/or storage of food stuffs.

The frequency with which these different wares were used and then subsequently broken over the course of the Caddo occupation at the site is seen in the counts of rim and body sherds for the three wares; no assumptions are made that uniform taphonomic effects occurred across the site, but for this purpose the number and kind of sherds do represent a proxy for the unknown number of vessels used, broken, and discarded across the site. The distribution of sherds from all three wares in the different excavation areas at the Murvaul Creek site occur in roughly the same proportions from one area to another (despite colluvial processes), with plain wares and utility wares being ubiquitous, but fine wares much less common. This being the case, at any one time, then, the different vessels of these three wares were in use in similar proportions in different domestic farmstead contexts at the site,
suggesting similar functional uses in both Middle (A.D. 1275–1370) and Late Caddo (A.D. 1457–1513) components.

Using the weight of utility ware sherds from the excavated areas at the Murvaul Creek site, and ceramic accumulation research by Varien (1999), what does the estimated weight of these sherds suggest about the possible length of the Caddo occupation at the site?

Conservatively, a total of 2,690 utility ware sherds is estimated to be in the current data recovery collection from the 65-x-15-m (975 m²) excavation area at the Murvaul Creek site. This total includes 1,476 utility ware sherds from the test units and Blocks 1–8 and an estimated 1,214 plain sherds from utility ware vessels. The latter is derived from the proportion of plain sherds estimated to come from the undecorated portions of utility ware vessels, which in turn is based on the fact that utility ware rims represent 39 percent of the rim assemblage, and hence 39 percent (n=1,214) of the 3,096 plain sherds in the overall assemblage.

These 2,690 sherds collectively weigh 8,882 g (based on an average sherd weight of 3.3 grams). Since the excavations in the 65-x-15-m excavation area represent an 8.7 percent (85 m²) sample of the larger area, the estimated number and weight of utility ware sherds that were likely present in the larger excavation area (and not destroyed during the acquisition of grog tempering materials) are 30,937 sherds weighing 102,089.6 grams. This weight does not represent a proxy for the number of vessels used at the site, or at any one household at the site. At an estimated 4,000 to 8,000 grams per year of utility ware accumulation through discard and breakage on a farmstead settlement (see Varien 1999), this weight value suggests that the Caddo utility wares in the excavation area at the Murvaul Creek site may have accumulated in roughly a minimum of 12.76–25.52 years of occupation.
Chapter 7: Lithic Analysis
by Arlo McKee, with contributions by Steve Tomka, Ph.D.

Introduction
The data recovery investigations at the Murvaul Creek site suggested that the site had been occupied during multiple periods during at least the Late Archaic and Middle to Late Caddo periods. Preliminary identification of the stone tools present in the collection suggested that these materials were likely mixed throughout the site due to both the redeposition of a portion of the site within multiple colluvial horizons as well as through bioturbation. The research design accordingly proposed that only a subset of nondiagnostic lithic materials be analyzed from what was assumed to be the best-preserved portions of the site. A preliminary screen of the collection was performed to identify all stone tools, which consisted of formal tools, cores, utilized flakes, informal bifaces, unifaces, and ground stone (Table 47). Additionally, a subset of unmodified debitage was analyzed from both feature contexts and from within the Ab- and E-horizons of the buried soil. This chapter presents the results of the analysis of the lithic artifacts recovered from the site during the data recovery excavations. Although the majority of the collection is represented by chipped stone tools and debris, incidentally modified lithic artifacts (fire-cracked rock) are additionally summarized below.

Methodology and Attributes
The lithic assemblage from the Murvaul Creek site consisted of a total of 2,201 specimens recovered from the data recovery investigations. Additionally, 483 lithic artifacts—primarily lithic debitage—were recovered from the test excavations conducted previously by PBS&J (Cliff and Perttula 2002). The goal of the lithic analysis of the data recovery collection was to address numerous broad questions based both on field observations and addressing a broader site context. The field observations and preliminary counts of the assemblage noted relatively few complete formal tools and a limited range of material types. A subset of both formal and informal tools was submitted for preliminary analyses. These results suggested that the collection was minimally used and a full microwear analysis was not recommended because it was unlikely to yield significant information. Accordingly, the basic lithic analysis was conducted with three main research themes in mind:

- Stage of reduction
- Resource availability and pretreatment
- Behavior and regional interaction

Material Types
The East Texas region has been cited as an area of limited readily available lithic natural resources (Banks 1990; Shafer 2007). Streambed gravels, rather than rock outcrops, are the primary source of lithic materials. Studies of streambed gravels in East Texas and western Louisiana suggest that siliceous fluvial gravels tend to be less than 5 cm in
Table 47: Summary of the Lithic Artifacts Recovered from the Data Recovery Investigations at Site 41PN175

<table>
<thead>
<tr>
<th>Site Component</th>
<th>Colluvium n (g)</th>
<th>Buried A-horizon n (g)</th>
<th>Buried E-horizon n (g)</th>
<th>Feature Fill n (g)</th>
<th>50x50-cm Unit n (g)</th>
<th>Disturbed Context n (g)</th>
<th>Grand Total n (g)</th>
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<tr>
<td><strong>Chipped Stone Tool</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projectile point (dart)</td>
<td>1 (6.4)</td>
<td>3 (8.3)</td>
<td>4 (14)</td>
<td>–(–)</td>
<td>1 (0.7)</td>
<td>1 (15.4)</td>
<td>10 (44.8)</td>
</tr>
<tr>
<td>Projectile point (arrow)</td>
<td>5 (2.7)</td>
<td>9 (5.4)</td>
<td>–(–)</td>
<td>3 (1.2)</td>
<td>–(–)</td>
<td>1 (0.6)</td>
<td>18 (9.9)</td>
</tr>
<tr>
<td>Complex detachment-based</td>
<td>4 (6.3)</td>
<td>1 (2.9)</td>
<td>2 (6.2)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>2 (7.3)</td>
<td>9 (22.7)</td>
</tr>
<tr>
<td>Simple detachment-based</td>
<td>13 (17.8)</td>
<td>6 (9.5)</td>
<td>3 (14.8)</td>
<td>–(–)</td>
<td>1 (2.1)</td>
<td>2 (3.1)</td>
<td>25 (47.3)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>23 (33.2)</td>
<td>19 (26.1)</td>
<td>9 (35)</td>
<td>3 (1.2)</td>
<td>2 (2.8)</td>
<td>6 (26.4)</td>
<td>62 (124.7)</td>
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<td><strong>Core</strong></td>
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<td>Refined–bidirectional</td>
<td>1 (3.1)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>1 (3.1)</td>
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<td>Refined–unidirectional</td>
<td>1 (27.4)</td>
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<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
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<td>1 (27.4)</td>
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<td>Unrefined tested cobble</td>
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<td>2 (25.2)</td>
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<td>–(–)</td>
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<td>4 (110.9)</td>
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<td><strong>Total</strong></td>
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<td>–(–)</td>
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<td>6 (141.4)</td>
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<td>–(–)</td>
<td>1 (139.7)</td>
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<td>Grinding slab</td>
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<td>1 (1899.8)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>1 (1899.8)</td>
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<tr>
<td>Nutting stone</td>
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<td>2 (578.3)</td>
<td>1 (304.4)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>3 (882.7)</td>
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<tr>
<td><strong>Total</strong></td>
<td>–(–)</td>
<td>3 (2478.1)</td>
<td>2 (444.1)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>5 (2922.2)</td>
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<td><strong>Unmodified Debitage</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Analyzed</td>
<td>–(–)</td>
<td>473 (216.54)</td>
<td>114 (84.7)</td>
<td>565 (51.56)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>1152 (352.8)</td>
</tr>
<tr>
<td>Unanalyzed</td>
<td>675 (405.99)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>–(–)</td>
<td>113 (100.7)</td>
<td>126 (99.5)</td>
<td>914 (606.19)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>675 (405.99)</td>
<td>473 (216.54)</td>
<td>114 (84.7)</td>
<td>565 (51.56)</td>
<td>113 (100.7)</td>
<td>126 (99.5)</td>
<td>2066 (958.99)</td>
</tr>
<tr>
<td><strong>Fire-Cracked Rock</strong></td>
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<tr>
<td></td>
<td>26 (156.6)</td>
<td>10 (48.6)</td>
<td>11 (279)</td>
<td>7 (264.6)</td>
<td>3 (11.5)</td>
<td>5 (24)</td>
<td>62 (784.3)</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td>728 (711.99)</td>
<td>505 (2769.34)</td>
<td>138 (868)</td>
<td>575 (317.36)</td>
<td>118 (115)</td>
<td>137 (149.9)</td>
<td>2201 (4931.59)</td>
</tr>
</tbody>
</table>
diameter (Heinrich 1987; Shafer 2011). These studies have additionally documented that interior colors vary considerably, but most are in the range of dull, brownish yellows, dark yellowish browns, weak reds, opaque light grays, and whites. The red colors that occur in many pebbles are due to the presence of iron oxides that have filled molds of calcite and dolomite inclusions, or have been finely disseminated into the microcrystalline quartz matrix (Heinrich 1987). Due to the identification of fossils and other inclusions, the ultimate source of the gravels is Paleozoic marine sediments that have eroded from the Arbuckle and Ouachita mountains. The gravels then accumulated within the Pleistocene coastal plain. Subsequent uplift of the plains and modern streams and rivers have further contributed to the deposition of these gravels across the area.

Low frequencies of nonlocal lithic materials were additionally noted in the collection. Typically, these were identified as high-quality translucent to semi-translucent gray chert that likely represents materials derived from Edwards sources in Central Texas. There is some hesitancy in attributing all of these materials as representing a long distance transport or exchange because some gray cherts are documented in the East Texas region, though the majority of these are opaque, rather than translucent specimens (Banks 1990:54; Shafer 2011:56–58). Additionally, other nonlocal materials (jasper and novaculite) occurred in the collection in very low frequencies, suggesting at least some interaction with the Red River valley and Ouachita region. However, it should be noted that novaculite cobbles are present in upland gravels within Northeast Texas.

**Chipped Stone Tools**

During the preliminary analysis phase of the project, the lithic artifacts were sorted into basic categories such as tools, debitage, and cores. Since the research design proposed analyzing only a subset of unmodified debitage, an additional screen of the artifacts sorted into the debitage category was performed in order to identify any tools that were misidentified during the initial sorting. All tools that were identified in the collection were then analyzed following the *TxDOT Chipped Stone Analytical Protocol* (dated March 6, 2013). This method employs both a taxonomic classification of each artifact, and then metric and categorical data are collected (these results are presented Appendix A-4). The taxonomic classification follows Andrefsky’s (2005:76) generalized morphological typology whereby all chipped stone tools are subdivided by the extent of modification that is observed. At the subgroup level, tools are classified as either core-based, complex detachment-based, or flake-based according to the reduction strategy employed. Core-based technologies suggest that the tool was formed primarily on a bifacial core. Flake-based tools were classified as simple detachment-based if the original flake morphology (platform, bulb of percussion, dorsal and ventral surfaces, etc.) could be readily distinguished, whereas complex detachment-based tools exhibited significant greater modification. At the next taxonomic level—class—the general technique of manufacture was identified. For simple detachment-based tools, the class designated whether the artifact was produced through a flake or blade technology. Complex detachment-based and core-
based tools were identified as either bifaces or nonbifaces at the class level. The subclass level distinguished whether or not the tool generally was produced to fit within a standardized or recognizable morphology. Under the subclass category, flakes and blades were categorized as either modified or unmodified from their original detachment form prior to use as a tool. Bifaces and nonbifaces were classified as either formal or informal depending on how expediently utilized the tool was. At the type level, tools were classified according to their function (e.g., projectile point, knife, scraper, graver), or, as in the case of unmodified flake tools, the artifacts were classified as expedient. Finally, a subtype was selected for those tools such as projectile points where a recognized classical typological name has been assigned (e.g., Perdiz, Kent, Ellis projectile points). For the purposes of this report recognizable projectile point tools were further summarized as either pertaining to dart point or arrow point technologies according to the general size and morphology of the artifact and all other tools are subdivided by type within each subgroup.

Basic metric information (e.g., maximum length, width, thickness, weight) was collected for all tools regardless of whether the artifact was a complete specimen. Additionally, numerous nonmetric attributes were collected for all tools according to the procedures outlined in the TxDOT Protocol. The complete results of all attributes collected can be found in Appendices A-1 through A-3. The basic nonmetric attributes included: reduction stage, portion (completeness), failure/discard reason, thermal alteration, edge morphology (distal, left, and right), flake scar pattern, edge construction type, and proximal edge grinding. Tool use was documented through numerous nonmetric categories to record both the location and relative abundance of wear patterns. The entire collection was analyzed for wear patterning using both a 10x and 20x hand lens. In most cases, this was sufficient to record the presence of use-derived polish and smoothing. However, during the preliminary analysis, a total of 20 artifacts was submitted for microscopic (microwear) wear analysis. The results of the preliminary microwear analysis have been incorporated into the results of this chapter. Where possible, the use wear analysis characterized the worked material as either “hard” or “soft”. However, as Odell and Odell-Vereecken (1980) have pointed out, determining the actual material worked is one of the more difficult aspects for wear analysis because multiple materials and mixed use of tools can often cause similar results. Nevertheless the “hard” and “soft” designation generally followed Odell and Odell-Vereecken’s (1980:101) classification where hard materials may have included bone, antler, and dry or hard woods (such as oak), and soft materials may have included meat, skin and fat, soft vegetal substances, and fresh of soft woods.

Additional metric information was recorded for all projectile points in the collection. All measurements were collected to the nearest 0.01 mm with a digital caliper. Only those dimensions that represent complete portions of a tool were collected. No attempt to estimate the final tool form was made for broken tools. In some cases, projectile points...
were damaged along one longitudinal side, and in these cases, only the undamaged measurements were reported.

Cores and Unmodified Debitage
Chipped stone cores represented a small portion of the collection. After being separated from tools and other unmodified debris, cores were classified by refined and unrefined varieties. Refined varieties were further subdivided into bidirectional and unidirectional forms, and unrefined cores were classified as tested cobbles. Further characterization of refined cores involved identifying whether these were used primarily to produce flakes or blades. The lithology of each artifact was then recorded using the same categories identified in the TxDOT lithic protocols. The amount of remaining cortex was additionally recorded in increments of 25 percent following the TxDOT unmodified debitage protocols. Metric attributes, such as maximum length, maximum width, maximum thickness, and weight, were recorded. The full analytical results are presented in Appendix A-5.

The unmodified debitage collection was analyzed according to the mass analytical approach outlined in the TxDOT Protocol for Debitage Analysis (see Appendix A-7). Unlike the other chipped stone artifact classes, only a subset of debitage from the site was analyzed. This subset included all debitage recovered from feature contexts and general unit levels from within or below the buried soil at the site. Together these comprise approximately 56 percent of the total debitage collection recovered during the data recovery excavations. The remaining unanalyzed portion of the collection was recovered from within the colluvium, other disturbed test units, and from the 50-x-50-cm units. Debitage from the latter contexts was omitted because the 50-x-50-cm units were excavated within such coarse levels that, unfortunately, stratigraphic boundaries were occasionally cross-cut within a level. Additionally, it was thought that the nondiagnostic artifacts recovered from within the buried soil presented the best opportunity to limit the examination of a mixed assemblage. This preliminary filtering resulted in a total analyzed collection of 1152 fragments of debitage. The remaining 914 debitage specimens were retained within the collection, but these were separated as unanalyzed materials.

The mass analytical approach employed has been covered in detail in the TxDOT Protocol for Debitage Analysis, so only a brief summary of the methods are provided below. Unmodified debitage from each provenience was separated according to eight categories of attributes: material, lithology, completeness, size grade, edge modification, thermal alteration, cortex, and platform. The determination of local versus nonlocal materials was previously discussed. An estimation of the flake completeness was recorded according to the presence of distinguishable features such as a platform, bulb of percussion, or clear dorsal and ventral sides. Complete flakes retained each of these characteristics. Flakes were recorded as Broken if the distal portions of the flakes were missing but the remaining diagnostic flake portions were intact. Fragments were identified as distal, medial, and distal-medial portions of flakes, but debitage was labeled as debris if no clear dorsal and
ventral surfaces could be discerned. The artifacts within each category were then passed through a nested set of USDA sieves with mesh sizes of 1, 0.75, 0.5, 0.25, and 0.125 inches. There were select cases where artifacts were recovered that were smaller than 0.125 inches (e.g., feature flotation samples), and these were labeled accordingly and no additional analysis was performed. Additional inspection for edge modification was made for each artifact in the 0.75- and 1-inch size ranges. For cases where edge modification was noted, the artifact was removed and analyzed as a chipped stone tool. Artifacts in the two largest size categories were then sorted according to the presence or absence of thermal alteration, and the smaller categories retained an indeterminate thermal alteration category. Artifacts from each category were then subdivided according the amount of cortex present on the dorsal surface. The artifacts were grouped by amount of cortex in 25 percent increments ranging from 0, 1–25, 26–50, 51–75, and 76–100 percent. Finally, each grouping of artifacts that contained a platform was further subdivided according to platform type, with seven recognized platform types: Indeterminate, Cortical, Flat, Faceted, Abraded, Complex, and Rejuvenated. The final analysis steps included recording a count and weight (to the nearest 0.1 g) of each final grouping of artifacts within each provenience. An estimate was additionally made concerning the minimum number of nodules represented in each provenience. Typically, this estimate was made through a qualitative judgment based on the number of discrete material types that were observed in each provenience, with a general tendency to lump cherts of varying colors together rather than splitting.

**Ground Stone**
A basic descriptive analysis of each artifact in the ground stone collection was performed (Appendix A-6). This included a basic characterization of each artifact according to the dominant functional type represented. However, it was recognized that in most cases the ground stone artifacts had been used for a variety of purposes such as abrading, grinding and hammering tasks. Additionally, this report summarizes the results of the organic residue analysis that was performed on the collection during the preliminary analytical phase of the project.

**Fire-Cracked Rock**
A limited analysis of the fire-cracked rock collection was performed for all proveniences at the site (Appendix A-8). The analysis included the separation of each provenience into raw material types and size categories. Both the lithology choices and size categories followed the TxDOT protocols for chipped stone artifacts. Additionally the type of thermal alteration was noted (cracked, crazed, discolored, etc.) for each group within the provenience. Counts and weights (to the nearest 0.1 g) were recorded for each group of artifacts within each provenience. However, due to the low frequencies of artifacts recovered, this yielded only one artifact per group within each provenience.
Chipped Stone Tools

Dart Points (n=10)
A total of 10 dart points and fragments was identified during the data recovery investigations (Figure 59). Of these points, only four were identified to a diagnostic type. The diagnostic points were San Patrice (n=1), Kent (n=1), Ellis (n=1), Angostura (n=1). The remaining six projectile points were too fragmentary to assign to a specific type. In general, the diagnostic dart points in the collection were recovered at depths that were to be expected based on the stratigraphy at the site (Table 48). That is, the oldest typed point (San Patrice) was recovered from well within the E-horizon, while the Ellis and Kent points were recovered from higher portions of the buried soil (though still within the E-horizon). However, when the context of the dart points is compared to the arrow point collection, there is clear indication that the assemblage is mixed, because arrow points were recovered from within the buried soil and three dart point fragments were recovered from within the Ab horizon at a similar stratigraphic position as the arrow points. The spatial patterning that is evident concerning the dart points is that all of the diagnostic points were recovered from Blocks 2 and 3 located at the southern end for the site (Figure 60). This does not suggest that the southern portion of the site was the location of the pre-Caddo occupation, because dart point fragments were located throughout the central and northern portions of the site.

Figure 59. Dart points and dart point fragments retrieved from the data recovery excavations at the Murvaul Creek site (41PN175).
**San Patrice (n=1)**

The San Patrice point (FS 691) recovered from the Murvaul Creek site belongs to the St. Johns variety as described by Duffield (1963). In general, the diagnostic characteristics of the San Patrice type are slightly to strongly concave bases, smoothed basal and stem edges, corner notching, slight to prominent shoulders, and short, triangular blades. The St. Johns variety is distinguished from other varieties mainly based on the prominent, oblique side notches that are situated immediately above the base. Both Hope and Goodwin varieties have much less pronounced side notches. At the Wolfshead site, 26 var. St John’s points were recovered and metric averages were reported (Duffield 1963). Lengths generally ranged between 20 and 34 mm (Table 49) depending on the amount of resharpening present; however, two specimens did range to 40 mm in length. Widths ranged from 17 to 26 mm, with an average of 21 mm. Although the tip is missing from the specimen recovered from the Murvaul Creek site, the length of the finished tool is near the longer end of the range reported by Duffield (1963), and the maximum width is within the reported range. Likely, the Wolfshead collection was subjected to a greater amount of resharpening than is present in the specimen recovered from the Murvaul Creek site.

San Patrice points were first described by Webb based on sites located along San Patrice Creek in Northwest Louisiana (Webb 1946). Duffield (1963) later described three varieties (St. Johns, Hope, and Goodwin) of the San Patrice type based on the Wolfshead site in San Augustine County, Texas. However, it was not until the report of the John Pearce site (Webb et al. 1971), located near Shreveport, that an isolable San Patrice component was identified. Based both on the stratigraphic association at John Pearce and radiocarbon dates from Horn Shelter No. 2 in Bosque County, Texas, it has been tentatively established that the San Patrice type is contemporaneous with the Dalton culture (Johnson 1989). This corresponds to the period between approximately 8500 and 8000 B.C. (ca. 10,440–9940 B.P.; Collins 1998:397).
Figure 60. Location of dart points recovered across the site.
The 11 San Patrice points recovered at Oak Hill Village were largely produced on local cherts (light gray, tan, brown, and red) and petrified wood. However, one specimen was made of a red and white chert that was suspected to be nonlocal material of an unknown source. Notches were present on the stem edges of seven points, suggesting that they were of the St. Johns variety. The remaining points lacked this notching and were placed in the Hope variety. The San Patrice collection from Oak Hill shows heavy resharpening whereby very little of the original point form was remaining. Most blades were stubby and triangular-shaped with convex lateral edges. Rogers interpreted that the degree of resharpening indicated that the San Patrice points were likely intentionally abandoned on the site rather than having been lost. The significance of this type at the Oak Hill Village reflects multiple visits to the site area by Late Paleoindian peoples, and it is not interpreted that the Caddo villagers at the site were curating and reusing these artifacts. Although the San Patrice point recovered from the Murvaul Creek site did not show a similar degree of resharpening, the position of the point well within the E-horizon at the site suggests that it was not likely curated by the Caddo inhabitants.

The San Patrice point recovered from the Murvaul Creek site was submitted for microwear analysis. This analysis did indicate the hafting approach employed by the tool’s manufacturer. Specifically, the morphology and its smoothness are suggestive of the wear pattern generated by sinew or other material that wrapped all the way up to and around the base of the blade. Light polish is present on one protrusion near the base of the blade. Haft-wear is minimal in terms of polish, suggesting perhaps that the stem was not tightly held in the shaft or foreshaft. This would be consistent with the hafting approach suggested by the lower blade polish that would draw the point back into the haft. Light polish is present on both faces of the point near the distal break (Figure 61). This may be light use-wear created by use of the specimen as a knife rather than exclusively as a projectile.

![Table 49: Selected Metric Attributes of Typed and Untyped Dart Points](image-url)

*San Patrice (n=1) (FS 691) – – – – – 6.62 6.40
*Angostura (n=1) (FS 545) – – – – – 6.62 6.40
*Kent (n=1) (FS 608) 30.51 8.46 20.90 11.94 13.06 7.74 4.8
*Ellis (n=1) (FS 641.1) 26.61 6.42 21.67 15.03 17.82 6.94 4.6
*Unclassified (n=6) (FSs 394, 507, 714, 1047, 1383, 1487)

*Min 33.88 5.59 25.12 12.22 14.58 4.46 0.6
*Max 35.09 11.62 26.30 17.33 21.38 12.07 15.4
*Mean 34.48 9.58 25.71 14.87 17.73 6.67 4.84

*(n-2*) (n=5) (n=2) (n=4) (n=5) (n=6) (n=6)

*n= number of specimens for which attribute could be measured
Angostura (n=1)

One heavily reworked projectile point attributed to the Angostura type was recovered from the Murvaul Creek site. The Angostura projectile point (FS 545) was initially identified as a complex detachment-based graver tool that was produced on a high-quality gray translucent chert that was thought to be nonlocal in origin. The tool was submitted for microscopic use-wear analysis as part of the preliminary feasibility studies. At this early stage of analysis, Dr. Tomka identified the medial point fragment as a heavily reworked Angostura point (see Appendix C).

Angostura points are attributed to the Late Paleoindian period between approximately 6500 and 6000 B.C. (Turner and Hester 1999). The lanceolate points are typically long and slender and have oblique parallel flaking. The bases of Angostura points are typically narrow and concave or irregularly straight. The medial section of the heavily reworked Angostura point recovered from the Murvaul Creek site does not retain the basal portion of the point; hence, the direct interpretation of this point type is tentative.

The microwear analysis conducted on Angostura FS 545 gave indication of the use of the artifact after it had been recycled from a projectile point. One margin above the narrower break face has been bifacially retouched to create a concave edge. The break face adjacent to this concave edge was employed as a graver. Step-fracturing of the edges of the blade break adjacent to the graver tip is also the product of the use of the tool as a graver. Use-polish is present on the body of the biface in the vicinity of the graver tip, as well as on the tip itself (Figure 62, left, right). One corner of the wider blade break also was employed as a graver tip. Subsequent to this use, the dulling of the graver bit led to a burin flake removal that also removed the entire bifacial edge. Following additional use of this break face as a graver, another attempt was made at creating a bifacial edge, and when this failed, the tool was discarded. A significant amount of heavy polish is present on both faces of the specimen near the former graver tips. The step-fracturing adjacent to the graver tip is also the result of utilization. In addition, diffuse polish is present on the entire body of the biface. Some of this polish may be the result of the original use of the tool as a knife. The well-
patterned flaking of the body of the specimen, as well as its biconvex cross section, is reminiscent of late Paleoindian or Early Archaic lanceolate projectile point forms (e.g., Angostura). Recycling of failed projectile points as gravers and the subsequent rejuvenation of the working edge through burin removals is commonly seen in Late Paleoindian and Early Archaic assemblages such as the specimens noted in the Lake Limestone region.

Kent \( (n=1) \)
Specimen FS 608 is a diagnostic Kent projectile point. Kent dart points are identifiable by their often asymmetrical triangular bodies, prominent medial ridge, squared to indistinct shoulders, and base that often retains cortex (Turner and Hester 1999). The specimen identified at 41PN175 fits each of these characteristics. These points were first identified at the Kent-Crane site, but they were not assigned to a diagnostic type in Campbell’s (1952) initial site publication. Suhm and Jelks (1962) later used the point collection from the Kent-Crane site to form the basis for the Kent type. Radiocarbon dates from the Kent-Crane site associate Kent points with the Middle Archaic (3156–2873 B.P.; 1206–923 B.C.) period. Although the latter portion of this assumed range does fit well with the Archaic date obtained from Feature 5 during PBS&J test excavations, other studies have placed this projectile point firmly within the Late Archaic period (ca. 700 B.C.–A.D. 1) in Southeast Texas (cf. Story 1990:222; Perttula 2005:210–211; Ricklis et al. 2012:181). Although the projectile type is better studied along the Texas Coast, a total of 14 Kent points was identified at the Oak Hill Village site in Rusk County, so it should not be surprising to find this type in the similar setting at the Murvaul Creek site.

The diagnostic Kent point recovered from the Murvaul Creek site was submitted for microwear analysis. This analysis suggested the right margin of the specimen (dorsal face up) retains a short segment of edge rounding derived from platform preparation in an attempt to remove a series of step-fractured flake scars that resulted from the poor quality of the raw material. The distal end of the blade, its tip, exhibits numerous arises with polish, as does the distal tip itself (Figure 63). Both faces of the point exhibit linear polish on flake ridges as well as step-fracture terminations. Haft-wear polish is present on both faces of the
stem and consists of localized polish on high flake-scar ridges. Flake-scar ridges along the blade also exhibit regular linear polish consistent with knife use. The combination of use-polished surfaces and their distribution is consistent with the use of the specimens as a projectile point and cutting tool.

Ellis (n=1)
Specimen FS 641.1 is a diagnostic Ellis projectile point. Ellis points are diagnostic by their short and thick bodies, shallow corner notches, weak to strongly expressed barbs, and expanding stem (Turner and Hester 1999). Suhm and Jelks (1962) additionally note that the Ellis bases are never as wide as at the shoulders. This type does closely resemble Edgewood and Ensor types; however, the point identified at the Murvaul Creek site most closely resembles the Ellis type in both size and overall form. This final determination of the point type was determined based on similarities with the points presented in Turner and Hester (1999:113, 2011:93), Suhm and Jelks (1962:Plate 94), and Fields and Gadus (2012a:Figure 7.5) Although Turner and Hester (1999) indicate that this type is typically reported in Northcentral and Central Texas, Prewitt’s (1995) survey of the diagnostic types show significant frequencies of Ellis points have been recovered from Northeast Texas. In contrast, Prewitt’s (1995) data for Ellis points are more closely centered with Central Texas, and Edgewood points had a similar distribution to Ellis. Eleven Ellis points were recovered from the Oak Hill Village site in Rusk County. Turner and Hester (1999, 2011:51) place Ellis points in the Late Archaic to Woodland period.

Although Edgewood and Ellis points are noted as very commonly occurring at sites in Northeast Texas with Late Archaic and Woodland components, the major recent investigations in the area have recovered only limited numbers of these points. Only one point fitting this description was recovered from the excavations at the Pine Tree Mound site (Fields and Gadus 2012a). At the Lang Pasture only point matching the Edgewood type was
recovered (Perttula et al. 2011). At the Hawkwind site, only 3 of the 107 recovered projectile points were identified as Ellis (Ellis et al. 2013). Eleven points fitting the Ellis style were recovered from Oak Hill Village (Rogers and Perttula 2004). In most cases where these points are recovered, local materials were exclusively used. The Ellis point recovered from the Murvaul Creek site appears to fit this pattern in that it was made on a local yellowish brown chert.

The Ellis point recovered from the Murvaul Creek site was submitted for microwear analysis. This analysis indicated that light polish is present throughout both faces of the specimen, suggesting engagement against soft material that came in contact with both high ridges and lower portions of the point’s topography (Figure 64). Polish is also visible on the flake-scar ridges formed by the removal of side-notching flakes of the stem. This polish is the result of hafting material being in contact with the stem of the point while in the shaft or foreshaft of the projectile (see Figure 64, right). Light smoothing also is present on the proximal ends of the blade. This smoothing, in combination with the localized polish, is consistent with the binding agent from hafting extending onto the blade itself. The specimen is complete and exhibits polish on both faces of the blade and hafting polish on both faces of the stem.

Figure 64. Ellis FS 641.1: (left) use-wear polish along bifacial edge; (right) haft-wear polish near base of blade.

Untyped Dart Points and Dart Point Fragments (n=6)
In total, six untyped dart points and dart point fragments was retrieved from the data recovery investigations. The nondiagnostic dart point collection consisted of three point stems and bases, one distal point tip, one projectile point perform, and one finished projectile point. The three point stems and bases are each similar in form and are suggestive of either the Ensor or Ellis types. If this categorization were correct, the points would lend support to a Woodland (ca. 200 B.C.–A.D. 600) occupation at the site (Turner and Hester 1999). However, multiple dart point types would also be applicable to these specimens. Two of the dart point stems were manufactured on locally available chert (FS
394) and quartzite (FS 714), but the third artifact (FS 1047) was produced on a lustrous light brown jasper that may have been transported from the Red River valley.

The distal dart point fragment FS 1383 was significant due to the pretreatment of the reddish brown chert. The artifact was produced on a very lustrous red and brown heat-treated chert. The lower portion of the artifact is missing due to a bending fracture that likely occurred as a result of production failure. The extant portion of the tool has been finely pressure-flaked on all edges. The tip is not finished and still comes to a blunted edge. No evidence of use-wear was present, which further suggests that the artifact was discarded as a result of a manufacturing error.

Specimen FS 507 is a tabular coarse-grained quartzite that was initially reduced to form a rough projectile point form. Cortex is retained over much of both faces, and the edges have been hard-hammered with most flakes terminating in step fractures. Although the point is in an early reduction stage, the stem and base have been formed and thinned. The point was likely abandoned during the thinning stage after several flakes exhibited irregular fracture patterns. No evidence of use-wear or hafting polish is visible on the artifact. Given that it is in an early stage of production, the point does not conform readily to any distinguishable projectile point forms. Instead, several varieties of Archaic dart points may have been the possible outcome.

Specimen FS 1487 is a corner-notched projectile point made on a high-quality translucent gray chert resembling that found in Central Texas. The point was produced on a flake with a cortical platform that is still retained as the base. The cortex is very smooth, resembling stream gravels, so it is likely that this material was available locally. The point was rather expeditiously bifacially flaked so that the dorsal and ventral faces are still readily distinguishable. Flakes removed from the dorsal face generally terminate at an off-centered medial ridge. The ventral face is only minimally bifacially flaked near the edges. The point has shallow corner notches that, in combination with the medial ridge and basal cortex, give the point a general similarity to the Kent type. However, the overall proportions of the point are outside the range generally fitting this type. Given that the point appears to have been rather expeditiously made, no type classification was made.

Specimen FS 1487 was submitted for microwear analysis, which indicated that both faces of the stem retain high linear polish on flake-scar ridges derived from hafting (Figure 65). The lateral edges of the blade exhibit microflaking resulting from manufacture rather than use. The convex face of this plano-convex specimen retains some localized polish near the tip of the specimen. This polish is reminiscent of impact-derived polish resulting from contact with bone. Although the specimen seems rather poorly manufactured, the presence of haft-wear (see Figure 65, left) does suggest that it was a fully functional point. Perhaps the quality of the manufacture says something about the context of manufacture, which appears to have been rather expedient.
Arrow Points (n=18)

Eighteen arrow points and arrow point fragments in total were found during the data recovery excavations at the Murvaul Creek site (Figure 66). Additionally, nine arrow points and fragments were recovered from the test excavations. The majority of the arrow points recovered from the data recovery excavations have contracting stems and can be assigned to the Perdiz or Perdiz/Bassett types. However, one parallel stemmed Bonham point and a portion of a suspected Friley point were also identified in the data recovery collection. The majority of the arrow points and arrow point fragments were identified near the central portion of the site within Block 4 (Figure 67). The stratigraphic placement of the points favored upper components of the site with the majority of points recovered from the colluvium (n=5) and buried A-horizons (n=9). Three arrow points, including two diagnostic points, were from within feature contexts. The diagnostic points from feature contexts included one Perdiz recovered from Feature 47 (FS 1871.24) and one Bonham point recovered from Feature 7 (FS 1802). Feature 47 was determined to be the result of bioturbation during the excavation and consequently was not dated. A hickory nutshell fragment from Feature 7 was radiocarbon-dated to cal A.D. 1460–1650 (cal B.P. 490 to 300) (Beta 344081), which is relatively late for the date range (ca. A.D. 800–1200) of Bonham/Alba points proposed by Turner and Hester (1999).

None of the arrow points and arrow point fragments was submitted for microwear analysis. However, all of these artifacts were examined for use-wear with both a 10x and 20x hand lens. The use-wear analysis suggests that hafting polish was present on 86 percent (n=6) of the specimens that retained the stems. Polish and microwear was also noted on 22 percent (n=4) of the tips and lateral edges. Twelve (67 percent) of the point fragments showed failures of the tips and/or stems consistent with impact fractures. Limited evidence of resharpening was present on four artifacts.
Bonham (n=1)

One diagnostic Bonham point (FS 1802) was recovered from the site. The specimen is a small parallel stem projectile point made from light pinkish gray chert. The lateral edges are concave and the tip is blunted and not well formed. The shoulders are prominent and rounded toward the parallel stem. The base is straight and has been thinned, though it is at a slight angle relative to the body of the point. The point has been more heavily worked on one face than the other, and it forms a bulbous lenticular cross section. These characteristics suggest that it fits within the Bonham type. Patchy polish was noted on both the tip and stem near the base.

As previously noted, the Bonham point was recovered from within a pit feature that was radiocarbon dated to the Late Caddo period (cal A.D. 1460–1650 [Beta 344081]). Bonham points are typically associated with Early Caddo period (A.D. 800–1200/1300) sites, suggesting that this date is anomalous for the type. Only limited Early Caddo period artifacts were recovered from the site; however, given that dates were recovered from the site extending back to the Late Archaic, it is likely that this point either represents a curated artifact or was a remnant in the matrix from an earlier occupation.
Figure 67. Location of arrow points recovered across the site. Note that the majority of the points were diagnostic as either Perdiz, Perdiz/Bassett, or were untyped. The two other point types, Bonham and the possible Friley point, were labeled for added reference.
**Perdiz (n=9)**

Nine Perdiz arrow points represent the most common projectile type collected from the data recovery investigations at the Murvaul Creek site. Perdiz points are commonly found in East Texas, but they are also generally attributed to the Toyah Period in Central Texas (A.D. 1300-1700; Prewitt 1983). Turner and Hester (1999:227) present an overlapping, but slightly more restricted date range of A.D. 1200–1500 for the type. Story (1990:251) has cited A.D 1200 as marking the period when Perdiz points begin to be more commonly found in the region, though initial occurrence and range of the type has not been well dated in the area (cf. Perttula et al. 2011:333).

The Perdiz points in the collection were produced on locally available chert (n=6), quartzite (n=2), and fossilized wood (n=1). Two of the arrow points—although unfinished—appear to be the Perdiz type. Cortex still remains on more than 75 percent of the dorsal surface of FS 1227, and the stem and lateral edges have been worked on both sides. Along the majority of the length of the left lateral edge is a long flake that has terminated in a step fracture. The tip of the point is rounded but has been worked on both faces. Likely, the point was abandoned after the removal of the left lateral flake due to the odd break. No evidence of use-wear is present. Although considered an unfinished Perdiz point, it may also carry the type Clifton. Specimen FS 1567.4 is a contracting stem projectile point that was made on fine-grained reddish quartzite. The point has a bulbous lenticular cross section because it appears to be unfinished on one side. Near the left shoulder, a thinning flake was removed that terminated at a severe step fracture. The left edge also appears to be ground for platform preparation. Due to a slight curvature in the blade at the medial section of the point, should another thinning flake have been removed from the left lateral side, the distal end would have additionally been removed. The point was likely abandoned during the production stage.

Among the overall Perdiz collection, there was little variation in the average length of each Perdiz point, with a blade length varying by only 1.4 mm (Table 50). However, the blade length was measured as a distance along the blade edge, and the total length among the Perdiz collection varied between 9.9 and 19.9 mm, with an average of 15.56 mm. Total widths of the Perdiz collection varied between 10.7 and 17.7 mm, with an average of 12.16 mm. The average length of the collection is much smaller than the comparable collection of Perdiz points from the Lang Pasture site, which averaged 23.24 mm in length (Perttula et al. 2011:323). The range of widths of the Murvaul Creek Perdiz collection does compare well with the average of the Lang Pasture site. Given the relatively small size of many of the contracting stem arrow points from Murvaul Creek, it was noted during the analysis that many specimens fit the size range of the Steiner type. However, the arrow points in the collection lack the characteristically exaggerated serrations of the Steiner type.
Table 50: Selected Metric Attributes of Typed and Untyped Arrow Points

<table>
<thead>
<tr>
<th>Type/Metrics</th>
<th>Average Blade Length</th>
<th>Stem Length</th>
<th>Maximum Width</th>
<th>Neck Width</th>
<th>Base Width</th>
<th>Maximum Thickness</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonham (n=1) (FS 1802.12)</td>
<td>12.35</td>
<td>6.38</td>
<td>13.46</td>
<td>6.65</td>
<td>6.51</td>
<td>4.53</td>
<td>0.8</td>
</tr>
<tr>
<td>Perdiz (n=9) (FSs 735.19, 779.5, 779.6, 1227.1, 1260.5, 1469.9, 1567.4, 1711.14, 1871.24)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>13.15</td>
<td>3.37</td>
<td>10.70</td>
<td>3.61</td>
<td>1.30</td>
<td>2.25</td>
<td>0.2</td>
</tr>
<tr>
<td>Max</td>
<td>14.90</td>
<td>5.95</td>
<td>17.17</td>
<td>5.61</td>
<td>4.00</td>
<td>5.04</td>
<td>0.7</td>
</tr>
<tr>
<td>Mean</td>
<td>13.92</td>
<td>5.03</td>
<td>12.16</td>
<td>4.76</td>
<td>5.03</td>
<td>3.14</td>
<td>0.44</td>
</tr>
<tr>
<td>Perdiz/Bassett (n=3) (FSs 709.16, 1631.6, 1711.15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>15.92</td>
<td>3.59</td>
<td>9.54</td>
<td>3.52</td>
<td>1.46</td>
<td>3.98</td>
<td>0.5</td>
</tr>
<tr>
<td>Max</td>
<td>17.67</td>
<td>4.33</td>
<td>14.75</td>
<td>3.85</td>
<td>2.16</td>
<td>5.25</td>
<td>0.6</td>
</tr>
<tr>
<td>Mean</td>
<td>16.8</td>
<td>4.01</td>
<td>12.13</td>
<td>3.74</td>
<td>1.87</td>
<td>4.49</td>
<td>0.57</td>
</tr>
<tr>
<td>Unclassified (n=5) (FSs 470.2, 1393.5, 1614.13, 1661.5, 1871.25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>-</td>
<td>-</td>
<td>8.66</td>
<td>4.45</td>
<td>-</td>
<td>3.09</td>
<td>0.2</td>
</tr>
<tr>
<td>Max</td>
<td>-</td>
<td>-</td>
<td>15.46</td>
<td>6.49</td>
<td>-</td>
<td>4.69</td>
<td>1.1</td>
</tr>
<tr>
<td>Mean</td>
<td>-</td>
<td>-</td>
<td>12.4</td>
<td>5.50</td>
<td>-</td>
<td>3.97</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Although few studies have been conducted that link metric attributes of Perdiz points to social identity, Arnn (2012:204–209) has suggested that the wide distribution of this point type may enable researchers to identify morphologic and metric differences that may be reflective of practices of different social groups. Johnson (1994) attempted such a study with a Toyah site in Central Texas with limited success. Within that collection, the Perdiz points averaged approximately 18.76 mm in length and 12.86 mm in width. This is also larger than the average length of the Murvaul Creek collection while maintaining a similar average width between the two collections. It may be useful in the future to utilize data gathered from sites across the state to additionally compare morphologic differences, such as symmetry or barb placement, between the Murvaul Creek collection to identify whether these basic differences were socially constructed rather than simply being a product of the average size of raw material that was available.

**Perdiz/Bassett (n=3)**

Three arrow points contained characteristics of both Perdiz and Bassett types (A.D. 1200/1400–1700; Turner and Hester 1999). Turner and Hester (1999) indicate that the primary difference between these two types is that Bassett points have very slight contracting stems, whereas Perdiz stems are well formed. Since there is no defining line between the blade-to-stem ratio of these two types, the contracting stem arrow points with slight stems compared to the blade lengths were assigned to the Perdiz/Bassett subtype. However, this designation was based on a qualitative judgment, rather than a definitive metric ratio between stem and blade lengths. Similar to the Perdiz collection, all of these
specimens were produced on locally available materials that did not show evidence of heat treatment. All of the Perdiz/Bassett points were also fragmentary due to impact fractures, and one (FS 1711.15) also showed evidence of subsequent reworking of one damaged shoulder. Given that these points all had evidence of use damage, it is likely that the comparatively small stems reflect reworked artifacts.

Each of the Perdiz/Bassett points were produced on locally available materials, each of a different lithology. Specimen FS 709 is of brown chert, FS 1631 was produced on fine-grained red quartzite, and FS 1711.15 is of fossilized wood. Impact fractures are present on all three specimens, but FS 1711.15 shows evidence of reworking. On this specimen, the right shoulder is slightly bulbous and is blunted rather than pointed like the left shoulder. This is due to the reworking of the shoulder after an impact fracture. Slight hafting polish was also noted on two of the specimens (FSs 1631 and 1711.15), and the latter specimen also showed patchy polish near the tip.

**Untyped Arrow Points and Arrow Point Fragments (n=5)**

Five arrow points and arrow point fragments were not assigned to diagnostic types. Three untyped arrow points were too fragmentary to accurately identify a type. One of these points (FS 1871.25) is suspected to have been a Friley point (A.D. 700–1100; Turner and Hester 1999) based on the recurved blade and relative size. However, this point is missing the stem and shoulders, so it was left as an unassigned subtype. Another point fragment, FS 470, was missing the tip, right shoulder, and stem from impact fractures and thus, although likely an intended Perdiz type, was not assigned to a subtype. Two other arrow point fragments (FS 1614 and FS 1661) were both missing diagnostic portions the points due to impact fractures.

Specimen FS 1393 is represented by only the medial and distal portions of the tool, and the lower portion is missing due to a production failure. The right lateral edge was first damaged from a flake removal that caused a fracture to develop to the medial point on the artifact. A second flake was removed from the right lateral edge that resulted in a critical failure with a step fracture in the central portion of the artifact. The remaining lateral edge portions are sinuous and do not appear to be in a finished form. Likely, this artifact was an intended arrow point such as a Perdiz, but without the base and shoulder, it is impossible to assign it a diagnostic type.

**Complex Detachment-based Tools (n=9)**

A total of nine complex detachment-based tools was collected from the data recovery excavations (Figure 68). This artifact category includes tools formed using flakes that were removed from a core, rather than bifacial tools that were produced through core reduction. The qualifying characteristic of these tools is that extensive modification has been performed on the tools so that flake attributes (platform, bulb of percussion, dorsal and ventral surfaces) are often no longer distinguishable, or are barely distinguishable. Additionally, included in this subgroup are projectile point fragments that are too
68. Complex detachment-based tools from the data recovery excavations at the Murvaul Creek site (41PN175).

Fragmentary to determine whether they were flake-based or core-based. These tools were subdivided into chopper and knife categories depending on the sharpness and wear polish visible on the cutting edge. Two specimens (FS 827 and FS 600) were classified as choppers, but these both likely represent unfinished tools that were discarded due to manufacture failures. Use-wear was also limited on the artifacts classified as knives, with shallow polish only being noted on one specimen (FS 629) and smoothing being noted on another (FS 1115). The majority of the other artifacts in this category likely represent either unfinished tools or specimens that were only very minimally used, and use-wear is not readily evident.

The majority of the complex detachment-based tools were recovered from the colluvium in Blocks 4 and 8 (n=4) or were found in disturbed units in Blocks 2 and 4 (n=2) (Figure 69). The remaining three tools were collected from within the buried soil in Blocks 3 (n=2) and 5 (n=1). No complex detachment-based tools were recovered from within or immediately adjacent to any feature context. Although the tools themselves are not diagnostic to the Caddo period, given that many were produced from locally available chert and fossilized wood and all were worked from small flakes, it is likely that these tools represent activities of the Caddo site occupants.
Figure 69. Location of complex detachment-based tools recovered across the site.
**Choppers**

Specimen FS 600 is a chunky brown chert biface with approximately 25–50 percent cortex remaining on two sides. The biface was in the initial reduction stage and was discarded due to a material flaw that resulted in a critical snap fracture. One side of the biface was flaked to a greater degree than the other. The minimally processed side was characterized by cortical removal flakes that terminated in prominent step fractures. No evidence of use-wear was observed.

Specimen FS 827 is a chunky brown proximal chert flake that was processed for bifacial reduction. The flake does retain an initial platform and distinguishable ventral face. However, several flakes have been removed from the dorsal face, suggesting a complex detachment-based grouping. The distal portion of the tool is missing due to a perverse fracture; hence, it is interpreted that this represents a failed biface. The left edge appears to be straight and was worked by several flake removals from the edge. On the dorsal face, one flake originating from the left edge terminates in a prominent step fracture. The right edge remains very coarsely worked. No use-wear was noted.

**Knives**

Specimen FS 535 is a small tertiary fragment of fossilized wood that was bifacially worked on the two lateral edges. The artifact has a thick lenticular cross section, and a portion of the tool is missing due to a bending fracture. Given that distinguishable dorsal and ventral faces were not identified, the artifact was classified as a complex detachment-based tool. However, the specimen does not appear to be a finished tool. Likely, it is a production-related discard due to a critical failure in the material. Fine pressure flaking was not observed, and the general form suggests the tool was in the early stage of manufacture.

Specimen FS 629 is a silicified wood flake fragment with one bifacially flaked edge opposite a perverse break face. The two lateral margins of this specimen also are missing, and the edge opposite the bifacially shaped working edge appears to have been intentionally left unmodified to form a type of backing. Both faces of the working edge exhibit polish that occurs on high and low areas (Figure 70). The two ends of the specimen may have been broken in use, but the tool appears to have continued to have been used judging from use-wear occurring on the break faces.

Specimen FS 671 is a small bifacial scraper that was produced on a chert secondary flake. Cortex remains on the base of the specimen. On the distal and left edges, bifacial pressure flakes were removed to retouch the edges. The right edge has a very steep angle and was apparently not used as a cutting surface. However, this edge does have a flake scar originating at the base that runs the entire length of the face. This likely represents a retouched edge. Small microflakes with prominent step fractures are present along the entire length of the distal and right edge. These scars indicate that the edges were used to cut relatively hard materials (e.g., hard wood, dry antler or bone).
Specimen FS 1070 is a small bifacial flake tool that has approximately 25 percent cortex remaining on the dorsal face. Small pressure flakes were removed from both the dorsal and ventral faces on all edges. The flake was likely a primary flake and the majority of the dorsal cortex was removed as part of edge preparation. The left lateral edge has microflakes on the surface resulting from use. No polish was observed. The combination of microflakes present on one edge and the lack of polish suggests that the tool was used to cut relatively hard materials (e.g. hard wood, dry antler or bone), but it was not used enough to cause a polish.

Specimen FS 1115 is a proximal biface fragment with smoothing along the base and lateral edges. Smoothing derives from platform preparation rather than use. Microscopic examination of the smoothed edges of the specimen revealed no use-wear polish. Instead, the edges appear to have been smoothed by rubbing a coarse material such as a percussor along the edge. The lateral margins exhibit a substantial amount of step-fracturing, which is consistent with grinding the edges in the process of platform preparation. The blade break occurred near the base of the specimen, and its morphology is similar to basal thinning failures. More precisely, the break morphology indicates two unsuccessful base thinning attempts. The first basal thinning attempt did not fully break the specimen but initiated an imbedded fracture plane that weakened the blade near the base. The second attempt at basal thinning created yet another fracture plane, and the specimen broke along this plane while the force also initiated a break along the first imbedded fracture line.

Specimen FS 1274 is a distal biface fragment. The tool was made on brown chert, and a material flaw resulted in the failure of the artifact. The specimen is finely worked on both the left and right lateral edges. The left lateral edge is strongly convex and rounds to form a tip with the right lateral edge. Small microflakes were observed on the left lateral edge on both faces of the tool. No polish was observed.
Specimen FS 1724 is a biface proximal fragment that was identified in Block 4, Unit 73, a unit that contained disturbed fill from the utility trench that was placed through the site (see Chapter 5). The perverse blade fracture suggests that it failed during manufacture, as do some of the irregular flake scars present on both faces of the specimen. Some localized smoothing is present on the edges of the biface, and these appear to represent remnants of platform preparation. Patches of coarse-grained inclusions are present on both faces of the fragment, and specks of orange residue on one such inclusion represents rusted metallic residue. Such residue is common on artifacts recovered from plowed fields where the plow impacts and rubs against the lithic artifact and leaves a line of metallic residue on its face. Over time, this metallic residue rusts, leaving the pattern seen on this artifact (Figure 71).

![Figure 71. Specimen FS 1724: rust spots on the body of specimen.](image)

**Simple Detachment-based Tools (n=25)**

The data recovery investigations recovered a total of 25 simple detachment-based tools that were spread across the site (Figure 72). Although these tools were recovered widely across the site, the highest frequency was recovered from Block 4 (n=14), which yielded approximately 0.38 simple detachment-based tools per test unit (Figure 73). This is approximately the same density as that recovered in Block 8 (n=2; 0.4 tools/test unit). The highest density of these tools per test unit area was recovered at the extreme northern end of the site in Block 7, where four tools were recovered. However, most of these tools were collected from within the colluvium in Block 4, so likely this pattern reflects postdepositional sedimentation, rather than a difference in activity areas across the site. In total, 9 simple detachment-based tools were collected from within the buried soil. These include specimens from Block 4 (n=4), Block 7 (n=1), and Block 8 (n=1) that have been previously mentioned. This total also includes all three specimens from Block 3 that were recovered from within the E-horizon of the buried soil.
Figure 72. Simple detachment-based tools from the data recovery excavations at the Murvaul Creek site (41PN175).
Figure 73. Location of simple detachment-based tools recovered across the site.
As expected, the materials represented in the simple detachment-based tools resemble the ratios observed in the unmodified debitage collection. The overwhelming majority of these tools was produced on locally available chert, quartzite, and fossilized wood. One small expediently utilized jasper flake was recovered (FS 687) that represents the only portion of the simple detachment-based tools that may have not been obtained locally. The artifact is very lustrous, suggesting that it was heat treated prior to use. Additionally, both the lateral and proximal edges show evidence of use-wear in the form of small microflakes that were not oriented. This suggests that the tool was used in a sawing motion.

The simple detachment-based tools were categorized into either modified or unmodified flake tools. The modified flake tool collection consists of scrapers, knives, drills, and gravers. However, in some cases there are tools that were used for multiple purposes. In these cases, the tool classification was assigned to the most prominent element on the specimen. This was most evident with the tools classified as scrapers, in which two were utilized additionally as gravers at one end. Unmodified flake and blade tools were simply classified as blades or expedient flake tools. Eleven of the simple detachment-based tools were submitted for microwear analysis, which indicated that the collection was utilized for a variety of tasks, including scraping and sawing soft wood, as well as one specimen (FS 1161) that was employed as a reamer.

**Modified Flake Tools**

**Scrapers (n=5)**

Specimen FS 641.2 is a marginally beveled secondary flake of silicified wood. The specimen is reminiscent of distally beveled unifaces common to South Texas during the Transitional Archaic and Late Prehistoric. Rather than having the distal end beveled, one of the lateral edges of the parent flake is beveled. It is difficult to distinguish any use-polish on the dorsal and ventral faces adjacent to the working edge because of the high natural polish of the raw material. This natural polish makes determining the use material difficult. Small grains of material are missing along the edge, indicating that the tool was used in a planing or shaving motion. The rounding and microcrushing evident immediately above and behind (proximal to) the working edge derives from hafting wear (Figure 74 left, right).

Specimen FS 1171 is a small brown tertiary flake that was used both as a scraper and as a graver. The artifact retains the primary flake characteristics of an abraded platform and distinctive dorsal and ventral faces. The distal end of the flake was minimally prepared with several small flakes removed from the edge to form a convex cutting surface. The left half of the distal end shows microflake wear with prominent step fractures, indicating that the tool was used to cut or engrave relatively hard materials. The point formed by the right lateral edge and the distal end forms a small tip that shows both microflaking and limited polish consistent with use as a graver.
Specimen FS 641.2: haft-wear on flake-scar ridge on dorsal face; use-wear polish on dorsal leading face of tool.

Figure 74. Specimen FS 641.2: (left) haft-wear on flake-scar ridge on dorsal face; (right) use-wear polish on dorsal leading face of tool.

Specimen FS 1198 is a small secondary brown chert flake that shows both use-wear and retouch on two lateral edges. The left lateral edge is convex, and use-wear is present primarily on the proximal end of the edge. Several step-fractured, use-derived flakes were removed from the dorsal surface, but only minimal polish is present. The right edge has both dorsal and ventral use derived microflakes present along the entire edge. Additionally, light polish is present along both faces. Both the microflakes and polish suggest that this end of the tool was used in a sawing motion to cut soft or green wood. A portion of the distal end of the flake is missing due to a snap fracture that originated at the intersection of the right lateral edge and the distal edge. At this point, the tool comes to a sharp tip that appears to have been broken and minimally retouched. This end was likely used as a graver.

Specimen FS 1218 is a small fine-grained quartzite flake that has two lateral edges retouched unifacially. The retouched flakes were removed from the ventral face, rather than the dorsal face. The right lateral edge has a sharper angle (roughly 25 degrees), whereas the left edge appears to be unfinished. No evidence of use derived polish was visible on the tool.

Specimen FS 1539 is a secondary flake of fine-grained yellow chert with coarse-grained inclusions. A concave edge was formed by the removal of a single flake adjacent to the proximal end of the flake. A cluster of microflake scars is present on the dorsal face of the concave surface (Figure 75, left), and immediately underneath it—on the ventral face of the concave surface—a crushed area with step-fractured microflake scars (see Figure 75, right). These microflake scars suggest that the tool was used on a relatively hard material (e.g., hard wood, dry antler, or bone). Light polish is present on the ventral face of the flake and on the working edge. It appears that the tool represents an expediently used scraper that subsequently was exposed to some postdepositional edge damage. The light, diffuse polish may be simply from prehensile holding of the artifact while in use.
Figure 75. Specimen FS 1539: (left) step-fracturing along concave working edge; (right) postdepositional crushing on ventral face.

Knives (n=4)

Specimen FS 167 is a small brown secondary flake that was bifacially worked on two lateral edges. Approximately 25 percent cortex remains on the proximal end of the dorsal face. The distal end of the tool is missing from a bending/impact fracture. Both worked edges have numerous bifacial microflakes removed from the edges. These suggest that the tool was used to cut or engrave a hard material. No evidence of fine polish was visible under 20X hand lens, and no evidence of hafting polish was observed.

Specimen FS 734 is a chert distal flake used as a scraper and bifacially modified on two lateral edges. The artifact was made on a very lustrous red chert that was thermally altered. The proximal end of the artifact is missing due to a bending fracture. The right edge is the most complete cutting surface. This edge was retouched with several pressure flakes. One large retouch flake was removed from the intersection of the distal end and the right edge, which has sharpened both the lateral and distal edges. This flake terminates with a prominent step fracture near the center of the artifact. Prominent microflaking is visible on all edges, with most microflakes terminating as coarse step fractures. The edges are ground, indicating that the tool was used to cut or abrade hard objects.

Specimen FS 911 is a bifacial thinning flake on brown chert that was bifacially modified on the distal and right edges. The flake platform is complex and shows multiple pressure flakes from the former working edge. One large rejuvenation flake was removed from the distal end on the dorsal face. As the right edge was being rejuvenated, the edge was critically damaged when a rejuvenation flake was removed from the center of the edge. No use-wear was noted on the artifact.

Specimen FS 996 is a small tertiary flake with cortex covering both the proximal and right lateral edges. The distal end rounds to the lateral end. Small pressure flakes were removed bifacially from the distal, right lateral and left lateral edges. Minimal patchy polish and small microflakes were observed on the lower portion of the right lateral and distal edges. This
suggests that the tool may have been used on relatively hard materials (e.g., hard wood, dry antler, or bone), though the artifact may have been used on mixed hard/soft materials. Retouch flakes were removed after the polish had developed on the ridges of the microflakes. One large retouch flake resulted in failure of the right lateral edge. This resulted in abandonment of the tool.

**Drill**

Specimen FS 1342 is a bulbous primary flake of brown chert that was worked into a drill on the distal tip. The dorsal face of the flake was bifacially worked to form a narrow drill. Although the artifact was not submitted for microwear analysis, use-derived microflakes with prominent step fractures indicate that the tool was used to cut or grind hard objects (e.g. hard wood, dry antler, or bone). No polish on the cutting surface was observed with the hand lenses. The distal tip is missing from a snap fracture.

**Graver**

Specimen FS 635 is a worked graver on a tertiary, translucent, banded light tan chert bifacial thinning flake. Although other artifacts in the collection were likely used as gravers, only this specimen appears to have been used exclusively for this task. The specimen was heat-treated and is very lustrous, and a small potlid scar is present near the distal end. The worked edge is the distal portion of the flake and one lateral end that forms a sharp point. The end has been unifacially worked with microflakes that show light polish within 2 mm of the edges. One large flake was removed from the lateral worked edge due to postdepositional damage. The fine polish on the edges suggests that the tool was used to cut soft materials.

**Unmodified Blade Tools (n=3)**

Specimen FS 724 is a light gray tertiary blade with a flat distal end and a triangular cross section. The lateral edges show evidence of use-wear, with numerous microflakes having been removed from both the right and left edges. The left edge of the blade is generally straight, but the right is concave. Polish is observed within 2 mm of the blade edges, which suggests that both edges were only minimally used before the tool was discarded. The wear patterns on the tool suggest that the tool was used to cut relatively soft materials such as soft or green wood.

Specimen FS 1174 is a fine-grained red chert secondary bladelet with expedient use-wear scars along the right lateral margin (Figure 76, left). The use-wear is heaviest on the dorsal face of the working edge, with flake scars in the range of 1.0–1.5 mm in length. However, smaller flake scars and shallow step fractures (see Figure 76, right) are also present on the ventral face of the working edge, indicating that the scraping motion was bidirectional in orientation (i.e., back and forth) along the material being worked. Light polish is present on the microflake-scar ridges on the dorsal face of the working edge (see Figure 76, left), suggesting a soft material such as soft wood or green wood being worked with the tool. The duration of the task was very short-term, since the wear is not extensive.
Specimen FS 1710 is a small secondary bladelet of fine-grained quartzite. Very minute and irregular flake scars along one edge have a scalloped appearance that is consistent with the use of the flake as an expedient knife (Figure 77). Sawing or whittling typically results in edge fracturing that is not invasive onto the edge, but rather removes entire segments of the thin and structurally weak edge. The microflake scarring scallops the edge rather than creating flake scars that are invasive onto the face of the tool. Continued use of the tool would result in the breakage of all weak portions of the edge and its stabilization at a new equilibrium between the strength of the raw material and the amount of force that is applied to the tool edge. The stabilized working edge would have a straight line appearance rather than the sinuous look provided by the scalloping. The scalloped appearance of the tool is consistent with tool use of a short duration and relatively soft material being worked.

**Unmodified (Expedient) Flake Tools (n=11)**

Eleven unmodified flake tools were identified within the collection. These artifacts largely represent tools that were utilized only for very light tasks before they were discarded. The manner of failure is indeterminate for most specimens, but bending or end shocks were noted on three artifacts. The raw materials used in the expedient tool collection included
chert (n=8), fossilized wood (n=1), jasper (n=1), and quartzite (n=1). Although thermal alteration was not noted in abundance among the lithic collection, approximately one third (n=4) of the expedient flake tools showed evidence of thermal alteration and all of these artifacts were made of chert.

Specimen FS 687 is a lustrous jasper tertiary flake that shows edge wear on the both lateral edges as well as the proximal end. The distal end of the artifact is missing from an impact or bending fracture. Small microflakes indicative of use-wear are present along with polish within 1 mm of the lateral and proximal edges. These microflakes are present on both the dorsal and lateral surfaces, and the scars are not oriented, which suggests that the tool was used in a sawing motion. No evidence of retouch was visible on the artifact.

Specimen FS 713 is a primary flake of fine-grained yellow chert. Use-wear is noted along one lateral edge, and postdepositional damage is present at two localized spots along the distal end. At one corner of the distal end, downward pressure from the dorsal face resulted in crushing the edge, and the same pressure resulted in the snap fracture of the opposite corner of the distal end. Highly patterned microflaking, consistent with scraper use, is present along one lateral edge (Figure 78). The edge remains rather sinuous, indicating that tool use was short-lived, and the force applied to the tool and worked material was not sufficiently great to wear down the edge to a more even alignment. Light use-polish began to develop on some flake-scar ridges.

Figure 78. Specimen FS 713: microflaking derived from use along dorsal face of working edge; note light use-polish on flake arises.

Specimen FS 732 is a small secondary flake of fine-grained chert with two lateral edges manifesting traces of use-wear. The most easily identifiable working edge has a semicircular—concave—morphology. Microflake scarring is relatively irregular, and polish is localized, light, and minimal in occurrence within the concave working edge (Figure 79, left). The opposite flake margin has a short segment of microflaking consistent with scraping use. This working edge is very sinuous, suggestive of short-term use. Microflake scars also are
 Specimen FS 732: step-fracturing within the concave working edge; irregular sinuous working edge opposite the concave edge.

Figure 79. Specimen FS 732: (left) step-fracturing within the concave working edge; (right) irregular sinuous working edge opposite the concave edge.

Present on the distal end of the flake, but they are likely the result of the original flake removal or subsequent postdepositional damage. The obtuse angle of these scars is most consistent with postdepositional alterations rather than use. No use-polish was noted on the sinuous edge or the distal end of the flake.

Specimen FS 915 is a small secondary red chert flake with a light brown rounded cortex covering all but the working edge. The material is very lustrous, suggesting that it was heat-treated prior to knapping. The left edge of the flake represents the interior portion of the nodule and the working edge. Along most of the length of the lateral edge are small microflakes representing scraping use. The ridges of the microflakes have been entirely polished, but the worked edge is sinuous. This suggests that the tool was only lightly used for cutting soft objects prior to discard.

Specimen FS 918 is a very small primary flake of brown and red chert that has an extensively potlidded dorsal surface and a rough cortical platform. The sinuous distal end of the flake shows evidence of use-wear. Microflakes are oriented toward the ventral face and maintain a steep angle relative to the edge angle. Many very small step fractures are present along the edge, suggesting that the tool was used for grinding. The ridges of the microflakes do exhibit light polish, though this is somewhat obscured by the luster of the heat-treated material.

Specimen FS 1147 is a short, fine-grained quartzite flake tool with a distal graver tip. The tip was formed by the intersection of the two lateral edges rather than being retouched into the current shape. The graver tip has two microflake scars that resulted from use and step-fracturing along one lateral edge that also derived from utilization (Figure 80). The localized polish present on the working tip suggests that the substance that was being worked was sufficiently soft enough not to “grind” the naturally polished surface but hard enough to create the microflake scarring.
Figure 80. Specimen FS 1147: (left) crushing, and (right) light step-facturing of the graver tip.

Specimen FS 1161 is an irregularly shaped longitudinal proximal flake fragment with a broken distal end. The two lateral margins as well as the flake scar on the dorsal face exhibit use-wear. The wear is in the form of microflake step-facturing and localized light polish. On the concave lateral margin, the use-wear tends to occur on the dorsal face of the edge and is reminiscent of scraping wear, although the combination of wear types and locations of use-wear suggests a more complex picture. The dorsal flake scar running the length of the specimen exhibits heavy step-facturing and some localized light polish (Figure 81, left). Use-wear on the two lateral edges is in the form of step-facturing on both faces of the edge and light use-polish in some of the step-facture scars (see Figure 81, right). In addition, the morphology of the distal tip fracture is indicative of lateral torque having caused the failure of the tip. The step-facturing seen on the dorsal ridge of the flake, the step-facturing present on both faces of the lateral margins, and the break morphology of the tip suggest that the tool was employed as a reamer.

Figure 81. Specimen FS 1161: (left) crushed dorsal flake arise; (right) light polish and step-facture scars along one lateral edge.
Specimen FS 1175 is a small secondary flake of yellow fine-grained chert with a semicircular working edge. Examination of the edge’s dorsal and ventral faces does not exhibit clear signs of postdepositional alterations; therefore, it is likely that the microflaking is the result of tool use. However, no polish was noted along the edge, and the irregular nature of the concave edge (Figure 82) suggests that the tool was used very lightly and discarded after brief use.

Figure 82. Specimen FS 1175: (left) microflaking on dorsal face of working edge; (right) uneven ventral face of working edge.

Specimen FS 1201 is a small proximal end of a dark red chert blade that has use-wear on the left lateral edge and a portion of the proximal edge. Only 7.9 mm of the worked edge remain because a snap fracture has removed the majority of the artifact. The extant portion shows microflake edge wear on both the dorsal and ventral faces. Patchy polish was observed on the ridges of several of the microflakes on both the dorsal and ventral faces. This is consistent with the tool being used primarily to lightly cut soft objects before being discarded. The patchy polish suggests only minimal or very light duty use of the tool.

Specimen FS 1630 is a secondary flake of silicified wood. It has one concave lateral edge that was employed in light scraping tasks. Small—less than 1 mm in length—microflake scars are present along the dorsal face of the working edge (Figure 83, left), and light step-fracturing is noted in the flake scars (see Figure 83, right). Judging from the size of the scars and their small number, the tool was utilized in the performance of very light scraping tasks, and the scraping motion tended to be unidirectional rather than bidirectional as in Specimen FS 1174.

Specimen FS 1692 is a secondary, distal flake fragment of fine-grained chert with two areas exhibiting scraper use-wear. The most extensive use-wear (Figure 84) is noted on the distal edge of the flake fragment near the cortical flake margin. This working edge has been used sufficiently long to result in the development of light use-polish such as noted in Figure 84. Use-wear scars are .5–.8 mm in length and very patterned, indicating very uniform pressure
and contact with the material being worked. More subtle use-wear is present along the break face of the flake fragment. In both instances, the utilization of the tool resulted in the development of slightly concave working edges.

**Cores (n=6)**
Six cores were found during data recovery excavations (Figure 85). None was recovered during the test excavations. All cores were collected exclusively from test units within Blocks 4 and 8 (Figure 86). Four of the six cores were from excavation levels within the lower portion of the colluvium. The remaining two cores were both from within the E-horizon of the buried soil from within Test Units 86 (FS 1749) and 117 (FS 1345) in Blocks 4 and 8, respectively. The northeast corner of Test Unit 86 was a location where two of the larger features (Features 7 and 9) came within proximity to each other; however, the core (FS 1749) from that unit was recovered from general matrix rather than feature fill. Given that both of these features date to the Late Caddo occupation, it is very likely that the context of the core is indicative of this time period as well. The remaining cores were not directly associated with any datable features, and whether they pertain to the Caddo occupation of the site area remains questionable.
Regardless of the age of the cores, the collection is indicative of very limited use of cores and reliance on locally available materials. Four of the six cores are of chert and two are of locally available quartzite. Three of the chert cores and one quartzite core are tested cobbles with only one to several flakes removed from an end. Only two cores exhibit refined platforms: Specimen FS 1040 is a bidirectional quartzite core recovered from Test Unit 116, and specimen FS 1592 is a small unidirectional chert core recovered from Test Unit 123. Both of these refined cores were collected from within the colluvium. In general, the core preparation appeared to follow a repeatable pattern whereby a flake was first removed from one side to create a platform. The core was then rotated and flakes were removed approximately perpendicular to the prepared platform. Specimen FS 1040 has two parallel platforms that show evidence of bipolar percussion, which was also observed in the debitage collection. The remaining cores in the collection are tested cobbles with only limited flakes having been removed from one end.

**Ground Stone (n=5)**

Five ground stone artifacts were from the data recovery investigations (Figures 87 and 88). Nearly all (n=4) the ground stone artifacts came from the Block 4 excavations (Figure 89). Only one hammerstone (FS 747) was recovered from the southern portion of the site within Block 2 (Table 51). The ground stone artifacts collected from Block 4 were all used for multiple purposes, including grinding plants, and to a lesser degree, they were used as
Figure 86. Location of cores recovered across the site.
Figure 87. Nutting stone and hammerstone ground stone specimens from data recovery excavations at the Murvaul Creek site (41PN175).
Figure 88. Large sandstone cobble, smoothed in the center and battered on the ends and side, from data recovery excavations at site 41PN175.
Figure 89. Location of ground stone recovered across the site.
Table 51: Ground Stone Artifacts from the Data Recovery Investigations

<table>
<thead>
<tr>
<th>Provenience</th>
<th>Classification</th>
<th>Lithology</th>
<th>Use Type</th>
<th>Wear Location</th>
<th>Max length (mm)</th>
<th>Max width (mm)</th>
<th>Max thickness (mm)</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS 711</td>
<td>Nutting stone</td>
<td>Quartzite</td>
<td>Polished, pecked, pitted, battered; striations</td>
<td>Multiple surfaces</td>
<td>91.21</td>
<td>62.93</td>
<td>33.78</td>
<td>287.3</td>
</tr>
<tr>
<td>FS 712</td>
<td>Nutting stone</td>
<td>Sandstone</td>
<td>Polished, pitted, battered, striations</td>
<td>Multiple surfaces</td>
<td>87.42</td>
<td>67.17</td>
<td>36.72</td>
<td>291.0</td>
</tr>
<tr>
<td>FS 747</td>
<td>Hammerstone</td>
<td>Sandstone</td>
<td>Battered</td>
<td>One end</td>
<td>60.73</td>
<td>49.44</td>
<td>37.87</td>
<td>139.7</td>
</tr>
<tr>
<td>FS 1746</td>
<td>Nutting stone</td>
<td>Sandstone</td>
<td>Polished, pitted, battered</td>
<td>Multiple surfaces</td>
<td>77.03</td>
<td>64.40</td>
<td>29.09</td>
<td>304.4</td>
</tr>
<tr>
<td>FS 1331</td>
<td>Grinding slab</td>
<td>Sandstone</td>
<td>Ground, polished, battered</td>
<td>One side, one end</td>
<td>200.00</td>
<td>122.08</td>
<td>53.21</td>
<td>1899.8</td>
</tr>
</tbody>
</table>

Abrading stones for chipped stone tool production. The presence of these ground stone artifacts in the central portion of the site suggests that this area was used for subsistence processing activities, as would additionally be suggested by the abundance of features in the area.

**Nutting Stones**

Specimen FS 711 is a well-polished and pitted quartzite cobbble with abundant abrading marks. The artifact is mainly flat and teardrop shaped. Two shallow pits, measuring approximately 26 mm in diameter, are present near the centers of the wider end on both faces. One face has two prominent striations, approximately 17 mm long by 2 mm wide, on the narrower end. The narrower point of the artifact also has numerous striations that extend to one of the long edges. The wider end has several battering marks. Both faces of the artifact are slightly crazed, suggesting that it was fired. Although the artifact is classified in the database as a nutting stone, it also served as an abrader, as well as likely a hammerstone. This artifact was submitted for pollen and residue analysis; however, the results concluded that since the artifact was burned, no pollen or residues were preserved.

Specimen FS 712 is a flat, triangular sandstone cobbble with that was worked on one flat face and multiple edges. One flat side has been polished from use and contains an approximately 25-mm shallow pit. The flat face is in the shape of a rough right triangle, with the short side exhibiting multiple striations along the edge. The corners of the artifact also appear to have been battered. The artifact was examined for pollen and starch remains, which yielded a local environmental signature of oak, pine, and elm. Pollen and phytoliths from the sunflower, mustard family, buckwheat, prairie clover, and rose family also yielded a signature of the local vegetation. The identification of **brassicaceae** remains may have been
ground as part of food preparation, though these mustard family remains may have also simply been a local natural signature.

Specimen FS 1746 is a flat rectangular red sandstone artifact that has been polished on one side and has been battered on multiple edges of the same side. In the center of the polished side is a very subtle shallow pit that is approximately 25 mm in diameter. The face has been polished and the central portion of the pit is slightly rougher than the surrounding face. Along one short edge of both the upper and lower face, the specimen has also been battered. Because of the coarseness of the material, it is difficult to determine if some of these battering marks are actually the result of the tool being used as an abrader. This artifact was not submitted for pollen or residue analysis.

**Hammerstone**
Specimen FS 747 is a sandstone pebble that has been slightly smoothed on the edges from wear and has light battering marks on one end. The degree of modification suggests that the stone was used in a limited fashion as a hammerstone before it was discarded. Discoloration on one edge suggests that the artifact was burned. However, given that pollen was recovered, this likely occurred prior to its use as a hammerstone. The pollen and starch analysis yielded a primarily local environmental signature dominated by *poaceae* pollen, but pine, oak, and sunflower pollen was also recovered. Although small quantities of the local ground cover vegetation were recovered from the artifact, it is likely that these were simply incorporated in the matrix, and their presence is not taken as evidence of the artifact being used as a mano.

**Grinding slab**
Specimen FS 1331 is by far the largest artifact recovered from the Murvaul Creek site. This artifact is a large, flat, oblong sandstone cobble that was used as a grinding slab as well as a battering stone. The upper face of the stone has a wide depression that has been ground and slightly polished. The ground depression is approximately 60 mm in diameter, but it does not form a distinct pit as seen on the nutting stones. The wider end along the long axis was also battered. One corner on the opposite end is discolored from thermal alteration. No striations were visible to suggest that the object was used as an abrader.

Pollen and starch analysis yielded the most complete record of both the local signature as well as possible subsistence remains among the ground stone specimens recovered from the site. Remains of pine, oak, hickory/pecan, gum, and elm represent the local forest cover, whereas the umbel family, as well as various marshelder groups of the sunflower, cheno-ams, hazel, and prairie clover, along with grasses were also represented. The residue of roots from the umbel family, marshelder, and/or grass seeds were likely remains of plants that were processed using this grinding slab.
Unmodified Debitage (n=2,066)
The unmodified lithic debitage recovered from the data recovery excavations at the Murvaul Creek site included a total of 2,066 artifacts. As previously discussed, analysis was performed only on the debitage recovered from within the buried soil (n=587) and identified features (n=565). The analyzed collection was represented by raw materials that were overwhelmingly locally obtained (Table 52). The vast majority of the collection is composed of brown and red chert debitage, with quartzite, and fossilized wood also being represented as characteristic of the locally available materials. These local materials comprise 95.7 percent of the collection by weight and 74 percent of the collection by count. A total of 274 fragments of microdebitage (<\(\frac{1}{8}\) in) was recovered from feature fill. Due to the size of these fragments, these artifacts were categorized as unidentified siliceous materials and no further analysis was performed. Regionally available materials represent approximately 3.5 percent of the collection by weight (2.2 percent by count). High-quality translucent gray chert that represents material resembling Edwards chert from Central Texas comprises the majority of the regionally available specimens. Jasper and novaculite were also recovered but in very low frequencies from the site. There did not appear to be any correlation between the recovery of nonlocal materials and the differing stratigraphic components. The goal then for the remainder of this summary is to attempt to identify whether there are differences in activities across the site.

Figure 90 shows the recovery of debitage from each feature or test unit quadrant according to site soil horizon. The majority of the lithic debitage was recovered from the central and northern portions of the site. Debitage appeared to be concentrated within the Ab-horizon, with lesser materials present in the E-horizon. The figure shows that the majority of the debitage recovered from the southern portion of the site was recovered from within the E-horizon. However, this tendency is due more to the thinness of the Ab-horizon (<10 cm) in these test units compared to elsewhere on the site. Overall, both a greater weight and count of debitage was present in the western portion of Block 4 near the concentration of numerous features. Likely, this area served as a primary workstation near a habitation or central hearth. Interestingly, Block 7 did not correlate with an increased frequency of lithics debris even though a hearth feature was identified immediately adjacent to that block and the PBS&J North Block. This may indicate that the area served a different purpose than the central portion of the site.

The aggregate weights of unmodified lithic debitage analyzed from the data recovery excavation were cross-tabulated to compare attributes between each block in an attempt to address how different activities took place across the site. In order to limit the number of unpopulated fields, it was necessary to group multiple blocks into categories. Debitage recovered from Blocks 2 and 3 was grouped as the Southern Blocks, and no debitage was analyzed from Block 1. Blocks 5–8 were all treated as the Northern Blocks, and Block 4 remained ungrouped with other blocks. Additionally, the debitage recovered from feature flotation was treated as a separate category. For each tabulation, an \(\chi^2\) test was performed on the matrix to statistically assess whether the population represented a random
### Table 52: Analyzed Debitage by Material Type and Site Component

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Ab-horizon n (g)</th>
<th>E-horizon n (g)</th>
<th>Feature Fill n (g)</th>
<th>Totals n (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indeterminate</strong></td>
<td>- (–)</td>
<td>- (–)</td>
<td>274 (3.06)</td>
<td>274 (3.06)</td>
</tr>
<tr>
<td>Unidentified silex</td>
<td>- (–)</td>
<td>- (–)</td>
<td>- (–)</td>
<td>274 (3.06)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>- (–)</td>
<td>- (–)</td>
<td>274 (3.06)</td>
<td>274 (3.06)</td>
</tr>
<tr>
<td><strong>Local</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chalcedony</td>
<td>- (–)</td>
<td>- (–)</td>
<td>3 (2.2)</td>
<td>3 (2.2)</td>
</tr>
<tr>
<td>Chert</td>
<td>353 (138.16)</td>
<td>83 (56.16)</td>
<td>238 (35.14)</td>
<td>674 (229.46)</td>
</tr>
<tr>
<td>Fossilized wood</td>
<td>16 (14.78)</td>
<td>6 (4.1)</td>
<td>6 (1.74)</td>
<td>28 (20.62)</td>
</tr>
<tr>
<td>Ironized sandstone</td>
<td>2 (1.2)</td>
<td>- (–)</td>
<td>- (–)</td>
<td>2 (1.2)</td>
</tr>
<tr>
<td>Limestone</td>
<td>3 (3.84)</td>
<td>- (–)</td>
<td>- (–)</td>
<td>3 (3.84)</td>
</tr>
<tr>
<td>Quartzite</td>
<td>86 (51.54)</td>
<td>16 (16.84)</td>
<td>17 (8.44)</td>
<td>119 (76.82)</td>
</tr>
<tr>
<td>Silicified limestone</td>
<td>- (–)</td>
<td>1 (1.6)</td>
<td>- (–)</td>
<td>1 (1.6)</td>
</tr>
<tr>
<td>Unidentified silex</td>
<td>- (–)</td>
<td>- (–)</td>
<td>22 (0.1)</td>
<td>22 (0.1)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>460 (209.52)</td>
<td>106 (78.7)</td>
<td>286 (47.62)</td>
<td>852 (335.84)</td>
</tr>
<tr>
<td><strong>Regional</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>8 (3.22)</td>
<td>7 (5.5)</td>
<td>4 (0.58)</td>
<td>19 (9.3)</td>
</tr>
<tr>
<td>Jasper</td>
<td>2 (1.8)</td>
<td>1 (0.5)</td>
<td>1 (0.3)</td>
<td>4 (2.6)</td>
</tr>
<tr>
<td>Novaculite</td>
<td>2 (0.2)</td>
<td>- (–)</td>
<td>- (–)</td>
<td>2 (0.2)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12 (5.22)</td>
<td>8 (6)</td>
<td>5 (0.88)</td>
<td>25 (12.1)</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>472 (214.74)</td>
<td>114 (84.7)</td>
<td>565 (51.56)</td>
<td>1151 (351)</td>
</tr>
</tbody>
</table>

For each debitage attribute, this generalization yielded $\chi^2$ results that were statistically significant to at least the 95 percent confidence level. In addition to this analysis, the tables presented below show the results of an adjusted residual analysis. This analysis determines the values that contribute to significant variation in the data given the total sample size (Haberman 1973). Values greater or lower than an absolute value of 1.96 are statistically significant deviations ($p \leq 0.05$) from the expected distribution and represent over- or under-abundance of a category in the data set.

Table 53 shows the aggregate weight of unmodified lithic debitage separated by size class and site area. The debitage pertaining to size classes smaller than 0.25 inch (6.4 mm) was removed from the sample. This was done because the field methods included 0.25-inch screening, and smaller size classes represent both an opportunistic sample from test units and finer recovery from feature flotation. Absent from the table is the 1-inch (25.5-mm) size class because the collection did not contain any debitage that was within this size category. The majority (83 percent) of the collection was within the 0.25-inch and 0.5-inch size categories. This trend toward the smaller size classes likely reflects the relatively small size of the locally available siliceous stream pebbles. Even with this tendency toward smaller
size classes, the adjusted residuals from the Southern Blocks appeared to be overrepresented in large debitage fragments and correspondingly underrepresented in the ¼-inch size class. This tendency toward larger size fragments may indicate a preference for this portion of the site to have been used for initial reduction tasks. Additionally, Block 4 was overrepresented in the ¼-inch size class, which may indicate that this area was used for resharpening or later stages of lithic reduction. Given that there was likely a structure present in this area, this preference for small materials may also be indicative of site cleaning whereby the larger fragments were removed to elsewhere on the site. The most likely location on site for lithic debris disposal would have been the midden area, which is represented by the Northern blocks. However, in this area only 2.7 g of the ¾-inch category were present. The adjusted residuals indicate that the Northern blocks were underrepresented in the large size category. It is therefore interpreted that if site cleaning was occurring in the Block 4 area, the large debris was being transported out of the study area.

Table 54 displays the aggregate weight of unmodified lithic debitage within each site area separated by the percentage of cortex that was present on the dorsal surface. Although the data were separated into five categories, the collection can be generalized into three equal partitions. Approximately one-third (by weight) of the collection had greater than 50 percent cortex, roughly one-third had less than 50 percent cortex and the final third was noncortical. Similar to the size grade data, the cortical data represent a measure for the degree of lithic reduction represented in the collection. It is assumed that as a material is worked, flakes containing the weathered exterior will generally be the first fragments to be removed (Andrefsky 2001). As the material is progressively worked, less cortex will remain and will be proportionately represented in an assemblage. Accordingly, based on the interpretation that the size grade data reflected a tendency for the southern portion of the site to be used for initial lithic reduction, it was assumed that this area would show a relatively high proportion of cortical debitage. However, the adjusted residuals suggest that the Southern blocks were overrepresented in noncortical debris and correspondingly lacking in the 51–75 percent category. Instead of being a primary lithic reduction area, the debitage recovered from the southern portion of the site, although large in size, were primarily tertiary flakes. Both the Northern blocks and features were also overrepresented in the middle two cortical categories. When directly comparing aggregate weights across each area, it is apparent that this overrepresentation does not reflect any exclusivity in these categories. Instead, the range of cortical specimens present across all areas of the site was fairly consistent.

Table 55 displays the aggregate weights of debitage analyzed from each site area separated by the platform type. Necessarily, the data reflects only complete and proximal flakes. Additionally, the data contains approximately 6 percent (13.28 g) of the collection that was assigned to an indeterminate platform type. Indeterminate specimens were assigned to those flakes that had a crushed platform from a hard hammer percussion that can be
Figure 90. Location of debitage recovered across the site.
Table 53: Summary of Lithic Debitage Recovered: Size Class by Site Area

<table>
<thead>
<tr>
<th>Block</th>
<th>¼ Inch</th>
<th>½ Inch</th>
<th>¾ Inch</th>
<th>Totals</th>
<th>p of χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Blocks</td>
<td>9.46 (-4.9)</td>
<td>26</td>
<td>19.8 (4.03)</td>
<td>55.26</td>
<td></td>
</tr>
<tr>
<td>Block 4</td>
<td>97.6 (2.08)</td>
<td>58.8</td>
<td>29.8</td>
<td>186.2</td>
<td></td>
</tr>
<tr>
<td>Northern Blocks</td>
<td>34.36</td>
<td>21.6</td>
<td>2.7 (-2.8)</td>
<td>58.66</td>
<td></td>
</tr>
<tr>
<td>Features</td>
<td>20.64</td>
<td>15.6</td>
<td>6.4</td>
<td>42.64</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>162.06</td>
<td>122</td>
<td>58.7</td>
<td>342.76</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note: Data show (0) statistically significant residuals

Table 54: Summary of Lithic Debitage Recovered: Cortex by Site Area

<table>
<thead>
<tr>
<th>Block</th>
<th>76–100%</th>
<th>51–75%</th>
<th>26–50%</th>
<th>1–25%</th>
<th>0%</th>
<th>Totals</th>
<th>p of χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Blocks</td>
<td>13.3</td>
<td>0 (-2.2)</td>
<td>10.9</td>
<td>7.1</td>
<td>23.96 (1.98)</td>
<td>55.26</td>
<td></td>
</tr>
<tr>
<td>Block 4</td>
<td>56.32</td>
<td>12.7</td>
<td>19.2</td>
<td>46.64</td>
<td>51.34</td>
<td>186.2</td>
<td></td>
</tr>
<tr>
<td>Northern Blocks</td>
<td>14.44</td>
<td>10.6 (3.72)</td>
<td>5.1</td>
<td>10.42</td>
<td>18.1</td>
<td>58.66</td>
<td></td>
</tr>
<tr>
<td>Features</td>
<td>9.52</td>
<td>0.84</td>
<td>12.2 (2.32)</td>
<td>9.96</td>
<td>19.04</td>
<td>51.56</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>93.58</td>
<td>24.14</td>
<td>47.40</td>
<td>74.12</td>
<td>112.44</td>
<td>351.68</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note: Data show (0) statistically significant residuals

Table 55: Summary of Lithic Debitage Recovered: Platform Type by Site Area

<table>
<thead>
<tr>
<th>Block</th>
<th>Abraded</th>
<th>Complex</th>
<th>Cortical</th>
<th>Faceted</th>
<th>Flat</th>
<th>Rejuvenated</th>
<th>Indeterminate</th>
<th>Totals</th>
<th>p of χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Blocks</td>
<td>3.5</td>
<td>6.54</td>
<td>19.7</td>
<td>6.1</td>
<td>3.54 (-2.31)</td>
<td>0</td>
<td>3.78</td>
<td>43.16</td>
<td></td>
</tr>
<tr>
<td>Block 4</td>
<td>4.58</td>
<td>10.74</td>
<td>51.7</td>
<td>2.14 (-2.9)</td>
<td>24.96</td>
<td>0.3</td>
<td>8.92</td>
<td>103.34</td>
<td></td>
</tr>
<tr>
<td>Northern Blocks</td>
<td>0.8</td>
<td>4.54</td>
<td>20.68</td>
<td>0.5</td>
<td>8.22</td>
<td>0</td>
<td>0.38</td>
<td>35.12</td>
<td></td>
</tr>
<tr>
<td>Features</td>
<td>1.2</td>
<td>1.26</td>
<td>9.3</td>
<td>6.4 (3.75)</td>
<td>6.52</td>
<td>0</td>
<td>0.2</td>
<td>24.88</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>10.08</td>
<td>23.08</td>
<td>101.38</td>
<td>15.14</td>
<td>43.24</td>
<td>0.30</td>
<td>13.28</td>
<td>206.50</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Note: Data show (0) statistically significant residuals

indicative of either the knapper applying too much direct force or when bipolar reduction strategies are used. Additionally, over half of the analyzed collection from Murvaul Creek is represented by debitage with cortical platforms. Many of these specimens had clear indication that they were placed on an anvil stone when they were removed from the core. For artifacts where there was clear indication of bipolar percussion, a note was opportunistically recorded in a comment field of the analysis sheet. However, these data were not culled into a separate analytical category. Future studies in the region may find it useful to modify the TxDOT protocols to explore more fully the prevalence of bipolar reduction in an East Texas collection.
The adjusted residual data suggest an underrepresentation of flat platforms in the Southern Blocks and an underrepresentation of faceted platforms in the central portion of the site. Faceted platforms were overrepresented in the feature fill. It is difficult to interpret these data other than to suggest that finer-scale reduction was taking place in immediate association with the activity areas that would have surrounded the features.

Completeness of the collection can be interpreted along with the site formation processes that have affected the preservation of the site. Although there could be impurities in raw materials that would have created anomalous breakages, disturbed areas of the site would be interpreted as having more flake fragments and debris than would be expected in undisturbed areas. According to Table 56, over half of the collection is represented by complete flakes, which is taken as evidence that the collection as a whole is relatively undisturbed. Given that the initial testing at the site suggested that the topsoil from the southern portion of the site had been stripped, it would seem likely that this area would be more fragmentary than other portions of the site. However, the adjusted residuals suggest an underrepresentation of debris (or shatter) and an over representation of broken (proximal) flakes. Given that the analyzed pieces in the collection represented only those specimens from within the buried soil, it is likely that, should the upper portion of the collection be analyzed, that there would be greater chance in identifying interpretable differences in the fragmentation across the site.

Table 56: Summary of Lithic Debitage Recovered: Completeness by Site Area

<table>
<thead>
<tr>
<th>Block</th>
<th>Complete</th>
<th>Broken</th>
<th>Fragment</th>
<th>Debris</th>
<th>Totals</th>
<th>p of X²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Blocks</td>
<td>34.22</td>
<td>8.9 (3.35)</td>
<td>6.14</td>
<td>6 (-2.06)</td>
<td>55.26</td>
<td></td>
</tr>
<tr>
<td>Block 4</td>
<td>94.22</td>
<td>8.66</td>
<td>42.68</td>
<td>40.64</td>
<td>186.2</td>
<td></td>
</tr>
<tr>
<td>Northern Blocks</td>
<td>31.36</td>
<td>3.72</td>
<td>10.58</td>
<td>13</td>
<td>58.66</td>
<td></td>
</tr>
<tr>
<td>Features</td>
<td>24.48</td>
<td>0.4</td>
<td>11.48</td>
<td>15.2</td>
<td>51.56</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>184.28</td>
<td>21.68</td>
<td>70.88</td>
<td>74.84</td>
<td>351.68</td>
<td></td>
</tr>
</tbody>
</table>

Note: Data show (0) statistically significant residuals

Table 57 displays the results of heat-treated versus nonheat-treated materials by site area. The data in the table represent only the 51 percent of the collection that could be definitively separated into heat treatment categories. The remaining portion of the analyzed collection was categorized as indeterminate regarding heat treatment. The heat-treated quartzite and chert in the collection were identified based on the presence of both a very lustrous appearance and a tendency toward redder hues than the nonheat-treated specimens. In some instances, potlidded flakes were also identified and categorized as heat-treated specimens. However, there was a tendency for the specimens to be categorized as indeterminate if heat treatment were in question. For portions of the collection where heat treatment was assigned, the majority was categorized as nonthermally altered. The adjusted residuals do suggest that both the features and Block 4 contributed
Table 57: Summary of Lithic Debitage Recovered: Thermal Alteration by Site Area

<table>
<thead>
<tr>
<th>Block</th>
<th>Yes</th>
<th>No</th>
<th>Totals</th>
<th>p of $\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Blocks</td>
<td>6.4</td>
<td>39.4</td>
<td>45.8</td>
<td></td>
</tr>
<tr>
<td>Block 4</td>
<td>12 (-3.12)</td>
<td>76.6 (3.12)</td>
<td>88.6</td>
<td></td>
</tr>
<tr>
<td>Northern Blocks</td>
<td>9.5</td>
<td>14.8</td>
<td>24.3</td>
<td></td>
</tr>
<tr>
<td>Features</td>
<td>14.7 (5.1)</td>
<td>7.3 (-5.1)</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>42.6</td>
<td>138.1</td>
<td>180.7</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note: Data show (0) statistically significant residuals

Fire-Cracked Rock (n=60)

Fire-cracked rock (FCR) was not recovered in abundance from the data recovery excavations at the Murvaul Creek site, and none was recovered from the PBS&J test excavations (Cliff and Perttula 2002). Sixty FCR artifacts were recovered in low densities from across the site. This represents roughly 2.7 percent of the total lithic collection. There did not appear to have been any patterning or concentration of these artifacts in association with features or other primary activity areas. Nearly half (43 percent) of the FCR, by count, was recovered from within the colluvium, and approximately an equal proportion of FCR was recovered from within the buried soil or within feature fill (Table 58). However, FCR recovered from within the buried soil accounted for approximately 62 percent, by weight, of the collection. This discrepancy was due to an overall larger size of artifacts recovered in the lower levels of the site. Given that similar size trends were not noted in other material classes, it is doubtful that this trend is evidence of size sorting from bioturbation or other factors.

The FCR fragments were sorted into rock material types using the same categories defined in the TxDOT chipped stone tools protocols. Figure 91 shows the materials represented by both artifact counts and weights both for all site contexts and separated by only those contexts within the buried soil. Unlike the unmodified debitage collection, the FCR assemblage was fairly evenly represented by chert, quartzite, sandstone, and fossilized wood. Given that no clear preference toward one material type over another was observed, it seems likely that the FCR assemblage represents both subsistence activities as well as lithic pretreatment for the production of chipped stone tools.
Table 58: Fire-Cracked Rock Recovered by Size and Component

<table>
<thead>
<tr>
<th>Component</th>
<th>6.3 mm (0.25 in) n (g)</th>
<th>12.5 mm (0.50 in) n (g)</th>
<th>19 mm (0.75 in) n (g)</th>
<th>25 mm (1 in) n (g)</th>
<th>Totals n (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colluvium</td>
<td>(-)</td>
<td>10 (18.8)</td>
<td>11 (46.2)</td>
<td>5 (91.6)</td>
<td>26 (156.6)</td>
</tr>
<tr>
<td>Ab</td>
<td>1 (0.1)</td>
<td>3 (7.1)</td>
<td>3 (18.1)</td>
<td>3 (23.3)</td>
<td>10 (48.6)</td>
</tr>
<tr>
<td>E</td>
<td>(-)</td>
<td>4 (5.3)</td>
<td>3 (10.2)</td>
<td>3 (144.1)</td>
<td>10 (159.6)</td>
</tr>
<tr>
<td>Feature</td>
<td>1 (0.4)</td>
<td>1 (1.2)</td>
<td>1 (4.8)</td>
<td>3 (95.6)</td>
<td>6 (102)</td>
</tr>
<tr>
<td>50-x-50-cm</td>
<td>(-)</td>
<td>2 (4.5)</td>
<td>1 (7)</td>
<td>(-)</td>
<td>3 (11.5)</td>
</tr>
<tr>
<td>Disturbed</td>
<td>(-)</td>
<td>2 (6.2)</td>
<td>1 (4.2)</td>
<td>2 (13.6)</td>
<td>5 (24)</td>
</tr>
<tr>
<td>Totals</td>
<td>2 (0.5)</td>
<td>22 (43.1)</td>
<td>20 (90.5)</td>
<td>16 (368.2)</td>
<td>60 (502.3)</td>
</tr>
</tbody>
</table>

Figure 91. Rock material types represented in the FCR collection from site 41PN175. These are separated by: a. FCR by Count – all contexts, b. FCR by Weight – all contexts, c. FCR by Count – Ab, E, and Feature components only, d. FCR by Weight – Ab, E, and Feature components only.

Fire-cracked rock is typically not recovered in abundance from Caddo sites in East Texas. Burned rock has been identified in the region at sites such as the Herman Bellow (41RK222), which contained large pits and rock hearths, and the Mockingbird (41TT550) site, which had widely scattered burned rock (Perttula 2004:376). Although both sites contained mixed assemblages, the burned rock recovered from sites are attributed to Late Archaic occupations or site use, and not to the Caddo Period occupations (Perttula 2004:376).
During the Woodland and Early Caddo periods, the recovery of burned rock at sites in East Texas is rare because, with the introduction of pottery to the region, directly heating foods in pottery vessels became a more common practice. It has additionally been noted that an increased reliance on horticultural practices for subsistence additionally required a more intensive and long-term heating than was previously needed (Nelson 2010). Hence, with the development of an increasingly sedentary lifestyle throughout the Woodland and early Caddo periods, the necessity to use rock as a heating source became increasingly rare.

There are two notable exceptions to the paucity of burned rock at Caddo sites in East Texas (Table 59). Investigations at the M. W. Burks site (41WD52) resulted in surface collection of more than 3,000 Caddo artifacts, of which over 85 percent were Caddo pottery sherds (Perttula 2005). Of the 221 lithic artifacts recovered, approximately 42.5 percent (n=94) was FCR. This was interpreted that hot rock cooking did take place at the site during the Titus phase of the occupation in order to supplement direct heating of foods within ceramic jars. A second exception was the Bob Turbeville site (41WD382) where limited test excavations yielded an Early to Middle Caddo farmstead or hamlet that contained a trash midden, possible house areas, and a human burial (Schroeder 1997). The limited materials recovered consisted of 93 prehistoric artifacts, of which 56 were lithic debris. Including the FCR recovered, all of the lithic artifacts from the Bob Turbeville site were attributed to chipped stone tool production and raw material preparation.

In addition to the above sites, numerous small burned-rock accumulations were identified at the Oak Hill Village site (Rogers and Perttula 2004). These small features were interpreted as remnants of rock-lined hearths, and many of these contained associated Gary and other dart points. No clear interpretation of whether these features pertained to the Caddo or previous occupations of the site was presented. Similarly, at the Lang Pasture site, FCR was identified in low concentrations across the site (Perttula et al. 2011). The occurrence of FCR was taken as evidence of at least occasional Caddo hot-rock cooking, and vertical distributions suggested that hot-rock cooking was more prevalent at areas representing older periods of the site occupation.

Given both the dispersed spatial extent of the FCR at the Murvaul Creek site as well as the narrow range of radiocarbon dates that was obtained from the site, it seems likely that the FCR collection indicates that both hot-rock boiling and direct cooking methods were being employed at the site. Additionally, when the material types of the collection are taken into account, it is apparent that the majority of the FCR collection is composed of siliceous materials that would have also been suitable for knapping. Results from both the projectile point collection and debitage collection suggest that a substantial portion of those collections had been heat-treated prior to use. Other materials, such as sandstone, siltstone, and ironstone, did not appear in the other chipped stone tool collection, and these would have likely been more useful for food production activities.
Table 59: Caddo Sites in East Texas with Reported Fire-Cracked Rock

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Site Number</th>
<th>Total Lithic Artifacts Reported</th>
<th>FCR Reported</th>
<th>Percent FCR in Lithic Collection</th>
<th>FCR Interpretation</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alligator Pond</td>
<td>41SM422</td>
<td>131</td>
<td>6</td>
<td>4.6</td>
<td>Hot-rock attributed to cooking earth ovens open pits, though no ovens or pit features were reported. No radiocarbon dates were reported.</td>
<td>Perttula and Walters (2012)</td>
</tr>
<tr>
<td>Polk Estates</td>
<td>41CP245</td>
<td>1302</td>
<td>16</td>
<td>1.2</td>
<td>Indirect heating/cooking methods were not considerably practiced; FCR was attributed to the lower Woodland component rather than the Middle Caddo component.</td>
<td>Perttula and Nelson (2006)</td>
</tr>
<tr>
<td>M. W. Burks</td>
<td>41WD52</td>
<td>221</td>
<td>94</td>
<td>42.5</td>
<td>Inconclusive as to whether the scattered FCR predated Titus Phase occupation. Hot-rock cooking may have supplemented direct heat cooking.</td>
<td>Perttula, Skiles, and Yates (2005)</td>
</tr>
<tr>
<td>Browning</td>
<td>41SM195A</td>
<td>856</td>
<td>9</td>
<td>1.1</td>
<td>Woodland site shows evidence that hot-rock cooking was not widely practiced; further, the site provides scant evidence for both stone boiling nuts in earthen pits and directly heating water in ceramic jars</td>
<td>Walters (2004)</td>
</tr>
<tr>
<td>South Lilly #4</td>
<td>41UR279</td>
<td>351</td>
<td>15</td>
<td>4.3</td>
<td>FCR was attributed to indirect cooking during the Woodland period, not the Caddo occupation.</td>
<td>Perttula et al. (2004)</td>
</tr>
<tr>
<td>Wolf</td>
<td>41SM195</td>
<td>735</td>
<td>1</td>
<td>0.1</td>
<td>One FCR artifact reported. No interpretation given.</td>
<td>Walters (2003)</td>
</tr>
<tr>
<td>Underwood</td>
<td>41CP230</td>
<td>187</td>
<td>10</td>
<td>5.3</td>
<td>FCR was attributed to the sporadic Middle and Late Archaic use predating the Late Caddo occupation</td>
<td>Nelson and Perttula (2003)</td>
</tr>
<tr>
<td>Bob Turbeville</td>
<td>41WD382</td>
<td>56</td>
<td>32</td>
<td>57.1</td>
<td>FCR was attributed to heat spalls and/or heat-fractured rock that was prepared for knapping, rather than for food preparation</td>
<td>Schroeder (1997)</td>
</tr>
<tr>
<td>Carlisle</td>
<td>41WD46</td>
<td>897</td>
<td>18</td>
<td>2.0</td>
<td>FCR was recovered primarily in surficial and mixed contexts. No interpretations were made.</td>
<td>Perttula et al. (1993)</td>
</tr>
<tr>
<td>Murvaul Creek</td>
<td>41PN175</td>
<td>2201</td>
<td>62</td>
<td>2.8</td>
<td></td>
<td>This report</td>
</tr>
</tbody>
</table>
Chapter 8: Radiocarbon Dates from the Murvaul Creek Site (41PN175)
by Robert Z. Selden, Jr., Ph.D.

Introduction
Twenty-seven radiocarbon (\(^{14}\text{C}\)) dates are available from the Murvaul Creek site, with two originating from features and archeological deposits identified during test excavations (Cliff and Perttula 2002) and 25 additional from contexts encountered during data recovery (Appendix B). This is among the largest samples of radiocarbon assays obtained from any single East Texas site, since the East Texas Radiocarbon Database (ETRD) (Perttula and Selden 2011) indicates that only six other sites within the region—George C. Davis (41CE19, Story 1997, 1998; Story and Valastro 1977), Pine Tree Mound (41HS15, Fields and Gadus 2012a), Oak Hill Village (41RK214, Rogers and Perttula 2004), George E. Richey (41TT851, Hatfield et al. 2008), William A. Ford (41TT852, Hatfield et al. 2008), and Kitchen Branch (41CP220; Perttula and Walker 2012)—have catalogs of over 30 \(^{14}\text{C}\) dates (see Selden and Perttula 2013). This preliminary synthesis of the dates from the Murvaul Creek site uses the ETRD to posit potentially contemporaneous sites within the region.

\(^ {14}\text{C} \) from the Murvaul Creek Site
The \(^ {14}\text{C} \) sample from the Murvaul Creek site includes dates from nutshell (n=11), pinecone scale (n=1), wood (n=2), ceramics (n=10), and corn (n=3) (Figure 92 and Table 60). The single anomalous nutshell (hickory) date (Beta-163092) was collected from Feature 5 during the testing phase, as was a much younger nutshell (hickory) date (Beta-163093) from Feature 6. The date for the pinecone scale overlaps with that of the early wood sample (Beta-344092). Interestingly, the earliest ceramic samples (Beta-344079 and -351054) were the only two (out of 11) that do not illustrate an age range contemporary with that of the dated samples of corn (Beta-344087, -344094 and -344091). The remaining samples have age ranges that overlap in various ways, and all of the dates from the Murvaul Creek site are explored thoroughly within the remainder of this section.

Methods
The ETRD informs synthesis of tempo and place for Woodland era (ca. 500 B.C.–A.D. 800) archeological sites within the East Texas region. Through a variety of academic, avocational, and cultural resource management pursuits, archeologists have obtained 77 \(^ {14}\text{C} \) dates from 35 Archaic period sites, 136 \(^ {14}\text{C} \) dates from 52 Woodland period sites, and 913 \(^ {14}\text{C} \) dates from 151 Caddo sites across East Texas. The bulk of these dates were collected with the intention of exploring locally based research questions and are used here to posit intersite contemporaneity.
All $^{14}$C dates in the sample (and the ETRD) were calibrated using OxCal 4.2 [74] (Bronk Ramsey 2013) and IntCal09 (Reimer et al. 2009). Older assays in the regional sample (ETRD) found to lack $\delta^{13}$C data used value estimates for fractionation correction as suggested by Stuiver and Reimer (1993:Table 1): -25‰ for nutshell and charcoal (C$_3$ plants), and -10‰ for charred maize (C$_4$ plants) (Perttula 1998a, 1998b; Perttula and Selden 2011; Selden 2013a).

The comparative sample was selected from the ETRD on the basis of median age. If the median age of a sample fell within ± 100 cal $^{14}$C years of a sample from the Murvaul Creek site, it was included in this synthesis. Dates omitted from the sample included those from sites lacking specific geographic coordinates, dates with a standard deviation greater than 200 years, or dates from nonarchaeological contexts (i.e., geoarchaeological profile, backhoe trench, or cutbank) on a site or near a site. All remaining dates comprise the foundation of the sample from East Texas. Aside from those elements listed above, no formally-defined measure of chronometric hygiene is employed herein. Data fields imported from the ETRD include site name, trinomial (site number), assay number, raw age, $\delta^{13}$C, corrected $^{14}$C age, 2-sigma age range, and median age.
## Table 60: Catalog of $^{14}$C Dates for the Murvaul Creek (41PN175) Site

<table>
<thead>
<tr>
<th>Assay No.</th>
<th>Dated Material</th>
<th>Raw Age</th>
<th>±</th>
<th>$\delta^{13}$C (%)</th>
<th>Conv $^{14}$C Age</th>
<th>±</th>
<th>1σ Age Range*</th>
<th>2σ Age Range*</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta-351059</td>
<td>Ceramic</td>
<td>440</td>
<td>30</td>
<td>-29.5</td>
<td>370</td>
<td>30</td>
<td>A.D. 1454–1519 (0.49), A.D. 1594–1619 (0.19)</td>
<td>A.D. 1447-1528 (0.55), A.D. 1553-1634 (0.40)</td>
<td>A.D. 1515</td>
</tr>
<tr>
<td>Beta-351057</td>
<td>Ceramic</td>
<td>490</td>
<td>30</td>
<td>-28.9</td>
<td>430</td>
<td>30</td>
<td>A.D. 1435–1470 (0.68)</td>
<td>A.D. 1421-1500 (0.91), A.D. 1507-1511 (0.01), A.D. 1601-1616 (0.04)</td>
<td>A.D. 1453</td>
</tr>
<tr>
<td>Beta-344077</td>
<td>Ceramic</td>
<td>470</td>
<td>30</td>
<td>-27.2</td>
<td>430</td>
<td>30</td>
<td>A.D. 1435–1470 (0.68)</td>
<td>A.D. 1421-1500 (0.91), A.D. 1507-1511 (0.01), A.D. 1601-1616 (0.04)</td>
<td>A.D. 1453</td>
</tr>
<tr>
<td>Beta-344076</td>
<td>Ceramic</td>
<td>610</td>
<td>30</td>
<td>-26.3</td>
<td>590</td>
<td>30</td>
<td>A.D. 1313–1358 (0.52), A.D. 1388–1403 (0.17)</td>
<td>A.D. 1298-1370 (0.68), A.D. 1380-1413 (0.27)</td>
<td>A.D. 1347</td>
</tr>
<tr>
<td>Beta-351056</td>
<td>Ceramic</td>
<td>740</td>
<td>30</td>
<td>-29.5</td>
<td>670</td>
<td>30</td>
<td>A.D. 1381–1305 (0.38), A.D. 1364–1385 (0.30)</td>
<td>A.D. 1274-1320 (0.53), A.D. 1351-1391 (0.43)</td>
<td>A.D. 1311</td>
</tr>
<tr>
<td>Beta-351055</td>
<td>Ceramic</td>
<td>750</td>
<td>30</td>
<td>-29.5</td>
<td>680</td>
<td>30</td>
<td>A.D. 1279–1300 (0.46), A.D. 1368–1381 (0.22)</td>
<td>A.D. 1270-1317 (0.60), A.D. 1354-1390 (0.36)</td>
<td>A.D. 1300</td>
</tr>
<tr>
<td>Beta-351058</td>
<td>Ceramic</td>
<td>750</td>
<td>30</td>
<td>-29.1</td>
<td>680</td>
<td>30</td>
<td>A.D. 1279–1300 (0.46), A.D. 1368–1381 (0.22)</td>
<td>A.D. 1270-1317 (0.60), A.D. 1354-1390 (0.36)</td>
<td>A.D. 1300</td>
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<tr>
<td>Beta-344078</td>
<td>Ceramic</td>
<td>720</td>
<td>30</td>
<td>-24.6</td>
<td>730</td>
<td>30</td>
<td>A.D. 1262–1287 (0.68)</td>
<td>A.D. 1224-1297 (0.95)</td>
<td>A.D. 1274</td>
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<tr>
<td>Beta-351054</td>
<td>Ceramic</td>
<td>850</td>
<td>30</td>
<td>-29.4</td>
<td>780</td>
<td>30</td>
<td>A.D. 1225–1268 (0.68)</td>
<td>A.D. 1212-1281 (0.95)</td>
<td>A.D. 1247</td>
</tr>
<tr>
<td>Beta-344079</td>
<td>Ceramic</td>
<td>1060</td>
<td>30</td>
<td>-26.7</td>
<td>1030</td>
<td>30</td>
<td>A.D. 988–1023 (0.68)</td>
<td>A.D. 898-919 (0.04), AD 962-1042 (0.90), AD 1108-1117 (0.01)</td>
<td>A.D. 1004</td>
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<tr>
<td>Beta-344091</td>
<td>Corn Cupule</td>
<td>100</td>
<td>30</td>
<td>-10</td>
<td>350</td>
<td>30</td>
<td>A.D. 1481–1523 (0.29), A.D. 1572–1630 (0.39)</td>
<td>A.D. 1457-1635 (0.95)</td>
<td>A.D. 1555</td>
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<tr>
<td>Beta-344094</td>
<td>Corn Cupule</td>
<td>400</td>
<td>30</td>
<td>-9.4</td>
<td>660</td>
<td>30</td>
<td>A.D. 1285–1306 (0.33), A.D. 1363–1385 (0.35)</td>
<td>A.D. 1277-1322 (0.48), A.D. 1348-1393 (0.48)</td>
<td>A.D. 1340</td>
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<tr>
<td>Beta-344087</td>
<td>Corn Kernel</td>
<td>30</td>
<td>30</td>
<td>-7.8</td>
<td>310</td>
<td>30</td>
<td>A.D. 1521–1591 (0.52), A.D. 1620–1643 (0.16)</td>
<td>A.D. 1485-1650 (0.95)</td>
<td>A.D. 1563</td>
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<tr>
<td>Beta-344081</td>
<td>Nutshell</td>
<td>350</td>
<td>30</td>
<td>-26.4</td>
<td>330</td>
<td>30</td>
<td>A.D. 1496–1530 (0.18), A.D. 1540–1602 (0.39), A.D. 1616–1634 (0.12)</td>
<td>A.D. 1477-1643 (0.95)</td>
<td>A.D. 1562</td>
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<tr>
<td>Beta-344090</td>
<td>Nutshell</td>
<td>310</td>
<td>30</td>
<td>-23.4</td>
<td>340</td>
<td>30</td>
<td>AD 1491–1526 (0.23), AD 1557–1603 (0.31), AD 1610–1632 (0.15)</td>
<td>AD 1470-1640 (0.95)</td>
<td>AD 1560</td>
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<td>Beta-344080</td>
<td>Nutshell</td>
<td>360</td>
<td>30</td>
<td>-25.5</td>
<td>350</td>
<td>30</td>
<td>A.D. 1481–1523 (0.29), A.D. 1572–1630 (0.39)</td>
<td>A.D. 1457-1635 (0.95)</td>
<td>A.D. 1555</td>
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<tr>
<td>Beta-163093</td>
<td>Nutshell</td>
<td>360</td>
<td>40</td>
<td>-25.3</td>
<td>360</td>
<td>40</td>
<td>A.D. 1465–1522 (0.36), A.D. 1574–1628 (0.32)</td>
<td>A.D. 1450-1635 (0.95)</td>
<td>A.D. 1542</td>
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<tr>
<td>Assay No.</td>
<td>Dated Material</td>
<td>Raw Age</td>
<td>±</td>
<td>δ^{13}C (‰)</td>
<td>Conv ^{14}C Age</td>
<td>±</td>
<td>1σ Age Range*</td>
<td>2σ Age Range*</td>
<td>Median</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
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<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Beta-344084</td>
<td>Nutshell</td>
<td>340</td>
<td>30</td>
<td>-23.5</td>
<td>360</td>
<td>30</td>
<td>A.D. 1466–1522 (0.39), A.D. 1575–1584 (0.05), A.D. 1590–1625 (0.24)</td>
<td>A.D. 1450-1530 (0.48), A.D. 1540-1635 (0.48)</td>
<td>A.D. 1536</td>
</tr>
<tr>
<td>Beta-344093</td>
<td>Nutshell</td>
<td>360</td>
<td>30</td>
<td>-24.7</td>
<td>360</td>
<td>30</td>
<td>A.D. 1466–1522 (0.39), A.D. 1575–1584 (0.05), A.D. 1590–1625 (0.24)</td>
<td>A.D. 1450-1530 (0.48), A.D. 1540-1635 (0.48)</td>
<td>A.D. 1536</td>
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<tr>
<td>Beta-344082</td>
<td>Nutshell</td>
<td>350</td>
<td>30</td>
<td>-23.6</td>
<td>370</td>
<td>30</td>
<td>A.D. 1454–1519 (0.49), A.D. 1594–1619 (0.19)</td>
<td>A.D. 1447-1528 (0.55), A.D. 1553-1634 (0.40)</td>
<td>A.D. 1515</td>
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<td>Beta-344088</td>
<td>Nutshell</td>
<td>400</td>
<td>30</td>
<td>-27.1</td>
<td>370</td>
<td>30</td>
<td>A.D. 1454–1519 (0.49), A.D. 1594–1619 (0.19)</td>
<td>A.D. 1447-1528 (0.55), A.D. 1553-1634 (0.40)</td>
<td>A.D. 1515</td>
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<td>Beta-344086</td>
<td>Nutshell</td>
<td>440</td>
<td>30</td>
<td>-26.3</td>
<td>420</td>
<td>30</td>
<td>A.D. 1438–1479 (0.68)</td>
<td>A.D. 1426-1516 (0.88), A.D. 1598-1618 (0.07)</td>
<td>A.D. 1460</td>
</tr>
<tr>
<td>Beta-344089</td>
<td>Nutshell</td>
<td>580</td>
<td>30</td>
<td>-25.9</td>
<td>570</td>
<td>30</td>
<td>A.D. 1320–1350 (0.41), A.D. 1391–1411 (0.28)</td>
<td>A.D. 1304-1365 (0.58), A.D. 1384-1423 (0.38)</td>
<td>A.D. 1350</td>
</tr>
<tr>
<td>Beta-163092</td>
<td>Nutshell</td>
<td>2990</td>
<td>40</td>
<td>-25.4</td>
<td>2980</td>
<td>40</td>
<td>1291–1280 B.C. (0.04), 1270–1129 B.C. (0.64)</td>
<td>1375-1340 B.C. (0.05), 1320-1110 B.C. (0.86), 1103-1073 B.C. (0.03), 1066-1056 B.C. (0.01)</td>
<td>1217 B.C.</td>
</tr>
<tr>
<td>Beta-344085</td>
<td>Pinecone Scales</td>
<td>1330</td>
<td>30</td>
<td>-29</td>
<td>1260</td>
<td>30</td>
<td>A.D. 689–753 (0.56), A.D. 760–775 (0.12)</td>
<td>A.D. 669-825 (0.92), A.D. 841-862 (0.04)</td>
<td>A.D. 737</td>
</tr>
<tr>
<td>Beta-344083</td>
<td>Wood</td>
<td>430</td>
<td>30</td>
<td>-26.3</td>
<td>410</td>
<td>30</td>
<td>A.D. 1441–1486 (0.68)</td>
<td>A.D. 1430-1522 (0.83), A.D. 1577-1582 (0.01), A.D. 1591-1620 (0.12)</td>
<td>A.D. 1468</td>
</tr>
<tr>
<td>Beta-344092</td>
<td>Wood</td>
<td>1220</td>
<td>30</td>
<td>-24.2</td>
<td>1230</td>
<td>30</td>
<td>A.D. 713–745 (0.19), A.D. 767–828 (0.35), A.D. 839–865 (0.14)</td>
<td>A.D. 689-752 (0.31), A.D. 761-882 (0.64)</td>
<td>A.D. 789</td>
</tr>
</tbody>
</table>

*All probabilities rounded to the nearest hundredth.
**Calibration Curve**

Conventional $^{14}$C dates used within the framework of this study were recalibrated using IntCal09 calibration curve (Figure 93). The curve serves as the basis for date calibration and can aid the process of archeological interpretation by highlighting temporal zones with reversals and plateaus. For instance, within the span of time assigned to the East Texas Woodland period (ca. 500 B.C.–A.D. 800), the calibration curve can be seen to have three notable reversals of varying degrees (370–220 B.C., A.D. 240–340, and A.D. 680–780). There are also three plateaus within the curve (500–420 B.C., A.D. 140–210, and A.D. 430–540). Although this does not produce clues regarding human behaviors, it does help to clarify why—even after combination—some date ranges have longer spans of probability for the calibrated date range.

![Figure 93. Possible sites of Late Archaic contemporaneity (per $^{14}$C determinations) with Beta-163092 from 41PN175 at 25-mile increments.](image-url)
Archeologically Contemporary Components

In beginning a discussion of the theoretical underpinnings in the archeological study of the ancestral Caddo region, chronology is an element of considerable importance, providing evidence that underscores when and where various events may have occurred. These data can be useful within a variety of discussions ranging from Caddo origins (Girard 2009; Perttula 2009; Schambach 1998) and demographics (e.g., Surovell and Brantingham 2007; Surovell et al. 2009) to trade and exchange. This is aided by the delineation of sites that contain evidence for components of sites that may be archeologically contemporary.

Upon identifying archeological components from a series of sites that appear to have been inhabited simultaneously, efforts can then be made to identify specific occupational episodes within those sites by using multiple sources of data (radiocarbon, ceramics, lithics, etc.). Through the use of such multiscalar approaches we can then begin to engage in a more meaningful dialogue regarding the networks that may have existed between groups (e.g., Allen et al. 1997; Brumfiel and Earle 1987; Janetski 2002; Orton et al. 1983; Parsons and Price 1971), the ceramic economy (including its location, organization, and production) (e.g., Cobb 1993; Costin 1991, 1993, 2001, 2005, 2007; Earle 1982; Mills and Crown 1995; Rice 1987), technological and functional attributes (volume, firing, and contents) (e.g., Jeske 1992; Rice 1987), identity (regional traditions and regional and interregional interactions) (e.g., Costin 1998; Duff 2002), and social organization (Perttula 1992; Perttula and Walker 2012).

East Texas Late Archaic 14C Determinations from 41PN175 and the ETRD

There are 77 dates in the ETRD for the East Texas Archaic. The following section explores the temporal and spatial distributions of 14C assays (see Figure 92 and Table 60), concluding with a comparison of summed probability distributions (SPDs) for key sites from this period (see Figure 93). Radiocarbon determinations that may be contemporary (based solely upon median age) with Beta-163092 (median age 1217 B.C.) include three dates from the J. Simms site (41NA290) (Beta-151115, Beta-151118, and Beta-151117), one date from 41UR77 (UGA-12972), and one date from 41HP118 (SMU-1970) (Table 61 and Figure 94). All three sites are more than 24 miles from the Murvaul Creek, the closest being the J. Simms site—around 24 miles to the southwest—then 41UR77, around 55 miles northwest, and then 41HP118, which lies almost 125 miles northwest. Each of these sites is located near major streams in the region.

East Texas Late Woodland 14C Determinations from 41PN175 and the ETRD

There are 136 radiocarbon dates in the ETRD for the East Texas Woodland period. The following section explores the temporal and spatial distributions of 14C assays via a comparison of summed probability distributions (SPDs) for key sites from this period (see also Selden 2012, 2013a).
### Table 61: Archaic $^{14}$C Dates for Components Contemporary with Beta-163092

<table>
<thead>
<tr>
<th>Site</th>
<th>Assay No.</th>
<th>Raw Age</th>
<th>±</th>
<th>$\delta^{13}$C</th>
<th>Conv $^{14}$C Age</th>
<th>±</th>
<th>$1\sigma$ Age Range*</th>
<th>$2\sigma$ Age Range*</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>41NA290</td>
<td>Beta-151115</td>
<td>2960</td>
<td>110</td>
<td>-26.9</td>
<td>2930</td>
<td>110</td>
<td>1301–1000 BC (0.68)</td>
<td>1415–895 BC (0.95), 869–853 BC (0.01)</td>
<td>1145 BC</td>
</tr>
<tr>
<td>41NA290</td>
<td>Beta-151118</td>
<td>2930</td>
<td>40</td>
<td>-24.1</td>
<td>2940</td>
<td>40</td>
<td>1256–1237 BC (0.08), 1215–1111 BC (0.50), 1103–1081 BC (0.08), 1065–1056 BC (0.03)</td>
<td>1291–1280 BC (0.01), 1270–1014 BC (0.94)</td>
<td>1156 BC</td>
</tr>
<tr>
<td>41UR77</td>
<td>UGA-12972</td>
<td>2980</td>
<td>40</td>
<td>-27.0</td>
<td>2950</td>
<td>40</td>
<td>1260–1115 BC (0.68)</td>
<td>1299–1026 BC (0.95)</td>
<td>1171 BC</td>
</tr>
<tr>
<td>41PN175</td>
<td>Beta-163092</td>
<td>2990</td>
<td>40</td>
<td>-25.4</td>
<td>2980</td>
<td>40</td>
<td>1291–1280 BC (0.04), 1270–1129 BC (0.64)</td>
<td>1375–1340 BC (0.05), 1320–1110 BC (0.86), 1103–1073 BC (0.03), 1066–1056 BC (0.01)</td>
<td>1217 BC</td>
</tr>
<tr>
<td>41HP118</td>
<td>SMU-1970</td>
<td>--</td>
<td>--</td>
<td>-21.5</td>
<td>2980</td>
<td>30</td>
<td>1266–1190 BC (0.50), 1179–1158 BC (0.10), 1145–1131 BC (0.08)</td>
<td>1371–1346 BC (0.02), 1316–1117 BC (0.93)</td>
<td>1218 BC</td>
</tr>
<tr>
<td>41NA290</td>
<td>Beta-151117</td>
<td>3030</td>
<td>40</td>
<td>-25.5</td>
<td>3020</td>
<td>40</td>
<td>1377–1338 BC (0.18), 1321–1252 BC (0.38), 1242–1213 BC (0.13)</td>
<td>1396–1153 BC (0.92), 1146–1129 BC (0.03)</td>
<td>1283 BC</td>
</tr>
</tbody>
</table>

*All probabilities rounded to the nearest hundredth. Missing values (--) were not reported in the original report.
Figure 94. Summed probability distributions from key East Texas Archaic sites illustrating the temporal position of Beta-163092.

Whether there is a Late Woodland or Formative Caddo occupation at the Murvaul Creek site lies beyond the scope of this synthesis, but several of the median dates fall within the latter range of the Late Woodland period. This could mean that the Murvaul Creek site (Figure 95 and Table 62) might be of considerable importance in current and future discussions aimed at delineating potential evidence for Caddo origins (when coupled with material culture analyses), those networks that existed between and among sites (Figure 96), and regional dialogues focused upon the development and organization of the Caddo cultural landscape. Although no Woodland-era dates were available from Louisiana for this synthesis, it remains important to look beyond the borders of Texas—particularly due to the geographic location of this site—for additional explanations, hypotheses, and connections.
Possible sites of Late Woodland contemporaneity (per \(^{14}\text{C}\) determinations) with Woodland occupation at 41PN175 at 25-mile increments.

**East Texas Caddo \(^{14}\text{C}\) Determinations from 41PN175, the ETRD, and NWLA Caddo dates**

Due to the substantive volume of dated Caddo sites in East Texas (n=913 dates from 151 sites) (Figure 97), the availability of those dates online (Perttula and Selden 2011) and in published form (Selden and Perttula 2013), no tables were produced for this section. In lieu of tables, geographic distributions of less than or equal to 75 miles were employed to illustrate—based solely upon median dates produced in OxCal—the location of possible contemporary components. For the East Texas dates, summed probability distributions were created for Caddo sites with 10 or more \(^{14}\text{C}\) dates to illustrate the temporal position of the Murvaul Creek site among these sites (Figure 98). The \(^{14}\text{C}\) dates employed in this synthesis from Northwest Louisiana are also plotted alongside those of the Murvaul Creek site to better illustrate where contemporary sites may might be said to occur (Figure 99). Figures 100 and 101 display those sites of possible contemporaneity with the Murvaul Creek site, and are segregated by temporal period.
<table>
<thead>
<tr>
<th>Site</th>
<th>Assay No.</th>
<th>Raw Age</th>
<th>±</th>
<th>( \delta^{13}C ) (‰)</th>
<th>Conv ( ^{14}C ) Age</th>
<th>±</th>
<th>1σ Age Range*</th>
<th>2σ Age Range*</th>
<th>Median</th>
</tr>
</thead>
<tbody>
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<td>41CE19</td>
<td>Tx-674</td>
<td>1420</td>
<td>100</td>
<td>-</td>
<td>1396</td>
<td>108</td>
<td>AD 542–723 (0.61), AD 740–770 (0.07)</td>
<td>AD 425–877 (0.95)</td>
<td>AD 639</td>
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<td>41TT372</td>
<td>Beta-71000</td>
<td>1420</td>
<td>60</td>
<td>-26.8%</td>
<td>1390</td>
<td>60</td>
<td>AD 595–682 (0.68)</td>
<td>AD 545–724 (0.89), AD 739–771 (0.06)</td>
<td>AD 643</td>
</tr>
<tr>
<td>41NA290</td>
<td>Beta-151116</td>
<td>1380</td>
<td>40</td>
<td>-24.5%</td>
<td>1390</td>
<td>40</td>
<td>AD 617–665 (0.68)</td>
<td>AD 573–688 (0.95)</td>
<td>AD 644</td>
</tr>
<tr>
<td>41NA226</td>
<td>Beta-183857</td>
<td>1280</td>
<td>60</td>
<td>-19.0%</td>
<td>1380</td>
<td>60</td>
<td>AD 598–688 (0.68)</td>
<td>AD 558–773 (0.95)</td>
<td>AD 651</td>
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<td>41DT62</td>
<td>Beta-52605</td>
<td>1370</td>
<td>110</td>
<td>-24.8%</td>
<td>1380</td>
<td>110</td>
<td>AD 556–773 (0.68)</td>
<td>AD 430–886 (0.95)</td>
<td>AD 657</td>
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<td>41DT6</td>
<td>Beta-51367</td>
<td>1370</td>
<td>80</td>
<td>-25.5%</td>
<td>1370</td>
<td>80</td>
<td>AD 595–718 (0.59), AD 743–769 (0.10)</td>
<td>AD 536–876 (0.95)</td>
<td>AD 663</td>
</tr>
<tr>
<td>41CE19</td>
<td>Tx-105</td>
<td>1120</td>
<td>90</td>
<td>-</td>
<td>1361</td>
<td>99</td>
<td>AD 582–775 (0.68)</td>
<td>AD 436–490 (0.03), AD 510–517 (0.00), AD 530–891 (0.92)</td>
<td>AD 676</td>
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<td>41NA285</td>
<td>Beta-204786</td>
<td>1340</td>
<td>40</td>
<td>-25.6%</td>
<td>1330</td>
<td>40</td>
<td>AD 652–695 (0.50), AD 701–707 (0.04), AD 748–765 (0.14)</td>
<td>AD 643–774 (0.95)</td>
<td>AD 686</td>
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<td>41TT847</td>
<td>Beta-242371</td>
<td>1360</td>
<td>40</td>
<td>-26.6%</td>
<td>1330</td>
<td>40</td>
<td>AD 652–695 (0.50), AD 701–707 (0.04), AD 748–765 (0.14)</td>
<td>AD 645–772 (1.00)</td>
<td>AD 686</td>
</tr>
<tr>
<td>41TT372</td>
<td>Beta-71006</td>
<td>1330</td>
<td>60</td>
<td>-26.1%</td>
<td>1310</td>
<td>60</td>
<td>AD 657–728 (0.46), AD 736–772 (0.22)</td>
<td>AD 635–876 (0.95)</td>
<td>AD 718</td>
</tr>
<tr>
<td>41AN38</td>
<td>Beta-236778</td>
<td>--</td>
<td>--</td>
<td>-26.2%</td>
<td>1290</td>
<td>40</td>
<td>AD 670–722 (0.43), AD 741–770 (0.25)</td>
<td>AD 653–783 (0.91), AD 789–812 (0.03), AD 845–856 (0.01)</td>
<td>AD 722</td>
</tr>
<tr>
<td>41SM273</td>
<td>Beta-173089</td>
<td>1310</td>
<td>40</td>
<td>-26.0%</td>
<td>1290</td>
<td>40</td>
<td>AD 670–722 (0.43), AD 741–770 (0.25)</td>
<td>AD 653–783 (0.91), AD 789–812 (0.03), AD 845–856 (0.01)</td>
<td>AD 722</td>
</tr>
<tr>
<td>41DT16</td>
<td>Beta-52242</td>
<td>1330</td>
<td>70</td>
<td>-25.9%</td>
<td>1310</td>
<td>70</td>
<td>AD 652–776 (0.68)</td>
<td>AD 612–883 (0.95)</td>
<td>AD 723</td>
</tr>
<tr>
<td>41BW692</td>
<td>UGA-13420</td>
<td>1270</td>
<td>40</td>
<td>-24.7%</td>
<td>1280</td>
<td>40</td>
<td>AD 676–729 (0.40), AD 736–772 (0.28)</td>
<td>AD 657–825 (0.93), AD 841–862 (0.03)</td>
<td>AD 730</td>
</tr>
<tr>
<td>41CP245</td>
<td>Beta-208773</td>
<td>1320</td>
<td>40</td>
<td>-27.5%</td>
<td>1280</td>
<td>40</td>
<td>AD 676–729 (0.40), AD 736–772 (0.28)</td>
<td>AD 657–825 (0.93), AD 841–862 (0.03)</td>
<td>AD 730</td>
</tr>
<tr>
<td>41HS231</td>
<td>Beta-236382</td>
<td>1300</td>
<td>40</td>
<td>-26.2%</td>
<td>1280</td>
<td>40</td>
<td>AD 676–729 (0.40), AD 736–772 (0.28)</td>
<td>AD 657–825 (0.93), AD 841–862 (0.03)</td>
<td>AD 730</td>
</tr>
<tr>
<td>41HS231</td>
<td>Beta-236383</td>
<td>1290</td>
<td>40</td>
<td>-25.4%</td>
<td>1280</td>
<td>40</td>
<td>AD 676–729 (0.40), AD 736–772 (0.28)</td>
<td>AD 657–825 (0.93), AD 841–862 (0.03)</td>
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</tr>
<tr>
<td>41DT16</td>
<td>Beta-52241</td>
<td>1300</td>
<td>60</td>
<td>-25.5%</td>
<td>1290</td>
<td>60</td>
<td>AD 663–775 (0.68)</td>
<td>AD 649–878 (0.95)</td>
<td>AD 735</td>
</tr>
<tr>
<td>41LR297</td>
<td>Beta-239524</td>
<td>1290</td>
<td>40</td>
<td>-25.9%</td>
<td>1280</td>
<td>50</td>
<td>AD 671–774 (0.68)</td>
<td>AD 599–895 (0.95), AD 925–937 (0.01)</td>
<td>AD 736</td>
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</table>
Table 62 (continued)

<table>
<thead>
<tr>
<th>Site</th>
<th>Assay No.</th>
<th>Raw Age</th>
<th>±</th>
<th>Conv ¹³C Age</th>
<th>±</th>
<th>¹σ Age Range*</th>
<th>±σ Age Range*</th>
<th>Median</th>
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<tr>
<td>41RK558</td>
<td>Beta-278035</td>
<td>1280</td>
<td>40</td>
<td>-25.9 ‰</td>
<td>1270</td>
<td>AD 682–774 (0.68)</td>
<td>AD 682–830 (0.89), AD 836–869 (0.06)</td>
<td>AD 737</td>
</tr>
<tr>
<td>41PN175</td>
<td>Group 4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1245</td>
<td>AD 692–749 (0.51), AD 764–779 (0.14) AD 795–800 (0.03)</td>
<td>AD 684–828 (0.89), AD 838–866 (0.06)</td>
<td>AD 742</td>
</tr>
<tr>
<td>41DT16</td>
<td>Beta-51372</td>
<td>1300</td>
<td>80</td>
<td>-26.0 ‰</td>
<td>1290</td>
<td>AD 654–782 (0.60), AD 789–810 (0.06), AD 848–855 (0.02)</td>
<td>AD 606–897 (0.94), AD 923–941 (0.01)</td>
<td>AD 744</td>
</tr>
<tr>
<td>41NA285</td>
<td>Beta-201990</td>
<td>1240</td>
<td>40</td>
<td>-23.9 ‰</td>
<td>1260</td>
<td>AD 680–779 (0.68)</td>
<td>AD 668–870 (0.95)</td>
<td>AD 744</td>
</tr>
<tr>
<td>41SM273</td>
<td>Beta-157990</td>
<td>1270</td>
<td>40</td>
<td>-25.7 ‰</td>
<td>1260</td>
<td>AD 680–779 (0.68)</td>
<td>AD 668–870 (0.95)</td>
<td>AD 744</td>
</tr>
<tr>
<td>41TT372</td>
<td>Beta-70994</td>
<td>1290</td>
<td>50</td>
<td>-26.4 ‰</td>
<td>1270</td>
<td>AD 670–778 (0.68)</td>
<td>AD 660–875 (0.95)</td>
<td>AD 744</td>
</tr>
<tr>
<td>41CE19</td>
<td>Tx-919</td>
<td>1310</td>
<td>80</td>
<td>–</td>
<td>1286</td>
<td>AD 665–820 (0.63), AD 842–860 (0.05)</td>
<td>AD 602–901 (0.91), AD 917–966 (0.04)</td>
<td>AD 751</td>
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<tr>
<td>41SY41</td>
<td>Beta-97897</td>
<td>960</td>
<td>70</td>
<td>-6.0 ‰</td>
<td>1270</td>
<td>AD 664–782 (0.58), AD 789–810 (0.08), AD 848–855 (0.02)</td>
<td>AD 645–896 (0.94), AD 924–938 (0.01)</td>
<td>AD 755</td>
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<tr>
<td>41NA49</td>
<td>Tx-4876</td>
<td>1280</td>
<td>100</td>
<td>–</td>
<td>1280</td>
<td>AD 665–870 (0.68)</td>
<td>AD 576–984 (0.95)</td>
<td>AD 760</td>
</tr>
<tr>
<td>41CE19</td>
<td>Tx-1223</td>
<td>1290</td>
<td>80</td>
<td>–</td>
<td>1266</td>
<td>AD 665–826 (0.61), AD 840–863 (0.07)</td>
<td>AD 622–972 (0.95)</td>
<td>AD 767</td>
</tr>
<tr>
<td>41DT6</td>
<td>Beta-51364</td>
<td>1270</td>
<td>60</td>
<td>-26.2 ‰</td>
<td>1250</td>
<td>AD 680–818 (0.62), AD 843–860 (0.06)</td>
<td>AD 657–895 (0.95), AD 927–935 (0.01)</td>
<td>AD 768</td>
</tr>
<tr>
<td>41NA285</td>
<td>Beta-221421</td>
<td>1250</td>
<td>40</td>
<td>-25.5 ‰</td>
<td>1240</td>
<td>AD 690–752 (0.36), AD 761–783 (0.12), AD 788–815 (0.13), AD 844–859 (0.06)</td>
<td>AD 680–882 (0.95)</td>
<td>AD 772</td>
</tr>
<tr>
<td>41RK214</td>
<td>Beta-107402</td>
<td>1130</td>
<td>50</td>
<td>-18.4 ‰</td>
<td>1240</td>
<td>AD 689–753 (0.33), AD 760–822 (0.27), AD 842–861 (0.08)</td>
<td>AD 669–890 (0.95)</td>
<td>AD 775</td>
</tr>
<tr>
<td>41LR152</td>
<td>Beta-153588</td>
<td>–</td>
<td>–</td>
<td>-28.7 ‰</td>
<td>1240</td>
<td>AD 688–827 (0.59), AD 840–864 (0.09)</td>
<td>AD 660–897 (0.94), AD 923–940 (0.02)</td>
<td>AD 779</td>
</tr>
</tbody>
</table>

*All probabilities rounded to the nearest hundredth. Missing values (–) were not reported in the original report.
Figure 96. Temporal position of Group 4 among East Texas Woodland sites with four or more $^{14}$C dates.
97. Possible sites of Caddo contemporaneity (per $^{14}$C determinations) with 41PN175 at 25-mile increments.

Figure 97. Possible sites of Caddo contemporaneity (per $^{14}$C determinations) with 41PN175 at 25-mile increments.

**Summary and Conclusion**

With the decreasing cost of attaining $^{14}$C determinations from increasingly smaller samples, archeologists are becoming ever more mindful of the research potential that $^{14}$C dates can offer (see Kuzmin and Keates 2005; Rick 1987; Steele 2010; Williams 2012). One trend evidenced here—and in other studies (see Surovell and Brantingham 2007; Surovell et al. 2009)—is that the number of younger components outnumbers that of older components. This observation plays an integral role in the recent push toward highlighting fluctuations in prehistoric demography via radiocarbon (Bamforth and Grund 2012; Buchanan et al. 2008; Faught 2008; Hinz et al. 2012; Peros et al. 2010), and the curative methods advanced to correct for taphonomic bias (Surovell and Brantingham 2007; Surovell et al. 2009).

There has been a recent decrease in the amount of research aimed at discussions of specific occupational episodes and the potential trade and/or exchange that may have occurred between sites (Agbe-Davies and Bauer 2011), which can contribute greatly to issues of power and identity throughout a region (Kelly 2011). However, recent technological and statistical advances have made it less complicated to remove investigator
Figure 98. Temporal position of the Murvaul Creek site among East Texas Caddo components with 10 or more $^{14}$C dates.
bias from the process of delineating sites with simultaneous temporal occupations (see Grove 2008, 2009, 2010).

Advancements in combining the analysis of $^{14}$C and data from other sources—stratigraphic (Bronk Ramsey 1995, 2007; Michczynski and Pazdur 2003), phases (Buck et al. 1991; Ziedler et al. 1998), architecture (Bayliss et al. 2007; Whittle et al. 2011),
Figure 100. Graphic showing locations of contemporaneous dated sites from the Formative Caddo (upper) and Early Caddo (below) periods.
Figure 101. Graphic showing locations of contemporaneous dated sites from the Middle Caddo (upper) and Late Caddo (below) periods.
paleoenvironmental records (Gearey et al. 2009), tephrochronology (Buck et al. 2003), climate (Kidder 2006), and even ceramic data (Buck et al. 1992)—can provide an integral toolkit for exploring potential associations between $^{14}$C determinations and archaeological datasets, providing testable hypotheses that can be validated or falsified with the addition of more data (Bayliss and Ramsey 2004). Bayesian models of radiocarbon have been employed for more than 15 years in Great Britain (Bayliss 2009; Bronk Ramsey 2008, 2009; Buck et al. 1996), and are widely employed within CRM endeavors (Bayliss 2009; Bayliss et al. 2005; Buck et al. 1994) with great success. Within the context of the Murvaul Creek site, each temporal period could benefit from further analysis of the trends highlighted here, aiding in the development of more substantive and empirically supported theories of social interaction within greater East Texas.

A regional model of trade and exchange within greater East Texas would occur at an appropriate scale to begin a discussion of cultural transmission—whether vertical (Shennan and Steele 1999:376), oblique (Shennan 2002:49), master/apprentice (Epstein 1998:688–693; Silver 1981:43–44), or horizontal (Cavalli-Sforza and Feldman 1981)—which might be further evidenced in innovative ceramic decorations (Hosfield 2009). Within that context, variation and transmission become important mechanisms of ceramic traditions along with their differential persistence in the archeological record (Neff 1996).
Chapter 9: Plant Remains from Site 41PN175, Panola County, Texas
by Leslie L. Bush, Ph.D.

Twenty flotation samples from site 41PN175 were submitted for evaluation of macrobotanical remains. All samples were taken from feature context; feature types consisted of pits (n=12), smudge pits (n=3), hearths (n=3), and postmolds (n=2). Flotation volumes ranged from 2 to 33 cubic decimeters (dm; “liters”), and the total volume of feature fill processed from the site was 269.75 dm³. Site 41PN175 is a Middle–Late Caddo habitation with a small Archaic component (THC Site Forms 5/1/2000, 5/7/2002). Radiocarbon dates indicate most site use occurred during a short period in the late fifteenth or early sixteenth century.

Setting

Ecological
Site 41PN175 is situated in Panola County south of modern Carthage, Texas, where Farm-to-Market road 10 (FM-10) crosses Murvaul Creek. Mean annual precipitation in Panola County during the period 1951–1980 was 46.2 inches (1173 millimeters [mm]). Precipitation is distributed fairly evenly over the year, with a slight dip in late summer. The frost-free season in Panola County averages 240 days and runs from March 16 through November 11 (Natural Fibers Information Center [NFIC] 1987:387–388).

Murvaul Creek drains into the Sabine River southeast of Carthage. The area lies squarely in the Pineywoods ecological region. Upland forests in this part of the Texas Pineywoods in presettlement times typically would have been shortleaf pine communities, where shortleaf pine (Pinus echinata) shared dominance with oaks (several species, of both red and white groups) and hickories (several species, but frequently Carya texana) (Diggs et al. 2006:88–89). Coves and small streams were characterized by mixed hardwood-loblolly pine communities that would have included black cherry (Prunus serotina), American holly (Ilex opaca), and sassafras (Sassafras albidum). The lowlands associated with Murvaul Creek would have supported flood-tolerant hardwoods such as white oak (Quercus alba), water oak (Q. nigra), sweetgum (Liquidambar styraciflua), beech (Fagus grandifolia), and magnolia (Magnolia grandiflora) (Diggs et al. 2006:89–90).

Vegetation Reconstructions
Commercial harvesting has resulted in significant changes in Pineywoods vegetation since the mid-nineteenth century, with plantations of loblolly pine replacing shortleaf and longleaf stands. Nonetheless, modern equivalents exist for most prehistoric plant communities in East Texas (Diggs et al. 2006:87). Pollen studies indicate that use of the modern vegetation zones described above is appropriate for understanding the plants and attendant animal resources available to people during the first and second millennia. Weakly Bog, situated in
the Post Oak Savannah vegetation region southwest of Panola County, provides some of the best data for vegetation reconstruction in the eastern half of Texas during the last 3,000 years (Bousman 1998). Pollen profiles from this bog indicate oak and later oak-hickory woodlands, suggesting that modern plant communities generally provide good analogs for Texas plant communities during the last 3,000 years. A recent study by Bruce Albert (2007) in southwest Upshur County provides supporting data. However, some fluctuations in rainfall and temperature have taken place (Bousman 1998:204). Spikes in grass pollen at approximately 500 B.P. and 1500 B.P. suggest drier conditions during those times (Bousman 1998).

Methods

Flotation samples from site 41PN175 were processed at the Geo-Marine Plano office in a SMAP-type flotation system (Pearsall 2000). Light fractions were caught in a 212-micrometer sieve, and heavy fractions were passed through a \( \frac{1}{16} \)" (1.6 mm) window screen. Separation was imperfect, with most carbonized plant material remaining in the heavy fractions. Carbonized material was picked from the heavy fractions and sent to Macrobotanical Analysis along with the light fractions. They were combined for examination and reporting here.

Prior to full analysis, some samples were scanned to select plant material for possible radiocarbon dating. Material for dating was subject to full radiocarbon protocols in the laboratory and was bagged and labeled separately from the other flotation material. That material is included in the flotation tables in this report along with the other material recovered from flotation samples.

After material for possible dating was removed, flotation samples were sorted according to standard procedures at the Macrobotanical Analysis laboratory in Manchaca, Texas. Both light and heavy fractions of each sample were size-sorted through a stack of graduated geologic mesh for ease of focus under the microscope, and all size fractions were examined under a stereoscopic microscope at 7-45X magnification. Materials that did not pass through the No. 10 mesh (2-mm square openings) were completely sorted, counted, weighed, recorded, and labeled. Weights were taken on an Ohaus Scout II 200 x 0.01 gram (g) electronic balance. The 2-mm size fraction was sorted into various categories of carbonized botanical remains and “contamination,” which at this site consisted of uncarbonized botanical remains such as rootlets, leaves, and grass stems as well as insects and burned soil. Contamination was weighed, recorded, and labeled only. Materials that fell through the 2-mm mesh (“residue”) were examined under a stereoscopic microscope at 7-45X magnification for carbonized botanical remains other than wood charcoal and hickory/walnut family nutshell. Identifiable material was removed from residue, counted, weighed, recorded, and labeled. Uncarbonized seeds and other plant parts were identified and recorded on a presence/absence basis on laboratory forms. As discussed below, uncarbonized plants are modern.
In addition to the three wood charcoal specimens selected for possible radiocarbon dating, wood charcoal identification was attempted for 20 randomly selected specimens larger than 2 mm from each flotation sample. In one case (Feature 79), a specimen of elm wood noted in sorting was added to the identified sample when it was not randomly selected for identification. Wood charcoal fragments selected for identification were snapped to reveal a transverse section and examined under a stereoscopic microscope at 28-180 X magnification. When necessary, tangential or radial sections were examined for ray seriation, presence of spiral thickenings, types and sizes of intervessel pitting, and other minute characteristics that can only be seen at the higher magnifications of this range.

Botanical materials were identified to the lowest possible taxonomic level by comparison to materials in the Macrobotanical Analysis comparative collection and through the use of standard reference works (Core et al. 1979; Davis 1993; Hoadley 1990; Martin and Barkley 2000; Musil 1963; Panshin and de Zeeuw 1980). Botanical nomenclature follows that of the PLANTS Database (United States Department of Agriculture, Natural Resources Conservation Service [USDA, NRCS] 2013).

Results and Discussion
Plants recovered are documented in Tables 63–65. The first table shows uncarbonized (modern) plants on a presence/absence basis. Tables 64 and 65 show carbonized (ancient) and semicarbonized (likely modern) plants by count and weight, respectively.

Archeological Versus Modern Plants
Uncarbonized seeds were not numerous, but they were present in 17 of the 20 flotation samples (see Table 63). The ubiquity of carpetweed (Mollugo verticillata) in the samples is notable since it indicates that flotation techniques were sufficient to recover this small seed (0.7-mm diameter). The 11 types of uncarbonized plant parts consist largely of seeds of weedy plants (n=9) typical of roadsides such as FM-10 and landscapes undergoing disturbances associated with archeological investigations. Fragments of pine wood and acorn nutshell were also noted, and these would also be expected in the site area. Uncarbonized seeds are a common occurrence on most archeological sites, and they usually represent seeds of modern plants that have made their way into the soil either through their own dispersal mechanisms or by faunalturbation, floralturbation, or argilliturbation (Bryant 1985:51–52; Miksicek 1987:231–232). In all except the driest areas of North America, uncarbonized plant material on open-air sites can be assumed to be of modern origin unless compelling evidence suggests otherwise (Lopinot and Brussell 1982; Miksicek 1987:231). Accordingly, uncarbonized seeds from site 41PN175 are interpreted as modern here, as are the pine wood and acorn nutshell.

The semicarbonized material is more difficult to interpret. As shown in Tables 64 and 65, it consists of pine wood, acorn nutshell, and bark. These taxa were also recovered in uncarbonized and carbonized forms at site 41PN175. Although it is possible that some
Table 63: Uncarbonized Material from Site 41PN175 Flotation Samples

| Lot # | 1800 | 1805 | 1810 | 1819 | 1840 | 1841 | 1940 | 1943 | 1968 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | Total Occurrences |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------------------|
| Carpetweed (Mollugo verticillata) | X | - | X | X | X | - | X | X | X | - | X | X | X | - | X | X | X | X | X | X | 16 |
| Flatsedge (Cyperus sp.) | X | - | - | - | - | - | - | X | X | - | - | - | - | - | - | - | - | X | - | 4 |
| Grass family (Poaceae) | - | - | - | - | - | - | X | X | X | - | - | - | - | - | - | - | - | - | - | 3 |
| Copperleaf (Acalypha sp.) | - | - | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | X | - | 2 |
| Pine wood (Pinus sp.) | - | - | - | X | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| Coneflower (Rudbeckia/Echinacea sp.) | X | - | - | - | - | - | - | - | - | - | - | - | X | - | - | - | - | - | - | 2 |
| Sedge (Carex sp.) | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Goosefoot (Chenopodium sp.) | X | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Goosegrass (Elymus indica) | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Purslane (Portulaca oleracea) | - | - | - | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | 1 |
| Acorn nutshell (Quercus sp.) | - | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Total Taxa in Sample | 4 | 1 | 1 | 2 | 2 | 2 | 1 | 4 | 0 | 4 | 4 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 3 | 1 |

NOTE: X = present
Roots and bark omitted
All plant parts are seeds unless otherwise indicated
Table 64: Carbonized and Semicarbonized Material Counts from Site 41PN175 Flotation Samples
Lot #
Feature
Portion
Level
Depth (cmbd)
Type
Liters processed
Wood
Pine (Pinus sp.)
White group oak (Quercus subg.
Quercus)
Oak (Quercus sp.)
Red group oak (Quercus subg.
Lobatae)
Hickory (Carya sp.)
Sweetgum (Liquidambar
styraciflua)
Ash (Fraxinus sp.)
Plum/cherry (Prunus sp.)
Boxelder (Acer sp.)
Sassafras (Sassafras albidum)
Willow/cottonwood (Salicaceae)
Possumhaw/Holly (Ilex sp.)
Black walnut (Juglans nigra)
Elm (Ulmus sp.)
American hornbeam (Carpinus
caroliniana)
Diffuse-porous hardwood
Ring-porous hardwood
Hardwood
Not examined for species
Total wood identified (n)
Corn (Zea mays)
Cupules
Glumes
Kernels
Squash (Cucurbita sp.)
Rind
Flower scar
River cane (Arundinaria gigantea)
Nutshell
Hickory (Carya sp.)
Hickory/walnut family
(Juglandaceae)
Acorn (Quercus sp.)
Black walnut (Juglans nigra)
Other Nut Parts
Hickory nut hull (Carya sp.)
Acorn nut meat (Quercus sp.)
Seeds
Sumac (Rhus sp.)
Copperleaf (Acalypha sp.)
Indeterminable

1800
1805
1810
1819
7
9
10
15
NE ¼, W ½ E ½, W ½
S½
W½
1
5
1
5
45-59
45-58
45-55
45-52
Pit
Pit
Smudge pit
Pit
24.00
23.00
2.00
7.50

1840
29
N½
1
56-70
Hearth
20.00

1841
1940
1943
30
87
88
S½
E ½2
N½
1
1
1
59-68
60-75
90-124
Pit
Smudge pit Hearth
3.00
9.00
33.00

1968
105
SE ½
1
50-60
Pit
4.50

2020
53

2021
57

2022
58

2023
62

2024
68

2025
72

2026
79

2027
85

2028
86

2029
89

2030
97

Flotation total

1
60-70
Pit
11.50

1
60-90
Pit
9.50

1
1
1
65-79
65-70
65-85
Pit
Smudge pit
Pit
14.00
5.00
11.25

1
60-74
Post
4.00

1
55-79
Pit
16.00

1
60-73
Post
3.75

1
60-67
Hearth
6.00

1
90-110
Pit
32.25

1
65-92
Pit
30.50

269.75

9
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14
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20

6
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16
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21
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4
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20

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17

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142
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1217
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291
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223
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25
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555
21

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174
20

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37
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275
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47
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604
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185
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12
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14
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5
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43
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21
5

137
30

63
20

199
40

51
13

17
4

34
9

61
13

4
8

8
6

127
45

885
220

8
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13
1
1

273


<table>
<thead>
<tr>
<th>Lot #</th>
<th>Feature</th>
<th>Portion</th>
<th>Level</th>
<th>Depth (cmbd)</th>
<th>Liters processed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NE W, W</td>
<td>E W</td>
<td>E W</td>
<td>45-59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 10 15</td>
<td>30 30</td>
<td>59</td>
<td>7.50</td>
</tr>
<tr>
<td>1000</td>
<td>Waterlily family (Nymphaceae)</td>
<td>- - -</td>
<td>- - -</td>
<td>- -</td>
<td>-</td>
</tr>
<tr>
<td>1001</td>
<td>Indeterminable</td>
<td>- - -</td>
<td>- - -</td>
<td>- -</td>
<td>-</td>
</tr>
<tr>
<td>2001</td>
<td>Pine bark</td>
<td>3 39</td>
<td>1</td>
<td>1894</td>
<td>1</td>
</tr>
<tr>
<td>2002</td>
<td>Resin</td>
<td>8 1</td>
<td>1</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>2003</td>
<td>Seeds</td>
<td>- -</td>
<td>-</td>
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<tr>
<td>2004</td>
<td>Other</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2005</td>
<td>Indeterminable</td>
<td>27 12</td>
<td>2</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>2006</td>
<td>Stem</td>
<td>- -</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2007</td>
<td>Liana</td>
<td>- -</td>
<td>-</td>
<td>-</td>
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<td>2008</td>
<td>Root</td>
<td>- -</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>2009</td>
<td>Semi-carbonized Plant Parts</td>
<td>2 8</td>
<td>4</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>Pine wood (Pinus sp.)</td>
<td>- -</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2011</td>
<td>Bark</td>
<td>- -</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2012</td>
<td>Acorn nutshell (Quercus sp.)</td>
<td>- -</td>
<td>-</td>
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</tbody>
</table>

| Total | 269.75 | 274 |

Table 64 (continued)
<table>
<thead>
<tr>
<th>Lot</th>
<th>Feature</th>
<th>Pinch Level</th>
<th>Depth (cm)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>Nutshell</td>
<td>1/4 to 1/3</td>
<td>1/4 to 1/3</td>
<td>1/4 to 1/3</td>
</tr>
<tr>
<td>1805</td>
<td>Pine (Pinus sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1810</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1819</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1840</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1841</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1843</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
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<td>1848</td>
<td>Conifer (Picea sp.)</td>
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<td>1854</td>
<td>Conifer (Picea sp.)</td>
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</tr>
<tr>
<td>2020</td>
<td>Conifer (Picea sp.)</td>
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<td>-</td>
</tr>
<tr>
<td>2021</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
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<td>-</td>
</tr>
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<td>2022</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2023</td>
<td>Conifer (Picea sp.)</td>
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<td>2024</td>
<td>Conifer (Picea sp.)</td>
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<td>2025</td>
<td>Conifer (Picea sp.)</td>
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<td>2026</td>
<td>Conifer (Picea sp.)</td>
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</tr>
<tr>
<td>2027</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2028</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2029</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2030</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2031</td>
<td>Conifer (Picea sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 65: Carbonized and Semicarbonized Material Weight in Grams from Site 41PN175 Flotation Samples

<table>
<thead>
<tr>
<th>Feature</th>
<th>Site 41PN175</th>
<th>Site 41PN175</th>
<th>Site 41PN175</th>
<th>Site 41PN175</th>
<th>Site 41PN175</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutshell</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hickory (Carya sp.)</td>
<td>121</td>
<td>0.27</td>
<td>-</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td>Black walnut (Juglans nigra)</td>
<td>0.03</td>
<td>0.01</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other nuts</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Seeds</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Notes
- Site 41PN175 provides data on carbonized and semicarbonized material weights from flotation samples.
- The table includes various features such as Nutshell, Hickory, Black walnut, and Seeds.
- The data is presented in grams for different sites.
<table>
<thead>
<tr>
<th>Lot</th>
<th>Feature</th>
<th>Portion</th>
<th>Level</th>
<th>Depth (in cm)</th>
<th>Type</th>
<th>Liters processed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NE ¼, W ½</td>
<td></td>
<td>1</td>
<td>45.89 Pit</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E ½, W ½</td>
<td>5</td>
<td>1</td>
<td>46.58 Pit</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>45-55 Smudge pit</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>59-68 Pit</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waterly family (Nymphaeaceae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Indeterminable</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Non-wood pine parts (Pinus sp.)</td>
<td>-</td>
<td>0.02</td>
<td>0.01</td>
<td>0.13</td>
<td>-</td>
</tr>
<tr>
<td>Cone scales</td>
<td>-</td>
<td>0.09</td>
<td>9.06</td>
<td>0.12</td>
<td>8.91</td>
<td>0.01</td>
</tr>
<tr>
<td>Resin</td>
<td>-</td>
<td>0.04</td>
<td>0.01</td>
<td>0.36</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Seeds</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>Bark</td>
<td>-</td>
<td>0.04</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Indeterminable</td>
<td>-</td>
<td>0.17</td>
<td>0.06</td>
<td>-</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>Stem</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Liana</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Root</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Semi-carbonized plant parts</td>
<td>Bark</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acorn nutshell (Quercus sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.07</td>
<td>0.01</td>
</tr>
<tr>
<td>Pine wood (Pinus sp.)</td>
<td>-</td>
<td>0.07</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total weight</td>
<td>2.82</td>
<td>1.31</td>
<td>17.59</td>
<td>0.26</td>
<td>3.98</td>
<td>2.50</td>
</tr>
<tr>
<td>Weight per liter</td>
<td>0.12</td>
<td>0.06</td>
<td>8.80</td>
<td>0.03</td>
<td>0.20</td>
<td>0.83</td>
</tr>
</tbody>
</table>

| Pit | Pit | Smudge pit | Pit | Heath | Pit | Smudge pit | Heath | Pit | Pit | Pit | Pit | Smudge pit | Pit | Post | Post | Heath | Pit | Pit | Pit |
|-----|-----|-----------|-----|------|-----|-----------|------|-----|-----|-----|-----|-----|-----------|-----|------|------|-------|-----|-----|-----|
| 0.17 | 0.12 | 8.80 | 0.06 | 0.20 | 0.83 | 1.19 | 0.41 | 3.02 | 0.07 | 0.44 | 0.16 | 2.91 | 0.15 | 0.61 | 0.46 | 0.69 | 0.12 | 0.25 | 0.17 |

| Site Total | 269.75 | 276 |
semicarbonized plants may have survived from the relatively recent Late Caddo occupation, the presence of these taxa in uncarbonized form suggests recent burning in the site area. The semicarbonized plant remains are therefore not interpreted as ancient plants. In addition, it is possible that some fully carbonized pine wood and acorn may also represent modern plants.

**Wood Charcoal**
A total of 55.24 g of wood charcoal was recovered. The contexts from which it was recovered indicate fuel use. As noted above, flotation contexts consist of secondary or tertiary waste disposal (pits and postmolds) and primary burning contexts (hearths and smudge pits). The wood charcoal should therefore reflect woody vegetation in the immediate site area (Asch and Asch 1986; Schackleton and Prins 1992). Identification was attempted for 398 wood charcoal fragments, a figure that includes wood for radiocarbon dating as well as systematic selection from flotation samples. Of that total, 383 were identifiable to the family, genus, or species. Oaks (*Quercus* spp.; n=149) and pine (*Pinus* spp.; n=142) were the most common woods identified. As noted above, some pine charcoal could represent modern burning. Hickory (*Carya* spp.; n=27), sweetgum (*Liquidambar styraciflua*; n=18), and ash (*Fraxinus* sp.; n=14) were also important in the assemblage (Figure 102). Other woods consisted of maple or boxelder (*Acer* spp.), sassafras (*Sassafras albidum*), willow or cottonwood (Salicaceae), possumhaw or yaupon (*Ilex* spp.), black walnut (*Juglans nigra*), elm (*Ulmus* sp.), and American hornbeam (*Carpinus caroliniana*). The wood charcoal assemblage, dominated by oak, pine, and hickory, indicates that fuel wood was usually taken from upland areas near the site, but the slopes and bottomlands near Murvaul Creek are also represented in sweetgum, ash, maple/boxelder, and willow/cottonwood.

**Agricultural Products**
Corn (*Zea mays* spp. *mays*) was present in seven of 20 samples. The features containing corn were identified in the field as smudge pits, hearths, and pits. The corn consisted primarily of cob parts (cupules and glumes; n=136), but some kernel fragments were also identified (n=5). The 39 cupules that were complete enough for measurement had an average width of 4.9 mm and a thickness (height) of 2.3 mm (Table 66; Figure 103). As shown in Table 67, corn cupules at 41PN175 fall into the smaller end of the range for Caddo corn but are similar in size to those from Oak Hill Village (41RK214) and the site 41TT852 hamlet. Although there is some overlap in size, the three cupules in Feature 57 were larger on average than the 36 in Feature 87, suggesting different types of corn in the two features. Both Perttula (1992:17–18) and Smith (1995:11) note that the Caddo planted two types of corn: one in the spring, or “little corn,” and one in the summer, a “flour corn.”

A second cultigen, domesticated squash (*Cucurbita* sp.), was present in two contexts, both pit features. Feature 89 yielded two flower scars (Figure 104), and Feature 79 produced a single rind fragment. At 2.7 mm in thickness, the carbonized rind fragment easily meets the “King’s Rule” criterion of 2 mm for domesticated squash (Peterson and Sidell 1996; Smith 1992:42).
River Cane
The flotation sample that produced most of the corn, Feature 87, was also the only feature to yield river cane (*Arundinaria gigantea*). The cane consisted of two stem fragments. Feature 87 was identified as a smudge pit in the field and also contained many pinecone fragments.

Nutshell
Hickory nutshell (thick *Carya* sp.) was common on the site, with a total of 18.60 g recovered from 18 of the 20 flotation samples. Black walnut (*Juglans nigra*) was less common, with 0.19 g recovered from three features. An additional 1.85 g of nutshell from the hickory/walnut family that could not be assigned to genus was also recovered. Acorn (*Quercus* sp.) occurred in 13 samples, but some of this may represent modern material, especially in Feature 57 and Feature 87 where acorn nutshell was also noted in semicarbonized and uncarbonized forms, respectively.

Other Seeds
Fifteen small, wild seeds were recovered in carbonized form. Thirteen of these, all from Feature 79, were sumac (*Rhus* sp.), a small tree or shrub that is usually found on forest openings and margins. Sumac is often spread by birds, who are fond of their fruits, and the plants can form large colonies by suckering (Simpson 1999:305). These two means of spreading frequently lead to an abundance of sumac in old agricultural fields. Sumac’s...
**Table 66: Corn Cupule (Zea mays) Measurements from Site 41PN175**

<table>
<thead>
<tr>
<th>Provenience</th>
<th>Width</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS 1940, Feature 87 (E ½), (^{14})C Beta 344091</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.3</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>5.4</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>3.7</td>
<td></td>
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<td>3.8</td>
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<tr>
<td>4.1</td>
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<td>5.8</td>
<td>2.5</td>
<td></td>
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<td>4.6</td>
<td>2.5</td>
<td></td>
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<tr>
<td>4.0</td>
<td>1.3</td>
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</tr>
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<td>3.0</td>
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<td>4.7</td>
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<td>5.3</td>
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<td>4.4</td>
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<td>6.3</td>
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<td></td>
</tr>
<tr>
<td>4.7</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td><strong>Feature mean</strong></td>
<td><strong>4.8</strong></td>
<td><strong>2.3</strong></td>
</tr>
<tr>
<td>FS 2021, Feature 57 (Level 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.4</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>4.4</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>2.0</td>
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</tr>
<tr>
<td><strong>Feature mean</strong></td>
<td><strong>5.7</strong></td>
<td><strong>2.0</strong></td>
</tr>
</tbody>
</table>

Measurements in mm
All cupules loose unless otherwise indicated
Figure 103. Corn (Zea mays) cupule widths from site 41PN175.

Table 67: Mean Corn Cupule (Zea mays) Measurements from Selected Caddo Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Cupule width</th>
<th>Cupule thickness (height)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak Hill Village (41RK214) Fea. 85</td>
<td>4.7</td>
<td>2.18</td>
<td>Elson et al. 2004</td>
</tr>
<tr>
<td>41PN175</td>
<td>4.9</td>
<td>2.3</td>
<td>this report</td>
</tr>
<tr>
<td>Oak Hill Village (41RK214) Fea. 86*</td>
<td>4.84</td>
<td>3.08</td>
<td>Elson et al. 2004</td>
</tr>
<tr>
<td>41TT852</td>
<td>4.99</td>
<td>2.87</td>
<td>Bush 2011</td>
</tr>
<tr>
<td>Pine Tree Mound (41HS15)</td>
<td>5.26</td>
<td>2.3</td>
<td>Bush 2012b</td>
</tr>
<tr>
<td>Henry M. (41NA60) Lot 160b</td>
<td>5.37</td>
<td>1.5</td>
<td>Bush 2010a</td>
</tr>
<tr>
<td>Stallings Ranch (41LR297)</td>
<td>5.38</td>
<td>3.06</td>
<td>Bush 2008</td>
</tr>
<tr>
<td>Sha’chahdinnih (41MR211) Lot 175</td>
<td>5.9</td>
<td>2.4</td>
<td>Goldborer 2002</td>
</tr>
<tr>
<td>41TT853</td>
<td>5.9</td>
<td>2.8</td>
<td>Bush 2011</td>
</tr>
<tr>
<td>Henry M. (41NA60) Lot 292</td>
<td>6.14</td>
<td>2.3</td>
<td>Bush 2010a</td>
</tr>
<tr>
<td>Henry M. (41NA60) Lot 160a</td>
<td>6.9</td>
<td>1.95</td>
<td>Bush 2010a</td>
</tr>
<tr>
<td>41SM404 Feature 1</td>
<td>7.05</td>
<td>3.36</td>
<td>Bush 2010b</td>
</tr>
<tr>
<td>Sha’chahdinnih (41MR211) Lot 52B</td>
<td>7.3</td>
<td>2.9</td>
<td>Goldborer 2002</td>
</tr>
<tr>
<td>Sha’chahdinnih (41MR211) Lot 51</td>
<td>8.08</td>
<td>3.8</td>
<td>Goldborer 2002</td>
</tr>
<tr>
<td>Sha’chahdinnih (41MR211) Lot 52A</td>
<td>9.2</td>
<td>3.3</td>
<td>Goldborer 2002</td>
</tr>
<tr>
<td>Winding Stair (3MN496)</td>
<td>6.5</td>
<td>n/a</td>
<td>Williams 2000</td>
</tr>
<tr>
<td>Ramos Creek (34MC1030) Lot 448.3</td>
<td>8.43</td>
<td>3.28</td>
<td>Dowd in preparation</td>
</tr>
<tr>
<td>Ramos Creek (34MC1030), all others</td>
<td>6.40</td>
<td>3.11</td>
<td>Dowd in preparation</td>
</tr>
</tbody>
</table>

*Average of measurements given in Table 91
Measurements in mm
small dry fruits can be eaten raw or cooked into a sort of lemonade. They persist on the plant through the winter, making them a valuable source of vitamin C. The fruits, leaves, and branches make an excellent dye, with sumac tannins acting as a natural mordant (Tull 1987:35). The leaves of the plant were commonly added to smoking mixtures (Knight 1975; Moerman 1998; Roemer 2011:164).

The copperleaf seed (*Acalypha* sp.) from Feature 88 is not the same species as the uncarbonized specimens in Table 63, but it may still be result of incidental burning since copperleaf has so few known economic uses (Moerman 1998). A final seed, also from Feature 88, was in poor condition and could not be identified.

**Tubers**

Three hundred eighty-one tuber fragments weighing 4.98 g were recovered from Feature 79, a pit that also contained the site’s only squash rind and sumac. The loose texture and braided external surface of the tuber fragments indicate they are aquatic tubers (Figure 105). The absence of gas canals eliminates lotus (*Nelumbo lutea*), making a species of the family Nymphaeaceae the most likely identification. The common East Texas species of Nymphaeaceae are white waterlily (*Nymphaea odorata*) and pondlily (*Nuphar lutea*, also called bull lily, cow lily, or spatterdock; Figure 106 (Turner et al. 2003). Blue waterlily (*Nymphaea elegans*) and yellow waterlily (*N. mexicana*) are also present but are more common in South Texas (Correll and Johnson 1970; Turner et al. 2003). Fragments of carbonized roots and stems associated with the tubers also support the identification of waterlily or pondlily.
Consumption of waterlily and especially pondlily tubers is documented for Native people of the Northeast (Parker 1910:105), California and Oregon (Murphey 1990:29), Montana (Blankinship 1905:17), Wisconsin (Smith 1923:71), and the southern Great Lakes region (King 1984:134). On the Plains, documented uses of plants with aquatic tubers refer to tubers and seeds of American lotus or seeds of white waterlily (Gilmore 1991:27; Kindscher 1987:245–246). In East Texas, historical accounts mention consumption of “roots” and “ground nuts,” but these seem to refer to terrestrial tubers (Swanton 1996:134), and terrestrial tubers have been identified from several East Texas sites (e.g., 41UR30). Nonetheless, the wet areas of much of East Texas would have supported large waterlily and pondlily populations in the past, as they do today.

The French explorer René-Robert Cavelier, Sieur de la Salle, described the process of gathering and cooking aquatic tubers, probably pondlily tubers, in a letter written from the Illinois country in late 1681 or early 1682:

La terre y produit naturellement quantité de racines bonnes à manger comme les ognons doux, ouabipena [onions in general], ouabicipena [Sagittaria latifolia], une autre racine excellent longue comme le doigt et grosse de mesme, les pommes de terre, l’ail, l’ognonnet et les macopines. Ces dernières servent de provision à la pluspart des Sauvages qu’il semble que la bonté du pays rend plus fainéants que toutes les autres de l’Amérique. Ils prennent ces racines dans les marais. Elles sont grosses comme le bras; d’autres un peu moindres. Il font un trou dans la terre où ils mettent un lité de pierres rougies au feu, puis un de feuilles, un de macopin, un de pierres rougies et ainsy jusqu’au haut qu’ils couvrent de terre et laissent suer là dedans leurs racines deux ou trois jours durant, après quoy ils les font bouillir et les mangent toutes seules ou avec de l’huile. C’est une assez bonne nourriture, pourveu qu’elles soient bien cuites, ce qu’on connoist à la couleur qui doit ester rouge, si elles sont cuites. Au contraire elles sont blanchastres, sy elles ne le sont pas assez; et alors elles prennent si cruellement à la bouches, au palais et à la gorge, qu’on n’en peut avaler. Elles se conservent sèches assez longtemps [Margry 1877:173–174]
Figure 106. Pondlily (Nuphar lutea). Illustration by Laura Line, University of Florida/IFAS Center for Aquatic and Invasive Plants.

[The earth naturally provides a quantity of roots that are good to eat such as sweet onions, onions in general, arrowheads, another excellent root as long and wide as a finger, potatoes, garlic, little onions and macopines\textsuperscript{3}. These latter serve as provision for the greater part of the Indians, whom it seems that the bounty of the country has rendered lazier than all the others in America. They gather these roots in the marshes. They are as big as an arm. They make a hole in the ground in which they make a bed of fire-reddened stones, then one of leaves, one of macopin, one of reddened stones and so forth up to the top which they cover with earth and their roots sweat inside there for two or three days after which they have them boiled and eat alone or with oil. It is a rather good food, provided they are well cooked, which one can know by the color, which must be red. On the contrary they are whitish if they are not cooked enough, and then they grab the mouth so cruelly, on the palate, in the throat that one cannot swallow any. They can be kept in a dry state for a long time [McCafferty 2003:124–125; 2008:67 (additional translation by the author)]

\textsuperscript{3} Charles Trowbridge (1938:65) may have been the first to identify macopines as pondlily rather than waterlily, but the conclusion has not been unanimous (e.g., Dunn 1919:76). Michael McCafferty recently credited archeologist and watergardener Duane Esarey with the identification (McCafferty 2008:67 fn 80).
A more complete account comes from the de Gannes manuscript, written around 1702:

Elles ont aussi quantité de Racines qu’elles amassent celles qu’elles Estiment le plus est la macopine, c’est une grosse racine qu’elles prennent dans les marais, je ne me suis jamais attaché a connoistre la fleur, ainsi je ne puis en parler, quoy que je les ayent vuës arracher de la terre au fond de L’eau, ou elles se mettent quelquefois jusqu’a la Ceinture si bien qu’elles se mettent souvent la teste dans l’eau pour les arraches, il y en a de grosses comme la jambe. Les sauvages assurent que c’est un poison estant crusés ce que j’ay de la peine a croire, Les femmes ont des peines estranges a les faire cuire, elles se mettent quelquefois trios et quatre Cabanes Ensembles, et font un trou dans la terre de cinq a six pieds, et de dix ou douze en quarre. Elles Jettent dedans quantité de Bois dans lequel elles mettent le feu, et quand il est bien allumé elles y jettent force Roches quelles ont soin de Retourner avec de gros Leviers jusqu’a ce quelles soient toutes Rouges, après quoy elles sont en petit espace de temps, et les Laissent de cette maniere trios jours, elles se reduisent a moitié de leur Grosseur ordinaire [Pease and Werner 1934:345–346].

[There are also many roots which the women gather. The one which they like best is the macopine. This is a big root which they get in the marshes. I have never tried to learn what the flower is like, so I cannot describe it, although I have seen the women pull the roots up from the ground at the bottom of the water, into which they sometimes wade up to the waist, and often duck their heads under the water to pluck them up. Some of them are as big as one’s leg. The savages say that they are poisonous when raw, which I hardly believe. The women have unusual difficulty in cooking them. Sometimes three or four cabins combine and dig a hole in the ground five or six feet deep and ten or twelve square. They throw a lot of wood into it, which they set on fire, and when it is burning briskly they throw in a number of stones which they turn over with big levers until they are red hot. Then they go in quest of a large quantity of grass which they get at the bottom of the water and which they spread over the stones as well as they can to the thickness of about a foot. After this they throw on many buckets of water, and then each cabin puts its roots in its own place as fast as they can, covering them over with dry grass and bark and finally earth. They leave them thus for three days, during which they shrink to half their former size [Quaife 1947:126–127]].

The waterlily or pondlily tubers at site 41PN175 thus point toward an East Texas tradition of earth oven cooking, parallel to the camas bulb cooking of Central Texas and the agave/sotol traditions of West Texas. The particular feature that produced the aquatic tubers at 41PH175 exhibited no evidence of in situ burning (Figure 107). It is therefore unlikely to have been an actual earth oven but rather served as a repository for earth oven debris. Feature 79 did contain 61 g of burned earth, perhaps pond muck that was burned and discarded along with the overcooked (carbonized) tuber parts.

Waterlily or pondlily buds—but not tubers—have been previously identified in East Texas. Eleven fragments of Nymphaeaceae buds were found in a wall post at Pine Tree Mound (41HS15; Feature 2.1559). Like the tubers, Nymphaeaceae buds are edible (Smith 1932:407), but the buds could also represent waste from medicinal use of stems. Daniel Moerman (1998) found uses of both waterlily and pondlily stems for pain relief among Native groups in British Columbia. The Thompson Indians took a cold decoction of pondlily stems or roots for internal pain, and the Okanagan-Colville applied waterlily stems directly on the tooth for toothaches (Moerman 1998:358, 360). These medicinal uses are part of
Figure 107. Profile of Feature 79 showing charcoal and burned earth but no evidence for in situ burning.

much broader use of Nymphaeaceae plants as sedatives or possibly hallucinogens. The blue lotus (*Nymphaea caerulea*) of ancient Egypt and Homer’s *Odyssey* continues to be used as a narcotic in some parts of Africa (Dobkin de Rios 1974:150). Waterlilies (*Nymphaea ampla*) are common in Mayan iconography, and some have suggested psychotropic use in that region (Dobkin de Rios 1974 and comments; McDonald 2013; Ott 1976).

**Sample Variation**
With the exception of Features 79 and 87, discussed below, flotation samples varied in the density rather than the content of their plant remains. As shown in Table 68, smudge pits contained a much greater density of plant remains than did other feature types.

Table 68: *Density of Botanical Remains at site 41PN175, by Feature Type*

<table>
<thead>
<tr>
<th>Feature Type</th>
<th>Number of Features</th>
<th>Carbonized Plants (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearth</td>
<td>3</td>
<td>0.24</td>
</tr>
<tr>
<td>Pit</td>
<td>12</td>
<td>0.48</td>
</tr>
<tr>
<td>Post</td>
<td>2</td>
<td>0.65</td>
</tr>
<tr>
<td>Smudge pit</td>
<td>3</td>
<td>4.30</td>
</tr>
</tbody>
</table>
Feature 79 and Feature 87, both pit features, were unusual in the types of plants they contained. Feature 79 was the only context to yield aquatic tuber fragments (pond lily or water lily). It also contained all the sumac seeds from the site, the squash rind, and two of the five corn kernels. Feature 87 was notable for containing most of the rest of the corn recovered on the site (119 of the 141 kernel, cupule, and glume fragments).

Plant Identifications from Previous Investigations
In addition to the plant taxa recovered in these 20 samples, previous investigations at the site recovered seeds of maygrass, persimmon, and purslane (Bush 2012; Dering 2002). The maygrass and persimmon are especially intriguing since they hint at cultivation of plants in addition to the corn and squash reported here. Maygrass has a long history of cultivation in the eastern woodlands of North America (Fritz 1990), and it is frequently found in low quantities on Caddo sites in Texas. At least one historic account describes Caddo persimmon trees as growing in “orchards” (Swanton 1996:132), and given the rapid adoption of another fruit tree, peach, by Native Americans of the southeast (Gremillion 1993), Solís’s description may in fact refer to Caddo silviculture.

Summary
Macrobotanical remains recovered from recent investigations at site 41PN175 consist of wood charcoal, pinecone parts, nutshell, river cane, corn, squash, sumac, and aquatic tubers. The remains reflect agricultural practices as well as exploitation of wild plants in the immediate site area. They also provide the first direct evidence for exploitation of aquatic tubers in East Texas.
Chapter 10: Geoarchaeological Analysis
by Charles D. Frederick, Ph.D. and Arlo McKee, with contributions by Caroline Masiello, Ph.D. and Xiaodong Gao, Ph.D.

Geomorphology, Site Setting, and Methods

Introduction
The site is situated on the northward sloping margins of a relatively flat landform that stands about 260 feet above sea level immediately adjacent to the southern side of the modern valley of Murvaul Creek (Figure 108). The flat-crested landform to the north of the site, the tread of which lies between 30 and 40 feet above the creek, appears to be either a constructional terrace or an erosional surface (or strath terrace) cut by Murvaul Creek in the distant past. The substrate at the site has been mapped by the Bureau of Economic Geology (1975) as the Eocene-aged Wilcox Group, undivided. The site is perched immediately above a section of Murvaul Creek named Daniels Ditch, which flows along the southern margin of the present-day valley.

The land surface within the site rises gently to the south and east, with a little over a meter of elevation increase across the portion of the site within the highway right-of-way (ROW) (Figure 109). The surface drops off significantly immediately north of the site at the southern side of the Murvaul Creek floodplain, and increases more than a meter outside the ROW to the east and south. A borrow pit is located immediately south of the site, and the existing highway borders the west side of the site.

Although the soils at the site have been mapped by Dolezel (1975), they appear to be incorrect, given that the site is mapped as the Nahatche Complex, which consists of Nahatche and Marietta series soils. Both of these series are described by Dolezel as occurring on nearly level bottomlands/floodplains and represent soils formed in recent alluvial materials. This description stands in stark contrast to the alfisols that occupy the majority of the site that closely resemble the Sacul series soils that are mapped immediately south of the site. These soils are described as having formed on gently to moderately sloping upland surfaces in the interbedded sandstone and shale deposits of the Wilcox Group.

Particle Size Analysis
The texture/particle size distribution of soil/sediment samples was determined on a Beckman-Coulter LS 13-320 lasersizer. Samples were first pretreated with concentrated hydrogen peroxide in order to remove organic matter, and dispersed with 5 percent solution of sodium hexametaphosphate. The results of these analyses are presented as percentages of sand, silt, and clay, as well as in the form of descriptive statistics advocated by R. L. Folk (1968) in his seminal work Petrology of Sedimentary Rocks. The descriptive statistics are presented in phi units (a negative log base 2 conversion of millimeters). In the phi system,
Figure 108. Map showing location of site 41PN175 (clipped from the Gary [east side] and Lake Murvaul [west side] quadrangles, USGS 2013).
Figure 109. Map of the site area showing the ground surface elevation within the right-of-way.
sands exhibit phi values between 0 and 4, silts between 4 and 9, and clay > 9 phi, but in order to facilitate comparison of the results obtained from the lasersizer with traditional granulometric methods, the silt-clay boundary was set at 6 micron (7.4 phi). The U.S. Department of Agriculture (USDA) soil texture class for each sample was determined using the Soil Texture calculator provided by the Natural Resources Conservation Service (NRCS 2014) website.

**Total Carbon and Stable Carbon Isotopic Ratio Analysis**

Determination of the carbon and nitrogen content and the stable carbon isotopic ratio of soil organic matter was performed by the Stable Isotope/Soil Biology Laboratory, which is part of the Analytical Chemistry Laboratory at the Odum School of Ecology, the University of Georgia. Samples were first dried and finely ground, and then sent to the lab for analysis. The carbon and nitrogen content was determined by Micro-Dumas combustion analysis on a Carlo Erba NA1500 C/H/N Elemental Analyzer that is coupled to a Thermo Delta V Mass Spectrometer via a Thermo Conflo III Interface.

**Magnetic Susceptibility**

Magnetic susceptibility was determined on a Bartington MS2 meter and MS2B sensor using samples that were packed into small 8-cc magnetically inert plastic boxes. Samples were weighed, and then the low and high frequency magnetic susceptibility was measured, with each value measured twice, and the average values were used to calculate the reversible, low and high frequency mass susceptibility ($\chi_{lf}$ and $\chi_{hf}$) and are reported in SI units ($10^{-8}$ m$^3$kg$^{-1}$). The coefficient of frequency dependency ($\chi_{fd}$) was also calculated and is reported as a percentage. The precise methods and equations used may be found in Gale and Hoare (1991:222–226) and Dearing (1999a, 1999b).

**Soil Micromorphology**

Samples collected for micromorphology consisted of small, oriented blocks carved from the excavation walls that were then wrapped in toilet tissue and masking tape, and subsequently dried, embedded in polyester resin under a vacuum, and then slabbed on a rock saw. Three large blocks of undisturbed natural sediments were collected to represent the stratigraphic samples for the site. Two of these were cut from the west wall of Block 8 (micromorphology samples 1 and 2, hereafter referred to as MM1 and MM2) and a third was collected from Block 4 (micromorphology sample 3 or MM3; Figure 110). Samples 1 and 2 were collected from about 10 centimeters (cm) apart, from the west wall of Block 8 in Test Unit 113 (MM1) and Test Unit 117 (MM2). Sample MM2 was collected from the sandy sediments above the paleosol from a depth of about 12 to 27 cmbs, whereas MM1 was collected stratigraphically beneath MM2, from about 20 to 45 cm depth and straddled the interface between the paleosol and the overlying sandy sediment. Micromorphology sample 3 (MM3) was collected from the east wall of excavation Block 4, Test Unit 122, and represents the E-horizon beneath the paleosol. Four thin sections were made from MM1, two from MM2 and two from MM3.
The block samples were first dried at low temperature \(50^\circ \text{Celsius} \) in a convection oven and then embedded in polyester resin under a vacuum. Samples were first unwrapped and then placed in a plastic container, and the provenience and orientation information transferred to the new sample container. Then the embedding medium, a 7:3 mixture of unpromoted polyester resin and styrene mixed with a small amount of methyl ethyl ketone peroxide catalyst, was added to the container to the upper edge of the sample but with care not to completely immerse the sample. The sample was then placed in a vacuum desiccator.
and placed under a vacuum with a vacuum pump. After a few minutes, the vacuum was released and more resin added if necessary, and then once again placed under a vacuum. This procedure was repeated about four times, after which the sample was removed from the desiccator, and resin once again added to nearly, but not completely, cover the sample. The next day, the samples were completely immersed in polyester and then allowed to cure for about a week. Once the polyester set, samples were placed in a low temperature (50˚C) convective oven overnight to completely harden the polyester. The samples were then slabbed with a rock saw using mineral oil as the lubricant. Slabs were subsequently scanned on a flatbed scanner, the locations for thin sections selected, and the position then drawn on a print of the slab. The thin section blanks were then cut from the slabs using a water-cooled trim saw, immediately dried, and then labeled, and notched for orientation.

The prepared blanks were then submitted to Spectrum Petrographics (Spokane, Washington) for thin section manufacture. Upon completion, the prepared 2-x-3-inch (in; 51-x-76 millimeters [mm]) thin sections were scanned at 1000 dpi using transmitted light on a flatbed scanner and an 8.5-x-11-in color print made. The enlarged prints of the slides were examined for features of interest, and then the thin sections were examined at low magnification on a Leica S8 APO binocular microscope that is equipped to permit transmitted polarized light microscopy. The lowest magnification on the S8APO permits viewing a 1-cm-wide area of the slide, whereas the highest magnification provides a 1.5-mm-wide field of view. High magnification examination was performed on a Leica DMEP polarizing light compound microscope. Photomicrographs of samples were collected using a Leica DFC280 digital camera using Leica Firecam 3.0 software. Description of the samples follows general guidelines provided by Bullock et al. (1985) and Stoops (2003).

**Site Stratigraphy**

The following section introduces the stratigraphic units recognized at the site, and is followed by a discussion of how these deposits vary within and immediately adjacent to the site. This in turn is followed by discussion of the stratigraphic context of the Caddo occupation, and the stratigraphic history of the site.

A variety of exposures was used to document the site stratigraphy. The first of these were the shovel tests that were excavated on a 5-m grid across the site within the highway ROW. The largest exposures were those afforded by the block excavations, and these provided broad windows into the site deposits that revealed a variety of details about its edaphic history. Finally, another set of shovel tests was excavated, with permission of the landowner, at 10-m intervals outside of the highway ROW to the east of the site. These tests were conducted in order to obtain a spatially dispersed set of soil samples for stable carbon isotopic analysis, but they also served as a coarse window into the stratigraphy and history of the site. From these points of observation, the deposits at the site can be divided into three broad groups, which in order of stratigraphic position from lowest to highest are: (1) the subsoil; (2) the Caddo soil; and (3) the colluvium.
Details of the site deposits elucidated below have been compiled from four profiles that were described and sampled in the field and subsequently analyzed in the lab (Figures 111 and 112). These four profiles present a range of contexts present at the site. Profile 1 was located on the south side of the site in excavation Block 3, and was the east wall of Test Unit 70. This excavation revealed the best exposure of the subsoil and represents deposits on the upslope end of the site. Profiles 2 and 3 are representative of deposits observed on the core of the site. Profile 2 was the south wall of Test Unit 111 in Excavation block 7, whereas Profile 3 was from the east wall of Test Unit 117 in Excavation block 8. Profile 4 was described and sampled in a shovel test excavation (BG14) that was situated 20 m east of the ROW immediately overlooking the Munvaul Creek floodplain, and is the most distal or downslope profile of the four. The field observations have been supplemented by detailed laboratory analysis, specifically for texture, magnetic susceptibility, total carbon, and stable carbon isotope composition. Petrographic observations were made for the colluvium and the Caddo soil, but no soil micromorphology samples were examined from the subsoil.

The Subsoil

The subsoil was not exposed by most hand-excavated units at the site, primarily because it was significantly below and much older than the Caddo occupation deposits. The subsoil was noted in the second phase shovel tests and in a few test unit excavations that were explicitly excavated to expose it, such as Profile 1 (east wall of Test Unit 20 in Block 3).

In general terms, the subsoil was an argillic horizon that had a field texture of clay loam and a firm consistence. This deposit exhibited a wide range of color variation with ped cores typically exhibiting colors between yellowish red (5YR 4/6, d) to dark red (2.5YR 4/8, d), which contrasted strongly with the ped faces and some pores that were dramatically highlighted by gray (10YR 6/1, d) iron depletions that imbued a very reticular appearance to the deposit. The reticular habit is an artifact of the pronounced structure formed in the lower subsoil, which was generally compound and ranged from strong medium prismatic to a strong coarse to fine angular blocky. Most peds exhibited common thick waxy clay coats and contained a few (0–3 percent) fine ironstone and plinthitic nodules. The loss-on-ignition analysis of this horizon in Profile 1 revealed a significant weight loss that is most prismatic to a strong coarse to fine angular blocky. Most peds exhibited common thick waxy clay coats and contained a few (0–3 percent) fine ironstone and plinthitic nodules. The loss-on-ignition analysis of this horizon in Profile 1 revealed a significant weight loss that is most
Figure 111. Plot of the results of laboratory analysis of the deposits exposed by Profiles 1 and 4.
Figure 112. Plot of the results of laboratory analysis of the deposits exposed by Profiles 2 and 3.
likely due to the loss of structural water by lattice expandable clays such as smectites (see Figure 111). No cultural material was observed in the lower subsoil, and this appears to be an ancient argillic horizon formed in either a Pleistocene terrace of Murvaul Creek or Eocene bedrock.

The Upper Subsoil (Bw-Horizon/Bt1-Horizon): The lower part of the upper subsoil was generally identified as an argillic horizon and had a texture of loam. It exhibited significantly less pronounced structure development (moderate coarse subangular blocky parting to strong medium to fine angular blocky structure) and was less red in color than the lower subsoil. This horizon had ped cores that ranged in color from brownish yellow (10YR 6/6, d) to strong brown (7.5YR 5/8, d), and ped faces that were highlighted by iron depletions that were very pale brown (10YR 8/2, d). It also contained common fine soft yellowish red (5YR 4/6, d) and dark red (2.5YR 4/8) iron masses and common waxy clay coats bridging sand grains and coating ped faces. Where this horizon rested on the lower subsoil, a gradual smooth boundary separated the two horizons.

The cambic or Bw-horizon was generally reddish yellow (7.5YR 6/5, d) and had pores and ped faces that where highlighted by very pale brown (7.5YR 7/4, d) iron depletions. This loam exhibited moderate medium subangular blocky structure that parted to strong fine angular blocky structure. A few fine black manganese concretions were generally present.

The Caddo Soil
Caddo occupation debris was clearly present in both the paleosol and the overlying colluvium. It is currently thought that most of the Caddo artifacts in the colluvium are in secondary context, with the only Caddo deposits in situ found in the paleosol and its underlying E-horizon, which together are here referred to as the Caddo soil.

The E-Horizon: This deposit rested directly upon the upper subsoil and was overlain by the paleosol. The E-horizon was a very pale brown (10YR 8/2, d) loam to sandy loam that generally exhibited a weak medium to fine subangular blocky structure. The mean particle size of samples of the E-horizon in the main block excavation were in the coarse silt range (approximately 4.9 phi) but considerably coarser, specifically a fine sand (approximately 3.1 phi) in Profile 4 outside the ROW immediately overlooking the floodplain. The carbon content in this horizon generally decreased from the top of the horizon, where it bordered the paleosol, to bottom, with average values between 0.1 percent and 0.2 percent. Magnetic susceptibility values, like the organic matter, declined through the zone from top to bottom, and averaged between 17 and 19 10^-8 m^3 kg^-1. Although small numbers of artifacts were encountered in this horizon, their number decreased prominently with depth. Several of the pit features, however, were excavated into this horizon.
Micromorphological Observations: The natural samples of the E-horizon were collected in Block 4, Test Unit 122 (MM 3) and two thin sections were made from this block. The framework grains of this portion of the deposit were primarily medium to very fine sand (0.3 to slightly <0.1 mm) that was >95 percent quartz, with small (<1 percent) rounded fine-sand-sized (0.1 mm) fragments of unoriented light brown (transmitted light) clay, few (2 percent) opaque minerals, and traces (<1 percent) of plagioclase feldspar. This deposit typically had a weak to moderately pronounced intergrain channel structure, less often a granular structure, and a c/f-related distribution ranging from chitonic to porphyric where the fine material was generally coarse to medium-silt-sized. A few (<2 percent) fine (0.3 mm) ferruginous nodules were also present, as well as thin (approximately 0.1 mm) black hypocoats (Mn or organic matter) lining pores. Evidence of redoximorphic activity in the form of dark brown ferruginous hypocoats and quasi-coats lining pores were also common in the E-horizon. In many places, this deposit had a mottled appearance and some of this was clearly redoximorphic in nature, but much of it was attributable to pedoturbation. Passage features were a common component of the E-horizon and ranged in size from 0.1 mm to more than 15 mm in diameter, but it was peculiar that these structures were often more visible in the embedded slabs and field photos than in the thin sections. Some passage features were noticeable in petrographic examination by the voids between fecal aggregates (quite apparent in cross-polarized light when the pores and voids were black) and by fabric deformation within individual fecal pellets, but older, coalesced passage features were difficult if not impossible to discern except where they destroyed or disturbed textural pedofeatures like laminations (see Chapter 11).

The Paleosol
One of the most striking pedologic features in the site profile is the paleosol, which was observed in three separate patches in and near the site: (1) in the ROW in the vicinity of the block excavations; (2) in an area between 20 and 50 m east of the ROW directly above the steeper scarp separating the terrace from the floodplain of Murvaul Creek; and (3) in the ROW at the southern end of the site just south of the area cleared for the site excavations (Figures 113 and 114). The Caddo soil most likely extended upslope to the south and east at the time of Caddo occupation of the site but is now only preserved in patches in lower slope positions because of postoccupation erosion and subsequent burial by gully mouth fans (Figure 115). As a stratigraphic feature, the paleosol pinches upslope and thickens downslope. Where it first appears the paleosol consists of a dark-colored sandy deposit that rests directly upon the upper subsoil, and is buried by the colluvium. As it thickens downslope, the paleosol gradually becomes a discrete stratigraphic feature resting upon the E-horizon, which also thickens downslope.
Figure 113. Map of the site and area to the east showing the location where the Caddo soil was observed (tan-colored areas). The large arrows show the location and presumed flow orientation of the presumed gullies that contributed sediment to these areas. The cross sections shown as dashed green lines are further explored in Figure 114.
Figure 114. Relationships between the major stratigraphic units at the site using data from within the project ROW and shovel tests excavated immediately east of it. Map in the bottom right corner (present in larger form on Figure 113) shows the locations of the six cross sections with respect to the site excavations and the shovel tests.
The paleosol exhibited a range of appearances within the site, mostly in terms of its color (specifically the Munsell value and chroma). Everywhere, this deposit exhibited a 10YR Munsell hue, but upslope and in the southern parts of the ROW, the paleosol was faintly melanized and had higher values and chromas than observed in the northern part of the site, where the values were significantly lower and the soil color darker. The darker-colored areas of the paleosol were thought to be indicative of a midden during the testing phase excavations (Cliff and Perttula 2002:29) and more formally defined as a feature during the
data recovery investigations, although there has been some disagreement about the anthropogenic attributes of the darker-colored deposit (discussed in more detail later).

In the vicinity of the main block excavations, the paleosol was a loam with mean particle size values like the E-horizon, of a coarse silt (approximately 4.9 phi). Downslope and east of the main block excavations, in the vicinity of Profile 1, the paleosol was considerably coarser, ranging from a loamy sand to a sandy loam, and with mean particle sizes in the range of a very fine sand (approximately 3.08 phi). The carbon content of the paleosol ranged from 0.23 percent to about 0.55 percent, and the parts identified as a midden had on average about twice the carbon content (0.4 percent) as the nonmidden paleosol (0.2 percent). The paleosol in some places exhibited a weak fine to medium subangular blocky structure, but elsewhere appeared massive. The top of the paleosol was, in some exposures, an abrupt erosional surface, and a clear, somewhat bioturbated interface in others. The lower boundary was clear to gradual and smooth. Most exposures of the paleosol were notably bioturbated and this imparted a mottled appearance to the deposit.

**Micromorphological Observations:** The upper boundary of the paleosol where sampled for micromorphology was knife sharp and penetrated by several passage features (0.3 to 1 cm wide) filled with coarser sediment from overlying sand and having traces of bow-like structures within (Figure 116). The framework was composed primarily of medium sand (0.3 mm) to very fine sand and with significantly lesser amounts of coarse silt (0.1 to 0.02 mm), primarily subangular to subrounded and composed primarily of quartz. There were rare grains of plagioclase feldspar (<<1 percent), a few pale brown aggregates that were of an unknown source (isotropic in crossed polarized light) and a few (2 percent) 0.3-mm fragments of charcoal. The microstructure ranges from pellicular to intergrain micro-aggregate, and the c/f-related distribution was enaulic to chitonic and in a few places almost porphyric. About 30 percent of the silt-sized intergranular aggregates were black, opaque material that was most likely organic matter. There was no clear pedality in this horizon.

**The Colluvium**

Burying the paleosol everywhere was a deposit of slope wash or colluvium that derives from erosion of the Caddo soil upslope (to the south and east) of the site. This deposit, where thick, was easily differentiated into two parts, lower and upper, on the basis of color, with the upper colluvium having a prominent red to yellowish brown (10YR 5/6, d) color and the lower colluvium a very pale brown (10YR 8/2, d) color. At the southern end of the site, a loose sandy deposit within which a weak A-horizon had formed, rested directly on the subsoil (see Figure 114), and this deposit was interpreted as colluvium, although its presentation in this setting was very different from that seen within the block excavations. In general terms, the colluvium was notably coarser-textured than the paleosol that it buries, despite containing fragments of redeposited subsoil. The color pattern of this deposit was consistent with an inverted profile, with the lower colluvium representing stripping of the paleosol and E-horizon, and the upper colluvium largely derived from erosion of the subsoil.
Lower Colluvium: The lower colluvium rested directly upon the paleosol, and the interface between these two deposits ranged from a knife-edge, slightly wavy erosional surface to a clear interface that had been blurred by the passage of soil fauna and flora. In the vicinity of the main block excavations this deposit ranged in texture from a sandy loam to a loam with a mean particle size in the very fine sand to coarse silt range (approximately 3.8 to 4.1 phi) and was clearly coarser textured than the paleosol it buries (see Figure 112). East of the ROW, in Profile 1, the lower colluvium exhibited alternating coarse and fine beds, with textures ranging from loamy sand, sandy loam, to loam (see Figure 111) and an average
mean particle size in the range of a very fine sand (approximately 3.8 phi). All exposures of
the lower colluvium exhibited sedimentary laminations. In the main block excavations, the
boundary between the upper and lower colluvium was a sharp erosional interface, but in
Profile 1, several organic-rich beds were present, which may be indicative of a brief period of
soil formation, although none of these exhibited elevated magnetic susceptibility values, in
contrast to the underlying paleosol and the weak soil formed at the top of the upper
colluvium. The majority of the lower colluvium exhibited carbon contents ranging from 0.13
percent to 0.31 percent and with average values in the main site area of about 0.28
percent. In proximity to the base of the unit were numerous redeposited rounded
aggregates of the paleosol, as well as small fragments of the subsoil.

Micromorphological Observations: As noted previously, the lower colluvium rested directly
upon the paleosol and was separated from it by a sharp eroded interface. In places, the
base of this deposit was laminated and contained few too many small rounded fragments of
redeposited A-horizon (see Chapter 11). The paleosol was noticeably finer-textured than the
lower colluvium and contained much more finely dispersed organic matter. The framework
ranged from >90 percent quartz sand to around 50 percent quartz sand, with the remaining
framework materials being redeposited fragments of the paleosol that ranged in size from
<0.5 mm to more than 3 mm. A few (<2 percent) of grains were iron-manganese
concretions and fragments of the Bt-horizon subsoil, and an occasional piece of charcoal.
The c/f-related distribution was largely monic to chitonic, and the microstructure was single
grain. Very few passage features were evident, but undoubtedly present.

Upper Colluvium: As was noted earlier, the upper half of the colluvium was distinctly redder,
and this deposit was identified in the testing report as a “reddened E-horizon” that was
initially thought to be due to the inclusion of “burned or fired soil” (Cliff and Perttula
2002:29–30). Field and subsequent petrographic examination of the upper colluvium
determined that the red color was attributable to the inclusion of numerous fragments of the
subsoil (Bw- and Bt-horizon) derived from soil erosion upslope.

The upper colluvium was a sandy loam, with mean particle size in the main block
excavations of a very fine sand (approximately 3.8 phi) and slightly coarser in Profile 1
(average of 3.47 phi). A thin (<10 cm), weakly developed A-horizon has formed immediately
below the ground surface at the top of the upper colluvium, and this soil contained between
0.3 percent and 2.1 percent carbon. The core of the upper colluvium exhibited carbon
contents between 0.17 and 0.5 percent with values increasing toward the top of the
deposit. In two of the three sections where the upper colluvium was examined in detail
(specifically P1 and P2), the deposit exhibited elevated magnetic susceptibility values
toward the modern ground surface, but this was not the case in P3, where the magnetic
susceptibility decreased upward through this deposit. Like the lower colluvium, this deposit
was conspicuously laminated in most exposures and generally lacked evidence of structural development.

**Micromorphological Observations:** The upper colluvium was delineated from the lower colluvium on the basis of a significant increase in material derived from the erosion of the argillic horizon upslope (most likely the lower subsoil) that imparted a slightly more red color to this deposit. The upper colluvium ranged from massive to laminated. Two forms of lamination were recognized, coarse and muddy. The coarse laminations were generally normally graded, with a coarser textured lower part and a finer textured upper part. The coarse textured lower parts were composed of medium to fine sand (0.05 to 0.1 mm) primarily subangular quartz, with a few opaque minerals, single grain microstructure, and monic to gefuric c/f-related distribution where the fine material was generally coarse silt. The fine textured parts of these graded laminations were composed of fine sand to coarse silt (0.01–0.02 mm) that was composed of 60 percent quartz (subrounded to subangular), 30 percent opaque minerals, and 10 percent heavy minerals (e.g., zircon or rutile, nonpleochroic high relief, mod birefringence, rounded grains), clearly placer-like heavy sand (Figure 117). The muddy laminations were much less common, 1–2 mm thick, and had a framework of medium to fine sand (0.1–0.3 mm), primarily (>90 percent) quartz with a few opaque minerals and fragments of reworked Bt-horizon (<2 percent). These laminations exhibited a chitonic to porphyric c/f-related distribution where the groundmass was light reddish brown fine silt to clay that was nonbirefringent and had a pellicular microstructure. In plane light, these laminae looked like thin clay lamellae but the lack of optical activity in the groundmass set them apart.

**Stratigraphic Trends**
The topography of the site within the Texas Department of Transportation (TxDOT) ROW is relatively flat, rising about 1 m from north to south across the 60-m-long cleared area, but the land surface immediately east and south of the site rises in elevation at a similar or even greater rate (detailed measurements were not collected), and this topographic variation is crucial to understanding the site stratigraphy and its late Holocene evolution. Figures 113 and 114 provide a broader view of how the site deposits vary both with respect to the local slope and spatially in and near the site, and Figure 115 illustrates how the site deposits evolved through time.

Within the TxDOT ROW, the thickness of the Caddo soil and the colluvium varies considerably, with both of these units thinning upslope to the south and east, and the Caddo soil pinching out entirely. The Caddo soil in particular exhibits pronounced spatial variation and occurs in three spatial groups (discussed previously; see Figure 113) that most likely represent the depositional ends of three shallow gullies that eroded into the Caddo soil and
subsoil upslope to the south and east. As can be seen on Figure 113, especially section line C-C', although the ground surface in this area is relatively flat today, it was once sloping and has been leveled out by deposition of colluvium. The Caddo soil may have once been present across the entire site area (as depicted in Figure 114), but today it is only present downslope and in areas that were once shallow depressions. Upslope to the south, clearly evident along section C-C', the upper subsoil rises in the profile and thins, as if it has been progressively denuded upslope. A similar trend can be seen in Section A-A'. In all, there appear to have been three sets of gully-mouth fans in proximity to the site, one flowing north outside the ROW to the east, one flowing northwest that deposited the fan within the ROW,
and a third located immediately south of the site that appears to have been formed by a westward flowing gully.

East-west cross sections at the northern end of the site show that the Caddo soil is not a continuous blanket as one might expect in a toe slope setting, but rather comprises two discrete depressions, separated by an elevated ridge of subsoil. One of these patches is in the TxDOT ROW, and the other lies between 20 and 40 m east of the ROW. The wavy top of the subsoil in this part of the site is suggestive of an earlier phase of gully erosion that significantly predates the Caddo occupation (most likely is of Late Pleistocene age).

Upslope of the site to the south and east, the shovel text excavations revealed a thin A-horizon formed in sandy sediment that rested directly upon the upper subsoil, which was generally much thinner than observed downslope. If the thickness of the upper subsoil observed in Profile 1 is representative of the pre-erosion thickness, then almost half a meter of the upper subsoil and the entire Caddo soil have been eroded from the slope above the site.

**Stratigraphic Position of the Caddo Occupation**

The Caddo occupation debris was clearly present in both the paleosol and the overlying colluvium. In some places, such as Test Unit 111, the artifact distribution is bimodal, with a peak in the lower colluvium, followed by a decrease in artifacts at the base of the lower colluvium, and then a second peak at the top of the paleosol. Elsewhere, as in Test Unit 117, the macroartifact distribution was unimodal, with the greatest frequency of artifacts occurring in the lower colluvium, and declining artifact frequency below the paleosol and into the E-horizon. However, examination of the microartifact distribution from Test Unit 117 shows a bimodal distribution (Figure 118).

As Cliff and Perttula (2002) note in the testing report, this pattern can be caused by at least three scenarios: (1) two separate Caddo occupation zones, one in the lower colluvium and a second in the paleosol; (2) bioturbation of post-Caddo occupation deposits, and (3) redeposition of Caddo artifacts by soil erosion upslope. The absence of features within the colluvium and the ubiquitous appearance of same in the paleosol suggest that the artifacts in the colluvium have been eroded from upslope and redeposited downslope during a phase of soil erosion that postdates the Caddo occupation. Two lines of evidence can be used to test this hypothesis: (1) chronological information from radiocarbon and optically stimulated luminescence (OSL) dating, and (2) a greater degree of rounding of the Caddo sherds recovered from the lower colluvium, as compared with sherds found in the paleosol.
118. Plot of the results of the depth distribution of the microartifacts and macroartifacts in Test Unit 117, along with the results of the OSL dating.

Figure 118. Plot of the results of the depth distribution of the microartifacts and macroartifacts in Test Unit 117, along with the results of the OSL dating.
**Dating the Erosional Event**

The period of soil erosion that created the colluvium can be dated by a close examination of the dates obtained from the site excavations, specifically the OSL dates and the radiocarbon ages.

**Optically Stimulated Luminescence Dating**

Three single-grained OSL dates were obtained from the site deposits in Block 8, Test Unit 114: two from the lower colluvium and one from the paleosol. The methods and results of this work are presented in detail by Dr. Bateman (see Appendix B-3) and the results are summarized below on Table 69. The three samples were dated using the single-grain method, which determines the period of time that has elapsed since each sand grain within a population of grains was last exposed to sunlight. In this particular case, the number of dated grains ranged from 54 to 74. The resulting grain-age distribution was analyzed using a finite mixture model (FMM), which identified distinct groups within the sample population. The ages for each group as well as the proportion of grains in the population comprising each group are listed on Table 69. The highlighted numbers in bold are thought to be the ages that best reflect the true burial age.

**Table 69: OSL Dates**

<table>
<thead>
<tr>
<th>Lab Code</th>
<th>Context</th>
<th>Depth (cm)</th>
<th>Zero Dose Grains</th>
<th>Number of Grains Dated</th>
<th>FMM Component</th>
<th>De (Gy)</th>
<th>Proportion of Grains (%)</th>
<th>Date (Years B.P.*)</th>
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<tbody>
<tr>
<td>Shfd 12032</td>
<td>Lower colluvium</td>
<td>23</td>
<td>14</td>
<td>74</td>
<td>1</td>
<td>0.40 ± 0.04</td>
<td>84</td>
<td>230 ± 20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>0.94 ± 0.20</td>
<td>12</td>
<td>540 ± 120</td>
</tr>
<tr>
<td>Shfd 12031</td>
<td>Lower colluvium</td>
<td>30</td>
<td>8</td>
<td>54</td>
<td>1</td>
<td>0.43 ± 0.08</td>
<td>59</td>
<td>280 ± 50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>1.18 ± 0.13</td>
<td>35</td>
<td>770 ± 90</td>
</tr>
<tr>
<td>Shfd 12033</td>
<td>Paleosol</td>
<td>45</td>
<td>0</td>
<td>64</td>
<td>1</td>
<td>1.71 ± 0.12</td>
<td>19</td>
<td>940 ± 80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>3.51 ± 0.23</td>
<td>36</td>
<td>1,940 ± 150</td>
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<td></td>
<td></td>
<td>3</td>
<td>7.36 ± 0.39</td>
<td>37</td>
<td>4,060 ± 270</td>
</tr>
</tbody>
</table>

* B.P.: before present

In general terms, the results support the field interpretation that the colluvium is significantly younger than the paleosol upon which it rests. The finite mixture model age for the base of the lower colluvium suggests that deposition of this unit began around 280±50 years B.P., and the deposit 7 cm higher in the profile yielded an age of 230±20 years B.P. Both of the samples from the lower colluvium contained a significant number of grains that have been recently reset (also called “zero dose grains”) that reflect modern disturbance of the deposit. The depth distribution of the zero dose grains is illustrated on Figure 118) and decreases with increasing depth, as has been documented elsewhere in Caddo-aged deposits (Frederick 2014).

The OSL age obtained for the paleosol, on the other hand, yielded a finite mixture model with three age components: 940±80 years B.P., 1,940±150 years B.P., and 4,060±270 years B.P. This sample was not collected exactly at the interface with the lower colluvium,
but rather about 15 cm below the top of the buried A-horizon. Bateman (2012) interpreted the 1,940 B.P. age as the one most likely to represent the true burial age, but given the context of this sample (a buried A-horizon) and the lack of any zero dose grains, it is likely that the youngest age component identified by finite mixture modeling represents the age closest to the time of burial of the paleosol by the lower colluvium. Bush and Feathers (2003) examined the OSL ages obtained from modern soils and paleosols buried beneath anthropogenic mounds in Louisiana and concluded that the youngest age obtained from buried soils most likely reflects the bleaching that occurs in soils at the ground surface and, hence for paleosols, is closest to the burial age of the paleosol. Close examination of the single-grain-age distribution for this sample indicates that the 940±80 B.P. FMM component reflects the eight youngest grains in the sample population, the youngest of which is 782 years B.P. The age of the oldest component from this sample (4060±270) most likely represents grains moved upward in the profile by bioturbation.

In summary, close examination of the data generated by OSL dating suggests that the erosional event at the site occurred after 940±80 years B.P., and around 280± 50 years B.P.

**The Paleosol and its Anthropogenic Alteration: The View from the Midden and Features**

**Background**

The test excavations conducted at the Murvaul Creek site (41PN175) recognized that the paleosol identified at the site changed considerably in character spatially across the site (Cliff and Perttula 2002). Cliff and Perttula noted in their report that in the northern end of the site the paleosol was darker in color and richer in artifacts compared to the southeast portion of the site, where it was almost nonexistent. It was postulated that this change in character might be indicative of a midden, but ultimately Cliff and Perttula (2002) were hesitant defining the paleosol as a feature. Although not recognized as a feature during the testing phase excavations, the paleosol comprised a prominent component of the data recovery stratigraphic framework in some parts of the site, and its variable presentation, specifically the spatial variation in melanization (or dark coloring) and artifact content, led to considerable discussion of its origins. In some places, the paleosol was a prominent dark deposit with numerous artifacts, whereas in other places it was weakly melanized, barely distinguishable from the underlying E-horizon, and lacking abundant artifacts. The fact that the area of most prominent melanization corresponded with the highest density of artifacts (Figure 119) led to the general conclusion that the darker-colored part of the paleosol was in fact a prehistoric midden and the dark color and sherd content an artifact of ancient Caddo refuse disposal practices. Based only on the data available immediately upon returning from the field, this hypothesis has received considerable debate among the researchers involved. The lack of faunal materials has led some to the conclusion that the paleosol is simply a natural feature that is not indicative of a classic kitchen midden.
Figure 119. Illustration derived from Figures 6 and 7 of McKee 2011, showing the spatial variation in artifact density as plotted by count (top half of figure) and weight (lower half of figure), with respect to the area identified during the data recovery excavations as the midden.
In order to assess the hypothesis that the darker-colored portions of the paleosol are a prehistoric midden and represent spatially concentrated anthropogenic alteration of the Caddo-age surface soil (aka. the paleosol), a suite of analyses was performed to document various attributes of the paleosol, within and outside of the area thought to be a midden. Furthermore, many of the same analyses were performed on a subsample of the matrix derived from various features, some of which are unquestionably of human origin (such as hearths, pits, and smudge pits) and others that were considerably more debatable (such as postmolds). The analytical methods chosen for this work consisted of determination of the organic carbon content, the stable carbon isotopic composition of soil organic matter, magnetic susceptibility, the concentration of various elements typically associated with human alteration of soils, and the use of Carbon-13 Nuclear Magnetic Resonance Spectrometry ($^{13}$C- NMR) to assess soil samples for the presence of charcoal.

The suite of methods chosen for this work reflects a growing body of research on anthropogenic alteration of soils, ranging from chemical alteration of soils at sites (cf. Linderholm 2007), floors (Barba and Ortiz 1992; Barba et al. 1996; Middleton 2004; Sánchez and Cañabate 1999), and middens (Marwick 2005; Villagran et al. 2009), to a rather new a rapidly expanding body of literature on soils rich in black carbon (BC) found in the South American tropics termed Amazonian Dark Earths (often abbreviated ADE) or referred to by their regional names, terras pretas and terras mulatas (e.g., Arroyo-Kalin et al. 2009; Knicker 2011; Lehman et al. 2003, 2004; Major et al. 2010; Schmidt et al. 2014).

The last decade has witnessed an intense interest in the origins and creation of such organic-rich, or more specifically BC-rich, soils because they are seen as one means by which carbon may be removed from the atmosphere (or sequestered) for long periods of time without a host of negative consequences, indeed with beneficial side effects for agriculture and other pursuits. Researchers interested in this goal have spent a considerable amount of effort attempting to characterize organic matter generated by fire (known in the literature as biochar or pyrogenic organic matter [abbreviated PyOM]) with respect to its occurrence, chemistry, and methods of assay. Some of this literature is directly relevant to the questions being addressed here.

**Processes Associated with Elemental Concentrations on Occupation Surfaces**

Chemical alteration of soils by past human inhabitants has been known for some time, with early work on phosphorus first elucidated by Olof Arrhenius (1934, 1955) and later championed in detail by Robert Eidt (1985; see also Holliday and Gartner 2007). A broader understanding of elemental alteration of natural soils by human activity has been known for some time (cf. Davidson 1988; Sokolof and Carter 1952) but less readily forthcoming because of the laborious process of assay. With the passage of time, the chemical analysis of soils has become more precise, rapid, and cheaper, and the use of broader elemental variation studies has become more common (cf. Entwistle et al. 1998, 2000; Hjulström and Isaksson 2009; Linderholm and Lundberg 1994). Through such work, it has become
apparent that there are several elements in addition to phosphorus that are commonly enhanced by long-term human activity (e.g., Arroyo-Kalin et al. 2009; Misarti et al. 2011; Wilson et al. 2009), and the most commonly cited include barium (Ba), calcium (Ca), cadmium (Cd), copper (Cu), potassium (K), magnesium (Mg), phosphorus (P), lead (Pb), strontium (Sr), titanium (Ti), and zinc (Zn). Until recently, most studies that have examined elemental variation have employed lab-based methods like atomic adsorption spectrometry or inductively coupled plasma spectroscopy, but with the advent of portable x-ray fluorescence, even that is beginning to change (cf. Gauss et al. 2013).

The specific behavioral/source material mechanisms of anthropogenic elemental enrichment remain somewhat ill-defined because of several factors, such as a lack of uniform chemical composition of inputs, a general lack of ethnoarchaeological baseline studies (e.g., Rondelli et al. 2014), and postdepositional processes that may obscure the original chemical inputs. Nevertheless, several studies have elucidated elemental relationships with specific materials or processes (see Misarti et al. 2011:1422, Table 1; Nielsen and Kristiansen 2014; Wilson et al. 2009). Many of the elements commonly observed to be enhanced by human activity cited previously are constituents of wood ash, the most common waste product of pre-industrial societies, excluding animal manure. The chemical composition of wood ash varies by plant and the temperature of the thermal environment that produced it, but in general terms, ash is rich in aluminum, calcium, iron, potassium, magnesium, manganese, sodium, phosphorus, sulphur, and silica, with calcium, potassium, magnesium, and iron being the four most commonly occurring elements (cf. Etiegni and Campbell 1991; Karltun 2011; Pittman 2006). Bone and charcoal may be critical in the enrichment of calcium, strontium, phosphorus, zinc, and copper (Wilson et al. 2008), and manuring has been associated with the enrichment of sodium, phosphorus, potassium, calcium, manganese, and strontium (Nielson and Kristiansen 2014).

**Strategy**

The investigative approach employed here used three sets of samples to assess the anthropogenic component of the soils at the site. The first set of samples comprised 61 samples of the paleosol collected from the walls of the unit excavations (Figure 120), 35 of which were collected from places where the deposit was thought to be a midden and 26 from places where the deposit was thought to be a natural paleosol. The second consisted of 29 soil samples collected from features during the excavation of the site, specifically seven smudge pits (Features 10, 48, 61, 62, 87, 94, and 105), eight pits (Features 6, 7, 9, 15, 30, 56, 58, and 68), four hearths (Features 29, 75, 86, and 88), and 10 postmolds (Features 14, 17, 18, 19, 21, 22, 24, 35, 37, and 103). Control samples were provided through a suite of 13 samples derived from three specific stratigraphic contexts that differ from each other but that were apparently unaltered by human activity. This suite consisted of four samples collected from the E-horizon beneath the cultural occupation, four samples
Figure 120. Locations of paleosol cube samples.
of the argillic horizon (also below the Caddo occupation), and five samples derived from the colluvium that mostly postdates Caddo occupation of the site.

Although the choice of control samples can be criticized because they were not collected from outside the site boundary, several factors influenced the choice of samples selected. First, the narrow project ROW formally constrained an understanding of the actual size of the Caddo site, and assumptions about the degree of Caddo land use outside the known site boundary were little more than conjecture. Second, researchers were cognizant of moving too far from the site for fear of changing geological conditions that would not provide an appropriate control for the deposits within the known site. Finally, the belief was that grouping samples from similar geologic/pedologic context would provide a useful baseline for assessing the degree of change exhibited by the cultural features in question.

Methods

Carbon and Nitrogen, and Stable Carbon Isotope
Determination of the carbon and nitrogen content and the stable carbon isotopic ratio of soil organic matter was performed by the Stable Isotope/Soil Biology Laboratory, which is part of the Analytical Chemistry Laboratory at the Odum School of Ecology, the University of Georgia. Samples were first dried and finely ground, and then sent to the lab for analysis. The carbon and nitrogen content was determined by Micro-Dumas combustion analysis on a Carlo Erba NA1500 C/H/N Elemental Analyzer that is coupled to a Thermo Delta V Mass Spectrometer via a Thermo Conflo III Interface.

Elemental Analysis
For the elemental analysis, the soil samples were first dried and then ground, and then submitted to the Analytical Service Center in the School of Environmental and Forest Services, University of Washington. The samples were analyzed by Dongsen Xue using a Thermo Scientific Model 6300 Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES). The soil samples were subjected to a strong acid digestion, specifically the EPA 3050 protocol (Environmental Protection Agency [EPA] 1996), which uses concentrated nitric acid, hydrogen peroxide, and hydrochloric acid in an effort to liberate into aqueous solution those elements concentrated by human activity (sometimes called the Theoretical Anthropogenic Fraction or TAF). Although this partial digestion method may not extract all of the TAF (cf. Peña-Icart et al. 2011), the EPA 3050 method is widely recognized as one of the most appropriate for the examination of anthropogenically concentrated elements.

Magnetic Susceptibility
Magnetic susceptibility was determined on a Bartington MS2 meter and MS2B sensor using samples that were packed into small 8-cc magnetically inert plastic boxes. Samples were weighed, and then the low and high frequency magnetic susceptibility was measured, with each value measured twice, and the average values were used to calculate the reversible,
low and high frequency mass susceptibility ($\chi_{lf}$ and $\chi_{hf}$) and are reported in SI units (10$^{-8}$ m$^3$ kg$^{-1}$). The coefficient of frequency dependency ($\chi_{fd}$) was also calculated and is reported as a percentage. The precise methods and equations used may be found in Gale and Hoare (1991:222–226) and Dearing (1999a, 1999b).

**Carbon-13 Nuclear Magnetic Resonance Spectroscopy**

Samples analyzed by solid state $^{13}$C Nuclear Magnetic Resonance Spectroscopy were performed at Rice University Department of Geosciences by Dr. Caroline Masiello and Dr. Xiaodong Gao. Samples for $^{13}$C-NMR analysis require in excess of 3 percent carbon to obtain a good signal in a reasonable amount of time, but none of the samples used here contained in excess of 1.6 percent carbon, so it was necessary to pretreat the samples in order to concentrate the carbon by removing some of the silicate fraction of the soil. This process has the added benefit of removing magnetic minerals than can interfere with the $^{13}$C-NMR analysis (see Skjemstad et al. 1994). For each sample, 5 grams of soil was added to a 50-ml plastic test tube, to which 50 ml of 3 percent hydrofluoric acid (HF) was then added. The samples were then mixed on a vortex stirrer and shaken on an orbital shaker for periods between 5 and 8 hours for a total HF digestion time of 18 hours. At the end of each digestion cycle (of which there were three), the samples were centrifuged at 2000 rpm for 10 minutes, after which the supernatant liquid was decanted and discarded, and the samples then refilled with hydrofluoric acid, resuspended, and then returned to the shaker. At the end of the 18-hour digestion, the samples were rinsed three times with distilled water (and centrifuged at 2000 rpm for 10 minutes after each rinse), and then decanted into glass vials and dried at 60°C. Upon drying, the sample separated into a thin organic surface layer over a white mineral layer, and for the NMR analysis, the surface organic layer was collected and the white sand beneath it discarded. Table 70 lists the carbon content of the samples before HF treatment and as used for the NMR analysis.

**Table 70: List of Samples Used in the $^{13}$C-NMR Study and Their Pre- and Post-Hydrofluoric Acid Treatment Carbon Attributes**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Context</th>
<th>Raw Carbon (%)</th>
<th>Post-HF Treatment Carbon (%)</th>
<th>Pre-HF treatment $\delta^{13}$C (per mil PDB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern soil (little or no charcoal)</td>
<td>1982, 0–5 cm, natural soil</td>
<td>na</td>
<td>7.28</td>
<td>na</td>
</tr>
<tr>
<td>Weakly melanized paleosol</td>
<td>TU 63, paleosol</td>
<td>0.27</td>
<td>na</td>
<td>-24.82</td>
</tr>
<tr>
<td>Moderately melanized paleosol</td>
<td>TU 80, paleosol</td>
<td>0.39</td>
<td>20.47</td>
<td>-24.18</td>
</tr>
<tr>
<td>Strongly melanized paleosol</td>
<td>1982, 40 cm, paleosol</td>
<td>0.45</td>
<td>10.98</td>
<td>-24.79</td>
</tr>
<tr>
<td>No soil development, only charcoal</td>
<td>F-10, smudge pit</td>
<td>1.55</td>
<td>8.97</td>
<td>-26.28</td>
</tr>
</tbody>
</table>
The $^{13}\text{C}$-NMR experiments were conducted on a Bruker Avance 200 MHz solid-state NMR at Rice University. The spectrometer was equipped with 4-mm magic angle spinning probe (MAS) and operated at a rotor spinning frequency of 7 kHz. Cross polarization (CPMAS) spectra were acquired by applying a 90 degree $^1\text{H}$ pulse, a 1.0 ms $^{13}\text{C}$ contact pulse, composite pulse proton decoupling, and a 5s recycle delay. The CPMAS pulse sequence was used in this study because its signal to noise ratio (S/N) is more than four times greater than DPMAS. However, CPMAS can sometimes be less quantitative and underestimate certain C components such as charcoal and lipids. Thus, researchers performed spin-counting for each spectrum to determine the C observability for the CPMAS experiments. The CPMAS offers a lower boundary for soil charcoal content because of this effect.

A molecular mixing model (MMM) (Baldock et al. 2004) was used to determine the charcoal content in each sample. Spinning sideband (SSB) was integrated and corrected during MMM calculation. The MMM additionally provides information on the degree of decomposition of the sample as reported in the alkyl/O-alkyl peak ratios.

**Results**

*Is there a Midden within the Paleosol at 41PN175?*

The short answer is yes. However, the results are little different from originally envisioned, as will be seen below. The results of the analytical work on the soil samples collected from the paleosol are presented in Table 71 and shown graphically on Figures 121, 122, and 123. Table 72 presents the results of a Student’s T-test comparing the samples that were identified in the field as midden with samples that were distinguished as nonmidden paleosol. Several of the assayed elements, specifically cadmium, copper, and titanium, yielded either trace values or were present in concentrations that were below detection limits and are generally excluded from discussion for this reason.

As can be seen on Figure 120, the midden crosses the project ROW obliquely, with the edge of the feature crossing the western side of the ROW farther north than on the eastern side of the ROW, and as a result, the full sample suite provides a fuzzy image of the transition between the nonmidden paleosol and the midden paleosol. Hence, Figures 121 and 122 present two ways of viewing these data. The left side panel presents a scatterplot of element concentration on the Y-axis versus the grid Northing for each sample on the X-axis and depicts the entire sample set, whereas the right side bar charts plot the elemental concentration for the samples along the western side of the sample block as if they are a single transect (albeit one that ignores the geographic separation between samples). The scatterplots somewhat obscure the edge of the midden given that the feature cuts obliquely across the ROW, but the column charts show the edge of the feature abruptly, as it was perceived in the field. Both illustrations of the data clearly show that the midden (denoted by the orange data points on the scatterplots and the orange background on the column plots) exhibits elevated values for most assayed properties. Figure 123 provides a spatial view of the elemental variation that has been altered by the use of a low pass filter in order
Table 71: Paleosol Elements
Cube
Number
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44

Midden
1=yes
0=no
1
1
1
1
1
1
1
1
1
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1

Northing
(m)
556.976683
555.993085
550.884691
549.553850
548.474984
546.123103
544.296234
549.702563
548.149420
520.228320
520.558982
521.497544
520.753802
519.611597
519.722781
518.977236
519.208453
519.369854
535.216862
536.481594
537.366833
538.304281
539.129057
540.001239
540.982466
541.903266
548.273871
548.049436
551.171469
548.211969
548.712007
550.119482
549.785097
547.959764
549.902153
545.825374
545.897432
544.593891
544.914322
542.268806
542.014013
541.562110
540.527637
539.526725

Easting
(m)
507.063412
506.823932
507.441570
508.197241
507.942551
514.402999
513.822425
513.325488
512.978359
509.219399
507.839763
505.264007
504.085334
503.845897
506.331325
505.352363
504.261213
505.783413
503.996538
504.263008
505.497965
505.715531
505.867471
506.052334
506.281640
506.490494
506.340944
507.412773
507.070704
511.430445
511.107655
511.926064
511.361341
512.549422
512.879924
514.630047
513.676865
514.220374
513.328819
506.949682
508.101882
508.394685
508.173946
507.932174

Barium
Ba
µg/g
194.51
192.97
143.25
142.66
162.97
56.52
61.21
102.62
74.94
32.80
26.25
29.62
31.96
45.19
38.57
45.12
38.97
40.57
58.43
38.22
62.95
96.63
53.48
86.92
69.27
90.97
144.92
125.12
117.11
107.22
87.27
90.51
80.36
63.63
70.02
50.30
51.53
46.93
69.18
78.23
92.81
88.61
90.80
59.66

Calcium
Ca
µg/g
163.02
103.19
136.39
147.58
163.86
49.60
106.70
111.34
64.21
76.51
68.38
35.50
46.88
34.73
46.79
476.58
144.41
83.07
718.99
88.40
47.56
92.93
85.20
78.85
134.62
76.63
219.61
211.12
206.71
95.08
99.18
125.94
285.85
465.89
136.28
335.29
87.47
85.93
71.18
77.40
287.20
127.26
53.27
58.94

Cadmium
Cd
µg/g
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
1.92
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND

Copper
Cu
µg/g
2.75
2.79
2.66
3.22
4.03
TR
TR
TR
TR
ND
ND
ND
ND
ND
TR
ND
ND
TR
TR
TR
TR
1.97
TR
1.83
TR
1.87
3.43
3.23
2.33
TR
TR
TR
TR
TR
TR
TR
TR
TR
TR
TR
TR
1.86
1.48
TR

Potassium
K
µg/g
277.03
267.22
263.56
252.36
279.46
188.37
217.41
210.17
216.82
199.94
191.00
176.93
186.74
179.44
219.92
182.54
180.43
200.63
187.75
191.26
178.39
213.90
178.18
228.01
211.25
227.32
265.63
241.18
277.52
243.13
243.85
221.61
239.81
235.07
213.66
210.92
227.94
301.81
235.58
224.46
245.83
243.62
280.80
196.19

Magnesium
Mg
µg/g
230.61
185.23
217.47
218.41
258.73
141.84
170.72
171.84
173.65
140.09
134.04
114.95
130.80
125.05
136.68
126.58
123.63
137.30
141.62
133.58
135.14
155.72
126.79
167.84
151.98
179.80
220.29
212.11
225.64
203.22
177.82
176.34
159.27
191.45
169.55
158.43
153.56
179.13
178.64
175.00
196.45
172.83
176.15
134.13

Phosphorus
P
µg/g
123.16
114.15
136.44
121.86
147.35
79.18
76.17
79.14
101.23
56.55
54.88
48.40
42.00
49.40
65.20
54.41
45.81
69.85
373.80
64.49
66.01
90.97
51.53
85.11
58.30
78.05
137.22
126.44
134.80
97.12
93.69
92.20
98.05
88.31
89.63
72.28
72.01
72.11
72.83
84.57
74.02
77.81
74.61
57.33

Lead
Pb
µg/g
5.34
5.50
5.80
6.03
6.67
3.94
4.30
4.63
7.11
4.16
3.76
3.46
3.41
3.74
4.84
3.38
5.25
3.75
4.26
3.96
3.75
4.28
3.67
4.56
4.30
3.95
5.25
5.36
5.59
5.41
6.00
4.70
4.59
4.47
4.67
4.61
4.29
4.49
4.43
4.49
4.52
4.66
4.34
3.50

Strontium
Sr
µg/g
5.79
3.78
4.20
4.30
5.38
1.34
2.11
3.22
2.13
2.00
1.53
1.18
1.68
1.92
1.55
3.13
1.83
1.50
5.34
1.59
1.79
2.58
2.07
2.99
3.45
3.33
4.96
4.76
3.85
3.09
2.31
2.75
4.14
2.97
2.12
1.78
1.78
2.05
2.42
3.61
3.61
3.77
2.85
1.71

Titanium
Ti
µg/g
0.17
0.24
0.16
TR
TR
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
TR
0.43
0.17
0.19
TR
ND
ND
ND
ND
ND
ND
0.22
ND
ND
ND
ND
ND

Zinc
Zn
µg/g
14.56
15.31
15.19
15.41
15.35
7.00
9.34
10.07
7.84
9.08
6.92
4.38
4.32
4.44
7.55
4.50
4.42
5.59
5.87
6.28
6.41
9.23
5.22
8.54
7.60
9.79
14.72
12.54
14.71
12.74
12.46
11.79
9.39
7.57
10.29
6.89
7.59
8.33
8.91
9.02
10.97
10.65
9.92
7.14

Total
Nitrogen
%
0.033
0.031
0.038
0.035
0.046
0.028
0.029
0.026
0.024
0.021
0.019
0.013
0.010
0.014
0.018
0.019
0.015
0.016
0.018
0.018
0.017
0.025
0.012
0.015
0.015
0.019
0.033
0.030
0.033
0.032
0.030
0.030
0.041
0.023
0.026
0.022
0.024
0.024
0.023
0.021
0.018
0.026
0.018
0.019

Total
Carbon
%
0.49
0.45
0.55
0.52
0.75
0.36
0.38
0.41
0.30
0.27
0.23
0.16
0.13
0.20
0.22
0.27
0.35
0.20
0.22
0.22
0.24
0.37
0.15
0.18
0.27
0.60
0.58
0.49
0.48
0.55
0.42
0.39
0.62
0.28
0.37
0.27
0.33
0.30
0.29
0.32
0.29
0.49
0.27
0.25

d13C
vs. PDB
-24.48
-24.79
-24.67
-24.91
-24.94
-24.45
-24.59
-25.25
-24.42
-25.73
-24.98
-24.84
-25.50
-24.81
-24.59
-24.82
-25.59
-24.34
-24.48
-24.91
-24.19
-25.08
-24.99
-23.39
-25.25
-26.47
-24.47
-24.37
-24.08
-25.01
-24.49
-24.18
-25.52
-23.50
-23.99
-23.48
-24.29
-23.85
-23.90
-23.84
-23.97
-25.34
-23.32
-22.98

C/N
Ratio
15.05
14.52
14.53
15.06
16.47
12.86
13.18
15.82
12.50
13.23
11.88
12.17
12.23
14.35
12.01
14.46
23.48
12.31
12.53
12.04
13.78
15.00
12.51
12.13
18.20
31.71
17.71
16.20
14.78
16.96
13.84
13.16
15.05
12.42
14.37
12.58
13.75
12.49
12.53
15.27
15.92
18.74
14.50
12.87

Magnetic
Susceptibility
(10-8m3kg-1)
23.8
24.5
24.6
22.2
24.4
16.0
16.9
18.8
20.9
22.8
35.6
20.1
21.5
21.6
26.1
19.0
18.3
27.7
22.1
18.7
22.0
19.4
20.6
21.4
18.4
28.4
29.6
25.6
27.2
21.0
18.0
21.1
12.1
14.9
21.9
17.2
18.2
19.9
19.5
23.5
21.3
18.7
21.6
27.7

Coefficient of
Frequency Dependence
(%)
5.3
7.0
4.6
5.3
7.4
6.3
7.7
8.1
10.0
4.2
4.7
5.9
6.7
1.6
4.7
7.1
6.2
8.0
8.7
11.7
6.6
7.4
7.4
8.3
6.9
7.7
7.0
11.2
12.1
11.8
8.1
5.1
6.0
5.0
5.6
6.4
14.4
13.3
15.0
15.6
5.8
4.8
8.3
7.1

317


Table 71 (continued)

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<th>Cube Number</th>
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<th>Northing (m)</th>
<th>Easting (m)</th>
<th>Barium (µg/g)</th>
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<th>Cadmium (µg/g)</th>
<th>Copper (µg/g)</th>
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<th>Strontium (µg/g)</th>
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<th>Zinc (µg/g)</th>
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<th>Total Carbon (%)</th>
<th>C/N Ratio</th>
<th>Magnetic Susceptibility (10^-8 m^3/kg)</th>
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Figure 121. Plots showing midden and nonmidden elemental data. **Left Side:** scattergram plotting elemental concentration (on the Y-axis) vs the grid northing for each sample (X-axis). Yellow squares are samples identified in the field as nonmidden paleosol, and the orange squares are samples identified as midden. **Right Side:** column charts of the elemental concentration for samples along the west side of the excavation blocks. Area of yellow background contains samples identified as nonmidden paleosol and the orange background are samples identified as midden.
Figure 122. Plots showing midden and nonmidden physical data. Plots similar to Figure 121 but showing results for total carbon, stable carbon isotopic composition, magnetic susceptibility and the coefficient of frequency dependence.
Figure 123. Color plot of the spatial variation in various properties assayed from the paleosol soil samples. The black dots show the locations of samples identified in the field as midden, and the white dots denote samples classified as nonmidden paleosol. It should be noted that the data sets for cadmium, copper and titanium all had either low or no values in the data set.
Table 72: Results of Students T-Test

| T-test Level of Significance | Barium (Ba) µg/g | Calcium (Ca) µg/g | Potassium (K) µg/g | Magnesium (Mg) µg/g | Phosphorus (P) µg/g | Lead (Pb) µg/g | Strontium (Sr) µg/g | Zinc (Zn) µg/g | Total Nitrogen % | Total Carbon % | δ13C vs. PDB | C/N Ratio | Magnetic Susceptibility (10^-8 m³ kg⁻¹) | Coefficient of Frequency Dependence (%) |
|-----------------------------|------------------|------------------|------------------|--------------------|--------------------|----------------|-------------------|----------------|----------------|----------------|----------------|------------|----------------|----------------|----------------|
| 0.1                         | Yes              | No               | Yes              | Yes                | No                 | Yes           | Yes               | Yes            | Yes            | Yes            | Yes            | No         | No               | No             |
| 0.05                        | Yes              | No               | Yes              | Yes                | No                 | Yes           | Yes               | Yes            | Yes            | Yes            | Yes            | Yes        | No               | No             |
| 0.001                       | Yes              | No               | Yes              | Yes                | No                 | Yes           | Yes               | Yes            | Yes            | Yes            | Yes            | Yes        | No               | No             |

| t Stat | P(T<=t) two-tail | t Critical two-tail | | | | | | | | | |
|-------|------------------|---------------------| | | | | | | | | |
| -7.87 | 0.000000         | 2.01                | | | | | | | | | |
| 1.64  | 0.108505         | 1.69                | | | | | | | | | |
| -4.70 | 0.000022         | 3.50                | | | | | | | | | |
| -5.23 | 0.000003         | 3.49                | | | | | | | | | |
| -0.81 | 0.424377         | 1.70                | | | | | | | | | |
| -3.59 | 0.000697         | 3.48                | | | | | | | | | |
| -2.50 | 0.015759         | 2.01                | | | | | | | | | |
| -5.42 | 0.000001         | 3.47                | | | | | | | | | |
| -6.08 | 0.000001         | 3.49                | | | | | | | | | |
| -5.78 | 0.000004         | 2.00                | | | | | | | | | |
| -2.36 | 0.021527         | 1.67                | | | | | | | | | |
| -1.79 | 0.079112         | 1.68                | | | | | | | | | |
| 1.61  | 0.115518         | 1.68                | | | | | | | | | |
| -1.45 | 0.153518         | No                  | | | | | | | | | |

Note: Cadmium, Copper and Titanium have been omitted.
to remove the abrupt trends between adjacent points that obscured the results of the site-wide analysis. The location of the samples with respect to the unit excavations are shown, as is the assignment of each sample into either midden or nonmidden paleosol. Although the spatial clumping of the samples set results in some distortions of the patterns, this portrayal of the data is perhaps the clearest with respect to correspondence of elemental variation and the location of the midden.

The results of the Student's T-test (see Table 68) comparing the samples identified in the field as midden to those identified as nonmidden paleosol indicate that the elemental concentrations of barium, potassium, magnesium, lead, zinc, carbon, and nitrogen represent different populations at the 0.001 level of significance, whereas strontium and the stable carbon isotopic ratio are significantly different at the 0.05 level of significance. Somewhat puzzlingly, the elements/properties most expected to be significantly different, namely calcium, phosphorous, and magnetic susceptibility, are not significantly different between the midden and the nonmidden paleosol, and this will be discussed in more detail below.

At the most fundamental level, the concentration of total carbon between the midden and the nonmidden paleosol samples are significantly different, as is to be expected if the degree of melanization of the midden samples is due to an increase in carbon content. The edge of the feature in the scatterplots is somewhat fuzzy, with carbon values at the edge of the midden falling within the range of variation of the paleosol away from the midden, but carbon concentration increases significantly farther to the north away from the feature’s edge. The column charts show the relatively abrupt and dramatic increase in carbon that is consistent with field perceptions that this feature was relatively discrete. The spatial plot of carbon content clearly shows that carbon content at the edge of the feature is transitional between the nonmidden paleosol and the area of greatest carbon concentration located north of Block 4. At the group level, the carbon values within the midden are twice the values of the paleosol away from the midden.

The stable carbon isotopic ratios obtained from the midden are, on average, 0.3 per mil heavier than the nonmidden paleosol, which suggests only a very a slightly greater amount of C$_4$ biomass contributed to the midden organic matter. The spatial plot of $\delta^{13}$C values on Figure 123 shows a faint image of the midden, with an area of high values along the northern edge of Block 4 and notably lower values south of this point. Examination of the scatterplot of $\delta^{13}$C values vs. Northing coordinate on Figure 122 shows two interesting trends: (1) a subtle but noticeable increase in $\delta^{13}$C values from south to north (Pearson product moment correlation coefficient r=0.19), and (2) a significantly wider range of carbon isotopic variation in the midden as compared to the nonmidden paleosol (the standard deviation for the midden is almost twice that of the paleosol). Both trends are consistent with the interpretation of the midden as an anthropogenically enhanced soil feature, specifically one that received more organic contributions than the natural forest soil, and
that those contributions contained a wider range of carbon isotopic values than is present in the local forest vegetation. The latter most likely is due to the contribution of organic material gathered by the Caddo from a relatively wide geographic area and then disposed of in this single place. That said, the carbon isotopic variation exhibited by the midden is significantly less than expected for a society presumably relying heavily on maize agriculture.

As noted previously, the elements that show the greatest concentration in the midden are those typically associated with anthropogenic enhancement, specifically barium, potassium, magnesium, lead, strontium, and zinc. All of these elements listed above clearly follow the spatial distribution of the midden (see Figure 123) and exhibit elevated values in both the scatterplots and column charts (see Figures 121 and 122).

The average value of calcium in the nonmidden paleosol is actually greater than the paleosol and exhibits a very wide range of variation, but much of the elevated calcium values are found at the very edge of the midden and therefore may still be the result of an anthropogenic process (i.e., cooking activities taking place in this area). Wilson et al. (2009) note that postdepositional processes such as differential leaching and absorption are one of the main complicating factors in the interpretation of soil element concentrations, and that may be one of the issues responsible for the variable calcium concentrations. The principle sources of calcium expected in a midden are contributed by wood ash and bone, both of which are notoriously unstable in the acidic soils of East Texas. Ash and bone are both prone to dissolution and leaching by meteoric water, and this process alone may result in anomalously low levels in the soil, even when enhanced by human additions. Furthermore, wood ash may have been used in food preparation (specifically in the preparation of maize masa or nixtamalization) by the Caddo rather than discarded. Interestingly, Misarti et al. (2011) note that this process has been associated with soil enhancement of calcium and strontium. And finally, bone, in the form of hydroxy-apatite, is less rapidly dissolved than the fine crystals of calcium carbonate present in wood ash, and may have a longer residence time, chemically speaking, in the soil than ash.

The case of phosphorus is also interesting. Phosphorus was the first element widely used in archaeochemical exploration and is, in general, thought to be quickly bound and fixed to stable soil minerals once added to the soil in organic form. Nevertheless, phosphorous values within the midden are only slightly greater than the nonmidden paleosol, and the results of Student’s t-test suggest that the differences between the two populations are insignificant even at the 0.1 level. That said, there is a weak positive correlation ($r=0.34$) between the concentration of P and sample northing, which indicates that there has been enhancement of the midden, albeit a subtle one. Although there is not much comparative work to draw upon for assessing the phosphorus enhancement of such sandy soils, Crowther’s (2002) analysis of bone dissolution in the Wareham Experimental Earthwork project in the sandy podzolic soils of the lowland heath experiment in the UK showed that
only 1 of the 200 samples analyzed exhibited any phosphorous enrichment and this was attributed to active leaching in well-drained sandy soils.

**Magnetic Susceptibility**

Magnetic susceptibility is an easily measured, nondestructive technique that represents the degree to which a sample may be magnetized. Although seemingly an obtuse property, there are a number of human activities that may enhance the magnetic susceptibility of a sediment or soil, and as such, this property has found use in archeological investigations in a variety of ways. Spatial variations in magnetic susceptibility created by human agency upon occupation surfaces are one of the fundamental reasons magnetic surveys yield archeologically useful results. Thus, there are a variety of human activities (e.g., burning, moving earth, disposing of waste) that may create or concentrate magnetic minerals that are subsequently detectible by measuring either the magnetic susceptibility of the soil/sediment or by measuring the spatial variation in the Earth’s total magnetic field. The magnitude of the magnetic susceptibility reflects: (1) the mineralogy, (2) the concentration of magnetic minerals, and (3) the magnetic mineral grain size and shape. Magnetic susceptibility alone is not very useful in identifying which magnetic minerals are present, but rather it is a rough index of the amount of magnetic minerals present. It reflects the concentration of magnetic minerals in a sample if only one magnetic mineral is present.

If the midden arose from the addition of thermal refuse to the soil, then it is logical to expect that the soil will exhibit magnetic susceptibility enhancement as well, as it is well established that heating of soils generally results in elevated magnetic susceptibility because of the formation of magnetite or maghaemite (sometimes called secondary ferrimagnetic minerals or SFMs; Dearing et al. 1996) from hematite or goethite during heating of earth or rocks (cf. Dalan 2008; Dalan and Bannerjee 1998). However, for this to happen, the host soil must contain hematite and goethite.

The results of the low-frequency mass-corrected magnetic susceptibility ($\chi_{lf}$) analysis indicate that the midden does not exhibit magnetic susceptibility enhancement with respect to the nonmidden paleosol, and the results of the Student’s T-test indicate that the values obtained from the two groups do not represent different populations even at the 0.1 (90 percent confidence) level. The similarity in the results can be clearly seen on the scatterplot and column chart (see Figure 122) as well.

The second magnetic property measured, the coefficient of frequency dependence, is the ratio of the magnetic susceptibility measured at two different frequencies and is expressed as a percentage, with values in excess of 10 percent generally viewed as indicative of the presence of frequency dependent superparamagnetic grains, which are often found concentrated in topsoils (cf. Dearing et al. 2001 and Le Borgne 1955). Most of the values measured for the paleosol and the midden were under 10 percent, with slightly more than twice as many samples from the midden exhibiting values >10 percent. That said, the
results of the Student’s T-test indicate that these two populations are not significantly different at the 90 percent confidence level.

One possible explanation for the lack of magnetic susceptibility enhancement is that the surface soils lack significant quantities of iron minerals to begin with and therefore fail to exhibit significant magnetic susceptibility enhancement following heating. In order to test this hypothesis, eight soil samples collected from the sample column in Test Unit 111, within the area of the midden, were measured at room temperature, and then again after heating to 450 °C and 950 °C in order to see how much of an increase may be expected when the site matrix is heated. The results, shown in tabular form on Table 73 and in graphic form on Figure 124 show that most of the samples experienced a modest increase in magnetic susceptibility when heated to 450 °C (average of 11.9±11.7 percent) and somewhat perplexingly, most samples experienced a decrease in magnetic susceptibility upon heating to 950 °C (average of 54.8±26 percent). The exceptions to these generalizations were samples from the midden that were unaffected by heating at all three temperatures.

### Table 73: Magnetic Susceptibility Data

<table>
<thead>
<tr>
<th>Sample</th>
<th>Context</th>
<th>Depth (cm)</th>
<th>Raw</th>
<th>450°</th>
<th>950°</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modern soil in colluvium</td>
<td>0–5</td>
<td>16.7</td>
<td>20.5</td>
<td>3.9</td>
</tr>
<tr>
<td>2</td>
<td>Modern soil in colluvium</td>
<td>5–10</td>
<td>17.2</td>
<td>20.2</td>
<td>5.2</td>
</tr>
<tr>
<td>3</td>
<td>Colluvium</td>
<td>20–25</td>
<td>19.7</td>
<td>22.8</td>
<td>7.2</td>
</tr>
<tr>
<td>4</td>
<td>Colluvium</td>
<td>25–30</td>
<td>17.6</td>
<td>17.7</td>
<td>6.8</td>
</tr>
<tr>
<td>5</td>
<td>Paleosol</td>
<td>40–45</td>
<td>25.6</td>
<td>23.1</td>
<td>25.7</td>
</tr>
<tr>
<td>6</td>
<td>E-Horizon</td>
<td>55–60</td>
<td>20.2</td>
<td>21.4</td>
<td>13.4</td>
</tr>
<tr>
<td>7</td>
<td>E-Horizon</td>
<td>60–65</td>
<td>19.3</td>
<td>20.1</td>
<td>8.2</td>
</tr>
<tr>
<td>8</td>
<td>E-Horizon</td>
<td>65–70</td>
<td>16.0</td>
<td>17.4</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td></td>
<td>19.0</td>
<td>20.4</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td></td>
<td>3.1</td>
<td>2.1</td>
<td>7.3</td>
</tr>
</tbody>
</table>

A second possible explanation for the anomalously low magnetic susceptibility readings from these deposits may be due to the effect of a fluctuating water table above the Bt horizon. It is well established that magnetic susceptibility values of soils that are seasonally saturated and reduced are lower than better drained soils that do not exhibit evidence of iron reduction and this property has been used to spatially delineate wetland soils (cf. Simms and Lobred 2011; Grimley and Vepraskas 2000; Williams and Cooper 1990; Mullins 1977). It is possible that the periodic saturation of the sandy epipedon at this site has resulted in enough alteration of the magnetic mineral assemblage to mask any depositional differences that might have once existed between the midden and the non-midden paleosol.

**Elemental Variation Among the Cultural Features**

As a complement to the midden analysis, as noted previously, many of the same analyses were performed for a suite of features from the site. The results of this work are presented on Table 74, summarized on Table 75 and in graphic form on Figures 125 and 126. The
rationale behind this work was twofold. First, petrographic examination of a wide range of features concluded that it was not possible to differentiate posts from the natural E-horizon but that other types of analyses such as elemental analysis may permit this (cf. van der Merwe and Stein 1972). Second, this work provides a broader context for understanding the range of elemental variation within the paleosol. For the purposes of comparison, the documented properties examined (elemental concentrations as well as magnetic properties and stable carbon isotopic ratios) for the various feature groups are compared with the values obtained from the E-horizon into which most were inset.

**Smudge Pits**
The most distinctive features examined were the smudge pits, which stand out from other features on several attributes, not the least of which is carbon. In specific, the smudge pits also exhibited elevated levels of barium, calcium, strontium, magnetic susceptibility, and stable carbon isotopic ratio, all of which are significantly different from the values obtained from the E-horizon. Although the values for several other elements appear on the plots of elemental concentration to be significantly different, such as phosphorus, lead magnesium, and zinc, the results of a two-way Student’s T-test assuming unequal variances did not support this at the 90 percent confidence level (Table 76).
### Table 74: Site 41PN175 Feature Elements

<table>
<thead>
<tr>
<th>Sample Class</th>
<th>Code Number</th>
<th>Provenience</th>
<th>Barium Ba (µg/g)</th>
<th>Calcium Ca (µg/g)</th>
<th>Cadmium Cd (µg/g)</th>
<th>Copper Cu (µg/g)</th>
<th>Potassium K (µg/g)</th>
<th>Magnesium Mg (µg/g)</th>
<th>Phosphorus P (µg/g)</th>
<th>Lead Pb (µg/g)</th>
<th>Strontium Sr (µg/g)</th>
<th>Titanium Ti (µg/g)</th>
<th>Zinc Zn (µg/g)</th>
<th>Total Nitrogen (µg/g)</th>
<th>Total Carbon (µg/g)</th>
<th>O13C vs. O12</th>
<th>C/N Ratio</th>
<th>Magnetic Susceptibility (10^3 m^2/kg)</th>
<th>Coefficient of Frequency (°C)</th>
</tr>
</thead>
</table>
Table 75: Feature Averages

<table>
<thead>
<tr>
<th>Context</th>
<th>Barium µg/g</th>
<th>Calcium µg/g</th>
<th>Potassium µg/g</th>
<th>Magnesium µg/g</th>
<th>Phosphorus µg/g</th>
<th>Lead µg/g</th>
<th>Strontium µg/g</th>
<th>Zinc µg/g</th>
<th>Nitrogen (%)</th>
<th>Carbon (%)</th>
<th>δ¹³C</th>
<th>Sr/Cu</th>
<th>Pb/Cu</th>
<th>Zn/Cu</th>
<th>P/Hg</th>
<th>Ni/Cu</th>
<th>Xf</th>
<th>Xfd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smudge Pit</td>
<td>347.7 ± 198.6</td>
<td>662.7 ± 401.2</td>
<td>248.6 ± 52.6</td>
<td>234.1 ± 56.2</td>
<td>110.9 ± 20.4</td>
<td>5.1 ± 0.7</td>
<td>15.5 ± 8.9</td>
<td>9.7 ± 3.6</td>
<td>0.029 ± 0.009</td>
<td>1.4 ± 0.6</td>
<td>-25.5 ± 0.8</td>
<td>48.4 ± 20.3</td>
<td>23.9 ± 6.9</td>
<td>5.5 ± 6.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pit</td>
<td>77.7 ± 11.1</td>
<td>95.7 ± 86.9</td>
<td>224.3 ± 30.8</td>
<td>160.8 ± 15.2</td>
<td>114.1 ± 20.6</td>
<td>4.9 ± 1.1</td>
<td>2.5 ± 0.9</td>
<td>6.7 ± 1.6</td>
<td>0.014 ± 0.002</td>
<td>0.2 ± 0.1</td>
<td>-24.2 ± 0.6</td>
<td>15.1 ± 4.2</td>
<td>23.8 ± 6.2</td>
<td>6.8 ± 0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearth</td>
<td>104.1 ± 8.6</td>
<td>152.2 ± 47.2</td>
<td>266.9 ± 22.8</td>
<td>191.5 ± 18.1</td>
<td>108.6 ± 20.0</td>
<td>5.2 ± 1.0</td>
<td>4.1 ± 0.9</td>
<td>10.1 ± 2.1</td>
<td>0.018 ± 0.001</td>
<td>0.3 ± 0.02</td>
<td>-23.9 ± 0.1</td>
<td>15.3 ± 1.0</td>
<td>31.8 ± 4.6</td>
<td>8.4 ± 0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post</td>
<td>54.9 ± 8.7</td>
<td>60.8 ± 12.6</td>
<td>215.1 ± 31.8</td>
<td>149.6 ± 22.6</td>
<td>83.2 ± 16.8</td>
<td>3.9 ± 0.3</td>
<td>2.2 ± 0.5</td>
<td>5.0 ± 0.9</td>
<td>0.012 ± 0.003</td>
<td>0.1 ± 0.1</td>
<td>-23.9 ± 1.0</td>
<td>11.1 ± 3.0</td>
<td>14.8 ± 1.7</td>
<td>5.4 ± 0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-horizon</td>
<td>63.5 ± 10.9</td>
<td>184.5 ± 124.6</td>
<td>261.5 ± 88.1</td>
<td>186.1 ± 73.1</td>
<td>83.4 ± 20.1</td>
<td>4.2 ± 0.6</td>
<td>3.8 ± 1.9</td>
<td>6.8 ± 1.4</td>
<td>na</td>
<td>0.14 ± 0.08</td>
<td>-24.4 ± 0.4</td>
<td>na</td>
<td>16.3 ± 2.1</td>
<td>4.7 ± 3.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bt Horizon</td>
<td>63.2 ± 23.6</td>
<td>194.9 ± 157.7</td>
<td>422.4 ± 212.5</td>
<td>386.0 ± 269.1</td>
<td>58.5 ± 9.7</td>
<td>4.8 ± 0.7</td>
<td>6.1 ± 5.3</td>
<td>9.9 ± 3.1</td>
<td>na</td>
<td>0.3 ± 0.3</td>
<td>-25.6 ± 1.5</td>
<td>na</td>
<td>20.8 ± 3.3</td>
<td>8.5 ± 1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colluvium</td>
<td>42.6 ± 14.3</td>
<td>93.2 ± 58.1</td>
<td>163.3 ± 33.9</td>
<td>137.3 ± 44.0</td>
<td>55.2 ± 9.5</td>
<td>3.3 ± 0.2</td>
<td>2.5 ± 1.3</td>
<td>5.5 ± 0.6</td>
<td>na</td>
<td>0.3 ± 0.04</td>
<td>-25.4 ± 0.2</td>
<td>na</td>
<td>21.8 ± 6.0</td>
<td>17.5 ± 13.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paleosol</td>
<td>57.5 ± 21.4</td>
<td>229.4 ± 212.1</td>
<td>206.8 ± 28.8</td>
<td>147.7 ± 26.1</td>
<td>78.9 ± 62.0</td>
<td>4.2 ± 0.7</td>
<td>2.4 ± 1.0</td>
<td>7.3 ± 2.1</td>
<td>0.019 ± 0.004</td>
<td>0.2 ± 0.1</td>
<td>-24.6 ± 0.5</td>
<td>13.5 ± 2.8</td>
<td>23.4 ± 5.0</td>
<td>7.3 ± 3.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midden</td>
<td>93.5 ± 37.9</td>
<td>156.1 ± 128.7</td>
<td>243.1 ± 26.9</td>
<td>185.8 ± 27.0</td>
<td>91.4 ± 24.0</td>
<td>4.9 ± 0.8</td>
<td>3.1 ± 1.1</td>
<td>10.7 ± 2.7</td>
<td>0.027 ± 0.007</td>
<td>0.4 ± 0.1</td>
<td>-24.3 ± 0.8</td>
<td>14.9 ± 3.5</td>
<td>21.4 ± 4.0</td>
<td>8.5 ± 3.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 125. Illustration shows the average (±1 standard deviation) for elemental concentrations obtained for specific features and other contexts at 41PN175.
Figure 126. Illustration similar to Figure 125 showing the variation in concentration of carbon, stable carbon isotopic ratio, magnetic susceptibility, the coefficient of frequency dependence, nitrogen content and the carbon to nitrogen ratio for specific features and other contexts at 41PN175.

**Hearths**

Hearths proved to have significantly higher magnetic susceptibility and concentrations of barium and zinc, but otherwise the values obtained from these features were not significantly different from the E-horizon. Although the average values for phosphorus appear to be significantly higher than the E-horizon, this was not supported by the T-test results.
Table 76: Results of a Two-Way Student’s T-Test Assuming Unequal Variances Comparing Feature Element Concentrations with the E-Horizon

<table>
<thead>
<tr>
<th>Feature</th>
<th>0.1 level of significance</th>
<th>Barium Ba µg/g</th>
<th>Calcium Ca µg/g</th>
<th>Potassium K µg/g</th>
<th>Magnesium Mg µg/g</th>
<th>Phosphorus P µg/g</th>
<th>Lead Pb µg/g</th>
<th>Strontium Sr µg/g</th>
<th>Zinc Zn µg/g</th>
<th>Total Carbon %</th>
<th>d13C vs. PDB</th>
<th>Magnetic Susceptibility (10⁻⁸ m³ kg⁻¹)</th>
<th>Coefficient of Frequency Dependence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smudge pits</td>
<td>t stat</td>
<td>3.774057835</td>
<td>2.65175385</td>
<td>-0.26911912</td>
<td>1.85118407</td>
<td>3.33797256</td>
<td>1.92563882</td>
<td>3.282816775</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>P(T&lt;=t) two-tail</td>
<td>0.009244581</td>
<td>0.021308838</td>
<td>0.801149328</td>
<td>0.07347322</td>
<td>0.01252988</td>
<td>0.009486505</td>
<td>0.002141387</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>t Critical two-tail</td>
<td>2.446911846</td>
<td>2.306004133</td>
<td>2.776445105</td>
<td>2.446911846</td>
<td>2.364624251</td>
<td>2.364624251</td>
<td>2.30604133</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hearth</td>
<td>t stat</td>
<td>5.836380504</td>
<td>-0.485941704</td>
<td>0.117507649</td>
<td>1.78597219</td>
<td>0.258721742</td>
<td>2.591163584</td>
<td>-0.645066646</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>P(T&lt;=t) two-tail</td>
<td>0.001114564</td>
<td>0.913883479</td>
<td>0.895408605</td>
<td>0.1737371014</td>
<td>0.080617929</td>
<td>0.546819794</td>
<td>0.003516247</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>t Critical two-tail</td>
<td>2.446911846</td>
<td>2.776445105</td>
<td>3.182446305</td>
<td>2.446911846</td>
<td>2.570581835</td>
<td>2.570581835</td>
<td>3.182446305</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pits</td>
<td>t Stat</td>
<td>2.099085242</td>
<td>-1.27948192</td>
<td>-0.826224459</td>
<td>-0.686359099</td>
<td>2.461304898</td>
<td>1.082015196</td>
<td>-1.434642873</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>P(T&lt;=t) two-tail</td>
<td>0.080579538</td>
<td>0.256822114</td>
<td>0.471014117</td>
<td>0.541776919</td>
<td>0.04903258</td>
<td>0.22470599</td>
<td>0.425593251</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>t Critical two-tail</td>
<td>2.446911846</td>
<td>2.570581835</td>
<td>3.182446305</td>
<td>2.446911846</td>
<td>2.228136842</td>
<td>2.776445105</td>
<td>2.364624251</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Post Molds</td>
<td>t Stat</td>
<td>-1.430464062</td>
<td>-1.981236123</td>
<td>-1.029269848</td>
<td>-0.980400688</td>
<td>-0.027036818</td>
<td>-1.194824229</td>
<td>-1.755477878</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>P(T&lt;=t) two-tail</td>
<td>0.211985087</td>
<td>0.141886826</td>
<td>0.379075477</td>
<td>0.399168143</td>
<td>0.979476286</td>
<td>0.298156191</td>
<td>0.07519428</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
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<td>t Critical two-tail</td>
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<td>2.570581835</td>
<td>2.776445105</td>
<td>3.182446305</td>
<td>2.262157158</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
**Pits**
Pits present a notably different chemical signature than the thermal features, but generally stand out with respect to only two properties: the phosphorus content, and magnetic susceptibility, the values of which are comparable to the thermal features. Otherwise, the pits are chemically similar to the E-horizon and the nonmidden paleosol.

**Posts**
Petrographic samples collected from the postmolds and adjacent matrix failed to identify attributes that would successfully distinguish them from the E-horizon within which they were typically found, but based on previous published studies, it was thought that other chemical or physical measures may permit the ability to distinguish postmolds from their surrounding matrix. In order to test this hypothesis, the fill from 10 postmolds was chemically examined and compared with four samples from the E-horizon, and the results failed on all counts. A two-way Student’s T-test assuming unequal variances performed on all measured elements and other attributes (e.g., low frequency magnetic susceptibility, coefficient of frequency dependence, and stable carbon isotopic ratio) failed to indicate a difference at the 90 percent confidence level, which suggests that there are insufficient differences between the presumed postmolds and their surrounding matrix to permit distinguishing them.

**Other Observations**
The argillic or Bt-horizon is clearly enriched in several elements, most notably potassium and magnesium, but there appears to be a slight enrichment of zinc and strontium as well. Given the nature of the geology at the site, it would seem logical for there to be a chemical similarity between the colluvium and the argillic horizon, but that does not seem to be the case except for concentrations of strontium, lead, and zinc, all of which are elevated in the Bt-horizon but not the colluvium.

Overall, the features most distinguishable from the others are the smudge pits, which are perhaps the most recognizable in the field as well. The hearths and pits also show distinct chemical differences from the E-horizon, and similarities with respect to phosphorus and lead and magnetic susceptibility.

*Is the Difference in Soil Color of the Midden Attributable to Pyrogenic Organic Matter?*

At this point, it seems apparent that on the basis of the elemental analysis, the presence of a midden within the paleosol is confirmed. Although the dark color of the midden corresponds to higher concentrations of elemental carbon, none of the assays to this point can demonstrate that this is the result of the inclusion of pyrogenic organic matter or black carbon, and indeed some of the results, such as the magnetic susceptibility, seem to suggest otherwise. Although petrographic examination of samples collected from the
midden did reveal the presence of charcoal in this feature, the dark color of the matrix is attributable to material in the silt- to clay-size fraction that cannot be identified as charcoal in thin-section, so some other method is necessary to determine the chemical structure of the finely disseminated organic matter in this deposit. In order to do this, the authors turned to solid-state Carbon-13 Nuclear Magnetic Resonance spectroscopy (or $^{13}$C-NMR).

Black carbon is the product of incomplete combustion of vegetation and occurs widely in sediments and soils. As currently conceptualized, there exists a continuum of black carbon products that form along a temperature gradient (cf. Hedges et al. 2000; Masiello 2004) with no clear-cut boundaries recognized between the functional categories (Schmidt et al. 2001). At the low temperature end of the continuum is slightly charred biomass that retains the morphology and chemistry of the source material (Hockaday 2006). At the high temperature end of the continuum are soot and graphite, which are refractory and formed by recondensation of gas phase elemental carbon atoms produced by the pyrolitic cracking of the carbon-carbon bonds in organic matter (Hockaday 2006:1). In between these two extremes lie char and charcoal, both of which retain some of the morphology of the original material but are increasingly dominated by aromatic chemical structures (Masiello 2004:202). Although the continuum concept seems widely accepted, distinguishing between each category is problematic. In addition to the degree of combustion, the size of the black carbon is important in how the material occurs and moves through the solum.

Efforts to quantify the amount of black carbon in soils and sediments have occurred in tandem with understanding of the chemical complexity of chars (cf. Knicker 2011; Krull 2009; Schmidt et al. 2001). Studies comparing the range of analytical methods useful in identifying and quantifying the amount of BC in soils and sediments have met with mixed results (cf. Hammes et al. 2007; Manning and Lopez-Capel 2009; Masiello 2004), with no single method providing a widely acceptable measure of biochar. These methods include thermo-gravimetry that measures weight loss upon heating, chemical oxidation using acid-dichromate or sodium hypochlorite, thermal-optical transmittance/reflectance, and UV photooxidation. These comparative studies have focused upon methods that can be used widely and rapidly on large numbers of samples and all have limitations as to what is actually assayed.

Discussions with researchers active in the field, specifically Dr. Caroline Masiello and Dr. Xiaodong Gao at Rice University, indicated that the best method to directly measure the presence of black carbon in a sample, specifically charcoal, is Carbon-13 Nuclear Magnetic Resonance spectroscopy, but this method is not useful for routine sample analysis. Given that the question concerning the midden directly revolves around the nature of the organic carbon in the feature, this recommendation seemed reasonable and so a study was designed to test the idea that the carbon in the midden was dominantly charcoal and not simply humified but uncharred organic matter.
Samples Analysed
As originally envisioned, it was anticipated this analytical procedure would assay the 61 paleosol samples, but this is not possible with $^{13}$C-NMR given the cost of instrument time and the length of time necessary to obtain good data for a single sample (which ranged from as short as nine hours to more than 16 hours). As a result, five samples were selected for analysis (Figure 127) that would allow testing the method, specifically by examining the organic matter present in contexts that can be considered a continuum from natural soil with little or no charcoal, to a smudge pit that was excavated into the E-horizon and for which all (or nearly all) of the organic matter present is pyrogenic in nature, specifically charcoal (Table 77). Between these end points lie the samples from the paleosol, one of which was selected from the dark-colored midden, one from closer to the edge of the midden, and one from well away from the feature.

Smudge Pit (Feature 10)
Smudge pits are shallow pits used to combust organic matter with the primary goal of creating smoke. In functional terms, smudge pits are recognized in the field as shallow pits with abundant charcoal, as opposed to hearths that, although may contain charcoal, typically have a wide range of thermal decomposition products because of a higher burning temperature and a more freely oxidizing thermal environment. Feature 10 was one of seven such features discovered during the excavation, and in its raw form this sample contained 1.55 percent carbon with a $\delta^{13}$C ratio of -26.28. This pit fill is thought to contain nearly pure pyrogenic organic matter given that its excavation removed the paleosol, although the presence of some paleosol organic matter may have entered the pit fill postabandonment.

The Paleosol
As noted previously, three samples were selected from the paleosol for $^{13}$C-NMR spectroscopy that reflected this range of apparent variation in carbon content as well as position with respect to the midden, as identified in the field during excavation.

- **Strongly Melanized Paleosol** (presumed midden; profile 1982, 40 cm, Test Unit 111, paleosol cube 2).
  This sample was located near the zone of highest carbon concentration within the midden and had 0.45 percent carbon with a $\delta^{13}$C ratio -24.79. The Munsell color was observed to be dark brown (10YR 3/3) when moist and brown (10YR 5/3) when dry.

- **Moderately Melanized Paleosol** (approaching margin of midden; Test Unit 80 paleosol, cube sample 32).
  This sample was significantly lighter-colored than the strongly melanized sample and had 0.39 percent carbon with a $\delta^{13}$C ratio -24.18. The Munsell color was observed to be dark yellowish brown (10YR 3/4) when moist and pale brown (10YR 6/3) when dry.
Figure 127. Map of 41PN175 showing the location of the samples used for the $^{13}$C- NMR study.
Table 77: Elemental Composition

<table>
<thead>
<tr>
<th>Context</th>
<th>Sample</th>
<th>N (wt %)</th>
<th>C (wt %)</th>
<th>H (wt %)</th>
<th>C/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern soil (little or no charcoal)</td>
<td>1982, 0–5 cm, natural soil</td>
<td>0.47±0.05</td>
<td>7.28±0.64</td>
<td>0.84±0.15</td>
<td>15.49</td>
</tr>
<tr>
<td>Weakly melanized paleosol</td>
<td>TU 63, paleosol, Sample 16</td>
<td>0.13±0.02</td>
<td>3.50±0.40</td>
<td>0.31±0.06</td>
<td>27.96</td>
</tr>
<tr>
<td>Moderately melanized paleosol</td>
<td>TU 80, paleosol</td>
<td>0.31±0.02</td>
<td>20.47±0.25</td>
<td>0.98±0.03</td>
<td>66.03</td>
</tr>
<tr>
<td>Strongly melanized paleosol</td>
<td>1982, 40 cm, paleosol</td>
<td>0.57±0.04</td>
<td>10.98±0.47</td>
<td>0.77±0.06</td>
<td>19.26</td>
</tr>
<tr>
<td>No soil development, only charcoal</td>
<td>F-10, smudge pit</td>
<td>0.53±0.01</td>
<td>8.97±0.75</td>
<td>0.67±0.06</td>
<td>16.92</td>
</tr>
</tbody>
</table>

- **Weakly Melanized Paleosol** (presumed unaltered forest soil; Test Unit 63).
  The weakly melanized portions of the paleosol are inferred to be vestiges of the Late Caddo period forest topsoil where it had experienced little anthropogenic alteration. This sample was collected from the paleosol in Test Unit 63 and contained 0.27 percent carbon with a $\delta^{13}C$ ratio of -24.82. The Munsell color was observed to be brown (10YR 5/3) when moist and very pale brown (10YR 7/3) when dry.

  **Modern A-horizon formed in colluvium <150 years old (profile 1982, 0-5 cm)**
  This very faintly melanized A-horizon is formed in the top 10 cm of the colluvium. The primeval forest that covered the site in the Caddo period was cleared sometime prior to 1938, and the pine-sweet gum-hickory forest with an understory of yaupon holly regenerated during the middle to late twentieth century. There is no known history of burning of this surface during the twentieth century. This sample was not assayed for carbon content or stable carbon isotopic composition, but samples from three columns where samples in similar stratigraphic position were assessed suggest that this sample contained between 0.59 and 2.11 percent C (based on weight loss on ignition) and had a $\delta^{13}C$ content between -26.06‰ and -27.58‰.

**Results and Discussion—$^{13}C$-NMR of the Soil Samples (XG)**

The $^{13}C$-NMR spectra can be divided into several chemical shift regions corresponding to different functionalities: alkyl C (0–45 ppm), N-alkyl/methoxyl (45–60 ppm), O-alkyl (45–95 ppm), di-O-alkyl (95–110 ppm), aromatic C (110–145 ppm), phenolic (145–165 ppm), and amide/carboxyl (165–215 ppm) (Figure 128).

The results of the molecular mixing model (Table 78) clearly support the inferences made in selecting these samples for analysis, with the smudge pit containing the greatest char content with approximately 67 percent, and the modern soil formed in the colluvium the least with 8 percent.
Two trends are present within the data. First, organic materials associated with natural soils (carbohydrates, proteins, lignin, and lipids) are highest in modern soil and show progressive declines in the paleosol as the degree of melanization increases, and as expected, are lowest in the smudge pit. Consistent with expectations, carbonyl and charcoal exhibit an
inverse trend, having the lowest values in the modern soil and progressively increasing through the midden and reaching a maximum in the smudge pit. Carbonyl reflects oxidation of lignins, and the increase in carbonyl reflects increasingly oxidized lignins in the midden.

Considered together, the results of the $^{13}$C- NMR analysis clearly support the field interpretation that the color of the midden is due to an increase in charcoal content. The organic matter in the most strongly melanized part of the midden is composed of almost 40 percent charcoal or about 31 percent more than is present in the modern soil formed in the colluvium. However, the weakly melanized paleosol was also abundant with charcoal. This suggests that the darkening of color of this horizon across the site was attributed at least in part to anthropogenic enrichment. Assuming that the composition of the modern soil is comparable to the pre-Caddo surface soil prior to occupation, then the charcoal content of the midden represents a significant increase in pyrogenic organic matter.

Summary

The results of this chapter have examined various lines of evidence that test whether there is a midden within the paleosol at the site and if the dark color within the paleosol is actually attributable to the presence of pyrogenic organic matter or merely humified organic matter. The results of the elemental analysis clearly show that the feature identified as a midden in the data recovery fieldwork is enhanced in most of the elements typically associated with anthropogenic alteration of soils: specifically, barium, potassium, magnesium, lead, zinc, carbon, and nitrogen, whereas strontium and the stable carbon isotopic ratios observed in the midden are significantly different from the paleosol but at a lower level of significance. Two elements that were expected to be clearly enriched in the midden, calcium and phosphorus, were not present in significantly different quantities, and this may be an artifact of leaching within these sandy, freely draining soils. However, calcium was present in abundance on the periphery of the midden area, which may have been a localized refuse area where faunal material was deposited, but was not a primary constituent of the entirety of the midden. Somewhat perplexingly, the magnetic susceptibility of the midden is not significantly higher than the paleosol, but the reasons for this are not immediately apparent.

Examination of the elemental concentration of feature fill as compared to various other natural contexts indicates that the smudge pits exhibit a clear elemental enhancement of carbon, barium, calcium, strontium, magnetic susceptibility, and stable carbon isotopic ratio. Pits exhibited clear enhancement of magnetic susceptibility and phosphorous, whereas hearths proved to have higher magnetic susceptibility and elevated concentrations of barium and zinc. Postmolds were undistinguishable from the E-horizon.

The last issue addressed concerned whether the dark colored portions of the midden were attributable to the presence of pyrogenic organic matter. To address this, a small sample suite representing the range of organic matter composition ranging from dominantly humified organic matter to dominantly pyrogenic organic matter was examined by $^{13}$C-
NMR, which is capable of quantifying the amount of charcoal present. The results of this study clearly demonstrate that the dark colored portions of the midden contain nearly 40 percent charcoal, and that the proportion of charcoal content correlates with the degree of melanization and total organic content. Hence, the dark color that distinguishes the paleosol is not attributable to the presence of humified organic matter, but is in fact an artifact of the presence of pyrogenic organic matter. Likely differences in the abundance or duration of pyrogenic additions could account for differences in color of the paleosol across the site.
Chapter 11: Results of Soil Micromorphological Examination of Soil Samples from Features at 41PN175
by Charles D. Frederick, Ph.D.

Introduction
This report summarizes the analysis of a suite of soil micromorphological samples collected from features at site 41PN175. Micromorphological observations made from the features are compared with the micromorphological attributes of the natural site deposits that are described in the discussion of the site stratigraphy in Chapter 10 (see Figure 110 for stratigraphic terms used in this report with respect to the deposits exposed by the site excavations).

The Feature Samples
Four types of features are represented in the sample suite: (1) posthole fills, (2) shallow pits, (3) a smudge pit and (4) a hearth. The largest group is the posts, which comprised 13 features positively identified as posts (F8, F14, F17, F18, F19, F21, F22, F24, F32, F35, F36, F37, F43) and two as possible posts (F39 and F20). Two samples were positively identified as shallow pits (F6 and F9) and two others were identified as possible shallow pits (F15 and F30). One sample was identified as a smudge pit (F10), and a single sample was identified as a hearth (F29). Twenty-five thin sections were prepared from the 22 feature samples, with most samples represented by a single thin section, but Features 6, 9, and 10 by multiple thin sections.

Cultural Features

Shallow Pits

Feature 6
This feature was described in the field as a large shallow pit measuring 60 cm (north to south) and 45 cm (east to west) and was about 13 cm thick. The fill of the feature was described in the field as dark yellowish brown (10YR 4/4). The field photo (Figure 129) shows the approximate location of the micromorphology block collected from this pit feature and the approximate location of the two thin sections. Upon close examination (Figure 130), the slides of this feature reveal three distinct sections: (1) the underlying E-horizon, (2) an organic-rich pit fill, and (3) a laminated fill. The E-horizon exhibits a strongly developed granular structure, contains a few 3–6-mm fragments of Fe-Mn concretions, and lacks significant organic enrichment. The pit fill is slightly coarser textured, contains about 2 percent finely disseminated organic matter, and also includes fragments of other material, some of which are aggregates of the A-horizon and others that appear to be fragments of laminated sediment, some of which appear to be significantly finer textured than the pit fill in general. A few larger fragments of charcoal and Fe-Mn concretions are present as well. The pit fill is overlain by a laminated deposit that exhibits multiple 2–3-mm-thick laminae composed of size sorted sand and coarse silt, and several of these normally graded laminae
Figure 129. Feature 6 profile. Upper Photo: view of section of Feature 6 showing the approximate location of the micromorphology sample. Lower Photo: expanded view of box shown in upper photo with approximate location of the two thin sections made from this feature (shown in Figure 130).
Figure 130. Feature 6 thin sections: Left: annotated view of plane light scans of the two thin sections made from Feature 6. Boxes show the location of the photomicrographs shown at the right. Top Right: view of two fining upward sand laminae in the laminated infill of Feature 6; arrows point from coarse base to fine top. Next-to-Top Right: enlarged view of the top of the organic-rich pit fill showing a broken iron-manganese concretion (“F”), a fragment of wood charcoal (“C”), and a fragment of a laminated infill (“SF”). Next-to-Bottom Right: enlarged view of organic-rich pit fill; note the many small black fragments of organic matter. Bottom Right: view of the E-horizon beneath the pit at same scale of previous photo showing lack of organic enrichment, slightly finer texture, and clearly visible structure.
are present. The contents of the pit are insufficient to determine its use, but it is clear that this shallow pit was filled in by natural overland flow following abandonment and that postdepositional bioturbation has partially destroyed the sedimentary structures left by the natural infilling process.

**Feature 9**

Defined as a 1.3-x-0.55-m shallow (13 cm) basin pit, this feature contained a mottled fill that ranged in color from 10YR5/2 to 10YR 5/3 with small amounts of 10YR6/3 (Figure 131). Two micromorphology samples were collected from this feature from which three thin sections were prepared. The precise location of the samples is not recorded in the notes and is unknown. One block sampled the lower interface and the pit fill, and two thin sections (9a and 9b) were made from this sample, whereas the second block primarily sampled pit fill but also included a small part of the underlying E-horizon, and a single thin section (9c) was prepared from this block.

The pit fill (in thin section 9b) appears to be composed of a mixture of A-horizon-like sediment and sediment of similar texture to the E-horizon but with abundant finely disseminated organic matter between framework grains. Much of the A-horizon-like sediment appears to be filling passage features and may have been introduced into the feature by postdepositional pedoturbation. Thin section 9c shows the presence of discontinuous 1–2-mm-thick sand to silt textured normally graded laminae that are resting almost on the lower interface (see Figure 131). Bioturbation has destroyed these laminae in two-thirds of this thin section, but their presence implies this feature filled in gradually with sediment derived from overland flow. Although the feature appears to have been extensively disturbed by postdepositional bioturbation, it is often difficult to see this in the thin sections, and is perhaps more readily apparent in the field photographs and polyester embedded blocks.

**Features 15 and 30**

Two other possible pit features were sampled for soil micromorphology. Feature 15 was described in the field as a 51-x-30-cm shallow basin (7 cm) pit that had a brown (10YR 4/4) matrix. Both the field photograph and the polyester embedded slab show this feature to have a mottled appearance, and this is attributable to mixing of two different sources of sediment. The darker-colored patches appear to be fragments of the paleosol, and these are slightly finer grained and have very finely disseminated organic matter. The lighter-colored portions of the feature fill bear a closer resemblance to the E-horizon in that they are slightly coarser textured, but contain more disseminated organic matter than the E-horizon and in coarser interstitial patches than the paleosol. The amount and nature of the organic matter is similar to that observed in the feature fill of Features 6 and 9.
Figure 131. Feature 9 profile and thin sections: Top: field photograph of the profile of the bisected Feature 9. Lower left: plane light scan of the thin section 9c showing the location of the two areas enlarged at right; dotted line delineates block of more or less intact laminated sediment. Lower Right, Upper Photo: enlarged image of well-defined fine sand to coarse silt normally graded 1–2-mm thick laminae; arrow points from the coarse base to the fine-textured upper part of the laminae. Lower Right, Bottom Photo: enlargement of a series of thin (1 mm or less) normally graded laminae; arrows indicate same as above.
Feature 30 was a 35-x-32-cm shallow (9 cm) basin pit with a fill of 10YR 5/2 inset into a matrix of 10YR 5/4. The fill exhibits an intergrain channel structure and the c/f related distribution ranges from chitonic to almost porphyric. The framework grains are fine sand and range from 0.1 to 0.2 mm in diameter, whereas the interstitial material appears to be coarse silt-sized. Charcoal fragments are present at a range of sizes, from slightly >1 cm to small material that ranges from slightly larger than most of the framework grains (0.4 mm) to medium to coarse silt-sized fragments that exist in the interstitial spaces between the framework grains (<0.2 mm). A prominent (>1-cm-wide, >5-cm-long) passage feature with a bow-like structure within it is present on the right side of the slide, but this is easily visible in the embedded slab and very difficult to discern in the thin section. The fill of this feature does not contain many obvious fragments of paleosol material (less than 2 percent 1–2-mm round patches), unlike some of the previously described pits, but the organic matter within the sample is consistent with the other pit features.

**Feature 10, Smudge Pit**

This 36-x-23-cm-wide shallow (10 cm) basin pit was striking in the field because it was filled with large charcoal fragments. The thin sections of this feature are equally impressive (Figure 132). The two thin sections made from this feature constitute an 11.1-x-3.8-cm section through the pit and can easily be divided into three sections: the underlying E-horizon, the charcoal-rich base, and a heavily bioturbated upper part.

The E-horizon into which the pit was inset exhibits an intergranular channel structure and a chitonic c/f related distribution. There appears to have been relatively limited downward bioturbation passing from the smudge pit above into the E-horizon, although it is clear that this has occurred in some places (particularly at bottom right of slide 10a). The base of the smudge pit, which rests upon the E-horizon, is characterized by numerous large fragments of charcoal, the largest of which measured about 3-x-2 cm and which retains very clear ring structures. These fragments have been progressively degraded by soil mesofauna, which pass through them separating the fragments with mineral matter. Several of the charcoal fragments, where surrounded by sandy sediment, are bordered by thin (0.1 to 0.3 mm) ferruginous hypocoats (see Figure 132, *Middle Right*). Ash is conspicuously absent from this deposit. The upper part of this feature is an artifact of soil fauna and is composed of multiple generations of passage features, some of which derived from the charcoal-rich portion of the smudge pit, and others that are filled with sediment more resembling the E-horizon. The largest such passage feature measures 2.0-x-1.7 cm.

**Feature 29 (PBS&J F6)**

This shallow pit feature was originally found by PBS&J and partially excavated during testing. Complete excavation by Geo-Marine revealed it to be 55-x-40 cm but of somewhat irregular shape in plan and about 13 cm thick from where it was first noted around 56 cmbs. The thin section of this feature indicates the presence of more and larger charcoal fragments
Figure 132. Feature 10 thin sections: Left: transmitted light scan of the two slides made from Feature 10, showing the three visible zones: the E-horizon underneath (at bottom), the charcoal-rich base (middle), and the bioturbated top (upper one-third). Top Right: enlargement of two different generations of passage features, one derived from the smudge pit (“O”) and one derived from either overlying or underlying less charcoal-rich sediment (“Y”). Middle Right: photomicrograph of the charcoal-rich base showing a passage feature (“P”) separating what was once a single large (1.5-x-1.2-cm) piece of charcoal; also note the dark reddish brown ferruginous hypocoating formed in the passage feature adjacent to the charcoal (“F”). Lower Right: crossed polarized light view of the intergranular channel structure of the E-Horizon; channels are black and labeled “Ch.”
than are present in the E-horizon natural matrix (Figure 133). Several of these near the bottom of the thin section are 2–3 mm long and surrounded by a broad hypocoat of ferruginous material, presumably derived from degradation of the charcoal. Near the top of the thin section is a long (2.5-cm) fragment of an overland flow lamination, which represents natural infilling of this pit feature. This lamination is broken by postdepositional bioturbation, but there is no clear micromorphologic evidence of this process that can be discerned other than the abrupt termination of the laminae and rotated fragments of the silt cap in the space it should have once covered.

![Figure 133](image)

Figure 133. Feature 29 (PBS&J Feature 6) thin sections: Left: plane light scan of the thin section from Feature 29; squares denote areas enlarged at right. Upper Right: enlargement of the laminae present in the upper half of the slide; the arrow points from the coarse base of this sheetwash feature to the fine-grained cap; the "P" refers to the large (3-x-1.5-mm) reddish brown grain just below it that appears to be a fragment of pottery or heated and manipulated argillic horizon; this fragment has some fragments within it that retain birefringence similar to the argillic horizon, but also shows internal plastic deformation. Lower Right: enlargement of charcoal fragments present in the lower part of the thin section showing ferruginous silt-sized hypocoat accumulated around the charcoal fragments (black).
The field photographs of this feature show several large fragments of burned earth within the feature fill, but only very small pieces were noted in the thin section. The fragment in the upper right part of Figure 133 appears to be one, and may be a small piece of pottery, or a fragment of burned earth originally derived from the argillic horizon.

Posts

The majority of the thin sections examined for this project were collected from posthole fills or presumed posthole fills, and one of the main goals of this work was to assess whether soil micromorphology could be used to positively identify posthole features. From a practical perspective, the likely petrographic signature of a posthole would be a more organic-rich deposit that contains fragments of charcoal (if the post were burned in situ) or disseminated organic matter if it decayed in place. If a different material had been used to shim or support the posts, then this would most likely be quite distinctive (cf. Courty et al. 1989:14, 255), as would fill derived from use-related activities such as sweeping (Reynolds 1994:24).

A prerequisite for performing this assessment was a detailed examination of the deposit into which these presumed features were excavated, and it was for this reason that analysis of the natural samples was performed first. Following this, the polyester embedded slabs and thin sections prepared from the 13 features positively identified as posts (F8, F14, F17, F18, F19, F21, F22, F24, F32, F35, F36, F37, F43) and the two possible posts (F39 and F20) were examined closely.

A few of the post samples exhibit noticeably darker-colored matrix material in the slabs (e.g., F14, F19, F21, and one of these [F19] had more than twice the carbon than the average value for posts; see Chapter 10:Table 70) but the majority exhibit a mottled appearance where the term “mottling” does not refer to redoximorphic features but rather the comingling of materials of different color as often happens by means of postdepositional bioturbation. Many of these samples also exhibit redoximorphic features such as ferruginous hypocoats, quasicoats, and nodules and iron-manganese concretions, but this was not the main source of the observed color variation exhibited by these samples. Most of the samples exhibited a moderately well-developed intergranular channel structure (like the E-horizon), one or more clear passage feature (like the E-horizon), and none contained significantly different material. A few contained a bit more charcoal than the E-horizon (e.g., F14, F22) but this was uncommon.

In conclusion, it was not possible to clearly distinguish postholes from the surrounding E-horizon on the basis of micromorphological attributes. Perhaps a broader based, multi-analytical approach would be more successful (specifically examining for bulk organic carbon and phosphorus, and possibly magnetic susceptibility; see Chapter 10, The Paleosol and its Anthropogenic Alteration: The View from the Midden and Features for more details).
Conclusions
The micromorphological work delineated differences among the three major deposits present at the site, noting clear differences among them. The colluvium is a classic expression of an eroded soil in that it contains material derived from this soil but in an inverse progression, with fragments of the topsoil present near its lower boundary, a middle section more characteristic of the E-horizon, and an upper section that contains numerous fragments of the Bt-horizon.

Several of the features, most notably the large shallow pits, preserve evidence of incremental infill associated with overland flow and support the interpretation that these were open depressions that gradually filled with sediment. The material visible in thin section was insufficient to identify the use of these structures, but many appeared to have an elevated organic carbon content that was visible as disseminated charcoal. A large number of samples of posthole fills were examined but it was impossible to distinguish between the E-horizon and the posthole fills using soil micromorphology alone. Indeed, although these deposits appear to have been extensively pedoturbated, this was not very visible in the thin sections, in part owing to the coarse nature of the deposits. The pedoturbation was more visible in the field photographs and the polyester embedded and slabbed blocks than in most of the thin sections.
Chapter 12: Microartifact Analysis
by Charles D. Frederick, Ph.D.

Introduction
During most archeological fieldwork in North America, site deposits are processed by sieving the soil through .25-inch (6.35 mm) hardware cloth in order to recover artifacts. Those artifacts smaller than 6 mm are generally too small and ubiquitous to tally on a routine basis, but studies emphasizing site formation processes have revealed that analysis of the small artifact assemblage in tandem with larger artifacts may shed light on both cultural and natural processes that may have affected the artifact assemblage (cf. Butzer 2008; McKee 1999; Schiffer 1987; Sherwood 2001). The analysis of microartifact assemblages can be done with both spatial and stratigraphic sample sets, and the questions the data may address vary depending upon the nature of the sample. In this particular case, the samples were collected from a stratigraphic column primarily intended to assess postdepositional alterations of the artifact assemblage.

In theory, the depth frequency of microartifacts in a profile should directly track with the macroartifact assemblage when the assemblage has been undisturbed, and exceptions to this generally indicate the presence of processes that have altered the artifact size distribution. This may happen during occupation of the site or after abandonment. The pre-abandonment process most commonly noted is when people cleaned areas and removed the coarse waste but left finer materials, which results in the spatial distribution of microartifacts as one of the best indicators of some former activity areas.

However, many postdepositional disturbance processes move large and small objects differently. For instance, large burrowing animals may move both macroartifact and microartifact assemblages indiscriminately, but small agents of bioturbation, such as ants and termites, can only move the small assemblage, thereby leaving the large materials behind and redistributing the small materials throughout the profile. Alternatively, flowing water may either concentrate the artifact assemblage from a more dispersed deposit, or selectively remove parts of it (or winnow it).

The stratigraphy of 41PN175 suggests two different postdepositional contexts are present: the Caddo soil and the colluvium.

The Caddo Soil
The Caddo soil has most likely formed from long-term weathering of either a Pleistocene age alluvial terrace of Murvaul Creek or the Eocene Wilcox Group. The development of an alfisol in these deposits indicates a prolonged period of pedogenesis occurred prior to occupation of this location by the Caddo in the Late Holocene. Prior to the period of slope erosion that created the colluvium, the most likely factor affecting the artifact assemblage is postdepositional disturbance by bioturbation. Although a variety of use and refuse practices
undoubtedly created the Caddo artifact assemblage, such sites typically do not preserve visible floors, most likely because of the trampling effects of foot traffic on sandy soils, as well as the high degree of pedoturbation such soils experience by burrowing animals. The soil micromorphology analysis noted the presence of numerous pedofeatures associated with the passage of small soil mesofauna (e.g., worms, insects) through the deposits, and field excavation also noted the presence of larger burrowers such as gophers.

The Colluvium
Unlike the Caddo soil, the colluvium retains some sedimentary structures created when this sediment was transported and deposited. Postdepositional disturbance within this deposit was primarily associated with small fauna such as insects and worms. A considerable portion of the Caddo artifact assemblage was recovered from the colluvium, but questions concerning the context of this deposit remain. Do these artifacts represent a Caddo occupation during a period of soil erosion and therefore comprise at least two stratified occupation surfaces? Or are the Caddo artifacts in the colluvium redeposited from upslope and completely out of their original cultural context? If the artifacts are in context then, as discussed above, the depth distribution of macroartifacts and microartifacts should match and be relatively discrete. Alternatively, if the artifacts have been redeposited, then significant mismatches with the macroartifact assemblage can be expected.

Methods
Samples collected from three columns—Profile 1, Test Unit 70, Block 3; Profile 2, Test Unit 111, Block 7; and Profile 3, Test Unit 117, Block 8 (see Figure 12)—were first soaked in water for more than 24 hours. A small amount of sodium hexametaphosphate was added to the water in order to promote disaggregation of the clays. The samples were then wet-screened through two sieves (4 mm [-2 phi], and 2 mm [-1 phi]), dried, and subsequently sorted under a low power binocular microscope (Leica S8 APO) into various artifact categories (primarily ceramics, debitage, and charcoal). These materials were then counted and weighed, and the results are presented on Tables 79, 80, and 81. Selected results are plotted on Figure 134.

Observations

Profile 1
This test unit is the southernmost of the three profiles. The sandy part of the soil profile was only 20 cm thick and rested upon the cambic Bw-horizon. The paleosol was not preserved in this exposure, and the thin A-horizon formed here in the top 10 cm is most likely colluvium. The macroartifact assemblage is fairly limited, and both lithics and ceramics peak in Level 2 in the E-horizon. The microlithic and microcharcoal assemblages were very scant and more or less tracked with the macrolithic assemblage.
### Table 79: Samples Collected from Profile 1, Block 3, Test Unit 70

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### Table 80: Samples Collected from Profile 2, Block 7, Test Unit 111

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<td>0 (-)</td>
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*Sample was from the 1-mm fraction, which was not otherwise picked
Table 81: Samples Collected from Profile 3, Block 8, Test Unit 117

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<td></td>
<td>Sample</td>
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<td></td>
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<td>12</td>
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The microceramic assemblage, however, is out of phase with the macroartifact assemblage, and a significant portion of the 2-mm-size-fraction ceramics was recovered to a considerable depth within the upper subsoil (the Bw-horizon). The widely dispersed microartifact assemblage and a relatively narrowly distributed macroartifact assemblage suggest postdepositional disturbance by small animal bioturbation.

Profile 2

Located in Block 7, Profile 2 has a 35-cm-thick deposit of colluvium, resting upon 15 cm of paleosol, which in turn rests upon a 25-cm-thick E-horizon. The macrolithic and macroceramic assemblages both exhibit broad unimodal distributions peaking in the lower colluvium. The microceramic assemblage exhibits a bimodal distribution with the main mode in the lower colluvium and a smaller mode in the paleosol (a distribution observed in the macroartifact assemblage in Profile 3). The 2-mm fraction of the microlithic assemblage, however, exhibits a sawtooth distribution throughout the colluvium, which does not match the macrolithic artifact distribution. Although this pattern could be formed by significant redistribution of the small artifacts by small fauna, the relatively intact (or bedded) nature of the colluvium implies a different process is responsible. In specific, this pattern is most likely the result of redeposition of the assemblage by flowing water, and it is most prevalent in the small debitage (2-mm fraction) samples, which are the most easily transported by low-velocity, low-current-depth, overland flow such as that which was associated with the deposition of the colluvium.

The depth variation of the microlithics is not mirrored by the microceramics or microcharcoal, both of which more or less match the bimodal distribution exhibited by the macroceramic assemblage.
Figure 134. Plot of the microartifact and macroartifact results from Profiles 1, 2 and 3. Also shown are the results of the radiocarbon dating of small charcoal fragments as well as the results of the OSL dating.
Profile 3
Both macroartifact assemblages exhibit broad unimodal depth distributions, but the modes are at slightly different depths: in the lower colluvium for the ceramics, and in the paleosol for the lithics. The microlithic assemblage exhibits a prominent bimodal pattern that is in phase with the macro assemblage within the paleosol and significantly out of phase with the macro assemblage in the colluvium, where the microlithics are most common and the macrolithics much less so. This implies that the assemblage within the paleosol is largely intact but the assemblage within the colluvium has been altered, either by cleaning, or by a process that favored movement of the microartifacts such as slopewash.

Discussion
Analysis of the microartifact assemblages yielded somewhat mixed results. In each profile, some of the microartifact assemblages are out of phase with the macroartifacts, but the pattern is inconsistent. In Profile 1, the microceramics are widely dispersed in the profile and out of phase with respect to the large ceramics, and this is most likely due to postdepositional disturbance by fauna. The microlithics in this profile are too few to interpret. In Profile 2, the microlithics are out of phase with the macrolithics, but the microceramics and microcharcoal distributions appear to closely mimic the macroartifact distributions. In Profile 3, the microlithics are out of phase with the macrolithics in the colluvium, but in phase within the paleosol. The microceramics exhibit a more polymodal distribution than the macroceramics but are not significantly dissimilar.

In the colluvium, two of the three profiles have microlithic distributions that are mismatched with macroartifacts and this is most likely due to redeposition by slopewash. Within the Caddo soil, the macroartifacts exhibit a slight downward dispersion that is generally more pronounced than the microartifacts, and the source of this mismatch is unknown.

OSL Dating and Microcharcoal AMS dating
In addition to examining the depth distribution of microartifacts, the authors also examined the age of the microcharcoal at various places in the stratigraphic profile in order to assess whether this material may provide different insights into the age and integrity of the artifact assemblage. Five pieces of microcharcoal from Profile 2 and three from Profile 3 were AMS dated, and three samples of sand within Profile 3 were dated using single-grain optically stimulated luminescence dating.

Profile 2
Five pieces of microcharcoal were dated from Profile 2 (see Figure 134, as indicated by the stars shown on the microcharcoal plots). Three samples were dated from the colluvium, and the ages of these samples are inverted, with the youngest of the three present at the base of the lower colluvium (0–270 years cal B.P. Beta-344097), and overlain by ages of 430–310 years cal B.P. (Beta-344096) (also in the lower colluvium) and 310–290 years cal B.P. (Beta-344095) within the upper colluvium. All three, however, imply the age of the
colluvium is less than approximately 400 years, but it is hard to assess the relevance of the material dated to the period of sedimentation of the slopewash. The apparent inversion is an expected outcome of progressive stripping of soil from upslope, which was noted within the appearance of the colluvium in thin section.

Two additional samples were dated from the E-Horizon, below the paleosol in this unit, and unlike the colluvium, these samples returned results in the correct stratigraphic order. The upper of these yielded an age of 1560–1520 years cal B.P. (Beta-344098), and the lower returned an age of 1820–1710 years cal B.P. (Beta-344099). These samples are significantly older than the Late Caddo occupation and may well represent charcoal preserved from older human occupations of this location.

Profile 3
Although the dating results from Profile 2 are interesting, Profile 3, with three AMS dates on microcharcoal and three single-grain OSL ages, provides some of the more interesting results. The two fragments of microcharcoal dated from the colluvium returned a result similar to that in Profile 2, with the ages in reverse order. The sample dated from near the base of the lower colluvium yielded an age of 480–320 cal years B.P. (Beta-344101), whereas the sample from the base of the upper colluvium yielded 620–530 cal years B.P. (Beta-344100). Interestingly, the latter date is approximately the same age as the Perdiz arrow point recovered from this test unit at a depth of 22 cm.

In principle, the two OSL dates from the colluvium should yield ages that more accurately date the deposition of the colluvium, given that it is exposure to sunlight during transportation of the sand that resets the OSL clock. The OSL dates from the colluvium did return ages in the correct order, with an age of 320–230 years B.P. (Shfd-12031) at base of the lower colluvium and 250–210 years B.P. at the base of the upper colluvium (Shfd-12032).

Two other samples were dated from the E-horizon in this profile. An AMS date was obtained on charcoal near the base of the E-horizon, and an OSL age was obtained from the top of the E-horizon just beneath the paleosol. Initially, the lowermost microcharcoal was dated because of the prominent increase in microcharcoal observed in the depth frequency curve that was thought that it could be associated with an older occupation. Nevertheless, the age returned by this sample (630–540 years cal B.P. Beta-344102) is consistent with the age of the Late Caddo occupation, and its presence at this depth is most likely the result of postdepositional disturbance.

The age of the sand at the top of the E-horizon in this profile as determined by the single-grain OSL age was 2090–1790 years B.P. (Shfd-12033). This is slightly older and stratigraphically higher than both of the pieces of microcharcoal dated from the E-horizon in Profile 2, but perhaps more directly relevant, this is significantly older than the two artifacts
recovered from this approximate stratigraphic position in Test Unit 117. One was a Perdiz arrow point, which has an approximate age of 800–500 years B.P. (Turner and Hester 2009) that was recovered from 55 cmbs, and the other was a potsherd collected from 44 cm that was radiocarbon dated and yielded an age of 690–660 years B.P. (A.D. 1260–1290; Beta-344078). The presence of artifacts dating to approximately 800–500 years B.P. in a matrix dating between twice to almost three times as old is most likely the result of pedoturbation that intruded younger artifacts into older deposits.

**Conclusions**

Considered together, the AMS ages on microcharcoal and the OSL ages indicate that deposition of the colluvium most likely began around 300 years B.P. and continued until at least 200 years B.P. AMS dates on charcoal within the sediments of the lower colluvium represent material shed from the upper part of the surface soil at the time that erosion began, resulting in AMS radiocarbon ages about the same age of or slightly older than this event near the base of the colluvium, and older dates from higher in the stratigraphic succession that represent the shedding of older charcoal from lower in the Caddo soil.

The radiocarbon ages obtained from microcharcoal within the E-horizon appear to be closer to the OSL age obtained for this horizon, but still younger than it at a greater depth. Temporally diagnostic artifacts from the same level as the OSL date were significantly younger than the matrix age. Considered together, these data support the hypothesis that the Caddo soil experienced some pedoturbation that resulted in downward deflection of younger artifacts into older sediments.
Chapter 13: Stable Isotopes: Searching for Spatial Evidence of Maize Agriculture Using Stable Carbon Isotope Analysis of Soils
by Brittney Gregory and Charles D. Frederick, Ph.D.

Introduction
Some aspects of ancient Caddo landscapes, such as preferred settlement locations and internal organization of the built environment, are fairly well understood, but other attributes are very poorly known. Perhaps the murkiest is the nature, location, and spatial organization of the Caddo agricultural landscape. It has been established by macrobotanical, skeletal, and isotopic studies of bone that the Caddo gradually adopted a farming lifestyle that involved the cultivation and consumption of maize and beans, although it seems apparent that the Caddo diet was less reliant upon maize than other contemporary Mississippian societies (cf. Perttula 1998c; Rose et al. 1990; Wilson and Perttula 2013). Ethnographic descriptions of Caddo settlements and fields from early European contact describe small fields typically set among their houses (cf. Joutel 1906; Weltfish 1937), with the most widely referenced illustration of this being the Teran Map of the Upper Nasoni settlement on the Red River, which was visited by a Spanish expedition led by Domingo Teran de los Rios in 1691–1692. Beyond this map, which depicts Caddo houses surrounded by agricultural fields/gardens and enclosed by bounding vegetation resembling hedges, little is known about their agrarian landscapes, and no useful information on this subject has emerged from decades of archeological field investigations. The goal of the work described here is to test if it is possible to use chemical residues preserved in the soils to spatially delineate the location of ancient maize agricultural fields in the vicinity of a Caddo occupation. The specific chemical residue employed is the stable carbon isotopic ratio of bulk soil organic matter, and the inspiration for this work derives from studies published from the Maya Lowlands of Guatemala and Belize, where this approach has been used in the last decade to provide insights on the location of Mayan milpas or maize fields.

Stable carbon isotope analysis has been used in archeology since 1948 when Calvin developed methods to detect isotopic fractionation (Van Der Merwe 1982). Carbon has two stable isotopes that do not decay with time, $^{12}$C and $^{13}$C. The latter comprises approximately 1.1 percent of all carbon on earth. The ratio of $^{13}$C to $^{12}$C found in organic substances varies in natural systems because of metabolic biases in how $^{13}$C is incorporated, and ratio is denoted by the delta notation, which expresses the molar ratio of the heavy to light isotope in a sample relative to the molar ratio of the heavy to light isotope in a standard and is expressed in parts per thousand or per mil. For carbon, the standard is carbon derived from the shell of fossil marine belemnites ($Belemnitella americana$) obtained from the Cretaceous Pee Dee Formation of South Carolina and is abbreviated PDB. Presently, atmospheric carbon dioxide has a $\delta ^{13}$C value of -8 per mil (Ehleringer et al. 2000), and plants generally bias or fractionate the $^{13}$C in their structures according to the processes associated with photosynthesis. Three different photosynthetic pathways are recognized: C$_4$, C$_3$ and CAM. Plants using the Hatch-Slack photosynthetic pathway, also known as the C$_4$
pathway, exhibit relatively small fractionation effects and generally have $\delta^{13}C$ values between -10 per mil and -15 per mil. The majority of C$_{4}$ plants are warm-season grasses (Nordt 2001). Photosynthetic fractionation effects are considerably greater for plants using the Calvin cycle or C$_{3}$ photosynthetic pathway, which generally have $\delta^{13}C$ values between -21 per mil and -30 per mil. The majority of vegetation, specifically trees, shrubs, forbs, and temperate season grasses, are C$_{3}$ plants (Nordt 2001). The third photosynthetic pathway is the crassulacean acid metabolism (CAM) and plants using this photosynthetic pathway may have $\delta^{13}C$ values ranging between C$_{3}$ and C$_{4}$. Nordt (2001:423) notes than virtually no isotopic fractionation occurs during the decomposition of soil organic matter and its subsequent incorporation into the soil organic matter pool, and this allows the isotopic composition of soil organic matter to be used as a tool for recognizing historical shifts between C$_{3}$ and C$_{4}$ ecosystems over a wide range of time scales that are relevant to climate change as well as land use (cf. Boutton 1996; Nordt 2001; Tieszen et al. 1997).

Since 2004, studies in the Maya Lowlands of Central America have applied carbon isotopic analysis of soil organic matter to better understand the location of ancient maize agricultural fields (e.g., Beach et al. 2011; Burnett 2009; Burnett et al. 2013; Johnson, Terry, Jackson, and Golden 2007; Johnson, Wright, and Terry 2007; Webb et al. 2004; Webb et al. 2007). The rationale underpinning this work is that the tropical forested environment in this region is dominated by C$_{3}$ plants and that widespread growth and use of *Zea mays*, a C$_{4}$ plant, should leave a legacy in the soil organic matter pool. This work started by looking at the variation in $\delta^{13}C$ with depth in soil profiles and noted a distinct enrichment with increasing depth, which was interpreted as evidence of the growth of C$_{4}$ plants in the past, most likely maize. It is interesting to note that none of the surface soil horizons retained isotopic evidence of C$_{4}$ biomass contributions, but rather it was the subsoil horizons at depths below 40 cm that exhibited higher $\delta^{13}C$ values indicative of C$_{4}$ biomass additions. However, it was noted in the first study and all subsequent studies that more than one process may yield the observed increase in $\delta^{13}C$ values with increasing depth and that a threshold value for $\delta^{13}C$ enrichment should be used to delineate places where C$_{4}$ biomass has altered the soil organic matter signature. The most significant process that may lead to an increase in $\delta^{13}C$ values with increasing depth is microbial fractionation of soil organic matter, but climate change and temporal variation in atmospheric $\delta^{13}C$ values may also play a role. Microbial recycling of soil organic matter apparently leads to a progressive enrichment (or higher) of $\delta^{13}C$ values in the older and deeper soil organic matter (see discussion in Ehleringer et al. 2000; Martinelli et al. 1996; Webb et al. 2004:1040) and the magnitude of this shift is thought to be between 1 and 3 parts per mil (Beach et al. 2011; Ehleringer et al. 2000).

In order to assess degree of C$_{3}$ biomass contribution to ancient soil profiles, several studies (Johnson, Terry, Jackson, and Golden 2007; Martinelli et al. 1996) noted the greatest difference in $\delta^{13}C$ values with depth (sometimes notated $\Delta^{13}C$) and generally used a
threshold value to delineate where the $\Delta^{13}$C value was in excess of that which could be expected by microbial enrichment, and this value ranged between 3 and 4 per mil.

**Application to Caddo Landscape Archeology**

The forested landscapes of East Texas, which are dominated by C$_3$ vegetation, appear to offer an opportunity similar to the Maya Lowlands, where stable carbon isotopes of soil organic matter may be used to identify places where maize agriculture was practiced in the distant past. In some ways, East Texas is more suited because there is no evidence of C$_4$ vegetation occurring in this region prior to historic-era clearance. Much of Central America was much more arid during the last glaciation (see discussion in Johnson, Wright, and Terry 2007), and the assumption of a continuous C$_3$ vegetative cover is not necessarily a reasonable one. However, in East Texas and Louisiana, pollen records suggest that forest has dominated for more than 30,000 years (Bryant and Holloway 1985; Delcourt and Delcourt 1985, 2004).

That said, the results of the phytolith study by Yost and Cummings (see Chapter 15, this volume) for the site deposits at 41PN175 must be considered. Yost and Cummings examined 10 soil samples collected from the site deposits beginning in the colluvium and extending down to the upper subsoil. The results of this work identified three zones, with the phytolith assemblage in the lower part of the profile (Zone C in the phytolith analysis, representing samples from the E and Bw soil horizons) that was low in pine needle and high in tall grass phytoliths and was cautiously interpreted as an open mixed prairie habitat with grasses, sedges, and a mixed forb community. Zone B, representing the majority of the Caddo soil, was noted to have a greater pine component and a decreasing tall grass component, as compared to Zone C. Yost and Cummings also noted that the paleosol contained more xeric short grass phytoliths and fewer mesic tall grass phytoliths than the top of the E-horizon, suggesting either more arid conditions or a relative decrease in tall grass taxa. Yost and Cummings, aware of the biased impressions phytolith studies alone may yield in dominantly forested environments, nevertheless consider the lower part of the soil profile as indicative of a prairie. Translating this image of the deposits into one directly relevant to the carbon isotopic composition is, however, challenging.

In light of the results of the Maya work where the apparent signature of past C$_4$ biomass additions was found lodged at depth in the subsoil rather than in the topsoil, the authors anticipated a similar result here, in part because the soil at the site is an ancient alfisol, which is a texture-contrast soil. Such soils have relatively coarse-textured A and E-horizons and finer-textured subsoil or argillic horizons at depth (Phillips 2001, 2007). Nordt (2001:427) has noted that stable C isotopes in coarse-textured (sandy) soils reflect vegetation shifts quickly and deeply, whereas fine-textured soils have relatively little carbon mobility with depth. This implies that the sandy epipedons of the site deposits may quickly adapt to changing organic matter inputs, but the subsoil, which consists of more clay, should retain a longer record of biomass contributions.
Methods
In order to assess this approach, the authors examined the stable carbon isotopic composition of bulk organic matter in two sample sets, one that was stratigraphic, and a second that was primarily spatial. Ideally, the stratigraphic samples would be assayed first in order to establish where in the stratigraphic profile evidence of C₄ enrichment may be situated, and thereby identifying the stratigraphic position of the spatial sample set. Nevertheless, this was not possible, so the two sample sets were collected in a fashion that would allow some flexibility once out of the field. Three stratigraphic profiles (designated Profiles 2, 3, and 4) were examined in detail. Profiles 2 and 3 were situated in the highway ROW, and Profile 4 was located northeast of the main excavations outside the highway ROW. Profile 2 was sampled at a 5-cm increment, whereas Profiles 3 and 4 were sampled at a higher stratigraphic resolution using clear plastic paleomagnetic boxes that were placed in the profile to form a continuous column sample of the deposits.

The spatial sample set was collected from both within and outside the highway ROW and utilized existing test unit and shovel text excavations within the ROW as well as a series of shovel tests spaced at 10-m intervals across a 40-x-60-m area located east of the new highway alignment. Following from the Mayan literature, the authors expected to document evidence of C₄ enrichment in the subsoil, but anticipated that some signal may remain in the Caddo period topsoil. However, the post-Caddo period of erosion complicated this simplistic image and necessitated a more complex sampling strategy that sampled every major stratigraphic unit present in the exposures. As a result, some exposures have as few as two samples (generally upslope and to the southeast where the modern A-horizon and the argillic horizon were sampled) and as many as five samples when the full complement of stratigraphic units was observed, typically toward the northern end of the site.

In all, 36 locations were profiled, and soil samples were collected from the A-, Ab- (when present), Bt1-, and Bt2-horizons. The samples were collected from the profile in small (2.5-cm) plastic paleomagnetic cubes, and once in the lab these were dried, weighed, and then ground before being submitted to the Stable Isotope/Soil Biology Laboratory of the University of Georgia Institute of Ecology for total carbon and stable carbon isotopic analysis. Due to the complete absence of calcium carbonate within the samples, no decalcification of the samples was necessary. The results of this carbon analysis are presented on Table 82.

The data were then analyzed in two different fashions in order to better understand the behavior of carbon throughout the site. First, the minimum and maximum δ¹³C values were subtracted to find the range (Δ¹³C) of isotope data within each profile. This calculation was used to take into effect the role of fractionation over time. Although this is a very broad brush analysis, especially given the complex agricultural and depositional environment of the site, it does provide data that accounts for the way carbon behaves over time. The
Table 82: Results of $\delta^{13}$C Analysis

<table>
<thead>
<tr>
<th>Unit</th>
<th>A-horizon</th>
<th>Ab-horizon</th>
<th>Bt1-horizon</th>
<th>Bt2-horizon</th>
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<td>TU15</td>
<td>-20.77</td>
<td>-26.79</td>
<td>-26.81</td>
<td></td>
</tr>
</tbody>
</table>

The second method that was used to analyze the data employed a carbon biomass equation that negates the effect of fractionation of carbon. Although this is not ideal, it does provide a detailed look at where C₃ and C₄ enrichment occurs within the profiles by horizon.

In order to determine the amount of C₄ biomass added to the sediment, the following formula from Nordt et al. (2002) was used:

$$\delta^{13}C_\text{soil} = (\delta^{13}C_{\text{C}_4})(x) + (\delta^{13}C_{\text{C}_3})(1-x)$$
Within this formula, $\delta^{13}C_{soil}$ is the $\delta^{13}C$ value of the sediment, $\delta^{13}C_{C_4}$ is the highest $\delta^{13}C$ (-28.4 per mil) representing the background C$_3$ forest, and $\delta^{13}C_{C_3}$ (-10.18 per mil) is the average $\delta^{13}C$ of maize calculated by Wilson and Perttula (2013). Once calculated, $x$ is the relative proportion of C$_4$ biomass and $1-x$ is the proportion of C$_3$ biomass. As is known, $\delta^{13}C$ values can vary in accordance with several environmental factors; however, when taken as general averages, the overall interpretation of the data is not affected (Nordt et al. 2002).

**Results**

**Variation of $^{13}C$ in the Stratigraphic Profiles**

The variation in $\delta^{13}C$ values of bulk soil organic matter with respect to depth below the modern ground surface for the three soil profiles is shown on Figure 135. The maximum $\Delta^{13}C$ values for the three profiles are 4.7 per mil, 4.62 per mil, and 5.03 per mil for Profiles 2, 3, and 4, respectively, which in terms of the scale employed by Johnson, Terry, Jackson, and Golden (2007) reflect a moderate $\delta^{13}C$ enrichment. Two of these profiles have samples for the entire stratigraphic sequence, whereas one only has samples for the upper part of the site deposits, specifically the colluvium and the Caddo soil. The results are discussed below in terms of the trends within the major stratigraphic units: the Caddo soil and subsoil, and the colluvium.

**The Caddo Soil and Subsoil**

All three profiles provide values for the Caddo soil (the Ab- and E-horizons), but only Profiles 2 and 4 have samples from the subsoil as well. All three profiles exhibit $\delta^{13}C$ enrichment with increasing depth, but the magnitude varies between them.

Profile 2 has a value of -24.38 at the top of the paleosol and a maximum value of -21.36 in the upper Bt-horizon for an overall shift of 3.02 per mil from the top of the Caddo period A-horizon to the subsoil. The total $\delta^{13}C$ enrichment for this profile (absolute value of the difference between maximum and minimum $\delta^{13}C$ values between ground surface and subsoil) is 4.7 per mil.

Profile 3, which does not include the subsoil, exhibits a $\delta^{13}C$ value of -24.25 per mil in the paleosol to -22.96 for the base of the E-horizon for a shift of 1.29 per mil. The lack of evidence of significant enrichment within the Caddo soil in this sample profile most likely misses the most enriched part, the subsoil. Although the $\delta^{13}C$ enrichment within the Caddo soil is negligible, the total $\Delta^{13}C$ enrichment for this profile is 4.62 per mil and implies a moderate enrichment has occurred. In Profile 4, the maximum shift in $\delta^{13}C$ is observed between the paleosol and the upper subsoil, where a shift of 5.03 per mil is observed.
Figure 135. Plots of $\delta^{13}C$ vs depth from Profiles 2, 3, and 4.
The Colluvium
The trend in stable carbon isotopic composition within the colluvium for Profiles 2 and 3 is similar, and both indicate an increasingly C₃ dominated signature from the paleosol up to the modern ground surface. Where the sample interval is close, as it is in Profile 2, it is apparent that there is considerable variation within this trend. Profile 4, however, exhibits a different pattern. From the top of the paleosol near 70 cm to about 15 cmbs, the colluvium exhibits a progressive enrichment of about 2 per mil, peaking at -22.61 at 19 cmbs, and then shifts almost 3 per mil toward a more C₃-rich signature ending at -25.24 at a depth of 10 cm.

This pattern can be interpreted in several ways. In one scenario, this trend reflects cultivation of C₄ grass like Bermuda grass on the site during the historic period and then subsequent regeneration of the forest in the period subsequent to abandonment of agricultural use of the area, sometime after 1940. Anecdotal evidence supporting this explanation may be found in a historical aerial image of the site from 1935 (Figure 136), which shows the area of the site to be a hayfield at that time. According to Vendramini (2009), Bermudagrass was introduced to the southeastern United States in 1751 at Savanna, Georgia, and improved varieties began to appear with the introduction of Coastal Bermudagrass in 1943. Therefore, it is possible that the hayfield that appears on the 1935 aerial image could be Bermudagrass, but not the Coastal variety, which was not introduced until eight years later.

Discussion
All three profiles exhibit δ¹³C enrichment with increasing depth, and in all three cases the Δ¹³C is in excess of that typically associated with microbial fractionation of soil organic matter, which implies that the soil profiles have experienced additions of C₄ biomass.

Spatial Variation of ¹³C in the Vicinity of the Site
As noted previously, the post-Caddo period of soil erosion complicated the sample of the deposits near the site, but also permits a more nuanced image of carbon isotopic composition through time. Results will be discussed both by depth and spatially across the site. To aid in this discussion, the section will be divided into results by horizon and will dissect the site much like a layer cake. By doing this, some interesting results were found regarding the spatial distribution of C₄ signatures in relation to depth.

The Modern A-Horizon
The modern A-horizon is formed at the top of the upper colluvium, covers the entirety of the site, and was sampled in 36 profiles. Overall, the most C₃-based δ¹³ value is -28.39 and the most C₄ based value is -20.77. Using a mass balance equation (cf. Nordt 2001) to calculate the amount of C₄ biomass that contributed to this horizon, it appears that almost one-fifth or 21.51 percent of the organic matter was contributed by C₄ vegetation. A map illustrating the
Figure 136. Aerial photographs of the site showing land use change through the twentieth century. Note August 1935 aerial photograph (top left) shows what appears to be a hayfield in site area at that time.
spatial distribution of the values shows that the samples with the most C₄ biomass are concentrated on the southern and eastern sides of the site (Figure 137). The C₄ biomass percentage decreases greatly with proximity to the floodplain scarp at the north end of the site. These data would suggest that C₄-related agriculture in historic times was focused on the terrace above/next to the stream. Further investigation into the site did in fact reveal historic farming in the 1930s and 1940s on this site.

**The Paleosol (Ab-horizon)**
The buried A-horizon was sampled in 72 locations, most in proximity to the block excavations in the highway ROW, and although there were not many samples, on average 15 percent of the sample was composed of C₄ biomass. Also, the isotope results were extremely variable, ranging from -22.90 to -28.18. Spatially, the C₄ biomass percentage increases toward the north end of the site. Additionally, the C₄ biomass percent is generally greater within the highway ROW and is much more variable within the portion of the Ab-horizon located outside the site boundary. However, because of the limited sample size and lack of aerial extent, interpreting these data is difficult (Figure 138).

**The Upper Subsoil (Bt1-horizon)**
The Bt1-horizon was analyzed in 31 profiles, with a maximum and minimum value of -22.25 and 28.33, respectively. When averaged, the overall C₄ biomass contribution is 10.5 percent, which makes it the lowest of all the horizons. When looking at the horizontal spatial distribution, however, this horizon shows the southern part of the site to be C₃-dominated and the northern part of the site with increased C₄ biomass (Figure 139). This pattern implies Caddo maize cultivation on the bench-like surface immediately overlooking the floodplain, but it is also possible that the C₃-rich values from the upper argillic horizon upslope and south/southeast of the site reflect C₃ biomass added to this horizon following soil erosion after Caddo abandonment of the site.

**Bt2-horizon**
The top of the Bt2-horizon was sampled in 35 profiles and has an average total C₄ biomass contribution of 19 percent. The highest and lowest values are -21.98 and -28.13. When the isotope data are analyzed spatially, there is a strong C₄ trend on the northern side of the site and a C₃ trend on the southern end of the site (Figure 140). This mirrors the Bt1-horizon and is again an indicator that maize may have been grown outside the site toward the stream during the time of occupation.
Figure 137. Map showing the spatial distribution of the C₄ biomass contributions to the A-horizon across the site with concentrations in the south.
Figure 138. Map showing the distribution of C₄ biomass contributions to the buried A-horizon.
Figure 139. Map showing the pattern of C4 biomass concentrated within the Bt1-horizon that strongly trends toward the north end of the site.
Figure 140. Map depicting the percent C₄ biomass in the Bt2-horizon; note the higher value clustering in the north.
Conclusions
Unfortunately, as noted above, using a mass balance equation to approximate the amount of C₄ biomass that has been added to the soil organic as advocated by Nordt (2001) fails to include or acknowledge any fractionation of the organic matter in the transformation from plant biomass to the soil organic matter pool. Hence, if there is a fractionation that occurs in this process (cf. Beach et al 2011; Ehleringer et al. 2000; Martinelli et al. 1996; Webb et al. 2004:1040) and it is as large as 3 to 4 per mil as suggested, then the mass balance approach just described yields incorrect and misleading information.

As noted previously, much of the Maya literature uses Δ¹³C (the maximum variation in the δ¹³C in each profile) to determine places where the soil organic matter had been enriched with C₄ biomass. This is an effective measure that works well for stratigraphically simple sections, but it yields a rather binary result (e.g., profiles with more than a 4-parts-per-mil shift toward C₄ have experienced enrichment with C₄ biomass, and the larger the shift, the more C₄ biomass was added in the past) that does not permit distinguishing when such enrichment may have occurred. Here, when the Δ¹³C data are plotted across the site with a threshold of 3 parts per mil, the entirety of the site seems to have been enriched by the addition of C₄ biomass, presumably due to agriculture. Although there are some places that show no evidence of C₄ enrichment, many of the Δ¹³C values show moderate to significant C₄ enrichment across the site (Figure 141). This is most likely a function of both modern and/or ancient agricultural practices, and the use of Δ¹³C does not permit distinguishing when this enrichment may have occurred.

A more temporally nuanced and stratigraphically relevant approach is to apply the same general approach to each stratigraphic unit, but instead of using Δ¹³C, employ a version of the mass balance equation to compensate for the microbial fractionation of 3 per mil. To do this, the authors assume an arbitrary δ¹³C value of -27 for soil organic matter formed under a natural forest with an entirely C₃ biomass assemblage, and then add 3 parts per mil to this number to compensate for microbial fractionation. The resulting value of -24 per mil is a threshold whereby soil organic matter with δ¹³C values greater than -24 have experienced enrichment (Figure 142).

When the current spatial/stratigraphic data are viewed this way, 18 profiles show C₄ enrichment of the modern A-horizon: one in the paleosol, three in the Bt1, and 12 in the Bt2. Additionally, 16 of the buried soil cubes collected from excavation walls showed C₄ enrichment. The modern A-horizon (Figure 143) shows a pattern of enrichment across the southern half of the site, most clearly in the upland part to the east and south of most of the block excavations. This pattern is presumably a function of historic-period agriculture, but the pattern does not precisely match the cleared area visible on the 1935 aerial photo. On the other hand, the spatial pattern exhibited by the Bt2-horizon (see Figure 142), which presumably is the portion of the profile where evidence of Caddo land use would be present,
Figure 141. Map depicting the $\Delta^{13}C$ as it varies from profile to profile across the site.
Figure 142. Map showing the locations with an excess of 3-parts-per-mil shift in δ\textsuperscript{13}C from a -27 baseline identified within the A-horizon.
Figure 143. Map showing the locations with an excess of 3-parts-per-mil shift in $\delta^{13}$C from a -27 baseline identified within the Bt2-horizon.
shows C₄ enrichment occurred primarily in the north end of the site and through most of the occupation area excavated within the ROW. This map implies that Caddo enrichment of the soil organic matter pool by C₄ vegetation (either in agricultural fields or in refuse disposal areas) occurred in the north end of the site and not in the upland to the south and east.

In summary, this study uses spatial and stratigraphic variation in the stable carbon isotopic composition of soil organic matter to document where the soil organic matter pool has been altered by the addition of C₄ biomass, presumably in association with the growing of C₄ plants or the disposal of refuse derived from them. This approach provides an alternative and complementary means of assessing Caddo agrarian landscapes that is different from that which is available through traditional archeological analysis alone. Although this is a relatively small-scale study, it demonstrates the potential of the method to inform on the spatial component of ancient agricultural practices in prehistory.
**Chapter 14: 3D Laser Scanning of Ceramic Artifacts**

by Arlo McKee and Christopher Goodmaster

**Introduction**

The data recovery excavations and geoarchaeological studies conducted at site 41PN175 suggest that the northern portion of the site has been buried by colluvium. This interpretation of the site stratigraphy contradicts the interpretations made during the PBS&J testing excavations, in which Cliff and Perttula (2002) identified a “reddened E-horizon” above the buried soil that was interpreted as in situ burning. However, the demonstration that the upper sediments at the site represent redeposited materials has been demonstrated through multiple sources. The transport of fine-grained sands and silt by fluid action is evident with the infilling of several pit features at the site, and OSL dates obtained from the colluvium above the buried portion of the site suggest that the site was buried during the Early Historic period; however, no features were present within the colluvium and no historic-period Caddo artifacts or features were discovered at the site. Additionally, both macro- and micro-artifacts found over the majority of the site show a peak in artifact frequency immediately above the buried soil, which is also indicative that the upper portion of the site has been transported from the uplands and redeposited on the northern portion of the site. The question remains, though, as to whether or not the artifacts recovered from the colluvium represent redeposited artifacts from up slope.

Studies regarding the effects of postdepositional processes on ceramic artifacts have been conducted with limited results in controlled settings (cf. O’Brien 1990; Skibo and Schiffer 1987); however, these studies have rarely been considered for analysis with prehistoric ceramic collections. Additionally, these studies have focused on understanding the weight percentage lost on the surface of ceramics rather than on understanding how abrasion may have affected the shape of the artifacts. Given that a starting weight of unbroken ceramics was unknown, it was thought that abrasion could be studied instead by examining the shape of the broken edges of the collection.

The research design recommended that one possible avenue for research of this topic was to study the abrasion patterns on the ceramic collection. Abrasion can be defined as any process that results in the deformation or removal of a material through mechanical forces (Schiffer and Skibo 1989). Ceramic sherds, like all detrital particles, are susceptible to abrasion from postdepositional processes such as transport and weathering. As ceramics are transported along with fine-grained sediment, the surfaces, and especially the edges, of the sherds are susceptible to further alteration. One way to measure this alteration is to assess the roundness of the broken edges of the sherds. Roundness is defined quantitatively as

\[ \sum_{i}^{n} \frac{r_i}{R} \]

\[ \frac{n}{n} \]
where the radius of a circle described on the $i$th corner of a grain is described by $r_i$, the number of corners on a particle is $n$, and $R$ is the smallest radius that will fit to the particle (Pettijohn et al. 1984). As particles are progressively abraded, the roundness of their edges should become progressively more gradual, which would be expressed by larger $R$ values in the above equation.

The degree of rounding of any detrital particle is dependent on its size, physical characteristics, and history of abrasion (Pettijohn et al. 1984:83). In respect to size, laboratory measurements of sand roundness suggest that rounding due to abrasion is very dependent on size, in which rounding slows dramatically as grain size decreases. Early experiments on quartz sand showed that over 20,000 km of transport, an angular sand particle would likely lose no more than 1 percent of its original starting weight (Kuenen 1959). However, given that ceramics are composed of less resistant materials than quartz sand, sherds are much more susceptible to abrasion than a homogeneous quartz grain. Experimental studies of ceramic abrasion suggest that the physical characteristics, especially paste composition and firing conditions, play at least as important a role in particle rounding as does material size (Skibo et al. 1997; Skibo and Schiffer 1987). Given the assumption that the transport distance from the adjacent uplands to the Murvaul Creek site area is short, the relative difference in roughness between the broken edges of redeposited sherds and the portion of the collection recovered from primary contexts would likely be very subtle.

**Methods**

In an attempt to quantify the degree of sherd edge erosion at the site, three-dimensional (3D) laser scanning was selected as an appropriate method to collect high resolution data to further investigate this problem. Based on Light Detection and Ranging (LiDAR) technology and trigonometric principles, 3D laser scanners are instruments that record precise and accurate surface data of objects in a nondestructive manner. Laser scanners employ a near-infrared laser to measure and record the distance to an object as an array of data points with spatial coordinates. Given the speed of these instruments, large numbers of data points can be collected quickly and at a high sampling interval, or density, across the artifact surfaces to create highly accurate three-dimensional digital models of the target object with a submillimeter spatial resolution. This process creates a dense array of data points with Cartesian coordinates often referred to as a point cloud. Point cloud data can then be analyzed by a wide variety of geospatial techniques. The use of this method has yet to be tested with respect to documenting ceramic abrasion; however, it has shown great utility in other ceramic studies (cf. Bouzakis et al. 2011; Karsik and Smilansky 2008), lithic reduction studies (Clarkson and Hiscock 2011; Clarkson et al. 2006; Lin et al. 2010), and postdepositional alteration of chipped stone tools (Grosman et al. 2011) where subtleties of research interest are often not visible to the unaided eye.
For this study, a sample of 525 sherds was selected from the recovered ceramic collection. The collection was separated by excavation block and stratigraphic horizon. A conscious choice was made to select sherds that were relatively equally represented from both the colluvium and buried soil contexts (Ab- and E-horizons). Additionally, a preference was made to select a greater number of sherds from the northern end of the site because it was thought that these contexts would likely represent the longest potential distance that a sherd would have been transported on the uplands. Individual sherds were chosen based on the presence of broken edges, typically greater than 2 cm in length, which were clearly not a result of artifact damage during excavation or subsequent laboratory processing. A representative broken edge of each sherd was scanned with a surface data resolution of approximately 0.09 mm encompassing the broken edge and the adjacent (usually exterior) vessel surface. After scanning, the point cloud data for each sherd were meshed to create digital surface models. The arbitrary coordinate system of each sample was then geometrically transformed using a modified principal axis transformation method to allow for profile extraction at a similar orientation among the samples. To accomplish this task, each surface model was translated to orient the vessel surface of each sherd generally consistent with an XY plane. The Cartesian origin (i.e., x,y,z = 0,0,0) was arbitrarily assigned to a point along the broken edge of each translated sherd model. Series of parallel cross sections, oriented to the YZ plane (i.e., transverse to the broken edge of each sherd), were generated, generally in 2-mm intervals, centered on the origin. An attempt was made to avoid extracting profiles from areas with surface decoration intersecting broken edges. When possible, five cross sections were extracted from each sherd. However, this was not always possible due to irregularities along the break edge, so three cross sections were extracted from many of the sherd scans. The data values of individual points along each cross section were then exported for analysis.

The data values from the XYZ cross sections were then imported to Matlab for analysis. A Matlab script was then used to identify the sherd break edge and find the best fit circle to that edge using the least squares method (Umbach and Jones 2000). This method finds a circle with a radius R and an origin (x,y) such that the distance from each point along the sherd edge to the edge of the circle (standard error [SE]) is minimized. The xy, R, and summaries of the SE data (sum of standard error [SSE], average standard error [ASE], maximum standard error [MaxSE], minimum standard error [MinSE], and standard deviation of standard error [SdevSE]) were then exported to a data table for each cross section.

Since the least squares method is dependent on the number of data points used in the analysis, it was important to determine the appropriate number of points that were necessary to accurately describe the break edge. An experimental sample of five sherds was selected to address both the number of data points needed for the analysis and to understand how resistant the collection, as a whole, was to abrasion. Five sherds were randomly selected from the collection and were broken in the laboratory. The sherds were
then tumbled in a Lortone QT12/QT66 rotary tumbler filled with moist construction sand for varying lengths of time. This tumbler is in general compliance with ASTM testing methods for studying abrasion of materials (ASTM International 2012). Based on the results of similar previous studies (e.g., Skibo et al. 1997; Skibo and Schiffer 1987), the times chosen for scanning varied, ranging from 5-minute intervals to 16 hours. In order to first understand the expected amount of abrasion, a pilot study using one sherd (FS 997) was first conducted in 5-minute intervals for 45 minutes and one additional measurement at 60 minutes. Cross sections were then extracted from the pilot sherd at 2-mm intervals and a best fit circle was applied to the edge.

The number of points used in the analysis was determined qualitatively by examining plots of each cross section and selecting the most fit circle that best described the edge of the sherd while minimizing the both the SSE and ASE data. The qualitative examination of the pilot sherd suggested that a range of points, from 15 to 31 points, most accurately depicted the sherd edge. Generally, the more rounded the sherd edge was required a greater number of data points to describe the break. The remaining data was analyzed using a Matlab script that selected the best fit circle using 15, 21, and 31 data points. Using these quantities of data points in the analysis and the average resolution of the 3D scanner data (0.0949 mm), a hypothetical right angle was constructed and a best fit circle was applied to the angle. Using 15, 21, and 31 points in the analysis resulted in a right angle being described as a circle with the best fit radii of 0.435, 0.601, and 0.875 mm, respectively (Figure 144). As such, these values should be taken into consideration when making interpretations concerning how much the sherds have been rounded due to abrasion.

Figure 144. Plot showing the best-fit circles to a hypothetical right angle with a 0.0949 mm resolution. The plot shows the data using 15 data points (red), 21 data points (green), and 31 data points (blue).
The results of the pilot sherd suggested a 5-minute interval was too short a timeframe to observe any quantifiable rounding of the sherd edge (Figure 145). Furthermore, the pilot study indicated that the range in variation across the broken edge of the sherd was too great to confidently characterize the sherd edge. The remainder of the sherds were then tumbled and scanned at much coarser tumbling times (0, 15, 30, 60, 120, 240, 480, and 960 minutes). In order to aid in repeatedly measuring nearly the same location on the broken edge, a small mark was incised on the sherd in order to provide a reference point. Ten cross sections were then extracted from each scan at 0.5-mm intervals transverse to the broken edge.

![Figure 145. Results of the first hour of tumbling the pilot sherd.](image)

The data show a gradual overall trend toward progressively wider fit radii. However, two spikes of smaller than expected radii were observed at the 15- and 35-minute scans. These readings were interpreted as anomalous noise due to variations in the locations along the sherd edge where the cross sections were selected.

As tumbling time increased, the five sherds did show a progressive rounding of their edges, though the data were not without some anomalous readings (Figure 146). Each of the sherds was scanned with freshly broken edges and exhibited a range from 0.598 mm to 1.081 mm. This shows that although each sherd was freshly broken, not all breaks resulted in a near right angle edge. Each sherd does show a consistency of the edges for the first 30 minutes of tumbling. Then the sherd edges actually stabilize or become subtly sharper on their edges through 240 minutes. During these intervals, the sherds did begin to appear visibly abraded, but the edges seemed to be failing because of microfractures, which caused a relatively stable overall roundness in the edges. With increased time, most sherds did show a progressive rounding, with an approximate 0.03-mm radius increase per hour of tumbling. However, a significant amount of noise was present in the data. The laser
scanner detected that as the sherd edge became more rounded, the progressive roundness was often expressed through multiple step fractures on the order of 0.1 to 0.5 mm wide. Likely, the sherds were expressing failure at points where large temper inclusions were present. The result is a data set with a wider average standard error and location along the sherd edge where multiple step fractures have added to one another to form relatively sharp breaks. The second cross section of sherd FS 1217.2 that was tumbled for 16 hours displays these step fractures prominently (Figure 147). Although the step fractures are most apparent in this scan, there was evidence throughout all sherds of this type of variation in association with temper.

Site Results
In total, 1,610 individual cross sections were extracted from 525 sherds collected from the Murvaul Creek site. The sherds were grouped by stratigraphic horizon (colluvium, Ab-horizon, and E-horizon) and by excavation block for the analysis. During the analysis, errors were occasionally identified within the data and it was necessary to omit many of the cross sections. These errors resulted from irregular breaks, surficial irregularities such as deep incisions near the break edge, and cross sections that were cut too short for the analysis. The resulting data set consisted of 1,408 cross sections that were extracted from 503 sherds (Table 83). Given the limited numbers of artifacts collected from the E-horizon, the
Plot of the best fit circle of a sherd tumbled for 960 minutes showing a prominent sharp step fracture near a temper location.

Table 83: Cross Sections Used in the Analysis

<table>
<thead>
<tr>
<th>Excavation Block</th>
<th>Colluvium</th>
<th>Ab-horizon</th>
<th>E-horizon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>433</td>
<td>132</td>
<td>3</td>
<td>568</td>
</tr>
<tr>
<td>5</td>
<td>56</td>
<td>49</td>
<td>3</td>
<td>108</td>
</tr>
<tr>
<td>6</td>
<td>29</td>
<td>9</td>
<td>6</td>
<td>44</td>
</tr>
<tr>
<td>7</td>
<td>78</td>
<td>102</td>
<td>13</td>
<td>193</td>
</tr>
<tr>
<td>8</td>
<td>148</td>
<td>276</td>
<td>71</td>
<td>495</td>
</tr>
<tr>
<td>Total</td>
<td>744</td>
<td>568</td>
<td>96</td>
<td>1408</td>
</tr>
</tbody>
</table>

sample from this area was necessarily limited in size. In general, the cross sections used in the analysis are representative of the range of artifacts recovered from all portions of the site.

Figure 148 below shows the entire site population separated by the number of cross sections that fit to a given radius. The mean of the entire population was 1.081 mm, which is similar to the results expected based on the experimental study. However, the histogram below shows that the data are right-skewed and contain a prominent double peak, with the first occurring near 0.713 mm and the second ranging between 0.9454 and 1.15 mm.
These data were further subdivided by both stratigraphic horizon and by excavation block (Figure 149). When examined by horizon, each of the three divisions is right-skewed, with the most prominent skewness occurring in the colluvium (Table 84). Although distribution of the Ab-horizon contains a mean of 0.94 mm, there is a prominent peak at 0.71 mm. This peak is identical to the first peak in Figure 148 above, which graphically displays that the Ab-horizon represents a unique distribution from the colluvium. The histogram of the E-horizon show a broader distribution that, although it is still slightly right-skewed, appears to be centered between the colluvium and Ab-horizon means. Both the higher mean (1.198 mm) and high degree of skewness in the colluvium is interpreted as indicating that the sherds from the upper portions of the site did indeed show some degree of increased abrasion when compared to the Ab-horizon. Interestingly, the slightly higher radii values of the E-horizon, when compared to the Ab-horizon, also suggest that some degree of abrasion occurs through the downward translocation of the sherds though time.
A secondary goal for the analysis was to identify whether or not abrasion varied among the excavation blocks at the site. The expectation was that the northern excavation blocks (e.g., Blocks 7 and 8) would have a greater chance at showing abrasion than the southern and central areas of the site. Additionally, in the northern portion of the site were greater amounts of modern disturbance. For instance, Blocks 5–7 were all directly associated with a two-track road, and numerous brush piles were located in these areas at the beginning of the field season. With the presence of these modern impacts, it was suspected that a greater degree of abrasion would be evident especially in the colluvial horizons through a wider standard deviation than other portions of the site.

Figure 150 displays the results of the sherds selected from the colluvium separated by excavation block. The data show that within each of the blocks was observed nearly the same mean (~1.2 mm) and standard deviation (~0.43 mm). No obvious trends were observed that indicated a significant variation in abrasion within this horizon across the site. Figure 151 further illustrates these data by plotting the mean radii of each block separated by stratigraphic horizon. Although no trends were observed in these data, it is important to
note that there is only an approximate 20 m separating the southernmost end of Block 4 and the northern most end of Block 8. It is likely that this distance between these blocks is too short to cause any difference in abrasion during transport. Additionally, the data suggest that the modern impacts to the ground surface have had no real impact to the site contents.

Intrinsic in this study is the assumption that within the buried soil would be a relatively equal record of abrasion across the site. In order to address this assumption data from the Ab- and E-horizons were combined and evaluated by block. This combination was done because the few cross sections that represented the E-horizon were collected from only six test units and such few points would have provided limited interpretations. With the Ab- and E-horizons combined, it can be seen in Figure 151 that limited variation does appear to exist across the site. Blocks 5 and 6 both contain best fit radius values over 1.0 mm. However, Figure 152 displays these results as histograms separated by block. This plot shows that though Blocks 5 and 6 do show slightly higher than average mean best fit radii compared to the other blocks, the data are also slightly left-skewed due to a relative lack of data points. Within these blocks, only Blocks 4 and 8 contain a sufficient sample to make an accurate generalization. Both Blocks 4 and 8 have mean radii under 1.0 and relatively low standard
deviations compared to the colluvial samples. It is likely that should a larger sample have been collected from the other blocks within these horizons that the data would have trended toward similarly lower radial values.

**Summary and Discussion**

The initial research design put forth the hypothesis that the appropriate measure for the roundness of a sherd edge would be expressed through differences in the gradient, or the change in the slope over the change in distance of the sherd edge. It was expected that sherds from the colluvium at the site would be statistically lower in amplitude and broader in standard deviation than sherds collected from other contexts at the site. However, upon inspection of the data and literature, it was apparent that this measure could be expressed easily through the radius of a best fit circle to the edge. The same expectation was made—that colluvial contexts would be expressed with higher radius values but additionally likely also higher range in variation of these values.
Taylor (2000) has discussed that the abrasion of ceramics is highly dependent on a number of factors. Of these factors, the artifact’s resistance to abrasion, physical composition, abrading medium, and soil chemistry all play a role in the postdepositional alteration of an assemblage. Concerning a sherd’s resistance to abrasion, prior experimental studies (e.g., Skibo et al. 1997; Skibo and Schiffer 1987) have shown that both clay composition and degree of firing are critical to understanding the amount of attrition that would occur in plowed soils or other erosional settings. Because of these factors, the experimental study within this analysis has been used to characterize the abrasion from Murvaul Creek assemblage. With the methods used and with this assemblage, it has been demonstrated that freshly broken sherds should contain relatively sharp edges that should be reflected in best fit radial values between approximately 0.5 mm and 0.8 mm. As abrasion increases, the sherd edges should become more rounded with time, with radial values tending above 1.0 mm. However, as abrasion time increases, temper within the sherds will also cause failures in this edge that appear as fresh breaks in the data. Because sherds are not homogenous clasts, clear spherical rounding is not always observed as would be suggested by detrital transport studies (e.g., Pettijohn et al. 1984).

The most concern was with accurately addressing the question of whether or not the artifacts contained within the colluvium were transported and redeposited on the site within the soil matrix. An additional possibility was that these artifacts were relatively in situ.
spatially, but had been translocated upward through the profile by bioturbation. If the artifacts were only transported vertically through the profile, then it would be likely that the abrasion on the sherds in the E-horizon would be similar to that seen from the collection in the colluvium. The data instead indicated that the colluvium had both a higher mean roundness and greater standard deviation than observed in the E-horizon sample. This suggests that the artifacts in the colluvium have indeed been subjected to additional abrasion that was not observed in deeper deposits. The most likely conclusion is that this additional abrasion is due to the horizontal motion of these artifacts as a result of the deposition of the colluvial deposits. Unfortunately, the relatively limited sample size and variation across the site have limited the ability to quantify the length or duration of this transport.
Chapter 15: Site Phytolith Reconstruction: Pollen and Phytolith Analysis of Ground Stone and Ceramic Residue, and Phytolith Analysis of Soil Samples from Site 41PN175, Panola County, Texas
by Chad Yost and Linda Scott Cummings, Ph.D., with assistance from R. A. Varney

Introduction
Site 41PN175 is a Middle to Late Caddo farmstead or hamlet located in Panola County, in eastern Texas. An initial submission of ground stone tools and ceramic sherds from site 41PN175 was first analyzed for pollen, phytolith, and starch grain remains. These analyses recovered and identified microscopic plant remains derived from processing and cooking activities. Following the completion of that study, 10 bulk samples from a soil column were submitted for a phytolith-based paleoenvironmental reconstruction.

Methods

Ground Stone Washes for Pollen and Starch
The use of ground stone in processing plants and animals may leave evidence on the artifact surface that includes concentrations of pollen and starch, which can be recovered by washing the ground surfaces.

First, all visible dirt was removed using tap water and gentle hand pressure to remove any modern contaminants. A small portion of each ground surface was tested with dilute (10 percent) hydrochloric acid (HCl) to detect the presence of any calcium carbonates. If present, these carbonates were removed with additional dilute HCl. Then, the ground surfaces were washed with a 0.5 percent Triton X-100 solution to recover any pollen and starch grains. The surface was scrubbed with an ultrasonic toothbrush and rinsed thoroughly with reverse osmosis deionized (RODI) water. Each sample then was sieved through 250-micron mesh to eliminate any large particles that might have been released during the washing process. After centrifuging, the samples were dried under vacuum, then mixed with sodium polytungstate (SPT), at a density of 1.8 g/ml, and centrifuged to separate the pollen and starch, which will float, from the silica, which will not. The samples were treated with hydrofluoric (HF) acid to remove silica, then acetylated for 3–5 minutes to remove any extraneous organic matter. The samples were rinsed several times with RODI water, then stained with basic fuchsin. A light microscope was used to count the pollen at a magnification of 500x. Pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible.
Pollen diagrams were produced using Tilia 2.0 and TGView 2.0.2. A plus sign (+) on the pollen diagram indicates that pollen was observed, in spite of the fact that pollen was not present in a sufficient concentration to obtain a full count. Total pollen concentrations were calculated in Tilia using the measurement of the ground/use surface washed in square centimeters (cm²), the quantity of exotics (spores) added to the sample, the quantity of exotics counted, and the total pollen counted and expressed as pollen per cm² of use surface. “Indeterminate” pollen includes pollen grains that are folded, mutilated, or otherwise distorted beyond recognition. These grains were included in the total pollen count, as they are part of the pollen record. The estimated microscopic charcoal abundance was calculated by recording individual microscopic pieces of charcoal during a portion of the pollen count, then allowing the computer to extrapolate from those observations to the quantity of charcoal present in the total count. This number is presented on the pollen diagram.

Pollen analysis also included examination for starch granules and, if they were present, their assignment to general categories. Starch granules are a plant's mechanism for storing carbohydrates. Starches are found in numerous seeds, as well as in starchy roots and tubers. The primary categories of starches include the following: with or without visible hila, hilum centric or eccentric, hila patterns (dot, cracked, elongated), and shape of starch (angular, elliptical, circular, eccentric). Some of these starch categories are typical of specific plants, but others are more common and tend to occur in many different types of plants.

**Ceramic Analysis for Pollen and Starch**

The use of ceramics for cooking occasionally leaves evidence in the form of visible residue on either the interior or exterior surfaces. Concentrations of pollen and starches from these residues are expected to represent plants that were processed using the ceramic vessels. The visible residue was removed using a dental pick and placed in a beaker with reverse-osmosis de-ionized (RODI) water. Each sample then was sieved through 250-micron mesh to eliminate any large particles that remained in the residue.

The samples were freeze-dried using a vacuum line, then mixed with sodium polytungstate (SPT) at a density of 1.8 g/ml, and centrifuged to separate the pollen and starch, which will float, from the silica, which will not. Any remaining clay that had infiltrated the ceramic residue was floated with the pollen and was further removed with a hot hydrofluoric acid (HF) treatment to remove silica. The samples then were acetylated for 3–5 minutes to remove any extraneous organic matter. The samples were rinsed with pure water, then stained with safranin.

A light microscope was used to count the pollen at a magnification of 500x. Pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of
Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible. Each slide was scanned using cross-polar illumination to search for and record starches.

Indeterminate pollen, microscopic charcoal abundance, starches, and the pollen diagram were discussed above, and that discussion will not be repeated here.

**Ceramic Analysis for Phytoliths**

Extraction of phytoliths from ceramic sherd residue was based primarily on heavy liquid flotation, as treatment with oxidizing chemicals was kept to an absolute minimum to preserve starch grains that, if present, are likely to be extracted along with the phytolith fraction. First, a small amount of residue was flaked from each ceramic sherd, then a sonicating toothbrush was used to remove residue adhering to the sherd surface. Next, nitric acid (HNO₃) was used to remove most of the organic fraction of each residue sample. Once this reaction was complete (a few days), each sample was rinsed thoroughly and centrifuged using short-duration spins (10 seconds at 3000 rpm) to remove clays. This step was repeated several times until no more clays remained in suspension. Next, a 5 percent solution of potassium hydroxide was added to each sample for 10 minutes to remove humates, and then thoroughly rinsed. Once most of the organic and clay fraction was removed, the silt and sand size fraction was dried under vacuum. The dried silts and sands were then mixed with potassium cadmium iodide (density 2.3 g/ml) and centrifuged to separate the phytoliths and starch grains, which will float, from most of the inorganic silica fraction, which will not. After several water rinses and then a final alcohol rinse, the samples were mounted in optical immersion oil for counting with a light microscope at a magnification of 500x. An initial count of 200 taxonomically significant phytoliths was first conducted, followed by a scan of the entire slide for rare-types derived from economically important plants. A phytolith diagram was produced using Tilia 2.0 and TGView 2.0.2.

**Phytolith and Starch Grain Extraction from Soil**

First, 15 ml of sediment from each sample was placed in a 500 ml beaker with 70 percent nitric acid (HNO₃) and boiled for 1 hour, then rinsed to neutral pH with water. Next, a 10 percent solution of potassium hydroxide (KOH) was added to each sample and thoroughly mixed. KOH aids in the removal of organic humic substances not removed by nitric acid. After the addition of KOH, the samples were allowed to settle by gravity for two hours, after which, the humates liberated from the sediments were decanted. The samples were then rinsed to neutral pH with water. Once these steps were complete, a 5 percent solution of sodium hexametaphosphate was mixed into each sample to suspend clay-sized particles. The samples were allowed to settle by gravity for two hours, after which, the clay-sized particles that were still in suspension were decanted. This step was repeated four more times until the supernatant was clear after two hours of settling time. The samples were then transferred to 50 ml centrifuge tubes and freeze-dried using a vacuum system, which freezes out all moisture at -107 °C and < 10 millitorr. The dried samples were then mixed.
with sodium polytungstate (SPT, density 2.3 g/ml) and centrifuged to separate the phytolith and starch grain fraction, which will float, from most of the inorganic silica fraction, which will not. Each sample was then rinsed with water to remove the sodium polytungstate, followed by alcohol rinses to remove any remaining water. After several alcohol rinses, the samples were mounted in optical immersion oil for counting with a light microscope at a magnification of 500x. A total count of 300 taxonomically significant phytoliths was first completed, after which, each slide was scanned for starch grains and for rare phytolith types of economic and ecological significance. A percentage phytolith diagram that includes frequency data for any starch grains observed was produced using Tilia 2.0 and TGView 2.0.2.

Discussion
Site 41PN175 is a Middle to Late Caddo farmstead or hamlet located in East Texas in Panola County. The Middle Caddo period lasted from about 1200 to 1400 A.D. The Late Caddo period spans a period of time from about 1400 to 1680 A.D. Initially, four ground stone tools and five ceramic sherds (collected from centimeters below datum [cmbd]) were submitted for analysis (Table 85). Pollen and starch analyses were conducted on all of the items, but phytolith analysis was conducted only on the ceramic sherds. At the completion of this work, an additional 10 bulk soil samples collected from a stratigraphic profile (cmbs) were submitted for a phytolith-based paleoenvironmental reconstruction. The stratigraphic paleoenvironmental samples are discussed first so that the environmental signal present on the ground stone tools and sherds can be better discerned.

Profile 2 Stratigraphic Soil Samples
Ten stratigraphic soil samples were collected from 5–90 cmbs and submitted for phytolith analysis. Each sample analyzed spans 5 cm of depth, with typically a 5-cm gap between samples. A total of 300 taxonomically significant phytoliths was counted for each sample, and a percentage phytolith diagram was produced (Figure 153). Stratigraphically constrained cluster analysis was conducted on the phytolith counts using the CONISS program (Grimm 1987), and the results are displayed as a dendrogram on the phytolith diagram. From the dendrogram, zones were delineated to group samples with similar assemblages and to define boundaries where significant changes in the phytolith record occur. The results discussion is organized by zone starting with samples from the lowest position in the profile.

Zone C (Samples 18, 16, and 14)
Zone C comprises three samples, 18 (85–90 cmbs), 16 (75–80 cmbs), and 14 (65–70 cmbs). Material from Sample 14 was dated 1820 ± 30 radiocarbon years before present (RCYBP), yielding a calibrated age range of A.D. 130 to 250. Samples 18 and 16 are described as being part of a Bw-horizon, and Sample 14 is described as part of the Eb-horizon. Typically, major changes in phytolith assemblages correlate well with soil horizons;
### Table 85: Provenience Data for Samples from Site 41PN175, Panola County, Texas

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Block</th>
<th>Unit</th>
<th>Level</th>
<th>Depth</th>
<th>Provenience Description</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>747</td>
<td>2</td>
<td>84</td>
<td>3</td>
<td>35–45</td>
<td>Ground stone from NW ¼ of unit</td>
<td>Pollen</td>
</tr>
<tr>
<td>733</td>
<td>4</td>
<td>76</td>
<td>4</td>
<td>35–45</td>
<td>Ceramic sherd from SW ¼ of unit</td>
<td>Pollen starch, phytolith</td>
</tr>
<tr>
<td>708</td>
<td>77</td>
<td>3</td>
<td>25–35</td>
<td>Ceramic sherd from SE ¼ of unit</td>
<td>Pollen starch, phytolith</td>
<td></td>
</tr>
<tr>
<td>711</td>
<td>4</td>
<td>86</td>
<td>3</td>
<td>35–45</td>
<td>Ground stone from SW ¼ of unit</td>
<td>Pollen</td>
</tr>
<tr>
<td>712</td>
<td>4</td>
<td>86</td>
<td>3</td>
<td>35–45</td>
<td>Ground stone from SW ¼ of unit</td>
<td>Pollen</td>
</tr>
<tr>
<td>1236</td>
<td>97</td>
<td>4</td>
<td>35–45</td>
<td>Ceramic sherd from SE ¼ of unit</td>
<td>Pollen starch, phytolith</td>
<td></td>
</tr>
<tr>
<td>1331</td>
<td>100</td>
<td>3A</td>
<td>35–42</td>
<td>Ceramic sherd from NE ¼ of unit</td>
<td>Pollen starch, phytolith</td>
<td></td>
</tr>
<tr>
<td>1536</td>
<td>125</td>
<td>3</td>
<td>25–30</td>
<td>Ceramic sherd from NW ¼ of unit</td>
<td>Pollen starch, phytolith</td>
<td></td>
</tr>
</tbody>
</table>

**Submission 2: Soil Profile 2 (cmbs**):  
| 2          | 7     | 5–10 | Colluvium | Phytolith |
| 4          | 15–20 | Phytolith |
| 6          | 25–30 | Phytolith |
| 8          | 35–40 | Ab-horizon | Phytolith |
| 9          | 40–45 | Phytolith |
| 10         | 45–50 | Phytolith |
| 12         | 55–60 | Eb-horizon | Phytolith |
| 14         | 65–70 | Phytolith |
| 16         | 7     | 75–80 | Bw-horizon | Phytolith |
| 18         | 85–90 | Phytolith |

* cmbd=centimeters below datum: artifacts collected below datum  
** cmbs=centimeters below surface: soil samples collected below surface

however, soil color and texture boundaries can be difficult to determine empirically in the field. Overall, Zone C is characterized by the lowest relative abundance of pine (Pinus spp.) needle phytoliths for the profile and an elevated abundance of elongate and trichome phytoliths from grasses, sedges, and forbs. Longleaf pine (Pinus palustris), but most likely shortleaf pine (Pinus echinata), are the possible sources for these pine needle phytoliths. Zone C was subdivided into C1 and C2 because the lowest sample (18) exhibited some subtle differences in the both the phytolith and the siliceous algal and sponge records. It should be noted that the spike in freshwater sponge spherasters in Sample 18 should not
Figure 153. Phytolith percentage diagram for Soil Profile 2, site 41PN175, Panola County, Texas.
be interpreted as indicating wet soil conditions. In fact, the opposite is more likely true here. Sponge spherasters are spherical bodies around 10 μm in diameter with short spiny projections. When lakes and ponds dry out, these microfossils can be easily redeposited by wind onto more upland settings. When looking at the normalized percentages of taxonomically significant grass silica short cells (last four columns on right side of diagram Figure 153), phytoliths from C₄ chloridoideae grasses peak in relative abundance for the entire profile in Sample 18. This suggests drier conditions existed at that time than for the overlying samples in Zone C. Sedge (Cyperaceae) phytoliths appear for the first time in Sample 16, as does a phytolith diagnostic of erect dayflower (*Commelina erecta*). *Commelina erecta* is a perennial herbaceous plant that prefers to grow in habitats that include rocky woods and hillsides, scrub oak woods, pine woods and barrens, sand dunes, and hummocks (Faden 2000).

In summary, the phytolith record from Zone C is characterized by the lowest occurrence of pine needle phytoliths and the highest abundance of grass/sedge/forb phytoliths (smooth elongates and trichomes) for the entire profile. Zone C is also characterized by a trend of increasing tallgrass (mesic soil, humidity) phytolith abundance and by a decreasing trend in shortgrass (drier soil) phytolith abundance. It should be mentioned that unlike pollen, phytoliths are only produced by certain families of plants, in particular, monocots such as grasses and sedges. Phytolith production in forbs, shrubs, and trees is infrequent. Thus, the most comprehensive paleoenvironmental reconstruction would include both pollen and phytolith records. In the absence of a companion pollen record, the phytolith record suggests that Zone C represents an open mixed prairie habitat with grasses, sedges, and a significant forb community. Zone C also appears to represent the beginning of a transition to the dominance of more mesic tallgrass taxa at the expense of dryland shortgrass taxa. This may be due to a long-term trend in increasing summer precipitation and humidity that continues into the lower portion of Zone B.

**Zone B (Samples 12, 10, 9, and 8)**

Zone B is represented by four samples, 12 (55–60 cmbs), 10 (45–50 cmbs), 9 (40–45 cmbs), and 8 (35–40 cmbs). Sample 12 is designated as part of the Eb-horizon, whereas the overlying samples (10, 9, and 8) are designated as part of the Ab-horizon. Material from Sample 12 was dated 1640 ± 30 RCYBP, yielding a probability-based calibrated age range of 350 to 530 A.D. This date anchors the bottom of the zone. Material from Sample 7 (30–35 cmbs), which was not submitted for phytolith analysis, was dated 150 ± 30 RCYBP, yielding a probability-based calibrated age range of A.D. 1670 to post-1950, and provides an approximation for the likely upper extent of the Ab-horizon and Zone B. Overall, Zone B is best characterized by a steadily increasing abundance of pine (*Pinus* spp.) needle phytoliths and a decreasing abundance of phytoliths from tallgrass Panicoideae grasses. Although they are decreasing in abundance, panicoid grasses remain dominant over shortgrass Chloridoideae grasses. Also, it should be noted that because of differences in shortcell phytolith production, Chloridoideae grass phytoliths tend to be overrepresented in
comparison to Panicoideae phytolith abundance. Thus, the relative abundance of shortcell phytoliths may not reflect actual abundance on the landscape. Zone B is also notable for the presence of maygrass (*Phalaris* spp.) phytoliths in Samples 8 and 10. For this area, *Phalaris caroliniana* is the most likely source for the *Phalaris* leaf phytoliths (rondels with angular keels) observed in these two samples. Maygrass tends to grow in moist to wet ground, and has an affinity for disturbance. Maygrass seeds were a well-known food utilized by many native groups in the eastern and plains regions of the United States (Moerman 1998:390–391).

Because of some subtle differences in the presence and absence of certain phytolith morphotypes, cluster analysis suggests that Zone B could be divided into two subzones, B1 and B2. This distinction is more obvious when viewing the normalized grass shortcell percentages in the four columns on the far right side of the Figure 153 diagram. Because only grass phytoliths with high taxonomic resolution are included in the normalized percentages, subtle changes in moisture availability and exposure can sometimes be discerned. B2 is characterized by increasing mesic tallgrass (Panicoideae) phytoliths and decreasing xeric shortgrass (Chloridoideae) phytoliths. The overlying zone B1 is characterized by an increase in xeric shortgrass taxa and the highest level of pine needle phytolith abundance for the profile. Zone B1 is also the stratigraphic position where a particular type of blocky conifer-type phytolith first appears. This phytolith is called a “Parallelepipedal” on the phytolith diagram, and is characterized as a square or rectangular body with parallel sides with an occasional singular wave along at least one margin. These phytoliths are found in the needles of many species of pine, but are produced in great numbers in loblolly pine (*Pinus taeda*), the most likely source for them here. It should be mentioned that although the eastern Texas Pineywoods region receives a significant amount of annual rainfall, well-drained sandy soils create xeric soil conditions for plant communities in this area. The perceived increase in xeric shortgrass phytoliths may reflect slightly drier conditions; however, it may simply reflect a decrease in tallgrass abundance due to increased pine abundance and fewer openings on the landscape for tallgrass taxa. This last hypotheses is somewhat supported by the increase in phytoliths derived from cool season C₃ grasses that is concomitant with increasing pine phytoliths. C₃ grasses are rare in this region and are typically restricted to riparian areas or to semishade to full-shade forested understories. The sudden increase in C₃ grass phytoliths from the subfamily Pooideae starts in the uppermost Zone B2 sample and continues throughout Zone B1. Other characteristics of the Zone B1 record include a spike in sedge (Cyperaceae) phytoliths, the presence of sunflower family (Asteraceae) and dayflower (*Commelina* spp.) phytoliths, and a slight rise in microfossils from moist soil and water organisms.

In summary, Zone B reflects a period of time with steadily increasing pine forest density and the development of a diverse herbaceous understory. The cluster analysis suggested bifurcation of Zone B may delineate two distinct successional stages, as pine canopy
development alters moisture and light availability to the herbaceous layer. Also, the emergence of a second conifer phytolith-type in Zone B1 suggests the presence of more than one species of pine. Phytoliths indicative of maygrass (*Phalaris caroliniana*) appear in this zone and may be derived from subsistence-related activities or natural disturbance.

**Zone A (Samples 6, 4, and 2)**

Zone A is represented by Samples 6 (25–30 cmbs), 4 (15–20 cmbs), and 2 (5–10 cmbs). These samples were collected from colluvium, and subsequent dating of material from Samples 2 and 5 (not analyzed here) indicate the possible incorporation of older upslope material deposited by erosion into this part of the profile. Sample 2 yielded an AMS date of 260 ± 30 RCYBP, which calibrates to 1520 to 1950 A.D. Sample 5 (22.5 cmbs) yielded an AMS date of 310 ± 30 RCYBP (1480 to 1650 A.D.), and the underlying Sample 7 (32.5 cmbs) yielded an AMS date of 150 ± 30 RCYBP (A.D. 1670 to post-1950). Thus, this age reversal indicates that older sediments were likely deposited from an erosional event or multiple events onto younger surfaces. It is possible that the uppermost sample from the Ab-horizon (7) represents the pine forest climax just before a major disturbance event. This disturbance event could have been caused by a catastrophic stand-replacing fire or timber harvest clear-cutting of the stand. Either of these events could have then produced conditions conducive to severe erosion and creation of the colluvial deposits. Since the phytolith records from these samples may reflect both in situ and disturbance sediments, no attempt to reorder the phytolith samples in the diagram was made. It is also difficult to make secure phytolith-based paleoenvironmental interpretations from Samples 2, 4, and 6 because of their temporal uncertainties and likely incorporation of mixed-age soils. The phytolith record from Sample 2 does share some affinity with that from Sample 8 (Ab-horizon), but without dates from Samples 4 and 6, reordering the samples would be very speculative.

**Ground Stone and Ceramic Residue Analysis**

**Ground Stone Sample 747**

A ground stone (Sample 747) was recovered from Unit 84, Level 3, at a depth of 35–45 cmbd. Pollen and starch analysis of the wash obtained from the use surface of this item yielded a record dominated by Poaceae pollen (Table 86, Figure 154), indicating either local growth of grasses or the grinding of grass seeds using this ground stone. Recovery of moderate quantities of *Pinus*, *Quercus*, and High-spine Asteraceae pollen represent local vegetation that included pine and oak trees and members of the sunflower family. Small quantities of *Carya*, *Celtis*, *Ulmus*, Apiaceae, *Artemisia*, Low-spine Asteraceae, Liguliflorae, Brassicaceae, Cheno-am, *Corylus*, and Rosaceae pollen represent hickory/pecan, hackberry, and elm trees, as well as a member of the umbel family, wormwood, members of the marshelder group of the sunflower family, members of the chicory tribe of the sunflower family, members of the mustard family, cheno-ams, hazel, and a member of the rose family growing locally. Although the quantity of microscopic charcoal was rather large, it was not as...
Table 86: Pollen Types Observed in Samples from Site 41PN175, Panola County, Texas

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARBOREAL POLLEN:</strong></td>
<td></td>
</tr>
<tr>
<td>Carya</td>
<td>Hickory, Pecan</td>
</tr>
<tr>
<td>Celtis</td>
<td>Hackberry</td>
</tr>
<tr>
<td>Liquidambar</td>
<td>Sweetgum</td>
</tr>
<tr>
<td>Pinus</td>
<td>Pine</td>
</tr>
<tr>
<td>Quercus</td>
<td>Oak</td>
</tr>
<tr>
<td>Ulmus</td>
<td>Elm</td>
</tr>
<tr>
<td><strong>NONARBOREAL POLLEN:</strong></td>
<td></td>
</tr>
<tr>
<td>Apiaceae</td>
<td>Umbel family</td>
</tr>
<tr>
<td>Asteraceae:</td>
<td>Sunflower family</td>
</tr>
<tr>
<td>Low-spine</td>
<td>Includes ragweed, cocklebur, sumpweed</td>
</tr>
<tr>
<td>High-spine</td>
<td>Includes aster, rabbitbrush, snakeweed, sunflower, etc.</td>
</tr>
<tr>
<td>Liguliflorae</td>
<td>Chicory tribe, includes dandelion and chicory</td>
</tr>
<tr>
<td>Brassicaceae</td>
<td>Mustard or cabbage family</td>
</tr>
<tr>
<td>Cheno-am</td>
<td>Includes the goosefoot family and amaranth</td>
</tr>
<tr>
<td>Corylus</td>
<td>Hazel</td>
</tr>
<tr>
<td>Eriogonum</td>
<td>Wild buckwheat</td>
</tr>
<tr>
<td>Fabaceae:</td>
<td>Bean or Legume family</td>
</tr>
<tr>
<td>Dalea-type</td>
<td>Prairie Clover</td>
</tr>
<tr>
<td>Nyctaginaceae</td>
<td>Four o’clock family</td>
</tr>
<tr>
<td>Poaceae</td>
<td>Grass family</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Rose family</td>
</tr>
<tr>
<td>Sphaeralcea</td>
<td>Globemallow</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>Too badly deteriorated to identify</td>
</tr>
<tr>
<td><strong>SPORES:</strong></td>
<td></td>
</tr>
<tr>
<td>Trilete</td>
<td>Fern</td>
</tr>
<tr>
<td>Selaginella</td>
<td>Spikemoss</td>
</tr>
<tr>
<td>Microscopic charcoal</td>
<td>Microscopic charcoal fragments</td>
</tr>
</tbody>
</table>

Total pollen concentration was approximately 23 pollen per cm² of ground surface washed.

**Ceramic Sherd Sample 733**

Ceramic sherd sample 733 was recovered from Block 4, Unit 76, Level 4 (35–45 cm bd). This sherd was submitted for pollen, starch, and phytolith analyses. No starch was recovered from the sherd residue. The sum for this sample is reported as “0” because no pollen was observed during the official, high magnification “count.” Therefore, a low magnification scan of the entire microscope slide was undertaken, yielding a few *Pinus*, *Poaceae*, and *Sphaeralcea* pollen, representing pines, grasses, and globe mallow. Microscopic charcoal was present. No pollen indicative of economic activity was observed.
Figure 154. Pollen diagram for 41PN175, Panola County, Texas.
The phytolith record from ceramic sherd Sample 733 appears to reflect mostly an environmental signal, as phytoliths from subsistence plants such as maize, beans, and squash were not observed (Figure 155). Phytoliths from grasses dominated the overall assemblage, with those derived from the Bambusoideae (*Arundinaria gigantea*) and Panicoideae most common. Buliform phytoliths were actually the most common phytolith morphotype observed, but they have limited taxonomic resolution. They are found in grass leaf material and are commonly produced by members of the Bambusoideae and Panicoideae, their likely source here. A few phytoliths derived from common reed (*Phragmites australis*) were observed in this sample and did not appear in any of the other samples analyzed. Only a few phytoliths were derived from plants that may have been utilized for subsistence. Two verrucate plate phytoliths derived from hackberry (*Celtis* spp.) fruits were recovered, and a few achene (seed) phytoliths from a member of the sedge family (*Cyperaceae*), possibly *Cyperus*, were observed. Both of these plants were utilized for subsistence by many groups (Moerman 1986; Peterson 1977; Wallace and Hoebel 1986); however, given the presence of cultigens at this site, they may simply be derived from the surrounding vegetation.

Diatom frustules and freshwater sponge spicules and spherasters were also recovered in the phytolith fraction from this sample and all of the other samples as well. Freshwater sponges inhabit ponds, lakes, and rivers, where they grow on the surfaces of rocks, logs, and branches. Diatoms are unicellular, photosynthetic algae distinguished by the possession of a silica cell wall. They can be found living in a wide variety of aquatic habitats, including seeps, wet walls, dry and damp soil, springs, streams, creeks, sloughs, lakes, rivers, ponds, marshes, lagoons, estuaries, mud flats, bays, and oceans. Most are cosmopolitan, found in many parts of the world under similar environmental conditions, and many species have predictable environmental requirements and pollution tolerances that directly affect diatom species composition. Because the relative abundance of diatoms and sponge spicules is much higher here than in the Profile 2 paleoenvironmental samples, their presence is likely derived from water used for cooking and processing foods.

**Ground Stone Sample 711**

Ground stone sample 711 was recovered from Unit 77, Level 4 (35–45 cmbd) and only examined for pollen and starch remains. The pollen record yielded primarily microscopic charcoal indicating that this piece of ground stone had been burned. Since this is the only piece of ground stone examined that did not yield a record, it is likely that burning destroyed the pollen record. A single pollen was noted while attempting to count this sample, and a total pollen concentration of 10 pollen per cm² of ground surface was calculated. Scanning the slide yielded Low-spine Asteraceae and Cheno-am pollen that probably represent pollen in the sediments in which this piece of ground stone was buried. Finally, no starch was observed in this sample.
Figure 155. Phytolith diagram for ceramic sherds from site 41PN175, Panola County, Texas.
Ground Stone Sample 712
Ground stone sample 712 was also recovered from Unit 77, Level 4, and only examined for pollen and starch remains. The pollen record yielded a total of 50 pollen and a calculated 37 pollen per cm² of ground surface. The record was dominated by *Quercus* pollen, representing oaks growing in the area. A moderately large quantity of *Pinus* pollen documents local growth of pines, and recovery of a small quantity of *Ulmus* pollen indicates that elms also grew in the area. Poaceae pollen was observed in moderate frequencies, suggesting the possibility that grass seeds were ground using this ground stone. Recovery of small quantities of Low-spine Asteraceae, High-spine Asteraceae, Brassicaceae, Chenopod, *Eriogonum*, Dalea-type, and Rosaceae indicate that local vegetation also included various members of the sunflower family, mustard family, cheno-ams, wild buckwheat, prairie clover, and a member of the rose family. The Brassicaceae pollen might be present as a result of grinding seeds from a plant in the mustard family or it might be present as part of the environmental signature. Though this sample contained microscopic charcoal, it was a smaller quantity than was noted in most of the other samples examined. No starch was observed in this sample.

Ceramic Sherd Sample 708
Ceramic sherd sample 708 was recovered from Level 3 of Unit 77. This artifact was examined for pollen, starch, and phytolith remains. The pollen record yielded a very large quantity of microscopic charcoal that indicates that the residue was charred. It might have been sufficiently charred to remove pollen or pollen might not have been a significant component of the residue. A few *Pinus*, High-spine Asteraceae, and Poaceae pollen, representing local vegetation that included pine, members of the sunflower family, and grasses, were observed while scanning this sample. No starch was observed in the residue from this sherd.

Phytolith analysis of the sherd residue yielded diagnostic evidence for maize (*Zea mays*). A total of three wavy-top rondels was observed (Figure 156, A–C). Wavy-top rondels can be produced in large numbers in the glume material for many varieties of maize (*Zea mays*). A small amount of these phytoliths can accompany the processing, cooking, and consumption of maize, and can be recovered from artifacts and features that represent these various activities. This particular phytolith appears to meet all of the requirements, as outlined by Pearsall et al. (2003), to be considered a maize (*Zea mays*) cob wavy-top rondeel. The main characteristics are that maize wavy-top rondels have a circular to oval base in outline (top view) that is flat, not concave in side view; the base must be longer than the body is high or tall; the top (the side opposite the rondeel base) is a single, complete wave that is equal to or less than the length of the rondeel base; and the peak or sides of this wave are not horns or spikes. Thus, the phytolith record from this sample indicates that maize was contained within or cooked using this vessel. A few hackberry fruit phytoliths were also observed in this sample, suggesting that they also may have been stored or processed using this vessel.
Maize cob phytoliths and grass seed starch grain recovered from ceramic sherds from site 41PN175, Panola County, Texas

A–C: Wavy-top rondel phytoliths diagnostic of maize (Zea mays) cob material, recovered from ceramic sherd residue sample 708.

D–E: Large lenticular Hordeum/Elymus-type grass seed starch grain recovered from sherd residue sample 1236. This starch grain is most likely derived from little barley (Hordeum pusillum). Image E is the grain viewed under polarized light.

F–H: Wavy-top rondel phytoliths diagnostic of maize (Zea mays) cob material, recovered from ceramic sherd residue sample 1536. The maize cob phytolith in image F is darkened from exposure to fire.

I: Dayflower (Commelina spp.) seed phytolith in top view; and J: in side view, recovered from Sample 1536.

Figure 156. Maize cob phytoliths and grass seed starch grain recovered from ceramic sherds from site 41PN175, Panola County, Texas. All micrographs taken at 500x magnification; the scale bar in J equals 10 μm and can be referenced for all images.

The phytolith-derived environmental record from this sherd had a very high relative abundance of Bambusoideae phytoliths. The only bamboo native to this area is river cane (Arundinaria gigantea). Based on the near absence of these phytoliths in the Profile 2 paleoenvironmental samples, these phytoliths are most likely derived from material used to build habitation structures or storage containers. Also observed was a phytolith derived from the needles of pine (Pinus spp.). Given recovery of relatively large numbers of pine needle phytoliths in sediments examined from this site, no economic interpretation is ascribed to the presence of phytoliths from pine needles in this sample.

**Ceramic Sherd Sample 1236**

Ceramic sherd sample 1236 was recovered from Unit 86, Level 3 (25–35 cmbd). This artifact was examined for pollen, starch, and phytolith remains. The pollen record yielded a few Fabaceae, Nyctaginaceae, Poaceae, and Rosaceae pollen representing a member of the legume and four o’clock families, grasses, and rose family. A very large quantity of microscopic charcoal was noted in this residue, suggesting carbonizing the food remains and probably cooking over high heat. Total pollen concentration was calculated at 14 pollen per cm² of ceramic surface.
The phytolith record yielded what appears to be a very strong environmental signal. No phytoliths from maize were observed in this sample. In fact, the overall phytolith assemblage was very similar to that described for ceramic sherd Sample 733 from Block 4, Unit 76. This phytolith record is characterized by a very high relative abundance of buliform and trichome phytoliths. These types of phytoliths are found in grass leaf and stem material, and are commonly produced by members of the Bambusoideae and Panicoideae, their likely source here. If river cane was used as thatch material, very small fragments would fall into any vessels open within the structure, and then be incorporated into cooking residue and foodstuffs.

Starch was recovered in the phytolith fraction. One very large starch grain was observed (see Figure 156, D–E). This grain was lenticular in cross section, a characteristic of *Hordeum* (little barley) and *Elymus* (wild rye) grass seed starch. Utilization of grass seed is well documented at Caddo sites. In particular, maygrass (*Phalaris caroliniana*) and little barley (*Hordeum pusillum*) were utilized (Perttula 2008). Both of these grasses are native to the region, but may have been intentionally cultivated. Morphometric data of little barley grass seeds from archeological sites suggest that this grass was domesticated. The recovery of a *Hordeum/Elymus*-type starch grain in this residue sample suggests that little barley grass was utilized and possibly cultivated by the site occupants.

**Ground Stone Sample 1331**

Ground stone sample 1331 was recovered from Unit 97, Level 4 (35–45 cmbd). This tool was examined for pollen and starch remains. Pollen analysis yielded a 30-grain count and a total pollen concentration of approximately 10 pollen per cm² of ground surface. This sample was dominated by *Pinus* pollen, which was accompanied by a moderate quantity of *Quercus* pollen and small quantities of *Carya*, *Liquidambar*, and *Ulmus* pollen, reflecting local trees that include pine, oak, hickory/pecan, gum, and elm. Recovery of small quantities of Apiaceae, Low-spine Asteraceae, Cheno-am, *Corylus*, *Dalea*-type, and Poaceae pollen reflect the presence of a member of the umbel family, various members of the marshelder group of the sunflower family, cheno-ams, hazel, prairie clover, and grasses. It is possible that roots from a member of the umbel family, marshelder seeds, and/or grass seeds were ground using this tool. No starch was observed in this ground stone sample.

**Ceramic Sherd Sample 1304**

Ceramic sherd sample 1304 was recovered from Unit 100, Level 3A (35–42 cmbd). This sherd was examined for pollen, starch, and phytolith remains. No pollen or starch grains were observed in this sample. Microscopic charcoal was not abundant.

Phytolith analysis of residue from sherd Sample 1304 yielded very few phytoliths, indicating a very low phytolith concentration in the residue. All of the phytoliths observed here appear to be derived from the surrounding environment. Interestingly, this sample yielded a high relative abundance of cross phytoliths derived from the Panicoideae subfamily. Crosses are
mostly found in grass leaf material, in maize, and also found in husk material. It is possible that maize husks were used to store or cook food within this vessel; however, phytoliths diagnostic of maize were not observed in this sample. The absence of pollen, starch, and near absence of phytoliths from this sample suggests that this vessel might have been used for cooking meat, was not heavily used, or was used for an activity that did not impart a signature from plants or vegetal foods.

Ceramic Sherd Sample 1536
Ceramic sherd sample 1536 was recovered from Unit 125, Level 3 (25–30 cmbd). Residue from this sherd was examined for pollen, starch, and phytolith remains. Pollen analysis yielded *Pinus*, *Quercus*, Apiaceae, High-spine Asteraceae, and Cheno-am pollen, reflecting plants observed in other samples that include pine, oak, a member of the umbel family, various members of the sunflower family, and cheno-ams. Total pollen concentration was noted as approximately 18 pollen per cm² of surface. No starch grains were observed in this sample.

Phytolith analysis of this sherd yielded three wavy-top rondels diagnostic of maize cobs (see Figure 156, F–H). Numerous other phytoliths not diagnostic of maize, but within the range of variation observed from modern *Zea mays* cob reference material, were also observed. Similar to the other ceramic sherd sample examined here with *Zea mays* cob phytoliths (Sample 708), this residue sample also yielded achene (seed) phytoliths from a member of the sedge family (*Cyperaceae*) and hackberry (*Celtis* spp.) fruit phytoliths. This suggests that sedge seeds and hackberry fruits were intentionally utilized for subsistence. Caddo subsistence included the use of gathered wild and weedy fruits, nuts, and seeds (Perttula 2008).

A phytolith diagnostic of seed from the dayflower plant (*Commelina* spp.) was also observed in the residue from sherd sample 1536 (see Figure 156, I and J). Two species of *Commelina* are native to eastern Texas, *Commelina erecta*, and *Commelina virginica*. Because this *Commelina* phytolith was severely eroded, identification to the species level was not possible. The intriguing aspect of this find is whether its presence here is a reflection of the intentional use of *Commelina*, or its inadvertent introduction to prepared foods. *Commelina* leaves and stems are edible after boiling. A modified leaf called a spathe encloses the seeds that form after flowering, so if used as a potherb, seeds (and their phytoliths) could easily become incorporated into the vessel residue. *Commelina* has numerous medicinal properties, but is better known as a weed of agricultural fields worldwide. A *Commelina* phytolith was also recovered in the Profile 2 paleoenvironmental Sample 16 (75–80 cmbs).

*Commelina* seed phytoliths have been recovered from archeological investigations of historic agricultural fields in Canada (Yost 2010b) and Connecticut (Yost 2010a), and from stone-lined prehistoric agricultural fields in Argentina (Yost and Cummings 2010). In the
Southwest, *Commelina* phytoliths have been recovered from a variety of Jornada features (stains, pits, middens, burials) and artifacts (ground stone, pottery residue, pipe residue). In one very striking study, thousands of *Commelina* phytoliths, representing many seeds, were recovered from fill, residue, and soil directly beneath an intact/fractured Jornada Brown bowl that had been left in place within a thermal feature from site LA 149260, located to the east of Carlsbad, New Mexico (Cummings et al. 2009). Thus, it appears that *Commelina* plants are both adventive weeds of cultivated areas, and are intentionally utilized for subsistence and/or medicinal purposes.

**Summary and Conclusions**

**Profile 2 Paleoenvironmental Summary**

Although exclusively phytolith-based paleoenvironmental reconstructions typically lack a good arboreal signal, species of pine (*Pinus* spp.) produce phytoliths in needle and cambium tracheary tissues that can be recovered in soils. In addition, oaks (*Quercus* spp.) produce phytoliths in their leaves and bark that can be recovered in soils as well. Thus, for this area, phytoliths from stratigraphic samples can provide a fairly good record of paleoenvironmental change. No oak phytoliths were observed in these samples, so they may have not been abundant enough to have left a phytolith record. The pine needle phytolith-type “globular with projections” recovered here is consistent in morphology with those produced by longleaf (*Pinus palustris*) and shortleaf (*Pinus echinata*) pines. The pine needle-type “Parallelepipedal” is most similar to those produced by loblolly pine (*Pinus taeda*). Thus, the phytolith record recovered here does have some resolution for arboreal taxa.

The phytolith record suggests that Zone C represents an open mixed prairie habitat with grasses, sedges, and a significant forb community. Zone C also appears to represent the beginning of a transition to the dominance of more mesic tallgrass taxa (Panicoideae) at the expense of dryland shortgrass taxa (Chloridoideae). Zone B reflects a period of time with steadily increasing pine forest density and the development of a diverse herbaceous understory. Shortleaf pine (*Pinus echinata*) is the species most likely present at this time. The emergence of a second conifer-type phytolith in Zone B1 suggests the possible presence of another species of pine, possibly *Pinus taeda*. Zone B may also delineate two distinct successional stages as pine canopy development alters moisture and light availability to the herbaceous layer. Phytoliths indicative of maygrass (*Phalaris caroliniana*) appear in Zone B and may have arisen from subsistence-related activities or a natural disturbance favorable to its proliferation. Zone A samples were collected from colluvium, and subsequent dating of material from Samples 2 and 5 (not analyzed here) indicate the possible incorporation of older upslope material into this part of the profile from erosion. Because of these temporal uncertainties, it is difficult to make secure phytolith-based paleoenvironmental interpretations for Zone A. What is certain is that pines appear to be present, but perhaps reduced in abundance from earlier times. A phytolith diagnostic of hackberry fruit (*Celtis* spp.) appears for the first time in Zone A.
Ground Stone and Ceramic Residue Summary

Four ground stone tools and five ceramic sherds from site 41PN175 were submitted for microbotanical analysis. Pollen and starch analysis was conducted on all of the items, while phytolith analysis was conducted only on the ceramic sherds. Pollen analysis of ground stone provides a good record of environmental pollen. This site was situated in or near a pine/oak woodland or forest. Other trees growing in the vicinity of the site include hickory/pecan, hackberry, gum, and elm. Pollen representing a member of the umbel family, wormwood, various members of the sunflower family including both the marshelder group and chicory tribe, members of the mustard family, cheno-ams, hazel, wild buckwheat, prairie clover, grasses, and a member of the rose family represent other vegetation growing in the vicinity of the site. Some of these plants are edible and/or have medicinal qualities and might have been exploited. It is possible that one or more pieces of ground stone examined were used to grind roots/tubers from a member of the umbel family, seeds from the mustard and/or grass families, or possibly Cheno-am seeds. Sample 747 yielded the largest quantity of Poaceae pollen, followed by Sample 712, suggesting that one or both of these pieces of ground stone was the most likely to have been used to grind grass seeds. Three of the four ground stone samples yielded counts. Sample 711 did not yield sufficient pollen for analysis because the artifact was likely burned after use, and as a result, the pollen record on the artifact was destroyed. Sample 711 contained the largest quantity of microscopic charcoal, suggesting that much or perhaps all of the pollen recovered in this sample represents the environment and is derived from the sediments in which this ground stone was buried because burning usually destroys pollen.

Pollen signatures from ceramic residues mimicked those from ground stone, in general. Fabaceae, Nyctaginaceae, and Sphaeralcea pollen, representing the legume and four o’clock families and globe mallow, were observed only in ceramic residue samples. Three of the five ceramic residue samples were heavily laden with microscopic charcoal, suggesting cooking at relatively high temperatures. Two (Samples 708 and 1236), in particular, yielded very large quantities of microscopic charcoal. Based on the presence of microscopic charcoal, it is unlikely that pollen recovered from these two samples represents cooking or food processing in these vessels. The burning of these specimens would have destroyed any pollen evidence.

Phytolith analysis yielded maize (Zea mays) cob phytoliths from ceramic sherd residue samples 708 and 1536, indicating utilization of maize by the site occupants. These same samples both yielded sedge (Cyperaceae) achene (seed) phytoliths and hackberry (Celtis) fruit phytoliths, suggesting their utilization for subsistence as well. Sample 1536 also yielded a dayflower (Commelina spp.) seed phytolith, suggesting that dayflower plants probably grew in the maize fields and might have been utilized as a potherb for subsistence.
Chapter 16: Regional Considerations and Drought History
by Leonard Kemp

Introduction
Archeological interest has increased in the past few years (Perttula 2012) regarding how environmental variability may have affected the relative density of Caddo communities in the Middle (A.D. 1200–1400) and Late (A.D. 1400–1680) Caddo periods of East Texas. Investigation of the Murvaul Creek site (41PN175), which was primarily occupied during the Middle-to-Late-Caddo period between approximately A.D. 1275 and A.D. 1618 (see Chapter 8), led to this present study that is “exploratory” in nature. Using modern climate data and multiple climate proxies, such as the tree-ring data from northcentral and southcentral Texas (Stahle and Cleveland 1988) and northwestern Louisiana (Bomar 1995; Perttula 2012) and the reconstructed Palmer Drought Severity Index (reconPDSI) derived from multiple tree-ring chronologies for the East Texas region (Cook and Krusic 2004), this study attempts to understand the potential impact of environmental variability on the relative density and size of Caddo communities in the Middle and Late Caddo periods of East Texas.

Anderson et al. (1995) warn that the co-occurrences of a deteriorating climate and characteristics of cultural instability need convincing documentation and arguments to cite causation. They suggest that simplicity should be the determining factor in modeling any relationship between the two (Anderson et al. 1995; cf Ingram et al. 1981) and propose the following parameters:

1. Limit the number of economic or social variables of study.
2. Use immediate climate effects, which are more recognizable than remote effects.
3. Minimize the area of study, which should ensure a greater chance of success.
4. Recognize that short-term climate effects are easier to detect than long-term effects.
5. Be aware that climate effects are more easily detected within societies dependent on agricultural production.

This study proposes that during times of drought Caddo communities would disperse and become smaller in order to mitigate food shortages and diminish negative environmental consequences (Kennett et al. 2007; cf Perttula 1996). Conversely, during normal or above normal precipitation, communities would tend to coalesce and become larger. With the goal of simplicity as outlined by Anderson et al. (1995), this study addresses this hypothesis by using an existing database of Caddo sites dated to specific times within the Middle and Late Caddo periods. By comparing site frequency and size with environmental trends, the expectation was that an estimate regarding the impact of changes in the local environment on Caddo communities could be made. Both modern climate and paleoclimate data are used to characterize potential environment variability.

Data and Methods
The primary data used herein have been culled from the third edition of the East Texas Radiocarbon Database created by Perttula and Selden (2011). At the time this study was conducted, this database represented the most complete compilation of radiocarbon dates
for sites in East Texas. The database contains 1,127 dates from 192 sites, but both the number of dates and the geographic inclusiveness has grown as a result of additional ongoing work since the time Perttula and Selden made the database publicly available. All sites within the database that fall within the Middle (A.D. 1200–1400) and Late Caddo (A.D. 1400–1680) periods (n=120) were selected to create a baseline for investigation of changes in settlement density.

Of the 120-site sample, only those 109 sites where spatial site size was obtainable were included in the portion of the analysis that addressed changes in site size as potentially dependent on environmental conditions. The Texas Archeological Sites Atlas (geographic information system [GIS]) maintained by the Texas Historical Commission) was the initial primary source for site size information. Only 47 sites that fell within the Middle Caddo period were available as polygons in the Atlas GIS records. The aerial extent of the remaining sites was digitized from a combination of Atlas Site Form records (n=31) and published site reports (n=31). Of the site boundaries digitized from Atlas Site Form records, eight were digitized from scanned field maps attached to the site forms, and the boundaries for the remaining 23 sites were estimated using bounding boxes or ellipses as indicated in the Site Form area fields. The remaining 11 Middle Caddo sites for which information was not sufficient to digitize or estimate site boundaries were omitted from the analysis, thereby reducing the sample size to 109 sites. Figure 157 presents these site locations and Table 87 lists the sites and their range of occupation within the drainage basins of East Texas.

Key to Figure 157 site distribution map:

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* Note: site boundary information was not obtained for the marked sites and these sites were not included in the site size analysis.

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4 All site area files that were digitized based on published site reports or scanned field maps will be submitted to TARL at the conclusion of this project to enable future research and site management.
Figure 157. Site distribution map.
The authors developed the following temporal groupings using the $2\Sigma$ range of dates for each site. The $2\Sigma$ range was selected based on the higher level of certainty over using either the $1\Sigma$ range or calibrated intercept date. Multiple radiocarbon dates from a site were grouped into a range of occupation when these dates were within 35 years of one another. If the dates were separated by more than 35 years, a new period of occupation was created. The dates from a site were placed within 50-year time spans as shown in the example below. However, this does not suggest that the authors are interpreting the sites as having multiple, punctuated occupations, but rather that the distribution of dates contained null values for certain periods. The null values could be interpreted as sampling bias, differences in averages in the statistical calibration curve, as well as multiple occupations.

For cases where only one date was reported for a site, it was assumed that that date was representative of the site occupation as a whole. Based on this parsing of radiocarbon dates, 30 Middle Caddo and 47 Late Caddo components were isolated; 43 sites contained both Middle and Late components (see Appendix E).

Recorded site size was derived from multiple sources: site reports, THC site forms, or THC atlas of archeological sites. Thurmond’s (1990:41) classification of site size derived from his study of sites located in the Cypress Creek drainage basin places those sites into three categories based on both artifact densities and site size. The categories Thurmond used were Limited Use Areas, Small Settlement, and Large Settlements. Limited Use Areas were classified by Thurmond as sites of less than 2,000 m$^2$ (0.2 ha). Small Settlements were classified as areas larger than Limited Use Areas, but smaller than 15,000 m$^2$ (1.5 ha), and the Large Settlement category contained any site larger than the 15,000 m$^2$ threshold.

This current analysis modifies Thurmond’s (1990) site classification into two categories: Small Sites and Large Sites. This modification was done because only three sites in the database would have been classified as Limited Use Areas using Thurmond’s strategy, and such a low number of sites in a category would have limited the potential for analysis. Under this current study’s classification, all sites smaller than 15,000 m$^2$ (3.707 acres) were classified as Small Sites and all others were classified as Large Sites. With this definition, 65 sites (59.6 percent) are classified as small and 44 sites (40.3 percent) are classified as large.
Site proximity was analyzed through ArcGIS software using the buffer tool coupled with the grouping of sites within the assigned 50-year time spans. A buffer tool creates polygons at a specified distance around a point or polygon. The buffer tool was used to create a multitier buffer of 7, 15, and 20 km around the site location. The rationale behind this particular set of measures was that a site falling within a 7–15 km radius of a large settlement may have had some degree of dependence on a larger settlement. Perttula (1996) suggested that a small settlement might be self-sufficient as much as 30 km from a large settlement. For the current purposes, a site is considered independent of another site if it is 20 km or more distant.

Modern and Prehistoric Patterns of Precipitation in Texas

Modern Climate Data and Drought
Modern climate data (1971–2000) from 58 weather stations located in East Texas indicate that the region receives the second highest amount of rainfall in Texas, with an average annual amount of rainfall of 120.70 cm (47.5 in) (National Oceanographic and Atmospheric Administration 2004). The majority of precipitation occurs during spring and late fall and winter, with the driest months being July, August, and September (Nielson-Gammon 1995; Riggio et al. 1987). Rainfall generally occurs in the form of thunderstorms. These rain events are variable both spatially and temporally (Nielson-Gammon 1995; Riggio et al. 1987). Despite the relative abundance of rainfall, research suggests that the eastern portion of Texas is only marginally better off than the rest of the state with respect to the frequency, duration, and severity of drought (Riggio et al. 1987).

Historically, drought in Texas is more common than any other climate event (Riggio et al. 1987). Drought is characterized by its frequency, duration, and severity. Drought is defined as “when soil moisture and rainfall are inadequate during the growing season to support healthy crop growth to maturity and to prevent extreme crop stress and wilt” (Carr 1966; cf Riggio et al. 1987). The worst recorded drought in Texas history occurred from 1950 to 1956. The cost of agricultural loss from that drought was estimated at more than $3 billion, or the equivalent of $26 billion in 2013 dollars (Lowery 1959; Texas State Comptroller 2013). This example illustrates the severe impact that drought can have on a modern economy; the impact of prolonged drought on a preindustrial culture is often cited as a major contributor to its devastation (Anderson et al. 1995; Benson et al. 2007; Ingram et al. 1981).

Riggio et al. (1987) analyzed the occurrence and magnitude of drought in Texas regions for a 50-year period from 1931 to 1985. A 3-month drought in East Texas occurred approximately 39 percent of the time compared to the state average of 40 percent. The 3-month drought in East Texas was characterized as the most extreme in comparison to other regions of the state (Riggio et al. 1987). Droughts of 6- and 12-month duration affected East Texas, respectively, 44 and 51 percent of the time, which is the same rate as the state
average. If similar conditions existed prehistorically, climate variability marked by drought would have had a significant impact on agricultural production and supposedly the density and size of Caddo communities.

**Paleoclimate Reconstructions and Drought**

Although modern data are useful in characterizing the climate of an area, those data cannot define the frequency, duration, or severity of drought conditions prior to modern data collection. Multiple climate proxies have been used to infer regional paleoenvironmental shifts. These proxies include tree-ring data from northcentral and southcentral Texas (Stahle and Cleveland 1988) and northwestern Louisiana (Bomar 1995; Perttula 2012), as well as the reconPDSI derived from multiple tree-ring chronologies for the East Texas region (Cook and Krusic 2004).

The PDSI is a standardized measure developed by meteorologist Wayne Palmer in 1965 that ranks the intensity of drought, coupled with its duration and spatial extent. The PDSI is a measure of the relative dryness or wetness of a specified geographic region. PDSI values range from -4 or less (extreme drought) to +4 or more (extremely wet conditions) with -1.9 to +1.9 equating to normal/near-normal precipitation. Stahle and Cleveland (1988) state that climate-sensitive tree-ring chronologies offer the best set of data to examine the timing, duration, and distribution of drought conditions. They analyzed the occurrence of drought in northcentral and southcentral Texas from 1698 to 1980 through the analysis of nine tree-ring chronologies and the reconstruction of a typical June PDSI. Based on their analysis, the climate data of the 50-year period from 1931 to 1980 represents the mean, variance, and probability of drought in Texas and correlates well with the tree-ring record for the past 283 years. Stahle and Cleveland (1988) found that an extreme decade-long drought occurs every 100 years. In addition, they found that as suggested by modern climate data that a moderate to extreme June drought is followed by drought conditions which persist in duration and severity.

Perttula (2012) uses tree-ring data (Stahle and Cleveland 1995) from northwestern Louisiana and climate/temperature reconstructions (Crowley 2000; Mann et al. 1998) to infer drought conditions in East Texas for the Late Caddo period (A.D. 1430–1680). He characterizes the region and its inhabitants as living in a “risky” environment characterized by moderate to frequent and severe dry and wet conditions. Perttula states that colder and drier conditions began in A.D. 1375 and continued through the 1400s. The most extreme period was between A.D. 1440 and 1470, with areas of East Texas being abandoned and other areas settled due to their relatively better conditions. Perttula (2012) notes that the Caddo developed strategies to mitigate the effects of short-term droughts of one to two years, but droughts on the order of a decade were unsustainable.
In 1999, Dr. Edward Cook developed a reconPDSI based on tree-ring chronologies as a proxy measure of precipitation. This initial reconstruction was extended back in some cases 2,000 years, and the scope of the study was enlarged in 2004 to include most of North America. It is vetted by a series of statistical tests and correlated to recorded climate data. This current inquiry will use both the 5-year average and the year-to-year record of the reconPDSI to characterize the period from A.D. 1200 to 1680. A synopsis of drought/moisture regimes grouped in 50-year periods for Grid Point 194 of Cook's North American reconPDSI is presented in Appendix E. The reconPDSI for the year A.D. 1200 with the grid point for East Texas located 45 miles northwest of Carthage in Panola County is presented in Figure 158.

An examination of the frequency and range of rainfall as shown in Figure 159 illustrates the 5-year average of reconPDSI for the period A.D. 1150–1690. Although the 5-year average has a tendency to diminish the frequency of individual drought regimes and periods of abundant precipitation, it is useful to show the general precipitation trend through time. The period from A.D. 1200 to 1249 was the only time period in which there was no deviation above normal precipitation in the data. This period is followed by a 100-year period (A.D. 1250 to 1350) of high variability of normal to above normal precipitation events with the exception of two moderate droughts in A.D. 1290 and 1345. This period would be expected to equate to favorable conditions for proto-agriculturalists. The period from A.D. 1350 to 1690 shows a decrease in the frequency of events, suggesting a period of relative climate stability. In addition, there appears to be an increase (approximately 91 percent) of near normal to increased moisture events. Low variability would imply that agricultural practices were sustainable and, coupled with sufficient rainfall, would ensure viable crop production. However, this period is also characterized by several episodes of moderate to severe drought occurring in A.D. 1365, 1450, 1455, 1510, 1565, and 1640. The assumption is that the consecutive periods of drought in A.D. 1450 and 1455 would have had a negative impact on an agricultural-based economy.

Results and Analysis

The development of Caddo settlements in East Texas was in part determined by the sustainability of their subsistence practices. Generally speaking, Caddo settlements are best described as dispersed and largely composed of small settlements that may have been spread over several to tens of kilometers (Perttula 1996). The author hypothesizes that one factor of site density is reflected by the fracturing or cohesion of communities linked to the effects of environmental conditions, specifically the frequency, duration, and severity of drought. Table 88 presents a two-part scenario of the effects of favorable and unfavorable environmental conditions on site size and dispersion in the East Texas Caddo region.
Effects of Environmental Conditions on Site Size and Dispersion

The premise is that favorable conditions (average/above average rainfall) will encourage the development of larger sites whereas periods of unfavorable conditions (drought) will contribute to dispersion of the communities. Figure 160 shows the percentage of small to large sites in 50-year periods from A.D. 1200–1680. The general trend over time illustrates that most time periods are represented by a fairly even split between small and large sites. This trend is constant with small sites averaging 51.7 percent and large sites averaging 48.3 percent of the total, though variations do exist from one time period to another. The Middle Caddo period (A.D. 1200–1399) appears to reflect a relatively consistent ratio of 1.12 small sites for each large site and the ratio for the Late Caddo period (A.D. 1400–1680) is 1.03 small sites for each large site.

However, this study is interested in a temporal scale that is theoretically more precise. Two 50-year periods differ from the general trend and are worth examining. The first period, A.D. 1250 to 1299, shows an increase (+14 percent) of small sites from the previous period with
small sites (n=9) dominating large sites (n=5) by approximately 36 percent. The period that follows contains over double the number of sites, which are evenly split between small sites and large sites.

Based on the current hypothesis, the period between A.D. 1250 and 1299 should represent a time when resources were stressed by drought. However, the period was relatively mild in terms of the severity and length of drought; it had three 2-year drought periods and one 3-year drought period (Table 89). Conversely, one single-year period of wetter than normal as well as a single 3-year period of wetter than normal conditions were also observed during
Figure 160. The percentage of small (light gray) and large (dark gray) sites is shown from A.D. 1200 to 1680. The counts for small and large sites are presented within each data bar.

Table 89: Number of Deviations from Normal to Near Normal Conditions

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<th>1-year Inc. Moist.*</th>
<th>2-year Inc. Moist.</th>
<th>3-year Inc. Moist.</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1150–1199</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>5</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>10</td>
</tr>
<tr>
<td>1200–1249</td>
<td>–</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>8</td>
</tr>
<tr>
<td>1250–1299</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>3</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>–</td>
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<td>–</td>
<td>1</td>
<td>7</td>
<td>7</td>
<td>–</td>
<td>–</td>
<td>15</td>
</tr>
<tr>
<td>1350–1399</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>–</td>
<td>10</td>
</tr>
<tr>
<td>1400–1449</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>–</td>
<td>12</td>
</tr>
<tr>
<td>1450–1499</td>
<td>–</td>
<td>1</td>
<td>–</td>
<td>4</td>
<td>2</td>
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<td>10</td>
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<td>–</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>–</td>
<td>–</td>
<td>13</td>
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<tr>
<td>1550–1599</td>
<td>1</td>
<td>–</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>–</td>
<td>–</td>
<td>11</td>
</tr>
<tr>
<td>1600–1649</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>–</td>
<td>10</td>
</tr>
<tr>
<td>1650–1699</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>6</td>
<td>3\</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>11</td>
</tr>
<tr>
<td>Grand Total</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>17</td>
<td>45</td>
<td>33</td>
<td>5</td>
<td>4</td>
<td>116</td>
</tr>
</tbody>
</table>

* Inc. Moist.=Increased Moisture
this time. This period of normalcy is remarkable because it followed the driest span documented for the entire 450-year period (see Figure 159). The previous 50-year span of A.D. 1200–1249 reflected the least favorable times (severe drought conditions). This span was characterized by a 5-year period of moderate to extreme drought that began in A.D. 1198 and continued through A.D. 1202. Four years of near normal conditions followed this period before reverting to a second 5-year drought period. Additionally, the period between A.D. 1200 and 1249 had two single-year droughts, two 2-year drought periods, and two 3-year drought periods. During this 50-year period, there were no single- or multiple-year periods of increased moisture within the region. This was the only instance where there was no wetter than normal period during the period of study.

One reasonable interpretation of the elevated numbers of small sites during the A.D. 1250 to 1299 period is that it might represent a period of recovery and return to normalcy from the harsh conditions during the previous period. Hence, the variation in the number of sites is out of synchronization with, or lags behind, changes in climatic pressures. The increase of small sites relative to large sites is not in agreement with the independent paleoclimatic conditions. The increase in small sites may represent a return to areas that had been abandoned during the previous severe drought.

The second period of interest, A.D. 1400–1449, shows a marked increase of large to small sites. The criterion of “favorable conditions” would suggest that this was a period in which average or above average precipitation was the norm. The reconPDSI data 5-year average shows a relatively stable period over time. Figure 161 below illustrates the year-to-year data that add nuance to this characterization. Even though there is a 3-year drought beginning in A.D. 1410 and an extreme drought in A.D. 1421, these episodes are bracketed by average or above average precipitation throughout the period. If one of the purposes for large sites was that they were redistribution centers of resources, then this was a time when resources would have been plentiful and food surpluses would have been likely. Hence, these conditions seem to support the hypothesis that favorable conditions would have resulted in a relative increase in the number of large sites compared to small sites.

The 5-year average of reconPDSI for the A.D. 1450–1499 period began with consecutive moderate to severe droughts. In the year-to-year data, this is represented by a 2-year drought, followed by two years of near normal conditions, and then a 5-year persistent drought. During this period, the relative number of small sites increased compared to large sites. This correlates with a decrease in the total number of large sites that was observed during the previous period. Such data seem to suggest the ability to track at this scale the increase of either small or large sites, which may be a factor of climate conditions. However, there remains the question of how representative the database is of the regional population.
Examining Regional Site Density as a Function of Climatic Conditions

The second scenario (Table 90) examines the spatial relationships of small and large sites through time within a radius of 7, 15, 20, and greater than 20 km from a large site. The percentage of sites in proximity (7 and 15 km) to a large site for the Middle Caddo period is 52.3 percent and for the Late Caddo period is 62.3 percent.

Table 90: Sites Within Each Given Distance from a Large Site

<table>
<thead>
<tr>
<th>Time Period</th>
<th># Large Sites</th>
<th>7 km % (n)</th>
<th>15 km % (n)</th>
<th>20 km % (n)</th>
<th>&gt;20 km % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200–1249</td>
<td>8</td>
<td>36.4 (4)</td>
<td>18.2 (2)</td>
<td>9.1 (1)</td>
<td>36.4 (4)</td>
</tr>
<tr>
<td>1250–1299</td>
<td>5</td>
<td>0 (0)</td>
<td>11.1 (1)</td>
<td>22.2 (2)</td>
<td>66.7 (6)</td>
</tr>
<tr>
<td>1300–1349</td>
<td>17</td>
<td>17.6 (6)</td>
<td>38.2 (13)</td>
<td>20.6 (7)</td>
<td>23.5 (8)</td>
</tr>
<tr>
<td>1350–1399</td>
<td>21</td>
<td>20 (11)</td>
<td>36.4 (20)</td>
<td>30.9 (17)</td>
<td>12.7 (7)</td>
</tr>
<tr>
<td>1400–1449</td>
<td>12</td>
<td>25 (5)</td>
<td>40 (8)</td>
<td>15 (3)</td>
<td>20 (4)</td>
</tr>
<tr>
<td>1450–1499</td>
<td>10</td>
<td>23.5 (4)</td>
<td>23.5 (4)</td>
<td>11.8 (2)</td>
<td>41.2 (7)</td>
</tr>
<tr>
<td>1500–1549</td>
<td>19</td>
<td>28.8 (17)</td>
<td>28.8 (17)</td>
<td>25.4 (15)</td>
<td>16.9 (10)</td>
</tr>
<tr>
<td>1550–1599</td>
<td>12</td>
<td>31.6 (12)</td>
<td>47.4 (18)</td>
<td>7.9 (3)</td>
<td>13.2 (5)</td>
</tr>
<tr>
<td>1600–1649</td>
<td>6</td>
<td>44.4 (4)</td>
<td>11.1 (1)</td>
<td>22.2 (2)</td>
<td>22.2 (2)</td>
</tr>
<tr>
<td>1650–1699</td>
<td>2</td>
<td>33.3 (1)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>66.7 (2)</td>
</tr>
</tbody>
</table>
Two 50-year periods differ from this general trend. The first period is A.D. 1250–1299 in which there are no sites within 7 km of a large site and approximately 67 percent of sites are 20 km or more from a large site (Figure 162). This is the same timeframe in which there is a dramatic increase in the number of small sites referenced earlier. As discussed previously, it appears to be a period of the return to normal or average conditions following extreme and prolonged drought. This pattern coupled with the increase of small sites likely represents resurgence by the Caddo in East Texas prior to its full adaptation of maize horticulture. Additionally, this time period can be taken as what would be expected for a dispersed settlement pattern.

The second period, which diverges significantly from the average proximity measure, is A.D. 1550–1599. Within this period, nearly 79 percent of the small sites are located within 15 km of a large site. Three site clusters are located within the Cypress and Sabine drainage basins and two clusters are in the Neches drainage basin (Figure 163). This would suggest “favorable conditions,” as defined by increased moisture and therefore agricultural productivity. The single-year ReconPDSI shows that a 6-year drought began in A.D. 1564 with moderate and severe drought conditions, followed by a 3-year moderate drought from A.D. 1571–1573. A period of normalcy or wetter than normal conditions followed until A.D. 1597 and 1598, in which severe drought occurred. These conditions would seem to contradict the assertion of favorable environmental conditions. Perhaps, social and political organizations had adapted by that time to permit a more dense population to weather severe drought conditions. Interestingly, the A.D. 1400–1449 period discussed earlier in reference to an increase of large sites also reflects a number of smaller sites coalescing around large sites.

In addition, there is only one occurrence of a small site within proximity to a large site during the A.D. 1650–1680 period. Both the number of sites and their proximity to one another is too low to examine the proposed criterion. However, this period is significant because it ends with the significant depopulation by the Caddo by 1680 (Perttula 1996). ReconPDSI data suggest that the period was characterized by extreme droughts in A.D. 1654 and 1670. However, there are no consecutive years of drought. The period had three single years of increased moisture and two 2-year periods of increased moisture. European diseases and increasing pressure from other Native American groups were likely more critical than environmental conditions at that period of time.

**Summary**
Thurmond (1990) is generally credited with the first in-depth settlement pattern analysis of the Caddo. Subsequent research by Perttula and others has laid the foundation for the ongoing research for which this analysis is in debt. As previously stated, this section is “exploratory” in nature, with the goal of examining settlement density in relation to climate.
Figure 162. Proximity of sites within 7, 15, 20 km, and beyond of large sites for the period of A.D. 1250–1299.
The proximity of sites within 7, 15, 20 km, and beyond of a large site for the period A.D. 1550–1599.

Figure 163. The proximity of sites within 7, 15, 20 km, and beyond of a large site for the period A.D. 1550–1599.
variability marked by the occurrence and duration of drought. Analysis of the available data indicates that the relationship between site size and spatial distribution and environmental conditions is not easily interpreted. Furthermore, the assumption that the sites within the East Texas Radiocarbon Database are truly representative of the temporal and spatial distribution of Caddo sites in East Texas is not well founded because the distribution of sites is a function of the archeological investigations that have been completed within East Texas. Equally important is the assumption that site size and spatial distribution are directly related to environmental variables. Archeologists have debated for decades concerning the role of the natural environment in relation to the development and intensification of agriculture. The adoption of important social or political organizational structures may also have played a significant role in allowing significant population densities in spite of deteriorating environmental conditions.

The most important prerequisite of this study is that of scale, specifically the assumptions concerning temporal scale. What are the appropriate temporal scales when examining the relationships between environmental change and human decisions? For the question investigated herein, the researchers considered that the more significant temporal scale would be on the order of 3-, 5-, and 10-year periods (Dincauze 2000; Jochim 1991). Within this scale, it was assumed that the decisions people made when evaluating whether or not a given location was suitable for habitation would be intimately tied to their given subsistence strategies and their perception of the sustainability of their resources. However, it is recognized that additional social factors, such as technological change and social pressures, may have had at least an equal influence on their decisions. Furthermore, the archeological data are hampered by the margin of error for radiocarbon dates, which within this analysis ranges from 40 to more than 100 years. Consequently, the date used for a site is actually a range that spans multiple 50-year periods and negates the specificity of climate shifts at this scale.

Given these qualifications, this study was able to identify trends for particular periods; however, the significance of such trends remains to be realized. As Anderson et al. (1995) have noted, researchers need to focus on a limited area, perhaps a single drainage basin, in which archeological data are comprehensive and well dated. Understanding the relationship of paleoenvironmental conditions and settlement systems requires a comprehensive database that is presently a work in progress.
Chapter 17: Ceramic Petrography: Petrographic Report of Five Pottery Samples (TKP1–5) from Site 41PN175, Panola County, Texas
by Leslie G. Cecil, Ph.D.

This report describes the petrographic analysis of 25 sherd samples excavated from site 41PN175. The samples were submitted in two separate phases. During the first phase, 20 samples were submitted and integrated into the analytical research design for the completion of the data recovery investigations. An additional five samples were later submitted for analysis, and those samples were compared to the results of the initial study. All images were taken in plane, polarized light with 5X magnification. Each image is a portion of one of the two fields that was counted for this analysis. Following the point count/temper group section of this report is an interpretation of these petrographic data. There are some interesting results that highlight the use of petrographic data to better understand Caddo behavior.

Methodology

Petrographic analysis allows the analyst to identify minerals that are present in the clay pastes of different vessels. Petrography allows analysis of many clay materials and inclusions at one time. One can study “the clay itself, natural inclusions in the clay, purposefully added inclusions, and glazes or slips on the clay surface” (Childs 1989:24).

Petrographic analysis has been adapted from geological techniques of analysis for the study of soils and rocks and is useful for archeological ceramics because, to a large extent, geological sources differ enough regionally to allow for comparison of different clays (Blatt 1992). These methods are applicable to pottery analysis because pottery can be regarded as metamorphosed sedimentary rock due to the composition of a sherd consisting of clastic grains imbedded in a clay paste that has been transformed to “rock” through the process of firing (Bishop and Rands 1982; Rice 1987b:376). Understanding these basic principles of geology plus other principles of optical mineralogy allow the description of pottery pastes and clays.

Although petrographic analysis is important to this research design, there are some limitations. Thin-sectioning may not produce the full mineralogical composition of a pottery sample due to sampling error and because the method of producing thin-section slides involves grinding and polishing of the sample (Orton et al. 1993). In addition to problems with sample preparation, petrographic analysis alone cannot determine the type of clay mineral in the sherd because of the refractive characteristics of clay minerals. Because of these limitations, petrography is often combined with x-ray diffraction in order to obtain a full mineralogical complement and INAA to obtain a full elemental complement.
The samples were cut with a wet saw for the preparation of thin section slides. The sherds were sent to Spectrum Petrographics where they were embedded in an epoxy block. The most fragile sherds were vacuum impregnated and then embedded in an epoxy block. The block was cut in such a manner that a thin section measuring .03 mm thick resulted. The resulting thin section allowed the author to identify minerals in the clay paste with the use of a polarizing microscope.

The polarizing microscope is composed of a light source, a polarizer, a condenser, a rotatable stage, objective, slots for a quartz wedge, an analyzer, and a Bertrand lens. Light originates from a light source at the base of the microscope and passes through the polarizer that aligns the light waves in a single plane or direction. The polarized light then passes through minerals on the rotatable stage and bends them according to the mineral structure because each mineral and inclusion transmits light differently and is thus identifiable (McLaughlin 1977). The objective magnifies the resulting light waves and the light passes through an analyzer. Analyzers allow light to vibrate in a plane perpendicular to that of the first polarizer. When the analyzer is in place (crossed nicols), birefringence colors appear and can then be compared to published charts to identify the mineral. If the crossed nicol color, angle of extinction, and other mineralogical characteristics are not sufficient in the identification of the mineral, the Bertrand lens and condenser produce interference figures that determine the mineral’s sign (uniaxial or biaxial). Interference colors, in addition to the techniques described above, allow identification of most minerals.

Thin-sectioning provides one objective means of classifying pottery pastes through the analysis of mineral size, shape, roundness, and frequency. Mineral size, shape, and roundness are established through a comparison of various graphs and tables (Shackley 1975:44–51). The most common geological method of determining the quantity of minerals in a thin section is point counting. Point counting determines the number of different minerals along a predetermined area (for example, 10 mm) of the length and width of the section (Chayes 1956). Various studies have employed different methods for counting the frequency of inclusions: Peacock (1973) uses a random grain selection; Middleton et al. (1985) use a variation of systematic sampling along linear transects with tests of accuracy for different thin-section samples; and Dickenson and Shutler (1979) use an area point count (all minerals, inclusions, and voids are counted in the field of view). Middleton et al. (1985) compared area counting to standard geological point counting and determined that the number of minerals counted was equal and the only difference was that area counting resulted in a smaller mean mineral diameter. Because mean diameter of minerals was not critical and I obtained similar point counts with standard point counts and area point counts (tested on 10 sherds of different matrices), I implemented area counting for a field of view with 4X magnification (all thin section images were taken at 5X magnification).
Before conducting an area count, the author scanned the sherd to determine the range of minerals and mineral sizes as well as to note any details of manufacturing techniques and slip thickness. After determining the types of minerals present, two standard image areas were counted to ensure that each area was representative of the sherds as a whole and to detect changes in the clay paste. The first counted area was located at the end of the slide farthest from the rim, and the second was determined by rolling a die and moving the slide the corresponding number of centimeters. For example, if the die showed a 5, the author moved the slide 5 cm and centered the microscope in an area that filled the standard image. For each mineral type, the range of mineral sizes (the smallest and the largest) was measured, the relative frequency as determined by Figure 164, the degree of sorting as determined by Figure 165, the mineral roundness as determined by Figure 166, the number of minerals in the standard image, the frequency of all of the minerals in the clay paste as determined by Figure 164, and the clay birefringence. Other abnormalities were also noted.

Results

Initial 20-Sample Submittal
As a result of the point counts, three basic paste groups with some variations within the basic paste groups emerged (see below). In addition to the differences in sandy pastes, the author observed two general clay paste categories: a micaceous clay paste (indicated by its high birefringence color) and a nonmicaceous sandy paste. In general, small quartz minerals, biotite, iron, organics, and rounded chert and feldspar most likely occur because they are part of the clay body that is due to weathering of the clay from a parent material. Culturally added inclusions include the angular, larger quartz, chert, and feldspar, and bone and grog. Finally, when there are no data for the organics category, the sherd was too dark indicating it was either fired in a reduced atmosphere or incompletely fired resulting in a dark-colored sherd.

Paste Group 1: Sandy Paste with Grog and Bone Inclusions
This paste group serves as the base paste group from which there are three variants (Paste Groups 1a, 1b, and 1c).

Biotite
No biotite inclusions were counted for this group.

Bone

<table>
<thead>
<tr>
<th>Size</th>
<th>Coarse (.5–1 mm) and Very Coarse (over 1 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Rare (&lt;1%)</td>
</tr>
<tr>
<td>Degree of Sorting</td>
<td>Poor</td>
</tr>
<tr>
<td>Roundedness</td>
<td>Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity</td>
</tr>
<tr>
<td>Raw Count</td>
<td>12</td>
</tr>
</tbody>
</table>
Clay Pellets
   No clay pellet inclusions were counted for this group.

Chert
   No chert inclusions were counted for this group.

K-feldspar
   No K-feldspar inclusions were counted for this group.
Figure 165. Sphericity/roundedness estimation chart (adapted from Orton et al. 1993:Figure A.5).

<table>
<thead>
<tr>
<th>Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Angular</td>
<td>Angular</td>
<td>Sub-Angular</td>
<td>Sub-Rounded</td>
<td>Rounded</td>
<td>Well Rounded</td>
</tr>
</tbody>
</table>

Figure 166. Inclusion sorting chart (adapted from Orton et al. 1993:Figure A.6).
Grog
- **Size:** Very Coarse (over 1 mm)
- **Frequency:** Rare (less than 1%)
- **Degree of Sorting:** Poor
- **Roundedness:** Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
- **Raw Count:** 6

Iron
- No iron inclusions were counted for this group.

Quartz
- **Size:** Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency:** Common (20%)
- **Degree of Sorting:** Fair
- **Roundedness:** Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
- **Raw Count:** 1579

Organics
- **Size:** Medium (.25–.5 mm) and Coarse (.5–1 mm)
- **Frequency:** Sparse (6%)
- **Degree of Sorting:** Poor
- **Roundedness:** Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
- **Raw Count:** 288

Voids
- **Size:** Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency:** Sparse (6%)
- **Degree of Sorting:** Poor
- **Roundedness:** Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear
- **Raw Count:** 122

One sherd (GMIP06) comprises this paste group. The sandy paste has a high micaceous content as exemplified by the high birefringent color. The quartz inclusions are a natural part of the clay as they are fairly well sorted throughout the paste and are not angular, suggesting that they have undergone some degree of weathering in the clay. Potters added grog and bone inclusions to the clay in this paste group. The grog inclusions are of two types: a dark brown/black sandy paste and those of this clay paste. Bone inclusions are yellow and tan in color. This paste group serves as the base paste group from which there are three variants (Paste Groups 1a, 1b, and 1c).
### Paste Group 1a: Sandy Paste with Grog and Bone Inclusions with Biotite

**Biotite**
- **Size**: Fine (.1–.25 mm), Medium (.25–.5 mm), and Coarse (.5–1 mm)
- **Frequency**: Rare to Sparse (2-3%)
- **Degree of Sorting**: Poor to Fair
- **Roundedness**: Linear
- **Raw Count**: High 99, Low 42, Average 73

**Bone**
- **Size**: Medium (.25–5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Sparse (3-8%)
- **Degree of Sorting**: Poor
- **Roundedness**: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity
- **Raw Count**: High 113, Low 15, Average 69

**Clay Pellets**
- No clay pellet inclusions were counted for this group.

**Chert**
- No chert inclusions were counted for this group.

**K-feldspar**
- No K-feldspar inclusions were counted for this group.

**Grog**
- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm) and Very Coarse (over 1 mm)
- **Frequency**: Sparse (3-5%)
- **Degree of Sorting**: Poor
- **Roundedness**: Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity; and Rounded, High Sphericity
- **Raw Count**: High 19, Low 12, Average 15

**Iron**
- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm) and Very Coarse (over 1 mm)
- **Frequency**: Rare (<1%)
- **Degree of Sorting**: Poor
- **Roundedness**: Rounded, High Sphericity and Veins
- **Raw Count**: High 10, Low 0, Average 5

**Quartz**
- **Size**: Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Abundant (25–30%)
- **Degree of Sorting**: Fair
<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roundedness</strong></td>
<td>Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity</td>
</tr>
<tr>
<td><strong>Raw Count</strong></td>
<td>High 2782 Low 1404 Average 2031</td>
</tr>
</tbody>
</table>

**Organics**

<table>
<thead>
<tr>
<th>Size</th>
<th>Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>Sparse (5%)</td>
</tr>
<tr>
<td><strong>Degree of Sorting</strong></td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Roundedness</strong></td>
<td>Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity</td>
</tr>
<tr>
<td><strong>Raw Count</strong></td>
<td>High 263 Low 124 Average 180</td>
</tr>
</tbody>
</table>

**Voids**

<table>
<thead>
<tr>
<th>Size</th>
<th>Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>Sparse (5%)</td>
</tr>
<tr>
<td><strong>Degree of Sorting</strong></td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Roundedness</strong></td>
<td>Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear</td>
</tr>
<tr>
<td><strong>Raw Count</strong></td>
<td>High 136 Low 87 Average 104</td>
</tr>
</tbody>
</table>

Three sherds (GMI30, GMI032, and GMI033) comprise this paste group variant. This is the same basic paste as Paste Group 1 with the addition of biotite inclusions. Though there are more biotite inclusions in this variant, they are most likely natural to the clay as this paste group has a high birefringent clay. Two of the samples (GMI030 and GMI033) also have visible iron in the clay paste (also a natural inclusion). The bone inclusions (a cultural addition) are tan (with some dark red inner areas) and light gray in color. The grog inclusions are of two types: a dark brown/black sandy paste and tan (perhaps of this same paste). Sample GMI030 appears to have a dark slip that is approximately .01 mm thick.

**Paste Group 1b: Sandy Paste with Grog and Bone Inclusions with Biotite and Chert**

**Biotite**

<table>
<thead>
<tr>
<th>Size</th>
<th>Fine (.1–.25 mm), Medium (.25–.5 mm), and Coarse (.5–1 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>Rare to Sparse (1–5%)</td>
</tr>
<tr>
<td><strong>Degree of Sorting</strong></td>
<td>Poor to Fair</td>
</tr>
<tr>
<td><strong>Roundedness</strong></td>
<td>Linear</td>
</tr>
<tr>
<td><strong>Raw Count</strong></td>
<td>High 139 Low 12 Average 46</td>
</tr>
</tbody>
</table>

**Bone**

<table>
<thead>
<tr>
<th>Size</th>
<th>Medium (.25–.5 mm), Coarse (.5–1 mm) and Very Coarse (over 1 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>Rare (1%) to Sparse (4-8%)</td>
</tr>
<tr>
<td><strong>Degree of Sorting</strong></td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Roundedness</strong></td>
<td>Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity</td>
</tr>
<tr>
<td><strong>Raw Count</strong></td>
<td>High 131 Low 8 Average 85</td>
</tr>
</tbody>
</table>
Clay Pellets
No clay pellet inclusions were counted for this group.

Chert
Size Medium (.25–.5 mm), Coarse (.5–1 mm) and Very Coarse (over 1 mm)
Frequency Rare (1%)
Degree of Sorting Poor
Roundedness Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity
Raw Count High 24 Low 1 Average 8

K-feldspar
No K-feldspar inclusions were counted for this group.

Grog
Size Medium (.25–.5 mm), Coarse (.5–1 mm) and Very Coarse (over 1 mm)
Frequency Rare (1%) to Sparse (3-5%)
Degree of Sorting Poor
Roundedness Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
Raw Count High 35 Low 5 Average 17

Iron
No iron inclusions were counted for this group.

Quartz
Size Very Fine (up to .1 mm), Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency Common to Abundant (20-30%)
Degree of Sorting Fair
Roundedness Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
Raw Count High 3370 Low 1935 Average 2501

Organics
Size Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency Sparse (5–6%)
Degree of Sorting Poor
Roundedness Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
Raw Count High 143 Low 0 Average 66
Voids

<table>
<thead>
<tr>
<th>Size</th>
<th>Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Sparse (5–7%)</td>
</tr>
<tr>
<td>Degree of Sorting</td>
<td>Poor</td>
</tr>
<tr>
<td>Roundedness</td>
<td>Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Rounded, Low Sphericity; and Linear</td>
</tr>
<tr>
<td>Raw Count</td>
<td>High 261 Low 100 Average 149</td>
</tr>
</tbody>
</table>

This paste group is different from Paste Groups 1 and 1a because of the occurrence of chert and because the clay base is not highly birefringent. Because the chert minerals are the same size and roundness as the sand (quartz), there is no reason to believe that they were intentionally added by potters. Instead, the chert is most likely a detrital component of the quartz sands that resulted from a weathering process. This may suggest a different clay source or variation of parent material within the clay bed. The bone inclusions are tan, dark brown, and black in color. This paste group exhibits a variety of different grog inclusions: (1) a black (reduced or incompletely fired) paste that has bone inclusions; (2) a black (reduced or incompletely fired) sandy paste; and (3) a brown to dark brown high birefringent clay paste. Samples in this group include GMI031, GMI034, GMI037, GMIP01, GMIP02, and GMIP05.

**Paste Group 1c: Sandy Paste with Grog and Bone Inclusions with Biotite and Chert and Feldspar**

**Biotite**

<table>
<thead>
<tr>
<th>Size</th>
<th>Medium (.25–.5 mm) and Coarse (.5–1 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Rare (1%)</td>
</tr>
<tr>
<td>Degree of Sorting</td>
<td>Poor</td>
</tr>
<tr>
<td>Roundedness</td>
<td>Linear</td>
</tr>
<tr>
<td>Raw Count</td>
<td>High 17 Low 2 Average 10</td>
</tr>
</tbody>
</table>

**Bone**

<table>
<thead>
<tr>
<th>Size</th>
<th>Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Sparse (4–8%)</td>
</tr>
<tr>
<td>Degree of Sorting</td>
<td>Poor</td>
</tr>
<tr>
<td>Roundedness</td>
<td>Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity</td>
</tr>
<tr>
<td>Raw Count</td>
<td>High 77 Low 53 Average 65</td>
</tr>
</tbody>
</table>

**Clay Pellets**

No clay pellet inclusions were counted for this group.
### Chert
- **Size**: Coarse (.5–1 mm) and Very Coarse (over 1 mm)
- **Frequency**: Rare (1%)
- **Degree of Sorting**: Poor
- **Roundedness**: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity
- **Raw Count**: High 6 Low 4 Average 5

### K-feldspar
- **Size**: Coarse (.5–1 mm)
- **Frequency**: Rare (1%)
- **Degree of Sorting**: Poor
- **Roundedness**: Angular, Low Sphericity and Sub-Angular, Low Sphericity
- **Raw Count**: High 2 Low 1 Average 1.5

### Grog
- **Size**: Coarse (.5–1 mm) and Very Coarse (over 1 mm)
- **Frequency**: Rare (1%) to Sparse (5%)
- **Degree of Sorting**: Poor
- **Roundedness**: Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
- **Raw Count**: High 31 Low 9 Average 20

### Iron
- No iron inclusions were counted for this group.

### Quartz
- **Size**: Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Common (15–20%)
- **Degree of Sorting**: Poor
- **Roundedness**: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
- **Raw Count**: High 1175 Low 890 Average 1033

### Organics
- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Rare (1%) to Sparse (5%)
- **Degree of Sorting**: Poor
- **Roundedness**: Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
- **Raw Count**: High 175 Low 21 Average 98
Voids
Size Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency Sparse (7%)
Degree of Sorting Poor
Roundedness Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear
Raw Count High 158 Low 119 Average 139

The two sherds (GMIP03 and GMIP10) that comprise this paste group are distinguished from those of Paste Group 1b because of the presence of K-feldspar minerals. The low frequency and similar roundness of K-feldspar in the sand (quartz) inclusions suggests that the K-feldspar inclusions are natural to the clay. This may suggest a fourth variation in the clay bed source or the same clay bed source as that of Paste Group 1b because only three total K-feldspar minerals were counted for this paste group. Though this could represent a factor in point counting, a scan of the slides for Paste Group 1b did not indicate the presence of K-feldspar. Nevertheless, the K-feldspar is not a culturally added inclusion. The bone inclusions (culturally added) are tan and dark brown in color. Grog inclusions (culturally added) represent black (reduced or incompletely fired) sandy paste sherds and tan (not highly birefringent) sandy paste sherds.

**Paste Group 2: Sandy Paste (Bimodal) with Grog and Bone Inclusions**

**Biotite**
Size Fine (.1–.25 mm), Medium (.25–5 mm), and Coarse (.5–1 mm)
Frequency Rare (1–2%)
Degree of Sorting Poor
Roundedness Linear
Raw Count High 52 Low 0 Average 30

**Bone**
Size Medium (.25–5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency Rare (2%) to Sparse (4-8%)
Degree of Sorting Poor
Roundedness Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity
Raw Count High 110 Low 6 Average 52

**Clay Pellets**
No clay pellet inclusions were counted for this group.

**Chert**
Size Coarse (.5–1 mm)
Frequency Rare (1%)
Degree of Sorting Poor
Roundedness Angular, Low Sphericity and Sub-Angular, Low Sphericity
Raw Count High 8 Low 0 Average 4
**K-Feldspar**
No K-feldspar inclusions were counted for this group.

**Grog**
Size: Very Coarse (over 1 mm)
Frequency: Rare (3%)
Degree of Sorting: Poor
Roundedness: Angular, Low Sphericity; Sub-Angular, Low Sphericity; and Sub-Rounded, High Sphericity
Raw Count: High 13, Low 5, Average 10

**Iron**
No iron inclusions were counted for this group.

**Quartz (small)**
Size: Fine (.1–.25 mm) and Medium (.25–.5 mm)
Frequency: Common (10-20%) and Abundant (30%)
Degree of Sorting: Fair
Roundedness: Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
Raw Count: High 2186, Low 129, Average 1477

**Quartz (large)**
Size: Coarse (.5–1 mm) and Very Coarse (over 1 mm)
Frequency: Rare (3%) and Sparse (6-8%)
Degree of Sorting: Poor
Roundedness: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity
Raw Count: High 134, Low 58, Average 96

**Organics**
Size: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency: Sparse (5–8%)
Degree of Sorting: Poor
Roundedness: Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
Raw Count: High 296, Low 0, Average 151

**Voids**
Size: Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency: Sparse (4-6%)
Degree of Sorting: Poor
Roundedness: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear
Raw Count: High 103, Low 69, Average 91
This paste group has three samples (GMI035, GMIP04, and GMIP07) that exhibit two different sizes of quartz (fine and large). The fine mineral size quartz (45–91% of all inclusions) appears to be part of the clay base as it demonstrates some degree of sorting and is less angular (weathering of the parent material to clay). The larger inclusions of quartz (4–17% if all inclusions) are more angular, less well sorted, and appear to be culturally added as temper. Bone (culturally added) is tan and dark brown in color. Grog inclusions demonstrate the use of two different types of pottery for temper: a dark brown/black (reduced or incompletely fired) sandy paste and a tan paste (not highly birefringent) with bone inclusions. Biotite inclusions were noted for GMI035 and GMIP07, and chert inclusions were noted for GMIP04 and GIMP07. This paste group was not subdivided into three different groups based on the presence or absence of biotite and chert because the more important unifying characteristic is the bimodal presence of quartz. However, the chert inclusions are most likely culturally added in this case (unlike the other paste groups) because of their angular nature. The chert was most likely part of the crushed, large, angular quartz sand and a by-product of the sand addition rather than a potter’s choice made during the manufacturing process. It is also likely that some other part of the GMI035 sample (not used for petrographic analysis) contained chert inclusions and were simply not included in the study due to sampling. Sample GMIP07 has an interesting color banding pattern—an incompletely oxidized core, an oxidized band, and an incompletely oxidized outer margin. According to Rye (1981:Figure 104), this pattern represents a reducing atmosphere during firing, the pottery was then “cooled rapidly in air, and reduced again.”

**Paste Group 3: Sandy Paste with Bone Inclusions and Biotite**

**Biotite**
- Size: Medium (.25–.5 mm)
- Frequency: Rare (1%)
- Degree of Sorting: Poor
- Roundedness: Linear
- Raw Count: High 10 Low 6 Average 8

**Bone**
- Size: Medium (.25–.5 mm), Coarse (.5–1 mm) and Very Coarse (over 1 mm)
- Frequency: Common (10-20%)
- Degree of Sorting: Poor
- Roundedness: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; and Rectangular
- Raw Count: High 220 Low 161 Average 191

**Clay Pellets**
- No clay pellet inclusions were counted for this group.

**Chert**
- No chert inclusions were counted for this group.
**K-Feldspar**
No K-feldspar inclusions were counted for this group.

**Grog**
No grog inclusions were counted for this group.

**Iron**
No iron inclusions were counted for this group.

**Quartz**
- Size: Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- Frequency: Common (10%)
- Degree of Sorting: Poor
- Roundedness: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
- Raw Count: High 292 Low 179 Average 236

**Organics**
- Size: Fine (.1–.25 mm), Medium (.25–.5 mm), and Coarse (.5–1 mm)
- Frequency: Sparse (5%)
- Degree of Sorting: Poor
- Roundedness: Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
- Raw Count: High 391 Low 152 Average 272

**Voids**
- Size: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- Frequency: Rare (3%)
- Degree of Sorting: Poor
- Roundedness: Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear
- Raw Count: High 48 Low 44 Average 46

The third main paste group does not have grog inclusions, but the clay paste is dominated by large bone inclusions (culturally added). The colors of the bone inclusions in these samples (GMI028 and GMI036) demonstrate the highest variability: white, tan, dark brown, and reddish-brown. The clay is highly birefringent.

**Paste Group 3a: Sandy Paste with Bone Inclusions and Biotite and Chert**

**Biotite**
- Size: Fine (.1–.25 mm), Medium (.25–.5 mm), and Coarse (.5–1 mm)
- Frequency: Rare (1–2%) to Sparse (5%)
- Degree of Sorting: Poor to Fair
- Roundedness: Linear
- Raw Count: High 67 Low 12 Average 39
**Bone**
- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Sparse (5–9%)
- **Degree of Sorting**: Very Poor to Poor
- **Roundedness**: Angular, High Sphericity; Angular, Low Sphericity
- **Raw Count**: High 276, Low 80, Average 165

**Clay Pellets**
- **Size**: Medium (.25–.5 mm) and Coarse (.5–1 mm)
- **Frequency**: Rare (1–2%)
- **Degree of Sorting**: Poor
- **Roundedness**: Rounded, High Sphericity and Rounded, Low Sphericity
- **Raw Count**: High 29, Low 0, Average 13

**Chert**
- **Size**: Coarse (.5–1 mm) and Very Coarse (over 1 mm)
- **Frequency**: Rare (1%)
- **Degree of Sorting**: Poor
- **Roundedness**: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity
- **Raw Count**: High 4, Low 3, Average 3.7

**K-Feldspar**
- No K-feldspar inclusions were counted for this group.

**Grog**
- No grog inclusions were counted for this group.

**Iron**
- **Size**: Very Coarse (over 1 mm)
- **Frequency**: Rare (1%)
- **Degree of Sorting**: Poor
- **Roundedness**: Veins
- **Raw Count**: High 10, Low 0, Average 3

**Quartz**
- **Size**: Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Common (15–20%) and Abundant (25%)
- **Degree of Sorting**: Very Good to Fair
- **Roundedness**: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
- **Raw Count**: High 2778, Low 701, Average 1606
**Organics**

- **Size**: Medium (.25–.5 mm) and Coarse (.5–1 mm)
- **Frequency**: Rare (3%) and Common (10%)
- **Degree of Sorting**: Poor
- **Roundedness**: Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
- **Raw Count**: High 285 Low 56 Average 155

**Voids**

- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Rare (1%) and Sparse (5%)
- **Degree of Sorting**: Poor
- **Roundedness**: Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear
- **Raw Count**: High 111 Low 83 Average 95

The three samples in this paste group (GMI029, GMIP08, and GMIP09) are similar to those of Paste Group 3, but also have chert inclusions. Though the chert in these samples is large and angular, it is within the range of the larger quartz inclusions, suggesting that it may not have been culturally added. If this is the case, this paste group may represent a different clay source within a similar clay bed or clay weathered from a slightly different parent material. The presence of clay pellets within the clay paste suggests that the clay and temper were not completely mixed in water or not completely ground during the initial processing of the clay. The clays of this group, like those of Paste Group 3, are highly birefringent. The bone inclusion colors are white, light tan, tan, and dark brown.

**Second 5-Sample Submittal**

Four of the five samples in this study are similar to those of previously established paste groups. One sample (TKP1, lot 463) does not match any of the previously established paste groups; therefore, a new bimodal quartz inclusion paste group is created. As with the previous samples, there are two general clay paste categories: a micaceous clay paste (indicated by its high birefringence color) and a nonmicaceous sandy paste. In general, small quartz minerals, biotite, and iron most likely occur because they are part of the clay body that is due to weathering of the clay from a parent material. Culturally added inclusions include the angular, larger quartz, chert, and K-feldspar minerals and bone and grog inclusions. Finally, when there are no data for the organics category, the sherd was too dark, indicating it was either fired in a reduced atmosphere or incompletely fired resulting in a dark-colored sherd.
**Paste Group 1a: Sandy Paste with Grog and Bone Inclusions with Biotite**

TKP5 (lot 672)

**Biotite**
- **Size**: Fine (.1–.25 mm) and Medium (.25–.5 mm)
- **Frequency**: Sparse (3%)
- **Degree of Sorting**: Fair
- **Roundedness**: Linear
- **Raw Count**: 80

**Bone**
- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Common (10%)
- **Degree of Sorting**: Poor
- **Roundedness**: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity
- **Raw Count**: 256

**Clay Pellets**
- No clay pellet inclusions were counted for this sample.

**Chert**
- No chert inclusions were counted for this sample.

**K-feldspar**
- No K-feldspar inclusions were counted for this sample.

**Grog**
- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Sparse (5%)
- **Degree of Sorting**: Fair
- **Roundedness**: Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Rounded, High Sphericity
- **Raw Count**: 42
Iron
No iron inclusions were counted for this sample.

Quartz
Size Very Fine (up to .1 mm), Fine (.1–.25 mm), and Medium (.25–.5 mm)
Frequency Common (15%)
Degree of Sorting Good
Roundedness Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
Raw Count 1015

Organics
Size Medium (.25–.5 mm) and Coarse (.5–1 mm)
Frequency Rare (2%)
Degree of Sorting Poor
Roundedness Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
Raw Count 42

Voids
Size Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency Rare (3%)
Degree of Sorting Poor
Roundedness Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear
Raw Count 27

This sample has a micaceous clay paste (indicated by its high birefringence color). Although this sample fits into this paste group, it has a higher frequency of bone and grog inclusions. At this point in the study, there is no reason to separate this sample into another subgroup as it follows the general trends and the ranges of the previously analyzed three samples.

Paste Group 1b: Sandy Paste with Grog and Bone Inclusions with Biotite and Chert

Biotite
Size Very Fine (up to .1 mm)
Frequency Rare (2%)
Degree of Sorting Fair
Roundedness Linear
Raw Count 18

Bone
Size Fine (.1–.25 mm), Medium (.25–.5 mm), and Coarse (.5–1 mm)
Frequency Rare (1–2%)
Degree of Sorting Poor
Roundedness Sub-Angular, Low Sphericity and Sub-Rounded, Low Sphericity
Raw Count 14
Clay Pellets
No clay pellet inclusions were counted for this group.

Chert
- Size: Very Coarse (over 1 mm)
- Frequency: Rare (1%)
- Degree of Sorting: Poor
- Roundedness: Angular, Low Sphericity
- Raw Count: 1

K-Feldspar
No K-feldspar inclusions were counted for this group.

Grog
- Size: Very Coarse (over 1 mm)
- Frequency: Rare (1%)
- Degree of Sorting: Poor
- Roundedness: Angular, High Sphericity and Angular, Low Sphericity
- Raw Count: 21
Iron
No iron inclusions were counted for this group.

Quartz
Size
- Very Fine (up to .1 mm), Fine (.1–.25 mm), and Medium (.25–.5 mm)
Frequency
- Abundant (30%) 
Degree of Sorting
- Good 
Roundedness
- Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
Raw Count
- 2714

Organics
Size
- Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency
- Sparse (6%) 
Degree of Sorting
- Poor 
Roundedness
- Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity (and possible lines separating areas of clay paste—see below)
Raw Count
- 130

Voids
Size
- Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency
- Rare (3%) 
Degree of Sorting
- Poor 
Roundedness
- Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear
Raw Count
- 61

This sample is a good example of this paste group. There are two elements that make this sample slightly different from the other samples that compose this group: brownish-yellow bone inclusions and odd divisions of clay or grog lined by organics or a very poor quality slip. Samples from 41PN175, and other Caddo sherds analyzed for this project, have bone inclusions with four basic colors: white, tan, dark brown, or reddish-brown. This sample has bone inclusions that are white and brownish-yellow, which is the first time the brownish-yellow-colored bone inclusion has been noted. This could represent a different kind of animal being used for temper. The second oddity of this sherd is the black linear pattern that appears around zones of clay (see the quartz plate image above figure TKP4.b). The clay pastes that are surrounded by the black lines are the same clay pastes as the parent sherd. This could represent the addition of clay pieces that were coated in organics and then added to the clay matrix. Alternatively, these black lines could represent a poor-quality slip, suggesting that these odd inclusions are grog. Although many of the clay pieces surrounded by black lines are angular in nature (suggesting grog), they are stacked next to each other without the typical spacing involved with grog temper inclusions. The latter
suggests that they are not grog inclusions. Unfortunately, higher magnification (20X and 40X) does not clear up this issue.

This sample also has an oxidized outer margin that is 1.6 mm thick.

*Paste Group 2: Sandy Paste (Bimodal) with Grog and Bone Inclusions*

![Image of TKP2 (lot 396)]

![Image of TKP3 (lot 454)]

![Image of TKP3 with slip/outer margin]

**Biotite**
- **Size**: Fine (.1–.25 mm) and Medium (.25–.5 mm)
- **Frequency**: Rare (1–2%)
- **Degree of Sorting**: Fair
- **Roundedness**: Linear
- **Raw Count**: High 94; Low 17; Average 55.5

**Bone**
- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Sparse (5%) to Common (10%)
- **Degree of Sorting**: Poor
- **Roundedness**: Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; and Rectangular
- **Raw Count**: High 94; Low 73; Average 83.5
Clay Pellets
No clay pellet inclusions were counted for this group.

Chert
Size Very Coarse (over 1 mm)
Frequency Rare (1%)
Degree of Sorting Poor
Roundedness Sub-Angular, Low Sphericity and Sub-Rounded, Low Sphericity
Raw Count High 9; Low 2; Average 5.5

K-Feldspar
No K-feldspar inclusions were counted for this group.

Grog
Size Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency Sparse (8%) to Common (10%)
Degree of Sorting Poor
Roundedness Angular, Low Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; Rounded, High Sphericity; and Rounded, Low Sphericity
Raw Count High 200; Low 22; Average 111

Iron
No iron inclusions were counted for this group.

Quartz (small)
Size Fine (.1–.25 mm) and Medium (.25–.5 mm)
Frequency Common (10–20%) and Abundant (30%)
Degree of Sorting Fair
Roundedness Sub-Angular, High Sphericity; Sub-Angular, Low Sphericity; Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity
Raw Count High 2607; Low 794; Average 1700.5

Quartz (large)
Size Coarse (.5–1 mm) and Very Coarse (over 1 mm)
Frequency Rare (3%) and Sparse (6%)
Degree of Sorting Poor
Roundedness Angular, High Sphericity; Angular, Low Sphericity; Sub-Angular, High Sphericity; and Sub-Angular, Low Sphericity
Raw Count High 77; Low 13; Average 45

Organics
No organics were counted for these samples because the paste was too dark.

Voids
Size Fine (.1–.25 mm), Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
Frequency Sparse (4-6%)
As the paste group name indicates, this is a sandy paste, but it is not a micaceous clay. Both samples are within range of the previous three samples used to establish this paste group. There are two different size categories of quartz inclusions: those natural to the clay (small and more rounded) and those culturally added (larger and angular). There is a high grog count for TKP3 (lot 454) because it appears that there are many small pieces of grog that were added in addition to the larger pieces of grog (these represent the dark brown/black clay matrix with quartz inclusions grog category). The smaller grog pieces may be explained by the following scenario: Imagine that one crushes up pottery for grog temper resulting in pieces of larger grog and then the fine dust. These fine dust particles are most likely represented by the small pieces of grog in this sample.

Sample TKP3 (lot 454) has an oxidized margin that is 2 mm thick. Within the oxidized zone close to the outer edge is a thin black line (approximately .1 mm thick). This could represent a slip (although this is not indicated on the hand sample) or it could represent a line of organic material that was migrating out of the sherd during the firing process. Given its location, the analyst would suggest that it is a slip, but would need a larger hand sample to conclude this assertion.

**Paste Group 2a: Sandy Paste (Bimodal) with Grog, Bone, Biotite, Chert, and Feldspar Inclusions**

TKP1 (lot 463)

**Biotite**

- **Size**: Fine (.1–.25 mm) and Medium (.25–.5 mm)
- **Frequency**: Rare (1%)
- **Degree of Sorting**: Poor
- **Roundedness**: Linear
- **Raw Count**: 26
<table>
<thead>
<tr>
<th>Material</th>
<th>Size</th>
<th>Frequency</th>
<th>Degree of Sorting</th>
<th>Roundedness</th>
<th>Raw Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone</td>
<td>Medium (.25–.5 mm), Coarse (.5–1 mm) and Very Coarse (over 1 mm)</td>
<td>Rare (3%)</td>
<td>Poor</td>
<td>Sub-Angular, High Sphericity and Sub-Angular, Low Sphericity</td>
<td>10</td>
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<tr>
<td>Clay Pellets</td>
<td>No clay pellet inclusions were counted for this group.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>Coarse (.5–1 mm) and Very Coarse (over 1 mm)</td>
<td>Rare (3%)</td>
<td>Poor</td>
<td>Angular, High Sphericity and Angular, Low Sphericity</td>
<td>9</td>
</tr>
<tr>
<td>K-feldspar</td>
<td>Very Coarse (over 1 mm)</td>
<td>Rare (1%)</td>
<td>Poor</td>
<td>Angular, Low Sphericity</td>
<td>1</td>
</tr>
<tr>
<td>Grog</td>
<td>Coarse (.5–1 mm) and Very Coarse (over 1 mm)</td>
<td>Rare (1%)</td>
<td>Poor</td>
<td>Sub-Rounded, High Sphericity; and Sub-Rounded, Low Sphericity</td>
<td>4</td>
</tr>
<tr>
<td>Iron</td>
<td>Coarse (.5–1 mm) and Very Coarse (over 1 mm)</td>
<td>Rare (1%)</td>
<td>Poor</td>
<td>Rounded, High Sphericity</td>
<td>4</td>
</tr>
<tr>
<td>Quartz (small)</td>
<td>Very Fine (up to .1 mm), Fine (.1–.25 mm), and Medium (.25–.5 mm)</td>
<td>Abundant (25%)</td>
<td>Good</td>
<td>Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity Rounded, High Sphericity; and Rounded, Low Sphericity</td>
<td>1372</td>
</tr>
</tbody>
</table>
**Quartz (large)**
- **Size**: Coarse (.5–1 mm) and Very Coarse (over 1 mm)
- **Frequency**: Sparse (5%)
- **Degree of Sorting**: Fair
- **Roundedness**: Angular, High Sphericity; and Angular, Low Sphericity
- **Raw Count**: 137

**Organics**
- **Size**: Medium (.25–.5 mm), Coarse (.5–1 mm), and Very Coarse (over 1 mm)
- **Frequency**: Sparse (5%)
- **Degree of Sorting**: Poor
- **Roundedness**: Rounded, High Sphericity
- **Raw Count**: 107

**Voids**
- **Size**: Coarse (.5–1 mm) and Very Coarse (over 1 mm)
- **Frequency**: Sparse (5%)
- **Degree of Sorting**: Poor
- **Roundedness**: Sub-Rounded, High Sphericity; Sub-Rounded, Low Sphericity; and Linear
- **Raw Count**: 141

This paste group is new to the 41PN175 petrographic samples. It is very similar to Paste Group 1c; however, the sandy paste has two different quartz size categories (bimodal). Though this is a sandy paste, the clay is highly micaceous (indicated by its high birefringence color). The chert and K-feldspar inclusions are part of the quartz temper that was culturally added, given their size and angularity.

**Petrographic Conclusions**
As is typical of most sherds from East Texas, the pastes are characterized as sandy pastes. While these samples all have a high frequency of quartz, there are two kinds of pastes: a highly birefringent (micaceous) clay paste and a nonbirefringent clay paste. The first paste tends to be well-fired resulting in a tan paste without oxidizing margins (inner or outer dark cores). The latter paste tends to be darker in color (this is usually the paste without counts in the organics category) suggesting that it is either not completely fired or was fired in a reducing (without oxygen) atmosphere. With the exception of two samples (GMIP007 and GMI035), the samples demonstrate that they were fired completely (oxidized or reduced). Sherd sample GMIP007 has reducing/cooling stripes suggesting multiple reducing firing episodes and sample GMI035 has a very prominent oxidized outer edge.

Though all the samples in this study are characteristic of a sandy paste, there is one sherd that demonstrates the possibility of all of the quartz inclusions representing culturally-added sand or well sorted clays and not sands that were part of the original clay. The sorting of the quartz inclusions in sample GMI029 is different from the others. The minerals are very evenly distributed in space and size. This indicates that either the sand was ground with a
specific consistency in mind or that the potter took great care in sorting/sifting/sieving the clay before manufacture. Given that there are also clay pellets present in the sherd paste, it is more likely that the sand was well ground with a specific consistency in mind and then added to a fine (not sandy), micaceous clay source.

Also similar to the majority of sherds from East Texas, grog and bone inclusions are prominent. All of the sherds in the analysis contained bone inclusions; however, not all samples contained grog inclusions. The bone inclusions ranged in color with the majority exhibiting a light to dark tan color. The second submission sample TKP4 (lot 1002) additionally contained brownish-yellow bone inclusions, which was only documented with this single sherd. Although no studies have been conducted as to the meaning of the different colors of bone, it is possible that the differences are a result of the temperature to which the bone was heated before crushing to make temper. In addition to the variety of bone colors, these samples also contained a variety of grog pastes types. The majority of the grog paste types were composed of highly birefringent tan pastes. While this study did not seek to determine if these tan grog pastes are the same pastes as the sherds to which they were added as temper, visually they are very similar. The second most prominent grog paste was a black paste with coarse quartz inclusions. Cecil has seen a similar paste in samples from grog samples from Titus County, Texas. While Cecil cannot determine at this time if they are the same pastes, they are visually similar. The third most common grog paste is a nonbirefringent tan paste with and without bone inclusions.

Additionally sample TKP4 (lot 1002) was unique to the collection with the presence of organic-lined clay inclusions or poorly slipped pieces of grog stacked next to each other with no spaces. It is suspected that the former is the reason for the black lines separating zones of clay matrix because it is very difficult to stack grog (either intentionally or unintentionally) in a clay matrix with no resulting spaces between the pieces of grog.

Sample GMI030 has a .01-mm-thick dark slip. The slip has very few quartz inclusions suggesting a well levigated clay used for the slip base.

Finally, there are no correlations among block, unit, or level. The only slight pattern exists within Paste Group 3. The majority of these samples were excavated from Block 4 (one was from Block 3). However, these results may not be surprising since the sherds were selected based on stylistic attributes rather than stratigraphic context. There is no reason to suggest that any of the sherds in this analysis represent nonlocal pottery; however, a chemical analysis will better answer this question.
Chapter 18: Neutron Activation: Neutron Activation Analysis of Additional Caddo Ceramics (GMI038–042) and Clays (GMI043–051) from 41PN175, Panola County, Texas

by Jeffrey R. Ferguson, Ph.D., and Michael D. Glascock, Ph.D.

Introduction

This report describes the preparation, analysis, and interpretation of five pottery samples (GMI038–042) from 41PN175 in Panola County, Texas along with 10 clay samples from the surrounding area (GMI043-051). The goals of the research are to examine both the internal compositional variability with the hope of determining local production signatures as well as compare these samples to the previous ten ceramic samples analyzed from the site (GMI028–037) (Ferguson and Glascock 2012) as well as the larger east Texas Caddo database. Sample IDs and some basic descriptive information are provided in Appendix F. The original (unadjusted) concentrations for the samples are provided in a separate Excel spreadsheet.

MURR has a large sample of data from Caddo ceramics from east Texas, primarily submitted by Tim Perttula; however, this region exhibits remarkable uniformity in raw clay composition over vast areas. This uniformity in the chemical composition of the raw materials has limited the potential for NAA to distinguish likely ceramic production locations (Ferguson et al. 2008). The current samples are from an area between regions 7, 8, and 9, and some of the samples match the core groups from all three regions, while the majority of the samples match a small group (Group 3) from Region 9. The clay samples are quite different from the ceramic samples (typical for raw clay samples) with the possible exception of samples GMI047, 048, and 049.

Sample Preparation

Pottery samples were prepared for NAA using procedures standard at MURR. Fragments of about 1 cm² were removed from each sample and abraded using a silicon carbide burr in order to remove glaze, slip, paint, and adhering soil, thereby reducing the risk of measuring contamination. The samples were washed in deionized water and allowed to dry in the laboratory. Once dry, the individual sherds were ground to powder in an agate mortar to homogenize the samples. Archival samples were retained from each sherd (when possible) for future research.

Two analytical samples were prepared from each source specimen. Portions of approximately 150 mg of powder were weighed into clean high-density polyethylene vials used for short irradiations at MURR. At the same time, 200 mg of each sample were weighed into high-purity quartz vials used for long irradiations. Individual sample weights were recorded to the nearest 0.01 mg using an analytical balance. Both vials were sealed prior to irradiation. Along with the unknown samples, standards made from National Institute of Standards and Technology (NIST) certified standard reference materials of SRM-
1633b (coal fly ash) and SRM-688 (basalt rock) were similarly prepared, as were quality control samples (e.g., standards treated as unknowns) of SRM-278 (obsidian rock) and Ohio Red Clay (a standard developed for in-house applications).

**Irradiation and Gamma-Ray Spectroscopy**

Neutron activation analysis of ceramics at MURR, which consists of two irradiations and a total of three gamma counts, constitutes a superset of the procedures used at most other NAA laboratories (Glascock 1992; Neff 1992, 2000). As discussed in detail by Glascock (1992), a short irradiation is carried out through the pneumatic tube irradiation system. Samples in the polyvials are sequentially irradiated, two at a time, for five seconds by a neutron flux of $8 \times 10^{13}$ n cm$^{-2}$ s$^{-1}$. The 720-second count yields gamma spectra containing peaks for nine short-lived elements aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The samples are encapsulated in quartz vials and are subjected to a 24-hour irradiation at a neutron flux of $5 \times 10^{13}$ n cm$^{-2}$ s$^{-1}$. This long irradiation is analogous to the single irradiation utilized at most other laboratories. After the long irradiation, samples decay for seven days, and then are counted for 1,800 seconds (the "middle count") on a high-resolution germanium detector coupled to an automatic sample changer. The middle count yields determinations of seven medium half-life elements, namely arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb). After an additional three- or four-week decay, a final count of 8,500 seconds is carried out on each sample. The latter measurement yields the following 17 long half-life elements: cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr). The element concentration data from the three measurements are tabulated in parts per million. Cody Rousch prepared the samples for irradiation.

**Interpreting Chemical Data**

The analyses at MURR, described above, produced elemental concentration values for 33 elements in most of the analyzed samples. Data for Ni in many samples was below detection limits (as is the norm for most New World ceramics) and was removed from consideration during the statistical analysis. Calcium levels were found to be high enough (up to 7.4 percent) in many specimens to require a calcium correction of the dataset. Because calcium has the potential to affect (dilute) the concentrations of other elements in the analysis, all samples were mathematically corrected to compensate for any possible calcium included effects (the data were examined before and after calcium correction and the results were similar). The following mathematical correction was used as it has been proven to be effective in other calcium-rich datasets (Cogswell et al. 1998:64; Steponaitis et al. 1988):

$$e' = \frac{10^6 e}{10^6 - 2.5 c}$$
where \( e' \) is the corrected concentration of a given element in ppm, \( e \) is the measured concentration of that element in ppm, and \( c \) is the concentration of elemental calcium in ppm. After the calcium correction, calcium was generally removed from the statistical analyses. Statistical analysis was subsequently carried out on base-10 logarithms of concentrations on the remaining 31 elements.

Use of log concentrations rather than raw data compensates for differences in magnitude between the major elements, such as calcium, on one hand and trace elements, such as the rare earth or lanthanide elements (REEs). Transformation to base-10 logarithms also yields a more normal distribution for many trace elements.

The interpretation of compositional data obtained from the analysis of archeological materials is discussed in detail elsewhere (e.g., Baxter and Buck 2000; Bieber et al. 1976; Bishop and Neff 1989; Glascock 1992; Harbottle 1976; Neff 2000) and will only be summarized here. The main goal of data analysis is to identify distinct homogeneous groups within the analytical database. Based on the provenance postulate of Weigand et al. (1977), different chemical groups may be assumed to represent geographically restricted sources. For lithic materials such as obsidian, basalt, and cryptocrystalline silicates (e.g., chert, flint, or jasper), raw material samples are frequently collected from known outcrops or secondary deposits and the compositional data obtained on the samples is used to define the source localities or boundaries. The locations of sources can also be inferred by comparing unknown specimens (i.e., ceramic artifacts) to knowns (i.e., clay samples) or by indirect methods such as the “criterion of abundance” (Bishop et al. 1992) or by arguments based on geological and sedimentological characteristics (e.g., Steponaitis et al. 1996). The ubiquity of ceramic raw materials usually makes it impossible to sample all potential “sources” intensively enough to create groups of knowns to which unknowns can be compared. Lithic sources tend to be more localized and compositionally homogeneous in the case of obsidian or compositionally heterogeneous as is the case for most cherts.

Compositional groups can be viewed as “centers of mass” in the compositional hyperspace described by the measured elemental data. Groups are characterized by the locations of their centroids and the unique relationships (i.e., correlations) between the elements. Decisions about whether to assign a specimen to a particular compositional group are based on the overall probability that the measured concentrations for the specimen could have been obtained from that group.

Initial hypotheses about source-related subgroups in the compositional data can be derived from noncompositional information (e.g., archeological context, decorative attributes, etc.) or from application of various pattern-recognition techniques to the multivariate chemical data. Some of the pattern recognition techniques that have been used to investigate archeological data sets are cluster analysis (CA), principal components analysis (PCA), and discriminant
analysis (DA). Each of the techniques has its own advantages and disadvantages which may depend upon the types and quantity of data available for interpretation.

The variables (measured elements) in archeological and geological data sets are often correlated and frequently large in number. This makes handling and interpreting patterns within the data difficult. Therefore, it is often useful to transform the original variables into a smaller set of uncorrelated variables in order to make data interpretation easier. Of the above-mentioned pattern recognition techniques, PCA is a technique that transforms from the data from the original correlated variables into uncorrelated variables most easily.

PCA creates a new set of reference axes arranged in decreasing order of variance subsumed. The individual PCs are linear combinations of the original variables. The data can be displayed on combinations of the new axes, just as they can be displayed on the original elemental concentration axes. PCA can be used in a pure pattern-recognition mode, i.e., to search for subgroups in an undifferentiated data set, or in a more evaluative mode, i.e., to assess the coherence of hypothetical groups suggested by other criteria. Generally, compositional differences between specimens can be expected to be larger for specimens in different groups than for specimens in the same group, and this implies that groups should be detectable as distinct areas of high point density on plots of the first few components. It is well known that PCA of chemical data is scale dependent (Mardia et al. 1979), and analyses tend to be dominated by those elements or isotopes for which the concentrations are relatively large. This is yet another reason for the log transformation of the data.

One frequently exploited strength of PCA, discussed by Baxter (1992), Baxter and Buck (2000), and Neff (1994, 2002), is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed samples) displayed on the same set of principal component reference axes. A plot using the first two principal components as axes is usually the best possible two-dimensional representation of the correlation or variance-covariance structure within the data set. Small angles between the vectors from the origin to variable coordinates indicate strong positive correlation; angles at 90 degrees indicate no correlation; and angles close to 180 degrees indicate strong negative correlation. Likewise, a plot of sample coordinates on these same axes will be the best two-dimensional representation of Euclidean relations among the samples in log-concentration space (if the PCA was based on the variance-covariance matrix) or standardized log-concentration space (if the PCA was based on the correlation matrix). Displaying both objects and variables on the same plot makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Such a plot is commonly referred to as a “biplot” in reference to the simultaneous plotting of objects and variables. The variable inter-relationships inferred from
a biplot can be verified directly by inspecting bivariate elemental concentration plots [note that a bivariate plot of elemental concentrations is not a biplot.].

Whether a group can be discriminated easily from other groups can be evaluated visually in two dimensions or statistically in multiple dimensions. A metric known as the Mahalanobis distance (or generalized distance) makes it possible to describe the separation between groups or between individual samples and groups on multiple dimensions. The Mahalanobis distance of a specimen from a group centroid (Bieber et al. 1976; Bishop and Neff 1989) is defined by:

$$D^2_{y,X} = (y - \overline{X})^T I_x (y - \overline{X})$$

where $y$ is the $1 \times m$ array of logged elemental concentrations for the specimen of interest, $X$ is the $n \times m$ data matrix of logged concentrations for the group to which the point is being compared with $\overline{X}$ being it $1 \times m$ centroid, and $I_x$ is the inverse of the $m \times m$ variance-covariance matrix of group $X$. Because Mahalanobis distance takes into account variances and covariances in the multivariate group it is analogous to expressing distance from a univariate mean in standard deviation units. Like standard deviation units, Mahalanobis distances can be converted into probabilities of group membership for individual specimens. For relatively small sample sizes, it is appropriate to base probabilities on Hotelling’s $T^2$, which is the multivariate extension of the univariate Student’s $t$.

When group sizes are small, Mahalanobis distance-based probabilities can fluctuate dramatically depending upon whether or not each specimen is assumed to be a member of the group to which it is being compared. Harbottle (1976) calls this phenomenon “stretchability” in reference to the tendency of an included specimen to stretch the group in the direction of its own location in elemental concentration space. This problem can be circumvented by cross-validation, that is, by removing each specimen from its presumed group before calculating its own probability of membership (Baxter 1994; Leese and Main 1994). This is a conservative approach to group evaluation that may sometimes exclude true group members.

Small sample and group sizes place further constraints on the use of Mahalanobis distance: with more elements than samples, the group variance-covariance matrix is singular thus rendering calculation of $I_x$ (and $D^2$ itself) impossible. Therefore, the dimensionality of the groups must somehow be reduced. One approach would be to eliminate elements considered irrelevant or redundant. The problem with this approach is that the investigator’s preconceptions about which elements should be discriminate may not be valid. It also squanders the main advantage of multi-element analysis, namely the capability to measure a large number of elements. An alternative approach is to calculate Mahalanobis distances with the scores on principal components extracted from the
variance-covariance or correlation matrix for the complete data set. This approach entails only the assumption, entirely reasonable in light of the above discussion of PCA, that most group-separating differences should be visible on the first several PCs. Unless a data set is extremely complex, containing numerous distinct groups, using enough components to subsume at least 90 percent of the total variance in the data can be generally assumed to yield Mahalanobis distances that approximate Mahalanobis distances in full elemental concentration space.

Lastly, Mahalanobis distance calculations are also quite useful for handling missing data (Sayre 1975). When many specimens are analyzed for a large number of elements, it is almost certain that a few element concentrations will be missed for some of the specimens. This occurs most frequently when the concentration for an element is near the detection limit. Rather than eliminate the specimen or the element from consideration, it is possible to substitute a missing value by replacing it with a value that minimizes the Mahalanobis distance for the specimen from the group centroid. Thus, those few specimens which are missing a single concentration value can still be used in group calculations.

Results
As is typical for East Texas Caddo ceramics, there is limited compositional patterning. This difficulty recently led to the attempt by Jeff Ferguson and Tim Perttula to reanalyze the entire east Texas Caddo database (Ferguson et al. 2008). The reanalysis was moderately successful at finding core groups for each of the 11 regions that divided the area (Figure 167), but there was such significant overlap between the core groups that it is rare to confidently assign unknown samples to a likely production region. The attempt to project these new data from Panola County against the East Texas Caddo database as well as the larger MURR ceramic database are described below.

Comparison with the East Texas Caddo Database
As described previously, the East Texas Caddo database has been the focus of a recent study (Ferguson et al. 2008). This reinterpretation did not result in the determination of region-specific production areas as initially hoped, with the possible exception of material from the northern portion of the study are along the Red River. Figure 167 is the regional map used by Ferguson et al. (2008). The samples in the current study are from the area between Regions 7, 8, and 9. The sample sizes of the regions vary considerably. Region 7 has one of the largest samples and includes both a large Core Group and a second group (Group 1) that separate slightly in chromium concentrations. Unfortunately, almost all of the regional core groups almost completely overlap with each other, with the notable exception of Regions 1 and 2. In order to facilitate the comparison with the East Texas Caddo subregional groups, the new data were calcium corrected and concentrations for Ni, Sr, and Ca were removed. Figure 168 is a plot showing the separation of the two main groups from Region 7 and the new samples.
Archaeological sites in northeast Texas from which pottery has been analyzed by neutron activation analysis. Drainage basins are shown and labeled. Site locations provided by T. Pertula, drainage basins obtained from Texas Parks and Wildlife.

Figure 167. Regional map of East Texas Caddo database.
A similar comparison is made to the Region 8 groups, with a few samples overlapping with the core group, but a majority showing some compositional variability, particularly in sodium (Figure 169).

A comparison with the Region 9 groups reveals a clearer pattern of affiliation. The same five samples (GMI028, 030, 034, 035, and 036) overlap with the Region 9 Core Group, but the core groups from all three regions overlap in bivariate plots and show little statistical difference. The samples in the tighter cluster have a similar composition to the Region 9 Group 3. This affiliation with Group 3 is most apparent in the sodium concentrations (Figure 170), but this pattern holds for other elements that differentiate Group 3 from the Core Group such as hafnium. Table 91 lists the group membership probabilities for the 41PN175 artifacts and the regional core groups. There are too few members in the Region 9 Group 3 to calculate membership probabilities.
Clay Comparisons
The majority of the clay samples are clearly distinct from the ceramics, particularly in their reduced concentrations of chromium. Figure 171 is a plot of the 41PN175 ceramics and the clay samples. Table 92 lists the membership probabilities for the clay samples.

Clay samples GM1047, 048, and 049 show a general similarity to the artifacts; however, as is usual with clay samples, they do not closely match the artifacts. The lack of a match does not indicate that these clays were not used in the production of these ceramics. The likely mixing or modifying clays as well as the addition of aplastics is a possible cause for the difference.

Conclusions
The interpretation of Caddo compositional data is complicated by at least two major factors: (1) the large-scale similarity of raw clays in the region, and (2) the frequent use of grog as temper. These factors all contribute to the difficulty in identifying the areas of production at multiple scales. The authors have demonstrated the similarity between some of the new
samples and the main reference groups from the three surrounding regions, and suggest that all of the samples could have been produced locally, although this is not possible to confirm. There is also a correlation between the cluster of samples and Group 3 from Region 9. Some patterned internal variability, particularly with regard to sodium and chromium concentrations, might be explained by the results of the petrographic analysis although the authors do not have any hypotheses as to what might cause these patterns.
<table>
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<th>ANID</th>
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Results are based on the following variables:
NA AL K SC TI V CR MN FE CO ZN AS RB ZR SB CS BA LA CE ND SM EU TB DY YB LU HF TA TH U
Membership probabilities(%)
Probability for each sample calculated after removal from original group.
Figure 171. Bivariate plot of chromium and sodium showing the separation of the 41PN175 artifacts and the associated clay samples.

Table 92: Group Membership Probabilities for Clay Samples Based on Mahalanobis Distance Projections

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Results are based on the following variables:
NA AL K SC Ti V Cr Mn Fe Co Zn As RB ZR SB CS BA LA CE ND SM EU TB DY YB LU HF TA TH U
Probability for each sample calculated after removal from original group.
The data recovery investigation of the Murvaul Creek site (41PN175) presented in this report has provided a data set pertaining to a small Middle-Late Caddo period settlement in the Middle Sabine River Valley. The excavations were conducted in advance of the planned road widening of FM 10 and bridge replacement over Murvaul Creek, approximately a mile north of Gary in Panola County, Texas. The fieldwork included the controlled excavations of just over 47 cubic meters of site matrix followed by the total removal of the site through mechanical excavation. This fieldwork resulted in the recovery of over 15,000 prehistoric artifacts, roughly 400 grams of ecofacts (primarily charred vegetal materials), and the identification of 76 features. Following the recovery of these materials a detailed research design (presented in Chapter 4) was developed, which included the detailed study of the artifact collection and site setting in order to mitigate the loss of information from the site as a result of the planned development. Many of the studies attempted through this project were experimental in nature and were conducted in an attempt to explore new avenues for research into Caddo archeological sites in East Texas. As such, the research projects individually resulted in both successes and failures, but ultimately each study resulted in the interpretation of a rich data set pertaining to a small Caddo community that was living near Murvaul Creek during the mid-thirteenth to early-sixteenth centuries. A summary of each of the studies, as they pertain to the research design, is presented in the sections that follow.

**Research Design Issues**

**Research Domain 1: Site Chronology and Site Integrity**

- **What is the chronology and history of the site stratigraphy?**

Based on initial test excavations, the Murvaul Creek site was recommended eligible for inclusion in the National Register in part because the site was thought to contain an isolable Middle–Late Caddo component (A.D. 1300–1600; Cliff and Perttula 2002). This period was based both on the character of the ceramic assemblage and the results of a single radiocarbon date that yielded a calibrated date range of A.D. 1440–1680. A second radiocarbon date obtained from the Cliff and Perttula (2002) investigations suggested a Late Archaic (cal. 1320–1060 B.C.) presence as well. The preliminary results from the current data recovery investigations include the retrieval of a Late Paleoindian/Early Archaic San Patrice projectile point, which further suggests that the site area had been used at least intermittently for a much longer period than was represented by the ceramic assemblage. Because of these data, it was thought that submitting samples for a variety of chronometric analyses would allow for a robust characterization of the site chronology.
The largest sample of dates came from feature contexts identified across the site. Fifteen charcoal samples selected from the data recovery investigations were submitted for AMS radiocarbon analysis. Additionally, 10 ceramic sherds were submitted for AMS analysis on bulk sherd organics. These dates, combined with the two feature AMS dates obtained during the test excavations, resulted in a total of 27 traditional AMS radiocarbon dates. As Dr. Selden reviewed in Chapter 8, these dates can be statistically separated into four occupational groups. Because of fluctuations of \(^{14}\text{C}\) in the calibration curve, each of these groups contain multiple statistically possible time periods. The largest sample of dates (n=15) is attributed to the Late Caddo period. These dates are ascribed to a variety of features and several dated ceramic sherds that were widely distributed across the site. The period between ca. A.D. 1450 and A.D. 1618 is therefore taken to encompass the main period of occupation on the site. Based on both the results of the ceramic analysis presented in Chapter 6 and the calibrated radiocarbon dates from features with preserved paleobotanical remains, the most likely date range for the main occupation of the site is the A.D. 1457–1513 period.

The remaining occupational group periods are each represented by a limited number of dates. Groups 2 and 3 are each represented by a single feature date and three ceramic sherds, and the 2\(\sigma\) age ranges overlap by a number of years. Group 2 is attributed to the likely periods of A.D. 1298–1370 and A.D. 1380–1402. The time periods for Group 3 are A.D. 1275–1300 and A.D. 1368–1382. Similar to the distribution of the Group 1 dates, both of these earlier groups are widely distributed across the site. The ceramic analysis did suggest that limited portions of the site (Blocks 3 and 5) contained both utility and fine wares that likely represented this initial Caddo occupation on the site. This is not to say that these earlier wares were only represented in discrete portions of the site, but instead that the ceramics were highly mixed within the assemblage from the later and more extensive period of Caddo occupation.

The fourth occupational group is represented by dates from two features identified in the northern portion of Block 4 and adjacent to Block 7. The group represents a Late Woodland or Formative Caddo presence on the site during the periods of A.D. 684–828 or A.D. 838–866. Unfortunately, little can be stated concerning this period of use of the site because no artifacts diagnostic of the period were identified on the site and only limited artifacts were recovered from the features.

In addition to the occupational groups recognized, several outliers were statistically separated from the sample. The first of these outliers is represented by the AMS date obtained from Feature 5 from the prior test excavations (Cliff and Perttula 2002). This date most likely pertains to the period of 1320–1110 B.C., which documents a Late Archaic presence on the site. The lithic assemblage recovered two projectile points that were likely to have been manufactured during the Late Archaic period. Additionally, a San Patrice
projectile point and a reworked fragment of a possible Angostura point were recovered. Based on both the recovery of lithic materials and the single dated feature, it is interpreted that although there is evidence that the site was used during periods prior to the Caddo occupation, the use of this area was infrequent at best.

The remaining two statistical outliers identified in Chapter 8 were both obtained from bulk organics obtained from ceramic sherds. In Chapter 6, Dr. Perttula discusses some issues with accepting the radiocarbon dates from all of the sherds as indicating the manufacture or use date. Specifically, one sherd that was also identified as an outlier in the statistical grouping, yielded an anomalous date that was much too old for the ceramic style of the sherd. Whether these dates call into question the occupational period of the site or the manufacture and use date of the ceramics is still considered up for question. A secondary goal of the dating analysis was to check the validity of using direct AMS dates from ceramics by submitting four sherds for additional thermoluminescence (TL) analysis. Unfortunately, the results of the TL analysis were impeded by the low firing temperatures of the sherds that yielded even older and more anomalous dates for most of the sherds. Based on this small pilot study, it is recommended that a much larger sample size be used if such a study is to be conducted again. Based on the totality of the dating results from the features and ceramic sherds, the remaining outliers are taken as suspect samples and the main periods of occupation of ca. A.D. 1275–1370 and A.D. 1457–1513 are considered representative of the site as a whole.

Chronology of occupational and erosional events

Through a number of exposures in small units and excavation blocks excavated both within the TxDOT ROW, and with landowner permission on the adjacent property east of the site, it was shown that the recognized stratigraphic units varied across the site. Three broad groups of deposits were identified which in order of stratigraphic position from lowest to highest are the subsoil, the Caddo soil, and the colluvium. Although the landform within which the site is situated was thought to be a stable upland constructed as either a constructional or strath terrace by Murvaul Creek at some time during the geologic past, the colluvial deposit, which was found to bury the Caddo soil at the northern end of the site, suggests that the landform was not as stable during the past few hundred years as was previously thought. Instead, the slight north-facing slope of the landform enabled portions of the landform to be eroded and redeposited on the site area. The timing of this event was dated through three OSL dates collected from the upper and lower colluvium and the Caddo soil. A considerable difference in age ranges was noted between the colluvium and paleosol samples. The paleosol results yielded date ranges from 940 ± 80 years B.P. to 4,060 ± years B.P., but as Dr. Frederick concludes in Chapter 10, the deposition of the colluvium most likely began around 300 years ago and continued until at least 200 years ago. This was determined from two OSL dates collected from the lower colluvium (320 ± 230 years B.P.) and the base of the upper colluvium (250 ± 210 years B.P.). However, it is still unclear
how rapidly sediment was shed during the beginning of the colluvial deposition, but it is
evident that the sand grains within the buried soil became less exposed to the ground
surface. The OSL mixing model results from the lower colluvium suggest that this unit was
initially deposited around 280 ± 50 years B.P. and the upper colluvium began depositing
around 230 ± 20 years B.P. Both these dates postdate all of the dates obtained from
cultural materials or features on the site. It is evident from these results that the main
period of instability of the landform occurred shortly after the Caddo occupation of the site.
However, there was no apparent link to the instability of the landform with the abandonment
with the site.

- **Microartifact analysis of early occupation**
The microartifact study, presented in Chapter 12, was conducted in part to assess the
reliability of using microcharcoal to date the occupations that may have preceded the main
Caddo use of the site. During the preliminary analysis of one microartifact profile, an
increase in microcharcoal with depth was noted that was not duplicated in either the macro-
or microartifact distributions. Given that Woodland and Archaic artifacts were recovered
from the excavations, it was thought that the greater amount of resonance time would have
caused a preference for earlier materials to be located deeper within the profile. The
hypothesis was that the increase in microcharcoal in this profile might provide an indication
for the timing of these earlier occupations. In order to test this theory, two additional
microartifact profiles were examined and eight microcharcoal samples were selected for
AMS dating.

Each of the microartifact profiles showed trends in the colluvium that suggested that the
artifact assemblage had been reworked through redeposition by slopewash. Within the
Caddo soil, the macroartifacts showed a downward-trending dispersion that was more
pronounced than that of the microartifacts. This downward dispersion was likely caused by
insect-scale bioturbation subsequent to the slow burial of the site. This level of bioturbation
was apparent in many of the test unit excavation profiles. This downward dispersion of
macroartifacts suggested that the macroartifacts were more prone to downward
translocation than the microartifacts were and somewhat called into question whether the
microcharcoal would accurately reflect the earlier occupation.

As expected from the OSL dating of the colluvium and the stratigraphic observations that
this horizon represented an inverted profile of eroded materials, the AMS results from
microcharcoal dates contained inverted dates. The youngest dates were observed at the
lowest portion of the colluvium (0–270 years cal B.P.) and the dates in the upper colluvium
ranged between 290–310 years cal B.P. and 620–530 years cal. B.P. Although these results
helped confirm that the artifacts contained within the colluvium represented redepsoited
materials, the dates obtained within the E-horizon yielded mixed results. The original profile
that showed an increase in microcharcoal with depth (Profile 3) yielded a radiocarbon date
of 630–540 years cal. B.P. (A.D. 1320–1410), which corresponds to the earlier intervals observed in the feature and ceramic dates. Profile 2 did not show a similar increase in microcharcoal, but the two radiocarbon dates obtained from the E-horizon yielded Woodland period dates of 1560–1520 years cal. B.P. and 1820–1710 years cal. B.P. (A.D. 390–430; A.D. 130–240). Whereas these dates may represent charcoal preserved from older human occupations of the site, the lack of repeatability of the results between profiles and the lack of artifacts pertaining to this period limit the usefulness of the results.

- **What processes are responsible for site formation?**
  - **Physical and chemical analysis of buried soil**

Considerable attention was paid in Chapter 10 to understanding whether the change in color of the Caddo soil across the site was attributable to intentional anthropogenic alteration. Specifically, the northern portion of the site, where the buried A-horizon exhibited a darker color in terms of a lower Munsell hue and chroma, was inferred to be a midden deposit. Cliff and Perttula (2002) observed during the test excavations that the northern portion of the site, where the buried soil was darkest in color, was also where higher artifact densities were observed. However, the lack of significant faunal preservation led to the hesitation at definitively terming this area as a midden deposit. In order to better understand what caused the differences in the buried soil color, a suite of 61 samples was collected from the buried A-horizon across the site. These samples were subjected to elemental, carbon isotopic, and magnetic susceptibility analyses and were compared between the presumed midden and nonmidden areas on the site. Additionally, five samples collected from midden, nonmidden, and feature proveniences were analyzed using $^{13}$C nuclear magnetic resonance spectroscopy ($^{13}$C- NMR) in order to determine whether the organic content in the midden samples was a product of pyrogenic organic enrichment as opposed to increased humified organic matter.

The results of the elemental analysis suggested that barium, potassium, magnesium, lead, zinc, carbon, nitrogen, and strontium levels, as well as the stable carbon isotopic ratio, were all significantly different between the midden and nonmidden samples. In the case of carbon, the total carbon content within many of the midden samples was found to be nearly twice the values of the non-midden paleosol samples. Though this result was not surprising given that it was assumed that the dark color of the midden samples was due to an increase in total carbon content, the results of the magnetic susceptibility analysis curiously did not show a significant enhancement in the midden samples. The expectation was that the midden samples would show elevated magnetic susceptibility values if the organic component consisted of previously heated materials such as charcoal and other refuse from hearths. However, because this was shown not to be the case, the additional effort in submitting samples for $^{13}$C- NMR analysis proved to be useful in distinguishing between pyrogenic and other organic matter. The results of the $^{13}$C- NMR analysis suggested that the dark-colored areas of the midden contained nearly 40 percent charcoal in the organic
fraction, whereas humified carbohydrates and lipids were found in greater abundances in nonmidden areas of the paleosol and modern soil. These results suggest that the northern areas of the site do contain greater inputs of charcoal, presumably from anthropogenic sources, that are consistent with terming the area as a midden in lieu of other preserved faunal materials. Additionally, the $^{13}$C- NMR study has demonstrated an additional method for addressing features such as these in the future.

- **3D laser scanning of ceramic abrasion**

As has been previously discussed, it was evident from the stratigraphic observations and excavation results that the artifacts recovered from the site were positioned both in the colluvium and the underlying Caddo soil. The dating results suggested that the colluvium had been deposited over the site area during the early historic period and that sediment contained microcharcoal that dated to the Middle–Late Caddo occupation. Although this suggested that site materials were included in the colluvium, it did not refute the possibility that these artifacts had been translocated upward through the profile through bioturbation, rather than through the horizontal erosion and deposition of the sediment. A 3D laser scanning analysis of the ceramic collection was conducted to characterize the ceramic abrasion within the collection. It was thought that the horizontal transfer of materials would have resulted in greater amounts of abrasion than if artifacts were simply transferred upward or downward through the profile. However, given that the transport distance was likely very short (on the order of tens or hundreds of meters) the difference in abrasion between the transported and nontransported sherds would likely be very subtle. Due to the high precision of the 3D laser scanner, this was thought to be an ideal instrument for exploring whether this abrasion information is recorded in the collection.

The 10 percent sample selected for analysis provided results that were consistent with the interpretation that the artifact collection had been transported and redeposited on the site within the colluvial sediment. The analysis revealed that the sherds contained within the buried A-horizon of the Caddo soil showed the least amount of abrasion along the sample sherd edges, which was consistent with a tendency toward freshly broken sherds. Some skewness toward more abraded sherds was found within the A-horizon; however, the samples from both the colluvium and underlying E-horizon appeared to have more abraded edges. The relatively small sample of sherds from the E-horizon did show increased abrasion when compared to the sample from the buried A-horizon; however, the sherds from the E-horizon were not as abraded as those observed in the colluvium. The interpretation was that the sherds from the E-horizon had been translocated downward through the profile by bioturbation. This translocation did cause some degradation of the sherd edges, but the vertical motion of the artifacts through the profile did not have the abrading effects as severe as that observed in the colluvium that had been translocated across the site.
Overall, the study demonstrated an additional method for assessing the site formation processes that may have affected a ceramic assemblage in East Texas. Both the results of the sample of artifacts analyzed from the site and the experimental study that was conducted as part of the 3D laser scanning analysis suggest that the method could be applied to additional sites or settings. However, given the subtleties observed in the progressive rounding of the edges through abrasion, a significantly large sample size is recommended for future work. The study that was conducted as part of the analysis of the Murvaul Creek collection included multiple cross sections collected from over 500 individual sherds. This resulted in a sample size of approximately 1,400 cross sections. Based on the results of this study, this sample size is likely near the minimum of what would be useful for statistically distinguishing between abraded and nonabraded sherds. Given that the method is nondestructive and that data can be collected and processed relatively rapidly, additional studies using this method of analysis would likely prove to be fruitful if even larger sample sizes were collected.

Research Domain 2: Environmental Conditions

- **Was there an abrupt period of climate change during the period of site occupation?**
  - **Pollen and phytolith analysis**
    
The paleoclimate at the site was reconstructed through phytolith analysis. This analysis was productive for addressing the setting during and prior to the Middle–Late Caddo occupation. However, given that sediments were mixed within colluvium at the upper portion of the site, this analysis was not as productive in addressing how the environment changed through time, especially for the period following the Caddo occupation. For this study, 10 stratigraphic samples that were correlated with four radiocarbon dates were submitted for analysis. The results of the analysis did show an overall trend of increasing forest density and canopy development between approximately A.D. 120 and A.D. 1670. Overall, the driest conditions were revealed in the record that was preserved in the Bt horizon. The phytolith record suggested that an open mixed prairie habitat with grasses, sedges, and a significant forb community existed on the site area at some time prior to cal. A.D. 120–250. Although the phytolith records likely underrepresented many arboreal species that do not produce prolific phytoliths, the lower portion of the site does show a trend of increasing summer precipitation that would have supported a mixed forest and grassland habitat. Within the buried A-horizon of the Caddo soil, which would have marked the main period of site occupation, the phytolith record showed a steadily increasing density of a pine-dominated forest along with the development of a diverse herbaceous understory. Both loblolly pine and maygrass appear in the samples submitted. The presence of loblolly pine suggests a diversity in the pine species present on the site. Maygrass was interpreted as representing either subsistence-related activities or natural disturbances. When analyzed, the samples from the colluvium were viewed as evidence of disturbance and few paleoenvironmental interpretations were made concerning the period following the Caddo occupation.
It is difficult to draw new conclusions concerning the paleoclimate based on the limited results of the phytolith analysis from the Murvaul Creek site beyond what studies from other sites in the region have shown. The investigations at the Lang Pasture site included the palynological analysis of several cores collected in Anderson County (Albert 2011b). Although sediments from that study were analyzed dating to nearly 7,000 years B.P., only limited results overlapped with the period documented at the Murvaul Creek site. The pollen and phytolith records from both sites document very little environmental change within the region during the past 1,000 years. A pine-oak forest appears to have been well established during the period, but the data from both sites indicate a rise in forbs and grasses prior to 1,000 years ago. At Lang Pasture, this interval of warming and drying conditions persists between approximately 3,000 and 1,000 B.P. The interval at the Murvaul Creek site that predates the Caddo occupation records only a portion of this interval, with grasses, sedges, and forbs constituting a major portion of the phytolith record. Although little variation was documented in the samples analyzed at Murvaul Creek, the regional drought history (presented in Chapter 16) documents that the Middle–Late Caddo interval was a period with multiple fluxes of precipitation. These drought periods would have had some effect on the prehistoric populations of the region, but the time-averaging nature of the phytolith and pollen records was likely not as sensitive to these precipitation changes during the period.

- **GIS paleoenvironmental data**

In order to further explore the effects that changes in precipitation had on Caddo communities, a review of the dendrochronological records of drought history was conducted and compared with the dated Middle–Late Caddo GIS records. The review of drought history records showed that the period between A.D. 1150 and A.D. 1690 contained considerable fluctuations in moisture over 5-year periods. Several periods were noted that contained multiyear droughts (e.g., A.D. 1365, 1450, 1455, 1510, 1565, and 1640) that were both severely dry and persistent over periods of several years and would have likely had a negative impact on cultures with an agricultural-based economy.

The GIS study utilized the available site records and radiocarbon dates to examine the spatial relationships between sites represented by similarly aged dates. A total of 109 sites exists in the East Texas records with sufficient data for analysis. Unfortunately, the results of the analysis were less than productive because of the temporal scale inherent in many of the radiocarbon dates. Likely trends do exist within the data available, but further research should be focused on limited areas, such as a single drainage basin, where archeological data are comprehensive and well dated. As such, this work should be considered a “work in progress” toward an archeological database that would enable future studies. By intensively dating additional sites, such as the work conducted at the Murvaul Creek site, eventually a large enough sample size will enable more productive results.
Research Domain 3: Subsistence and Seasonality

- **Macrobotanical, Pollen, and Phytolith Data**

Twenty flotation samples were selected from features across the site for macrobotanical analysis. The goal of the analysis was to identify the extent of domesticated plants, such as maize, as well as other wild or native plants, in the diet of the inhabitants of the Murvaul Creek site. Additionally, a secondary goal was to determine whether evidence of seasonality was present in the collection, but it was not possible with the collection to address this issue. In Dr. Bush’s analysis (presented in Chapter 9), the results indicated that significant wood charcoal and agricultural remains were within the collection. The wood charcoal was dominated by species of oak (*Quercus*), pine (*Pinus*), and limited hickory (*Carya*), which suggested that upland resources were primarily being exploited as fuel sources. Additional lowland varieties of sweetgum (*Liquidambar styraflua*), ash (*Fraximus*), boxelder (*Acer*), and willow/cottonwood (*Salicaceae*) were also present in the collection, which suggests an opportunistic use of fuel sources from the surrounding area. Important edible products consisted of domesticated plants such as corn (*Zea mays*) and squash (*Cucurbita*), as well as wild resources such as river cane (*Arunginaria gigantean*), nutshells, sumac (*Rhus*) seeds, and waterlily (*Nymphaea odorata*) or pondlily (*Nuphar lutea*) tubers. Although the initial test excavations did not find corn, numerous cob parts and kernel fragments were identified in seven (35 percent) of the 20 samples submitted for the data recovery analysis. The measurements on cupules suggested that the corn consumed at the site was comparable in size to the collection from the Oak Hill Village site, as well as to that from site 41TT852. Additionally, the variation identified in the collection suggests that more than one type of corn may have been used at the site. The scant squash remains did appear to have been domesticated varieties, and the sumac seeds recovered suggested either that dyes or smoking mixtures were being produced on the site. The nutshells common in the collection consisted primarily of hickory (*Carya*; 90 percent) and black walnut (*Juglans nigra*). Additionally, acorns (*Quercus*) were present in 13 samples, but these were also likely attributable to modern materials. Still, the most unique remains found were the 381 tuber fragments recovered from Feature 79. The tuber fragments represent either waterlily or pondlily that had been processed on the site. Waterlily buds, but not tubers, have been identified on one site in East Texas (Pine Tree Mound—41HS15). Additionally, the test investigations recovered seeds of maygrass, persimmon, and purslane (Bush 2012; Dering 2002). Overall, these findings document that a diverse range of plant foods was being used at the site.

- **Isotopic evidence of maize agriculture**

An early goal formulated during the initial planning of the data recovery investigations was to address the extent to which maize agriculture was practiced at or near the Murvaul Creek site area. According to ethnohistorical accounts (cf. Joutel 1906 [1687]; Weltfish 1937), small farmsteads were often placed in locations that were within or immediately adjacent to...
fields and gardens. Although these accounts of fields exist, they are difficult to confirm archeologically because of the ephemeral nature of the fields.

It was thought that one approach for addressing this issue was to analyze the spatial component of the stable carbon isotopic signature from both on-site and locations adjacent to the TxDOT ROW. Since the C₄ isotopic signature of corn differs significantly from the background C₃-dominant signature of the pine forest setting, the expectation was that, should the area have been used as a Caddo agricultural field, the C₄ signature should persist somewhere in the soil profile. With landowner permission, a series of shovel tests was excavated in a 40-x-60-m area adjacent to the TxDOT ROW in order to collect soil samples for isotopic analysis. The 200 samples submitted for isotopic analysis confirmed a significant variation of C₄ inputs within the profile that was suggestive of anthropogenic sources. However, these concentrations were centered on the distal edge of the landform overlapping with the area identified as the midden. Although the data from the isotopic study were successful in portraying areas of anthropogenic enrichment, the refuse disposal practices of the inhabitants of the site overshadowed the potential ability of this method to identify Caddo agricultural fields.

Research Domain 4: Technology, Typology, Change, and Implementation

- Lithics
The lithic collection from the Murvaul Creek site data recovery excavation consisted of a total of 2,201 specimens. Debitage comprised the overwhelming majority of the collection (93 percent), and only 28 temporally diagnostic projectile points were recovered. The remainder of the collection consisted of 25 simple detachment-based flake tools, 9 complex detachment-based tools, 6 cores, 5 ground stone artifacts, and 62 fragments of fire-cracked rock. Analysis of both the lithic tools and debitage was conducted following the TxDOT protocols for lithic analysis. The goals of the analysis were to 1) identify the basic reduction stage of the collection, 2) identify the range of activities represented by the collection, 3) to characterize the raw material selection and preparation, and 4) to verify whether stratigraphic differences were present on the site.

The diagnostic projectile points in the collection consisted of four dart points and 13 arrow points. The dart points and arrow points were collected from all stratigraphic levels in a mixed assemblage. Additionally six dart point fragments and five arrow fragments comprised the nondiagnostic portion of the projectile collection. No single style dominated the dart collection and only single specimens of San Patrice, Angostura, Ellis, and Kent points were represented. The dart point collection was largely represented by finished and resharpened or repurposed tools. For instance, the Angostura point consisted of only a medial fragment of a point that had been reworked for use as a graver. However, one nondiagnostic specimen did appear to be an early reduction stage archaic projectile form that was worked on a locally available tabular fragment of quartzite. This suggests that both
tool production and resharpening may have been occurring at the site intermittently since the Late Paleoindian period. Many of the specimens showed microwear patterns that suggested that they had been used both as projectile points and multipurpose cutting tools. The majority of the collection did appear to be produced on locally available chert and quartzite with no evidence of thermal pretreatment; however, two specimens appeared to have been produced on Central Texas chert and one small point fragment was made on a light brown jasper that was likely from the Red River Valley.

The diagnostic arrow point collection was represented by 9 Perdiz, 3 Perdiz/Bassett, and 1 Bonham point. Impact fractures were present on nearly all of the specimens, and there was some evidence that resharpening of the tools was being conducted on the site. All of the arrow points were produced on locally available chert, quartzite and fossilized wood. Only one Perdiz point showed any evidence of thermal pretreatment of the material. Metrics from the Perdiz points were compared to other sites with sufficiently reported metric data and it was observed that the points from the Murvaul Creek site were fairly small for the type. Although the collection was within the range of variation observed at other sites, such as Lang Pasture, it is worth noting that the growing database collected using the established TxDOT lithic protocols should enable an adequate database for addressing regional variations in projectile types.

The complex detachment- and simple detachment-based tools in the collection displayed the range of activities for which the lithics were used. A range of use wear was noted on the bifacial choppers and knives in the collection. Many specimens had no evidence of use other than edge grinding that may have indicated that the tools were abandoned during the production stage. One knife did show use polish on both the ridges and low areas of the edge, suggesting that it was used to cut softer materials such as wood or bone. The simple detachment-based tools were represented primarily by expedient flake tools (n=11), but scrapers (n=5), bifacial knives (n=4), unmodified blades (n=3), one graver, and one drill were also recovered. The microscopic use wear analysis suggested that the majority of the tools were utilized for a variety of tasks, including scraping and sawing of soft wood or bone. Additionally, one damaged specimen was employed as a reamer. As with other tools, there was only limited evidence that thermal pretreatment was employed for the collection dominated by locally available raw materials.

The debitage analysis was conducted on roughly half of the collection, which was contained within the Caddo soil and within features. Similar to the tool assemblage, over 97 percent of the identifiable materials were locally available chert, quartzite and fossilized wood. Only 25 specimens of regional materials were found in the collection. The majority of the regional materials were high-quality gray Central Texas chert, which suggests some limited interaction or exchange with areas southwest of East Texas. Jasper and novaculite were also present in the collection in very low numbers, which suggests limited interaction with...
the Red River Valley and Ouachita areas. The analysis also indicated that all stages of reduction were present in the collection. The collection was relatively split between cortical percentage categories and roughly half of the complete and proximal flakes exhibited cortical platforms. The analysis attempted to determine whether different areas on the site were utilized for different purposes, but this analysis produced equivocal interpretations between categories. For instance, size-grade analysis suggested that initial reduction was being conducted on the southern end of the site and smaller flakes resembling resharpening or tool finishing activities were occurring near block 4. However, debitage from the southern blocks were also largely noncortical, which suggested that initial reduction was being completed elsewhere. There was a consistent trend though that faceted platforms and smaller debitage were recovered from areas within and immediately surrounding features. Overall, the collection appeared to suggest that all stages of lithic production were being conducted across the site.

- Ceramic Assemblage

The ceramic collection from the data recovery investigations at the Murvaul Creek site consisted of a total of 7,325 artifacts. As a whole, the sherds in the collection were very small, and 2,396 were designated as sherdlets considered too small for detailed analysis. The remaining 4,929 sherds in the collection contained both plain and decorated sherds, and sherds with decorated elements comprise approximately 30 percent of the collection. A detailed analysis of the collection was presented in Chapter 6. The basic goals of this analysis were to (1) determine whether Caddo iconography existed on the sherds and to place the collection within a regional identify, and (2) to characterize the technology of the collection and assess whether there was evidence in the collection that displayed technological change or adaptation to an intensification of maize agriculture.

It was noted that the collection contained very few engraved sherds, which significantly limited the distinction of Caddo iconography in the collection. The engraved motifs convey symbolic messages of community beliefs (world structure and cosmos) and represent the community’s social identity. Contents of the vessels are unknown, but they would have also had symbolic meaning to the community. Other sites in the region, such as Pine Tree Mound, contain funerary objects that suggest that people believed in a world with multiple realms (lower world, middle realm of everyday life, upper celestial realm), and vessel motifs reflect a sacred *axis mundi* that connected the realms through the four quarters of the world (Gadus and Fields 2012:507). Other motifs, such as a scroll with a cross within a circle, also reinforce this connected world because of the connective relationship between the circle and the four axes of the cross within the circle. These motifs were expressed on carinated bowls, compound bowls, and bottles and have been defined in the Big Cypress Creek basin. In the middle Sabine and Angelina basin there was a key iconographic motif of a representational image of a rattlesnake. This design has been found in at least 16 sites dating from the thirteenth to the seventeenth centuries in both the Sabine and Big Cypress
drainages. No definitive grave goods or rattlesnake motifs were identified at the Murvaul Creek site, but other decorative elements, such as hatched, cross-hatched curvilinear and vertical ladders, cross-hatched triangles, and pendant triangles, that were found on the site have also been found on other sites with the rattlesnake motif. This association suggests that the Murvaul Creek inhabitants did have a close connection with other groups in the Sabine and Big Cypress drainages. Other elements, such as rayed circles/sun elements and the swastika cross-in-circle, were found on the site and suggest that there was a shared view of the layered cosmos with other sites such as Pine Tree Mound.

Technological adaptation can be readily addressed through the abundant utility vessels from the site. Utility vessels from Murvaul Creek are almost exclusively jars which were used for cooking and storing foodstuffs. All of the diameters of both the utility wares and other fine wares suggest that the vessels served individual family consumption needs. The utility ware jars were much thicker than the fine wares and were likely intended for cooking and heating foods and liquids as well as long term storage. Fine wares were generally thinner and would have likely been used as serving vessels.

The abundance of brushed pottery is used as a proxy for increased maize consumption in East Texas Caddo sites. At the Murvaul Creek site more than 62 percent of the decorated sherds have brushing as the main decorative element. Brushed utility wares appear in assemblages after ca. A.D. 1200–1250 and have been shown to dominate in utility ware assemblages by the early 15th century. This was also a period that has been shown through stable carbon and nitrogen isotopes that maize consumption had considerably increased in the region (see Wilson 2012:112–115, Wilson and Perttula 2013). This increase in brushed pottery was likely a technological advantage that helped facilitate the long cooking times that were required for the preparation of hominy, a gruel prepared with crushed corn kernels, wood ash, meat, and beans (cf. Meyers 2006:511; O’Brien et al. 1994; Pierce 2005).

- How local is the ceramic assemblage?
The petrographic (Chapter 17) and neutron activation studies (Chapter 18) included the examination of 25 ceramic sherds from the Murvaul Creek site. The main goal of these studies was to address the provenance of the sherds to identify whether social interaction in the form of ceramic trade or exchange was evident in the collection. Additionally, it was thought that by analyzing geologic clay samples collected from a 5-mile radius of the site would help characterize the range in variation in the chemical signature that would have been present when potters gathered raw materials from the area. Unfortunately these analyses failed to suggest that any of the ceramic samples submitted were from nonlocal sources. The data presented by Ferguson and Glascoc in Chapter 18 suggested simply that the clay sources likely contained mixtures of materials from the East Texas region, and that grog as a common tempering agent in Caddo pottery has impacted the ability to
distinguish intra-regional variations in the data; this has been MURR’s interpretation of the East Texas Caddo INAA database for a number of years now. The petrographic work presented by Dr. Cecil identified several distinct paste and temper groups in the collection submitted for analysis, but ultimately concluded that the entire collection consisted of materials local to the region.

A subsequent reanalysis of individual elements in the data from Murvaul Creek was conducted by Dr. Selden (see Chapter 6). This reanalysis suggested that the Murvaul Creek site is positioned between an elemental divide with materials representing the Claiborne group having elevated concentrations of aluminum, dysprosium, europium, lanthanum, lutetium, neodymium, scandium, samarium, terbium, and ytterbium that are not evident in the ceramic collections from the Murvaul Creek site. Several of the geologic samples collected from south of the site did fit well with the Claiborne group, and it is possible to conclude from this reanalysis that the potters responsible for the Murvaul Creek ceramics were likely obtaining clay either within the adjacent stream bed or from a location nearby, but north of the site. Additionally, this analysis suggested that two different, but still nearby, clay sources were used for vessel manufacture.

Research Domain 5: Settlement Systems and Intrasite Structure

- Are there recognizable patterns that would suggest types or number of structures present?

A total of 113 soil stains was identified and investigated as features during the data recovery investigations. The overwhelming majority of these stains were identified in plan view at the interface between the Ab- and E-horizons as locally contained dark-colored matrix that appeared to penetrate into the E-horizon. When each of the stains was bisected 48 were revealed to be the result of disturbances, such as burned or decayed tree roots or rodent burrows. The remaining 65 features were classified according to probable function as postholes, pits, smudge pits, or hearths. Because extensive bioturbation was noted that blurred many of the boundaries, 23 features remained as possibly of cultural origin and 42 features were determined to be undoubtedly cultural.

A representative sample of features was submitted for both elemental and micromorphological analysis for comparison with natural samples taken from across the site. The goal of these analyses was to use the physical analyses to identify properties that could aid in the distinction between soil stains of cultural origin and stains resulting from other natural disturbances. Nineteen thin sections were produced from features for micromorphological analyses (see Chapter 11) and samples from 29 features were selected for elemental analyses (see Chapter 10). Unfortunately the results were somewhat limited in defining the common properties among cultural features that could aid in cultural feature recognition. The smudge pits from both studies were easily discernible from the natural E-horizon samples by the abundance of charcoal in thin-section and concentrations of barium,
calcium, strontium, magnetic susceptibility and stable carbon isotopic signature. Pit features were notably different from the other thermal features, but were only distinguishable from the natural samples on the basis of the phosphorus and magnetic susceptibility values. None of the posthole features were distinguishable from the natural E-horizon either in thin-section or by any other laboratory properties. Bioturbation on multiple scales was noted in every sample submitted for micromorphological analysis, and it was apparent that even postholes that were easily recognizable in the field (based on their color contrast and form) as being of cultural origin were indistinguishable from the natural samples through the application of any of the laboratory methods.

The cultural origin of the remaining 65 features (and probable features) could not be ruled out based on physical analysis, so the spatial arrangement of the 65 features and possible features was examined with the assumption that all were culturally derived. The spatial arrangement of these features across the project area led to the conclusion that two discrete areas, designated as Clusters 1 and 2, were present on the site (see Chapter 5:Figure 23). Both feature clusters were situated on the western side of the project area and were contained within roughly rectangular areas 4–7 m on a side. Additionally, each area had a tendency for posthole features to be located near the edges of the clusters, though there was considerable overlap with other feature types, such as pits and smudge pits along the periphery. These arrangements led to the conclusion that the clusters likely represented outdoor work areas, with postholes representing drying racks or possibly a ramada. Designated outdoor work areas, such as ramadas or work platforms, have been identified at several other sites, such as Lang Pasture (41AN38) (Perttula et al. 2011), Tallow Grove (41NA231) (Perttula 2008), and the Ear Spool site (41TT653) (Perttula and Sherman 2008) in East Texas. In each of these other cases the areas interpreted as ramadas consisted of clusters of postholes and pits that were arranged in a generally square shape, approximately 3 m on a side (cf. Perttula 2008:Figure 5-3). Both of the feature clusters at the Murvaul Creek site are considerably larger than what has been observed elsewhere for structures of this type, though it is conceivable that, at least in the Cluster 1 area, that the area represents multiple closely associated outdoor work areas. Based on the findings at these other East Texas sites, dwelling structures are typically in very close association with the outdoor work areas. It is very likely that at Murvaul Creek that either bioturbation has resulted in the degradation of a sufficient number of posthole features to have prevented the positive identification of additional structures or that structural remains are present outside of the TxDOT ROW. However, interpreting the excavated site as primarily an outdoor work area would also help explain one reason that daub or other significant building or storage areas were not identified.

- **Was there indication of population size?**
The ceramic assemblage was analyzed to examine the length of occupation of the site. The study used studies of breakage rates of utility wares on other farmstead settlements (cf. Varien 1999) that reflected an average breakage rate of 4–8 kg per year for a nuclear
family. In Chapter 6 it was reviewed that the 2,690 utility sherds recovered from the excavations weighed approximately 8,882 g. Since the entire site had not been excavated, it was estimated that the collection likely represented 8.7 percent of the total site area. Based on these estimates, Dr. Perttula estimated that the entire site would likely contain roughly 102,090 g of utility sherds. This led to the conclusion that the Murvaul Creek site was likely occupied over the course of a minimum of 12–26 years. Based on the cluster of radiocarbon dates centering around A.D. 1457-1513, and the likelihood that wood structures may only have lasted 10-20 years before they would have to have been replaced or substantially reconstructed, it is very likely that this is an adequate interpretation for the length of the main occupation of the site. Although there was certainly evidence that the site had been occupied intermittently during other periods, the bulk of the feature and artifact collection represents a farmstead that was occupied for a single generation.
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