Modeling Hunter-gatherer Ceramic Production and Use: A Test Case from the Upper Texas Coastal Plain

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Abstract

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Archaeological research continues to document the manufacture and use of ceramic containers in hunter-gatherer contexts in times and places unexpected by conventional anthropological and archaeological theories of ceramic vessel use. The upper Texas coastal plain is a unique area because of its long-standing tradition of ceramic vessel production and use by relatively egalitarian, mobile hunter-gatherers. Traditional models of ceramic vessel production and use associate pottery with significant social, political, and/or economic change. In order to assess the roles of hunter-gatherer pottery in food production and processing, storage, and prestige contexts, I evaluated three sets of hypotheses of pottery function derived from traditional archaeological ceramic theory, behavioral ecology, and foraging theory.

I analyzed pottery from three late ceramic period (AD 600-contact) archaeological sites on the upper Texas coastal plain by paring traditional and developing analytical methods: 1) morphological analysis of attributes on ceramic vessels relating to vessel use and the degree of labor invested in production; 2) petrographic sourcing to detect degrees of movement and trade; 3) analysis of organic residues absorbed in the vessel body to determine types of food resources used; 4) thermoluminescence dating of pottery to achieve temporal control.

Analysis of manufacturing attributes and use-wear characteristics of ceramic assemblages from three upper Texas coastal plain archaeological sites indicate that while vessels were engineered for direct use over heat, they were infrequently used in this manner. Organic residue signatures from selected sherds indicate that pottery was

used for processing plant foods, especially on the site located on the coastal margin, but in upland and interior sites it was used for processing plants and large-bodied mammals.

While the results of these analyses do not unequivocally disprove any other of the three vessel function hypotheses, they do provide more insight on mobility patterns and diet. Luminescence dates indicate that at least some of the portions of the sites are contemporaneous. Assuming that portions of these sites are contemporaneous, I suggest that there were two separate populations on the upper Texas coastal plain. The coastal margin population relied on primarily on small-bodied, r-selected resources, and a more mobile inland population used greater amounts of large-bodied resources. Mineralogical data indicate that the minerals in UTCP pottery samples are of local provenance, which is expected for groups with low residential mobility. Local mineralogical sources and the overall undecorated nature of the pottery assemblages suggest that UTCP wares were not frequently associated with ceremonial or social/political/economic prestige events.

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DEDICATION

For my mother who taught me her love of people,
and for my father who taught me his love of the land.

CHAPTER 1: GOALS AND CONTRIBUTIONS OF THIS STUDY

Traditionally, archaeologists have assumed that the presence of pottery can be used to infer a fairly sedentary settlement pattern and a reliance on starchy seeds and/or cultigens (e.g., Childe 1951). This has been a traditional assumption in parts of the American Southeast, in particular the Lower Mississippi Valley (LMV). The upper Texas coastal plain (UTCP) lies immediately south and west of the LMV cultural region, and has similar environmental and cultural characteristics (Figure 1.1). Like most of their LMV neighbors, UTCP groups made and used pottery (possibly as early as 2,600 B.P.; Ensor and Ricklis 1998), and continued doing so through contact with Europeans and Euro-Americans. While some LMV groups, particularly the Caddo, shifted to horticulture beginning around AD 800, UTCP groups continued hunting, fishing, and gathering wild foods. While some aspects of upper Texas coastal plain hunter-gatherer adaptations are known, others are not as well understood. In particular the degree of mobility and the nature of mobility patterns of groups occupying this area are not fully known. Some aspects of subsistence are well documented, while others—such as the nature and significance of plant use—are not.

Using pottery to understand hunter-gatherer variability

Prior to 12,000 years ago, hunting and gathering wild foods was the way all human groups made a living worldwide (Thomas and Kelly 2006). As the oldest form of human socioeconomic organization, hunter-gatherer adaptations through time and across space are diverse, yet are characterized by a reliance on wild foods (Kelly 1995; Kuhn and Stiner 2001). Clearly there is no one "form" of this adaptation. Hunter-gatherer societies vary considerably in their subsistence practices, mobility, and social organization (Kelly 1995). For example, while harvesting wild foods defines hunter-gatherers, some hunter-gatherer societies use certain resources so intensively that the distinction between wild and domesticated food is blurred. Other societies may engage in long-term storage to such a high degree that they do not resemble the stereotype of highly mobile hunter-gatherers uninterested in acquiring large amounts of resources they cannot immediately use. A strong interest in understanding how small-scale, non-agricultural societies function and evolve has been part of archaeology since its earliest days (Kelly 1995). Current research continues to document and explain the immense variability in this earliest form of economic and social organization among humans.

A promising yet underutilized tool for understanding economic and social variability in hunter-gatherer societies is pottery. Focusing attention on the function of pottery in hunter-gatherer contexts has the potential to increase understanding of the variety of subsistence, settlement, and social adaptations in which ceramic vessels have been adopted. Studies of ceramic function have the potential to provide deeper insight on the nature of hunter-gatherer subsistence, settlement, and social/economic stratification.

The purpose of this dissertation is to evaluate three possible explanations of the circumstances under which prehistoric hunter-gatherer groups chose to make and use ceramic vessels on the upper Texas coastal plain (UTCP). This is accomplished by analyzing the functions of pottery manufactured by Late Prehistoric period (AD 600-contact) hunter-gatherers on the UTCP. While this study ostensibly contributes to regional knowledge of the UTCP, the information gained here also contributes to general comparative knowledge of hunter-gatherer pottery. The research presented here is predicated on the idea that pottery use is related to both social and economic behavior. The work is designed to advance archaeological understanding of economic and social contexts in which pottery was made and used, as well as hunter-gatherer adaptations in general, including diet, coping with food shortages, the role of food production, prestige behavior, and socioeconomic inequality.

Pottery function and hunter-gatherer adaptations: theoretical approaches

In traditional archaeological thought, pottery belongs to a suite of behaviors associated with food production and sedentariness (Childe 1951; Rice 1987). Indeed, pots can be useful tools for efficiently processing and storing domesticated food resources among sedentary populations. Ceramic vessels are useful in processing plant foods, as they allow prolonged unattended boiling over fire, a process which helps break down silica cell walls to increase digestibility. Food storage is an ideal function of pottery; storage in ceramic vessels protects foodstuffs from vermin and moisture (Rice 1987). Discovery and documentation of pottery in contexts of hunter-gatherer societies has called into question conventional ideas of ceramic vessel function. Archaeologists continue the process of creating new models of pottery production and use among forager societies. Current models of ceramic vessel manufacture and function are commonly based in environmental, economic, or ideological perspectives. Human behavioral ecology has the potential to combine aspects of these current models and thereby address the interplay between physical and social environments and pottery production. Originally developed in the biological sciences (where it is referred to as behavioral ecology), human behavioral ecology has been used for decades by anthropologists to develop models to understand human behavioral and cultural diversity in past and present societies (Smith 1983; Winterhalder and Smith 1992). Models generated from human behavioral ecology premises have been used to understand the diversity of hunter-gatherer resource procurement, group mobility, and other aspects of behavior. By using tools derived from human behavioral ecology, models can be created which utilize pottery as a data set to address larger issues in hunter-gatherer archaeology. The construction of models of pottery use using premises derived from human behavioral ecology is discussed in detail in Chapter 3.

Environment, archaeology, and ethnohistory of the upper Texas coastal Plain

The upper Texas coastal plain (UTCP) cultural area stretches between the Sabine and Brazos Rivers, and extends from the immediate coastal margin up to 200 miles inland based on environmental characteristics and the ranges of historic native groups in this area (Figure 1.1; Aten 1983). It includes the lower portions of the Sabine, Trinity, and Brazos Rivers, as well as the lower and middle portions of the

San Jacinto River. The modern environment is assumed to be similar to that in which prehistoric pottery–using hunter-gatherers lived—although this may be due to the paucity of paleoenvironmental information in the area. The UTCP is divided into four basic environments: 1) inland longleaf pine and pine-hardwood forests traversed by the Angelina and Neches Rivers and encompassing the Conroe-Livingston area; 2) inland oak savannas and grasslands; 3) coastal upland prairie such as the Allens Creek area, the upper section of the Lower Trinity, and the upper and middle sections of the San Jacinto River drainage; 4) coastal marsh-prairie zone, which includes Sabine Lake, Galveston Bay, Brazos Delta and West Bay (Aten 1983; Ricklis 2004a).

Environment

In the modern environment inland rivers link with the sea, creating lakes, estuaries, brackish and freshwater marshes, bays, and barrier islands (Gagliano 1984; Jeter et al. 1989; Ricklis 2004a). This is also where the grasslands of the west meet the woodlands of the east, creating upland prairie environments spliced with southwest-northeast oriented bands of pine and oak-hickory woodlands. When speaking of prehistoric human occupations, the four ecozones of the UTCP are often collapsed into two basic environments: the immediate coastal margin, including the shoreline and barrier islands, and inland prairie (Story 1990). The juxtaposition of these rich environments provided a large suite of plant and animal resources present by 2,000 BP (Ca. 500 BC) when the shoreline stabilized at its modern level and the barrier islands achieved their present sizes and locations (Gagliano 1984; Ricklis and Blum 1997). By 2,500 BP (Ca. 550 BC) modern biota were established on the Texas Gulf Coastal Plain, indicating a modern climate (Story 1990), although pollen records in central Texas suggest that the modern post-oak savanna characteristic of the area was not in place until 1,500 years ago (Bryant and Holloway 1985). Most of the pollen data supporting this interpretation are derived from lakes and bogs in areas adjacent to the UTCP (Bryant and Holloway 1985). A single notable exception is Aronow Bog northeast of Houston which has yielded high amounts of oak pollen and charcoal dating to 1,010 BP (Ca. AD 940), suggesting a drier environment (Beck at al. 2001). Pollen cores from Aronow Bog show an increase in arboreal pollen and a decrease in charcoal around 170 BP (Ca. AD 1780) (Aten 1999). It is unknown whether this change in vegetation is due to climatic factors or anthropogenic fire suppression.

Modern food resources

Many species of modern animals and plants would have been available to groups living on the coastal margin, including various species of saltwater and freshwater fish, the brackish water clam *Rangia cuneata*, and to a lesser extent, oyster (*Crassostrea virginica*). Fish species have overlapping spawning times from late summer through winter, when they are at their maximum weights and easy to capture in large amounts in the tidal passes of estuaries and bays (Nieland and Wilson 1993; Pearson 1929; Soto et al.1998). Inland areas also have aquatic fauna, including various species of freshwater mussels and freshwater fish such as alligator gar (*Lepisosteus tristoechus*). It is probable that in the past, deer—having reached their heaviest weights before winter—would have been attracted to inland groves of nut trees in the fall (Hall 1998). Deer are currently found on the coastal margin as well. Pronghorn (*Antilocapra americana*) had a more extended prehistoric range than recently and may have been present in the westernmost portions of the inland UTCP. Small mammals would also have been available to inland groups (Davis and Schmidly 1994; Moore 1995).

A variety of edible nuts, seeds, roots, and fruits are common to both the coastal margin and inland prairie environments (Hall 1998; Stahl 1995; Tull 1987). Cattail (*Typha* sp.) is available in both coastal and inland riverine environments and has edible seeds, roots, and stalks. Water lily (*Nymphaea odorata*), cane (*Arundinaria* sp.), and bulrush (*Scirpus californicus*) also have various edible parts available throughout the annual cycle. Major inland plant resources available include pecan (*Carya illinoiensis*), oak (*Quercus* sp.), and hickory (*Carya texana*) nuts, which become available in the fall. The pods of the honey mesquite (*Prosopis glandulosa* var.

glandulosa) are available in the summer, as is the fruit of the prickly pear cactus (*Opuntia* sp.). Prickly pear pads are available throughout the year. Plants with comparatively higher harvesting and processing costs which were economically significant in the prehistoric Southeast include amaranth (*Amarantus* sp.), available in the summer and fall, as well as chenopodium (*Chenopodium* sp.) and pickerelweed (*Pontederia cordata*) which have various parts available during all seasons.

Interannual variability in the local natural environment probably affected prehistoric subsistence and mobility patterns as well. Coastal fish and shellfish populations are subject to irregular catastrophic mortality from changes in salinity caused by weather (such as sudden cold fronts common in the region) and changes in sedimentation rates (Akberali and Trueman 1985; Aten 1999; Theroux and Wigley 1983). Tidal passes between barrier islands commonly fill with silt over periods of several years and other passes open, creating more productive fishing locations elsewhere. Catastrophic weather events such as hurricanes and tropical storms can change the abundance and distribution of prey and may have made it necessary for groups to relocate.

Archaeology

Archaeological sites in this area have yielded a variety of terrestrial and aquatic fauna characteristic of the modern environments previously described. Coastal margin sites dating after 5,000 B.P. are typically characterized by shell middens containing aquatic fauna. There is no evidence of a significant maritime adaptation in this area, although one or two examples of marine mammals have been recovered from coastal margin sites, probably the result of prehistoric beach combing activities (Hester et al. 1989). Terrestrial fauna recovered from coastal sites range from large-bodied prey such as deer and the occasional bison to smaller animals such as raccoon and turtle. Inland sites contain comparatively few faunal remains, probably because the inland archaeological record does not have shell middens which alter soil chemistry and subsequently preserve faunal remains as in the cases of coastal margin shell-bearing sites. Bison remains are present on inland (and sometimes coastal) archaeological and paleontological sites, although they are absent in the UTCP by AD 500 and do not reappear until around AD 1200-1300 (Dillehay 1974).

The role of edible wild plants in UTCP subsistence practices is not well understood. Plant remains are extremely rare in archaeological sites in this area (see Ensor and Ricklis 1998 for a report of a nut hull found at the Eagle's Ridge site). Isotope and dental analysis of human remains from Mitchell Ridge, a late prehistoric and historic coastal margin site, indicate decreasing consumption of marine foods over time and a possible increase in finely ground plant foods (Huebner 1994, Powell 1994). Other studies of human remains on the inland portion of the Texas coastal plain suggest greater dependence on C3 rather than C4 pathway foods, at least in the Late Archaic (ca. 1500 BC-AD600; Huebner and Boutton 1992).

UTCP groups most likely had to move to some extent in order to meet their dietary needs; how frequently they moved and where they moved on the landscape are questions which remain of interest to archaeologists working in the region. Researchers working in this area have hypothesized that groups moved between coastal margin and inland environments (Aten 1983), perhaps aggregating on the coast during the winter months and moving to dispersed settlements to pursue large game in the summer and fall (Moore 1995; Ricklis 1996). This idea of seasonal transhumance between the coastal margin and inland areas is not supported by bioarchaeological information derived from individuals interred in Late Archaic and Late Prehistoric cemeteries. These studies suggest that coastal margin and inland groups may have been distinct populations who had little contact with one another. At least some coastal UTCP groups had very little stress from disease or interruption of metabolic growth based on a sample of Late Prehistoric burials (ca. AD 800-1528). Individuals from inland cemeteries during the same period had slightly higher frequencies of physiological disruption, although it is uncertain whether this is from diet or disease (Powell 1987). A subsequent study of another Late Prehistoric coastal cemetery indicated many individuals experienced high rates of endemic disease and possibly poor nutrition (Powell 1990). Other research indicates that coastal margin and inland area groups had distinctly different frequencies of treponematosis, implying that there were distinct groups of people who occupied each area and did not mix with one another (Wilson 2001). Yet the overall homogenous style of projectile points and ceramics across the area suggests that groups had a great deal of contact with one another.

Coastal margin and inland groups may have pursued separate resources. Other research on human remains indicates that at least at some Late Archaic inland sites, 85% of the diet was comprised of C3 pathway plants with similar isotopic signatures to deer and nuts (Huebner and Bouton 1992). It is possible that deer and nuts were so plentiful on the inland portion of the coastal plain that inland groups did not need to move from the interior to the coastal margin for subsistence purposes, although the archaeological information available is inconclusive. It is also plausible that groups moved between coastal and inland environments in order to overcome predictable seasonal resource shortages. Furthermore, residential movement on larger temporal scales may have been necessary, as weather patterns and geologic changes are often parts of patterns which last more than a single annual cycle.

Ethnohistory

Cultural groups as they were identified and named by early Spanish, French, and Anglo-American visitors are sometimes referred to in archaeological discussions; ethnohistoric descriptions suggest that while groups had distinct languages, they had a common economic and cultural background. The *Atakapa* occupied an area around Neches and Sabine Rivers which extended into southwestern Louisiana. The *Akokisa* (including the *Han*) lived immediately to the south and west, and their range extended to just south of Galveston Bay. The *Karankawa* range—including a group referred to as the *Coco* living between Galveston Bay and the Brazos River—may have overlapped with that of the *Akokisa*. Karankawa were reported to live from the southern portion of Galveston Bay south to the Nueces River. The *Bidai* occupied an exclusively inland area northwest of Galveston Bay (see Aten 1983 and Newcomb 1993 [1961] for detailed maps of posited group home ranges).

Accounts from early travelers and later settlers provide glimpses of what prehistoric foraging may have been like on the UTCP. According to historic accounts, individuals fished, but neither lines nor nets were used. Instead, fish were taken with bow and arrow (Gastchet 1891). There is archaeological and ethnohistoric evidence of waterfowl hunting; one ethnohistoric account mentions people taking waterfowl eggs (Gastchet 1891). Food production does not appear to be critical or widespread among prehistoric groups occupying the UTCP. A few ethnohistoric accounts claim that groups living on the northeast inland portion of the UTCP did cultivate maize, but the location and extent of this posited cultivation remains unknown from the archaeological record (Aten 1983; Kniffen et al. 1987; Weddle 1985).

The spatial distribution of these food resources varied temporally throughout the annual cycle. Members of the historic Atakapa group northwest of Galveston Bay are reported to have hunted bison seasonally (Kniffen et. al 1987). Ethnohistoric accounts indicate that groups moved to different locations to take advantage of fish and roots of water plants available on a seasonal basis, during the winter months (Cabeza de Vaca [1542] 2003). Cabeza de Vaca's first account of UTCP natives near or on Galveston Island indicates that there was some seasonal movement:

> They inhabit this island from October to the end of February. They sustain themselves on the roots that I have mentioned, which they dig out from under water in November and December. They have waterways and they do not fish apart from this period; from then on they eat the roots. At the end of February they go to other places to look for food because at that time the roots begin to sprout and become inedible. (Cabeza de Vaca 2003 [1542]).

It is not clear from this account or others where or how much people shifted their residences during the annual cycle. Some ethnohistoric accounts mention people from different ethnic groups converging on the same highly productive inland pecan grove locations (Hall 2000). Other ethnohistoric accounts describe the homes of UTCP groups as being comprised of poles and mats which could be taken down easily in an hour or two and moved, sometimes by canoe (Gastchet 1891; Kniffen et. al 1987). Such portable homes could be an indication of high residential mobility that had antecedents in the prehistoric period, or perhaps groups became more mobile as Anglo-American settlement affected their land-use patterns.

In summary, the environment, archaeology, and ethnohistory of the UTCP give us a picture of a hunter-fisher-gatherer society who made and used pottery as part of their adaptation to an environment rich in wild foods which were almost continually available throughout the annual cycle (although they are not necessarily spatially consistent). Other aspects of UTCP pottery period adaptations are less clear, including the nature and extent residential mobility, the amount of plant use—including cultigens—and the role(s) pottery played in these adaptations.

Goals and contributions of this study

In this study, premises of human behavioral ecology have been used to generate three sets of hypotheses concerning pottery use on the UTCP, and these are briefly described below. In order to begin modeling pottery use to unravel the complexity and variety of hunter-gatherer adaptations, as well as their functions as tools in hunter-gatherer societies, I have developed three sets of hypotheses presented here in the null form. A more detailed discussion of the hypotheses can be found in Chapter 3.

Hypothesis 1a: Ceramic vessels on the UTCP were used as tools to process starchy seeds and/or domesticates.

As mentioned earlier, processing plant foods such as starchy seeds is most effectively done over a direct heat source. Vessels with thin walls conduct heat more effectively than thick-walled vessels. Thin walls also minimize cracking and vessel failure caused by differential cooling of interior and exterior vessel walls (Rice 1987). Thus, if UTCP pots were used primarily to process plant foods such as starchy seeds, then thin walls would be a desirable characteristic. Wide orifices allow unimpeded access to vessel contents, a desirable attribute for vessels used for food processing (Rice 1987).

Pots used to cook high volumes of plant resources commonly exhibit sooting on their exterior and evidence of thermal spalling. Sooting is comprised of carbon and resins deposited on the vessel surface as the result of fuel combustion and can indicate if a vessel was used over heat (Hally 1983, Skibo 1992). Soot is most commonly identified on archaeological ceramic vessels as patches on the interior and exterior portions of the vessel wall. The location of sooting on the vessel can give information on the position of the vessel relative to the heating source. Thermal spalling is also evidence of use over a direct heat source. Spalling consists of holes created by the vaporization of water in the vessel wall. Spalling can occur when water contained in the clay body vaporizes due to firing, or when foods are simmered over direct heat and run out of liquid (Skibo 1992). Vessels intended for frequent use over heat should also have low frequencies of surface treatments which act to limit the porosity and permeability of the vessel. Vessels used to process large amounts of plant foods would be expected to retain organic residues of these resources.

Hypothesis 1b: Ceramic vessels on the UTCP were used as tools to process meat from large-bodied resources.

If UTCP pots were used primarily to cook meat from large-bodied animals, then manufacturing characteristics associated with thermal performance over direct heat would not be desirable. Instead, attributes associated with the physical stability of vessels and their resistance to mechanical shock would be more useful in processing animal foods. If large mammals were commonly processed in UTCP pots, then minerals in vessel pastes the organic residue signatures could be expected to come from non-local sources, the result of groups moving to follow game with large home ranges. If mammals were commonly processes in these vessels, the organic residue would be comprised of large mammals.

Hypothesis 2a: Ceramic vessels on the UTCP were used for "front-loaded" storage.
Hypothesis 2b: Ceramic vessels on the UTCP were used for "back-loaded" storage.

Parts of the empirical expectations for both of these hypotheses are based upon the premise that narrow vessel orifices, thick walls, large sizes, and surface treatments which reduce permeability are make effective storage containers. Orifices of storage vessels are often constricted in order to restrict access to their contents (Rice 1987). Thick walls are useful for storage vessels because they protect the pot from the effects of mechanical shock (Rice 1987). Since storage vessels do not need to be moved often, large size may not be a constraint of vessel performance (Longacre 1985). Surface treatments limiting vessel permeability are desirable when vessels are used to store liquids (see Rice 1987 for examples and exceptions). Vessels used primarily for storage would be expected to have little or no evidence of use over direct heat. Vessels used primarily for "front-loaded" storage would contain foods which must be highly processed prior to storage (Bettinger 1999). Such a storage strategy requires relatively high labor investment in preparing foods for storage. Foods requiring extensive processing prior to storage are unlikely to be left behind as groups moved large distances on the landscape, as leaving the stores would make them vulnerable to theft from animals or other people. Such a storage method is most useful to groups who have relatively low degrees of residential mobility because stores can be guarded. In the case of "back-loaded" storage, food processing costs are low. Instead, preparation costs are incurred when the foods are prepared for consumption. Bettinger (1999) suggests that a "back-loaded" strategy would be most useful to foragers with high degrees of mobility. Stores could be collected and cached with a smaller amount of investment than "front-loaded" stores. Thus, foragers using a "front-loaded" strategy would most likely be using pots made from local raw materials, since they are expected to be tethered to their stores, while more mobile groups would have found a "back-loaded" strategy more useful.

Hypothesis 3: Ceramic vessels on the UTCP were used as objects for gaining and/or maintaining social, economic, or political prestige.

Ceramic vessels can be used to gain and maintain various forms of social, economic, and/or political prestige. Prestige wares can function as objects of wealth in and of themselves, or they can be a symbolic good used to legitimate authority (Rice 1999). Pots can also be used as tools for redistributing wealth, such as serving vessels used for feasting (Hoopes 1995, Rice 1999). The empirical expectations for this hypothesis are predicated on the following assumptions: prestige wares exhibit high frequencies of substantial labor investment (Hayden 1995). Degrees of labor investment can be measured by observing attributes of vessel construction and surface treatment, including decorative embellishment. Utilitarian vessels are expected to have little surface treatment or decoration (Costin 1991, Costin and Hagstrum 1995, Hayden 1998). Such vessels may also be more desirable if they are made from exotic materials or are a rare trade item. The paste of vessels used primarily in social or political contexts may contain materials (aplastics or clays) from non local sources. It is also possible that the primary function of ceramic vessels was to disseminate exotic foodstuffs in social or political contexts. If this was a common function of UTCP wares then assemblages from this area would be expected to contain organic residues of exotic foods outside the local cultural area.

Methods

While many kinds of archaeological data can be used to test the hypotheses discussed above, the archaeological record of the UTCP (and possibly the nature of certain hunter-gatherer adaptations) leaves few avenues of inquiry except for direct study of sherds. For example, grinding stones are often excellent indicators of plant processing but are not present in the archaeological record of the area, probably because there are few local rock sources. Groups may have processed plant resources using wooden implements, a processing tool archaeologically and enthohistorically documented in the Eastern Woodlands and South Texas (e.g., Collins and Hester 1968; Gilliland 1975; Krieger 1956; Willoughby 1935). Faunal remains can be very useful in assessing the nature of the diet of groups in this area. Some sites (especially shell-bearing sites) have well-preserved samples of faunal remains, while others (especially non-shell bearing sites on the inland portion of the study area) have fewer, if any. Thus, sherds are the primary unit of analysis for this study.

Hypotheses concerning vessel function are tested using standard and newly developed methods of ceramic analysis on 5,155 sherds from three Late Prehistoric period (AD 1100-contact) sites located in distinct microenvironments: coastal margin, upland prairie, and an area which straddles both of these zones. Four types of analyses were conducted on sherds to determine the function of vessels from these three UTCP sites: non-destructive measurements and observations on sherds, petrographic analysis of vessel fabric, organic residue analysis of absorbed lipids in sherd walls, and luminescence dating of sherds from each site.

Initially, sherds were analyzed using a series of non-destructive techniques to gain information on vessel size and shape, manufacturing characteristics of vessels pertaining to potential function, and evidence of use for particular tasks. Sherds were measured in order to calculate the size of the vessel (where possible) and the average thickness of vessel walls. The types of inclusions in the sherd pastes were identified and their frequencies were estimated. Other manufacturing characteristics such as surface treatments were identified and their frequencies estimated. The type and frequency of use wear characteristics pertaining to use over heat were also recorded.

Sherds representing a variety of surface treatments and use wear characteristics were selected from the assemblage of each site to be analyzed in thin section to determine if the minerals in sherd pastes were of local origin, or if sherds were from non-local geological sources and therefore possible trade wares. Sherds representing a variety of surface treatments and use wear characteristics were selected for organic residue analysis to determine the presence and nature of food residues. A homogenous sample of sherds was dated from each site using luminescence to determine if the sherds were manufactured at the same time the sites were occupied.

Thesis structure

Chapter 2 summarizes the culture history of the UTCP and adjacent cultural areas. Chapter 3 introduces the theoretical issues implicated with studying ceramic vessel function to learn more about hunter-gatherer adaptations. I describe in detail the three main hypotheses summarized above. I then explain how these hypotheses pertain to subsistence, mobility, and social aspects of hunter-gatherer societies in general and how they are theoretically linked to the possible function(s) of ceramic vessels on the UTCP. Chapter 4 describes the three sites which were the focus of this study (Figure 1.1). Chapter 5 focuses on the results of the non-destructive analyses and explains how they are used to evaluate the hypotheses detailed in Chapter 3. Chapter 6 presents the results of the sourcing study and the information it provides in terms of evaluating the hypotheses. Chapter 7 presents the results from organic residue analysis of selected sherds and evaluates the hypotheses using this data. Chapter 8 synthesizes the implications of the data analyses for determining the functions of UTCP ceramic vessels, and evaluates the significance of this information for research on hunter-gatherer pottery in general, as well as suggested directions for future research.

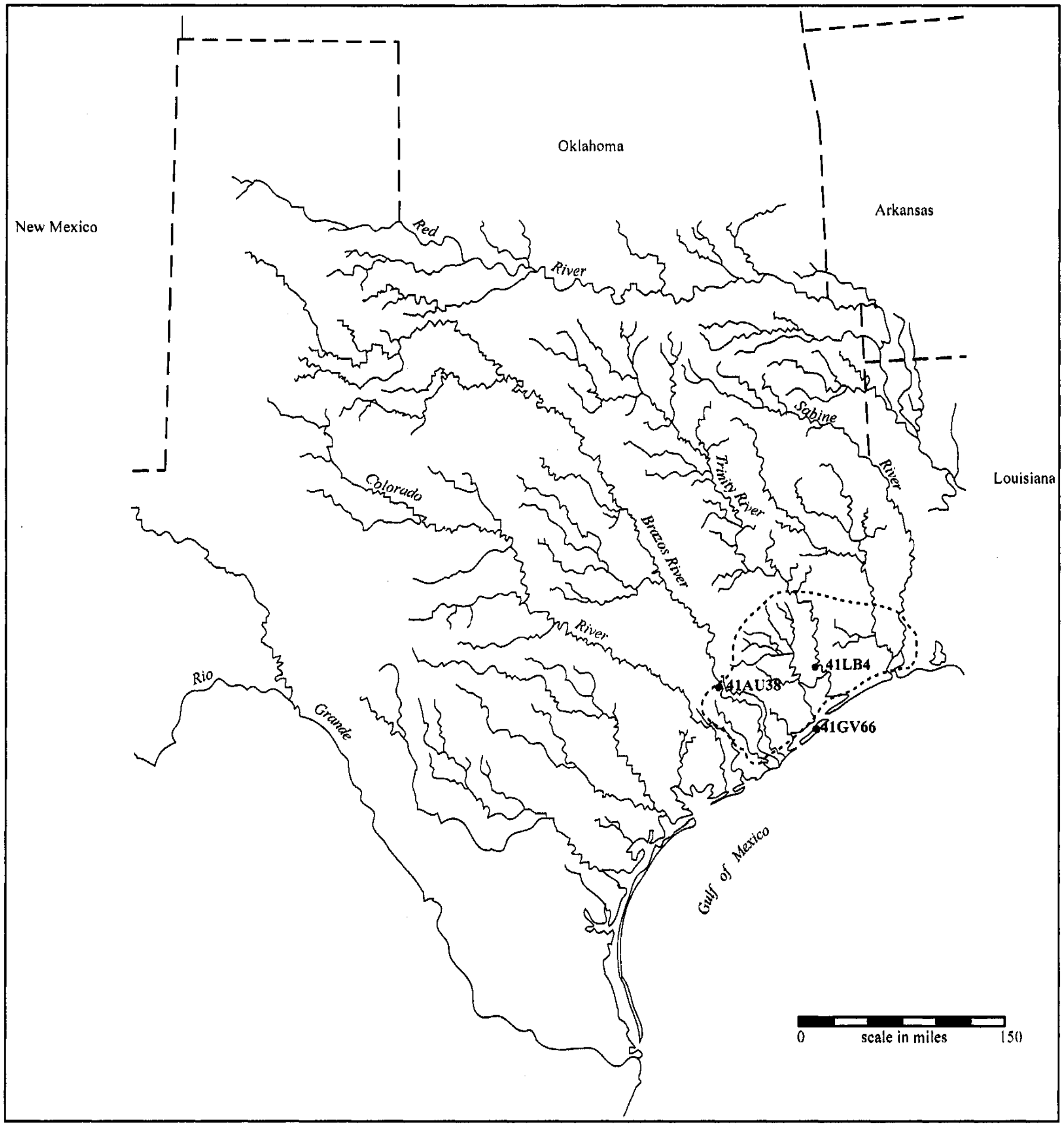


Figure 1.1 Map of the Texas coast with sites included in this study. Dashed line indicates boundaries of upper Texas coastal plain cultural area.

CHAPTER 2: THE PROBLEM OF HUNTER-GATHERER POTTERY ON THE UPPER TEXAS COASTAL PLAIN

People began using ceramic vessels on the coastal margin of the upper Texas coastal plain around 2070-1900 B.P., and possibly as early as 2600 B.P. (Ensor and Ricklis 1998). Inland, ceramics appeared somewhat later by 1500 B.P. (Aten 1983; Ensor and Ricklis 1998). These dates are late compared to those in the rest of the Southeastern United States, where the earliest pottery dates between 5000 and 3000 B.P. (Sassaman 1993). Immediately adjacent to the UTCP, the earliest wares are dated between 3691 and 2791 B.P. (Gibson and Melancon 2004).

The prehistoric area of the UTCP lies immediately south and west of the cultural traditions of the Lower Mississippi Valley (LMV), and shares some cultural traits with the region. Yet the coastal margin and inland cultural adaptations of the UTCP have distinct characteristics which separate the region from the LMV. Like most of their LMV neighbors, UTCP groups continued using pottery through contact with Europeans and Euro-Americans (Figure 2.1). Yet in contrast, UTCP groups continued their hunter-gatherer adaptation while some LMV cultures—mainly the Caddo—shifted to horticulture. There is evidence among some other LMV groups of cultigen use (corn/beans/squash), and wild starchy seeds (Kidder 2002; Kidder and Fritz 1993), although it is not clear how important these plant foods were to LMV inhabitants prior to AD 700 (approximately 1600 B.P.; Kidder 1992). Village settlements are known in the Woodland era LMV, suggesting that some LMV populations had high degrees of sedentariness. Elaborate mortuary practices and interregional trade networks suggest social stratification and complex economic/political systems.

While some aspects of UTCP hunter-fisher-gatherer adaptations are known, others are not as well understood. In particular the degree of mobility and the nature of mobility patterns of groups occupying this area are not fully known. Some aspects of subsistence are well documented, while others—such as the nature and significance of plant use—are not. While there is no tradition of building ceremonial mounds on the

UTCP, it is possible that some of the items associated with burials may be implicated in ceremonial behavior associated with acquiring social/political prestige. The ceramic-era culture histories of the LMV and UTCP are summarized in this chapter, with details on subsistence, mobility, and social stratification in these regions, and pottery developments which might relate to these factors.

The succeeding sections of this chapter outline the basic cultural developments of cultural areas adjacent to the UTCP: the northern and southern portions of the Lower Mississippi Valley including the Caddo cultural area. Then the culture history of the UTCP coastal margin and inland areas is presented, followed by a brief culture history of the central Texas coastal margin, which has some cultural traits in common with the UTCP. The chapter ends with a review of the "Akokisa" model of cultural evolution on the UTCP which guides most of the work done in the region to date.

Lower Mississippi Valley

The prehistoric cultures of the area known as the Lower Mississippi Valley (LMV) occupied an area which stretches from what is now central Arkansas south to coastal Louisiana. It is hypothesized that early LMV pottery traditions diffused slowly from the Atlantic southeast, where the earliest wares are dated to 4,500 B.P. (Sassaman 1993; Walthall 1980). Cultural adaptations throughout the region had varying degrees of sedentariness, plant use, and social/political/economic complexity (as evidenced by trade networks, earthworks, and mortuary practices). Archaeologists working in the area hypothesize that by 3000 BC (roughly 4,500 B.P.), groups in the LMV engaged in seasonal subsistence rounds and had base camps where they were sedentary for at least part of the annual cycle (Jeter et al. 1989). The archaeological record in the northern portion of the LMV indicates that northern LMV cultures used starchy/oily seeds and developed a strong reliance on maize by the Mississippian Period. Use of cultigens and starchy seeds, conceptually linked with other cultural developments in the American Midwest and Southeast, is less evident throughout the ceramic periods on the coastal portions of the LMV. Evidence of hierarchical social ranking varied between cultural periods and regions throughout the LMV, but appears to be generally greater in the northern LMV and trans-Mississippi South.

Northern Lower Mississippi Valley

By AD 600-1000 (roughly 1400-1000 B.P./Plum Bayou Culture) sites in southeastern Arkansas contain hickory nuts and acorns, as well as starchy seeds such as chenopod, maygrass, knotweed, sumpweed, and little barley. Bottle gourd is present in some sites, as well as maize kernels (Rolingson 2002). In northeastern Arkansas around AD 1000-1500 (approximately 1,000-500 B.P.), Mississippian people consumed maize, starchy seeds and nuts (Jeter and Williams 1989).

Mississippian cultural occupations were typified by high population concentrations in single locations, some of which were fortified with palisades. Cultures in eastern and northwest Mississippi (Baytown Period/culture) built villages clustered around mounds. By the protohistoric period, some groups in the northern portion of the LMV were highly sedentary. The arrangement of houses in rows in Mississippian villages in this area indicates community planning. Storage pits are common features in the archaeological record, which suggests that populations may have been sedentary for at least part of the annual cycle (Jeter and Williams 1989).

In contrast to the central and southern LMV, the northern portion of the Valley has yielded more evidence of contact with the Midwest (i.e., Hopewell and Cahokia cultures) in the form of exotic trade goods such as mica and copper cutouts, galena, and items with raptorial bird designs. Microblade and core technology, hoes, chunky stones, and shared pottery types indicate influence from Cahokia and other areas north of Arkansas. Mississippian groups in the northern LMV were involved in trade of shell-tempered pottery, non-local chert, galena, copper, and marine shell. Pyramid-shaped mounds were arranged around central plazas, suggesting large ceremonial activities. By AD 1500, the northern portion of the LMV was still the site of Mississippian culture, with nucleated settlements with palisades and maize cultivation.

Exotic trade goods such as marine shell, salt, exotic cherts from the Midwest, copper and galena are present in some sites from this time period (Jeter 1989).

Trans-Mississippi South

To the north and west of the central and southern LMV (in what is now western Arkansas, eastern Oklahoma, northwest Louisiana, and northeast Texas) the Fourche Maline culture (ca. 300 BC-AD 800) occupied what eventually became the Caddoan homeland. By about AD 800 (approximately 900 B.P.), the Fourche Maline culture had transitioned to the distinct Caddo culture (Figure 2.2). Generally, Fourche Maline material was characterized by bone, sand, and grog-tempered pottery, Gary dart points, hoe-type tools, boatstones, platform pipes, and large amounts of grinding stones (Jeter et al. 1989; Schambach 2002). There is not much direct evidence for starchy/oily seed use or maize horticulture, although it is not clear if this is a result of prehistoric people not using these resources or a bias in flotation recovery techniques (Schambach 2002). The hoes (sometimes referred to as "double-bitted axes") may have been used for cultivating, and the large amounts of grinding implements suggest heavy use of plant foods. Fourche Maline villages have large, deep midden deposits which indicate they were occupied for long periods of time. There is no evidence of storage pits (Schambach 2002). Fourche Maline groups buried selected individuals in mounds, and in the latter part of this cultural period, burials contained ornaments made from human and animal bone, cremations, and boat stones. There was no evidence of trade with Marksville cultures to the south.

Like their Mississippian counterparts, the Caddo cultivated maize and other tropical cultigens (although there is little or no information on plant use between AD 700 and AD 1000; about 1300-1000 B.P.). Both societies had hierarchical social structures (as indicated by non-local grave goods), and an intense ritual and ceremonial life as evidenced by mound-based civic and ceremonial centers (Perttula 1992). Although the Caddo did engage in warfare, Caddo villages did not have palisades as Mississippian centers did. Instead, Caddoan ceremonial centers appeared to be relatively unoccupied while most of the population lived in dispersed farmsteads along river valleys. In addition to maize, squash, and gourds, the Caddo utilized wild foods including nuts, wild starchy seeds (including maygrass, amaranth, chenopods, and sunflower), deer and a wide variety of other wild fauna. Caddoan groups were engaged with long-distance trade as well; marine shell, effigy pipes and large crystals of quartz, galena, bauxite and glauconite were present in Caddo graves. Other grave goods included arrow points, bifaces, knives, and celts, and finely made pottery (Perttula 1992). The presence of ceramic types common to the LMV, Plains and Texas in Caddoan sites indicate exchange of pottery and/or ideas. The Caddoan Spiro mound complex in eastern Oklahoma has evidence of trade with Cahokia (Jeter and Williams 1989). Interaction between Caddoan and Mississippian groups peaked during this period of time, as evidenced by similar styles of pottery, house styles and mound construction techniques. Skeletal analyses indicate that by AD 1100-1300 Caddoan consumption of maize was quite high (Perttula 1992). On the eve of contact with Europeans the Caddo were also engaged in extensive trade networks reaching west to New Mexico, north to the Arkansas River, and south to the Gulf of Mexico. By contact, the Caddo were trading locally procured salt and bow wood along with horses, Native American slaves from the Plains and Southwest, and finely made pottery (Jeter 1989; Perttula 1992). While they continued to cultivate maize and beans at contact, Caddo settlements became dispersed, burial mounds were used less, and burials contained fewer grave goods (Jeter 1989).

Southern Lower Mississippi Valley

Southern LMV cultures often did not develop nucleated settlements or planned communities like many groups in the northern LMV. In coastal sites throughout the ceramic periods, the presence of *Rangia cuneata* (clam), various sizes of mammals, and fish have been interpreted to indicate that coastal groups relied more heavily on wild resources and maintained a more mobile settlement pattern relative to their northern neighbors (Jeter et al. 1989). Information on wild and domesticate plant use on the coastal portion of the LMV is limited. Some gourd seeds have been documented in Tchefuncte Period (Figure 2.2) contexts, but information on other domesticated plant foods is lacking (Jeter et al. 1989; Kidder 2002). In the Marskville Period (Figure 2.2) evidence of wild plants has been found, there is no evidence of starchy seeds or cultigens (Jeter et al. 1989; Kidder and Fritz 1993; Kidder 2002). The Late Prehistoric cultures of central and eastern Louisiana (Plaquemine) showed very little evidence of maize cultivation or consumption (Figure 2.2). Locations of Plaquemine Period settlements on both fertile natural levees with well-drained soils and estuarine locations lead some researchers to hypothesize that coastal groups were aggregated in sedentary settlements on the levees for horticultural activities and then dispersed for seasonal fishing and shellfishing activities. Whether inland Plaquemine groups actually cultivated plants is unknown (Jeter and Williams 1989).

At time of contact, sites in the coastal area of Louisiana have little evidence of plant cultivation, long-distance trade, and social ranking. There is evidence that Mississippian groups from Florida and the Northern LMV moved into the area bringing concepts of horticulture and social ranking (Jeter and Williams 1989). Inland groups used some maize, cucurbita, chenopodium, knotweed, and amaranth. Some historic groups such as the Tansa, Natchez, and Houma cultivated maize and beans and consumed wild nuts.

Evidence of earthworks and interregional exchange, often implicated with some level of social/political economic complexity, are present mostly at sites in the inland portion of the southern LMV. The earthworks and interregional exchange system of Poverty Point are most notable during the period of 1700-500 BC (approximately 3,500-2,500 B.P.), although mound building activity in the LMV and greater American Southeast dates earlier than Poverty Point (e.g., Russo 1994; Saunders et al. 2005). Material culture consists primarily of dart points typologically similar to those found in large portions of what are now Louisiana, Arkansas, southeastern Oklahoma, and southeastern Texas (Jeter et al. 1989). Pottery with a variety of temper types/inclusions was present at Poverty Point, and perhaps earlier

(Gibson and Melancon 2004). The decline of Poverty Point as a center of long-distance exchange coincided with a lessening of trade throughout the region (Jeter et al. 1989).

Hopewell-style cordmarked, paddle-stamped, and fabric impressed pottery types (e.g., Mazique Incised, Baytown Plain, and Coles Creek Incised) in southern LMV burials and domestic ceramic assemblages suggest contact with Hopewell culture in the Midwest. Other Hopewell trade goods such as mica cutouts and copper are rare in southern LMV sites, leading researchers to question the idea of direct contact between Hopewell and Marksville cultures (Jeter et al. 1989; Kidder 2002). Burial customs of inland groups were characteristic of Hopewell, such as mass burials in conical mounds with grave goods, may indicate social stratification as all members of society appear to be buried in this manner (Jeter et al. 1989). Ceremonial behavior in inland and coastal Plaquemine cultures (Figure 2.2) is evident in mortuary features, which include burials in charnel houses (wooden structures often built on mounds and used to house human remains). Mortuary ceremonialism appeared to be elaborate in some cases (Jeter and Williams 1989). Coastal burials from all time periods lack grave goods, which has been interpreted to mean a lack of social stratification. Between AD 1100 and 1200 Cahokia (roughly 800 BP)—a major center of complexity and interregional interaction in the Midwest— reached a cultural zenith. While contemporaneous cultures in central and eastern Louisiana had settlements with a Mississippian-style layout of nucleated settlements around mounds, it is unknown if there was communication between Mississippian, Coles Creek and Cahokia cultures.

Upper Texas Coastal Plain

The upper Texas coastal plain (UTCP) is located in a physical environment similar to that in which the cultures of the Lower Mississippi Valley were situated, and was culturally linked to these groups through shared pottery types (Aten 1983; Ensor and Ricklis 1998; Walthall 1980; Wheat 1953; Figure 2.1). Paleoindian and Early

Archaic sites are rare on the landscape, probably because they do not resemble later sites. Early sites may not be visible because they are under water from Holocene sea level rise and/or stream prograding, which buried them under alluvium (Aten 1983; Ricklis 2004a).

Archaic Period: Coastal Margin

The Archaic Period on the UTCP coastal margin was characterized by preceramic shell midden occupations dating as early as 4,500 B.P. Shell middens (sites whose matrix is primarily shell) and shell-bearing sites (those with relatively small amounts of shell) are found dating throughout the remainder of the prehistoric record, and often contain numerous faunal remains but little botanical material. UTCP Archaic middens contain dart point styles typical of Archaic Period sites across Texas, especially of the inland northeastern portion of the state. Lithics are the most common artifact on Archaic Period sites, yet they are scarce throughout the UTCP, making the preceramic chronology somewhat nebulous (Ensor and Ricklis 1998). What is known is that the Archaic Period, divided into the Early Lithic Period (7000-4000 BC), Middle Lithic Period (4000-1000 BC) and Late Lithic Period (1000-300 BC); was characterized by distinct dart point styles commonly found in other cultural regions of Texas and the LMV (Jeter et al. 1989; Ricklis 2004a; Story 1990b). Most lithics from the UTCP are usually classified as nonlocal cherts from unspecified locations. Local stone varies considerably in composition and utility for knapping (Ensor 1995). Local sources included quartzites and petrified wood from Trinity River and San Jacinto River gravel deposits, and possibly alligator gastroliths (Aten 1983; Ensor and Ricklis 1998). Higher quality stone was often from non-local sources (Ensor and Ricklis 1998). Lithics from the Middle Lithic Period were often made from Edwards Plateau chert cobbles from the lower Colorado River, and possibly the Brazos and Guadalupe River drainages (Ensor and Ricklis 1998). At some sites such as Eagles Ridge (41CH252), Late Archaic raw material quality became relatively poorer compared to the Middle Lithic Period, as people used more local resources and smaller pieces of material (Ensor and Ricklis 1998). It has been speculated that perhaps high reliance on local lithic resources indicates stringent social boundaries (Ensor and Ricklis 1998).

The mobility pattern(s) of Archaic Period populations are not clear. On the UTCP, microstructural analysis of shell growth rings on the brackish water clam *Rangia cuneata* from archaeological sites have commonly been used to estimate season of occupation. Occupations often appear to be late spring/early summer. At Eagles Ridge, Middle Lithic Period shellfish data indicate a winter/spring occupation, while late Lithic Period data suggest a shift to strictly spring season gathering (Ensor and Ricklis 1998). Some upland delta sites such as Eagles Ridge may have been used to take advantage of upland resources at times when lowland areas were inaccessible due to spring flooding in the delta (Ensor and Ricklis 1998). Research by Aten (1999) indicates that seasonality data may be problematic, as *Rangia cuneata* have environmentally driven growth, and may be responding to temperature changes not linked with seasonal change. Fish otoliths indicate that Eagles Ridge was occupied year round during the Middle Archaic Period, with an emphasis on spring/summer and fall, which has been interpreted to mean that people were relying on a broad base of resources (Ensor and Ricklis 1998).

It has been suggested that sites become more frequent on the landscape in the Late Archaic (Aten 1983; Ricklis 2004a). Late Archaic occupations at such as that at the Harris County Boys School site (41HR80 and 41HR85) have more dense cultural material in Late Archaic compared to Middle Archaic occupations. Compared to the nonlocal lithic raw materials common in Middle Archaic sites, Late Archaic sites lithic raw materials frequently consist of local pebbles, suggesting that coastal populations traveled and/or traded less frequently to obtain lithic raw materials (Ensor and Ricklis 1998). Archaic Period cemeteries are not known on the coastal margin (Aten 1983).

Archaic Period: Inland Area

In contrast to coastal margin Archaic Period sites, inland Archaic Period sites typically had little faunal or botanical material. Lithic assemblages included dart point types common to northeastern and southeastern Texas. However, East Texas point styles such as Palmer, Johnson, Graham Cave and Big Sandy are not present on the UTCP (Ricklis 2004a; Story 1990b). Site types include low density artifact scatters on pimple mounds, which have been argued to be short duration hunting camps (Moore 1995). Other inland sites had preceramic and ceramic components, suggesting long periods of occupation, which may indicate high residential stability despite technological changes over time in lithics and ceramics (Moore 1995). Large base camp-type sites in inland settings suggest to some researchers that perhaps there was an inland adaptation distinct from the coastal margin (Ensor and Ricklis 1998). Archaic cemeteries were present in the southwestern portion of the inland UTCP, and sometimes contained more than 200 individuals. Nonlocal items such as corner-tang knives made from Edwards Plateau chert, boatstones from southwestern Arkansas, and marine shell ornaments occurred as grave goods in burials between 700 BC and AD 400 (roughly 2500-2400 B.P.), leading Hall (1981) to propose that there was interaction between the inland coastal plain groups and others on the coastal margin, Edwards Plateau in Central Texas, and LMV groups during this time period (Hall 1981).

Ceramic Period: Coastal Margin 485/70 BC-AD 500

Pottery appears on the coastal margin of the UTCP somewhere between 485 and 70 BC (Aten 1983; Ensor and Ricklis 1998; Figure 2.2). Early UTCP pottery resembled Lower Mississippi Valley Tchefuncte and Mandeville wares in decoration and construction. Thus, archaeologists have speculated that pottery appeared on the UTCP as the result of westward movement of people and/or ideas from the lower Mississippi Valley, and was possibly maintained as a technological tradition by small-scale interaction with Lower Mississippi Valley cultures (Ensor and Ricklis 1998;

Moore 1995; Patterson 1993). How rapidly the technology was adapted is also a matter of speculation; ceramic vessel technology may have been adopted gradually, although the dates of the early ceramic component of Eagles Ridge (41CH252) overlap with similar Tchefuncte and Mandeville wares in the Lower Mississippi Valley. The similarities indicate little if any time lag between the use of the wares in the LMV and their adoption on the UTCP (Ensor and Ricklis 1998; Ricklis 2004a).

Roughly during this time span, the well-known Tchefuncte culture in the central and southern portions of the Early Woodland LMV (Tchula period: 600/500-100 BC/AD 1, roughly 2,550-2,100 B.P.) was characterized by Kent dart points, clay balls similar to Poverty Point objects, and middens of the brackish water clam *Rangia cuneata*. Tchefuncte pottery is distinctive artifact of this cultural area and time period. Tchefuncte Plain pottery has been described as low-fired, poorly wedged, contorted paste with silt and silt-size quartz grains, a small amount of fine sand, and incidental inclusions of vegetal matter and hematite nodules (Ford and Quimby 1945). Decoration techniques include incising, rocker stamping, dentate stamping, fluting, drag and jab incising, pinching and punctuating, and cord impressing (Ensor and Ricklis 1998). Vessels commonly have podal base supports (Gertjejansen and Shenkel 1983). UTCP Tchefuncte-style ceramics do not have the sculpted bases characteristic of the LMV Tchefuncte, but they are otherwise similar in paste and decorative techniques (Ensor and Ricklis1998). Mandeville wares were commonly tempered with coarse sand, and were poorly smoothed, deep bowl and jar forms with flattened to slightly rounded bases. This early pottery was replaced by a local undecorated sandy paste ware known as Goose Creek Plain by about AD 200 (approximately 1800 B.P.). The pastes of Goose Creek wares were more thoroughly worked than Tchefuncte and Mandeville pottery. Tchefuncte wares appear to have dropped out of the UTCP record by the Clear Lake Period (AD 425; Table 2.1). Early UTCP ceramics were originally thought to occur in low densities (Aten 1983) but the large volume of pottery recovered from the Eagles Ridge site suggest that ceramic-making was quickly well-established in the UTCP (Ensor and Ricklis 1998). Marksville wares, common in the

LMV during this period, were non-existent in the UTCP—except for small amounts of Marksville sherds in the Sabine Lake area (Ricklis 2004a). Although UTCP pottery types became more distinct from LMV types, the local ceramic typology commonly used in the UTCP is modeled on Phillips' 1970 typology for the Lower Mississippi Valley, which emphasizes paste types (Aten 1983).

The transition from the Archaic to Early Ceramic Period was also marked by a shift from Kent to Gary dart points. Socketed bone points characteristic of LMV Late Woodland Period cultures (such as Troyville and Coles Creek, Figure 2.2) were present in the Clear Lake through Turtle Bay Periods (Table 2.1). Lithics in early ceramic occupations indicate an emphasis on conserving raw materials (by reworking bifaces) and focusing on local raw materials from the Trinity, San Jacinto and Brazos River valleys (Ensor 1995). Distinct Galveston Bay area cemeteries have led some to infer that groups began to establish distinct social boundaries just after the Clear Lake Period, instead of during the Round Lake Period as originally posited by Aten (Ensor and Ricklis 1998).

Ceramic Period: Coastal Margin AD 500- AD 1528

The Late Ceramic Period on the coastal margin began with the appearance of expanding stem-style Alba, Catahoula, and Scallorn arrow points around AD 700 during the Turtle Bay Period (Ricklis 2004a; Table 2.1). By AD 1200 or 1300, Perdiz points, bifacial knives, and drills were common in coastal lithic assemblages, which some researchers link with the return of bison to the coastal prairies at this time (see environmental section and Dillehay 1974; Ricklis 2004a). While the coastal margin of the UTCP has LMV ceramic types and differential distribution of grave goods (see below), the trajectory of cultural change on the UTCP does not follow that of many other Southeastern groups (Story 1990b). UTCP groups never developed ceramic assemblages with high frequencies of cord and fabric-impressions, burial mounds, or the stratified social organization common to the Woodland Period (1000 BC-AD 950, roughly 2800-1200 B.P.). By AD 800, local Mississippian cultural manifestations, including long-distance exchange and maize-beans-squash horticulture appear among the Caddoan groups in what are now Oklahoma, Arkansas, Louisiana, and East Texas. In contrast to the Woodland and Mississippian cultural developments throughout much of the Southeast, subsistence on the UTCP appears to remain focused on the terrestrial and littoral resources commonly appearing in Archaic Period occupations.

There has been some disagreement over the formal term for describing ceramic occupations; a fact which reflects the difficulty of placing what is essentially the Archaic period with ceramic vessels into a cultural stage which articulates neatly with cultural stages of the adjacent Lower Mississippi Valley and other Southeastern cultural complexes. Occupations from all ceramic periods are typically referred to as the "Mossy Grove" tradition (Story 1990b), commonly understood to be characterized by undecorated sandy paste ceramics, Gary and Kent dart points, and Alba, Catahoula, Perdiz, Scallorn, Agee, and Homan arrow points. These artifact types were common to large portions of the western gulf coastal plain and inland south Texas (Aten 1983). Some researchers have argued that "Mossy Grove" should really be linked with the Woodland Period defined simultaneously in other parts of the Southeastern United States, as UTCP pottery assemblages contain conidial shapes and cord marked surface treatments common in other areas of the Woodland Southeast (Aten 1983; Schafer 1975). Ensor and Carlson (1988) point out that the incised and punctated motifs present on some UTCP pottery most closely resemble Gulf Formational Period assemblages further east on the Gulf Coastal Plain. Some changes in ceramics occurred in the Late Prehistoric Period; grog temper becomes very common in ceramics around AD 1000 at the end of the Turtle Bay Period (Aten 1983; Table 2.1), and vessels with Coles Creek-Plaquemine designs appear on some sites (Ricklis 2004a). Rockport, a Late Prehistoric ceramic type with characteristic asphaltum surface treatments has been documented on upper Texas coastal and inland sites (Ellis 1995; Ricklis 1994; Figure 2.2).

Researchers working in the area have argued that higher populations can be inferred during the Late Prehistoric Period, as barrier island sites such as Mitchell Ridge around AD700/800 showed signs of increasingly dense occupations (Aten 1983; Ricklis 2004a). Burials in coastal cemeteries like Mitchell Ridge had varying amounts of grave goods, including engraved bird bone whistles, and beads made from shell and bird bone. In addition to rising populations, Ricklis has argued that social complexity can be inferred from the distribution of grave goods in the four prehistoric cemeteries at Mitchell Ridge (Ricklis 1994). At this site, the cemeteries were contemporaneous, but one clearly had more grave offerings per burial than the others. Ricklis argues that the distribution of grave goods supports the idea that some members of this society were spatially set apart from others, indicating ranking within the group.

Ceramic Period: Inland Area

By AD 500 pottery appeared on the inland portions of the UTCP (Ricklis 2004a; Figure 2.2), later than it did on the coastal margin. Early assemblages were sand-tempered, but by AD 1000 grog temper was common in ceramic assemblages throughout the coastal and inland UTCP. Some bone tempered wares were present on inland sites as well (Ricklis 2004a). Pottery in the northeastern portion of the inland UTCP was reported to have some stylistic similarities to Caddo wares, including brushed and punctuate designs. These design similarities could indicate contact between UTCP inland and Caddo groups (Ricklis 2004a). Around AD 600/700, the bow and arrow appeared. In the northeastern portion of the inland UTCP, Gary points and ceramics were found together, and in the later portion of the Ceramic Period Alba, Catahoula, and Perdiz arrow points were present (Ricklis 2004a). In the southwestern portion of the UTCP (near the lower portion of the Brazos River), Gary, Ensor, and Godley dart points were present and Scallorn arrow points appeared later in the ceramic period.

Inland Ceramic Period sites had few faunal remains, although deer, raccoon, turtle, and fish remains were sometimes present. Ethnohistoric accounts claimed that some groups in the northeastern portion of the UTCP cultivated maize (1993). Sites were often located on uplands overlooking river valleys, leading Moore (1995) to hypothesize that inland groups were most likely tethered to waterways for transportation, potable water, and food resources such as fish, reptiles, and medium-small animals. Moore hypothesizes that inland peoples dispersed into small groups during the warm seasons, and aggregated into larger groups during the cold season. As population increased, large bands were forced to fission, allowing social organization of lineage-based bands to remain the same. Each of these social units generated a series of sites in varying categories that would reflect a seasonal round arrayed along stream channels, which in time came to reflect social boundaries (Moore 1995). Moore further hypothesizes that transhumance may not have occurred b/t the inland and coastal zones of the UTCP. As noted previously, a study of human remains noted higher frequencies of treponematosis (a result of endemic and venereal syphilis, and yaws) among individuals interred in coastal margin cemeteries compared to those from inland cemeteries, and that this trend did not change through time. It is inferred that coastal populations were denser and more spatially constrained than inland populations (Wilson 2001).

Historic Period

The Historic Period on the coastal margin began with the shipwreck of Álvar Núñez Cabeza deVaca and crew members of the Navarro Expedition in November 1528. Originally looking for the mouth of the Mississippi River, the expedition's ships were blown off course by a storm. Some of the crew landed on an island whose description is similar to Galveston Island. Cabeza deVaca, in his attempts to return to previously established Spanish settlements in New Spain, traveled throughout coastal and inland Texas and Mexico for nine years. His account of the journey provides the earliest ethnohistoric account of native life on the UTCP. Other European explorers followed. Simars deBellisle, part of an expedition headed to Louisiana, landed in Galveston Bay in 1719 and was taken captive after he and four other people went ashore and were left by their party. DeBellisle traveled to the San Jacinto River and met natives on an island in Galveston Bay and traveled with them as a slave/servant, after the death of his travel companions. The establishment of New Orleans in 1718 brought French traders into contact with UTCP native groups. Trader Joseph Blancpain traded furs with natives starting in 1729; a French trading post was established in the UTCP area in 1754. This interaction between UTCP natives and the French provided some historical documentation of trade not only between natives and Europeans, but between native groups.

Moore has suggested that European accounts of trade between native groups indicate that native groups were trying to maintain their traditional adaptations (Moore 1995). He points out that the Akokisa remained hunter-gatherers, even when their Caddo neighbors did not, and suggests that the Akokisa traditionally traded meat for agricultural products and littoral resources for lithic raw materials (Moore 1995). An ethnohistoric account mentions Atakapan groups trading smoked fish, marine shell, moss, tar, and feathers with Caddoan groups for lithic raw materials, bow wood, and pottery (Kniffen et al. 1987). Interestingly, historic Atakapan groups are described in this account as making little pottery themselves. Even though they apparently knew how to make it, they preferred to trade with the Karankawa for it. Other ethnohistoric accounts describe Karankawa trading for sea shells (usually conch) and a bean-like fruit (possibly mesquite pods) for skins, cane, and ochre (Ensor and Ricklis 1998).

The Spanish tried to counteract the French presence by establishing Presidio de San Augustine de Ahumada near what is now the town of Anahuac at the mouth of the Trinity River, and Mission Nuestra Senora de la Luz del Orcoquisac, on Trinity Bay in 1756. The Mission Period (AD 1720-1771) was short-lived and effectively ended with the abandonment of the presidio and the mission (Aten 1983). Euro-American settlement of the inland area began somewhere between 1823 and 1825, when a group of settlers led by Stephen Austin obtained land grants from the Mexican government to settle in along the lower Brazos River in the modern counties of Fort Bend and Brazoria. By AD 1840, natives of the UTCP are rarely mentioned in period accounts (see Moore and Donachie 2001 for one exception). Archaeologists infer that this decrease in native populations is largely due to mortality from introduced diseases from the time of initial contact with Europeans, and movement associated with dislocation of UTCP and adjacent groups (Moore and Donachie 2001).

Central Texas Coastal Margin

The cultural area of the central Texas coastal margin extends from approximately south of the upper Texas coastal plain around Matagorda Bay to the northern shore of Baffin Bay (Ricklis 2004b; Figure 2.1). The earliest unequivocal evidence of human habitation is dated to about 7500 B.P. Early occupations consist of thin but dense layers of oyster (*Crassotrea virginica*); some shells appear to be modified into knife-like tools. There were few other faunal remains. Artifacts found on the surface of the shell layers included Uvlade and Gower dart points, and flakes. Shoreline occupation during the period of 5800-4200 B.P. was marked by *Rangia flexuosa* middens, fish otoliths, and an array of Archaic Period dart points including Gower, Tortugas, Bell, and early triangular-style points. A set of postmolds has been documented on one site (Ricklis 2004b). Seasonal analyses of oyster shell from Early Archaic middens indicated a winter-spring occupation. There are no sites documented for the time period between 4200 and 3100 B.P., except for a possible oyster scatter with no associated artifacts (Ricklis 2004b). Sites became common on the landscape between 3100 and 950 B.P., starting about the time sea level stabilized at the modern level around 3000 B.P. (Ricklis 2004b). Shell middens dating to this Late Archaic Period contained Catan, Kent, Godley, and Matamoros dart points, as well as knives, scrapers, and bone tools. Shell tools, often made from conch shell were common. Faunal material, especially fish and deer bone, were more frequent than in earlier sites. Analyses of growth rings on oyster shell indicate that shell midden sites were occupied winter through spring. Ricklis (2004b) has reported one cemetery possibly dating to the Late Archaic.

The Late Prehistoric Period began around AD 1000 (about 1000 B.P.) with the appearance of plain, sandy paste pottery and Fresno and Scallorn arrow points. By AD 1250/1300 Perdiz arrow points and asphaltum-coated (tarred) pottery appear on the coastal margin, forming a distinctive cultural period known as Rockport. Notched rims and bowl, jar, and olla forms are common in Rockport ceramic assemblages. Rockport wares are found as far north as southern Galveston Bay. The geographical distribution of Rockport extends from the immediate shoreline to 40 kilometers inland. In addition to asphaltum-coated pottery, the Rockport Period was distinguished by unifacial scrapers, bifacial knives, drills, prismatic blades, ceramic pipes coated with asphaltum, bone points, awls, bird bone beads, and shell tools. The Rockport lithic assemblage was similar to that of Toyah groups living more than 40 kilometers inland. Toyah pottery—usually classified in Texas typologies as Leon Plain—is not coated with asphaltum, and has high frequencies on bone temper. Rockport is associated with the historic Karankawa culture. Ethnohistoric accounts describe Karankawa groups living in large fall/winter season camps on the shoreline, and then dispersing into smaller inland camps in the spring and summer (Ricklis 2004b).

Akokisa Model

The longstanding and influential model of cultural evolution on the UTCP is Aten's "Akokisa Model" (Aten 1983; Table 2.1). Aten created the model working backward from historic period population estimates and early historic accounts of population aggregation and dispersal. Historically, UTCP groups were observed to aggregate in villages of 400-500 persons in the winter months, and disperse into band-sized groups in the warm season. Aten hypothesizes that population gradually increased through time, and large village groups began to fission when they had over 450 members. During the Late Archaic Period, groups expanded into unoccupied spaces on the landscape while they maintained a fairly stable archaic tool kit (without pottery).

Aten argues that during the period of AD 100-AD 800 there were changes in UTCP subsistence and social organization. People developed or adopted technologies designed to extract more energetic returns from food resources: pottery, bow and arrow, and fish weirs (Table 2.1). There is no remaining physical evidence of fish weirs, although weirs were mentioned in ethnohistoric accounts on the UTCP and the LMV coasts (Aten 1983; Jeter 1989). Mortuary practices changed as well, as burials become visible on the landscape during the Mayes Island Period (AD 425-600). Aten interprets changes in technology as indicators of subsistence change. He argues that as populations grew and groups became more packed on the landscape, competition for resources increased. Aten interprets the appearance of cemeteries during the Turtle Bay Period (AD 650-1000) as indicators of increasing territoriality where cemeteries marked the locations to which members of particular groups were closely tied. Increases in population and territoriality led to a subsequent reduction of foraging ranges, which in turn affected the availability of large-bodied resources. As a result, people used a wider range of small-bodied species as their resource procurement range decreased. As a result of reduced foraging ranges, groups become more sedentary. The period between AD 800-1700 marked increased innovation in ceramic design and expansion of bow and arrow use, which might have increased hunting efficiency to counter declining return rates. Aten admits that the increased use of the bow and arrow in the historic period could also have been a result of the return of bison to the area and the burgeoning fur trade with Europeans, rather than an indication of more efficient capture of small-bodied prey (Aten 1983).

The Akokisa model is used in various modified forms in the region today. For example, other researchers have hypothesized that as groups became less mobile, they may have increased their focus on littoral resources. Separate settlement systems for the inland and the coast may have been in place by the end of the Late Archaic, most likely due to population increase, which in turn increased socio-political complexity and participation in regional economic spheres within the inland and coastal margin areas (Ensor 1998). Ceramic vessels are implicated in this family of models in several ways. Pots are interpreted as markers of technological change in response to the changing availability in resources due to territorial packing of the landscape. They are also visible links of contact and/or trade with other cultural regions with documented archaeological and historic records of long-distance trade, warfare, large earthworks, elaborate ceremonial behavior, and social ranking. In other words, the presence of ceramic vessels on the UTCP continues to be used to infer a semi-sedentary to sedentary hunter-gatherer adaptation with high population densities, limited mobility, and exclusive rights to food resources and in some cases food production and/or an increasingly intensive reliance on wild plants (Moore 1995; Story 1985, 1990b). Design styles similar to those found on LMV wares have been used to infer UTCP participation in regional trade, and complex structures of social organization (Aten 1983; Ricklis 2004a).

UTCP vessels appear in contexts that make their roles in food production and storage unclear. Their functions remain unknown, although their presence is frequently used to interpret site function (Moore 1995). Researchers have speculated about vessel function among UTCP hunter-gatherers. Pots may have functioned as generalized tools used for a variety of tasks (Ellis 1995; Ensor and Ricklis 1998). Other ideas of function include rendering grease, direct cooking (Ensor and Ricklis 1998), indirect cooking (Ellis 1995), tar processing, processing and storage of plant products (Moore 1995), and general storage and transport of goods, including foodstuffs (Moore 1995). More generally UTCP adaptations still are not well understood. While most (if not all) groups in this area do not appear to have engaged in food production or long-term storage, the extent and nature of food storage in this region is not known. Like some groups living in the coastal portions of the LMV, UTCP foragers may have depended little on starchy seeds, or they could have depended on them quite heavily like many other Eastern Woodland Period populations in the American Southeast.

Did Geography and Climate Affect Cultural Change?

The upper Texas coastal plain (UTCP) is part of the Gulf Coastal Plain physiographic province. The region is comprised of wedges of sediment which have been deposited by river activity since the Cretaceous (65 mya). These sediments dip gently seaward at an angle of five feet or less per mile. Thus, the region has little topographic relief (Spearing 1991). The highest areas lie in the northeastern and central portions where elevation averages 500 feet above sea level. Modern climate on the UTCP is characterized as humid subtropical with warm to hot summers. Annual rainfall ranges from 56 inches near the Sabine River to 37 inches near the Brazos River, and peaks in the summer and winter months (Swanson 1995). Tropical disturbances (including hurricanes) are common and have been known to produce more than ten inches of rain in a 24 hour period. Hurricane season lasts from June through November, peaking June through September. Since the beginning of modern recordkeeping in 1871, the Texas coast has averaged one hurricane every other year, with the longest recorded gap between storms being nine years (Swanson 1995). Not only are these storms a physical threat, but they also significantly alter the environment. Storm surges can reach up to 30 miles inland and submerge portions of the landscape. Storm activity can also close tidal passes, open new ones, and change sedimentation rates in bays and estuaries.

Due to the paucity of the pollen-bearing locations (e.g., lakes, bogs, caves) on the UTCP, the primary source of information on long-term environmental change in the area is the hydro-geologic record. By 20,000 B.P. (Late Wisconsin), glacial ice was at its maximum thickness and the Gulf shoreline ranged as far as 160 kilometers south of its present location (Lewis 2000). Starting after 18,000 B.P. sea level rose rapidly as a result of deglaciation. Rivers downcut as they carried increased amounts of meltwater to a low sea level. Dates on foraminifera from offshore sediments and shell from barrier islands indicate that the Gulf experienced several stages of eustatic sea level rise as the result of major climatic changes. These rises occurred in a stepwise fashion. At the onset of deglaciation, sea level on the Gulf rose rapidly until about 10,000 B.P. when the shoreline stabilized. This stillstand was followed by another rapid rise ending in another stillstand between 8700 and 7000 B.P. Another rapid rise occurred after 7000 B.P. and another stillstand around 6000 B.P.; after another period of rapid rise, the modern stillstand was achieved somewhere between 5000 and 2000 B.P. (estimates vary, see Lewis 2000; Ricklis and Blum 1997; Ricklis 2004b, Ricklis 2005). Overall sea level rise may explain in part the low number of Early Archaic and Paleoindian Period sites, as many of these earlier sites should be currently located offshore (Lewis 2000). (These older sites may also be subject to subsidence resulting from modern oil, water and gas extraction on the UTCP.) Recent work in the Lower Mississippi Valley drainage suggests that there were repeated flooding events between 3000 and 2600 B.P. which affected human occupation of the area (Brown and Kennett 1999; Kidder 2006). It is not currently known if the Texas coastal plain was affected in a similar manner.

Pollen data from southern and central Texas are used to infer the vegetation and climate history of the area (Story 1990a). Pollen taken from locations adjacent to the UTCP indicate that between 22,000 and 14,000 B.P. central Texas was comprised predominately of deciduous forest, while south Texas was composed of grasslands and oak scrublands (Bryant and Holloway 1985). This is interpreted to indicate the climate of these areas of the state were cooler and more humid than they are at present. Between 14,000 and 10,000 B.P. pollen records from central Texas indicate a steady decline of arboreal pollen and an increase in grass pollen, indicating a warming and drying trend. Although east Texas has generated almost no pollen data (probably due to poor preservation), pollen records from Louisiana at this time show a deciduous woodland environment. From 10,000 B.P. to the present, south Texas has no pollen records.

Analysis of charcoal from archaeological sites in the area suggests modern species such as mesquite, willow, and pecan were in place by 6,000 B.P. In central Texas, declines in arboreal pollen and increases in grass suggest a continuation of the warming and drying trend. The oak-hickory mosaic characteristic of the present may have been in place early in the postglacial period. Other estimates place the appearance of modern vegetation closer to 1,500 B.P. or perhaps 3,000 B.P. (Bryant and Holloway 1985). North Texas records suggest the possibility that the oak savannah became established as early as 9,000 B.P. (Bryant and Holloway 1985). It is possible also that modern seasonal conditions existed as early as 5500-4500 B.P. By 2500 B.P. modern biota are fully established on the Texas coastal plain (Story 1990a).

Limited pollen and faunal data indicate that climate may have fluctuated during the last 2000 years (Beck et al. 2001; Dillehay 1974). Pollen records from the one bog which has been cored in the UTCP indicate that around 1010 B.P. the area had high amounts of grass, oak, and charcoal, although it is not clear if this is the result of climate change or anthropogenic burning. Around 170 B.P. (European contact) there appears to be an increase in arboreal pollen (Beck et al. 2001). The changing presence and absence of bison remains in archaeological sites on the southern and Gulf Coastal Plains have been interpreted to indicate that bison experienced changes in their range and population density due to climatic shifts (Dillehay 1974). Based on faunal data from selected sites, Dillehay argues that bison were present on the southern plains between 10,000 and 6000/5000 BC, and then absent between 6000/5000 and 2500 BC. Dillehay argues that this initial period of absence correlates well with the Altithermal Period as characterized by Antevs 5500-2000 B.C., suggesting that grasslands may have been dessicated during a relatively warm, dry climatic period. Bison reappear on archaeological sites present between 2500BC and AD 500 and are absent again between AD 500 and 1200/1300. Dillehay notes that there was documented climatic change at the end of the 13th Century. He argues that drought conditions in the Southwest indicate that bison may have moved eastward to West Texas in the Llano Estacado area, north of the Lower Pecos Valley.

Bison are present on archaeological sites dating AD 1200/1300 or later, suggesting that the coastal prairie intrudes and recedes between AD 500 and the historic period (Stahl 1995).

Conclusions

People began using ceramic vessels on portions of the UTCP around 2000 B.P., much later than in other areas of the Southeastern United States. Pottery use on the inland upper coast and central coastal margin occurs even later; AD 500 (1500 B.P.) and AD 1250/1300 (approximately 400 B.P.), respectively. Like their neighbors in the Lower Mississippi Valley, UTCP groups continued using pottery right up through contact with Europeans and Euro-Americans. Unlike many LMV groups, they do not appear to have left archaeological signatures associated with intensive use of cultigens, wild starchy seeds, or highly sedentary village settlements. UTCP mortuary practices do suggest some ceremonial behavior, but it is not known if this is linked with stratified social systems documented in some portions of the LMV. Pottery can play critical roles in contexts of subsistence, mobility, and social complexity, but the role(s) of pottery on the UTCP are not currently understood. Explanations for the continued use of pottery on the UTCP implicate intense use of plant foods, including starchy seeds and/or cultigens. Pottery may have become more attractive to UTCP foragers as their territories became packed through time and group mobility declined as a result of limited home ranges. Pottery may have also been a useful ceremonial or symbolic object in yet undocumented social and political contexts. Determining the functions and distribution of UTCP pottery will contribute to our understanding of UTCP hunter-gatherer diet and mobility, as well as our understanding of pottery and its context in hunter-gatherer adaptations.

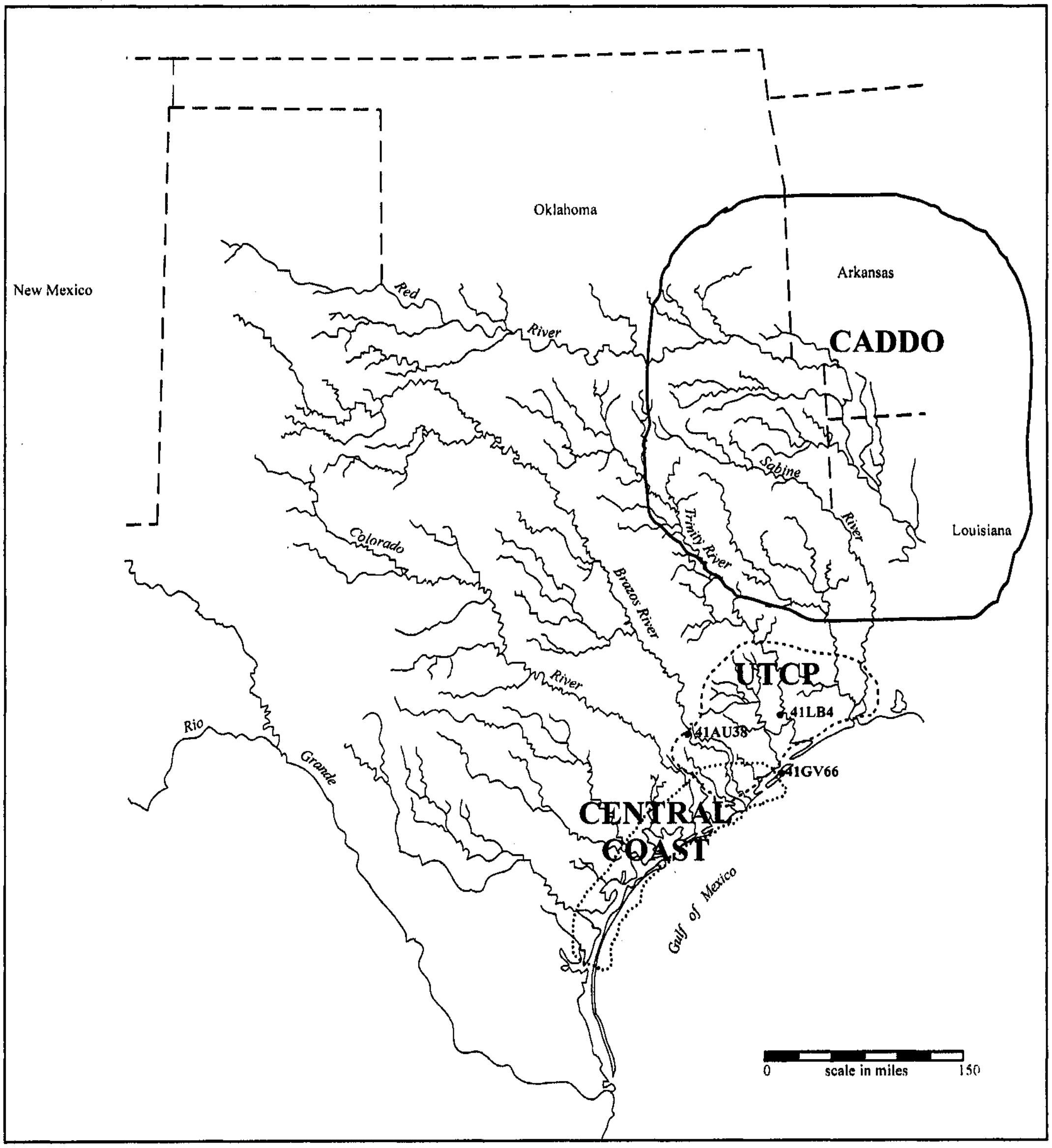
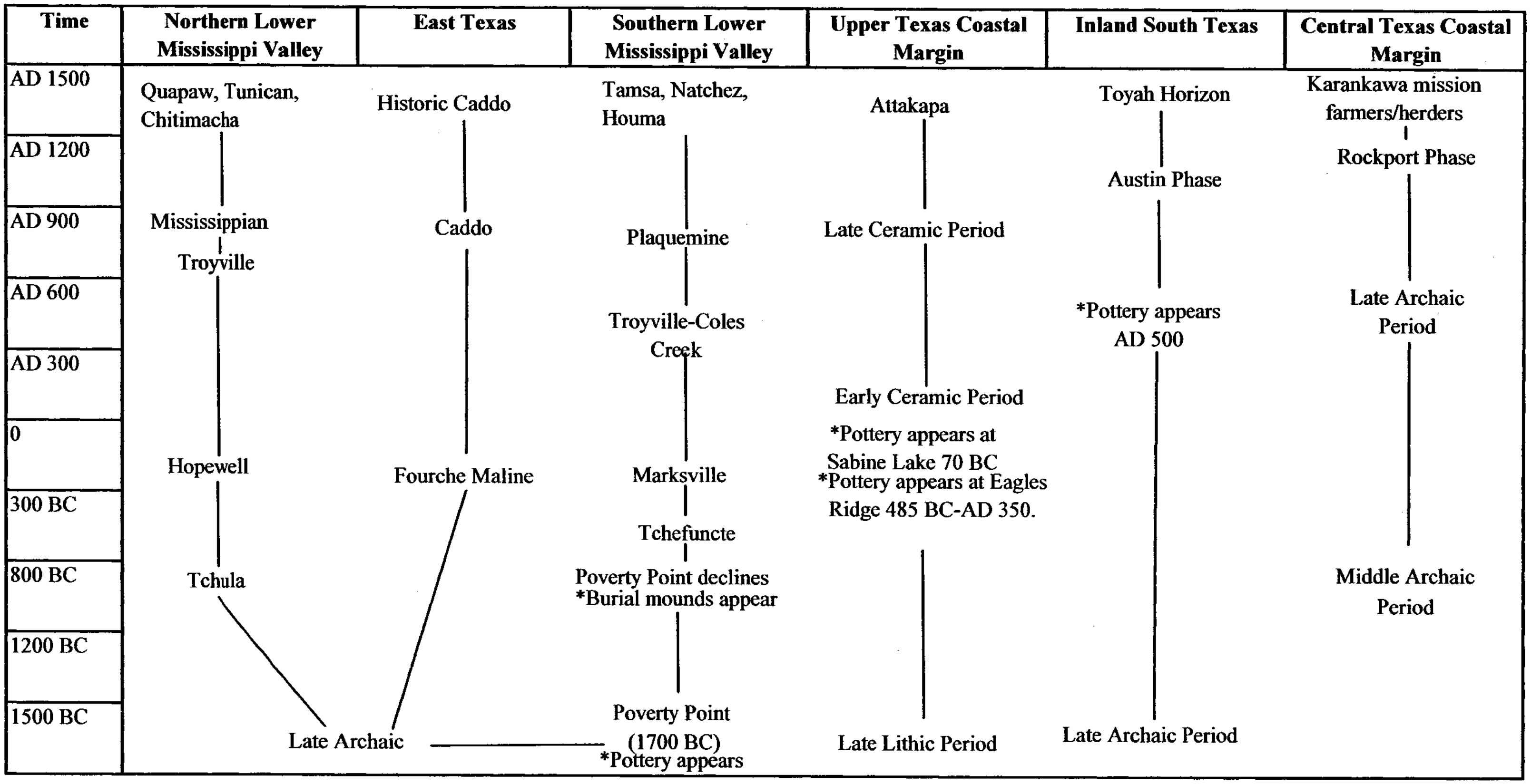


Figure 2.1 Map of the Texas coast indicating adjacent cultural areas.



Time	Northern Lower Mississippi Valley	East Texas	Southern Lower Mississippi Valley	Upper Texas Coastal Margin	Inland South Texas	Central Texas Coastal Margin
AD 1500	Quapaw, Tunican, Chitimacha	Historic Caddo	Tamsa, Natchez, Houma	Attakapa	Toyah Horizon	Karankawa mission farmers/herders
AD 1200					Austin Phase	Rockport Phase
AD 900	Mississippian Troyville	Caddo	Plaquemine	Late Ceramic Period		
AD 600			Troyville-Coles Creek		*Pottery appears AD 500	Late Archaic Period
AD 300				Early Ceramic Period		
0	Hopewell	Fourche Maline	Marksville	*Pottery appears at Sabine Lake 70 BC *Pottery appears at Eagles Ridge 485 BC-AD 350.		
300 BC			Tchefuncte			
800 BC	Tchula		Poverty Point declines *Burial mounds appear			Middle Archaic Period
1200 BC						
1500 BC	Late Archaic		Poverty Point (1700 BC) *Pottery appears	Late Lithic Period	Late Archaic Period	

Figure 2.2 Basic culture history for the UTCP and adjacent regions. After Aten 1983; Jeter et al. 1989; Ricklis 2004; Story 1990.

Table 2.1 Culture history of ceramic periods on upper Texas coastal plain after Aten 1983. Activites referred to in the Akokisa Model are present in the rightmost column.

Time	Archaeological Record	Activities Represented in the Akokisa Model
AD 1700-1800: Orcoquisac Period	European objects appear. Grog-tempered wares decline sharply; sandy pastes dominant in pottery assemblages	Increasing interest by specific groups in demarcating their territories.
AD 1350-1700: Old River Period	Less grog-tempered pottery some bone-tempered pottery. Sandy paste, arrow points increase.	
AD 1000-1350: Round Lake Period	Grog-tempered pottery appears; design elaboration on sandy paste pottery. Small lithic drills appear. Cemeteries appear.	
AD 650-1000:Turtle Bay Period	Higher frequencies of incised and red filmed ceramics; arrow points appear.	Establishment of distinct social groups. Demarcation of specific group territories. Technological innovations to obtain more resources.
AD 425-600: Mayes Island Period	Small amounts of incised and red filmed pottery. Mortuary practices visible ca. AD 300. Posited use of fish weirs.	
AD 100-425: Clear Lake Period	Tchefuncte, Mandeville, Goose Creek Plain pottery. Gary dart points, socketed bone points	Adding new resources to diet, and/or processing others more intensively.

CHAPTER 3: THEORETICAL ORIENTATION

Determining the kinds of economic and/or social behavior associated with archaeological pottery in hunter-gatherer societies is a relatively new area of scholarship (e.g., Arnold 1999; Eerkens 2002, 2003, 2004; Sassaman 1993; Simms, Bright and Ugan 1997). In order to create useful models of hunter-gatherer pottery production and use, I draw upon previous theoretical work in hunter-gatherer studies as well as ceramic theory. Here I review theoretical work in both areas, and assess its utility for modeling hunter-gatherer social and economic behavior. I then discuss how human behavioral ecology addresses critical issues raised by other theoretical approaches. I then present models of hunter-gatherer pottery use. The chapter closes with a discussion of some of the possible socio-economic implications of pottery use.

Hunter gatherers and ceramic vessels: making sense of variability

The term "hunter-gatherer" encompasses a wide variety of social and economic behavior (Kelly 1995). Hunter-gatherer behaviors vary considerably, including those implicated with food procurement, food sharing, addressing risk, and acquiring or maintaining social/political power. Current research and theory continues to challenge and dispel outdated ideas of hunter-gatherer social and economic homogeneity and simplicity (Kuhn and Stiner 2001; Kusimba 2005; Price and Brown 1985; Sassaman 1993). While rigid categorization of a "typical" hunter-gatherer adaptation is an impediment to understanding variability in human economic and social behavior (Kelly 1995), researchers continue to point out that a distinguishing feature of all hunter-gatherer adaptations is a reliance on wild foods (Kelly 1995; Kuhn and Stiner 2001). The "wildness" of food resources also varies (Smith 2001) as does the degree to which hunter-gatherer groups rely on them (Kelly 1995). Nonetheless, a reliance on wild game and plants characterizes all hunter-gatherer adaptations.

Traditional associations between pottery production and sedentary, food-producing societies are based on the premise that the kinds of in which tasks these groups typically engage allow them to take full advantage of ceramic vessels (e.g., Childe 1951). As sedentary societies, such groups are able to easily absorb some of the costs of pottery production such as the time it takes to process clays, form vessels, wait for vessels to dry before firing, and fire them (Arnold 1985). The idea of pottery as a craft practiced exclusively by sedentary groups is based in part on a limited sense of the properties of pottery: a tool for use over direct heat and prolonged storage. In fact, the refractory properties of ceramic vessels do recommend them for use over heat, especially for resources which require prolonged boiling such as domesticated seeds and grains (Hoopes and Barnett 1995). Ideal designs for long-term storage vessels include thick walls to increase vessel resistance to mechanical failure and subsequent loss of contents. With these performance characteristics come tradeoffs: vessels engineered for use over heat or long-term storage are too fragile or bulky to be frequently moved and therefore unattractive to groups with high degrees of residential mobility. Yet the potential properties of ceramic vessels are considerably more varied than traditionally realized. For example, it is possible to use pottery for indirect heating as well as direct heating tasks (Linton 1944; Sassaman 1993), and the performance attributes of pots suited for indirect heating are different than those for direct heating. Ethnographic study of hunter-gatherer pottery indicates that vessels can be engineered to maximize their portability as well (Reid 1990). Ethnography and archaeology have provided examples of hunter-gatherer production and use of ceramic vessels (e.g., P. Arnold 1999; Eerkens et al. 2002; Gayton 1929; Hoopes 1995; Hoopes and Barnett 1995; McGee 1971).

Previous approaches to modeling

Diffusion

One of the oldest and most commonly evoked explanations for hunter-gatherer pottery use around the world is the idea that knowledge of the craft spread from adjacent pottery-using cultures. Originally developed and used by archaeologists working in other regions of the world (e.g., Meggers et al. 1965), the concept of diffusion was invoked to explain the origins of early ceramic vessels in the American Southeast, specifically in Florida and Georgia (Ford 1966; 1969; see Sassaman 1993 for a detailed discussion), and their later appearance in assemblages west of those areas, including the Lower Mississippi Valley and the Gulf coast (Jenkins et al. 1986; Walthall 1980). In the case of the UTCP, vessel technology appears to have arrived via the Lower Mississippi Valley (e.g., Aten 1983; Ricklis 2004). Although diffusion is most likely an accurate description of how pottery spread throughout the American Southeast, it is not an appropriate means to explain *why* pottery technology was accepted (Sassaman 1993).

Cultural ecology and hunter-gatherer ceramic studies

The theoretical school of cultural ecology has influenced the modeling of hunter-gatherer pottery use in two distinct ways. Most commonly recognized among many American archaeologists is the application of cultural ecology to studies of hunter-gatherer behavior. Also recognized by archaeologists who routinely work with pottery is the influence of cultural ecology on modeling pottery use in general.

Cultural ecology has had a long and influential history in archaeology, especially hunter-gatherer studies. The early theoretical work as originally developed by Julian Steward was concerned with the effects of the natural environment on human evolution (Kelly 1995). This early version of cultural ecology was predicated on the idea that human behavior is closely tied to the natural environment. Steward applied this idea to his study of hunter-gatherers in the Great Basin, arguing that there were "core" behaviors in human societies which were primarily motivated by efficiency in food-getting behavior. Thus, knowledge of the environment could be used to generate expectations about human behavior. While archaeologists often take issue with the idea that the natural environment determines all aspects of human behavior, they generally agree that much subsequent theoretical work owes much to Steward's ideas. The New Archaeologists drew upon Steward's work in their efforts to investigate hunter-gatherer behavior at the scale of the landscape (Bettinger 1991). A prime example and an influential basis for much of the subsequent research on hunter-gatherer mobility and subsistence was Lewis Binford's work on seasonal differences between sites sampled at a regional level (Binford 1964, 1980; Lovis et al. 2005).

Theoretical work on the interplay between resource use, settlement systems, and technological change continues to be developed (e.g., Binford 2001). Although rarely specifically discussed in the regional literature, Binford's work has greatly influenced UTCP regional models of social and economic change and those of other hunter-gatherer groups who use pottery. Binford's modeling of resource intensification and technological change figures prominently in the previously described Akokisa Model. For example, Binford proposes that territorial behavior among hunter-gatherers increases with increasing population pressure. Territoriality has the potential to limit mobility and thus the types of food resources to which a given group has access (Binford 2001). Therefore, hunter-gatherers who prior to territorial packing relied on large-bodied terrestrial resources, are predicted to respond to the limited access to these resources by taking a higher frequency of small-bodied prey. Fewer species may be taken, which in turn can decrease the temporal variance of resources, causing groups to move less. Groups previously focused on terrestrial resources are predicted to take aquatic resources if they have the opportunity to do so. Hunter-gatherer groups who do not have access to aquatic resources are expected to rely more on plants (Binford 2001).

These dietary changes are accompanied by increased investment in a variety of more efficient procurement and processing technologies. Such technologies allow hunter-gatherers to extract more energetic returns from an increasingly circumscribed environment (Binford 2001). Technological change is especially easy to envision in terms of aquatic resources, where nets and weirs can be used to take resources in bulk. Pottery can be used as a tool to increase energetic returns of foods, particularly plant foods. Small seeds are a prime example of a food which is more nutritional and palatable when processed using heat. Pottery can be particularly well-suited to heating tasks. There are implications of possible territorial constraints in terms of both resource procurement and storage. Being able to acquire resources in bulk may create opportunities to store excess food, and pots are implicated in storage tasks as well. Finally, as the environment becomes more packed with people, particular locations predictably rich in resources are dominated by a few individuals who exclude others from access and thereby create socioeconomic inequality in their social units (Binford 2001).

Cultural ecology has influenced theoretical work in ceramic studies. The concept of ceramic ecology was first formalized in Frederick Matson's "Ceramics and Man" conference (Matson 1965; Feathers 1990). Matson's own contribution emphasized environmental (e.g., raw clay, fuel) and cultural factors (e.g., water and food processing needs, potter social status), positing that doing so explained spatial and temporal variation in ceramic vessel technology. During this same time period, Lewis Binford published "Archaeological Systematics and the Study of Culture Process" in which he advocated the study of archaeological phenomena such as pottery in a systemic context (Binford 1965). Drawing upon ceramic ecology, Dean Arnold continued looking for universal factors linking pottery use to culture in his *Ceramic Theory and Cultural Process* (Arnold 1985). In his search to create generalizations about pottery production and use in various cultures, Arnold employed a systemic approach in which pottery production and use is reduced or amplified by a variety of environmental and cultural factors.

Over the years, both cultural ecology and ceramic ecology have encountered similar criticisms. Both larger applications of cultural ecology and those dealing specifically with ceramic vessels rely heavily on ethnographic information. Indeed, ethnographic information has proven useful in creating and testing hypotheses about hunter-gatherer behavior. Critics have asserted that it can be problematic to assume that specific ethnographic and archaeological cases resemble one another and make it difficult to explain why the archaeological record is different from ethnographic cases (Bettinger 1991; Feathers 1990). Cultural ecology and ceramic ecology have also been subject to charges of environmental determinism and reductionism, with some arguing that it is unlikely that a few environmental variables can be used to explain how human social systems evolved (Trigger 1989). Others have argued that models based in cultural and ceramic ecology may not be useful when seeking to explain changes in hunter-gatherer subsistence, mobility, and pottery use over time because it emphasizes commonalities between individual cultures or cases rather than variation in responses. Some archaeologists have argued that cultural (and ceramic) ecology are unable to adequately predict or explain the circumstances under which hunter-gatherers will use pottery (Bettinger 1991; Rice 1996; Trigger 1984).

Granted, the circumstances affecting ceramic vessel production and use are far more complex than a purely environmental approach would lead us to believe. Yet cultural ecology has been influential in hunter-gatherer and ceramic theory precisely because it does emphasize commonalities between individual cases, which are the focus of much archaeological research. For example, in *Ceramic Theory and Cultural Process*, Dean Arnold (1985) discusses a diverse set of factors which affect demand for ceramic containers in cultures worldwide, from weather patterns to household economics.

Economic approaches

In 1989, James Brown introduced an economic model of pottery production and consumption which built on the concept of economic demand for pottery. Brown originally developed the model to explain the initial adoption of ceramic vessel technology. In providing the context for the model he questioned the assumption that pottery was adopted because it was necessarily functionally superior to other container types, an idea which has greatly influenced subsequent ceramic studies emphasizing not only economic but social approaches (e.g., Hoopes and Barnett; Vitelli 1995, 1999). Brown argued that an increase in demand for containers was the catalyst for the initial use of pots. Thus, the pace of pottery production is affected by an overall demand for containers. It is the particular efficiency of the pottery production process that recommends its adoption. For example, ceramic vessels can be fired in batches, one of the attributes which allows potters to easily scale up production when demand for containers increases. The nature of pottery manufacture allows pots to be made in stages, which means there can be pauses in manufacture to complete other necessary tasks (this was also noted by Arnold). Given these features of pottery production, the appearance of ceramic vessels was not necessarily a solution to changes in dietary and food processing techniques, but rather a means of helping groups solve their time allocation problems. The idea of pottery as tool to facilitate the allocation of labor has gained a foothold in ceramic studies (e.g., Crown and Wills 1995; Eerkens 2004; Sassaman 1993). In addition, Brown's model influenced the orientation of ceramic theory toward models which take social and behavioral conditions into account. Dissatisfaction with the inadequacy of models which gave primacy to the natural environment to explain hunter-gatherer and pottery production impacted archaeological theory in general and ceramic studies in particular.

The model has the power to explain why we might see changes in vessel frequency in the archaeological record: demand for containers increases to an extent that people are willing to incur the costs of pottery production (or increased pottery production). Yet the model has sometimes been used in a circular manner. Most applications of the model hypothesize an increase in demand for containers at a point in the local archaeological record when they appear or become more frequent in the archaeological record. The researcher then supplies a reason for the increase in demand; rather than deriving it from the model itself. An example of this use of Brown's economic model is the claim that the appearance of ceramic vessels at

Poverty Point was the result of increased demands for containers. Such containers were necessary for cooking practices needed to feed the army of workers involved in the construction of earthworks, as well as the public functions associated with earthworks (Gibson and Melancon 2004). Such an explanation is entirely possible, but in this case the explanation is applied rather than tested. Here, as in many cases where the model is used, the appearance or increase in pottery is the result of increased demand for containers.

Social roles of pottery

While it does not directly identify the factors influencing the demand for ceramic containers, Brown's model has provided a means for other researchers to envision the nature of pottery adoption and use within a variety of contexts. Archaeologists have begun to develop theories to understand the uses of pottery and its role in larger socioeconomic contexts. Initial work in this area was begun by Sassaman in his research on the slow spread of pottery technology in the southeastern Atlantic coastal plain (Sassaman 1993). Using data which indicated early pottery in this area was used for heating tasks Sassaman inferred that pottery was a tool for reducing food processing time or expanding the amount of food processed. He argued that increasing construction, ceremonial, and provisioning obligations during the Shell Mound Archaic Period created shifts in the time budgets of hunter-gatherer groups. While the time budget problem had an economic component Sassaman emphasized that it existed due to social factors or the "social demands of labor" (Sassaman 1993, 1995). The slow diffusion of pottery technology across the southeastern coastal plain and Piedmont was inhibited by socioeconomic factors as well. In the context of regional soapstone networks which were a means of acquiring and maintaining power and status among men, as well as maintaining social ties, pottery was initially a weak interloper favored by women experiencing increased demands on their labor. Thus, according to Sassaman, pottery was initially used by those outside male social networks and prestige competition—women and those in dispersed settlements living far from hubs of regional soapstone trading networks. In this model, the role of pottery in a given society is not strictly economic. Pottery becomes a tool that changes settlement and subsistence patterns, and access to resources and power (Sassaman 1993).

Other models of the role of pottery in societies have focus on potential socioeconomic roles of pottery, but in a manner emphasizing the potential uses of pottery in social actions. In his work on prestige technologies, Brian Hayden distinguishes between material culture designed for everyday, practical applications and that used in social contexts. Items created for social tasks can be further divided into two types: 1) objects designed for non-competitive alliances and ritual purposes; 2) objects used to in surplus-based competitions for prestige (Hayden 1998). Items intended for prestige tasks allow their owners to display "wealth, power, or control over resources" (Hayden 1995). Hayden hypothesizes that many technological processes were responses to the demands of prestige-based competition (e.g., pottery, metallurgy, ground stone cutting tool manufacture, domestication). Only later did they assume practical, utilitarian functions in everyday life. In some cases prestige competition is a catalyst for technological advances in utilitarian function (Hayden 1995). In this model pottery is prized for its aesthetic appeal and the fact that a great deal of labor can be invested in its manufacture. In order for prestige goods to enter and gain use in a given society, two conditions must exist: 1) the area must be rich in natural (food) resources; 2) aggrandizers must be present. Thus, the initial use of technologies such as pottery depends upon an abundance of resources (Hayden 1990). Hayden argues that aggrandizing individuals are present in any given population—a point that remains speculatively philosophical and therefore must be taken on faith. This assumption of the theory lowers its predictive value.

Others argue that pottery may have originated as part of a ritual process in which the act of making pottery had ritual value (Vitelli 1995; 1999). In this scenario, a useable container is not the goal. Instead, the process of making the pot is integral to the ritual, and is initiated and presided over by women. In Vitelli's case study of ceramic vessels from Franchthi Cave in Greece, she argues that Early Neolithic wares were the result of this ritual practice and that their low frequency and poor construction support her assertion. Middle Neolithic pottery assemblages from Franchthi Cave exhibit a higher frequency of vessels. Middle Neolithic assemblages have a great variety of shapes that are difficult to produce and fire. Overall vessel size is small, leading Vitelli to conclude that the production and use of Middle Neolithic pots at Franchthi was primarily for social display. Not until the late Neolithic do pots appear to be used in routine food preparation, when they are larger and less effort is used to manufacture them. The portion of Vitelli's research devoted to explaining the presence of Early Neolithic pottery is difficult to evaluate in terms of other assemblages. How does one know if a given assemblage was in fact created by shaman-potters? The portion of the scenario addressing the Middle Neolithic wares is similar in some respects to Hayden's conception of pottery being used as a social tool rather than to address immediate needs presented by the natural environment. Models such as these are difficult to operate and evaluate, because many possible attributes of ceramic vessels can be useful in social tasks.

Human behavioral ecology and modeling hunter-gatherer pottery use

The previous discussions of theoretical approaches highlight three critical aspects of modeling hunter-gatherer pottery and use. First, while it is important to study individual cases, many archaeologists are ultimately concerned with the general circumstances of pottery adoption and use. Second, models must take into account the costs, benefits, and tradeoffs of pottery production and use, rather than simply assuming pottery is desirable in all cases. Third, models should address the effects of the natural environment and social contexts of pottery production and use. I argue here that human behavioral ecology is a useful theoretical platform for modeling hunter-gatherer ceramic use because it takes the above issues into account. It has also been useful in creating models which are simple and testable (Winterhalder and Smith 1992). For these reasons I use human behavioral ecology as a tool to generate hypotheses concerning hunter-gatherer pottery production and use on the UTCP in the subsequent section.

Definition and features of human behavioral ecology

Human behavioral ecology examines human behavior in an ecological context using principles of evolutionary theory and optimization. This theoretical approach focuses on determining how ecological and social factors influence and shape behavioral flexibility within and between human populations (Winterhalder and Smith 1992). Originally developed in the biological sciences (where it is referred to as behavioral ecology), human behavioral ecology has been used for decades by anthropologists to develop models to understand human behavioral and cultural diversity in past and present societies (Smith 1983; Winterhalder and Smith 1992). Models generated from human behavioral ecology premises have been used to understand the diversity of hunter-gatherer resource procurement, group mobility, and other aspects of behavior.

There are three key assumptions of human behavioral ecology theory which allow it to be useful for explaining variability in behavior, modeling economic decisions, and accounting for socially-oriented behavior as well as behavior directly linked with the physical environment. These assumptions include natural selection, methodological individualism, and optimization constraints. Since behavioral ecology is concerned with the evolutionary basis of human behavior, it draws heavily on the concept of natural selection (Winterhalder and Smith 1992). Briefly the theory of natural selection posits that on average over time, more individuals are born than can successfully reproduce and this is so due to environmental constraints (Winterhalder and Smith 1992). Individuals who can engage in reproductively optimal behaviors when responding to their environment will be more reproductively successful (i.e. leave greater numbers of offspring) than those who do not or cannot. Methodological individualism is simply the idea that the actions and intentions of individuals constitute the properties of larger groups, such as societies. Thus, the properties of groups are derived from the choices of their individual members (Smith and Winterhalder 1992:39). Two additional corollaries of methodological individualism as conceived in human behavioral ecology are that individuals act rationally and out of self-interest. The final assumption is that human behavior seeks to be optimal with regard to reproductive fitness, although it cannot always be so because humans must often compromise between particular goals and available options. Thus, the premise of optimal behavior is often referred to as "constrained optimality" (Winterhalder and Kennett 2006:11).

Natural selection is a key aspect of behavioral ecology, which enables the theory to acknowledge and explain variability in human behavior using the concept of natural selection operating on given variability. Thus, human behavior assumes a plasticity which can be accounted for by theory (Winterhalder and Smith 1992). Built into human behavioral ecology is the acknowledgement that environment is complex because it includes physical, biological, and social aspects. Therefore the terms "environment" is broadly characterized in human behavioral ecology (Winterhalder and Smith 1992). This inclusive definition of environment allows human behavioral ecological theory to be used to investigate the diversity of human behavior. The emphasis of human behavioral ecology on modeling ultimate rather than proximate causes for human behavior enables the researcher to investigate the reasons for a spectrum of behavior, rather than focusing on particular explanations for individual cases (Winterhalder and Smith 1992).

Human behavioral ecology is not only a means of addressing ultimate causes of variability in behavior, but it offers a useful array of tools for modeling behavior from an economic perspective. The assumption of optimization applies to the economic aspects of human behavioral ecology models. In addition, basic concepts derived from microeconomic theory are used to model human behavior in a variety of contexts, including non-market economies such as those of hunter-gatherers (Winterhalder and Kennett 2006). These basic concepts include the marginal value theorem, opportunity costs, discounting, and risk-sensitive behavior. The marginal value theorem holds that the consumption of a good or participation in a given activity has not only an initial but also a marginal value that changes with quantity (e.g., amount consumed or time spent). The marginal value of goods and activities is what an individual uses to determine when to stop consuming or to do something else. The decision to change behaviors is also mediated by opportunity costs, or the return an individual can gain from engaging in another activity.

Another economic concept—discounting—is not used in this current study of pottery production. Discounting refers to the behavior of discounting the rewards of an activity which requires individuals to initially incur costs and wait for a delayed return. A shift from foraging to food producing involves the concept of discounting, as food producers must pay the costs of planting and tending food resources up front and must wait for a harvest with uncertain returns. The concept of discounting has not been widely utilized, but its potential application to models of the transition to agriculture has implications for some pottery studies (Winterhalder and Kennett 2006). Risk-sensitive behavior is also an economic concept useful in human behavioral ecology models, including those concerned with technological change (Fitzhugh 2001). While not directly addressed in the particular hypotheses presented here, it is an application which has implications for the adoption of ceramic vessel technology.

General criticisms of human behavioral ecology models

Critics have argued that the focus on optimal behavior does not capture the complexity of human decision-making. Also according the environment such a large role in explanation strikes some as smacking of environmental determinism. These criticisms can be addressed by briefly highlighting some main assumptions of the theory. Behavioral ecology draws upon the concepts of methodological individualism, rational action, and optimization in order to create useable models. Methodological individualism posits that the actions of individuals comprise the properties of groups. Thus, it is individuals who make decisions, and they can respond to cultural ideas of success in addition to biological directives (Smith and Winterhalder 1992; Kelly

1995). Behavioral ecology also assumes that people are rational actors whose decision-making is guided by self-interest (Smith and Winterhalder 1992). A key assumption of the concept of optimization is that reproductive fitness can be measured using the proxy of foraging efficiency, where an individual either maximizes food gathered or minimizes time spent foraging. There are other possible reasons to forage efficiently rather than just to eat. For example, time for non-foraging activity may be scarce. It is also important to realize that foragers can use excess food to gain access to mates, engage in reciprocity, or other actions which ultimately enhance their reproductive fitness (Kelly 1995). And while all behavior is not reproductively optimal, behaviors in a given population will tend toward optimal (Kelly 1995). What makes behavioral ecology most useful to modeling ceramic vessel use in socioeconomic contexts is its capacity to generate testable models with explicit assumptions.

Recasting traditional and recent models of ceramic vessel function

Traditional models of ceramic production and use rely on one or both of the following two primary conceptions of their function: as tools to reduce the high processing costs of food, or as tools to reduce risk by storing food. More recent models suggest that ceramic vessels are used primarily to confer social/political prestige on those individuals who have access to them or to their contents. Traditional conceptions of hunter-gatherers subsistence, mobility, and ethos emphasize hunting, high residential mobility, lack of long-term storage, and an emphasis on egalitarian behavior (e.g., Lee and DeVore 1968). Subsequent research indicates that these behaviors are points along a continuum of variability in hunter-gatherer lifeways (Kelly 1995). Therefore, hunter-gatherer societies vary in their overall consumption of plant foods with high procurement/processing costs, mobility, degree of storage, and aggrandizing behavior.

The empirical predictions of the hypotheses described below rest on multiple lines of evidence. In Table 3.1, hypotheses are described in a matrix form, listing presence/absence or nature of vessel attributes expected for each hypothesis: wall thickness, vessel morphology, porosity, and source of aplastics, amount of decorative treatment, heating use, and food residue. These attributes are of two kinds: those relating to the intended performance of the vessel, and those that are the result of how the vessel was actually used. Performance attributes affect how pottery can be used, but there is always the possibility that performance attributes are incidental and do not relate to pottery function. This problem is addressed by creating empirical expectations which include both performance and use attributes. If functional attributes are in fact related to performance, then there should be a correlation of use wear and performance attributes. Some of the empirical expectations hold true for more than one hypothesis, raising the possibility that one hypothesis cannot be differentiated from another. This potential problem of equifinality is avoided, as at least one empirical expectation differs between the hypotheses. The empirical expectations for each set of hypotheses concerning food processing, storage, and prestige tasks are described in greater detail below. Discussions of the hypotheses and their implications precede the discussion of empirical expectations.

Food production

Anthropologists and archaeologists have long linked the manufacture and use of ceramic vessels with agriculture (Hoopes and Barnett 1995). Archaeologists have commonly associated the adoption of ceramic vessels with the Neolithic period (e.g., Childe 1951; Rice 1987). Food production is more broadly defined as the intensive uses of wild plant species through varying levels of domesticate cultivation (Smith 2001). There is a strong intellectual link between intensive plant use and pottery (Hoopes and Barnett 1995); and in the Americas, empirical links between intensive wild plant use and pottery have been demonstrated (Braun 1983; Eerkens 2004). Ceramic vessels can minimize processing costs of r-selected resources, particularly plant foods such as starchy seeds (Bright et al. 2002; Eerkens 2004; Gremillion 2004). In ecological terms, "r-selected resources" are types of animals and plants which develop rapidly and reproduce early (often only once), have relatively small body size, are short-lived, and are prone to catastrophic mortality (Hayden 1981; Rafferty 1985). These resources typically have small home ranges and concentrated productivity. A corollary to the plant processing function is the idea that ceramic vessels can be used to reduce food processing costs, particularly when the maximum amount of nutritional/caloric value must be extracted from existing resources (Braun 1983; Reid 1990). Many of these species are so-called "r-selected resources" and include plants, shellfish, and small mammals. Thus, pottery use is often associated with heavy use of resources which have high procurement and/or processing costs, including starchy seeds.

Pottery can be used to process a variety of foods in many different ways. Ceramic vessels can be used for baking, steaming, boiling, mixing, grinding, pounding, and/or soaking foods to prepare them for consumption or further processing (Hally 1983). While there are definite empirical links between pottery use and r-selected resources, there are also cases where pots have been used to process large-bodied resources with considerably lower processing costs, such as large terrestrial mammals (e.g., Reid 1984). In some instances, ceramic containers can be used to render toxic foods edible and coarse grains digestible by allowing prolonged unattended boiling over fire which helps break down silica cell walls in plant foods and increase digestibility. Pots can also be used to help break down the connective tissue in meat and thus increase its palatability.

In order to understand how much UTCP inhabitants were focused on starchy seeds or large mammals, it is most useful to focus on the heating properties of ceramic vessels. Pottery can be used in a variety of direct and indirect heating methods: cooking without liquid (including "dry" boiling, roasting, and parching), simmering, and boiling in liquid (Reid 1990). Each of these cooking techniques is suited to particular types of foods. So-called "dry" cooking heats foods to about 150 degrees C and does not necessarily require ceramic vessels. Simmering occurs between 88 and 85 degrees C and is very effective in breaking down the connective tissue in meat.

Ethnohistoric information indicates that simmering can be best accomplished by indirect heating methods in which rocks or fired clay balls are heated placed in vessels to cook the contents—this is sometimes referred to as "stone boiling" (Reid 1990). Ethnoarchaeological work indicates that simmering can also be accompanied without clay balls and can be used to process starchy plant foods such as rice (Skibo 1992). Placing vessels directly over flames or coals is more useful when attempting to bring the contents to a boil (about 100 degrees C). Direct heating is particularly suited to gelatinizing the grains of starchy seeds, a process which occurs at about 93 degrees C (Reid 1990).

Hypothesis 1a: Ceramic vessels on the UTCP were used as tools to process starchy seeds and/or domesticates.

If groups are consistently using their pottery for processing domesticates or starchy wild plants, then vessel assemblages overall would have high frequencies of pots with construction attributes geared toward performance over direct heat (Table 3.1). If vessels were created for use over direct heat, then they would be expected to have thin walls with a uniform thickness for effectively conducting heat, and round bases and smoothly curving walls to make them more resistant to thermal shock. Vessel porosity should be low to prevent loss of liquid contents through the walls and help vessel contents to a boil. Mineral non-plastics such as sand or grog should be present in vessel pastes to increase resistance to crack propagation from thermal stress. Decoration is expected to be minimal, as pots used for food processing are utilitarian items. Instead, any marks on the pots would be in the form of soot indicating use over direct heat. Any organic residues present in the vessels should reflect cultigens or wild starchy plants. It is possible that the functional attributes of uniformly thin walls, rounded bases, low porosity, and local minerals in vessel pastes will not be present in the assemblages. Yet the use-wear attributes of sooting and plant food residues are necessary conditions to infer plant processing over heat.

Hypothesis 1b: Ceramic vessels on the UTCP were used as tools to process meat from large-bodied resources.

In contrast, if vessels were used in contexts of large animal hunting and high residential mobility, then they should display attributes enhancing their portability, such as thick walls to withstand resistance to mechanical shock. Fiber temper could be used to create a porous, lightweight vessel body resistant to crack propagation. If there are mineral inclusions, then at least some should be from non-local sources, as groups pursuing large animals would be expected to have extensive home ranges. Groups focusing on large-bodied resources have utilized indirect heating techniques and therefore built vessels that had insulating properties and resistance to mechanical shock from boiling stones or clay balls, such as thick walls and thick, flat bases. Flat bases would also be more likely to be present on vessels not used over direct heat, as there would be no need to avoid angular forms more susceptible to thermal shock. Pots would not be expected to be highly decorated, as they are utilitarian wares. There would be no evidence of use over direct heat, and again pots would not be highly decorated. Food residues in indirect heating vessels should reflect high degrees of large animal processing. In order to infer a relationship between large animal consumption and residential mobility, the necessary attributes are paste from non-local sources, and large animal residues.

Storage strategies

Ceramic vessels are also traditionally modeled as tools used to improve storage efficiency and minimize the risk of losing valuable food (Rice 1987). Storage of food is an ideal function of ceramic vessels, as the physical properties of pottery can be manipulated to enable it to protect foodstuffs from vermin and moisture (Rice 1987). Long-term storage behavior is usually associated with food production and high degrees of sedentism, although there is a high probability that storage was used by groups who had varying degrees of food production and sedentism (e.g., Damp and Vargas 1995). Indeed, almost all hunter-gatherer societies, past and present, store food during at least part of the annual cycle (Binford 1980). Anthropologists have recognized different storage strategies from ethnographic research and theoretical work. The types of storage groups employ depend on the temporal and spatial distribution of food resources, the cost of defending stores, and the nature of possible benefits of sharing the stores (including trade and reduction of risk) and the size of resource packages.

Food storage allows people to average food surpluses in order to buffer against temporally predictable shortages, typically during the annual cycle (Goland 1991; Wiessner 1982). Yet a food storage strategy is only useful to groups who can consistently generate a sufficient surplus to cover their shortages (Cashdan 1992; Dyson-Hudson and Smith 1978; Goland 1991). Groups who experience predictable spatial food shortages may solve the problem by moving frequently and maintaining social networks to facilitate this movement (Wiessner 1982). Research among modern hunter-gatherer societies indicates that groups who experience little or no food shortages have little incentive to store (Goland 1991; Testart 1982). In these cases, groups would be expected to pursue other strategies.

Storage as a strategy can create the benefit of alleviating resource shortages, but there are also potential costs involved. Stores may have to be defended from others who have not contributed to their procurement or processing, but can benefit from consuming or trading them. Defending stores commonly entails costs: individuals or groups may have to remain in one location in order to defend stores (Dyson-Hudson and Smith 1978). Remaining in a single area can be problematic to groups whose subsistence practices require them to be mobile. Behavioral ecological models predict that groups will defend stores only when the costs of defense are lower than eating or trading additional calories. It is possible that some storage strategies would have appealed to residentially mobile hunter-gatherer groups (Bettinger 1999a, 1999b). Storing resources with minimal preliminary processing costs may have been an attractive strategy for mobile groups facing unpredictable shortages. In the warm, humid climate of the UTCP, such resources were most likely nuts and seeds. Most of the processing costs of preparing such "back-loaded" resources for storage are incurred when they are consumed, not when they are stored. In contrast, "front-loaded" resources have high processing costs to prepare them for storage. On the UTCP, front-loaded resources consisted of roots, meat, and fish Storage can entail other costs as well: there can be physical risks entailed in defense and potential social costs of refusing to share with others. The risks of refusing to share are discussed in greater detail below.

Other strategies can provide benefits similar to those of storage. Groups or individuals may use forms of sharing such as trade or reciprocity to address potential resource shortages. Exchange (trade) with adjacent groups can enable hunter-gatherers to average spatial and temporal fluctuations in resources, especially when the groups are located in different ecozones, or have different resource procurement systems which complement one another, such as hunter-gatherers and horticulturists (Spielmann 1986). Trade may also allow groups to "store" social obligations to use during lean times in the future (see Wiessner 1982 for an example of !Kung hxaro practices). Sharing (reciprocity) can be used to reduce the risk of loss of resources, but it is a strategy which makes sense only under certain conditions (Cashdan 1985). In order for reciprocity to be a viable strategy there must be lots of individuals or groups who could potentially sustain accidental loss but few which sustain loss at any given time. That is, reciprocity works for those experiencing local scarcity but regional abundance. Groups with higher frequencies of sedentism are expected to find storage to be a more attractive strategy rather than incurring the costs of moving people to goods (Cashdan 1985).

Individuals or groups may also elect to share their resources with others who do not aid in their procurement. Good providers may tolerate theft to avoid costs incurred from conflict (what Winterhalder terms a "cost of strife"; Winterhalder 1997:125), and theoretically they can still expect larger shares of a resource "packet" they acquire rather than sharing portions of a poor hunter's packet. Sharing can also entail other benefits ultimately related to reproductive fitness such as political alliances and access to mates (Bliege Bird and Bird 1997). But there are good reasons not to share—at least not too much. Individuals who scrounge resources from others may lower the overall average food acquisition rate and hurt the group. And while there may be little or no cost to sharing a large resource or "lumpy" packet, sharing smaller packets of resources makes less sense from the perspective of a successful forager (Winterhalder 1997). Thus, resources which come in small packages are less likely to be shared. Storage may in fact be a useful strategy when such resources are predictably synchronized as well (Hawkes 1992; Winterhalder 1997). Given this reasoning, it makes sense that pottery use among hunter-gatherers may not be associated with sharing behavior, but rather the private procurement, storage, and processing of small-package resources which do not require cooperation to acquire (Eerkens 2004).

Storage hypotheses

As previously discussed, storage behavior has been observed in hunter-gatherer societies. Storage is linked with fairly sedentary societies where small-package resources are common in the diet and sharing is minimal. Such a "front-loaded" storage strategy is used for foods which require a lot of initial time and labor investment to prepare for storage. A "back-loaded" storage strategy may be useful in cases where groups are fairly mobile and are therefore interested in limiting the costs of preparing and possibly losing stored foods to people or animals that could raid caches. Thus, if and how ceramic vessels are used for storage has implications for the mobility of hunter-gatherer groups.

Hypothesis 2a: Ceramic vessels on the UTCP were used for "front-loaded" storage.

Generally, vessels designed for storage have thick walls to increase vessel resistance to mechanical shock Thick-walled vessels are common in domestic contexts where household occupants could accidentally bump into vessels (Table 3.1). Making a storage vessel would not require the added cost of taking time to create walls of uniform thickness, as storage vessels would not be subject to thermal stress that a wall with uniform thickness can minimize (Rice 1987). Orifices of storage vessels should be narrow to restrict access to contents so that stores would be less affected by vermin or loss of contents when vessels are accidentally bumped (Skibo 1992). Porosity of storage vessels should be low to limit loss of liquid contents, and mineral sources of temper would most likely be local for such utilitarian pots in fairly sedentary groups. Decorative treatment would most likely be low and it is unlikely that vessels would be used over heat. It is also possible that vessels used for "front-loaded" storage

All of these attributes can apply to vessels both front and back-loaded storage strategies. The use attribute which can be used to differentiate between these strategies is the presence or absence of food residues and possibly mineral inclusions from local geologic sources. Most "front-loaded" stores have high fat or oil, or other contents with semi-liquid to liquid properties. Therefore, pots used in a front-loaded strategy would be expected to have high frequencies of organic residue from liquids or fats. It is possible that it would be difficult to differentiate between pots used for front-loaded storage and those used for processing resources using indirect heating methods, as the front-loaded storage hypothesis relies on low porosity and variable wall thickness, both of which are useful but not absolutely necessary attributes for a storage vessel.

Hypothesis 2b: Ceramic vessels on the UTCP were used for "back-loaded" storage.

In a back-loaded strategy, foods are processed minimally if at all prior to storage. Storage of dry items figures predominantly in "back-loaded" storage strategies, an excellent example of a back-loaded food is nuts, which can be stored in the shell. If pots were used primarily for "back-loaded" storage, then pots would have little organic residue signatures, as foods would leave little if any organic residue in the vessel walls. If "back-loaded" storage strategies are most useful to highly mobile foragers as Bettinger's model predicts, then it is probable that vessels would have mineral inclusions from non-local geologic sources. Pots which were highly porous and/or have fiber inclusions would be ideal for highly mobile groups. It is important to note that pots intended for "back-loaded" storage would have the same performance attributes as pots intended for "front-loaded" storage. Thus, use wear data—in the form of organic residue—and must be obtained in order to assess front and back loaded storage hypotheses. Sourcing studies would also be helpful in evaluating this hypothesis. Back-loaded storage can be differentiated from other functions by the lack of an organic residue signature.

One possible exception to the "front-loaded"= "wet"/ "back-loaded"= "dry" reasoning is the storage of water which is useful to all groups with varying degrees of mobility. Water storage vessels would have most of the performance attributes discussed above, except for a food residue signature. Therefore, water storage vessels may resemble those used for dry storage and there is no certain way to distinguish between the two. Vessels used for water storage may also be porous and therefore not match the porosity expectations for storage vessels. Thus, water storage is a potential confounding factor when trying to determine storage strategy and related mobility patterns using ceramic vessels.

Prestige and costly signaling

In the past few decades, archaeologists have conceptually linked ceramic vessel production with prestige behavior in two ways: pottery as one of a suite of crafts practiced by specialized producers in societies with some degree of social/economic complexity, and as a ware which can be used by individuals or groups to gain and maintain social status or accrue other social benefits in societies which may have a very low degree of complexity. Relationships between the production of ceramic vessels and social/economic prestige are common in the study the development of societies with a complex organization of labor, in which elite patrons support the production and redistribution of vessels over a large territory. While the research presented here focuses on foraging societies rather than state or empire-based societies, I use concepts from craft specialization research to develop empirical expectations for wares produced by foraging societies.

Recent research has focused on the idea that ceramic vessels were used as tools to accrue social and political prestige in foraging societies (e.g., Hayden 1995; Rice 1996). Although prestige models are not traditionally consistent with the social structure documented for socially egalitarian, residentially mobile hunter-gatherers, ethnographic research suggests that there are forms of prestige behavior among groups traditionally described as socially egalitarian (Bliege Bird and Smith 2005; Lee 1972). While socially egalitarian hunter-gatherers typically emphasize individual autonomy and movement, and accruing material possessions is often at odds with these values, there are examples of craft traditions in foraging societies traditionally described as socially egalitarian—such as the !Kung (Bliege Bird and Smith 2005; Wiessner 1982). It is not known if ceramic vessels are made and used as prestige items/tools by hunter-gatherer societies with high degrees of egalitarianism, or if the use of pottery in prestige contexts is restricted to societies exhibiting greater degrees of social inequality. Generally, ceramic vessels have the potential to be ideal prestige items, as they can be made to be aesthetically pleasing and rare or exotic materials can be used in their construction (Hayden 1995). The manufacture of ceramic prestige wares typically involves greater labor investment in the form of decorative embellishments such as surface design, color, and luster (Costin and Hagstrum 1995; Hayden 1998). This high degree of labor investment is often attributed to the primary functions of prestige wares: to appear desirable through their beauty, rarity, and/or the high cost of their production (Hayden 1998), and to communicate social and political information to those who make and use them (Costin and Hagstrum 1995). Recent ethnographic research suggests that in some cases, pottery production can be converted into other kinds of fitness-enhancing benefits (such as obtaining well-to-do husbands; Bliege Bird and Smith 2005). However, pottery can also be produced using a minimum of labor investment in societies with varying degrees of complexity. These types of wares are available to most if not all members of a society, and are usually intended for utilitarian tasks. In such cases vessel manufacture reflects the desire to minimize production costs (Costin 1991; Costin and Hagstrum 1995), and construction indicates a primary role as everyday tools (Braun 1983).

Ceramic vessels are potentially implicated with prestige behavior in another manner. The actual value of ceramic vessels can also derive from the items within that may be of social or economic significance, such as exotic foods and/or intoxicants (Arthur 2002; Hoopes and Barnett 1995). Ethnohistoric information and anthropological theory indicate that the processing, display, and consumption of such foods are of social and political value (Hayden 1995). The creation, display, and sharing of exotic foods can be used in a competitive manner to signal political strength, gain power, or create/strengthen political alliances (Bliege Bird and Smith 2005; Hayden 1990). Logically, the containers for these foods would be subject to public display. Therefore, pottery used in prestige tasks may be highly crafted in order to enhance its aesthetic appeal and showcase the high amount of labor needed to make it (Hayden 1995).

It is possible that the presence of pottery alone could reflect prestige-oriented behavior. In some contexts pottery might have been so novel that its rarity may have had a symbolic significance (e.g., Vitelli's work in Greece). Proponents of this idea argue that pots used in non-utilitarian contexts such as ritual feasts need not necessarily display fine craftsmanship or high labor investment. Small vessel size and overall low vessel frequency would indicate that pots were rare items with possible ritual significance or prestige value. While it is possible that relatively undistinguished-looking pottery may have functioned in this manner, it is also possible that there are other reasons as to why vessels would be small and appear infrequently in the archaeological record.

Recent work in costly signaling theory has the potential to reconcile symbolic interpretations of ceramic use and theories grounded in economic adaptation (Bliege Bird and Smith 2005). The term "costly signaling" is used to refer to behaviors which otherwise appear to negatively affect individual fitness, were it not for their social context. In pottery production, time spent making (or learning how to make) elaborate or finely crafted wares is time which could be spent in other pursuits. Costly signaling is expected in circumstances where there is variation in a population of a given attribute which can be signaled, observers can gain from accurate information about variation in quality. Those who give costly signals stand to benefit if the receiver attends to the message. Bliege Bird and Smith argue that costly signaling can be honest communication if it cannot be faked. Recipients of signals can test the accuracy of the signal, so liars can be found out. Costly signaling has the potential to explain behavior which appears to be wasteful or altruistic, by arguing that it actually is not. Costly signaling theory emphasizes that the benefits to the signaler are "symbolic capital" which can be converted into other types of currency.

Forms of costly signaling which have the potential to directly or indirectly involve the production and use of ceramic vessels include sharing food or other resources on an unconditional basis, competitive feasting and other "wasteful" subsistence behavior, and labor-intensive craft traditions. An example of costly signaling is presented by Bliege Bird and Smith (2005): among the Achuar-Quichua of Ecuador, it appears that women who are skilled pottery makers may actually be able to better secure marriages to politically-well connected men. Married women can signal their abilities and political connections through performing their craft skillfully. Pottery production may also be logically linked with competitive feasting. The production and serving of feast foods may require aesthetically pleasing vessels exhibiting high labor investment which assist in creating the signal. Here, the signal is comprised of the labor available for creating the pottery as well as the labor to prepare for and host such large gatherings. Using the logic of the nascent theory of costly signaling, pottery used for prestige tasks such as serving would be expected to have visible indicators of high labor investment, and skill (which takes time to acquire).

Hypothesis 3: Ceramic vessels on the UTCP were used as objects for gaining and/or maintaining social, economic, or political prestige.

Despite the name, costly signaling modeling does not require that a signal actually have a high cost. Some signals are simply not possible to fake (see Bliege

Bird and Smith 2005 for examples). Signaling by making and/or using ceramic vessels most likely entails committing time (logically in the form of labor) which could have been spent on other tasks. There are two types of costs involved in pottery manufacture: procuring raw materials and labor investment in creating the finished product. At first glance, the pottery of the UTCP does not appear to be costly to produce. Clays in this area are plentiful and in a sense pre-mixed with non-plastics and ready to use for vessel manufacture (Ellis 1992). As ubiquitous as they are, these clays can hardly be described as rare and difficult to procure. Most researchers have reasonably assumed that these vessels are made from local materials widely available throughout the area, but the geologic provenance of these wares has not been investigated. Pottery may be costly in terms of labor investment as well. It is possible that UTCP pottery was costly to manufacture and therefore made a useful prestige good. It takes time and skill to create attributes such as uniformly thin walls and extensive decorative treatment. Previous observations of UTCP pottery assemblages indicate that many wares are predominantly plain with little decorative surface treatment (e.g., cordmarking, stamping, incising, punctuation, red wash). Whether UTCP vessels contained rare or costly foods useful in prestige display contexts is unknown. Pots could have contained cultigens, possibly traded from the Caddo. The domestic contexts and plain appearance of the ceramic vessels themselves make them unlikely prestige goods. While some vessels have been recovered from burial contexts, the great majority of sherds have been found in activity and midden areas.

If the intended use of UTCP vessels was for prestige tasks then vessel bodies would be expected to exhibit high degrees of labor investment: thin walls, and high amounts of decorative treatment (Table 3.1). Vessels may be composed of raw materials which are rare or difficult to procure, such as clays from other regions. If this is the case, vessel assemblages would have high amounts of sherds with non-local mineral inclusions in their pastes, as it is costly to travel to different regions and to transport raw materials for pottery manufacture. Even pastes with minerals from local sources can indicate costly signaling if the raw materials require a great deal of time or labor investment to acquire. The latter would be plausible if local clays are rare or vary in their quality spatially. It is also possible that pots were implicated in other activities associated with social and economic aggrandizing behavior, such as feasting. If vessels were used for such social tasks, then they would be expected to have distinctive shapes, either shallow shapes with wide orifices for serving the contents or specialized shapes suited to a particular consumption or processing use (e.g., cylinder-shaped vessels used to serve beverages in Mesoamerica). Wares used for serving or processing exotic foods should bear organic residues of these non-local or rare foods. Vessel porosity and heating use wear might be expected to vary depending on the specific tasks it was used for. The single attribute which must be present in high frequencies in order to infer any type of prestige function is decorative treatment, as it is the one attribute that differentiates the prestige hypothesis from all others.

Socio-economic implications of pottery manufacture and use

The above hypotheses are logically related in various ways. The theoretical links between food production and storage have empirical implications for ceramic vessel assemblages. If one function of food production is to address temporal resource then people may store surpluses in order to average such shortages over time. Vessel attributes would form a bimodal distribution, indicating two basic vessel functions clustered around food processing and storage. Assemblages may reflect trade-offs between processing and storage functions: vessels may simultaneously display evidence of thermal use-wear and porosity-limiting attributes. Pots may have been used for processing activities not requiring direct heat, such as grinding in which case pots may have use wear and manufacturing attributes such as scratches walls of variable thickness (since the vessel would not need to effectively conduct heat).

It is also possible that food production/intensive plant processing were not major strategies for foragers with pottery. Imported domesticates could have been a component of forager diets, and could have been obtained from adjacent food producing groups, possibly in exchange for local foods (Spielmann 1986). Sourcing and residue data could support this if vessel pastes are from non local sources and residues indicate non local domesticated foods. If storing food surplus was not a common strategy, then groups might have dealt with temporal or spatial resource shortages using a residentially mobile strategy. If so, the organic residue data may reflect this by showing high frequencies of large animal residues.

Food production/intensive use of plants and storage may also be linked with social and economic complexity (Cohen 1985). Complex social institutions may result from competition, environmental and social circumscription, and reduced economic options. These conditions occur when groups focus on temporally and spatially variable resources due to population packing and subsequent reduced mobility. Reduced mobility may affect the ability of groups to follow large-bodied resources such as large game animals, and result in their increased reliance on r-selected resources through time. In this scenario, ceramic vessels could be used to lower processing costs of these resources, and vessels should show high frequencies of thermal use, and high frequencies of starchy seed residues. Anthropologists have argued that socio-political contexts affect and are affected by storage (Fitzhugh 2003). Social elites can control surplus and direct its distribution. Ceramic vessels can play a role in the redistribution of surplus as tools for feasting. Vessels used in such contexts of public redistribution are expected to be highly decorated with wide orifices for their role as elite serving containers. Distributions of decorative and size attributes across a given ceramic assemblage may appear multimodal, indicating two or three groups of vessels which are functionally different from one another. Frequent evidence of semi-permanent to permanent settlement might be in the archaeological record (such as postmolds or housefloors). Trade for exotic items other than pottery would also be frequent in the archaeological record. Burials should indicate differing levels of grave goods (including ceramic vessels) indicating differential social status. The expectations presented here are evaluated in a case study located on the upper Texas coastal plain (UTCP). In order to apply the models to the study area, it is necessary to consider the particular nature and distribution of food resources, as well as cultural information of this region.

Table 3.1 Expectations for hypotheses discussed in text. After Hayden 1998; Reid 1990; Rice 1987; Sassaman 1993.

	Wall thickness	Vessel morphology	Porosity	Source of asplastics	Decorative treatment	Heating use wear	Food residue
PROCESSING							
starchy seeds	thin, uniform	round base, smooth wall curvature	low	mineral, local	low	high	cultigens/wild starchy plants
large-bodied resources	thick, uniform	flat base, wide orifice	high	fiber, local or non-local	low	low	large animals
STORAGE							
Front loaded	thick, variable	narrow orifice	low	mineral, local	low	none	high frequency of food residues
Back loaded	thick, variable	narrow orifice	low to high	local or non-local	low	none	little or no residue
PRESTIGE							
Serving or procesing	thin, uniform	shallow/special shapes, wide orifices	variable	variable, non-local	high	high to none	exotic foods

CHAPTER 4: SELECTED SITES

In order assess hypotheses concerning hunter-gatherer pottery use and its relationship to diet, mobility, and social/political behavior, sites from the upper Texas coastal plain (UTCP) needed to meet certain criteria. Since this research is focused on increasing understanding of mobility and subsistence practices, it was important to select a variety of site types from different ecozones. Sites of different sizes were selected using the reasoning that large and small sites may represent different occupations in a seasonal round, or possibility different mobility strategies. For the same reasons, it was also important to select sites representing different occupation types (e.g., cemeteries, large shell midden sites, sites without shell middens). For example, large sites may have been places where people congregated as part of their settlement pattern, and possibly engaged in ceremonies or feasts. Sites in different ecological zones were selected as well, in order to account for the possibility that different ecological zones contained different settlement patterns, or that sites in different zones were parts of the same settlement system. This was particularly pertinent considering the existing idea that groups moved between inland and coastal margin areas on a seasonal basis.

Analysis of ceramic assemblages from contemporaneous sites facilitates analytical comparisons between assemblages, as well as the sites themselves. This way, any differences between sites can be properly interpreted in terms of spatial difference, rather than temporal change. While many existing collections of pottery in this area are available for research, many are from sites which lack absolute dates, or were not systematically excavated. Some sites have absolute dates (though not necessarily precise) and sound recovery and documentation. Sites which appeared contemporaneous were selected; the discussion of luminescence dates later in this chapter indicates that all three of the selected sites were occupied at roughly the same time, although some dates from two of the sites suggest earlier occupations—or earlier pottery—than the radiocarbon dates.

Information on diet from individual sites can be used to assess the conclusions from analysis of pottery assemblages. Therefore, sites with additional data on diet, in the form of plant, animal, and human remains were selected. Botanical remains are rare in archaeological sites in the region, and only a very few sites have evidence of plant use. Animal remains are more common, although less so in sites without shell (shell can alter soil chemistry and help preserve bone). The region does have cemeteries, some of which have been excavated. Samples of human remains from some of these cemeteries have been analyzed in dietary studies. Sites with burials are also useful in addressing the prestige behavior hypothesis, it was important to include sites which may yield detectable evidence of social ranking. Sites with burials are ideal because the presence of status differences can be determined by examining the amount and types of burial goods.

Ceramic assemblages were chosen from three of these well-documented sites: 41GV66, 41AU38, and 41LB4. All were chosen because they yielded radiocarbon dates which fell into the Late Prehistoric Period (AD 1100-contact), which facilitated analytical comparisons between them. In addition to their dates, each site had particular aspects which promised to lend insight into testing the hypotheses. Mitchell Ridge (41GV66) is a large site with four cemeteries and was reported to have high frequencies of decorated ceramics. Some sherds were noted to have decoration styles similar to pottery styles in the Lower Mississippi Valley (Ricklis 1994). Excavations at Honeycomb (41LB4) revealed nut fragments, and features thought to be postmolds—perhaps indicating some sort of structure related to settlement. Little Bethlehem (41AU38) was chosen because it is located on the inland potion of the upper Texas coastal plain and thus represents inland adaptations on the gulf coastal plain. This site is less than a kilometer from the well-known Archaic Period Ernest Witte site, which contains burials and grave goods sourced to regional trade networks, indicating possible mobility and/or prestige activity.

41GV66 "Mitchell Ridge"

Mitchell Ridge (41GV66) is located on a relict beach ridge near the midpoint of the axis which runs parallel to the length of Galveston Island, on the leeward side (Figure 4.1). At 8-10 feet above sea level the site occupies one of the highest points on the Island and overlooks the shallow inlet of Eckert Bayou, an old tidal pass that was most likely filled in by sediment prior to occupation of the site (Ricklis 1994). Lagoon-dwelling species in the shell hash underlying the site date to about 3483 BC and suggest that that the site was adjacent to a quiet lagoon during human occupation. Cultural materials were most likely deposited on the ridge and swale topography as it was being filled in with eoalian sands and vegetation. The site is located on the cultural boundaries of the historic Akokisa and Karankawa groups. It includes occupation areas and four cemeteries dating from AD 700/800 to ca. AD 1660, and has yielded over 25,000 sherds—the largest ceramic assemblage of any site in the UTCP (Ricklis 1994). Radiocarbon dates of human remains, charcoal, and shell suggest the most intensive occupation of the site occurred after AD 1250 (Ricklis 1994).

Roughly a kilometer long and more than half a kilometer wide, portions of the site were first excavated by Rice University and the Houston Archeological Society from 1974-1978. The Texas Archeological Society conducted its annual field school at the site in 1978. More recent work was conducted by Coastal Archaeological Research, Incorporated under the direction of the United States Army Corps of Engineers (Galveston District) after human remains were discovered during construction of a pilot canal for a housing development. Under the direction of Robert Ricklis, Coastal Archaeological Research crews carried out testing and excavation of selected portions of the site between January and July of 1992. Coastal Archaeological Research also conducted an analysis of field records and artifacts from the 1974-1978 excavations, concluding that much of the original provenience information had been lost when the collections were re-housed in a local museum not long after the original excavations (Ricklis 1994). Given this information, I decided to focus on sherds collected from the more recent excavation in 1992.

In addition to the four discrete burial areas, the 1992 testing revealed high concentrations of domestic refuse, especially in the northeastern portion of the site known as the "Block Excavation" (Figure 4.2; see Figure 4.3 for a plan view of the Block Excavation). This particular area roughly 200 meters southwest of the bayou yielded the greatest density of artifacts and non-burial features on the site. I focused my analysis on the sherds from this area, because it had a high density of artifacts with good provenience. Concentrating on sherds from a domestic context also allowed me to avoid using destructive analytical techniques on sherds which could have been associated with mortuary practices. Provenience was tightly controlled in the block excavation and as a result of this and overall sherd density it provided a large amount of sherds with the best chronological control at the site. Shovel tests indicated that cultural deposits in this area were approximately 20 centimeters below surface and were contained in a dark brown fine sandy soil layer 15-20 centimeters thick (Rickis 1994; see Figure 4.4 for representative profiles). This cultural layer was capped by a mainly sterile layer similar in color and texture and 15-20 centimeters thick. Below the cultural layer was another sterile layer of light brown sand 10-15 centimeters thick, which was underlain by a lighter colored sterile matrix of fine sand and shell hash (Rickis 1994).

The Block Excavation covered a 72 square meter area comprised of contiguous 2 by 2 meter units. The upper 10 centimeters of sterile soil were removed by machine. Workers then staked a grid; shovel skimmed the remaining five centimeters of sterile soil, and used trowels to expose the cultural layer. This portion of the hand excavation used a mixed strategy where the cultural matrix was initially removed as one layer, and later in five centimeter arbitrary levels when it was discovered that some portions of the block had a cultural layer thicker than previously thought (Ricklis field notes 1992). The cultural matrix was sieved through 1/8" screens. Flotation samples were taken from in and around features, although they yielded no botanical material except for small pieces of wood analysts could not identify. No carbonized plant remains were recovered from the site.

The block excavation yielded radiocarbon dates from AD 1280-1440, as well as 7,018 sherds and 12 features (Ricklis 1994). Features consisted of shell-lined hearths, unlined hearths, an unburned pit, and a semicircular depression almost four meters square containing a shell and pottery-lined hearth, which Ricklis suggested might have been a house floor (see Figure 4.3 for locations and types of features). Artifacts other than pottery included stone tools, pumice and sandstone cobbles, bone tools including an unusual scraper/smoother made from a bison scapula, bird bone beads and whistles, worked shell, 510 pieces of asphaltum (tar that occurs naturally in the area), and five pieces of worked glass interpreted to be associated with a later occupation to the south of the block excavation (Ricklis 1994:86-87).

Faunal materials recovered include 6,343 fish bones and 1,885 mammal bones. Species represented in the block and throughout the site include large mammals such as deer (*Odocoileus virginianus*) and a few bison bones (*Bison bison*), as well as smaller mammals such as coyote (*Canis latrans*), river otter (*Lutra canadensis*), and hispid cotton rat (*Sigmodon hispidus*). Birds and reptiles are also present (see report for full species list). The majority of bones (75%) are fish and include gar (*Lepisostens* sp.), black drum (*Pogonais cronis/Archosargus robatocephalus*), sheepshead (*Archosargus probatocephalus*), sea catfish (*Arius felis*), sea trout (*Cynoscion nebulosis*), red drum (*Sciaenops ocellata*), as well as shark teeth and a stingray spine. Shellfish are present in smaller quantities, with 95% of the shellfish sample comprised of oyster (*Crassostrea virginica*). Seasonality studies of the oyster indicate that 26% of the oysters were harvested in the autumn and 48% in the winter. Analysis of non-ceramic remains led Ricklis to conclude that the site had been occupied principally in the fall and winter, and that while terrestrial remains indicated contact with the mainland, food procurement was geared primarily toward fishing (Ricklis 1994). The majority of terrestrial mammal bones are deer and hispid cotton rat.

Analysis of human remains and associated grave goods provides useful information on interregional interaction, social complexity, and diet. The oldest burial dates to about AD 84 and is temporally distant from the other burials and materials dated at the site, most of which are suspected to be AD 1250 or younger (Ricklis 1994). Grave goods include lithics, bone and antler tools, pumice cobbles, shell and shell beads, engraved whistles made from whooping crane bones, red and yellow ochre, otoliths, shark teeth, and small, rounded clusters of pebbles and drum teeth that may have been parts of rattles (Ricklis 1994). Protohistoric and historic burials contain European trade beads and pieces of metal. Prehistoric burials have few goods which could not be obtained locally. Shell bead manufacture could have been time-consuming and therefore a way of displaying status and/or wealth (Ricklis 1994). It is interesting to note that none of the burials contain pottery, except one particular sherd which appears to be an accidental intrusion of adjacent refuse (Ricklis 1994). Grave goods are not evenly distributed over the burial population; adult male burials are more likely to have goods and in a greater variety than adult female burials. Some children and subadult burials contain grave goods. Since not all burials are contemporaneous with one another, it is difficult to determine if there is any spatial differentiation in the distribution of grave goods. Therefore, Ricklis concluded he could not address the possibility that burial groups were spatially divided according to status.

Human remains from the cemetery portion of the site were the focus of dietary studies (Huebner 1994; Powell 1994). Dental data indicate that Late Prehistoric individuals had more enamel wear and dental attrition than later groups, possibly from a gritty diet of berries (many of which contain hard parts), nuts, and hard seeds or maybe food not thoroughly cleaned. Some dental polishing is present, similar to that of known mastication of fibrous plants such as roots. Subsequent historic burials contain individuals with less severe enamel damage and dental attrition, but more caries and dental calculus, possibly indicating a change it diet and/or food preparation (Powell 1994). Stable isotope analyses conducted by Huebner indicate that as a group, prehistoric individuals had diets comprised of 2/3 to 3/4 marine foods while diets of historic individuals are comprised of 1/3 to 1/ 2 marine foods (Huebner 1994). It is also interesting to note that Powell's conclusion that the differences between prehistoric and historic burial groups at Mitchell Ridge in terms of skeletal morphology and diet may be due to the incursion of non-local people in the area during the historic period, or from intermarriage with Europeans, although he does not rule out the possibility that there was dietary change to maize or vegetable horticulture in the UTCP during this period.

The Mitchell Ridge pottery assemblage appears predominantly comprised of local wares, although some UTCP design styles do resemble lower Mississippi valley culture historical types (e.g., Coles Creek Incised, Mazique Incised, and Harrison Bayou Incised) that Ricklis posits were local copies of these wares. The 1970's excavations recovered two sherds that appear non-local (Caddoan or lower Mississippi Valley) in design and construction. In addition to the shell and sherd-lined hearth in the block, other parts of the site yielded features with and without pottery which may have implications for assessing the storage hypothesis. One pottery vessel was buried in a pit with unarticulated fish and other animal skeletons in it, possibly indicating storage of these items (or disposal as refuse). Another feature was comprised of an ash-stained pit with faunal remains, and could possibly have been a storage pit (Ricklis 1994). Postmolds are also present at the site, and one configuration is semicircular, with little debris in or around it, similar to ethnohistoric descriptions of fish-drying structures used by groups living further south on the Texas coast (Ricklis 1994). Other possible functions of the structure could be a charnel house (given the presence of secondary burials on the site) or sleeping quarters (Ricklis 1994).

41LB4 "Honeycomb"

Honeycomb is a small shell midden (40x15 meters) habitation site located 40 miles east of Houston, on a tributary linking the current channel of lower Trinity River with one of its older channels (Figure 4.5; Ensor 1995). Just south of the modern town of Liberty, the site is in the vicinity of the short-lived Mission Nuestra Senora de la Luz del Orcoquisac (1756-1771). Initially tested in 1969 and 1971 by Lawrence Aten, the site is on the National Register as part of the Orcoquisac Archeological District. This delta area is laced with ponds, brackish and freshwater marshes, swamps, and wooded bottomlands, and is fringed by grassy uplands. Radiocarbon dates indicate the site was occupied ca. AD 1200-1670 and inhabitants probably lived in an immediate environment similar to the one at present, although the course of the river shifted during the span of occupation and most likely changed the salinity of the surrounding water which may have affected the types of aquatic species present (Nordt and Jacob 1995). The bulk of the midden was most likely created between AD 1250 and 1500 (Ensor 1995). Three sherds from Test Unit 1 yielded dates which fell into this range (Figure 4.6; Table 4.1).

The site was most recently tested by Geo-Marine Incorporated as part of a contract with the United States Army Corps of Engineers Galveston District to delineate and determine the integrity of sites within the Wallisville Lake Project Area, a large water control project. The focus of the work was primarily on documenting historic occupations. During November and December of 1993 and January of 1994, Geo-Marine crews excavated three test units at the site totaling eight square meters (see Figure 4.7 for location of test units and all shovel tests). All cultural matrix was water screened through 1/4" mesh. Two square meters from Test Unit 1 were screened using 1/8" mesh in an effort to look for historic trade beads. Trenching and auguring were also used to delineate the boundaries of the site. Work revealed that the site was overlain by about 90 centimeters of very recent (20th century) overburden (see Figure 4.8 and 4.9 for extent of overburden). Subsequently test units were opened by shoveling the overburden and removing subsequent layers with hand tools. Site stratigraphy was divided into three zones; the first of which was comprised of a very dark silty clay averaging 12 centimeters in thickness with occasional fragments of shell and pottery. Zone two was the shell midden with a black silt clay matrix which ranged from trace amounts of shell to 27 centimeters thick. Most of the cultural materials were contained in this layer. Excavations were terminated in zone three (a soil similar to that in Zone 2) due to the lack of shell and artifacts, and the fact that the water table was reached—despite efforts to siphon water off with a bilge pump (Ensor 1995). Some portions of Zone 2 in Test Unit 3 contained only isolated concentrations of shell. In some places sherds were present but not the shell midden.

Excavations yielded 3,035 sherds, 46 lithic tools and 1, 290 flakes, and nine features. Sherds exhibited greater variability in form and decoration than other sites investigated in the area, leading Ensor to conclude that perhaps the site was formed by longer occupations, and/or higher populations (Ensor 1995). Lithic materials appear to be mostly from local river gravels; a couple of pieces of chert and quartzite may be linked to central and northeast Texas sources. Features consisted of three "surface hearths"—mounded clusters of pottery, bone, lithics, burned and unburned shell (see Figure 4.10 for location of these features). Two clusters of pottery bone and shell were documented, as well as two small, round depressions filled with cultural debris interpreted to be postmolds. Two basin-shaped features with pottery, bone, lithics, burned shell and ash were also documented.

Fauna recovered from the site include a variety of fresh and saltwater fish: gar (*Lepisosteus* sp.) bowfin (*Amia calva*), various species of catfish (Ariidae/*Aurius felis*/*Bagre marinus*), perch or bass (Perciformes), black and red drum (*Pogonais cromis* and *Sciaenops ocellata*), croaker (*Micropogonais* sp.), freshwater drum (*Aplodinotus grunniens*), and sheepshead or porgie (Sparidae). Alligator (*Alligator mississippiensis*), and various species of turtle and snake are present, as well as duck (Anatidae), cottontail (*Sylvilagus* sp.), swamp rabbit (*Sylvilagus aquaticus*), squirrel

(*Sciurus* sp.), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), raccoon (*Procyron lotor*), deer (*Odocoileus* sp.), and unidentified carnivores. Bones from several of these species were burned (Shaffer 1995). Although little pollen was found, carbonized plants included a charred fragment of hickory nut, leading the analyst to posit possible hickory nut processing at the site (Dering 1995). Seeds of the pepper vine (*Ampelopsis* sp.) and bedstraw (*Galium* sp.) were also preserved, and are known to have medicinal uses among historic peoples in the southeast. Charred fragments of wood were also identified: maple (*Acer* sp.), hickory (*Cayra* sp.), hackberry (*Celtis* sp.), holly (*Ilex* sp.), sycamore (*Platanus occidentalis*), oak (*Quercus* sp.), sweetgum (*Liquidambar styraciflua*), cypress/juniper (*Taxodium/Juniperus*), basswood (*Tilia* sp.) and elm (*Ulmus* sp.) were burned at the site.

41AU38 "Little Bethlehem"

Little Bethlehem is located on the inland portion of the coastal plain on the edge of an old bluff-like meander scar of the Brazos River overlooking the river's floodplain, approximately 70 kilometers east-northeast of Houston and immediately north of the town of Wallis (Figure 4.11). A shallow, unstratified site with a single radiocarbon date of AD 1480+/-80, it is one of several sites in this area located on the bluff (Hall 1981).

Little Bethlehem is 900 meters from the well-known predominantly Middle Archaic-Early Prehistoric cemetery site Ernest Witte (41AU38), which was the source for one of the few studies of dietary bone chemistry in the area (Huebner and Boutton 1992). Little Bethlehem is located 700 meters from Allens Creek, an intermittent stream with six recorded sites on its banks. Little Bethlehem rests on a gradual slope leading down to a drainage notch in the bluff line and was occupied when the Brazos switched from the eastern side of the valley to its present course (Hall 1981). Prehistoric occupation of the inland coastal plain appears most dense in the stream and river valleys, which are heavily wooded with pecan, oak, and elm. These areas are immediately adjacent to oxbow lakes and swampy areas, a potential source for waterfowl and game (Hall 1981). Upland prairies have few signs of prehistoric occupation, except for small, infrequent scatters of artifacts (Hall 1981). This area of the UTCP lies in the historic range of the Tonkawa, Karankawa, and possibly Atakapa. Hall notes that the lithic and ceramic artifacts resemble culture historical types found around Galveston Bay. There is no evidence of direct contact with Europeans or Anglo-Americans at Little Bethlehem.

The 1974 Texas Archeological Salvage Project (TASP) excavations of the site uncovered debris characteristic of domestic occupation. A former owner of the land recalled seeing human remains eroding from the bluff at some point previously (Hall 1981). The site was recorded in 1972 when the TASP survey crew noticed cultural materials eroding from the top layer of soil of the bluff. It was subsequently excavated in 1974 as part of a project to mitigate the effects of a proposed nuclear generating station operated by Houston Lighting and Power Company. Workers placed a grid on the site and excavated 14 1x2 meter units and one 1x1 meter unit in 10 centimeter arbitrary levels, sieving all matrix through 1/4" screens (Hall 1981; see Figure 4.12 for location of excavation units). No natural stratigraphy appeared to exist; probably a result of modern plowing activity and post-depositional argilliturbation of the Lake Charles Clay (a soil formed from the underlying Pleistocene Beaumont Clay) in which deposits were located. The cultural matrix averaged 40 centimeters in thickness and extended 40-50 centimeters below the surface, terminating at the Beaumont Clay (see Figure 4.13 for a representative profile). In addition, four backhoe trenches were cut to determine the boundaries of the site, which is about 130 meters on its longest axis and 40-50 meters in width. Trenching and excavation exposed a total of 2400 square meters. The northwest portion of the site cuts across sandy loam deposits, which are commonly the result of gully-like washes filling with colluvium as they drain the prairie uplands to the river. Cultural materials have subsequently been found below such sandy deposits at other sites, leading Hall to conclude in retrospect that older cultural deposits may have been below the apparent colluvium.

Excavation yielded 877 sherds and 31 sediment samples from controlled vertical and horizontal contexts. Five features were uncovered, including refuse piles, concentrations of burned mussel shell, and clusters of sandstone cobbles and burned clay nodules. These burned clay nodules ring clusters of burned bone fragments from deer, raccoon, snake, and fish, combined with charcoal and a few sherds. Whether these nodules are the same as the "clay balls" typically described from more recent excavations on inland sites is unclear (Moore 1995). It is still not clear to archaeologists working in the inland UTCP today if these clay ball objects were used for food preparation tasks, and whether or not they are associated with pottery use. Other tools include a variety of arrow points made from local cobbles which can easily be found on sandbars of the Brazos, and six marine shell whorls, some apparently used as pendants. Five of these shell whorls were previously recovered by the landowner who claimed they were associated with the human remains he observed eroding from the bluff (Hall 1981).

Thus, portions of Little Bethlehem may have contained burials at some point. But the site most likely had other roles in the settlement pattern as well. Hall notes that there was a greater variety of lithic debris at this site than the others around it, and hypothesizes that Little Bethlehem was a site of comparatively intense lithic manufacturing. One cobble fragment is described as a possible grinding stone, but no other possible food processing tools are present, except for pottery. Many sherds have bone inclusions. Bone-tempered ware are known and described as "Leon Plain" in central and inland south Texas and sometimes "Orcoquisac Plain" closer to the coastal margin. The original analysis of the sherds revealed wares with a combination of bone and grog temper not seen in the area before (Hall 1981). Fauna recovered from the site include a variety of freshwater fish: bowfin (*Amia calva*), gar (*Lepisosteus* sp.), catfish (*Ictalurus* sp.), bass (*Morone* sp.), and drum (*Aplodinotus grunniens*), as well as small amphibians and reptiles. Blue goose (*Chen caerulescens*), duck (*Anatidae* sp.), and coot (*Fulica Americana*) are present. Large mammals include deer (*Odocoileus virginianus*) and the radius, carpal and tooth of a horse, and a bobcat (*Lynx rufus*) mandible. No bison bones were found. Smaller mammals include: opossum (*Didelphis marsupialis*), cottontail (*Sylvilagus floridanus*), squirrel (*Sciurus* sp.), gopher (*Geomys bursaris*), cotton rat (*Sigmodon hispidus*), and raccoon (*Procyon lotor*) (Lord 1981). The majority of freshwater mussel represented is *Ligumia subrostrata*.

While no human remains were recovered from Little Bethlehem, a small group of Late Prehistoric (AD 920-1480) burials was excavated at the nearby Ernest Witte site (41AU36), and one individual Late Prehistoric burial was unearthed at Leonard K (41AU37). None of the Late Prehistoric Period burials at either site had grave goods, unlike the more than 200 Archaic and Early Prehistoric Period (2600 BC-AD 950) burials at Ernest Witte, which had boatstones similar in source and manufacture to those found in the lower Mississippi Valley. Some of those early burials include corner tang knives, which have a wide distribution throughout the central and southern plains. Marine shells are also present, although the distribution of these species ranges from relatively local Texas waters to Florida and the eastern seaboard, so it is difficult to determine how distant their source ultimately was. Burials at Ernest Witte after AD 200 have fewer of these exotic artifacts, leading Hall to conclude that while inland groups may have participated in interregional exchange networks in the Archaic and Early Prehistoric periods, their social, political, and/or economic spheres contracted by the Late Prehistoric.

Luminescence dates

Successful interpretation of pottery use and production depends upon accurate dating. Without sound dates, it is impossible to distinguish temporal from contemporaneous differences in pottery use and production between the selected sites. While the chosen sites are roughly contemporaneous with one another, some of their radiocarbon dates are problematic, as is often the case in this area. One of the most common materials used for radiocarbon dating shell-bearing sites on the UTCP is *Rangia cuneata* shell. Marine reservoir effects on *Rangia* shell dates appear to be highly variable throughout the UTCP (Aten 1999). Charcoal is rare in most sites, and in some cases recovered charcoal has been combined from different strata in a given site simply to obtain enough material for a radiocarbon sample. A seriation of pottery types is commonly used in the area (Aten 1983), but the majority of wares in this study are plain and lack the stylistic attributes necessary for a robust seriation (Dunnell 1978). Thermoluminescence is an ideal dating method for research on the production and function of pottery because it directly dates the material and event of interest (Feathers 1997). Not only is thermoluminescence dating of pottery routine (Feathers 1997), it is highly practical in this area where marine reservoir effects on shell are poorly understood and sherds greatly outnumber charcoal. Recent advances in luminescence methods and instrumentation have improved the accuracy and precision of the technique. The accuracy of luminescence can be greater than radiocarbon in that the luminescence produces calendar dates which do not require calibration (Feathers 2000). Most importantly for the purposes of this study, luminescence dating offers the only direct means of determining when pots were manufactured and used on the upper Texas coastal plain. Each of the sites in the study has reported radiocarbon dates from previous studies. Radiocarbon methods require an associational argument between the organic material being dated and pottery, which negatively affects the accuracy of our understanding of the timing of pottery use and manufacture (Feathers 2000).

Luminescence dating is based on the fact that some minerals found in crystalline minerals found in archaeological materials (such as pottery, sediments, and lithics) have microscopic structural imperfections which trap free electrons. In the case of pottery, the trapped electrons are released when pots are heated above 500 degrees Celsius, a situation which occurs during manufacture and/or use. The release of electrons from these “traps” essentially resets the luminescence “clock” of the material to zero. After this event, traps begin to refill as a function of natural radioactivity. In the laboratory, the traps are emptied again by heating samples above 500 degrees Celsius (in the case of thermoluminescence) or exposing them to light (in the case of optically stimulated luminescence). The intensity of the luminescence signal is proportional to the accumulated radiation dose. In order to relate this signal to time, two quantities must be assessed. The first, called equivalent dose, is an estimate of the amount of absorbed radiation does required to produce the natural luminescence signal. It is divided by the second, the dose rate, to determine the age. The dose rate is measured from current radioactivity of the sample and its immediate surroundings, on the assumption that the dose rate has not changed significantly through time, due to the long half lives of the relevant radionuclides. After this equivalent dose rate is determined, the radioactivity of surrounding sediments is measured using a sample of soil in which the object was found. Dividing the first dose rate by the second produces the age of the materials being dated (see Aitken 1985 for a detailed overview of the method).

Sherds in close proximity to one another on a given site (preferably in the same unit) were chosen for dating. Choosing sherds with similar locations facilitates interpretation of the age of the site and the pottery. For example, dates from sherds from different levels of the same unit can be another means of assessing the accuracy of the dates: if one or some dates are out of stratigraphic order, then perhaps they are problematic. In order to obtain dose rates for the surrounding sediments, sediment samples were taken from Mitchell Ridge (41GV66) and Honeycomb (41LB4). In the case of Little Bethlehem (41AU38), sediment samples were originally collected from each arbitrary level of excavation units during the 1974 testing. Small portions of these samples (100 grams or less) were used in the current study.

Both thermoluminescence and optically stimulated luminescence dates were obtained for the samples. Thermoluminescence measurements were made with a Daybreak 1100 reader using a 9635Q photomultiplier. Optically stimulated luminescence dates were obtained using a Risø TL-DA-15 reader. Both methods were used because they are independent of one another. Thus, one can be used to check the accuracy of the other. When dates from different methods on the same material do not agree, it is commonly due to the thermoluminescence signal fading (which occurs when trapped electrons are lost over time) while the optically stimulated luminescence signal does not. If fading has occurred, the age of the sample will be underestimated unless a correction is made. For this reason, fading was tested for in these samples. Dates from both luminescence methods may also disagree for other currently unknown reasons. Using both methods can help identify a potential problem with one of the analyses.

Radiocarbon dates (2-sigma calibrated) were originally reported from Mitchell Ridge (Ricklis 1994), Honeycomb (Ensor 1995), and Little Bethlehem (Hall 1981). Their ranges are illustrated in Figure 4.6, along with the luminescence dates obtained in this study.

Luminescence dates were obtained from three sherds from the block excavation portion of Mitchell Ridge (41GV66; Figure 4.3). Sherds were selected from successive layers of unit N0E0. A grog-tempered, asphaltum-coated sherd from a depth of 5-10 centimeters yielded a date between AD 1239 and 1357 (UW 1334), which falls within the distribution of radiocarbon dates for the block excavation potion of the site (Figure 4.2; Table 4.1). The sandy paste sherds from the lower depths of the same unit yielded older luminescence dates. The sherd from the 10-15 centimeter depth dates between 123 BC and AD 371 (UW 1335), the other from 15-20 centimeters dates between 172 BC and AD 702 (UW 1336; Figure 4.2; Table 4.1). It is not clear if these older dates indicate that pottery was being used in the block excavation portion of 41GV66 this early in time. Both sandy paste sherds yielded optically stimulated luminescence (OSL) dates older than the geologic formations of the area, although it is unclear why this is the case (Feathers, Appendix A). These anomalously old OSL dates from these two samples are not reliable, therefore only the thermoluminescence dates were considered.

The sherd from the 15-20 centimeter layer (UW 1336) produced a thermoluminescence (TL) date which was corrected for fading. If the fading correction is not used, the date would be around AD 700. With the correction, the date is 265±437 BC. No other dates from the block excavation are this old, although dates from other portions of the site overlap with the luminescence dates from the block excavation. Ricklis reports that one radiocarbon date on human bone from the 1970's era excavations is between 45 BC and AD 310 (Ricklis 1994), which overlaps with UW 1335 and UW 1336. Additional dates from human remains at the site range between AD 670 and AD 1215 (Ricklis 1994). Thus, while old when compared to the other dates from the block excavation, UW 1335 and UW 1336 are not anomalously old within the context of the entire site. While these early luminescence dates could be slightly older than the Early Ceramic Period dates for the UTCP (AD 100-425) they overlap with the Early Ceramic component dates at Eagles Ridge (41CH252; Ensor and Ricklis 1998). Given the current information, OSL dates for the two sandy paste sherds are problematic, yet it is possible that the TL dates from these represent older occupations. As it stands, further dates need to be obtained to determine if in fact sherds from the block excavation predate AD 1052.

In contrast to the sherds from Mitchell Ridge (41GV66), three sherds from Honeycomb (41LB4) yielded luminescence dates very similar to the radiocarbon dates obtained from the 1993-94 Geo-Marine testing. A grog-tempered sherd (UW 1338) and a sandy paste sherd (UW 1339) from the 10-15 centimeter level of Unit 1 yielded dates AD 1298-1422 and AD 1305-1457, respectively (Figures 4.2, 4.9 and 4.10; Table 4.1;). A sandy paste sherd from the 15-20 centimeter level of the same unit (UW 1337) dated between AD 1168 and AD 1270 (Figure 4.2; Table 4.1). Radiocarbon dates from charcoal samples in the 10-15 centimeter and 20-25 centimeter levels of Unit 1 closely bracket the luminescence dates.

A single radiocarbon date from Little Bethlehem (41AU38) lies between AD 1400-AD1560, leading investigators to conclude that it did have a Late Prehistoric component (Hall 1981). During the present study, luminesence dates obtained from four sandy paste sherds from consecutive layers of Test Pit 1 gave older dates (Figure 4.2; Table 4.1). Sherds which produced these dates overlay two lower arbitrary levels containing Ensor and Lange dart points but no pottery. Given the styles of the dart points and the absence of pottery, the lower portion of the site was interpreted to be a Middle or Late Archaic occupation (Hall 1981). Two sherds from the 20-30 centimeter level of Test Pit 1 yielded dates of AD 913-1065 (UW 1333) and AD 937-1177 (UW 1332; Figures 4.2 and 4.13; Table 4.1). UW 1333 is an OSL date, as the TL date most likely has fading. UW 1332 is a TL date, as the OSL date is anomalously old (Feathers, Appendix A). The other two dates are problematic, given the current knowledge of the age of ceramics in the inland portion of the Texas coastal plain, but at least one is not completely implausible. The date from UW 1330 places ceramics on the site between 90 BC and AD 318, before the commonly understood appearance of ceramics on inland sites (around AD 550-950; Hall 1981). This early date was produced by OSL; the TL date is between AD 1040 and 1336. While the TL date is probably subject to fading, it is much more plausible given what we know about the ages of ceramic vessels in the inland area, the radiocarbon date from this site, and the fact that the sherd comes from the level above the earlier dates (10-20 centimeters; Figure 4.2). The fourth date (UW 1331) is relatively old (7 BC-AD 303) but cannot be easily dismissed. While the TL date of UW 1331 is affected by fading, the OSL date is derived from excellent data (Feathers, Appendix A). The problem with the OSL date on UW1331 is that it is simply older than the known age of pottery on the interior Texas coastal plain. Given the Archaic Period artifact assemblages in the lower levels of this site, it is possible that this early pottery date is accurate. While a single date may not cause us to revise our current understanding of pottery on the inland portion of the Texas coastal plain, UW 1331 warrants further consideration and research.

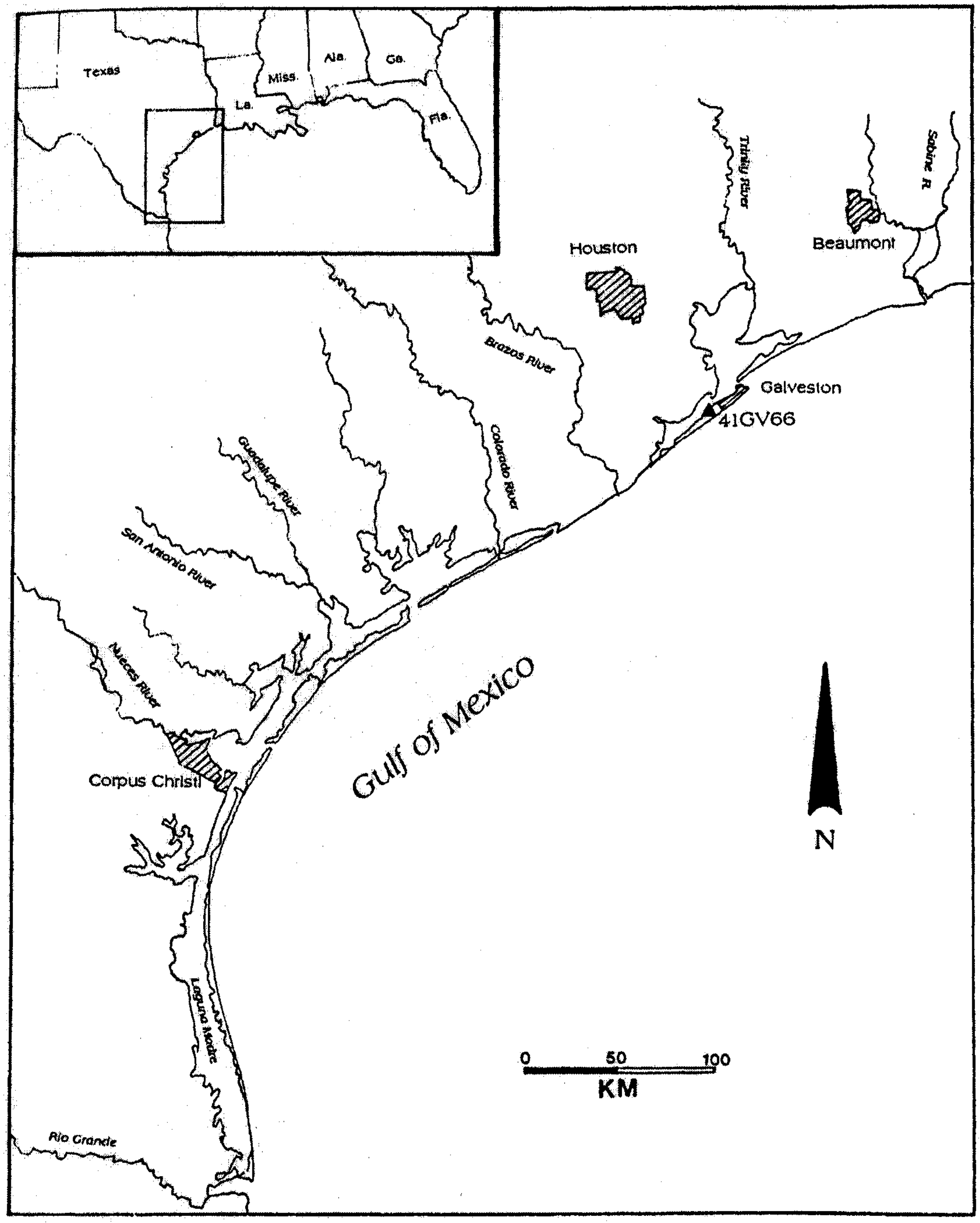


Figure 4.1 Location of Mitchell Ridge Site (41GV66). From *Aboriginal Life and Culture on the Upper Texas Coast: Archaeology at the Mitchell Ridge Site, 41GV66, Galveston Island.*

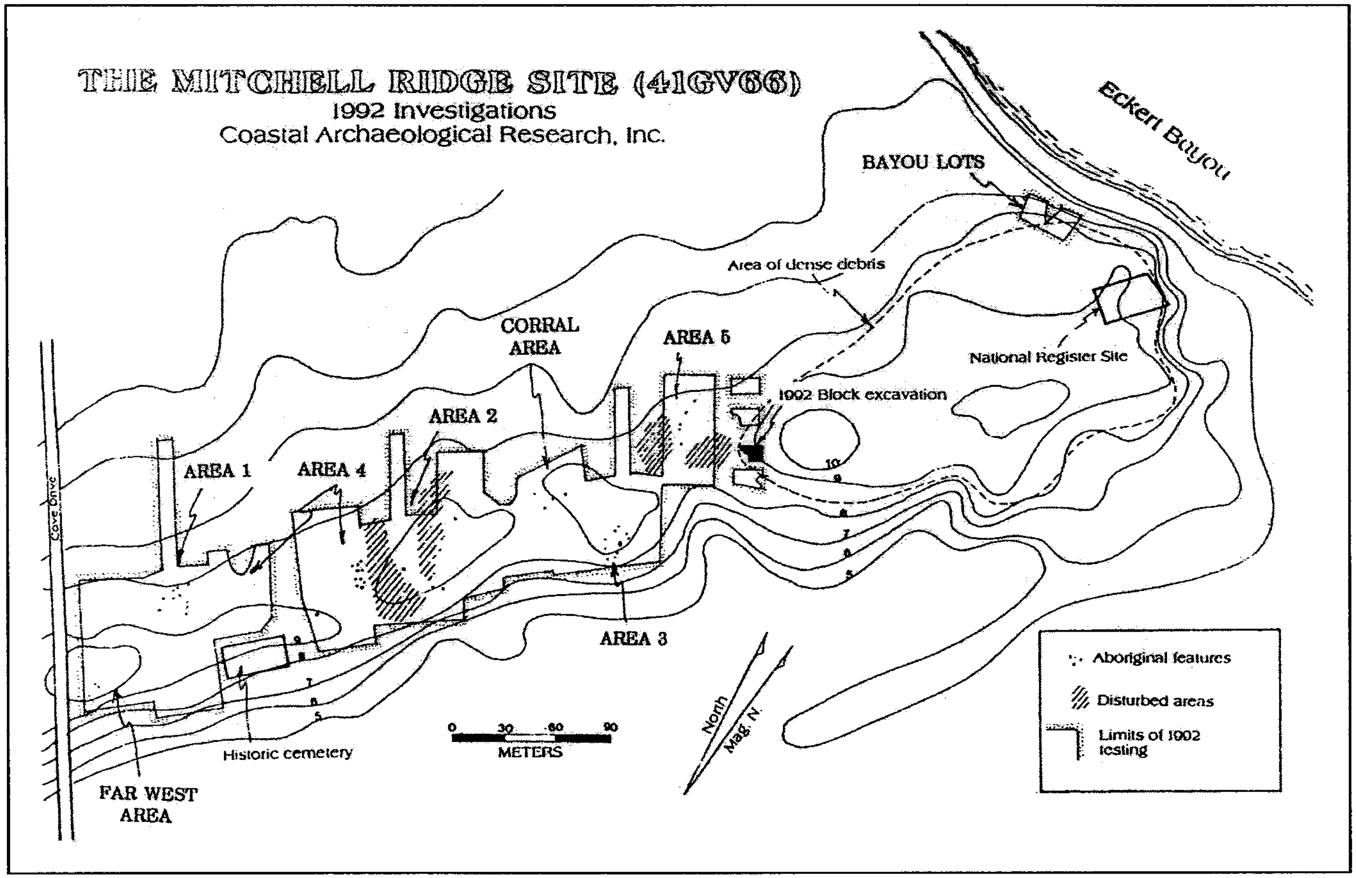


Figure 4.2 The 1992 excavations of Mitchell Ridge (41GV66). The Block excavation is indicated in black. From *Aboriginal Life and Culture on the Upper Texas Coast: Archaeology at the Mitchell Ridge Site, 41GV66, Galveston Island.*

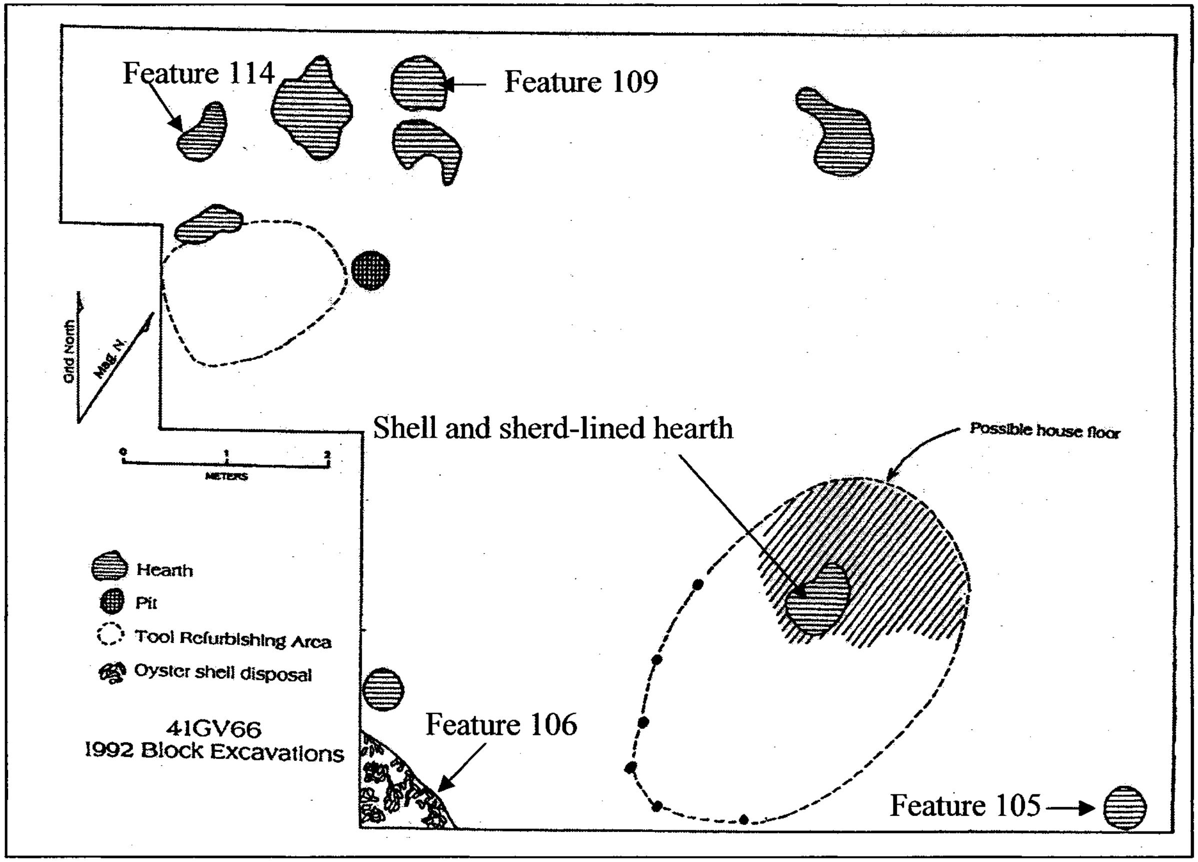


Figure 4.3 Plan view of Block excavation with features at Mitchell Ridge (41GV66). Features labeled with numbers indicate where sherds were sampled for luminescence dating. Modified from *Aboriginal Life and Culture on the Upper Texas Coast: Archaeology at the Mitchell Ridge Site, 41GV66, Galveston Island.*

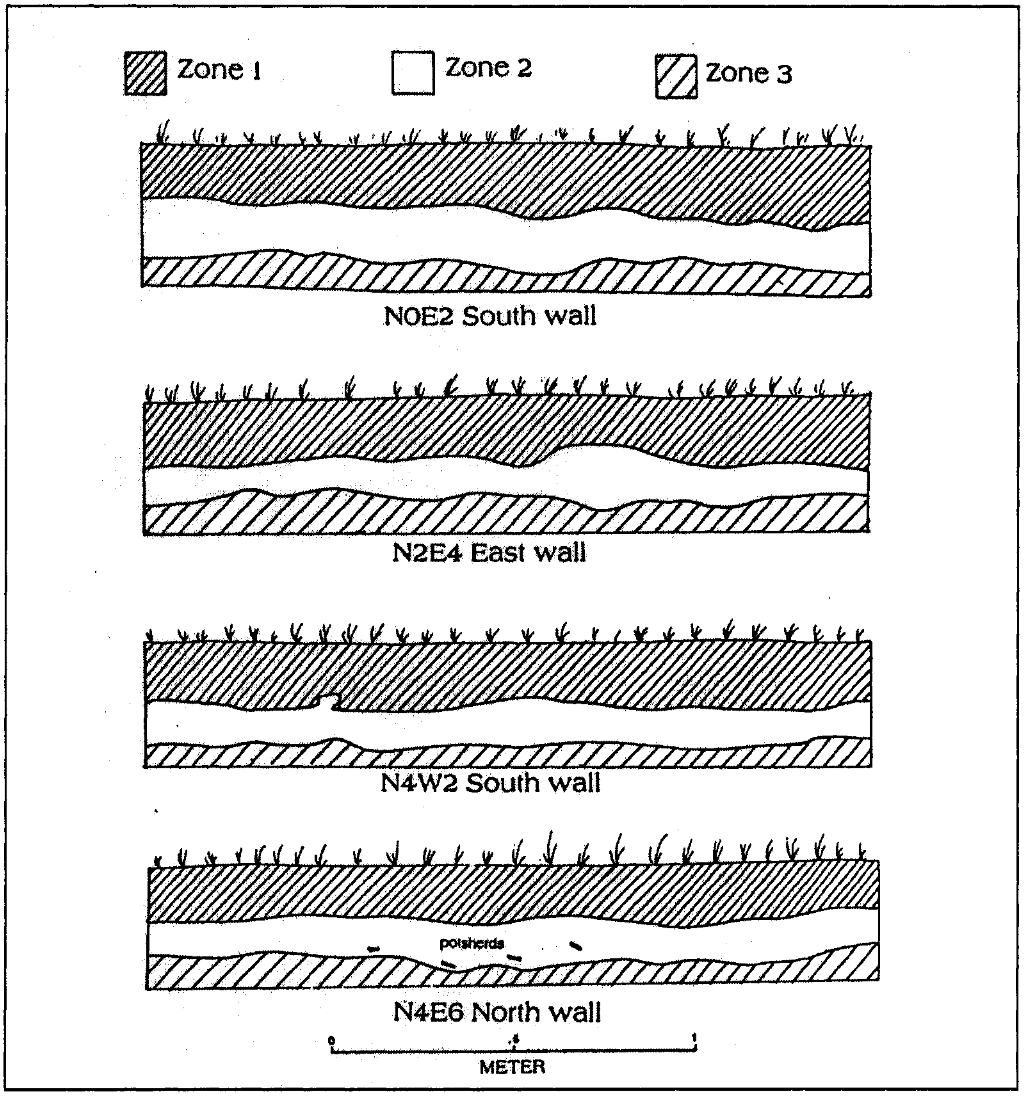


Figure 4.4 Representative profiles of the Block excavation at Mitchell Ridge (41GV66). From *Aboriginal Life and Culture on the Upper Texas Coast: Archaeology at the Mitchell Ridge Site, 41GV66, Galveston Island.*

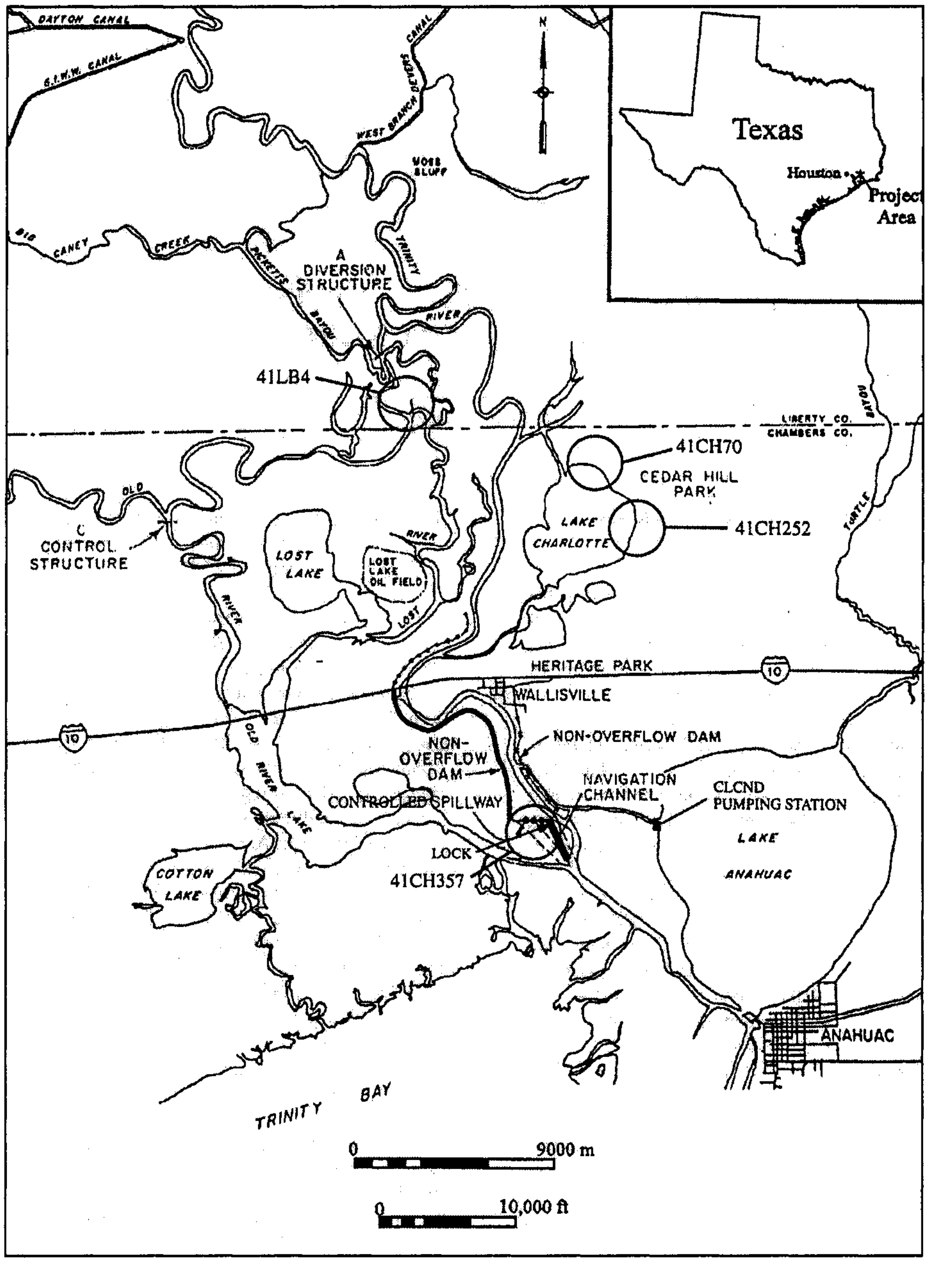


Figure 4.5 Location of Honeycomb (41LB4). Modified from *Archeological Test Excavations at Four Shell Midden Sites in the Wallisville Lake Project Area, Chambers and Liberty Counties, Texas*

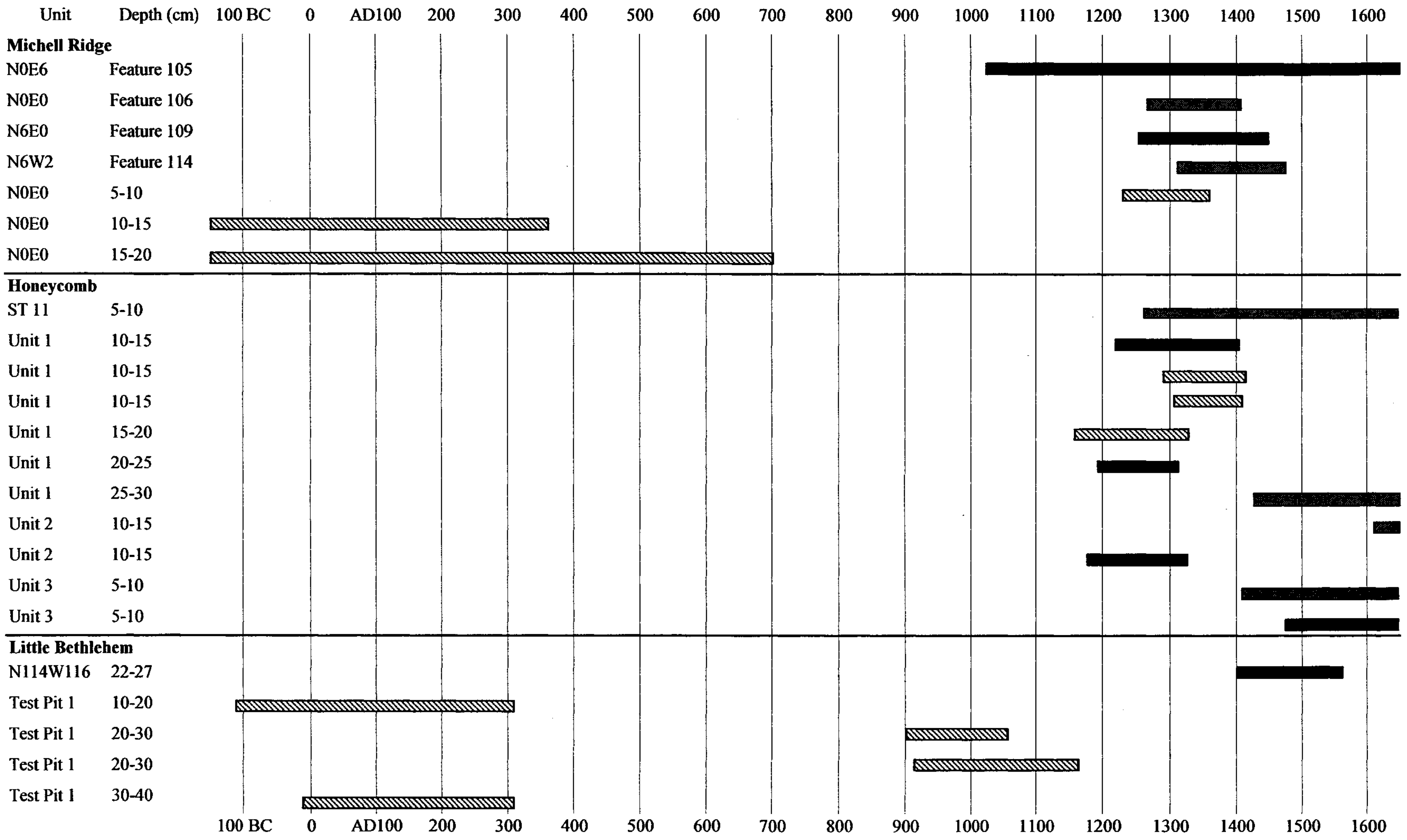


Figure 4.6 Dates from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem
■ charocal ■ shell ▨ ceramic

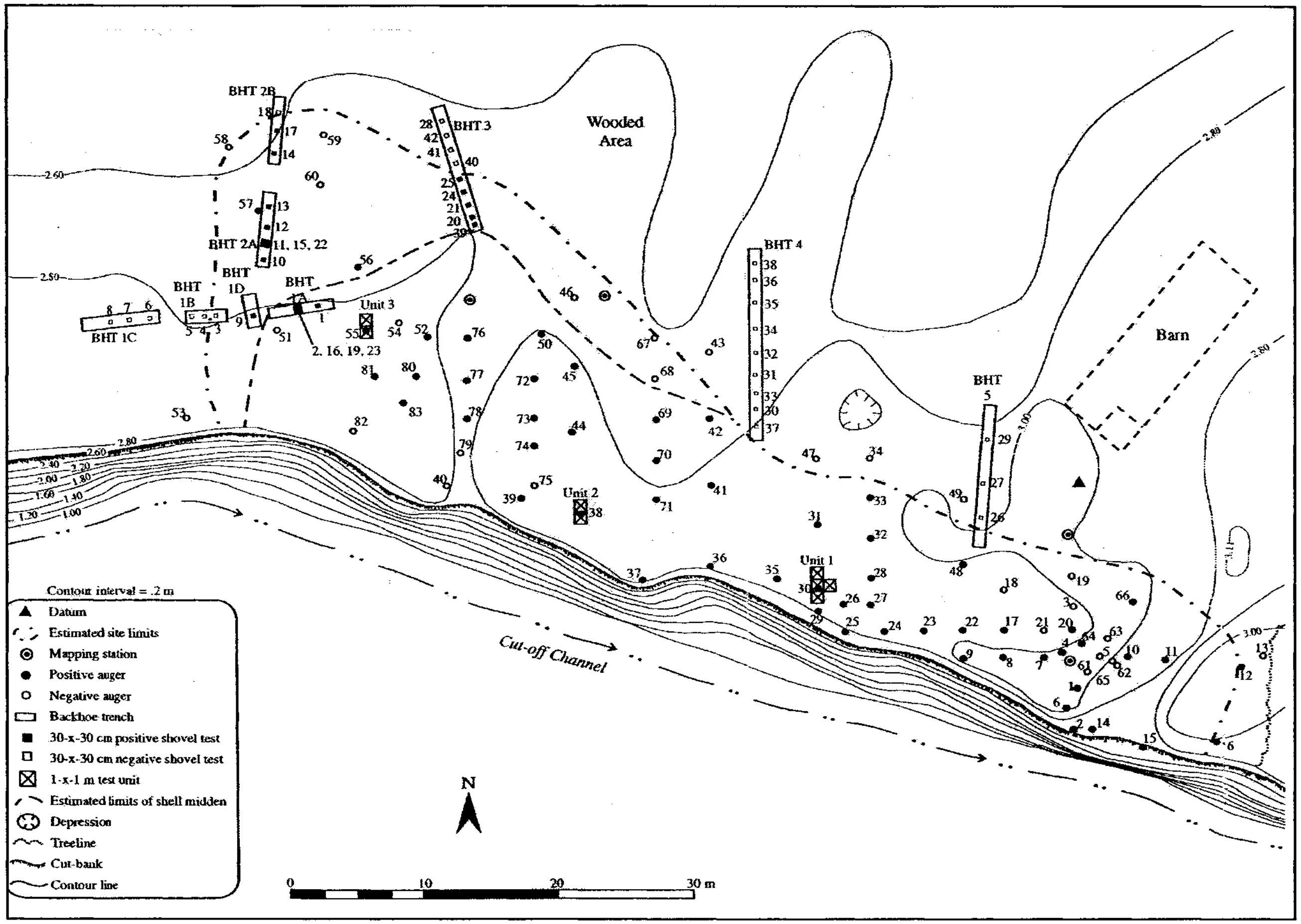


Figure 4.7 Map of 1994 testing of Honeycomb (41LB4). Note locations of Test Units 1, 2, and 3 and Shovel Test 11, which contained sherds used in luminescence dating. From *Archeological Test Excavations at Four Shell*

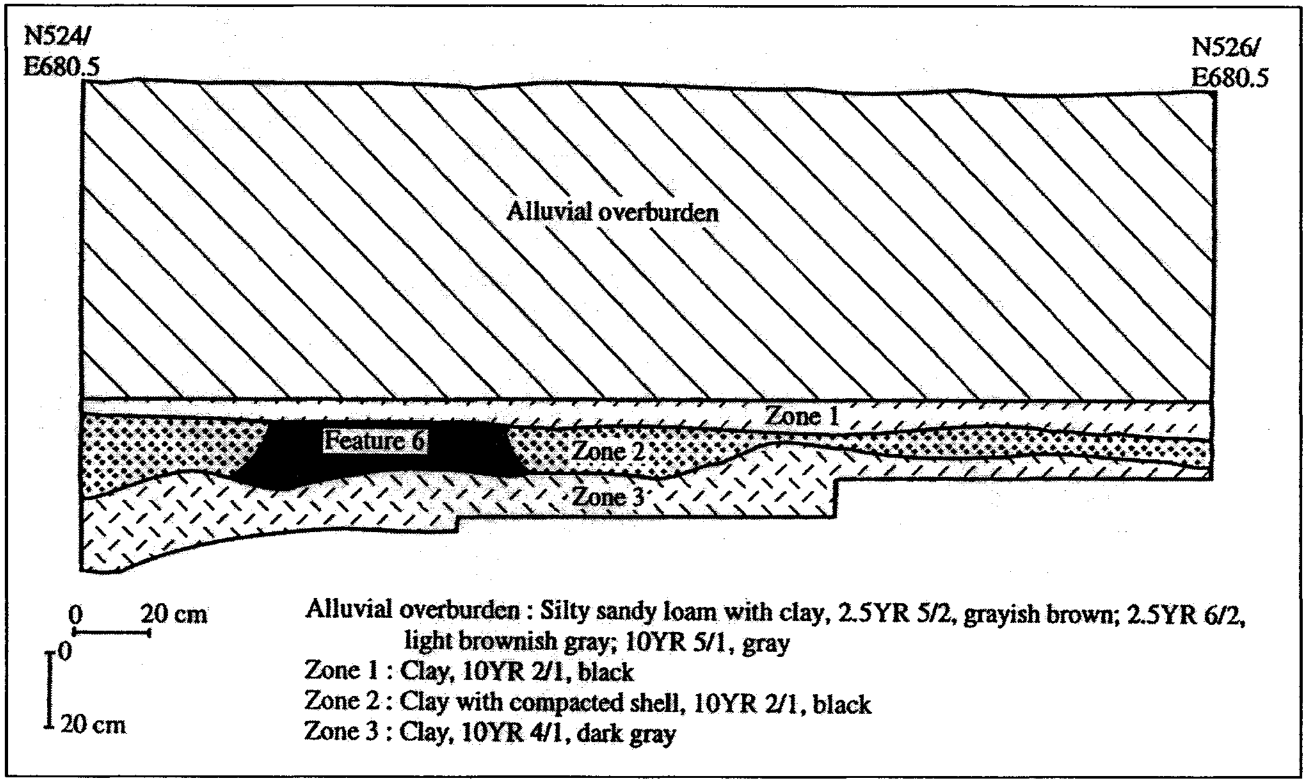


Figure 4.8 Profile of west wall of Unit 1 from Honeycomb (41LB4). Sherds from this unit were dated using luminescence. From *Archeological Test Excavations At Four Shell Midden Sites in the Wallisville Lake Project Area, Chambers and Liberty Counties, Texas*

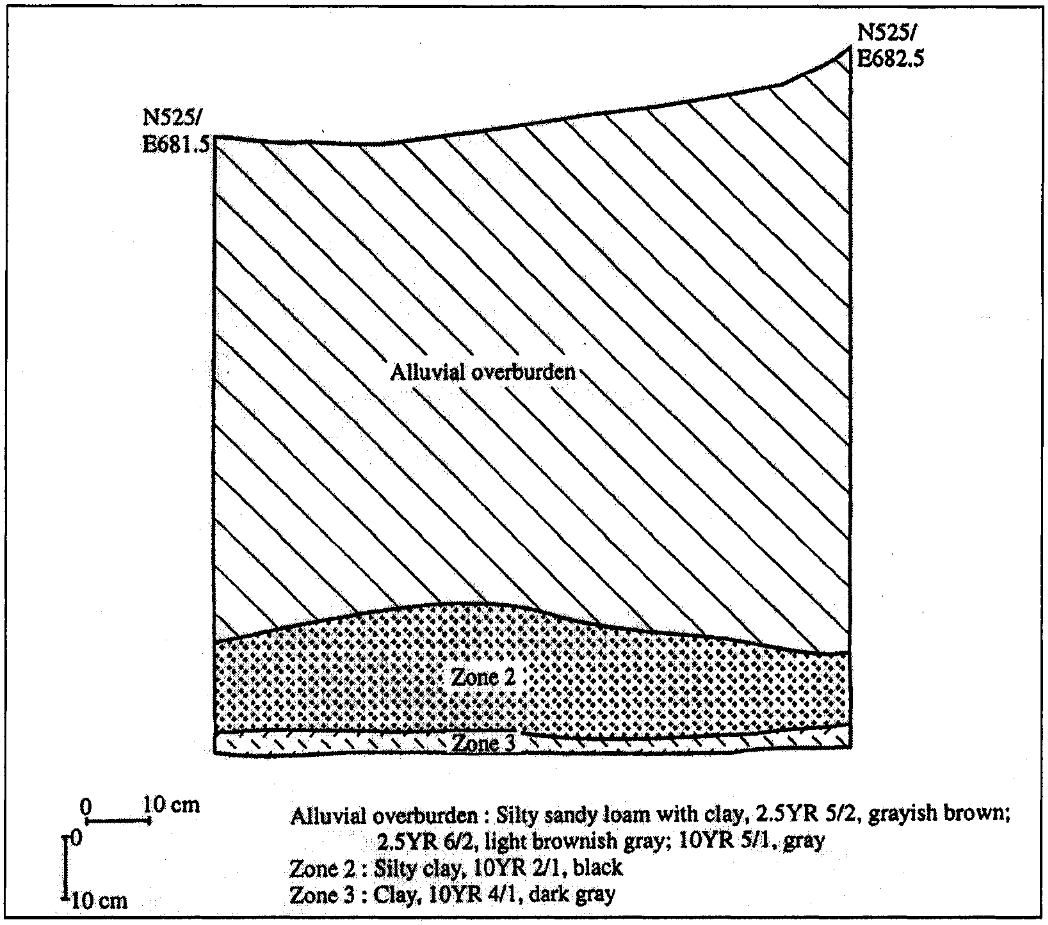


Figure 4.9 North wall profile of Unit 1 at Honeycomb (41LB4). Zone 2 contains cultural materials. Luminescence dates were obtained from sherds in this unit. From *Archeological Test Excavations at Four Shell Midden Sites in the Wallisville Lake Project Area, Chambers and Liberty Counties, Texas*

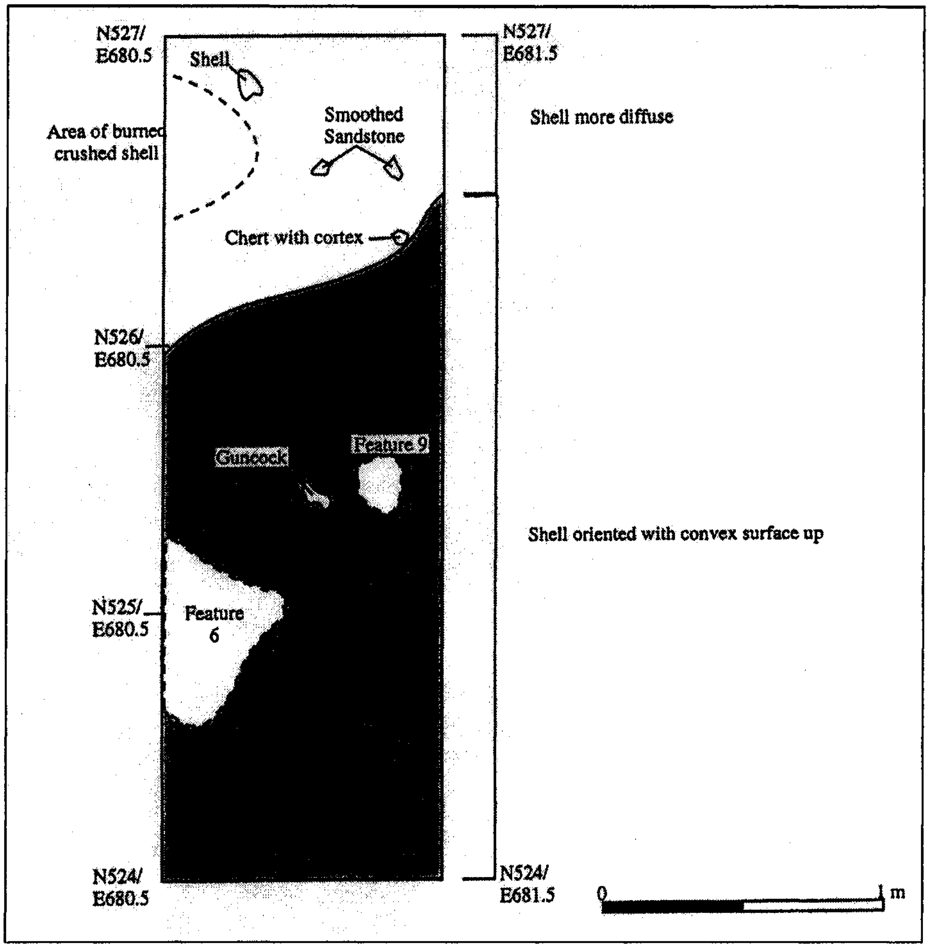


Figure 4.10 Plan view map of Unit 1 at Honeycomb (41LB4). Luminescence dates were obtained from sherds in this unit. The black area notes the orientation of shells in the midden. From *Archeological Test Excavations at Four Shell Midden Sites in the Wallisville Lake Project Area, Chambers and Liberty Counties, Texas.*

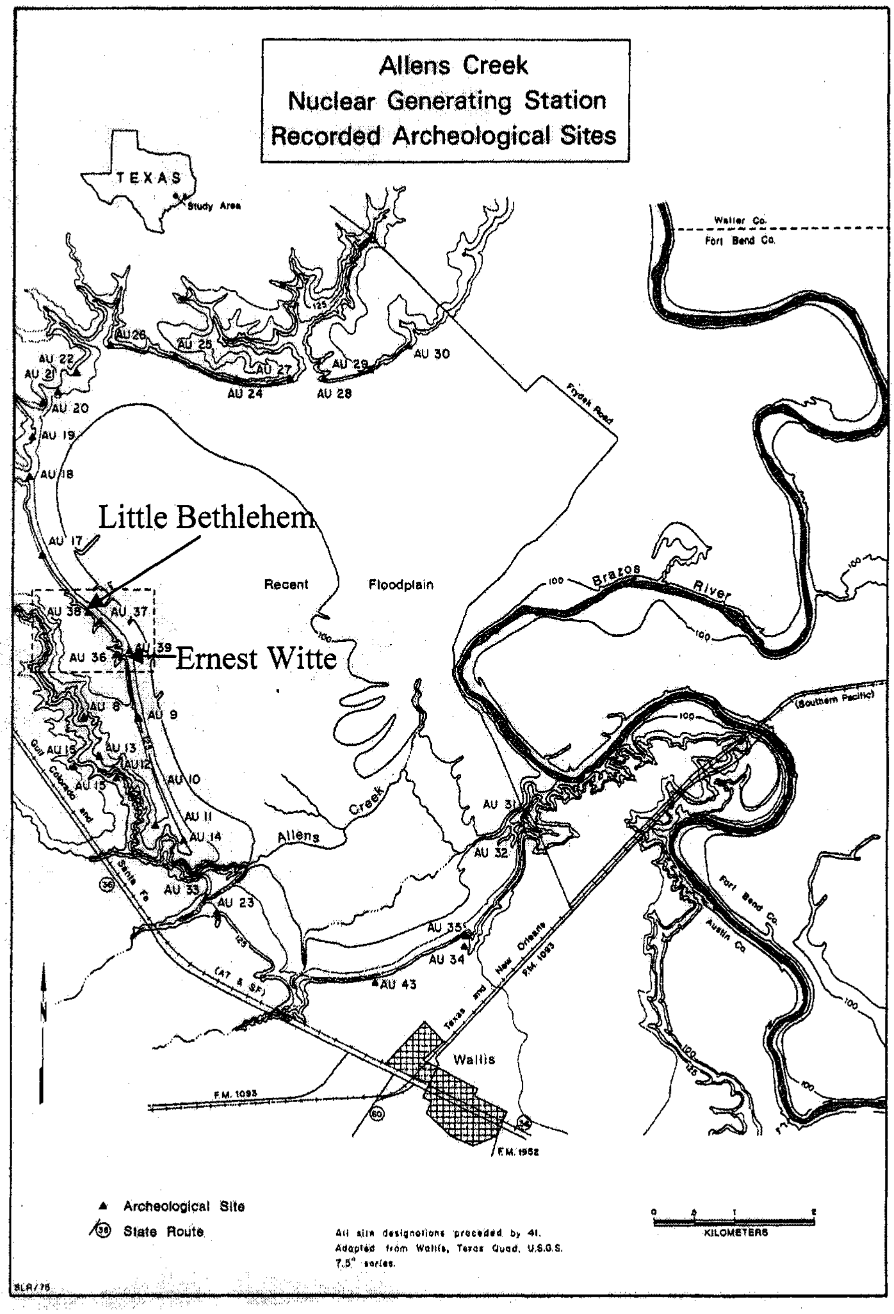


Figure 4.11. Location of Little Bethlehem (41AU38) and Ernest Witte (41AU36). Modified from *Allens Creek: A Study in the Cultural Prehistory of the Lower Brazos River Valley, Texas*

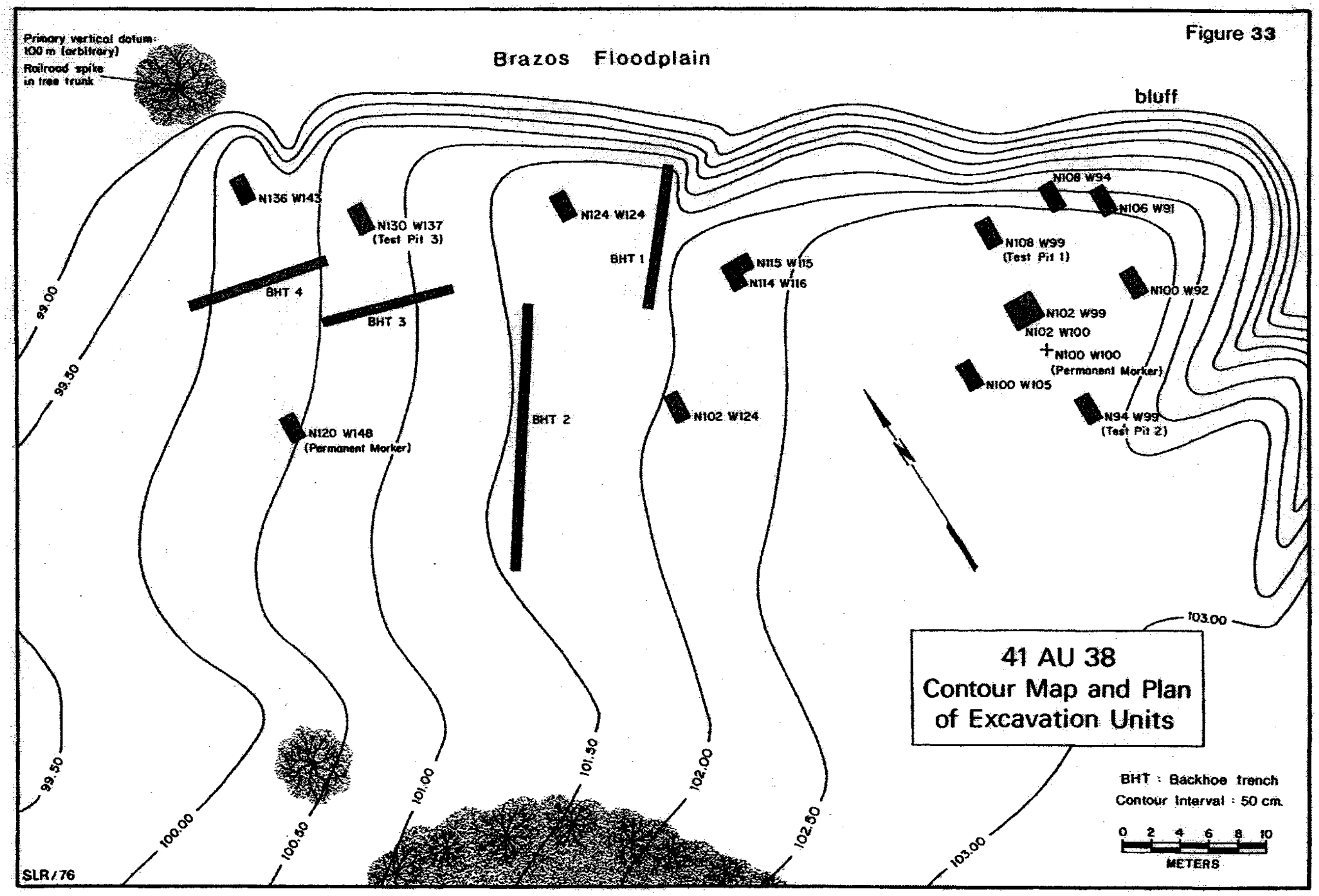


Figure 4.12 1972 excavation map of Little Bethlehem (41AU38). From *Allens Creek: A Study in the Cultural Prehistory of the Lower Brazos River Valley, Texas*

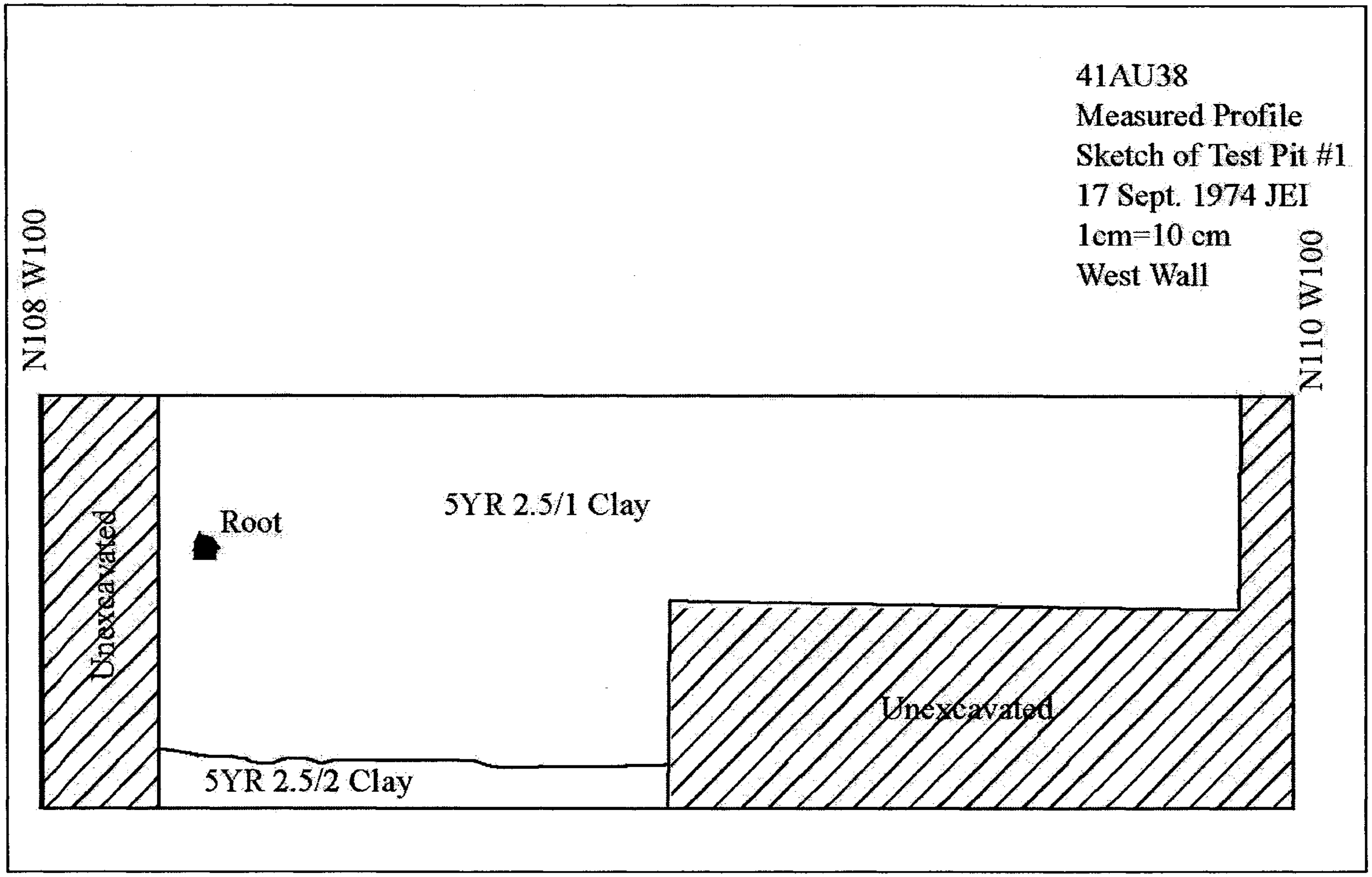


Figure 4.13 Profile of west wall of Test Unit 1 at Little Bethlehem (41AU38). Sherds from this unit were dated using luminescence. Redrawn from field notes made September 17, 1974 by Jake Ivey.

Table 4.1 Radiocarbon and luminescence dates from Mitchell Ridge, Honeycomb, and Little Bethlehem showing provience, depth, and material dated.

Lab number	Date	Provenience	Depth (cm)	Material type
Mitchell Ridge				
Beta-55867	AD1280-1408	N0E0	Feature 106	oyster shell
Beta-55863	AD 1260-1449	N6E0	Feature 109	charcoal
Beta-55862	AD 1052-1657	N0E6	Feature 105	charcoal
Beta-55866	AD 1320-1467	N6W2	Feature 114	oyster shell
UW1334	AD 1239-1357	N0E0	5-10	grog tempered, asphaltum
UW1335	123 BC-AD 371	N0E0	10-15	sand tempered sherd
UW1336	172 BC-AD 702	N0E0	15-20	sand tempered sherd
Honeycomb				
Beta 72735	AD 1285-1645	Shovel test 11	5-10	burned *Rangia* shell
Beta 72736	AD 1300-1665	Unit 1	25-30	*Rangia* shell
Beta 72737	AD 1435-1950	Unit 3	5-10	*Rangia* shell
Beta 72738	AD 1670-1950	Unit 2	10-15	*Rangia* shell
Beta 72730	AD 1460-1670	Unit 3	5-10	charcoal
Beta 72731	AD 1229-1411	Unit 1	10-15	charcoal
Beta 72732	AD 1200-1320	Unit 1	20-25	charcoal
Beta 72734	AD 1170-1310	Unit 2	10-15	charcoal
UW1337	AD 1168-1270	Unit 1	15-20	sand tempered sherd
UW1338	AD 1298-1422	Unit 1	10-15	grog tempered sherd
UW1339	AD 1305-1457	Unit 1	10-15	sand tempered sherd
Little Bethlehem				
TX-2065	AD 1400-1560	N114 W116	22-27	charcoal
UW1330	90 BC-AD 318	Test pit 1	10-20	sand tempered sherd
UW1331	7 BC-AD 303	Test pit 1	30-40	sand tempered sherd
UW1332	AD 937-1177	Test pit 1	20-30	sand tempered sherd
UW1333	AD 913-1065	Test pit 1	20-30	sand tempered sherd

CHAPTER 5: ASESSING HYPOTHESES USING MORPHOLOGICAL AND USE WEAR DATA

Three sets of hypotheses on possible functions of ceramic vessels used by Upper Texas coastal plain (UTCP) hunter-gatherers were developed and discussed in Chapter 3. One set of hypotheses addresses the potential uses of pottery as food processing containers. In this set, there are two hypotheses: 1) pots were used as tools for intensive processing of domesticated and/or wild plant foods, which in turn might indicate some level of food production. 2) Pots may have been used as tools to process meat from large-bodied resources. A second set of hypotheses posits that pots could also have been used as storage vessels, either to store foods as part of a low-mobility settlement strategy, or store foods as part of a high-mobility storage strategy. A third line of reasoning hypothesizes that pots were objects primarily for creating and maintaining socio-political prestige. In order to test these three sets of hypotheses, I examined pottery assemblages from three sites on the UTCP: Mitchell Ridge (41GV66), located on the leeward side of Galveston Island; Honeycomb (41LB4), which straddles upland and lowland environments near the coastal margin, and Little Bethlehem (41AU38), located on the inland portion of the Texas gulf coastal plain near the lower Brazos River. These three assemblages were analyzed using three sets of methods: non-destructive analyses of manufacturing and use-wear characteristics, mineral sourcing of non-clay inclusions in sherds, and organic residue analysis of lipids contained in vessel walls. This chapter discusses how the above hypotheses were assessed using manufacturing and use-wear characteristics on sherds from three archaeological sites on the upper Texas coastal plain.

Analysis of vessel function

Archaeologists have commonly used three methods in their efforts to better understand the function of ceramic vessels (as well as other artifacts): the physical location of the pots themselves, how the pots were constructed, and direct evidence of how they were used. Researchers traditionally investigate the physical contexts of pottery, (e.g., within burials, domestic contexts, or association with food processing tools) in order to infer behavior from these patterns. Doing so can be problematic in light of post-depositional alteration and other factors (see Feathers 1990 for a full discussion). Inferring vessel function and use from archaeological sites is particularly problematic in many hunter-gatherer archaeological records, including the UTCP. Physical contexts of ceramic vessel production (such as kilns and wasters) are quite rare in the archaeological record of hunter-gatherers in general, and are nonexistent in the archaeology of the UTCP. Much of UTCP pottery occurs in domestic areas of sites, but the specific nature of these contexts is often difficult to interpret (see Feature 110-A from Mitchell Ridge for a notable exception of a sherd and shell-lined hearth). In order to determine how UTCP vessels were made and used, data must be gathered from the vessels themselves (Costin 1991). Thus, the remainder of this chapter is devoted to describing how the above hypotheses were assessed using manufacturing characteristics and use wear data obtained directly from sherds.

Analyzing pottery construction

A common approach to understanding vessel function entails investigating how pots are constructed to understand how they functioned (e.g., Braun 1987; Hally 1986; Juhl 1995; Pierce 2005; Reid 1990; Rye 1976; Schiffer and Skibo 1992). Previous research has provided much information on pottery function, particularly food preparation and storage. This research is predicated on the idea that certain aspects of the manufacture of a given tool (in this case pottery) can measurably affect its suitability for a task. Thus, pots intended for particular tasks are predicted to have attributes which enhance their performance in this task. It is important to realize that while particular attributes may be optimal for a given task, they are subject to constraints of materials, time, and prior knowledge. Nonetheless, analysis of pottery manufacture is a viable means of investigating vessel function, particularly when paired with other analytical methods such as use-wear. Four groups of attributes are particularly useful to focus on when looking at vessel function in terms of food processing and storage: vessel wall thickness, other aspects of vessel morphology (including vessel shape and size), types and sizes of non-plastic inclusions, and presence, type, and distribution of surface treatments.

Vessel wall thickness and uniformity of thickness affects a pot's performance over heat in several ways. The thickness of walls can determine how well the vessel conducts heat, how resistant the vessel is to mechanical stress, and how resistant the vessel is to thermal stress. Thermal conductivity is defined as the ability to conduct heat from one face of the vessel to another (outside to inside), and can be measured as the time it takes for the temperature to change between the outside and the inside walls (Braun 1983). Research has indicated that on average, thin-walled vessels are best able to withstand the stress caused by sudden, extreme changes in temperature—such as coming into and out of a cooking fire (Braun 1983). The degree of uniformity of wall thickness with a given vessel can also affect its performance over direct heat. This is because thinner portions of the wall have a less pronounced thermal gradient than thick portions. Therefore, if vessel walls are not uniform in thickness, thermally-induced stress becomes localized when the vessel is heated or cooled (Rice 1987). Researchers have argued that thin-walled vessels not only reduce vessel failure during heating tasks but reduce fuel consumption, presumably because they heat more efficiently than thicker-walled pots (Schiffer and Skibo 1992). For storage purposes, thick-walled vessels would be better able to absorb mechanical shock without distorting or failing (Braun 1983), although they can also be useful in preventing contents of a pot from boiling over, especially when simmering foods (Pierce 2005). Constructing larger vessels with fairly wide orifices may prevent boilovers as well (Pierce 2005).

Vessel morphology can affect the performance of a pot in terms of storage. For example, overall vessel size may be implicated with storage functions, with fairly large vessels being useful for long-term storage. Smaller vessels may offer a larger volume to surface area ratio which could enhance performance during heating tasks (Juhl 1995). Smaller vessels may also be more useful than larger ones for short-term storage, or storing foods which spoil quickly (Juhl 1995). Research indicates that vessel shape (curved or angular) can also have an effect on a pot's performance over heat. Such rounded forms decrease localized points of stress. For example, research indicates that rounded base forms perform more effectively over heat, rather than more angular forms such as flat-bottomed bases (Braun 1983, Rye 1976). Heating effectiveness of a vessel can also be enhanced by restricting the size of the orifice and therefore reducing heat loss through evaporation (Hally 1986; Linton 1944). We can expect this quality to be selected by prehistoric potters in cases where it was important to bring the contents of the pot to a boil without the vessel boiling dry quickly. Nonetheless, pots used for boiling would not be expected to have openings so narrow that there was a significant risk of the contents boiling over. Furthermore vessels used for any sort of food processing using heat—whether boiling, simmering, or parching—would have to have orifices at least wide enough to fit a hand or a utensil through, in order to access the contents (Hally 1986).

Research on the effects of non-plastic inclusions on ceramic vessel performance has implications for assessing hypotheses concerning cooking and storage functions of pottery. Non-plastic inclusions including temper type and concentration, as well as the size and frequency of pores in the vessel body can affect the response of the vessel to mechanical and thermal stressors (Tite et al. 2001). The strength of a vessel affects its ability to retain its contents. Thus, strength is an important quality for vessels used for cooking and/or storage. Vessels with high strength have higher resistance to mechanical stressors. Research indicates that vessels with high strength are created with low amounts of temper and high firing temperatures (Tite et al. 2001). There are two components to thermal stress which can affect the initiation and propagation of cracks in vessel walls: 1) differential expansion and contraction of vessel walls during temperature changes; 2) differential thermal expansion of temper particles and clay matrix (Tite et al. 2001). Various minerals expand at different rates, but quartz, the most common mineral in many ceramic bodies expands at a much higher rate than the vessel body (Rye 1976). In contrast, empirical tests indicate that grog has a similar thermal expansion rate to the vessel body, as do limestone and shell (Rye 1976; Steponaitis 1984). Yet grog temper is less resistant to crack propagation (Tite et al. 2001). The size and frequency of mineral and grog inclusions can affect the thermal performance of a vessel as well (Rye 1976). For example, large grog particles can reduce the thermal stress gradients in vessel walls, while smaller quartz inclusions may reduce the amount of thermal stress on the vessel during heating tasks (Steponaitis 1984). Experimental research indicates that vessels created with high amounts of temper and fired at low temperatures have greater resistance to thermal stress (Tite et al. 2001). Pores are created from the loss of organic material from the vessel walls during firing, leaving voids. Vessel porosity is also affected by differential expansion of paste constituents, the packing of paste particles, and firing temperature. Pores may not only increase resistance to mechanical shock but may also make the vessel more resistant to crack propagation (Juhl 1995; Rye 1976). Porous voids encompassing quartz grains may possibly accommodate expansion of the grains, thereby enhancing the performance of a sand-tempered vessel over heat (Woods 1986).

Surface treatments on ceramic vessels can also provide information on vessel use. Surface treatments are usually associated with utilitarian functions of pots, and are set apart from decoration. Decorative surface treatments—those which have no impact on a vessel's performance—can indicate the degree of labor invested in vessel production. However, some attributes may be both utilitarian and decorative. Many of the surface treatments described above cannot be readily assigned to functional or decorative categories. Covering the vessel walls with a sealant, applying a slip to them, or burnishing them can be decorative techniques, but can also be used to limit the permeability of a pot. Surface treatments such as combing and cordmarking can be used to roughen the exterior surface of a vessel making it easier to handle when wet (Pierce 2005).

Previous research indicates that the liquid storage properties of a vessel can be improved by applying sealants and/or by burnishing vessel walls (Juhl 1995). Resin coatings can reduce the permeability of the vessel and can be applied to help a vessel retain liquids or to minimize damage by abrasion (Skibo 1992; Rice 1987). There is some experimental evidence that sealants and other surface treatments such as slipping and polishing can also enhance the heating properties of ceramic vessels (Schiffer 1990). While surface treatments on the exterior portions of vessel walls also limit permeability, resin applied to the vessel interiors is especially effective in lowering the amount of water which can pass from the interior to the exterior vessel wall and turn to steam. Thus, pots with surface treatments limiting permeability bring their contents to a boil more quickly on average than untreated vessels. In some experimental cases, vessels with high permeability fail to boil water at all (Skibo and Blinman 1999). Vessels with permeability-limiting surface treatments tend to lose less water and therefore do not need to be monitored and refilled as frequently during the heating process as frequently as vessels whose permeability is not limited by these means. Unlike slipped and polished surfaces, resin coatings on the interior walls are not subject to thermal spalling (Schiffer 1990). Surface treatments such as burnishing can also reduce vessel porosity.

Analyzing direct evidence of vessel use

Although looking at a finished product and working back through the manufacturing stages can be useful in addressing questions about vessel function, it is also important to approach these studies with the understanding that prehistoric solutions to engineering problems may very well have involved trade-offs (e.g., creating a more narrow orifice diameter in a cooking pot to make the ware less vulnerable in the drying stages before firing). Thus, some attributes of vessel manufacture may be affected by multiple considerations. Furthermore, the potential function of a vessel may or may not be the same as what it was actually used for. While archaeologists can better understand function of a vessel by observing aspects of its design, observing physical indications left on vessels through their use can be combined with information on vessel construction in order to create more robust interpretations of vessel use. Use-wear studies have been common in ceramic function studies for a few decades (e.g., Hally 1986; Skibo 1992). Analysis of use-wear on hunter-gatherer pottery can be especially helpful in clarifying if it was used for cooking tasks over direct heat. An absence of use-wear attributes associated with processing food over heat, combined with morphological attributes characteristic of vessels used for storage (such as thick walls), may indicate that such wares were used for storage.

Pitting and spalling: the result of two different processes

Attributes which are particularly helpful in determining the nature of vessel use include marks on vessel wall from use over heat, such as small holes created by the expansion of water in the vessel body when heated (spalls), as well as carbonized food and fuel deposits on vessel walls (soot marks). Recording the presence and distribution of spalling on sherd surfaces can provide information on use over a direct heat source. Hally hypothesizes that pitting consists of cone-shaped holes which can appear on vessel walls for a variety of reasons related to vessel manufacture: rapid loss of water during firing, fire cracking, and lime spalling ($CaCO3$). Pits can also result from use: thermal shock (from rapid heating and cooling of a vessel), chemical corrosion from alkaline and acidic solutions used to process seeds and maize, and physical abrasion resulting from pounding, stirring, etc. Pitting is usually attributed to use when distributions of pits between vessels are too similar to one another to be explained by manufacturing processes alone (Hally 1983). Pitting as the result of use has also been distinguished from that resulting from manufacturing by noting its location exclusively on vessel interiors. Whatever its cause, pitting does not commonly occur on the exteriors of vessels in southeastern assemblages analyzed by Hally. The pitting Hally found occurs on vessels exclusive of sooting, which led him to conclude that pitting is the result of abrasion and not thermal factors (Hally 1983). Ethnographic observations made by Skibo (1992) indicate that pitting is caused by loss of temper particles due to abrasion. Skibo noted that pitting does occur on vessel exteriors—especially bases—when full pots are placed on sand or other abrasive surfaces and temper particles are dislodged in the process (Skibo 1992). Thus, pitting appears to be the result of mechanical abrasion, and can occur on any vessel which is subject to stirring, washing, or other abrasive processes.

In contrast to pitting, Skibo's ethnographic observations of Kalinga wares indicate thermal spalls are found almost exclusively on vessel interiors. Thermal spalls are circular in shape, and commonly range from 1-3 mm in diameter (Skibo 1992). They are the result of water vaporizing within the ceramic body and steam pushing off a portion of the interior surface. Spalling is most common in vessels used to cook foods over low heat using little water. Any remaining water is lost in this simmering process. Spalling is most commonly found on the middle portion of the vessel body. It is less frequent on the upper and lower portions of the vessel body, probably because they are at higher angles to the heat source and thus deflect more heat than the middle portion of the vessel. Ethnographic work indicates that pitting and spalling can coincide on the upper interior portion of a vessel. In contrast, there is little to no spalling when pots are filled with water for boiling (Skibo 1992). Thus, making observations on the frequency of spalling on sherds is helpful in assessing hypotheses concerning vessel use over heat to process starchy foods (Table 5.1).

Sooting

Sooting is comprised of carbon and resins deposited on the vessel surface as the result of fuel combustion. Soot is most commonly identified in archaeological ceramics as carbon patches on the interior and exterior portions of the vessel wall, which can occur during firing in an oxidized atmosphere, cooking over direct heat, or even by burning dwellings or other structures containing pots. Sooting on the exterior of the vessel is the by-product of wood combustion. The outer layer of exterior soot can be removed by wiping or rubbing, while another inner layer—most likely composed of resins and carbon—is more permanent (Skibo 1992). Sooting on vessel exteriors is most common on the middle portion of the vessel, and thins near the rim and base (Tables 5.1 and 5.2). On vessels used over direct heat, sooting is completely absent from the base, as this portion of the vessel has been oxidized from close proximity to the heat source. The exact positioning of sooting on the vessel exterior can vary according to the position of the vessel relative to the heating source (Skibo 1992). Interior sooting is often the result of charred food adhering to vessel walls and thus can indicate whether a vessel was used over heat (Hally 1983, Skibo 1992). Carbon patterns on the interiors of vessels vary depending on the mode of cooking used. In cooking foods with little or no water, sooting appears everywhere on the vessel interior except just below the rim, including a carbon patch on the base (Table 5.1). When food is boiled in plenty of water, interior sooting usually appears in a band of varying widths (most likely due to the varying water levels in separate cooking events) across the mid section of the vessel, excluding the rim/neck area and base (Skibo and Blinman 1999). Scratches can occur from manipulating the contents of pots and also from washing vessels to remove soot (Skibo 1992). This latter source of scratching often has a particular unidirectional assembly of numerous fine scratches (Skibo 1992).

As with studies of vessel construction, use-wear studies can also have confounding factors. For example, there is no reason to assume that ceramic vessels were used for one type of task in their lifetimes; pots could have been used in various aspects of food preparation other than boiling, such as soaking foods, or storing prepared foods (Hally 1986). Pottery can also be used for heating tasks pertaining to work other than food preparation (e.g., tanning, dyeing, carrying fire, or burning offerings; Hally 1986). Even when a pot fails and ceases to exist as a tool, sherds can be used in other food preparation tasks (Sullivan et al. 1991) or even as tools to create more pots (Varela et al. 2002). All of these activities have the potential to leave use-wear traces on the vessel. Pottery exists in high enough frequencies on UTCP sites that it seems likely that its primary useful form was vessels, not sherds. Other studies indicate that sherds used as tools in food processing are typically found in particular contexts, such as sherds used to line roasting pits. Sherds used as potter's tools appear to have very distinct patterns of use-wear which cannot be readily attributed to other uses.

Performance expectations for UTCP pottery

Vessel performance characteristics are affected by trade-offs between function, materials available, and other constraints (such as time or scheduling conflicts). Thus, when assessing performance properties of pots, we must keep in mind that performance attributes are subject to the above constraints. Ideally, we would expect particular combinations of performance and use-wear attributes to be present in the assemblages in high frequencies if a given hypothesis is true. If UTCP hunter-gatherer pots were used primarily as tools for food processing involving direct contact with a heat source, then we would expect them to be created in ways which would enhance heating tasks and food processing. Vessels used in direct heating tasks are expected to be utilitarian wares constructed in such a way that they allow easy access to contents and effectively conduct heat. Thus, vessels used over direct heat should be undecorated and have orifices which are wide enough to allow a hand to pass through to access the contents, and walls should be uniformly thin (Table 5.3). There should be a low frequency of porosity-limiting surface treatments on exterior walls, and high frequencies of spalling and sooting on vessel walls. If these vessels were used primarily as tools to store food, then vessels should be unadorned utilitarian wares with some means of limiting access to their contents, and be resistant to mechanical shock (Table 5.3). Storage vessels should have narrow orifices, thick walls, high frequencies of porosity-limiting surface treatments, and low frequencies of spalling and sooting on vessel walls. In contrast, vessels used for serving or other prestige-enhancing functions would be expected to have wide orifices for easy access to contents, and formation techniques which are time consuming to create, such as uniformly thin walls, and a high frequency of decorative surface treatments (Table 5.3).

Methods: Units of Analysis and Measurement

Assemblages as Units of Analysis

When archaeologists characterize pottery assemblages, they often think in terms of vessels, but collect data from sherds. Certainly the object of interest is vessels, as these are the tools prehistoric people used. In comparison, sherds are the result of depositional factors. Yet focusing on sherds is understandable, considering that whole vessels are fairly rare in the archaeological record (this is very true in the case of the UTCP). Whole vessels often come from particular depositional contexts, such as burials. Such contexts are not representative of the whole inventory of pottery in a given culture (Feathers 1990). Focusing on the vessel as the unit of analysis may be appropriate given certain research questions pertaining to reconstruction of cultural practices, or estimating the nature of site occupations (e.g., Longacre 1985; Shapiro 1984). Methods other than refitting, such as constructing vessel lots or estimating the minimum number of vessels have been used (e.g., Chase 1985; Orton 1993). Sometimes sherds can be fitted together to form complete or nearly complete vessels, but refitting is time consuming and in many cases on the UTCP leads to little additional information on how vessels were made and used (see Hood 1998 for an exception). The generally highly fragmented nature of the ceramic collections from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38) led me to conclude that refitting would provide little additional information about vessel manufacture or use.

Since the research focus in this study is on the relationship between the function and use of pottery by hunter-gatherer groups and how these groups use the landscape, the interest lies in the frequencies of attributes related to functional design and use-wear of pottery. Thus, the primary interest is not how many pots are in a given assemblage, but the proportion of various attributes between assemblages. Given the research goal, it is not only impractical but unnecessary to convert sherds into vessels for purposes of analysis. Instead, the assemblage can be used as the unit of analysis (Orton 1993).

Sherds as Units of Measurement

While it may not be practical or necessary to use vessels as the unit of analysis, using the assemblage as the unit of analysis can be problematic when working with sherds. All sherds are not equal. Some are bigger than others, and therefore may carry more information. For instance, in assemblages where decoration does not cover the entire vessel (as is often the case in UTCP assemblages) larger sherds may be more likely to have decoration than smaller sherds. Particular types of vessels (e.g., thin-walled pots; cooking pots; pots with sandy pastes) may break more easily into smaller pieces than other kinds of pots, leading one to believe that there were more pots of whatever sort (e.g., thin-walled, etc.) relative to other types (e.g., thick-walled) than there actually are. Rocek (2002) has demonstrated that focusing on larger sherds to the exclusion of smaller ones can introduce bias into summary statistics of sherd thickness. If certain surface treatment and/or use-wear attributes are affected by sherd size, and assemblages are being compared, then it must be determined if the sherd sizes between assemblages are comparable. Surface treatment and use-wear attributes are most likely to be affected by sherd size in this study, because these attributes do not always cover the entire surface of the vessel. It is possible that smaller sherd sizes could affect the distribution of surface treatment and use-wear attributes; smaller sherds may have less information, as larger sherds have greater surface area than smaller ones.

In order to determine if sherd sizes were comparable between sites, the maximum length of each sherd was taken. Other studies have compared sherd size between assemblages using weight (e.g., Pierce 1999) but it was not practical to do in this case, as some sherds had been refitted and joined together by previous analysts prior to the curation of the assemblages. Potential biases in this study were addressed by measuring the longest axis of the sherds and using measurements in conjunction with sherd counts to compare sherds within and between assemblages. All sherds originally collected were included in the analyses described in this chapter, except for the block assemblage from Mitchell Ridge (41GV66). In the interests of time, a 20% random sample was analyzed from each lot from Mitchell Ridge for a total of 1244 sherds. The Mitchell Ridge (41GV66) and Honeycomb (41LB4) assemblages contain sherds refitted and glued by previous analysts. To avoid comparing sherds with larger vessel sections, measurements and observations were made on individual sherds in the refitted vessel section, rather than treating the entire vessel section as a single sherd. Since it was not possible from a curation perspective to take apart joined sherds, I determined sherd size by measuring the maximum lengths of the sherds. Using calipers, it was possible to treat each sherd in a group of joined sherds as a separate sherd. Average maximum sherd lengths are reported in Table 5.4. A comparison of these means using single factor ANOVA where $F=128.09 >$ the critical value for F 2.99 ($p>.55$) indicates that sherd size was not comparable between assemblages.

Given this, the question of whether or not sherd size affects the amount of surface treatment and use-wear attributes in a given assemblage becomes more important. Of the nine possible classes of surface treatments, seven were present in the Mitchell Ridge (41GV66) and Honeycomb (41LB4) assemblages, and four were present in the Little Bethlehem (41AU38) assemblage (Table 5.4). Therefore, in terms of types of surface treatments Little Bethlehem is not as rich of an assemblage as Mitchell Ridge and Honeycomb. It is possible that both sherd size and sample size are affecting the richness of the Little Bethlehem assemblage, yet all three classes of use-wear attributes are represented in all three assemblages. Clearly not all attributes are being affected by sherd size. It remains possible that some surface treatments are simply not present in inland assemblages such as Little Bethlehem (41AU38). Mitchell Ridge (41GV66) sherds have the highest amounts of striations, sooting, and spalling than the other two assemblages, which may be expected since Mitchell Ridge has the largest average sherd size. Yet Little Bethlehem (41AU38) has a higher frequency of spalling than the Honeycomb (41LB4) assemblage, even though Little Bethlehem has smaller and fewer sherds than Honeycomb. Although sherd size is not statistically comparable between assemblages, the assemblage with the smallest sherd size does not have the lowest frequency of all use-wear attributes, which is unexpected if sherd size is completely affecting the presence and frequency of attributes on sherd surfaces.

Methods: Measuring vessel construction and use attributes

Vessel thickness

The thickness of each sherd was measured using digital calipers. Thickness was reported as one measurement; one measurement was taken at the approximate center of the sherd, another was taken at an edge. If the second thickness measurement varied more than 1 millimeter from the first, thickness was qualitatively indicated as "variable" in a separate column on a spreadsheet.

Vessel diameter and curvature

In order to determine vessel size, orifice diameter was measured on rim sherds large enough to obtain a reasonable estimate, using a standard template. Measuring the curvature of body sherds can provide information on the size and shape of the vessel, even if the location of this measurement on the vessel is not known. Measuring curvature on body sherds can be challenging because it is sometimes difficult to orient a body sherd to its proper position on a vessel. Curvature of sherds can be measured using various mathematical descriptions of vessel geometry (Feathers 1990; Smith 1983). Accurately inferring the curvature of handmade vessels from sherds can be problematic as most calculations of vessel curvature are based on geometric symmetry, and many handmade pots have geometric irregularities. Furthermore, although measuring curvature allows calculation of vessel diameter at some point on the vessel, it does not necessarily produce a true maximum diameter of the vessel. In this study, vessel horizontal curvature was estimated by measuring body sherds using a specially designed micrometer which measures both chord length and length of curve (Feathers 1990). This method was chosen because its error has been well estimated in previous studies (Feathers 1985, 1990). Previous studies indicated that calculations of vessel diameter were most accurate using sherds with chord lengths of 40 mm or greater (Feathers 1990, pages 380-381). In this study measurements of horizontal curvature were taken on all sherds with a maximum chord length of 50 mm or greater, provided the sherd was not a base. Vessel diameter was calculated from these measurements using the equation:

$$R = \frac{(c/2)^2}{2h + h/2},$$

where R is the radius of the circle, c is the length of the chord, and h is the height of the chord (Figure 5.1).

Vertical curvature was not taken because sherds were very small on their vertical axes. Previous work with other collections containing small sherds suggests that vertical curvature measurements have high degrees of inaccuracy, most likely associated with small chord length (Feathers 1990). Body sherds were oriented prior to measurement of horizontal curvature by observing the orientation of vessel coils. There were limitations to this method of measuring body sherds. Not all could be properly oriented as some were too small to observe coils or did not have significant curvature. Nonetheless, numeric descriptions such as the ones obtained help give a sense of the vessel sizes represented in the assemblages.

Vessel shape

Vessel shape (e.g., rounded versus angular) was estimated qualitatively using two steps. First, sherds were classified by body part: rim neck, shoulder, body, and base (after Rice 1987). Then, their shapes were characterized using a combination of Rice's guidelines and known vessel morphology types in the UTCP. Vessel shapes were characterized according to categories described in by Rice (1987:216). These categories are based on vessel proportions (ratio of height to body diameter). Categories were modified using terminology used to describe vessel forms common on the UTCP. According to Rice, a bowl form has a height between one third of the maximum vessel diameter and equal to the diameter, and may have a restricted or unrestricted orifice, but no necks. A jar is a vessel with a neck and restricted orifice with a height greater than its maximum diameter (Rice 1987). Whole vessels are rare on the UTCP, but the few which have been recovered are often described as "jars", probably because their height is greater than their diameter. Yet they often do not have restricted orifices. In this study, any vessel with a height greater than its diameter is referred to as a jar. UTCP jars with relatively restricted orifices or a collar are described as "globular jars". Jars with unrestricted orifices and no collars are called "concial jars". Bowls are identified using the definition described by Rice (1987).

Non-plastic inclusions

The types of non-plastic inclusions (e.g., sand, grog, bone, shell, or other materials) in each sherd were observed on a freshly broken cross section under 10X magnification using a binocular dissecting microscope. The quantity of inclusions was expressed as a categorical frequency (e.g., 0-25%, >25-<50%, >50-<75%, >75->100%, 100%). Size was estimated using a visual version of the Wentworth Scale. Frequency of inclusions was estimated using a visual scale after Courty et al. 1989.

Surface treatments

Surface treatments which have been previously recognized in UTCP pottery assemblages include: slipping, burnishing, combing, incising, stamping, cordmarking, punctuation, as well as scraped and wiped surfaces. All sherds were inspected macroscopically for evidence of these types of surface treatments. Tar (resin) was occasionally identified using a binocular dissecting microscope with 10X magnification, as it was sometimes present in very small quantities, probably due to post-depositional weathering (Figure 5.1). Surface treatments aside from tar were identified using Owen Rye's book *Pottery Technology: Principles and Reconstruction* (1976) which contains photographs and illustrations for each type of surface treatment. Identifications were also made based on previous experience with UTCP ceramic assemblages. Slipping is achieved by spreading a mixture of fine clay suspended in water on a clay surface before firing, producing a non vitreous coating (Rice 1987). In UTCP assemblages it usually appears as a red coating on the exterior of the vessel (Figure 5.2). This type of slip is commonly referred to as "red film" in the UTCP literature (Aten 1983). Burnishing is a luster producing surface treatment achieved by rubbing a hard, smooth implement on a leather-hard vessel and re-aligning clay particles, packing them more closely together (Rice 1987). This re-alignment of clay particles can reduce porosity of a pot.

Due to its ability to produce great luster, burnishing may not be solely for limiting porosity of a vessel, but also for decoration. The amount of burnishing can vary between vessels. Thus, vessels with detectable but low frequencies of burnishing may not have originally been intended to have low porosity. Combing is achieved by dragging a serrated or multi-pronged tool across a clay surface while it is still soft or leather hard (Rice 1987; Rye 1981; Figure 5.3). Incising—in which a pointed tool is used to cut lines on leather hard or soft clay surfaces—is one of the most common surface treatments in UTCP ceramic assemblages (Rice 1987; Rye 1981). Incising is usually confined to a small area just below the rim on UTCP vessels (Figure 5.2).

Stamping, cordmarking, and punctation are all particular methods of impressing plastic or leather hard clay surfaces (Rye 1981). These three methods of impression are common in ceramic assemblages in the American Southeast, and are sometimes reported in UTCP assemblages. Stamping is a surface treatment produced by pressing an implement to a soft clay surface to create an impression (Figure 5.4). Cordmarking is a kind of stamping achieved by pressing a cord-wrapped paddle to a soft clay surface (Rye 1981). Punctation is a surface treatment produced by pressing an implement on a soft clay surface to form a depression (Rice 1987; Figure 5.2). Scraping (sometimes referred to as scoring) is a secondary manufacturing characteristic. In other UTCP assemblages, scraping was apparently sometimes performed using the edge of a bivalve (Ellis 1992). Wiped surfaces are created by passing a hand or soft material (such as grass) over a wet clay surface (Rye 1981). In both techniques non-plastic inclusions may leave drag marks on the vessel surface. Such techniques have been used in known cases of pottery manufacture where the potter was trying to thin the walls of the vessel (Rice 1987).

Use wear characteristics

Identification of spalling and sooting was performed according to descriptive information provided in Hally (1983) and Skibo (1992). Unlike pitting, spalling has a distinctive conical form when viewed under low magnification (Skibo 1992; Figure 5.5). Sooting can be confused with blackened areas on vessels resulting from firing. Here, sooting was recorded when the dark area had a particularly dense and textured appearance (e.g., Figure 5.6). Identifications were made by looking at the interior and exterior of each sherd surface at 10X magnification using a binocular dissecting microscope. The body part each sherd represented was recorded to gain a sense of the nature of the distribution of use wear over vessel bodies.

Results

Vessel construction attributes

The overall thickness of body, rim and base sherds can reasonably be expected to vary from one another, and in the case of all three archaeological sites, mean thickness varies between body parts of the vessel in a predictable fashion. As the most frequently represented vessel portion, the distribution of thickness measurements of body sherds follows a similar visual pattern for all three sites (Figure 5.7). Rim portions of vessels are generally thinner than bases, as indicated in the distributions of rim and base thickness (Figures 5.8 and 5.9). Given this, it is reasonable to partition the distribution of wall thickness by vessel body part. When the means of body thickness measurements between all three sites are compared, they do not differ from each other statistically, as $F=67.478$ ($p<0.00$) (F statistic=863.139). Thickness is also not highly variable within any given sherd at any of the three sites; although 20.25% of the sherds at Mitchell Ridge (41GV66) were characterized as varying in thickness more than 1 mm—close to a quarter of the assemblage. The other two sites have even fewer sherds which vary in thickness; Honeycomb having 8.9% and Little Bethlehem with 13.22%.

Very few rim or body sherds from any of the sites were large enough to measure orifice diameter or body curvature. The few that were large enough on which to make accurate measurements came from the Mitchell Ridge (41GV66) and

Honeycomb (41LB4) assemblages ranged between 8 and 41 cm (Figure 5.10). Diameters of 11 sherds from Mitchell Ridge (41GV66) cluster in the 20-28 cm range, with a mean of 25 cm (Table 5.5). In contrast, the 11 sherds from Honeycomb cluster between 8 and 19 cm, with a mean of 13.25 cm (Table 5.5). Due to the overall small size of the sherds in all three assemblages vessel shape could not be reconstructed, with the exception of two groups of sherds from Honeycomb which join together to form jar shapes with 12 cm orifice diameters.

Mitchell Ridge (41GV66) and Honeycomb both have sherds large enough to calculate the horizontal curvature of a portion of the vessel. The Mitchell Ridge (41GV66) sample consisted of 54 sherds yielding horizontal body curvatures clustering between 5 and 19.9 cm (Figure 5.11). The Honeycomb curvatures (n=35) cluster in the 10-19.9 cm range. There were no sherds in the Little Bethlehem (41AU38) assemblage large enough to measure. On average, horizontal curvature in the Mitchell Ridge assemblage is smaller, while the Honeycomb assemblage has greater curvature, although these differences could be the result of difference in sample size (Table 5.6).

Identifying the amount and types of non-plastic inclusions using low magnification can be difficult. Using higher magnification on machined thin sections enables the analyst to make more accurate estimates, but this is not practical for large assemblages from economic or conservation standpoints. Thus, any analysis of the amount and type of non-plastic inclusions in archaeological pottery assemblages must balance the demands of accuracy with the constraints of practicality. Since this study includes petrographic analysis, it was decided to compare the estimates obtained from freshly broken sherds viewed at 10X magnification to thin sections made from the same sherds to determine how much more accurate the thin section estimates of inclusions are. Thin sections were made from 19 sherds for petrographic analysis. The results of the mineralogical analysis of these thin sections are discussed in the next chapter. The comparison revealed that eight out the 19 (42%) estimates of inclusion frequency from freshly broken sherds viewed at 10X magnification were incorrect. Of these eight discrepancies, five were the result of underestimating the type and/or frequency of inclusions in low magnification analysis. The other three were overestimates of the amount and type of inclusions using low magnification techniques. In four of the eight samples, discrepancies were the result of underestimating the amount of bone or grog inclusions from freshly broken cross sections.

Two main conclusions arise from these comparisons. First, making estimates of inclusions in UTCP assemblages by looking at sherds in thin section under magnification higher than 10X provides a more accurate estimate of the amount and type of inclusions in sherds. Technically the estimates from freshly broken cross sections of these 19 sherds were a little more than 50% accurate, but this accuracy is not as high as estimates derived from thin sections. Second, analysis of thin sections is much more likely to detect inclusions present in low frequencies (between 5 and 20%). In some sherds, bone and grog inclusions are present in very low frequencies and are mixed with sand. Estimating the amount of inclusion types by looking at freshly broken cross sections under low magnification is most accurate when inclusions are present in high frequencies.

Nonetheless, freshly broken cross sections give much information about the type and frequency of non-plastic inclusions. Sand is by far the most frequent non-plastic inclusion in vessel bodies in each of the three sites (Figure 5.12). Sherds from Honeycomb and Little Bethlehem also have high frequencies of grog and bone inclusions, respectively (Figure 5.13). Although grog temper is found in a little over half the sherds in the assemblage (54.43%), it never appears exclusively from sand but is rather mixed with sand. This is also the case with the fairly frequent bone inclusions in Little Bethlehem sherds (Figure 5.14). In contrast to sand, when grog or bone inclusions occur, they do so at low frequencies (Figures 5.15 and 5.16). In many cases sherds have fewer than five visible pieces of non-plastics (except for sand) in a cross section. Trace amounts of ferric and calcium carbonate concretions, shell and hematite are commonly present.

The fact that a little over half of the Honeycomb assemblage contains grog temper is of special consideration when evaluating the idea that UTCP vessels may have been designed for use over direct heat. The high frequency of thin walls correlate with grog temper. Variability in wall thickness was recorded as presence/absence data creating nominal-scale categories. Temper frequency was recorded as ratio-scale categorical data. Therefore, it was appropriate to use Yule's Q statistic to evaluate the strength of the possible correlation. Q can be calculated from 2x2 tables of nominal-scale data. When $Q=1$ the variables are perfectly correlated (Shennan 1990). In the Honeycomb assemblage the correlation between grog temper and walls which do not vary in thickness appears high with $Q=0.986$. Yet these results can be misleading, as non-variable wall thickness appears almost evenly distributed between sherds with and without grog. In other words, the correlation could be a coincidence. There appears to be no such correlation between grog temper and variable wall thickness in the Mitchell Ridge (41GV66) ($Q=0.04$) and Little Bethlehem ($Q=-0.10$) assemblages.

Surface treatments with potential decorative purposes occur in low frequencies in all assemblages. Honeycomb yielded the most decorated sherds—5.4% of the whole assemblage. The most common decorative surface treatment is incising, which usually occurs near the rim of the vessel. Other treatments typically occurring in UTCP assemblages were present in small amounts. These include combed surfaces, surfaces coated with red film, punctuated, and stamped surfaces (Table 5.7).

Other surface treatments may or may not have served decorative purposes. The Mitchell Ridge (41GV66) sample included 70 sherds with varying amounts of tar on them; 56 of the Honeycomb sherds also had tar on some portion of their exterior or interior surfaces (Table 5.7). This surface treatment is common in the central Texas coastal area and often occurs in thin wavy lines on the exterior or vessels (Ricklis 1996). It is often associated with the historic Karankawa (Ricklis 1996). Tar (commonly referred to as asphaltum) is present on interior and exterior portions of sherds. The distribution of tar on vessel bodies in UTCP assemblages make its function unclear. Tar could have been used as decoration, as it apparently is in Rockport-type assemblages on the central Texas coast. Some Rockport vessels are completely coated with tar on the exterior, and such coverage may indicate a utilitarian function as well—either to limit porosity or to protect vessels from abrasion. In the cases of Mitchell Ridge (41GV66) and Honeycomb, sometimes the surface of a sherd was entirely covered by tar resin, while in other cases only a few small flecks were present. Some resin was only detectable when the sherd was viewed using 10X magnification. Some sherds also exhibited burnishing, a surface treatment which can be considered decorative, but can also be useful in limiting the porosity of the vessel walls (Rice 1987). Less than 1% of the sherds in any of the three assemblages exhibited burnishing. Another surface treatment which did occur in higher frequencies consisted of striations, mostly present on the interior of the vessel, but sometimes also on the exterior (Table 5.7). This surface treatment is common in UTCP pottery assemblages but its potential functions have not been investigated (Ellis 1992; Suhm and Jelks 1962). Similar marks have been noted in ethnographic studies of pottery manufacture and are commonly described as "scraping" (see photograph in Rice 1987, page 137; Rye 1981). Scraping is often used to thin walls or remove surface imperfections (Rice 1987).

Use wear

Skibo's experimental work indicates that vessels used primarily for simmering tasks (heating food with little water) have a high frequency of spalling on their interiors, excluding the lower body and base areas. Sooting is heavy on vessel interiors and is concentrated on the middle portion of the body and the base. In comparison, pots used primarily for boiling tasks have no spalling on their interiors. Some sooting is occasionally present, but not in the thick deposits observed on vessels used for simmering tasks. Scratches were observed to often be the result of wiping soot off of vessel surfaces. The rim scratches commonly present on vessels used for boiling are often the result of the abrasion from utensils (Skibo 1992). Use wear signatures for simmering and boiling vary little on the exterior of pots. Both processes create heavy deposits of soot on the middle exterior portions of the vessel body, and areas of scratches caused by washing soot off of the vessel.

Sherd assemblages from all three sites have a small percentage of spalling on their interiors (Table 5.8). Spalling on interior portions of body sherds—expected if vessels were used for simmering starchy foods—is particularly low (Table 5.19). Across all assemblages, sooting on vessel bodies and bases appears low as well. The Mitchell Ridge (41GV66) assemblage has more sooting in general compared to the other two assemblages, and definitely more sooting on exterior portions of body and base sherds than on sherd interiors (Tables 5.8 and 5.9). Honeycomb (41LB4) body sherds also have more exterior sooting than on their interiors (Tables 5.10 and 5.11). In contrast, the Little Bethlehem (41AU38) assemblage has about an equal amount of sherds with sooting on their interiors and exteriors (Tables 5.12 and 5.13). Bases appear in these assemblages in very small numbers, so greater sample sizes may give a more accurate sense of what proportion of these assemblages were used over direct heat. Sooting is frequently present on the small sample of bases in the Mitchell Ridge (41GV66) and Honeycomb (41LB4) assemblages. Based on Skibo's experimental work, patches of soot appear on interior portions of bases of vessels used over low or indirect heat, such as those used to simmer starchy foods like rice (Skibo 1992; Tables 5.1 and 5.2). Based on this information, Mitchell Ridge vessels may have been used to simmer starchy foods in some cases. More puzzling is the higher percentage of sooting on the exterior portions of bases in this assemblage. The dark areas on these exterior bases could have been misidentified as sooted when in fact the dark patches are the result of fireclouding or residual tar. Perhaps the soot appeared on these bases as the result of using them for heating tasks after they ceased to be part of a vessel. Sooting on bases could also be a use wear pattern previously unrecognized.

Since scratches are often associated with soot removal, it makes sense that a low frequency of sooting and a high frequency of scratches could indicate that pots could have been used over heat. The majority of sherds from all three assemblages have fairly low frequencies of scratches. Among the individual sherds where scratches were observed, the density of scratches is relatively low, in most cases less than 25 percent (Tables 5.8-5.13). This generally low frequency of scratches on individual sherds does not match the observed pattern of dense scratches associated with washing sooted vessels known to be used over heat (Skibo 1992).

Discussion

The measurements and observations discussed in this chapter (vessel wall thickness, vessel orifice diameter and horizontal curvature, the nature and frequency of non-plastic inclusions, surface treatments, and use wear attributes) provide some information to evaluate the three sets of hypotheses related to cooking, storage, and prestige functions of pottery. One set of hypotheses asked whether pots were used to process foods using direct or indirect heating methods. The data presented here support the idea that UTCP pots may have been used over direct heat, although this cannot be demonstrated unequivocally. A key aspect of vessel construction of pottery from all three sites is the uniform thickness of sherds. Moreover, the distributions of sherd thicknesses are clustered around 3-8 mm, much thinner than the 10 cm walls of pottery used for indirect heating among hunter-gatherer groups in the American Northwest, including Alaska (Reid 1990). More geographically closer to the UTCP, Braun describes Mississippian "thick-walled" vessels as being between 10-15 mm in thickness, while the "thin-walled" vessels used for direct heating tasks range from 6-12 mm (Braun 1983). UTCP vessels fall well within this thin-walled range.

Other morphology data present a less distinct picture of how vessels might have been used to process foods. The few bases identified in the assemblages are rounded, supporting the idea that pots were designed to perform well over heat. The data on vessel orifice diameter are limited; and come from sherds in the Mitchell Ridge (41GV66) and Honeycomb (41LB4) assemblages. Generally, most orifices are wide enough to pass a hand through for easy access to contents, suggesting that vessels were used for some sort of food processing. It is interesting to note that sherds from Honeycomb have on average smaller orifices, five in the 8-10 cm range. These orifice diameters are a little too small to allow a hand easy access to vessel contents, unless these sherds represent cups or small bowls; such wares have been documented on other UTCP sites (Hood 1998). Unfortunately there is very little information about vessel shape from these assemblages. It is clear that horizontal curvature is less flat in the Honeycomb (41LB4) assemblage than in the Mitchell Ridge assemblage. The Mitchell Ridge assemblage has comparatively larger orifice diameters and less curvature than the Honeycomb assemblage. Based on orifice diameter and curvature measurements, vessels from Mitchell Ridge (41GV66) are larger on average than those from Honeycomb. It is possible that the overall smaller vessel orifice diameter at Honeycomb simply indicates that pots were smaller and there were fewer individuals present at the site at a given time than at the significantly larger site of Mitchell Ridge (41GV66). The difference in the distributions of orifice diameters and body curvature between Mitchell Ridge (41GV66) and Honeycomb may also indicate that these two sites were for different activities which in turn are reflected in the ceramic assemblages. It is possible that the overall smaller wares at Honeycomb were used for storage and the Mitchell Ridge (41GV66) wares were used for food processing and/or serving.

There is significant variation in non-plastic inclusions between sites. Mitchell Ridge (41GV66) and Honeycomb have high frequencies of sherds with grog temper compared to Little Bethlehem. The fact that a little over half of the Honeycomb assemblage contains grog temper is of special consideration when evaluating the idea that UTCP vessels may have been designed for use over direct heat. The high frequency of thin walls appears to be correlated with grog temper in the Honeycomb assemblage. The presence of bone inclusions in relatively high frequencies is not unexpected at Little Bethlehem, as local researchers consider bone-tempered wares to be common on the inland portion of the Texas coastal plain. Bone temper is not common on the coastal margin, but it has been noted on coastal margin sites in small quantities, as it is in this study. It is not currently known if bone temper has any properties that would make vessels more useful for heating or any other tasks in particular.

The correlation of use wear attributes associated with use over direct heat (sooting, spalling) with thin vessel walls and grog inclusions would bolster an argument for the design and use of UTCP vessels over direct heat. Yet sooting and spalling occur in such small frequencies that their presence is negligible. Spalling is most common to interior portions of body sherds, rather than rims or bases, indicating that perhaps some pots were used to simmer foods. In the Mitchell Ridge (41GV66) and Honeycomb assemblages, there is more exterior than interior sooting (27% for Mitchell Ridge and 11.8% for Honeycomb).

In terms of the food processing hypotheses, the data are mostly based on very small percentages of the assemblages. The major exception to this is the wall thickness data, which unequivocally indicates that vessel walls exhibit a thinness which is uniform within and between sites. Whether this is linked with using vessels to process foods over direct heat is unclear. Yet anecdotal evidence from attempts to replicate UTCP pottery suggests that in order to create pottery from the local clays available, prehistoric potters may have needed to make thin walls of a uniform thickness in order to create a vessel which would survive firing (Black 1988; Hill 1975). UTCP clays are smectites, which due to their crystal structure and particle shape and size, absorb and lose water easily. Thus, pots made from local clays which are not sufficiently dried are more prone to failure during firing. Gertjejansen and Shenkel (1983) note in their experiments on replicating Tchefuncte-style wares from similar clays in nearby Louisiana that 8 mm appears to be an optimal wall thickness for these vessels: thick enough to support walls during the drying stages before firing, and thin enough to reduce the chances of pots warping, cracking, or spalling during firing. Thinner walls also dry far more quickly than thicker ones, especially in areas with high humidity such as the UTCP (Hill 1975). This is an important consideration if UTCP groups were very mobile, as drying appears to take anywhere from four days to five weeks depending on the weather (Black 1988; Gertjejansen and Shenkel 1983; Hill 1975). The longer the drying time the more risk there is of pre-firing failure, as sudden weather changes affecting humidity and precipitation levels can also destroy leather-hard vessels (Hill 1975). Thus, pottery drying time could have been an important factor for UTCP potters to control.

Successful firing may also have been an important consideration when creating vessel sizes and shapes. Rounded vessel shapes appear common in all assemblages judging from the morphology of the sherds. In fact, there are no sherds which exhibit an angularity which might suggest angular forms. Pottery replication work indicates rounded shapes made from local clays appear to fare better on average during firing than angular shapes (Black 1988). In terms of shape, vessels made from local Louisiana clays which are 28 cm or less in diameter tend to fire in a very predictable manner. Vessels over 23 cm high can be difficult to fire (Gertjenjansen and Shenkel 1983). Use of non-plastics—any non-plastics—also appear to reduce failure when firing wares made from local clays by helping a fine, wet clay dry more thoroughly before firing (Black 1988).

Nonetheless, the use wear data indicate that at least a small portion of each assemblage was used over direct heat. Yet this low frequency of use wear signatures associated with use over direct heat may also indicate that UTCP assemblages were primarily used to process large-bodied animal resources using indirect heating methods. This hypothesis is somewhat supported, although mostly by negative evidence. Assemblages from all three sites have low frequencies of porosity-limiting surface treatments (such as burnishing, slipping, and resin coatings), which would be expected in vessels used to process foods without bringing them to a boil. Yet none of the assemblages examined in this study contain sherds which suggest flat bases.

The lack of heating use-wear signatures in these assemblages lends support to the hypothesis that vessels were mostly used for storage. Low frequencies of sooting and spalling suggest that overall assemblages may not have been used over direct heat. If thin walls were necessary for vessels to survive firing, then they may not be an accurate indicator of whether vessels were designed for storage or not. Yet surface treatments commonly associated with increasing the liquid storage capacity of vessels are rare in all three assemblages. Tarred treatments comprise less than 5% of the Mitchell Ridge (41GV66) sample and less than 2% of the Honeycomb sample. There are no tarred sherds in the Little Bethlehem assemblage. Less than 1% of the sherds in any of the three assemblages have any burnishing. Vessels from these assemblages do not appear to have been engineered specifically for storage, at least not wet storage. It is possible that these pots were used for dry storage. Additional information from residue analysis may provide another means of evaluating hypotheses concerned with "front-loaded" and "back-loaded" storage strategies.

Concerning the prestige hypothesis, the low levels of decoration in all assemblages indicate that a great deal of labor was not invested in decorating the vessels. The notably thin walls of the majority of vessels could have been used as a signal to others that the individual maker possesses a high level of skill to make such wares, or that individuals using these wares are displaying their ability to make or acquire pottery which is costly because it is time-consuming to make. This argument might be more convincing if replications of vessels with local clays did not strongly suggest that vessels without thin walls are highly impractical as they have less chance of surviving firing. The relatively wide orifice diameters in the limited sample of the

Mitchell Ridge (41GV66) assemblage support the idea that vessels at this site were used for preparing and/or serving food for large groups of people. This idea is supported by the overall large size of the site and the fact that it has four cemeteries, suggesting that it may have served as a focal point for spiritual life and associated ceremonies. In order to accept the hypothesis that vessels at any of these sites were used in prestige tasks, assemblages should have high frequencies of decorative surface treatments, and none of these assemblages do. It is also possible that post-depositional alteration of sherds has obscured use wear and surface treatments, and this has implications for all sets of hypotheses. In this analysis, only four sherds from Mitchell Ridge (41GV66) were identified as being noticeably eroded; 37 sherds from Honeycomb were identified as such and 5 sherds from Little Bethlehem. It is possible many more sherds in the assemblages are eroded and it was not recognized at the time of analysis. It would be useful to look at other UTCP pottery assemblages in a similar manner to determine if they too have low frequencies of surface treatments. For examples, previous studies have noted that there is not much exterior sooting on other UTCP pottery assemblages (Ellis 1992).

Conclusions

Data collected from manufacturing and use wear attributes on three vessel assemblages from the UTCP do not unequivocally indicate how pottery was used. The information gained from these three assemblages suggests that at least a small frequency of vessels were used over direct heat. The low frequencies of interior spalling and sooting in all three sherd assemblages suggest that either a high frequency of vessels were not used over direct heat, or may have been used to boil foods over direct heat rather than simmering. Either possibility supports the idea that UTCP groups were not processing high amounts of foods over heat with low amounts of water, such as starchy seeds or cultigens. Particular types of non-plastics were not necessarily being selected by potters for their individual performance properties.

Perhaps these mixtures indicate that the primary purpose of non-plastics was to make raw clays more workable, and thus any sort of non-plastic would suffice. Or perhaps a mixture of inclusions indicates no particular function of a vessel (e.g., heating) but rather that pots were generally multipurpose tools used in a variety of tasks. While vessel wall thickness (especially in the case of Honeycomb) suggests that vessels were engineered for use over heat, other aspects of the manufacturing process confound this interpretation. Thin walls may have been necessary to work with the unforgiving local clays in the UTCP region.

Data on surface treatments associated with storage of liquids or use over heat is low as well. It is not clear if some surface treatments, especially those associated with limiting vessel porosity were subject to post-depositional erosion. Vessels may not intended for particular tasks of heating or storage, but instead functioned in both capacities. Organic residue data provide more information on front and back loaded ("wet" and "dry") storage and thus provide some information on how frequently these pottery assemblages were used for purposes other than heating.

The roles of these vessels in prestige activities are difficult to assess as sherds are too small to determine vessel morphology and size. Small amounts of decoration on a small fraction of each vessel assemblage suggest that some vessels may have been used in contexts where display or communication of information was important.

Although the data pertaining to vessel construction and use do not fully support or refute any of the three sets of hypotheses, they do highlight some noticeable differences in assemblages between sites. Most notably, the ceramic assemblages from the coastal margin sites of Mitchell Ridge (41GV66) and Honeycomb (41LB4) have higher amounts of grog temper, suggesting that vessels were constructed to perform well over heat. Honeycomb in particular has a high correlation between thin vessel walls and grog temper, and the Mitchell Ridge assemblage has vessel bases with a relatively high amount of sooting on their interiors, which correlates with Skibo's experimental findings on vessels used to simmer starchy foods.

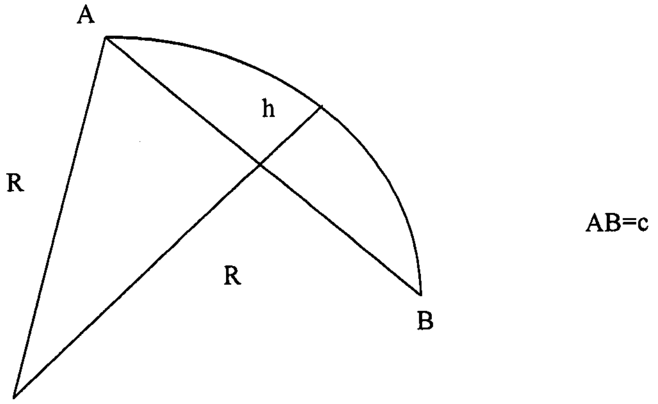


Figure 5.1 Diagram of vessel diameter measurements.

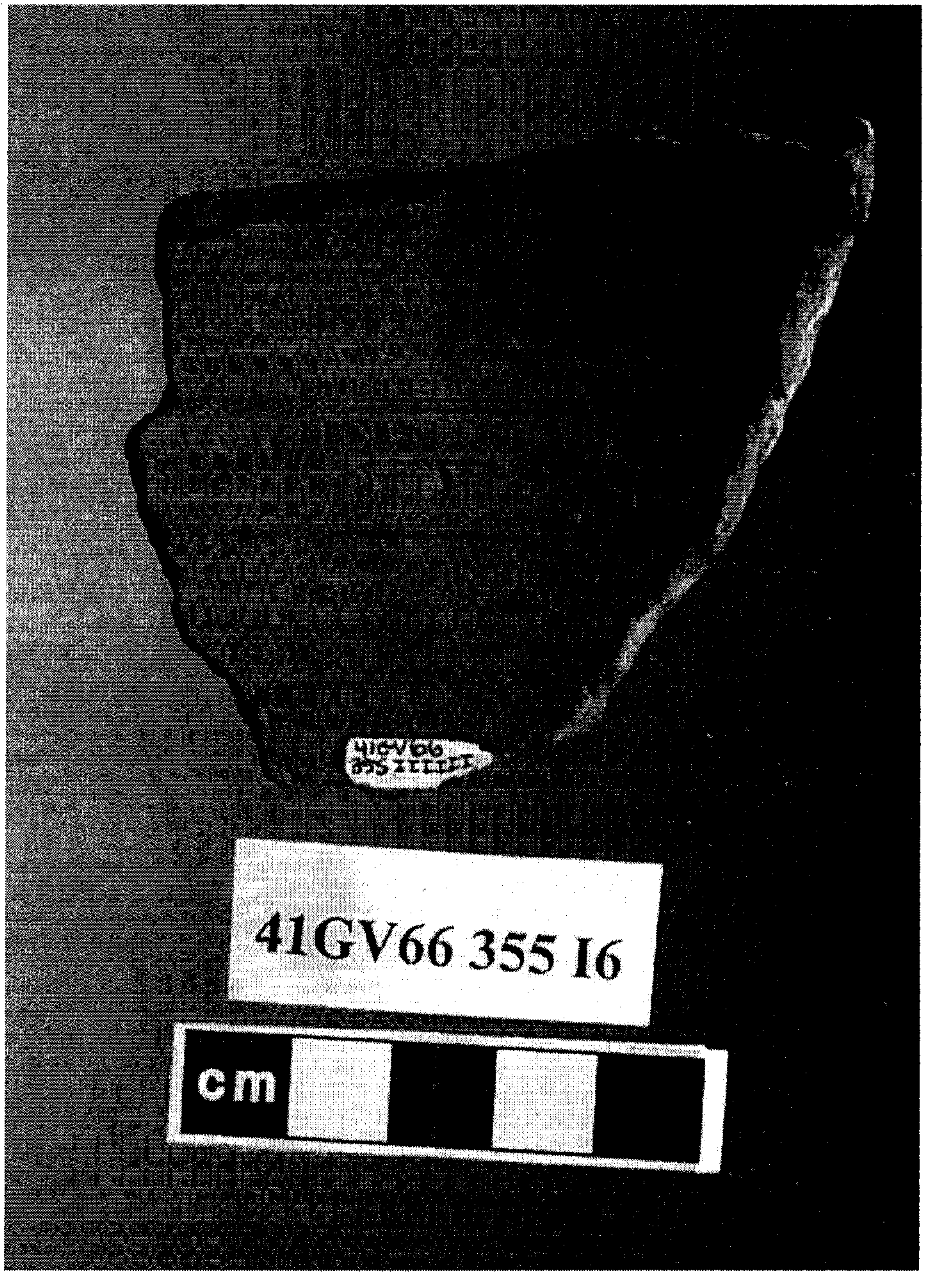


Figure 5.2 An example of resin surface treatment on the interior of a sherd from Mitchell Ridge (41GV66). While pieces of the tar still adhere to part of the surface, an even larger area is stained black, indicating that there was more resin on the surface than is now present. *Courtesy Texas Archeological Research Laboratory.*

Figure 5.3 Rim sherds with incised and punctated designs from Honeycomb (41LB4). Note darker areas on sherds (indicated by arrows), which are red wash or "film".
Courtesy Texas Archeological Research Laboratory.

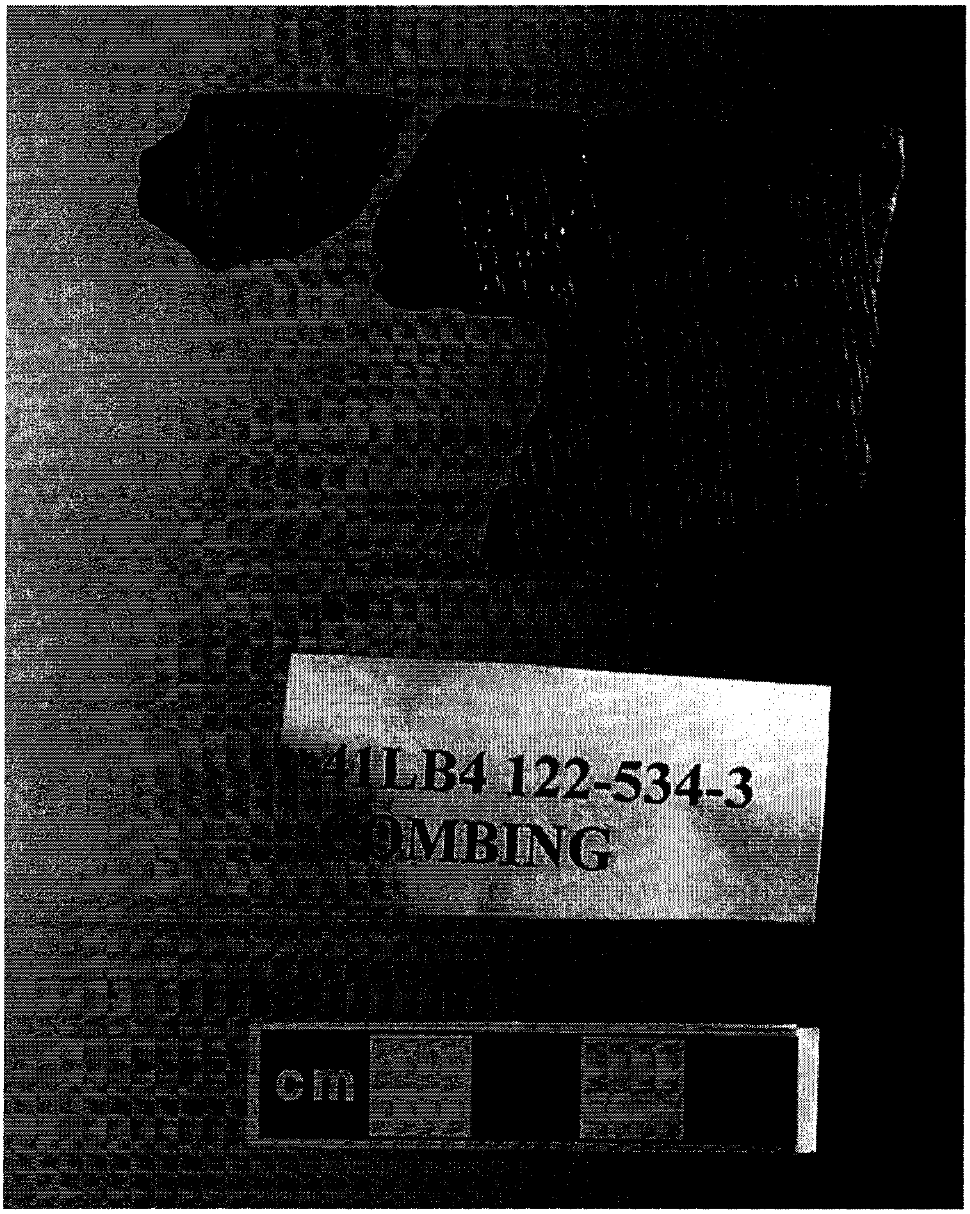


Figure 5.4 Rim sherds from Honeycomb (41LB4) with combing.
Courtesy Texas Archeological Research Laboratory.

Figure 5.5 A stamped or cord pressed interior of a sherd from Little Bethlehem. *Courtesy Texas Archeological Research Laboratory.*

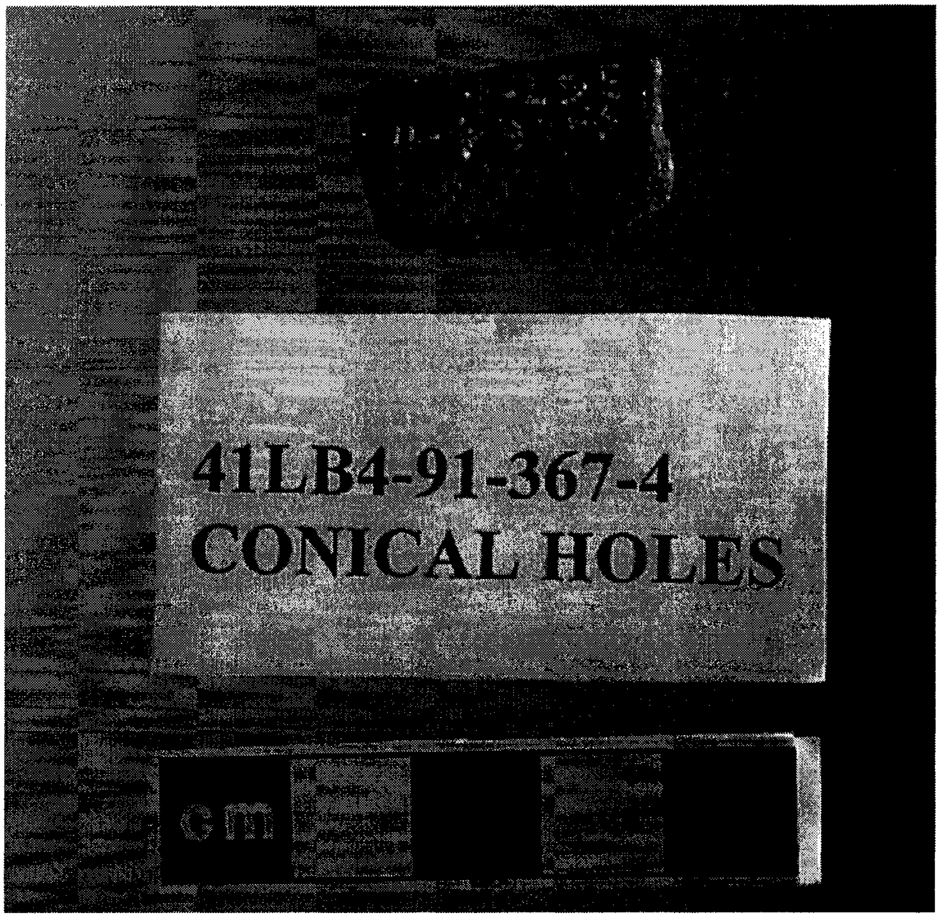


Figure 5.6 Spalling on interior of a rim sherd from Honeycomb (41LB4). Entire surface of sherd is covered with spalls. *Courtesy Texas Archeological Research Laboratory.*

Figure 5.7 An example of sooting from Mitchell Ridge (41GV66). The exterior of this sherd is completely covered with dark, textured material identified as soot. *Courtesy Texas Archeological Research Laboratory.*

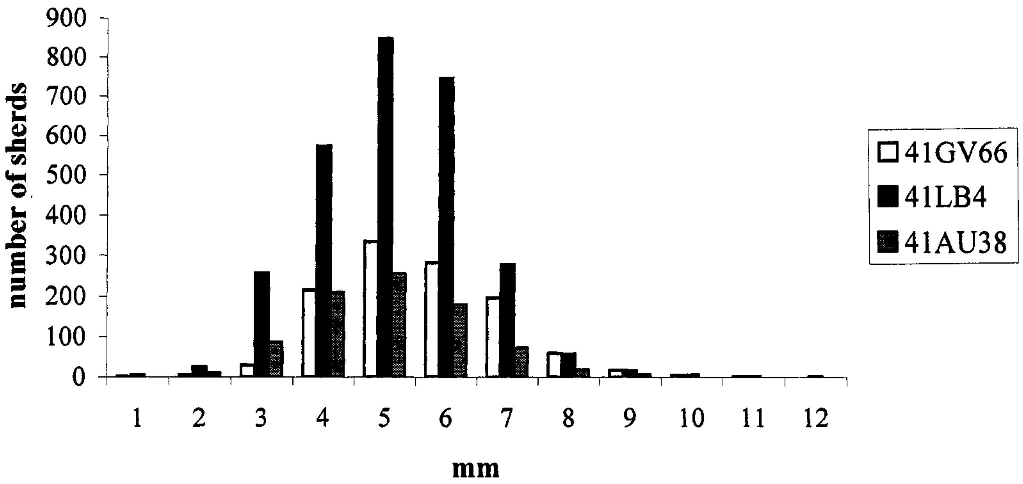


Figure 5.8. Body sherd thickness by site in pottery assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

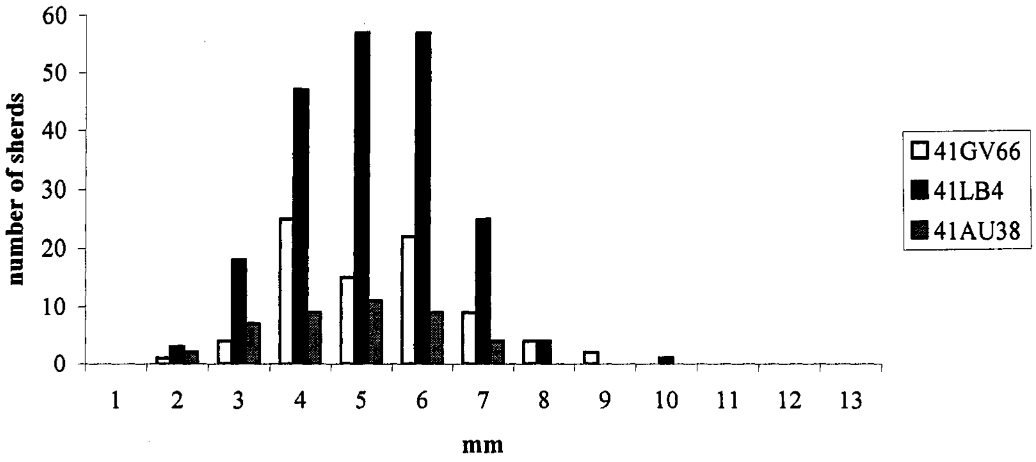


Figure 5.9. Rim sherd thickness by site in pottery assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

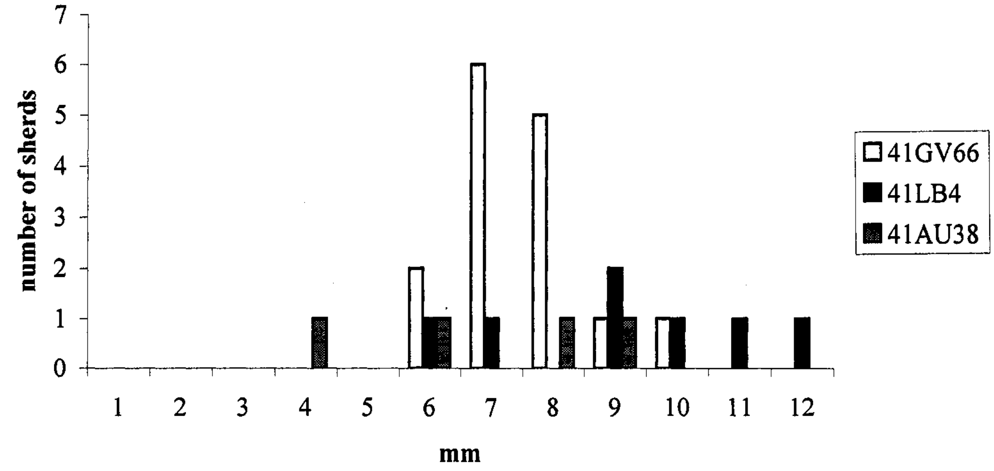


Figure 5.10. Base sherd thickness by site in pottery assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

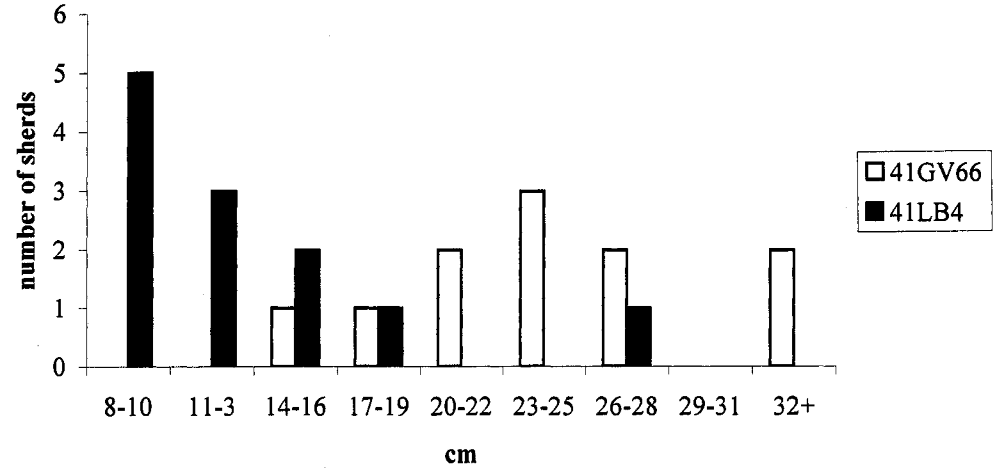


Figure 5.11. Orifice diameter by site in pottery assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), Little Bethlehem (41AU38).

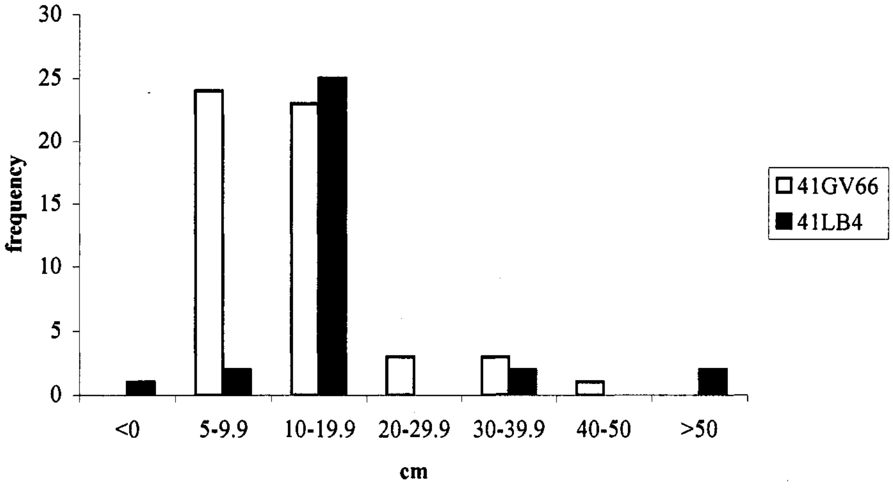


Figure 5.12. Calculated vessel diameter of body sherds greater than 50 mm in pottery assemblages from Mitchell Ridge (41GV66) and Honeycomb (41LB4).

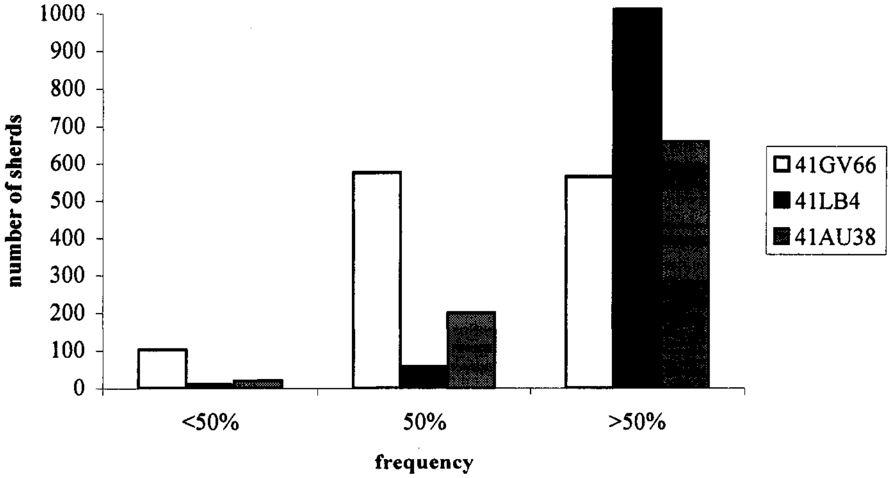


Figure 5.13. Frequency of sand inclusions in pottery assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4) and Little Bethlehem (41AU38).

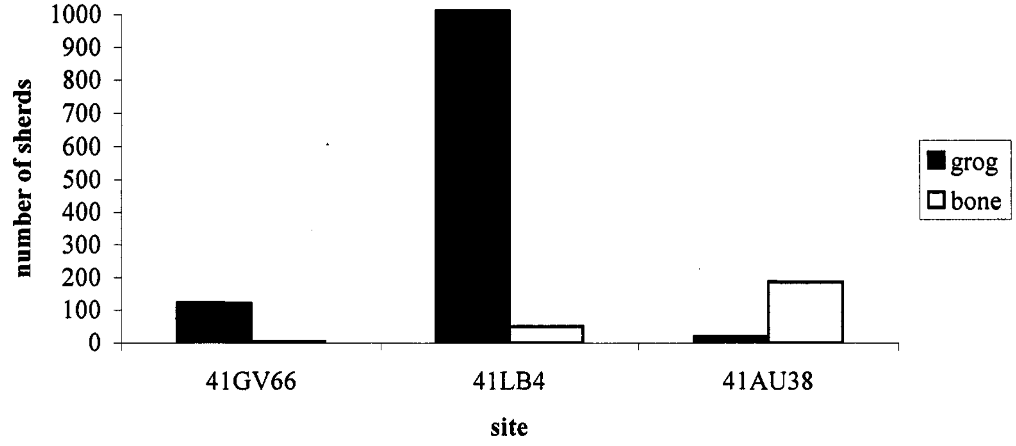


Figure 5.14. Distribution of grog and bone temper by site in pottery assebmlages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

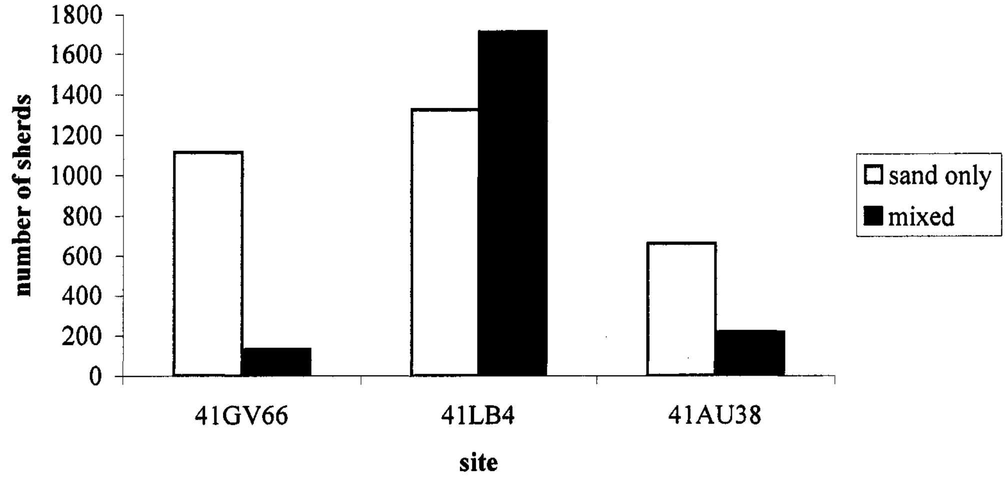


Figure 5.15. Mixture of inclusions by assemblage in assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

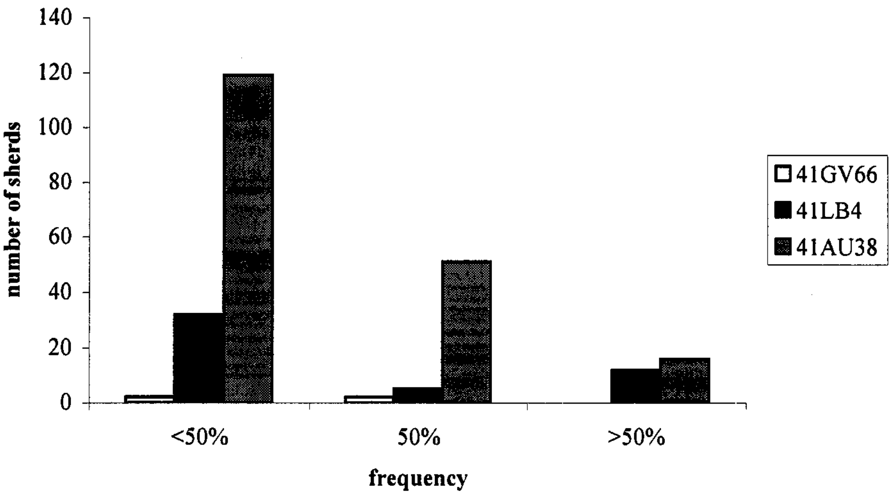


Figure 5.16. Frequency of bone inclusions in pottery assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

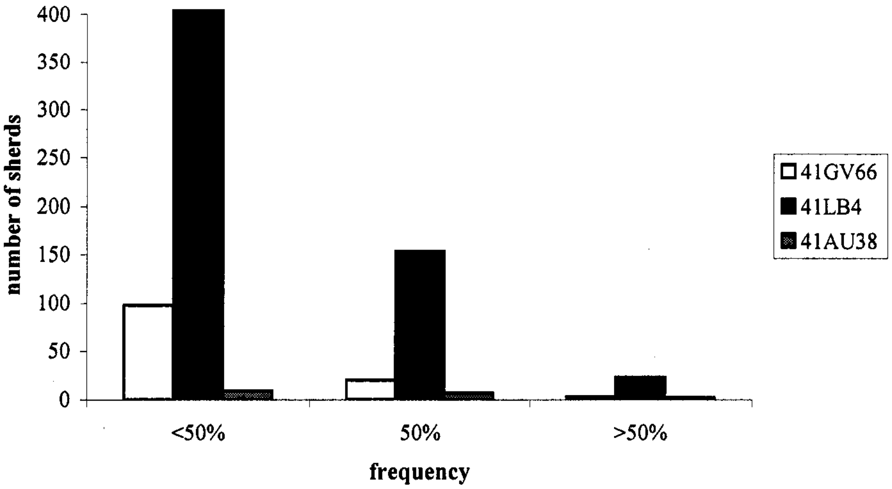


Figure 5.17. Frequency of grog inclusions in pottery assemblages from Mitchell Ridge (41GV66),Honeycomb (41LB4), and Little Bethlehem (41AU38).

Table 5.1 Use wear profile of vessels used for simmering starchy plant foods. After Skibo 1992.

	interior	exterior
rim/upper neck	spalling, no abrasion	some linear scratches, chips
upper body	spalling; sooting	thin layers of soot; polish
middle body	heavy spalling; scratches; soot patch	heavy sooting; scratches
lower body	sooting; scratches	sooting; scratches
base	sooting patch; scratches	no soot; circular abraded patch

Table 5.2 Use wear profile of vessels used for boiling. After Skibo 1992.

	interior	exterior
rim/upper neck	abrasion	frequent linear scratches, chips
upper body	pitting; sooting	thin layers of soot; polish
middle body	fine scratches; sooting	heavy sooting; scratches
lower body	sooting	sooting; scratches
base	scratches; occassional sooting patch	no soot; circular abraded patch

Table 5.3 Expectations for food processing, storage, and prestige hypotheses. After Hayden 1998; Reid 1990; Rice 1987; Sassaman 1993.

	Wall thickness	Vessel morphology	Porosity	Decorative treatment	Heating use wear
PROCESSING					
starchy seeds	thin, uniform	round base, smooth wall curvature	low	low	high
large-bodied resources	thick, uniform	flat base, wide orifice	high	low	low
STORAGE					
Front loaded	thick, variable	narrow orifice	low	low	none
Back loaded	thick, variable	narrow orifice	low to high	low	none
PRESTIGE					
Serving or procesing	thin, uniform	shallow/special shapes, wide orifices	variable	high	high to none

Table 5.4 UTCP ware attributes in relation to sample size in the assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

Assemblage	**N**	**Average maximum sherd length (mm)**	**Types of surface treatments**	**Use wear classes**
Mitchell Ridge	1244	24.17	7	3
Honeycomb	3034	20.69	7	3
Little Bethlehem	877	16.9	4	3

Table 5.5 Descriptive statisitcs of orifice diameter measurments for Mitchell Ridge (41GV66) and Honeycomb (41LB4).

Orifice Diameter (cm)		
	Mitchell Ridge	Honeycomb
Mean	25	13.09
Median	25	12
Standard Deviation	7	5.22
Range	25	18
Minimum	16	8
Maximum	41	26
Count	11	11

Table 5.6 Descriptive statisitcs of horizontal curvature measurments for Mitchell Ridge (41GV66) and Honeycomb (41LB4).

Horizontal Curvature (cm)		
	Mitchell Ridge	Honeycomb
Mean	13	20
Median	10	13
Standard Deviation	8.33	33.4
Range	44.35	217.47
Minimum	5.66	-52.99
Maximum	50	164.48
Count	54	35

Table 5.7 Percentages of surface treatment attributes in assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

	Mitchell Ridge	Honeycomb	Little Bethlehem
Tarring exterior	4.01	1.28	0
Tarring interior	1.67	0.56	0
Burnishing exterior	0.4	0.03	0
Burnishing interior	0.98	0	0.23
Combing	0.08	0.3	0
Cord Marking	0	0	0.11
Filming	0.08	0.16	0
Incising	2.2	4.4	1.3
Punctation	0.08	0.49	0
Stamping	0.08	0	0.11
Striations	29.99	13.28	5.25

Table 5.8 Percentages of sherds in Mitchell Ridge (41GV66) assemblage with use wear on their interiors. Percentages are broken down by vessel section.

vessel section	sooting interior	spalling interior	scratching interior	total count
rim	16	9	11	82
body	11	3	17.5	1143
base	31.5	0	16	19

Table 5.9 Percentages of sherds in Mitchell Ridge (41GV66) assemblage with use wear on their exteriors. Percentages are broken down by vessel section.

vessel section	sooting exterior	spalling exterior	scratching exterior	total count
rim	34	3.5	16	82
body	20	4	18	1143
base	52	0	26	19

Table 5.10 Percentages of sherds in Honeycomb (41LB4) assemblage with use wear on their interiors. Percentages are broken down by vessel section.

vessel section	sooting interior	spalling interior	scratching interior	total count
rim	9	2	11	212
body	4	0.71	8	2813
base	0	0	29	7

Table 5.11 Percentages of sherds in Honeycomb (41LB4) assemblage with use wear on their exteriors. Percentages are broken down by vessel section.

vessel section	sooting exterior	spalling exterior	scratching exterior	total count
rim	13	2	7.5	212
body	9	36	231	2813
base	1	0	3	7

Table 5.12 Percentages of sherds in Little Bethlehem (41AU38) assemblage with use wear on their interiors. Percentages are broken down by vessel section.

vessel section	sooting interior	spalling interior	scratching interior	total count
rim	5	5	14	42
body	5.5	1	5.5	830
base	0	0	0	4

Table 5.13 Percentages of sherds in Little Bethlehem (41AU38) assemblage with use wear on their exteriors. Percentages are broken down by vessel section.

vessel section	sooting exterior	spalling exterior	scratching exterior	total count
rim	17	2	12	42
body	6	0.96	9	830
base	0	0	50	4

CHAPTER 6: MOVEMENT, TRADE, AND VESSEL MANUFACTURE: THE MINERALOGICAL DATA

Introduction: Implications of Sourcing for Hypotheses

Traditionally, pottery manufacture and use are not associated with hunter-gatherer societies with high degrees of residential mobility. Archaeologists have frequently operated on the assumption that the physical properties of pottery make it too bulky for frequent transport. Furthermore, pottery manufacture requires people to stay in one place, which may inhibit their ability to access food resources in other locations. The transport costs of clay may be high or groups frequently on the move (Eerkens 2002). Yet the presence of pottery has been documented among mobile hunter-gatherers (Eerkens 2002). Instead of seeing pottery as an indicator of sedentism among hunter-gatherer societies, it can be used to investigate group mobility and trade, as is commonly done with food-producing and/or groups with high degrees of sedentism.

Sourcing pottery addresses questions of how pots have moved across the landscape, either through movement of groups of people, and/or trade. In turn, trade can involve the movement of individuals, or goods in a "down-the-line" fashion. Geologic sourcing has been used to better understand the degree of mobility of populations and the nature of trade between groups (e.g., Bishop 1980; Eerkens et al 2002; Ferring and Perttula 1989; Glascock 2002). In turn, understanding group mobility and trade has implications for hypotheses concerning food processing, food storage, and self-aggrandizing behavior in small-scale societies. In particular, the degree of group mobility has implications for what kinds of resources are being taken and how they are processed. If the geologic sources of pots are varied, then we might expect that groups were pursuing predominately large-bodied food resources with large home ranges. Such large ranges would require a high degree of group mobility. This idea can be tested using sourcing data, and cross-checked using morphological/use-wear and organic residue data. The degree of group mobility has implications for storage strategies in hunter-gatherer societies as well. Pots with a variety of geologic sources may indicate a high frequency of mobility, which may indicate that groups are moving rather than relying on storage to fill spatial and/or temporal gaps in resources.

Sourcing data can also be used to address models of the role of ceramic vessels in prestige economies. Vessels from non-local sources may have functioned as prestige items, indicating to others that their owners were able to obtain rare, exotic items. Exotic goods may also indicate political, economic, or social connections. Such connections may indicate contact with elites, and/or may have been used to enhance individual or group social/political standing in local societies. While trade cannot always be distinguished from group movement, it is reasonable to expect that trade might be distinguished from mobility by the frequency of pots from non-local geologic sources and other data such as faunal seasonality. Determining how vessels were distributed across the landscape provides data which can be used to help test hypotheses of vessel function and use in hunter-gatherer societies. On a regional level, sourcing studies can contribute to our understanding of the nature of mobility and trade, as well as ceramic vessel function and use on the upper Texas coastal plain.

Expectations for Mobility and Trade: Distribution of Food Resources

The archaeological record of the upper Texas coastal plain contains numerous examples of hunter-gatherer pottery, but the degree of group mobility in this region is unknown. We can develop expectations for how mobile UTCP groups were by relying on theoretical relationships between the type and distribution of food resources on the landscape, and mobility and storage. This theoretical work continues to draw upon ethnological and archaeological research on relationships between resource use, mobility, and storage. Similar theoretical relationships are being developed between the distribution of resources and trade between groups, and they are summarized here. The nature and distribution of food resources on the UTCP is then discussed, followed by general expectations for pottery function and use in this region based on resource information.

Ethnographic research indicates that the degree of group mobility in hunter-gatherer societies may be linked with the type as well as the distribution of food resources on the landscape. Both the spatial and temporal distribution of resources is empirically linked with the degree of group mobility. Groups focusing primarily on small-bodied and aquatic resources often have smaller foraging ranges. In contrast, groups maintaining high degrees of mobility often do so given their frequent pursuit of large-bodied prey (Binford 2001; Stenton 1991). The spatial and temporal distribution of resources can also affect the degree of group mobility. If food resources are abundant in a particular area, groups may have no reason to move elsewhere. If resources are spatially dispersed, then groups may need to be more mobile in order to pursue them. Likewise, in cases where different resources are temporally variable, groups may need to move in order to take advantage of resources as they become available.

The degree and type of mobility as well as the interplay between prehistoric settlement and subsistence on the UTCP are not completely understood. Excavations of UTCP sites have yielded a variety of large and small-bodied fauna. The presence of large-bodied fauna with large home ranges, such as deer and bison, could indicate that upper Texas coast hunter-gatherers maintained residential mobility in order to frequently pursue such prey. Or perhaps a few of these animals occasionally came near enough to be taken without the need for changing residence. Based on environmental reconstructions and the seasonal availability of key resources, the inhabitants of this region appear to have lived in a highly productive environment rich in wild foods available throughout the annual cycle beginning about 2000 B.P. (Story 1990). Groups may or may not have moved between coastal and interior portions of the coastal plain. Perhaps some groups remained on the interior of the coastal plain throughout the annual cycle (Story 1990). Or there could have been distinct groups in both the coastal margin and interior who engaged in cooperative resource procurement on the border of each others' territories (Ricklis 1996). Certainly physical geography was unlikely to constrain group foraging ranges, as the Gulf Coastal Plain is characterized by a uniformly low elevation. And while much of the area is traversed by waterways and/or subject to seasonal flooding, this sort of environment is navigable by watercraft, which may have facilitated group movement between resource patches (Moore 1995). More information on UTCP subsistence and mobility will help determine the roles ceramic vessels had in food processing in this hunter-gatherer society. Despite the plentiful food resources on the coastal margin, it is plausible that periodic changes in local resource abundance may have necessitated groups moving to other resources, and/or trading with adjacent groups for food. This may also have been the case for inland coastal plain groups, who most likely experienced resource abundance in the fall, but may have had lean times in other seasons. Coastal margin groups may have had smaller foraging ranges, and focused more on small-bodied and aquatic resources, while interior groups maintained greater mobility in the process of pursuing large-bodied prey.

There is also a theoretical relationship between the distribution of food resources and degree of food storage. Anthropologists have identified various storage strategies in ethnographic research and theoretical work. Many hunter-gatherer societies store food to some degree during the annual cycle (Binford 1980). Food storage allows people to average surpluses in order to buffer against shortages the temporal distribution of resources during the annual cycle (Goland 1991; Weissner 1982). Yet in order for a food storage strategy to be useful, groups must be able to consistently generate a sufficient surplus to cover their shortages (Cashdan 1992; Dyson-Hudson and Smith 1978; Goland 1991). Groups who experience predictable spatial food shortages may instead solve the problem by moving frequently and maintaining social networks to facilitate this movement (Weissner 1982). Storage may require groups to be more sedentary. This idea is discussed later.

Recent archaeological research has focused on the idea that ceramic vessels were used as tools to accrue social and political prestige in foraging societies (e.g., Hayden 1995; Rice 1996). While accruing material possessions is often at odds with values (such as individual autonomy and movement) in socially egalitarian hunter-gatherer societies, there are examples of craft traditions in foraging societies often described as socially egalitarian (Bliege Bird and Smith 2005; Weissner 1982). Hayden has argued that ceramic vessels have the potential to be ideal prestige items, as they can be made to be aesthetically pleasing and rare or exotic materials can be used in their construction (Hayden 1995). Recent ethnographic research suggests that in some cases, pottery production can be converted into other kinds of fitness-enhancing benefits (such as obtaining well-to-do husbands; Bliege Bird and Smith 2005). Ceramic vessels may be implicated with prestige behavior in another manner. The actual value of ceramic vessels can also derive from the items within that may be of social or economic significance, such as exotic foods and/or intoxicants (Arthur 2002; Hoopes and Barnett 1995). Ethnohistoric information and anthropological theory indicate that the processing, display, and consumption of such foods are of social and political value (Hayden 1995). The creation, display, and sharing of exotic foods can be used in a competitive manner to signal political strength, gain power, or create/strengthen political alliances (Bliege Bird and Smith 2005; Hayden 1990). Vessels of non-local provenance and/or exotic foods can be obtained through trade. Therefore, another means assessing the hypothesis of ceramic vessels functioning in prestige contexts.

At first glance, the pottery of the UTCP does not appear to be costly either in terms of raw materials or labor. Clays in this area are plentiful and in a sense pre-mixed with non-plastics and ready to use for vessel manufacture (Ellis 1992). As ubiquitous as they are, these clays can hardly be described as rare and difficult to procure. Most researchers have reasonably assumed that these vessels are made from local materials widely available throughout the area, but the geologic provenance of these wares has not been investigated. Whether or not UTCP vessels contained rare or costly foods useful in prestige display contexts is not clear. Logically, pots may have contained cultigens such as maize, possibly traded from the Caddo. Ceramic vessels are implicated in these proposed trade patterns in various ways. The wares themselves may not have been attractive to the Caddo, as they had their own pottery tradition, but perhaps UTCP or Caddo wares containing trade foods or other goods were passed between cultural areas. The greater decorative variety of Caddo wares relative to UTCP wares may also have been desirable to UTCP groups as items to indicate status, as in the ability to maintain social and/or trade ties with outside groups or in the possession of exotic pottery. Thus, there are many reasons why both inland and coastal groups on the UTCP might have traded pottery and its contents with Caddo groups. Even if food shortages did not occur in a predictable fashion, interior and coastal groups may have maintained trade relations with the Caddo for a variety of reasons: to exchange foodstuffs to gain greater nutritional variety (such as bison or fish for maize, e.g., Spielmann 1986), or to maintain social ties to buffer against lean times and/or for marriage alliances. UTCP groups may have also traded with the Caddo or groups to the west for lithic materials, as the coastal plain has very few raw material sources.

In summarizing expectations for the provenance of UTCP ceramic vessels, we would expect that if groups were highly mobile, high frequencies of pottery in UTCP assemblages would have mineral inclusions from non-local sources. As discussed above, the degree of group mobility depends on how mobile food resources are, and how much they are clustered in time and space. Based on environmental information, we would expect UTCP hunter-gatherers to have some degree of seasonal mobility as a means of responding to somewhat predictable spatial and temporal variability in food resources. Given the many small-bodied resources (e.g., shellfish) present in the region which were most likely plentiful in many areas of the region, UTCP hunter-gatherers are expected to have had little incentive to store foods. This might not be the case if population density increased to the point where populations outstripped food resources, which they may have experienced as spatial and temporal gaps in food availability. If groups are moving frequently around the landscape, and/or storing little food, we would expect pottery to be from non-local geologic sources. The undecorated wares common in many ceramic assemblages in the region underscore the expectation that pots are not prestige items, and therefore few if any are expected to be from non-local geologic sources. While analysis of morphological and use-wear characteristics of UTCP vessels provides some information about group resource use, storage, and prestige behavior, sourcing data can be used in conjunction with this information to assess hypotheses concerning the nature of food processing, storage, and prestige behavior.

Sourcing Methods

Archaeologists have used various sourcing methods to address archaeological questions of movement and trade for many decades. Chemical characterization methods have been applied to archaeological questions since the mid-nineteenth century, although mineralogical analyses of ceramic pastes were more common in the early twentieth century (Neff et al. 1992; Shepard 1936). During the past few decades, chemical characterization methods have become more commonly used in archaeological sourcing studies, while the frequency of mineralogical studies has decreased (e.g., Arnold et al. 1991; Bishop 1980, Glascock 2002; Neff et al. 1992; Sayre 1957). Recently, combinations of chemical characterization and mineral analysis methods have been used to address questions of group movement and/or trade (e.g., Montana et al. 2003; Perttula et al. 2001; Stoltman et al. 1992).

Chemical or elemental sourcing methods commonly used in the past few decades include neutron activation analysis (NAA), various inductively coupled plasma techniques (ICP), x-ray florescence (XRF) and Particle induced x-ray emission (PIXE). Elemental analyses of ceramic materials typically focus on anions commonly associated with ceramic materials, such as silicates, carbonates, sulfates and hydroxides, halides, oxides, and sulfides (Hancock 2000). Two of the most commonly used methods are NAA and ICP, which basically measure the kind and abundance of elements in a given sample. In NAA the sample is disaggregated (ground up), dissolved, and bombarded with neutrons and them measuring the gamma emission. ICP methods involve heating the sample in a hot gas (plasma), which produces excited atoms whose light wavelengths are measured. Chemical analyses are often performed quickly by a laboratory specializing in the work, and the methods can be used with relatively small amount of ceramic material.

Determining geological provenance of pottery using mineralogical data continues to be done decades after Anna Shepard's ground-breaking work (Shepard 1936) on sourcing pottery pastes using their mineral inclusions (e.g., Dickinson 1998; O'Malley 1981; Porter and Szuter 1978; Shepard 1965; Stoltman 1989, 2001). Petrography is commonly used in geology to describe and classify rocks in thin section in order to study their origin, occurrence, structure, and history. While the method does require specialized knowledge and training on the part of the operator, it not only allows researchers to provide information about the geologic source of a sherd, but also about the nature of its manufacture; such as the size and orientation of particles, as well as pores or voids in the ceramic body.

Generally it is assumed that ceramics with different chemical or mineralogical constituents are from different geologic sources. This idea has been more specifically stated in the Provenance Postulate, which Neff suggests can apply to both chemical and mineralogical sourcing methods: "Sourcing is possible as long as there exists some qualitative chemical or mineralogical difference between natural sources that exceeds the qualitative or quantitative variation within each source." (Neff 2000:107-108). Despite the elegance of the idea, linking ceramic pastes with specific source locations can be problematic. Often during the process of ceramic manufacture, materials are added or deleted from ceramic pastes in the course of levigation (removal of coarse particles) of raw clays or addition of non-plastic materials. These actions can alter the chemical and mineralogical composition of pots (Arnold et al. 1991; Blackman 1992). Pottery can also absorb residues during use and/or burial which in turn can add to its chemical signal (Neff 2000; Stoltman 2001). Thus, when bulk ceramic samples are analyzed using chemical sourcing methods, it is not always clear whether the information obtained pertains to paste, temper source, or the addition or leaching of materials during use or burial. These conditions can affect the validity of results when the chemical composition ceramics is used to determine geological location on the landscape (Neff 2000). It can also be difficult to reliably link pots to a particular location if the variability in elemental concentrations in temper is high and similar to those of the clay (Neff 2000). Thus, it cannot be assumed chemical sourcing methods identify raw material sources. Rather, these methods can be used to show there is little or no difference between the ceramic sample and samples of potential raw materials. Differences in composition cannot automatically be interpreted to indicate differences in source material.

Researchers have pointed out that in order to accurately determine geologic provenance of ceramic vessels, other non-elemental methods may be useful (Neff 2000). Such methods can range from macroscopic (design, color) to microscopic (Rands and Weimer 1992). Unlike chemical constituent analyses, mineralogical analysis can enable the analyst to distinguish between temper and clay composition (Stoltman 2001). When coupled with elemental methods, mineralogical analysis may indicate differences in ceramic paste composition not revealed in chemical methods (Stoltman et al. 1992). In addition, mineralogical analysis of petrographic thin sections can provide information on manufacturing attributes, such as the presence of glazes and slips (Ferring and Perttula 1987). Furthermore, petrographic thin sections can be inspected to gain a sense of types and frequencies of temper and pores in a ceramic body.

Sourcing in continental basins such as the upper Texas coastal plain can be complicated by geologic sources and relief which are homogenous over large areas of land. Large river systems can mix sediments and effectively homogenize sources. In such cases, the variability of mineral constituents of sediments between source areas may actually not exceed that within a single source area. Very little sourcing research has been done on UTCP pottery (see Skokan 1995, 1996 for studies in the Brazos drainage). Some have been conducted in the Caddoan cultural area in what is now Southeastern Oklahoma/Southwestern Arkansas/East Texas (Ferring and Perttula 1987; Perttula 2002). In order to test the hypotheses discussed at the beginning of the chapter, sourcing data were necessary. Information on the frequency and type of inclusions and pores in the ceramic paste would also be useful in evaluating the hypotheses. In order to avoid some of the possible problems with distinguishing between clay and temper sources, as well as to learn more about the frequency and types of aplastic inclusions and pores of the ceramics in this region, it was decided to focus initial efforts on a mineralogical analysis using petrographic methods. The data generated in this study may provide a starting point for future studies in the UTCP region and adjacent cultural areas.

Local and exotic ceramic types

Our current knowledge of the provenance of UTCP pottery is limited, although ceramics are commonly assumed to be made from local clays on the gulf coastal plain. Occasionally pottery styles resembling those from the Caddo area and the Lower Mississippi Valley (LMV) appear in UTCP assemblages (Moore 1995; Perttula 2002; Ricklis 1994). UTCP pottery is distinctively plain in comparison to Caddoan and LMV wares. UTCP vessels are generally thin-walled with little decoration. What embellishment does occur is usually on the lip and/or rim of the vessel (see Aten 1983; Suhm and Jelks 1962 and Chapter 5 of this study for examples). In contrast, Caddoan wares commonly exhibit many decorative styles which have been classified in a comparatively complex type-variety system (Phillips et al. 1951; Suhm and Jelks 1962). Not only do Caddoan pots have a variety of decorative styles much greater than among UTCP wares, but Caddoan wares appear to have a greater variety of shapes than UTCP vessels. LMV wares are also distinctive in their amount and variety of decoration compared to UTCP wares. Most other LMV pottery types of the Late Prehistoric Period have distinctive design treatments quite different from UTCP wares. Many Late Prehistoric/Mississippian LMV wares are tempered with shell, a rare inclusion in UTCP wares.

However, there are some similarities between a few LMV and UTCP pottery types which suggest that local and non-local sherds may not be distinguishable from one another. For example, sherds with design motifs known in the LMV area as

"Harrison Bayou Incised", "Coles Creek Incised" and "Evansville Punctated" have been documented in UTCP assemblages (Ricklis 1994). In UTCP assemblages, these types are described as "Goose Creek Incised" (incised sherds with sandy pastes) and "San Jacinto Incised" (incised sherds with grog temper). Most of these types are rounded, globular or jar forms without handles or lugs, similar to vessel forms which have been described for the UTCP (e.g., Hood 1998; Ricklis 1994; Takac et al. 2000). Grog-tempered wares with vertical or oblique incised lines resemble the LMV type "Mazique Incised" and the Caddo type "Dunkin Incised", but these Caddo vessel types appear to have mostly flat bottoms, which differs from what is currently known about vessel form in general for UTCP wares (Phillips et al. 1951; Suhm and Jelks 1962). Baytown Plain, a grog-tempered plain ware has also been documented in the LMV and UTCP (Aten 1983; Phillips et al. 1951). Sherds with decorative elements common in Caddo wares have been identified in small quantities in some UTCP sites (Moore, personal communication 2007; Perttula 2002).

Sedimentary Petrographic Provinces

Multiple factors influence geologic provenance: types of source rocks, landscape relief, and climate. Landscape relief affects the kinds of source materials available to local potters, in that the higher the relief, the more rocks and their constituent minerals are subject to mechanical abrasion. The climate of source areas can affect the chemical weathering of source rocks and minerals as well; humid climates often accelerate weathering while arid climates often allow relatively more rock fragments and feldspars to remain in source materials (Basu 1976; Suttner 1974).

Geologic Setting of the Upper Texas Coastal Plain

The archaeological sites included in this study are located in a region which spans five major geologic formations. These formations appear as a series of ocean-trending wedges of sediment parallel to the coastline. The Trinity and Brazos Rivers are the major transport agents of sands to and on the UTCP. Both rivers flow through

Cretaceous, Permian, and Pennsylvanian sedimentary rocks, which include limestones, shales, sandstones, mudstones, marl, and fossil-bearing rocks (Figure 6.1; Texas Bureau of Economic Geology 1967, 1968, 1970, 1972, 1974, 1975, 1982, 1987, 1991, 1992). As a result of these source rocks, as well as the long transport of rock fragments through humid climates, the minerals common to the UTCP are quartz and some of the so-called "heavy" minerals, such as kyanite, hematite, staurolite, garnet, zircon, and tourmaline, among others (Bullard 1942, Hsu 1960). Feldspars appear in small amounts, but are generally rarer than in adjacent regions (Bullard 1942, Hsu 1960). Geologic knowledge of the nature and distribution of minerals in recent sands has been investigated in the Brazos drainage (Sultan 1964). Sultan sampled recent sands from the Brazos River spanning different ages of bedrock, from Quaternary by the coastal margin to Permian where the river forks southeast of the modern city of Lubbock (Figure 6.1). The distributions of quartz, feldspar, and rock fragments are characterized by high amounts of quartz and rock fragments and low amounts of feldspars (Figure 6.2). While there is some variability in amounts of these three grain types, it is important to note that this variability is not patterned within geologic formations. For example, Quaternary sediments on the gulf costal plain vary considerably in their quartz and rock fragment content. Geologic formations of other ages overlap the distribution of Quaternary sediments. Given the overlap in variability of grain types between bedrock formations, geologic sources in the Brazos River drainage on upper Texas coastal plain do not appear highly variable.

In order to gain more information about local sources in the Trinity drainage, sands were collected from Honeycomb (41LB4)—located on an old channel of the Trinity River—and a cutbank of the middle Trinity River (Figure 6.1). Sands from Mitchell Ridge (located on a relict beach ridge on Galveston Island) and a cutbank on the lower Brazos River adjacent to where Little Bethlehem was originally located were also sampled in order to get a sense of how sediments from archaeological sites compared with recent sands from the Brazos and Trinity River drainages (Figure 6.1).

Prior to analysis, grain mounts of sand-sized particles were created by splitting and sieving the sand samples. The thin section laboratory at the Department of Earth and Space Sciences at the University of Washington mounted the medium size fraction (0.5-.125 mm) on petrographic slides. The samples were then analyzed to assess the variability in mineralogical composition and frequency of common minerals such as quartz, feldspars, and rock grains within and between these samples in order to determine how much they differed from one another. While all characterized by high amounts of quartz, sands from both archaeological sites have higher amounts of rock fragments than the river sediments (Figure 6.3). When compared with recent sands from the Brazos, the lower Brazos sample from this study has higher amounts of quartz and lower amounts of feldspars and rock fragments. While there is some variability in quartz, feldspar, and rock fragment content of sands in the UTCP, there appears to be little if any pattern to this variability between river drainages, at least when focusing on the three most common groups of mineral/grain types. Given that there is little patterned variability between the river drainages of the upper Texas coastal plain, sourcing pottery from archaeological sites to particular drainage basins to understand the movement of groups within this region is not promising.

There is the possibility that UTCP geological sources are distinct from adjacent regions, allowing testing of the mobility and prestige hypotheses which are concerned with movement and/or trade between adjacent cultural areas. To the northeast of the UTCP in the Caddoan cultural area is a geologically diverse region (Ferring and Perttula 1987). Northeast Texas contains the Cretaceous and Tertiary source rocks through which the Trinity River flows. Outside the Caddoan homeland, but within their sphere of trade In Southeastern Oklahoma the Ouachita Mountains are comprised of Paleozoic sandstone and shale which contain feldspars and volcanic/metamorphic rock fragments. The Wichita Mountains are comprised of igneous rocks, and the Llano Estacado has metamorphic sediments from the Rocky Mountains (Figure 6.1; Ferring and Perttula 1987). Given the occurrence of metamorphic rocks in regions like the Ouachitas, sands from these sources are expected to have high amounts of polycrystalline quartz (Basu et al. 1975). In contrast, sediments from the UTCP are more mature and most likely have much less polycrystalline quartz as a result of chemical weathering (Harrell and Blatt 1978). Comparatively little work has been done with sands from the Trinity drainage (Ferring and Perttula 1987). If pottery was from plains sources (possibly via Caddo trade), then it would have higher amounts of rock fragments and feldspars than the more mature sediments/sands from east Texas and the Gulf coastal plain. Sands from eastern Texas and southeastern Oklahoma are comparatively high in quartz and low in feldspars and rock fragments. Ferring and Perttula (1987) note that grains from eastern Texas and southeastern Oklahoma are rounded. Their analysis of quartz, feldspar and rock fragments indicates that the Washita River area has higher amounts of rock fragments and feldspars than the other areas they sampled. Other areas have less than 10% feldspar and less than 10% rock fragments. The Ouachita Mountain area has the same amount of rock fragments as the Washita River area, but lower amounts of feldspars (Q=80-95%; F=3-5%; L=5-15%). The Sabine River area is distinguished by its relatively high amounts of monocrystalline quartz.

Analysis UTCP grain mounts created in this study indicates that mineral assemblages from the Caddoan and UTCP cultural areas do differ from one another somewhat. Compared with the data in the Caddo area compiled by Ferring and Perttula, grain mounts of sands from UTCP sites have much lower frequencies of undulose quartz (Qu) (Table 6.1). Frequencies of polycrystalline quartz (Qp) are higher in the samples from the Ouchita Mountains and the Washita River than in the UTCP (Figures 6.4 and 6.5). Feldspars are higher in the Washita River area than in other areas in the Caddoan region. Yet total feldspars for the Washita River drainage are similar to frequencies in UTCP grain mounts from this study as well as Sultan's data from the Lower Brazos (Table 6.1) Grain mounts prepared for the present study appear similar in their frequencies of feldspars to previous work with recent sands in the lower Brazos River drainage (Table 6.1; Sultan 1964). Given this information, it appears that undulose quartz and polycrystalline quartz grain frequencies would be most helpful in differentiating Caddoan from UTCP sherds.

To the east of the UTCP lies the Mississippi Delta, an area with similar low relief and humid climate. The source materials of the Mississippi River create mineral assemblages richer in dolomite, pyroxenes, epidote, biotite, and amphiboles than further west along the gulf coast (Hsu 1960). In contrast to all of the areas previously discussed, the mineral assemblages of the central and southern Texas coast are derived from granites and other Precambrian igneous and metamorphic rocks, as well as Cenozoic igneous rocks, and have a high abundance of basaltic hornblende with a very distinctive red-brown color (Bullard 1942).

In the UTCP, the main geologic formations are composed of highly plastic clays and clayey sands, which have surface expressions containing clays, sands, and gravels (Sultan 1964). Given that local clays shrink and swell greatly, it is likely that prehistoric potters took advantage of the already naturally occurring non-plastic inclusions to mitigate shrinking during vessel production (Ellis 1995). These deposits of naturally-tempered clays are thought to have been used by prehistoric people for pottery manufacture (Aten 1983). Thus, sand-sized particles in the sherd pastes can be identified and compared to known local sands to determine if the vessels were manufactured from local materials.

Petrography Methods

In order to compare sherds with grain mounts of the local sand sources, 20 sherds with a variety of non-plastic inclusions, designs, and surface treatments were selected. Archaeological petrographic studies commonly have sample sizes of 20-40 sherds, most likely because of the time-intensive nature of the analysis and the desire to avoid destruction of large amounts of an assemblage. During the course of analysis, one slide was broken. Thus, data is reported for 19 sherds instead of 20. Thin sections were made by Spectrum Petrographics Incorporated of Vancouver, Washington. Sherds were impregnated with blue epoxy, and two sections were cut from each sherd perpendicular to the vessel wall and mounted side by side on petrographic slides. Each slide was ground to a uniform thickness of 30 microns, and the interior wall of each sherd was marked with an orientation notch on the slide. Initially a few slides were stained with sodium cobaltinitrite to detect potassium feldspars, and with barium chloride and rhodizonate to detect plagioclase, as it is often difficult to distinguish these feldspars from one another as well as from quartz. When it was determined that there was very little plagioclase in the three samples originally treated, staining was discontinued for the remainder of the slides, as the stains obscure the visibility of other minerals.

The thin sections and grain mounts were analyzed using a Nikon Labophot2-Pol polarizing microscope with 4, 10, 20, and 40X objectives, using the point counting method described in Middleton (1985). Points were counted at 1 mm intervals; 200 points were counted in samples where possible, but several sherds were small enough that this was not possible. In these cases, as many points as possible were counted. The 20 and 40X objectives were frequently used, as grain sizes in the sherds were quite small, often only a fraction of a millimeter. In rare instances where an inclusion or pore was greater than 1 mm in diameter, it was counted once and then skipped over in subsequent transects. Due to their overall small size, some grains were difficult to see. Where a confident identification could not be made, the grain was counted as "unknown". Grain mounts were counted using the same method, without counting pores, bone and grog.

Mineral inclusions were identified based on published descriptions of mineral relief, physical properties, color, and form (MacKenzie and Guilford 1980; Nesse 1991). Identifications were also made using region-specific descriptions of minerals in thin section (Bullard 1942).

Results

Frequencies of undulose quartz, polycrystalline quartz, and feldspars in sherds from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem

(41AU38) were compared in this study (Table 6.1). Single factor ANOVA analysis revealed that these three mineral types do not statistically vary from one another in any of the three sites, where the critical value for F=3.6337. For undulose quartz, F=2.1199. For polycrystalline quartz, F=1.4468, and for feldspars F=2.3069. When compared with UTCP grain mounts, the frequency of undulose quartz content in sherd thin sections is statistically different (F critical value=3.1273; F=4.5221). Undulose quartz frequencies in UTCP sherd thin sections are also statistically different from that reported by Ferring and Perttula (F critical value=3.0724; F=18.0596). In contrast, there are no statistically significant differences in polycrystalline quartz content (where F critical value=3.0724 and Qp F=0.7798) and feldspar content (F=1.2992) between the UTCP and Caddoan sherds. UTCP mineral assemblages strongly resemble detrital mineral assemblages common to the area and do not contain basaltic hornblende common in the Rio Grande drainage or the dolomite and amphiboles present in the Mississippi River delta area (Bullard 1942; Hsu 1960). Frequencies of undulose quartz do vary between the three sites, but these frequencies are not as high as those from sherds associated with Caddoan trade (Figure 6.6).

Porosity

Inspection of petrographic thin sections of UTCP sherds indicates that studying such samples has the potential to provide information on the porosity and permeability of vessels. Due to the fact that sherd sections in this study were impregnated with blue epoxy resin, it was easy to identify and count pores while gathering mineral data. The frequencies of pores in this analysis were determined and then compared with existing data from two other sites—41BO79 and 41GM281—in the lower Brazos area (Skokan 1995, 1996). Inclusions and pores in thin sections from 41BO79 and 41GM281 assemblages were point counted using the same method described in the previous section (Skokan 1995, 1996). Porosity of sherds from these two sites in the Brazos River drainage ranged between 4.5-25 percent (Figure 6.7). Sherds from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38) generally ranged between 8.3-24.4 percent (Figure 6.7). One sherd yielded 32.6 percent pores. Another sherd had an unusually high amount of pores: sample 41GV66-508-C from the Mitchell Ridge site had a pore frequency of 44.4 percent. Generally, pores in the samples from Mitchell Ridge, Little Bethlehem and Honeycomb are lenticular and oriented parallel to the vessel wall. The pore shapes in sample 41GV66-508-C are also larger and more rounded than those in the other samples in this study as well as those from 41BO79 and 41GM281 (Figures 6.8 and 6.9).

Bone inclusions

Sherds with crushed bone in their pastes are fairly common in south and central Texas, including the interior portion of the upper Texas coastal plain (Hall 1981, Walter et al. 2004). They are less frequent but sometimes still present on the coastal margin (Aten 1983). Overall counts of sherds with bone inclusions from the three sites in this study resembled such a pattern: four sherds from Mitchell Ridge were identified as containing bone; 49 Honeycomb were identified as having bone. Little Bethlehem, an inland site had 186 sherds originally identified as containing bone. Of the sherds thin sectioned, five of the sherds contained bone: two from Mitchell Ridge (41GV66), one from Honeycomb (41LB4), and two from Little Bethlehem (41AU38). The amount of crushed bone in the sherds varies considerably ranging from 0.49 percent-42.74 percent. Counts of bone in thin sections reveal that some sherds have just a few pieces of bone (Appendix C; samples 41AU38-72-A2 and 41GV66-413-A), while others had much greater frequencies of bone. This range in variation of bone inclusions is reflected in the data collected from sites 41BO79 and 41GM281 as well, where 10 out of 31 samples with bone (0.5-10.5 percent). Of those 10 samples, 4 had bone and grog (grog ranging from 6.2-14.5 percent—Skokan 1995, 1996). As previously noted in chapter four, types of non-plastics in sherds in this study were often mixed, and the thin section data bear this out as well: one sherd has both bone and grog; all sherds with bone inclusions also have sand (Table 6.2). Some sherds originally described as shell in the initial sort using a binocular microscope were determined to contain bone instead when analyzed as thin sections. This is due to the fact that bone has a distinct structure when viewed in thin section at higher magnification (Figure 6.10).

Discussion

Generally, the mineral constituents in the sherd thin sections appeared similar to one another between UTCP assemblages. Monocrystalline quartz is the most common mineral in all thin sections. Smaller amounts of polycrystalline quartz and undulose quartz are also present. Small amounts of feldspars are present in all sherds. The frequency of undulose quartz in UTCP sherd thin sections is statistically different from UTCP grain mounts, as the sherd sections have higher frequencies of undulose quartz. Yet the sherd sections have a significantly lower frequency of undulose quartz compared to Caddoan sherds analyzed by Ferring (Ferring and Perttula 1987). Why the frequency of undulose quartz in UTCP sherds is greater than UTCP grain mounts, but less than Caddoan sources, is not clear. Perhaps a greater sample of sands from both areas would reveal even greater variability within sources than currently realized. While there are no minerals of non-local provenance in the sherds, the frequencies of many minerals in sectioned sherds are lower than in the grain mounts. Thin sections appear to contain almost exclusively quartz and small amounts of feldspars. Larger portions of a given sherd may need to be sampled in order to generate the frequency of mineral types similar to grain mounts. The few non-quartz, non-feldspar minerals observed in thin section correspond with the local mineral assemblage identified by Bullard and Hsu. Even so, “local” is a broad term in the UTCP. The lower Trinity and Brazos River drainages appear to have similar mineral assemblages, which is expected given their similar geologic sources. However, the igneous and metamorphic rocks in the Caddoan cultural area can allow differentiation between raw material sources in portions of that area and the UTCP. Given this, analysis of these 19 samples suggests that people living on the UTCP had little if any contact with their Caddoan neighbors to the northeast—either through trade or direct movement. Additional sourcing studies may provide more information on the variability of mineral types in geologic sources.

Aside from providing information about location of raw materials, analyzing UTCP sherds in thin section has provided information about the frequency, shape, and orientation of pores. Pore frequency, shape, and orientation of pores in all but one sherd were fairly uniform. The exception, sample 41GV66-508-C has a high frequency of pores relative to the other samples. The shape and size of these pores is also different from other samples. The sherd was originally recovered from the matrix of a feature interpreted as house floor, whose surface covered most of a 2x2m unit (Ricklis 1994). No other sherds used in this study were recovered from features. Looking at more sherds from the feature may indicate if there is a correlation between the location of the sherds and their pore structure. Sherds located in features associated with house areas may have been used for different tasks, or were subject to some sort of post-depositional leaching in these locations. Perhaps the information on pore frequency presented here, along with information from two other sites in the Brazos drainage area can provide a baseline for future studies in the porosity and permeability of ceramic vessels in this region. Additional information would be helpful in determining how porous and permeable UTCP pots are.

Analyzing thin sections also provides a more accurate means of identifying non-plastic inclusions and their frequencies. Sherd sections from two samples in this study had small amounts of bone, so small as to call into question the idea that bone was being selected for specific performance properties as a temper. Perhaps bone was simply incorporated as a result of processing clay in the proximity of household debris. These low frequencies of bone inclusions may indicate that performance properties specific to bone were non-existent, not known, or simply not preferred at all times. The mixture of bone and other non-plastics such as grog and sand may indicate a desire for *any* non-plastic inclusions, and thus bone was added as part of a suite of non-plastics rather than being specifically selected, as is plausible in the cases of sherds with much higher frequencies of bone.

In terms of the hypotheses presented at the beginning of this chapter, the data from this study support the idea that UTCP pottery was locally manufactured and was not being obtained from the Caddo—at least not frequently. Instead, the local provenance of the mineral inclusions in the pastes supports the idea that vessels were used for everyday utilitarian tasks. Furthermore, the local provenance of these samples underscores what archaeologists working in the area have commonly assumed; that UTCP pottery was locally produced. The porosity data are more difficult to interpret in relation to the original hypotheses, as there is little comparative data on porosity collected in this area (with the exception of Arnold 1975 for Caddo wares, and Skokan 1995, 1996 for inland coastal plain wares).

Conclusions and future work

Petrographic sourcing is useful in linking pottery with actual geological sources on the landscape. Petrography is useful in a large regional context such as the UTCP when looking at interactions between UTCP groups and other groups such as the Caddo. Future sourcing work on the UTCP may fruitfully focus on possible interactions between hunter-gatherer groups in the south and central Texas coast and the UTCP. Sourcing studies may be more fruitful in the Rio Grande, and possibly the Colorado drainages, the as the mineral assemblages of sands from these drainages are part of physiographic provinces separate from the Brazos and Trinity sands (following Hsu 1960).

In addition to sourcing data, petrographic analysis of thin sections can be used to assess hypotheses concerning the suitability of vessels for liquid storage. Porosity affects the ability of ceramics vessels to resist spalling and abrasion (both mechanical and chemical). Vessels with high porosity are also known to have high thermal insulation. Not only can sherd thin sections be examined to determine the frequency, shape and orientation of pores, but the size and interconnectedness of pores can be described metrically to create porosity and permeability estimates. Larger sample sizes are necessary to get an accurate sense of the range in variation of pore size, frequency, and structure in UTCP assemblages. Experimental work with local raw materials may clarify exactly what frequencies, shapes, and sizes of pores are most optimal for tasks such as storage and cooking. Future work can include collecting information on pore size and placement using petrography and other methods (Harry 2004; Rice 1987).

An additional windfall of petrographic analysis of sherds in thin section is information on non-plastic inclusions. Using this method to analyze inclusions is not practical for analyzing the paste of every sherd, but can be useful when accurate identification of non-plastic inclusions is difficult but highly desired. Analysis of bone inclusions in thin section may also give more information about what species were present on archaeological sites, particularly useful information on sites which have no other faunal remains (Walter et al. 2004). The work presented here helps establish three data baselines for future studies of sourcing, porosity, and analysis of bone temper in pottery from this area.

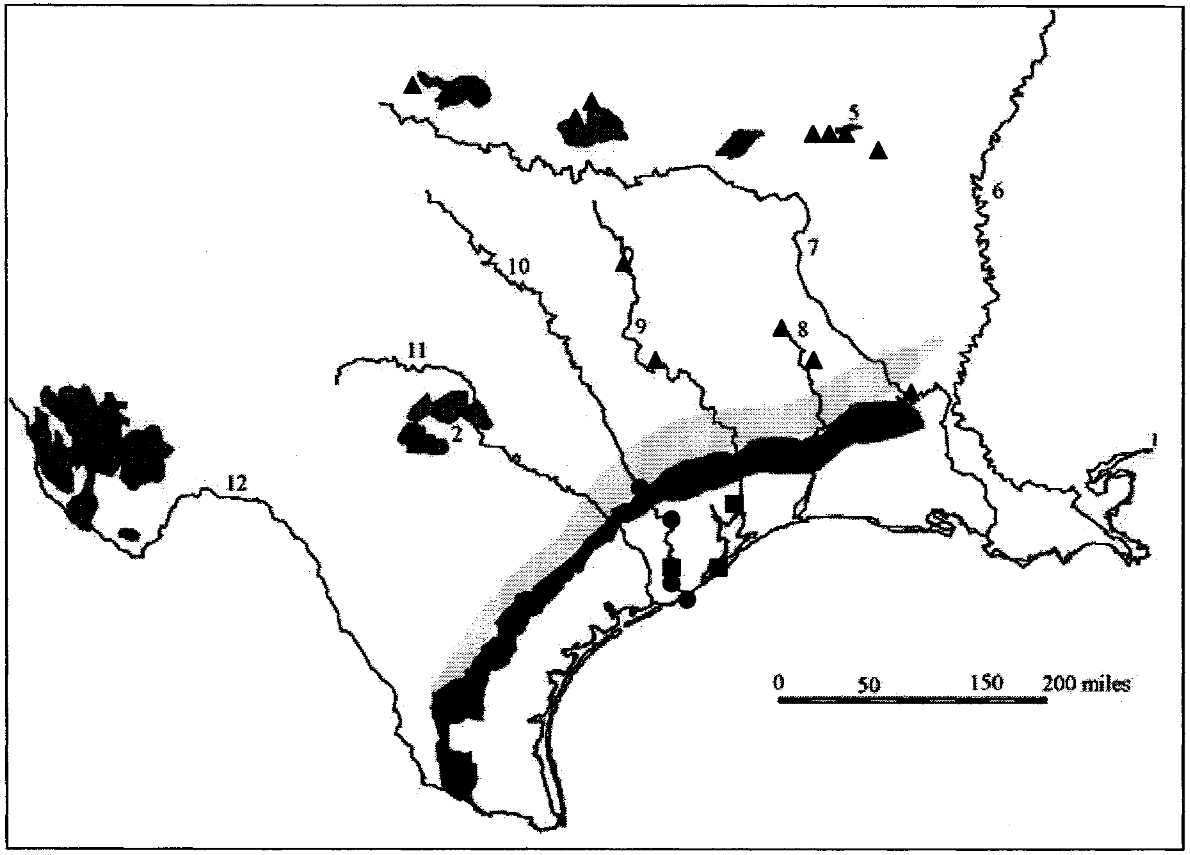


Figure 6.1 Simplified geologic map of the gulf coastal plain. Triangles indicate sites sampled by Ferring and Perttula (1987); circles indicate sites sampled by Sultan (1965). Squares denote samples taken from sites in this study. Long, light gray area is the Willis Formation. Long, darker gray area is the Lissie Formation. South and east of the Lissie Formation is the Beaumont Formation. Mountain ranges: 1=Chisos, 2= Llano Uplift, 3=Washitas, 4=Arbuckles, 5=Ouachitas. Rivers: 6=Mississippi, 7=Red, 8=Sabine, 9=Trinity, 10=Brazos, 11=Colorado, 12=Rio Grande.

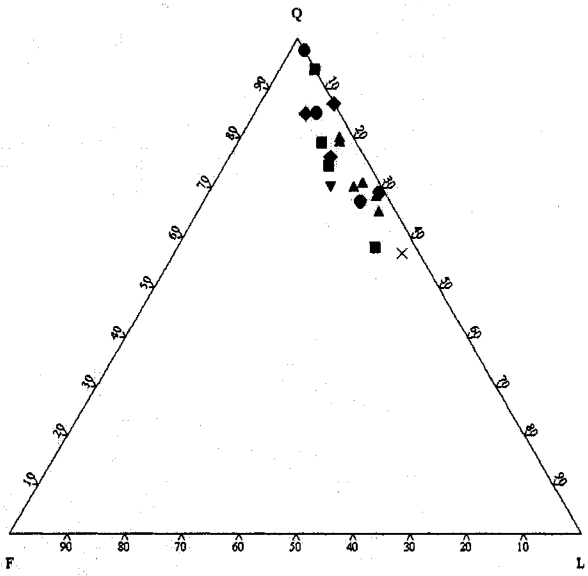


Figure 6.2 Quartz, feldspar, and rock fragments in Brazos drainage sands reported by Sultan 1964. ■ =Quaternary bedrock, ▲ =Tertiary, ● =Cretaceous ◆ =Pennsylvanian/Mississippian, ▼ =Permian (Clear Fork), × =Permian (Salt Fork)

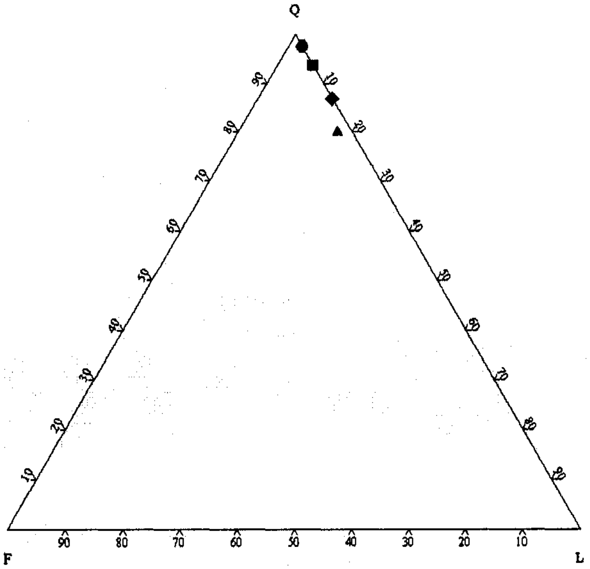


Figure 6.3 Quartz, feldspar, and rock fragments in sands from the upper Texas Coastal plain ■ =lower Brazos River, ▲ =Mitchell Ridge (41GV66), ● =middle Trinity River ◆ =Honeycomb (41LB4).

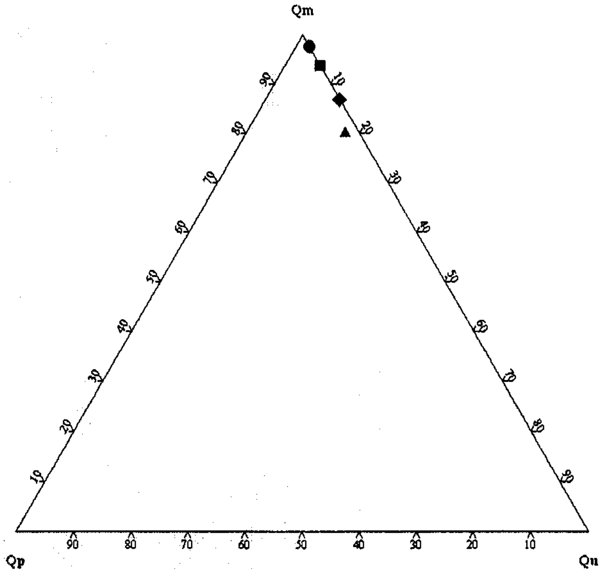


Figure 6.4 Monocrystalline quartz (Qm), polycrystalline quartz (Qp), and undulose quartz (Qu) in sands from the upper Texas coastal plain ■=lower Brazos River, ▲ =Mitchell Ridge (41GV66), ●=middle Trinity River ◆ =Honeycomb (41LB4).

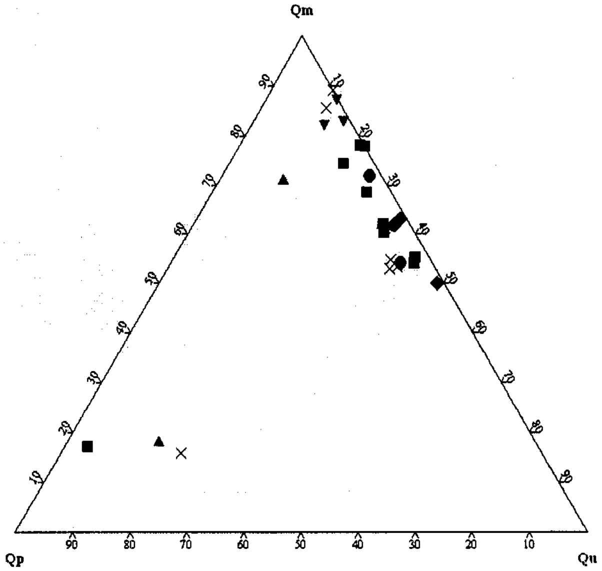


Figure 6.5 Monocrystaline quartz (Qm), polycrystalline quartz (Qp), and undulose quartz (Qu) in sherds from Caddoan homeland and plains region sites. ■ =Arkansas River, ▲ =Ouchaita Mountains, ● =Red River, ◆ =Trinity River, ▼ =Sabine River, × =Washita River.

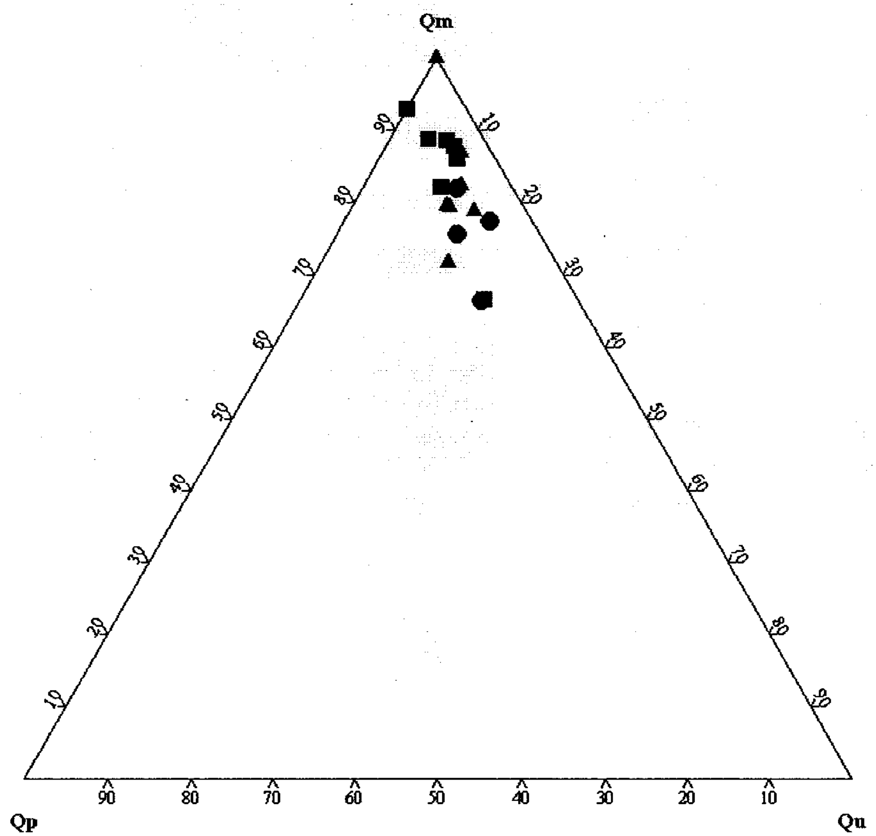


Figure 6.6 Monocrystalline quartz (Qm), polycrystalline quartz (Qp), and undulose quartz (Qu) in sands from the upper Texas coastal plain ■=Mitchell Ridge (41GV66), ▲=Honeycomb(41LB4), ●=Little Bethlehem (41AU38).

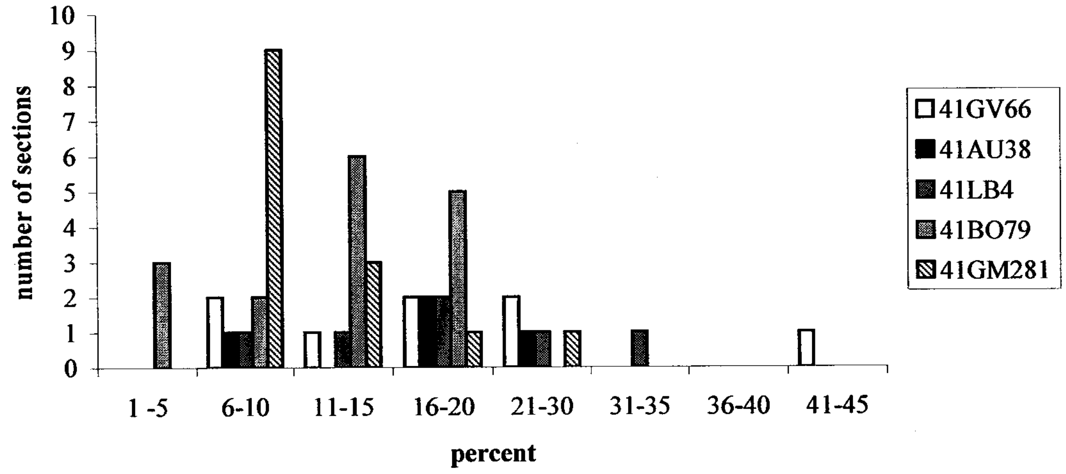


Figure 6.7 Percentage of pores in sherds from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38). 41BO79, 41GM281 are located in the Brazos River drainage and were analyzed by Skokan (1995, 1996).

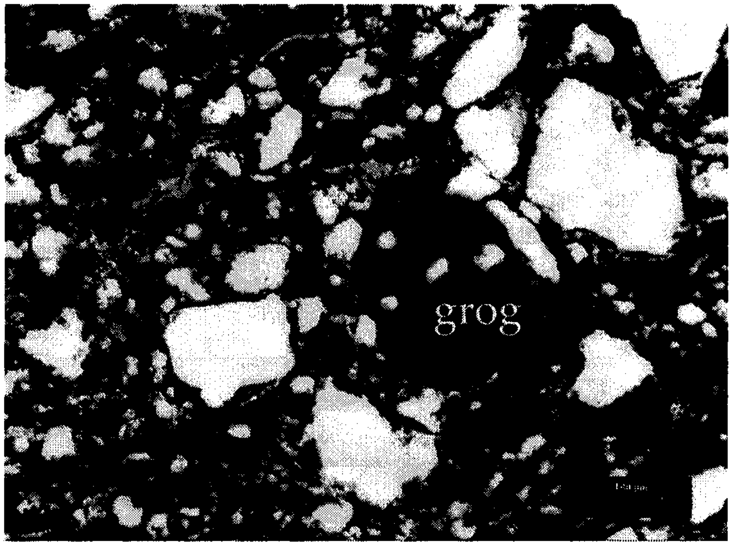


Figure 6.8 Average pore structure illustrated in a sherd from Honeycomb (41LB4).

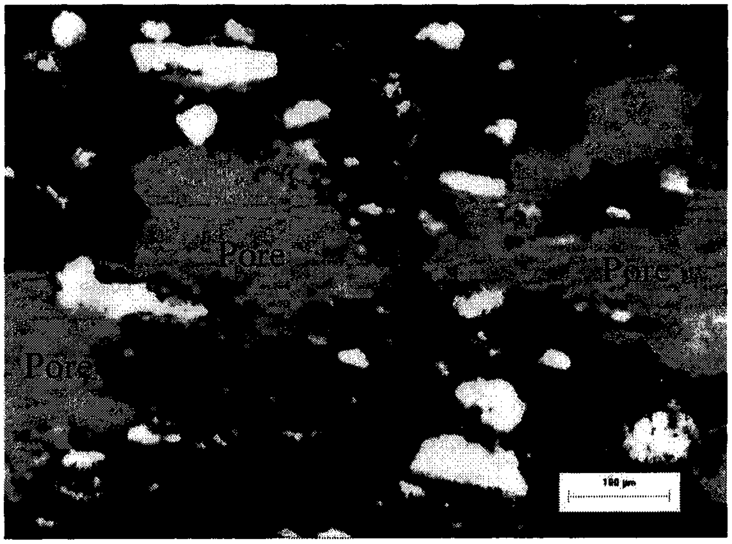


Figure 6.9 Anomalous pore structure in sample 41GV66 508-C from Mitchell Ridge (41GV66).

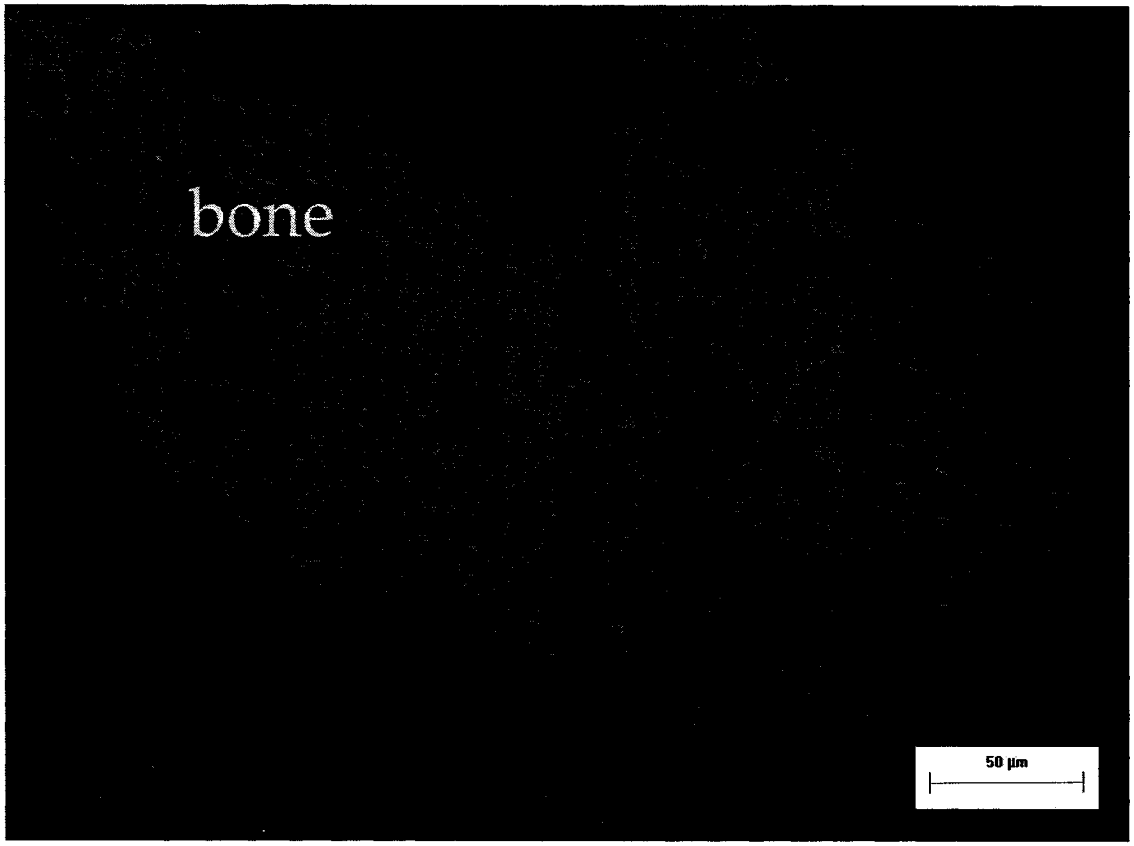


Figure 6.10 Bone inclusion in thin section from sherd in Little Bethlehem (41AU38) assemblage. The lighter area filling up almost the entire frame is a single fragment of bone. Dark oval areas within the lighter field are osteocytes.

Table 6.1 Counts of mineral types for selected sherds from UTCP

Sample ID	Qm*	Qu	Qp	Li	Fk	Fp	Epi	Hor	Mu	Tou	Sta	Zir	Gar	Il	Ap	Ky	Mo	Rbo	Sp	Ti	Unk	N
Mitchell Ridge (41GV66)																						
41GV66-452-Y4	39	3	2	1									2	2					3		1	90
41GV66-362-G6	87	10	9	10	1								1						10		10	219
41GV66-413-A	136	7	10	8									2						4		4	228
41GV66-399-D	6	2	1	1																		12
41GV66-389-I5	74	8	4	4														1	1			109
41GV66-508-C	13		1	1	7	1												1			1	45
41GV66-511-G	65	6	3	5										2			1	4			6	123
Honeycomb (41LB4)																						
41LB4-96-394-10	28	6	5	9	1								1		1				1		1	67
41LB4-127-769-8	8			1										3				1		2		20
41LB4-135-752-O2	14	2	1	3						1									2			41

* Grain types: Qm=quartz; Qu=undulose quartz; Qp=polycrystalline quartz; Li= rock fragments; Fk=potassium feldspar; Fp=plagioclaise; Epi=epidote; Hor=hornblende; Mu= muscovite; Tou=tourmaline; Sta=staurolite; Zi=zircon; Ga=garnet; Il=ilemite; Ap=apetite; Ky=kyanite; Mo=monzanite; Rbo=; Sp=spinel; Ti=titanite (sphene); Unk=unknown

Table 6.1 Counts of mineral types for selected sherds from UTCP sites.

Sample ID	Qm	Qu	Qp	Li	Fk	Fp	Epi	Hor	Mu	Tou	Sta	Zir	Gar	Il	Ap	Ky	Mo	Rbo	Sp	Ti	Unk	N
41LB4-144-519-2	46	5	2							1												86
41LB4-151-802-5	63	12	5	2								2	4	1			1	4				148
41LB4-8-93-7	35	5	4	3								1	1	1				1				117
41LB4-76-397-15	54	8	6	8	4							2	2								1	125
41LB4-143-529-227	31	7	2	2						1									1		1	86
Little Bethlehem (41AU38)																						
41AU38-54-N	50	7	4			1						1	2	2	2				2			117
41AU38-16-Y	31	7	2	3	9							1										63
41AU38-72-A2	81	27	14	2	18	4			1			3	3									204
41AU38-74-B	31	6	4	4	2							3										58

* Grain types: Qm=quartz; Qu=undulose quartz; Qp=polycrystalline quartz; Li= rock fragments; Fk=potassium feldspar; Fp=plagioclaise; Epi=epidote; Hor=hornblende; Mu=muscovite; Tou=tourmaline; Sta=staurolite; Zi=zircon; Ga=garnet; Il=ilemite; Ap=apetite; Ky=kyanite; Mo= monzanite; Rbo=; Sp=spinel; Ti=titanite (sphene); Unk=unknown

Table 6.1 Counts of mineral types for selected sherds from UTCP sites.

Sand Samples																						
Lower Brazos	30	0	0	2						3	4		2	8	1	2		34			13	104
Mitchell Ridge (41GV66)	29	1	2	7	1		1	9		5	3		2	60			2	21			2	155
Middle Trinity	39		2	1				1			5			22				28				98
Honeycomb (41LB4)	37	2	1	6			3	1				1	2	3	1	9					21	98

* Grain types: Qm=quartz; Qu=undulose quartz; Qp=polycrystalline quartz; Li= rock fragments; Fk=potassium feldspar; Fp=plagioclaise; Epi=epidote; Hor=hornblende; Mu= muscovite; Tou=tourmaline; Sta=staurolite; Zi=zircon; Ga=garnet; Il=ilemite; Ap=apetite; Ky=kyanite; Mo=monzanite; Rbo=; Sp=spinel; Ti=titanite (sphene); Unk=unknown

Table 6.2 Counts of pores in thin sections of sherds from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38)

Sample ID	Pore	Grog	Bone
Mitchell Ridge (41GV66)			
41GV66-452-Y4	18		18
41GV66-362-G6	52	25	
41GV66-413-A	46	2	7
41GV66-399-D	1		
41GV66-389-I5	14		
41GV66-508-C	20		
41GV66-511-G	29	1	
Honeycomb (41LB4)			
41LB4-96-394-10	6	1	
41LB4-127-769-8	2	2	
41LB4-135-752-O2	7	8	
41LB4-144-519-2	13	13	
41LB4-151-802-5	34	17	
41LB4-8-93-7	14		50
41LB4-76-397-15	30	10	
41LB4-143-529-227	28	8	
Little Bethlehem (41AU38)			
41AU38-54-N	11	0	35
41AU38-16-Y	10	0	
41AU38-72-A2	50	0	1
41AU38-74-B	10	0	0

CHAPTER 7: RESDIUE ANALYSIS

Increasing understanding of prehistoric hunter-gatherer diets on the upper Texas coastal plain (UTCP) allows evaluation of three possible explanations of the circumstances under which some hunter-gatherer groups choose to make and use ceramic vessels. This is accomplished by analyzing pottery manufactured by Late Prehistoric period hunter-gatherers on the UTCP to understand ceramic vessel function within the context of these societies. Given that ceramic vessels are common tools in food processing, storage, and serving activities, such research also sets us on a path of developing ceramic vessel analyses as a way of better understanding diet among foraging groups, how they cope with food shortages, the relationship between diet and mobility, and the relationship of food storage to mobility. Information on diet can also help us better understand the development of social and political complexity and its relationship to food procurement and/or production.

In accordance with these ideas, three sets of hypotheses were developed and detailed in Chapter 3. The first set of hypotheses concerns the nature of UTCP Ceramic vessels in this region may have been used as tools to process starchy seeds and/or domesticates. An alternate hypothesis is that ceramic vessels on the UTCP were primarily used as tools to process meat from large-bodied resources. Information on diet enables us to learn more about ceramic function in this area, but also the relationships between diet and residential mobility. If pots were used to process cultigens or wild starchy plants the organic residues recovered from vessels should reflect this. Likewise, if the predominant organic residues in pots are large mammals, then they may be the primary resources consumed.

Another aspect of vessel function that has implications for residential mobility in hunter-gatherer societies is pottery used for storage. As previously discussed, storage behavior has been observed in hunter-gatherer societies. The kind of storage strategies foraging societies use is linked to the nature of their particular resource base, and the degree of their residential mobility. Thus, if and how ceramic vessels were used for storage has implications for the mobility of hunter-gatherer groups. Storage entails two main types of costs: the cost of preparing resources for storage and the cost of defending the stores. Bettinger (1999a, 1999b) has identified two basic types of food storage strategies. Hypothetically, the so-called "front-loaded" storage strategy is most useful to groups who are relatively sedentary and where small-package resources are common in the diet and sharing is minimal. Such a "front-loaded" storage strategy is used for foods which require a lot of initial time and labor investment to prepare for storage. Groups engaged in a "front-loaded" strategy are willing to store foods which require a high degree of up-front processing costs prior to storage.

In contrast, a "back-loaded" storage strategy may be useful in cases where groups are fairly mobile and are less likely to assume high processing costs up front. Instead, they are interested in limiting the costs of preparing and possibly losing stored foods to people or animals that could raid caches. Relatively mobile foragers might pursue a so-called "back-loaded" strategy in which focuses on foods which can be stored with little or no processing. Instead, individuals and groups pay processing costs when preparing the stored foods for consumption. The "back-loaded" strategy enables groups with high degrees of residential mobility to assume fewer costs associated with processing foods for storage, because the processing costs are only incurred when the resources are consumed. Any loss of stores due to theft (because mobile groups cannot always stay in one place to guard their stores) costs less because little time was invested in processing the resources for storage. Investigating pottery function may answer questions about the nature of group mobility. With this in mind, two hypotheses concerned with pottery potentially functioning as storage containers were developed. The first hypothesis posits that ceramic vessels on the UTCP were used for "front-loaded" storage. If this is the case, the implication might be that groups had very little residential mobility. The second hypothesis proposes that ceramic vessels on the UTCP were used for "back-loaded" storage, and therefore that groups in this region have high degrees of mobility.

Organic residue data has implications for the storage hypotheses as well. Foods most commonly "front-loaded" include meat, fish, and in some cases processed plant foods (Bettinger 1999a, 1999b; Hally 1983). These foods often have high fat or oil content that requires them to be processed prior to storage. Due to their high fat/oil content, they are more likely to be absorbed into the walls of vessels they are stored in. Therefore, pots used in a front-loaded strategy would be expected to have high frequencies of organic residue from liquids or fats. In a "back-loaded" storage strategy, foods are processed minimally if at all prior to storage, and thus are less likely to be stored in a state which would allow their residues to seep into vessel walls. Storage of dry items figures predominantly in "back-loaded" storage strategies, an excellent example of a back-loaded food is nuts, which can be stored in the shell. If pots were used primarily for "back-loaded" storage, then pots would have little organic residue signatures, as foods would leave little if any organic residue in the vessel walls. One possible exception to the "front-loaded"= "wet"/ "back-loaded"= "dry" reasoning is the storage of water which is useful to all groups with varying degrees of mobility. Water storage vessels would have most of the performance attributes discussed above, except for a food residue signature. Therefore, water storage vessels may resemble those used for dry storage and there is no certain way to distinguish between the two. Porosity may be limited in vessels intended for water storage, but in some ethnographic cases pots with porous walls may be preferred for water storage in order to keep water cool (Rice 1987). Thus, there is a possibility that vessels may have been used primarily to store water is a potential confounding factor in evaluating storage hypotheses.

Vessels may have been used as items to accrue or increase social, political, or economic prestige. Not only do ceramic vessels have to potential to be exotic trade items used to gain and maintain social and political prestige, and they can also be used as objects for serving or processing rare foods. Vessels from non-local sources may have functioned as prestige items, indicating to others that their owners were able to obtain rare, exotic objects. Non-local foods may also indicate political, economic, or social connections. In some contexts in Eastern North America, maize is an example of a food whose consumption appears to be restricted to a few high-status individuals in a given group (Hayden 1992; Rose et al. 1991) Such connections may indicate contact with elites, and/or may have been used to enhance individual or group social/political standing in local societies. It is also possible that non-local foods were traded to supplement local food shortages, and had little to do with trade with elites. For example, the exchange of maize for animal products has been noted in the American Southwest and Canada (Speilmann 1986; Zarrillo and Kooyman 2006). These two types of trade might be distinguished from one another by examining the frequency of non-local foods in pots. A low frequency of non-local foods may indicate trade with or among elites, while high frequencies of pots with non-local foods may indicate large-scale group movement. Thus, evidence of exotic foods in upper Texas coastal plain vessels could lend credence to the idea that pottery was used in prestige contexts. Wares used for serving or processing non-local foods should bear organic residues of foods, which in the case of the UTCP is most likely maize. If vessels were a part of trade with or among elites, then it is expected that a small amount of vessels in a given assemblage should have residues of non-local foods such as maize.

Extracting and analyzing residues from pottery from these sites can complement what is currently known about hunter-gatherer diets in this area by revealing portions of the dietary spectrum (such as plants) that often cannot be observed by other means (Heron and Evershed 1993). This is especially the case for the upper Texas coastal plain, where non-shell bearing sites commonly have little or no faunal remains, and many sites lack human burials. In addition, additional information on foods contained in UTCP pots can be used to further assess hypotheses of vessel function, which in turn pertain to the nature of subsistence, mobility and social stratification in this hunter-gatherer society. Traditionally extraction of organic residues (particularly lipids) from archaeological ceramics has been used to address questions about prehistoric diet. Organic residue data may also be useful in determining if exotic foods were prepared or served in ceramic vessels. Thus, residue data can also be used to investigate hypotheses concerning the role of pottery in prestige economies.

Ecology of the Upper Texas Coastal Plain: Implications for Hypotheses

The upper Texas coastal plain (UTCP) is divided into four major vegetation zones: 1) inland longleaf pine and pine-hardwood forests; 2) inland oak savannas and grasslands; 3) coastal upland prairie; 4) coastal marsh-prairie, including the coastal margin. Located in a generally humid, subtropical climate, these zones contain numerous microenvironments such as coastal grasslands, point bar grasslands, riparian forests, stunted riparian forests, floodplain forests, bluff-top forests, mixed conifer and hardwood forests, conifer/sweetgum forests, fresh-water swamp, fresh-water and salt water marshes (Ensor and Ricklis 1998). Various aquatic environments with varying levels of salinity exist along the gulf shoreline as well: barrier islands, back barrier lagoonal shoreline, lagoons between barrier islands and the mainland, open primary bays (such as Galveston Bay), secondary bays (such as Clear Lake, San Jacinto Bay, Trinity Bay), and river delta areas at the heads of secondary bays (Ensor and Ricklis 1998). These environments have a wealth of wild foods, although the productivity of the environment does fluctuate during annual and longer-term time scales.

Temporal and spatial availability of food resources on the UTCP

UTCP environments had a variety of large-bodied animal resources. Edible plants, including species with starchy seeds, are present in this region today, and were most likely available to prehistoric groups in this region. Inland woods, swamps, and grasslands contained deer, eastern cottontail rabbit, gray fox, red fox, coyote, skunk, fox squirrel, opossum, hispid cotton rat, lizards, and birds. In prehistory bison, black bear, cougar, bobcat were also present. Freshwater streams in the bottoms contain gar, buffalo, crappie, sunfish, fresh-water drum, channel catfish, and blue catfish (Table 7.1). Nuts such as hickory (*Carya sp.*), and walnuts (*Juglandaceae sp.*) are available in river bottoms, and black hickory with its edible nuts is found on the edge of flood plains. Pecan trees (*Carya illinonensis*) are common in stream bottoms in western coastal plain. Acorns from various oak species are also available. Oak species (*Quercus*) with fairly low tannic acid levels (and therefore possibly more palatable) include white (*Q. alba*), chestnut (*Q. prinus*), coastal live (*Q. virginiana*), bur (*Q. macrocarpa*), and chinkapin (*Q.* muhlenbergii). Plants which produce starchy and oily seeds intensively used in parts of the American Southeast are present on the UTCP. Amaranth, (*Amaranthus sp.*) has edible seeds, greens, and can be used as red dye. *Helianthus annus,* a member of the sunflower family has edible seeds; *Helianthus maximiliani* has edible tubers. Chenopodium (*Chenopodiacae sp.*), including lamb's quarters, goosefoot, pigweed, and quelite salado can be eaten as greens, herbs, and seeds. Seeds can be prepared by grinding into flour, boiling, or toasting. In addition, many other plants such as docks, pokeweed, thistles, nettles, ground cherries, and elderberries are available almost continuously throughout the annual cycle (Stahl 1995). Giant ragweed (*Ambrosia trifida*) spreads rapidly through human disturbance and has edible seeds. It also can be used to make rope, medicine, and dye. Prickly pear, (*Opuntia engelmanni/sp.*) has edible fruit and pads. Camass (*Camassia scilloides*) can be eaten raw, boiled, or baked. Wild onion (*Allium sp.*) has edible bulbs and stalks, and the skins can be used for dye.

Lowland deltaic swamps and marshes were home to raccoon, swamp rabbit, muskrat, weasel, mink, river otter, and eastern gray squirrel. Reptiles such as alligator, turtles, and snakes are present in archaeological assemblages, as are frogs and toads. Other amphibians such as hellbenders (*Cryptobranchus alleganiensis*), and other salamanders could have been used as food resources, although whether they actually were or not is unclear (Ensor and Ricklis 1998). Marine fish species were also present in river deltas: sea trout, spotted sea trout, Atlantic croaker, red drum, striped mullet, Gulf flounder, southern flounder, sheepshead, gafftopsail catfish, and blue fish. Clams (*Rangia cuneata*) lived in brackish water marshes. Lowland areas have edible plants which must be processed if they are to be consumed regularly. Arrowhead, or wapato (*Sagittaria sp.)*, an aquatic plant usually found in shallow wetlands, has edible tubers (Tull 1987). The tubers of the water lily (*Nymphaea odorata*) can be baked and peeled but are inedible when raw. Common in all environmental zones, cattail, (*Typha sp.*) has many edible parts. Flower-pod clusters can be boiled and eaten as corn on the cob.

Seeds can be separated and parched by burning off fluff. Roots are edible when boiled or roasted; eating them raw can cause vomiting (Tull 1987).

Coastal margin areas provided access to marine fish species and oyster (*Crassostrea virginica*), which lives in more saline environments than the brackish water clam *Rangia cuneata*. Although both are available intertidal and subtidal areas of bays and estuaries, *Rangia* occupy the first 1-4 m of shallow water in these areas (Theroux and Wigley 1983). *Rangia* are influenced by water salinity, which in turn is influenced by watershed runoff, tide level, and wind direction. They are a patchy resource; some areas have abundant clams. Large numbers are spawned, and they have an average lifespan of eight years. Thus, their populations can rebound quickly (Fairbanks 1963). Cotton rats also available as indicated at coastal sites such as 41GV66, although it is not clear if they were used as food (Ensor and Ricklis 1998).

Major food resources found on UTCP archaeological sites indicate that many foods were generally available throughout the annual cycle. A possible period of annual stress may have been late winter/early spring, when fish runs slowed and large terrestrial mammals had low weights. Groups may have had to retain some degree of mobility in an environment which was subject to seasonal flooding, as well as unpredictable storms. Such events almost certainly changed the spatial distribution of food resources in the region. Various fish species have overlapping spawning times. Several fish species are available in large amounts as they travel through the passes between the barrier islands and large and secondary bays. The bottoms of the large bays are sandy, with mud bottoms around the river mouths. Secondary bays are mudbottom and shallow and no more than three feet deep. Drum and croaker family species are commonly found in juvenile and subadult stages in saltwater bays and lagoons (Ensor and Ricklis 1998). Spotted sea trout frequent bays and beaches in grassy areas. Black drum have been observed spawning from January-May and July-November in the Gulf near the entrances to bays and lagoons (Nieland and Wilson 1993; Pearson 1929). During spawning, the adults move from bays to the open Gulf in large schools. This phenomenon is well-known by modern fishermen who place nets over the narrow passes and channels to the secondary bays in order to catch schooling fish heading into open water. The young return to the secondary bays to grow to adulthood. In the Northern Gulf black drum weigh on average 20 kg can be taken with relatively little effort because they spend most of their time in the shallow waters of secondary bays (Nieland and Wilson 1993). Mature red drum are available in large schools between August and November between passes in the barrier islands as they move to the open gulf to spawn. During the cold months, the fish gradually move out into the deeper waters of the Gulf. When the young hatch they return to the secondary bays where they live in seagrass beds (Pearson 1929; Soto et al. 1998). They grow rapidly their first two years, reaching over one foot their first year alone. They can reach up to five feet in maturity (when they are 3-4 years old). Red drum can grow quite quickly in high temperature waters and are easy to capture at night when they spawn (Comyns et al. 1989). They rapidly reappear in bays and lagoons during the spring. The spotted sea trout spends most of its life cycle in estuarine areas. Between April and September, spotted sea trout spawn within the bays and lagoons. The spawning period is protracted, so there are not as many fish present in one place as with drum species. In the late fall and winter sea trout move to deeper water because they are sensitive to the cold. They prefer grass-bottomed, shallow bays. Adults stay in the deeper water, but come near the shore to feed and spawn. Atlantic Croakers spawn from October to February near the mouths of passes to shallow bays and lagoons. They are not as available as other fish species because they live mostly in coastal waters and do not usually live after the first spawning (Pearson 1929; Soto et al. 1998).

Edible plants would have been available nearly throughout the annual cycle. From winter through spring, cattail shoots are available. Throughout the spring months the shoots of river cane are available. Fruits such as dewberries, blackberries, persimmon, and mulberry appear in April and May. Bulrush roots, shoots and seeds are available in spring, summer, and fall. Grapes are available in summer. In fall, tubers and nuts become available, including arrowhead/Wapato (*Sagittaria sp.*), pecan, black hickory, black walnuts, and various species of acorns. For inland groups, resource shortages were most likely spatial in nature, such as large game animals moving or changes in productivity of nut groves (Hall 1998, 2000). For example, pecan trees produce nut crops every two years.

Resource availability also varies on larger, inter-annual time scales. Tidal passes can be closed off as sediments shift after severe storms. Fish can die in large numbers when the shallow waters of the bays become too saline during summer droughts; cold waves in the winter can kill fish in the more shallow bays. (Pearson 1929). Adult bivalves such as clam and oyster are immobile, and thus highly susceptible to fluctuations in salinity, temperature, oxygen levels, and turbidity. Red tides caused by the algae *Gymnodinium breve* are documented in the Texas portion of the Gulf and usually occur between August and February (Texas Parks and Wildlife website). Fillet or muscle parts of fish, crabs, and shrimp are still edible during a red tide, but oysters, clams, mussels, whelks, and scallops can accumulate toxins in their tissues which can linger for weeks or months.

Expectations for UTCP hunter-gatherers

Could pottery have been primarily a tool for food storage on the UTCP? As discussed in chapter two, storage is a most viable strategy when groups are capable of generating a consistent surplus, and when the distribution of food resources is predictable in time and space. Other important factors influencing storage are to what degree groups are willing to bear the costs of preparing foods for storage and defending the stores, rather than address shortages through sharing. The “package” size of the resources actually used may also be a factor affecting storage strategies. Resources in larger packages are more likely to be shared because they come in bulky packages and thus would not be stored. The spatial and temporal distributions as well as the population dynamics of the wide array of edible plant and animal species of the UTCP render long-term storage a strategy of limited appeal for human inhabitants. On the coastal margin, plentiful and temporally consistent amounts of fish could theoretically be stored. Catastrophic events (weather and other causes of massive prey attrition) could have affected storage strategies as well, although it is unclear whether people could have used storage to buffer against such unpredictable losses. Groups might have had to shift their location to take advantage of other productive groves. Ready access to resources would have been most easily obtained by maintaining a degree of residential mobility (Aten 1983).

With the abundance of a variety of wild foods, UTCP foragers would probably not devote time and energy to processing large amounts of starchy seeds. Instead, groups would be expected to move when higher-ranked resources with lower processing costs resources became depleted, unless movement was constrained for some reason (e.g., environmental packing). Given the spatial and temporal distribution of food resources on the UTCP, we would expect that foragers in this region would store little and instead resolve resource shortages primarily by moving—if they were not otherwise constrained. Coastal margin populations would have access to a variety of resources predictable in time, but not always in space. Most of these resources have relatively high processing costs, such as preparing fish and shellfish for storage. Roots would have required less processing time to store, but they may have been prone to rot in such a damp climate and could have not been stored for long periods of time. Significant storage may have been unnecessary and costly strategy for coastal margin groups.

The nature of food resources in inland environments would be expected to provide groups there little incentive to store as well. Ethnohistoric accounts indicate that the prickly pear fruit was widely consumed, but never prepared for storage as it required too much effort to dry (Kniffen et. al 1987). Still other resources may have been naturally "stored" on the landscape, such as fish arriving during spring floods and being trapped in small bodies of water (Hall 1998). One commonly used method of fishing during the contact period was catching a fish in these small pools using bare hands (Gashtchet 1891). Inland groups did have access to foods which could be easily "back-loaded" such as nuts and seeds. In sum, many plant and aquatic resources require labor-intensive processing to prepare them for storage. As long as UTCP groups had relatively unrestricted movement across the landscape to solve resource shortages, there was probably very little reason for them to store food. In keeping with Bettinger's hypothesis concerning "back-loaded" storage, it is possible that inland groups stored nuts as a low-cost way of alleviating resource shortages.

UTCP groups could have obtained non-local foods such as maize from their Caddoan neighbors. Locally available foods may have been consumed in ceremonial contexts as well. For example, sotol plants (*Dasylirion* sp.) grow in the western inland portion of the study area and can be used to create intoxicants. The historic Karankawa are described as consuming a caffeinated tea brewed from yaupon leaves (*Ilex vomitoria*) in large quantities during celebrations and ceremonial events (Newcomb 1993 [1961], Tull 1987). It is possible that UTCP pots were used to trade, process, and/or serve maize from or among elites. It is also possible that pots were used to process and/or serve local foods at ceremonial functions.

Dietary Information from Selected Sites

An examination of the faunal, plant and bioarchaeological remains from the three sites selected for this study may further refine our expectations for the outcome of organic residue analysis of pottery. In addition, a review of the faunal remains may also provide a list of animal resources consumed at the sites which can be compared with the residues obtained from pottery samples. The amount and types of faunal remains are discussed in this section. Previous analyses of the fauna at Mitchell Ridge (41GV66) and Little Bethlehem (41AU38) included gar (*Lepisosteus tristoechus*) scales and vertebrae in the number of identified specimens (NISP). The published report of Honeycomb (41LB4) fauna did not include counts by element, so it is unknown how much gar scales, vertebrae, and turtle carapace contribute to the NISP at this site. The number of fish present at these sites was most likely inflated by including all gar scales and vertebrae, as they are very distinctive and thus could be disproportionately represented in the assemblage. Turtle carapace, gar vertebrae and scales are very visually distinctive faunal elements. They are more likely to be identified than other species and thus may be disproportionately represented relative to other species. This in turn can affect the proportions of fish and reptiles represented at the sites. Given this, turtle carapace fragments, gar scales, and gar vertebrae were removed from the NISP for Mitchell Ridge (41GV66) and Little Bethlehem (41AU38).

Mitchell Ridge (41GV66) is located on a relict beach ridge on Galveston Island. Faunal remains recovered from the 1992 excavation include 6,531 bones identifiable to at least genus, and often species. The analysis of these remains indicated that the majority of the faunal assemblage was composed of fish (Table 7.2). Other frequently represented species include shellfish and medium-sized to small mammals (such as raccoon and cotton rat). In the Mitchell Ridge faunal assemblage for the block excavation 74 turtle carapace fragments, 2,282 gar vertebrae and 177 gar scales were identified in the 1992-1994 analysis. When these are removed from the total number of elements in the assemblage, medium-small mammals become the most frequently represented group of fauna at the site (Table 7.2). Fish drop to 18 percent of the assemblage, and the frequency of shellfish increases. These adjustments present a picture of frequent small mammal use at the site—mostly hispid cotton rat—(*Sigmodon hispidus*) and use of shellfish, with fish still being fairly strongly represented in the assemblage.

Honeycomb (41LB4) is located on a previous channel of the Trinity River, and straddles both brackish and freshwater environments, as well as upland and lowland environments. Thus, the site would be expected to have a variety of species from these habitats. Although faunal identifications from the 1994-1995 analysis are not reported by element, MNI were calculated in addition to NISP tallies. Interestingly, while 4,570 gar elements were identified, the MNI for gar was calculated to be 3. While Shaffer (1995) reported a total of 17,784 faunal specimens, he was able to identify 8,611 of these specimens to *vertebrata* only. Thus, they were left out of the NISP presented here (Table 7.3). Three more specimens could only be identified as "mammal" and thus were also left out of the NISP here. The categories for small/medium and medium/large mammals are used for Honeycomb instead of small/medium and large mammal categories used for Mitchell Ridge and Little Bethlehem due to the fact that 2,463 specimens were identified as medium/large mammal only. Twenty were identified as small and or medium mammal, and three were identified as "very large mammal". Thus, the NISP reported in this analysis is 9,348. Freshwater mollusks reported from Honeycomb include *Glebula rotundata, Lampsilis hydiana, Potamilus purpurat, and Quadrula apiculata. Rangia cuneata* are also reported in the assemblage (Ensor 1995). The published report of Honeycomb fauna did not include counts by element, so gar scales, vertebrae, and turtle carapace could not be removed from the NISP. Based on the 1995 analysis, the faunal assemblage at Honeycomb is dominated by fish and medium/large mammals (Table 7.3).

The Little Bethlehem (41AU38) faunal assemblage had 429 turtle carapace fragments. (164 *Pseudmys* sp.; 130 *Terpene* sp.; 135 unidentified), 144 gar vertebrae, 742 gar scales, and 426 unidentified fish vertebrae (Lord 1981). When these elements are removed from the faunal sample, Little Bethlehem still has a high frequency of reptiles and freshwater fish, followed by large mammals and medium-small mammals (Table 7.4).

Botanical information

Botanical remains are extremely rare on the UTCP. A few botanical remains were recovered from Honeycomb, including one hickory nut fragment, and some bedstraw and pepper vine seeds, the latter of which are known to have been used for medicinal purposes in other parts of the Southeast (Dering 1995). No botanical remains are reported from Mitchell Ridge or Little Bethlehem.

Skeletal data

Stable carbon and nitrogen isotope analyses of individuals from the four Late Prehistoric cemeteries on Mitchell Ridge (41GV66) indicate that people buried at the site had diets which consisted of 2/3 to 3/4 marine foods (Huebner 1992). Tooth wear patterns suggest that individuals had diets consisting of "gritty" foods. This could indicate that individuals were consuming high amounts of nuts, seeds, and berries, and/or the food was poorly cleaned (Powell 1994). Information about diet on the inland portion of the UTCP comes primarily from a study of Archaic period sites by Huebner and Button (1992). The analysts concluded that that approximately 85 percent of the diet was comprised on C3 pathway foods, such as deer and nuts.

Methods

Various organic residue extraction methods have been used on prehistoric pottery for decades (e.g., Dunnell and Hunt 1990; Eerkens 2005; Evershed 1993; Evershed et al. 1997; Freestone et al. 1985; Heron and Evershed 1993; Hill and Evans 1989; Malainey et al. 1999a, 1999b, 1999c). There have been many recent successful applications of lipid analysis to archaeological research questions. Dudd et al. (1999) found evidence for dietary change between Bronze Age and Neolithic occupations at a site in Wales. Kimpe et al. (2004) used lipid analysis and morphological data to create a functional classification of wares in southwest Turkey. In North America, Eerkens successfully identified pinon nut residues in the pottery of Great Basin hunter-gatherers (Eerkens 2005). Plant residues have been successfully identified in several studies, most notably leafy plants (Eversherd et al. 1997), and isotopic studies of C3 and C4 plants, including maize (Morton and Schwarcz 2004; Woodbury et al. 1998). Closer to the UTCP, work in the Caddo cultural area with climate and depositional environments similar to the UTCP indicates that analysis of lipids from UTCP ceramics may be successful (Marchbanks 1989). Lipids have also been successfully extracted from burned rocks in south Texas (Quigg et al. 2001), although further experimental work on the effects of specific food processing techniques on the integrity of the lipids may need to be done (Buonasera 2005). In contrast, analysis of organic residues has never been conducted on UTCP ceramics.

Since the early 1990s organic residue research has focused primarily on identifying plant and animal products associated with lipids (fats and oils). Lipids have been the primary focus of analyses because they have a high rate of survival in the archaeological record. These fats and oils (lipids) are mainly comprised of fatty acids, which are insoluble in water and are more abundant than other lipids such as sterols and waxes. Fatty acids naturally occur as triglycerides, which are comprised of three fatty acids attached to a glycerol molecule by ester-linkages. Fatty acids are conventionally referred to using a shorthand format Cx:yωz. The "Cx" describes number of atoms which make up the length of the carbon chain of a particular fatty acid. The "y" denotes the number of double bonds or points of unsaturation, and the "ωz" indicates the location of the most distal double bond on the carbon chain. Thus, the fatty acid "C18:1ω9" is a mono-unsaturated isomer with a chain length of 18 carbon atoms with a single double bond located nine carbons from the methyl end of the chain. Here the shorthand designation is used. For example, "C16:0" refers to a saturated fatty acid with a chain length of 16 carbons (Malainey, Appendix D).

Lipid analysis has some limitations and potential confounding factors. In lipid analysis foods cannot usually be identified with a high degree of specificity. This is because there is a narrow range of fatty acids in most fats and oils. Thus, fatty acid analyses often focus on making more general identifications of plant and animal products by matching structures of chemical compounds or relative proportions of a mixture of compounds to known products (Eversherd 1993). While the fatty acid composition of uncooked plants and animals provides important baseline information, it is not possible to directly compare modern uncooked plants and animals with highly degraded archaeological residues. Certain types of fatty acids, such as unsaturated fatty acids, are found widely in fish and plants and decompose more readily than saturated fatty acids, sterols or waxes. During burial, fatty acid constituents can degrade, disappearing or forming other compounds (see Appendix D for a more detailed discussion). It is also possible that they may be subject to relatively high hydrolysis and/or contamination from fatty acids from bacteria found in the soil (Heron et al. 1991; Regert et al. 1998). While fatty acid contamination from the soil can be factored into residue analysis because of distinct signatures (Evershed and Tuross 1996), high incidences of hydrolysis may create yields of organic compounds too low to use for analysis, a special concern with residues from humid, wet environments such as the UTCP. Even when bacterial contamination can be factored in to analysis, it is still necessary to compare archaeological residues with known standards which resemble archaeological residues. Researchers have attempted to identify archaeological residues using standards (expressed as percentages or ratios) based on of modern uncooked foods (Marchbanks 1989; Skibo 1992). A major problem noted by Skibo (1992) is that archaeological residues do not resemble the original fatty acid composition of modern uncooked foods.

Recent research has focused on identifying criteria which can be used to distinguish between fatty acid compositions of various foods (Malainey et al. 1999a, b). Criteria were developed for identifying the fatty acid compositions of 130 uncooked plant and animal species in central Canada (Malainey et al. 1999a, Appendix D). The work revealed distinct differences between large mammal fat, large herbivore meat, fish, plant roots, greens, and berries/seeds/nuts (Malainey et al. 1999a, Appendix D). In addition, 19 modern plant and animal resources similar to those on the upper Texas coastal plain (e.g., deer, fish, and turtle) were cooked in replica vessels. Fatty acids were measured periodically during a simulated degradation process. Similar work was performed with plant and animal resources from inland south Texas (Quigg et al. 2001; Appendix D).

This work identified seven categories of lipids (Table 7.5). The "large herbivore" category is comprised of deer, bison, antelope, javelina, and sotol plants and is distinguished by high levels of C16:0, C18:1, and C18:0. One known example of javelina (collared peccary) remains has been noted on the UTCP, but it is not clear if they are actually associated with human occupation of the area (Lundelius, personal communication 2006). A "high fat content food" category includes rendered fat and high fat nuts/seeds and is distinguished by high levels of C18:1 and low levels of C18:0. A "medium fat content food" category includes mesquite, corn, cholla, fish, turtle, and snail and is distinguished by low levels of C18:0 and relatively high levels of C18:1. A "medium-low fat content plant" category includes prickly pear and Spanish dagger pods (the latter of which were probably not present on the UTCP). This food category is characterized by lipids with low levels of C18:0, and slightly higher levels of C18:1 than low fat content plants. "Low fat content plants" include greens, roots, some berries, and low-fat/starchy seeds. This category is characterized by low levels of C18:1 and C18:0 and high levels of medium chain fatty acids. The mixing of different types of foods can be detected to some extent as well. The "plant and large herbivore" category contains foods described above and is characterized by high levels of C18:0 and medium chain fatty acids. A "medium fat content food and plant" category is characterized by high levels of C18:1 and relatively low levels of 18:0, plus medium chain fatty acids (for further description and a discussion of the experimental work, see Appendix D and Malainey et al. 1999a, b, and c). These findings were then applied to prehistoric assemblages from 18 Western Canadian sites. The food resources identified by fatty acid composition are consistent with faunal and tool assemblages from the sites (Malainey et al. 1999c).

Sampling UTCP assemblages

Residue analysis has never been performed on pottery from the upper Texas coastal plain. For this reason as well as economic constraints it was decided to submit a small sample of sherds for residue analysis. Vessels may have been used to process more than one type of resource, although this situation can sometimes be detected (Malainey et al. 1999c). This potential problem can be mitigated by focusing on residue signatures across a given site assemblage, rather than focusing on a single pot. Therefore, multiple samples from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38) were analyzed in order to effectively evaluate the original hypotheses. One set of hypotheses addresses use of pots to process foods using direct or indirect heat. A potential problem could exist with analyzing the residues of sherds used over direct heat, as the heat of cooking fires may oxidize food residues. Since the base of a cooking vessel is more likely to come into direct contact with fire, it was decided to select rim and neck sherds, which represent portions of the vessel which residues from cooking come into least contact with heat sources. Vessels used for boiling foods have been observed to retain organic residues in the rim/neck area where they naturally collect during the boiling process (Charters et al. 1993). In order to detect associations between types of cooking and type of resources, sherds displaying characteristics of use over heat (i.e., sooting and spalling), and attributes associated with use over heat (grog temper) were selected as part of the sample.

Since it is possible that UTCP assemblages may have been used for both cooking and storage, residues may be located in different areas of vessel bodies. Furthermore, given that fatty acids in archaeological ceramics have the potential to degrade; it is possible that sherds from the UTCP might retain no organic residue signature. There are two possible explanations for the lack of a residue signature: either sherds have been subject to post-depositional processes that have affected the amount of lipids present in a given sample, or foods may have been processed in vessels using primarily dry processing techniques such as parching and steaming, rather than “wet” food preparation techniques such as boiling. These outcomes could be particularly problematic when evaluating the storage hypotheses. Therefore, lower body and base portions of the vessels were sampled as well. Contents on bodies and bases would settle and not be burned off by heat, and the neck which is known to retain high amounts of residue during boiling (Charters et al. 1997; Malainey, personal communication, 2004). In order to detect potential use of pots to process non-local foods, possibly as a part of ceremonies to display or accrue social/political/economic prestige, sherds with high frequencies of decorative surface treatments were also selected. An additional sampling consideration was to analyze sherds weighing eight grams or greater, as sherds lighter than this often do not yield enough residue for analysis (Malainey, personal communication, 2004).

Twenty-six sherds weighing at least eight grams were selected for analysis. The sample consisted of nine sherds from Mitchell Ridge, 11 sherds from Honeycomb, and six from Little Bethlehem (Appendix E). In order to address hypotheses concerning food processing, 11 rim sherds, and 13 body sherds were selected from each of the three sites. Eight sherds with interior and/or exterior sooting were chosen for analysis from each of the three sites. Eleven sherds with grog temper were sampled from Mitchell Ridge (41GV66) and Honeycomb (41LB4). No grog-tempered sherds large enough for analysis were present in the Little Bethlehem (41AU38) assemblage. In the interests of obtaining information to help assess the storage hypotheses, two bases from the Mitchell Ridge (41GV66) assemblage were sampled. The other two sites did not have base sherds large enough for residue analysis. In order to get a sense of what kinds of foods might be associated with ceremonial/aggrandizing contexts, three of the most heavily decorated sherds which were large enough for analysis were selected; a rare cordmarked sherd from Little Bethlehem (41AU38), and one incised and one punctuate sherd, each from Honeycomb (41LB4).

Sherd samples were sent to Dr. Mary E. Malainey at the University of Manitoba for analysis. Samples were prepared by the lab, and a detailed description of methods and equipment used is provided in Appendix D:269-271. Since residues from the interior location on the sherd are less subject to post-depositional alteration than those present on the surface, the first 1-2 millimeters of the outer surfaces were removed. The inner portion of the sherd was crushed and placed into a solution to separate organic and inorganic particles from one another (see Appendix D:269 for specific protocol). The subsequent organic residues were analyzed using a Varian 3800 gas chromatograph (instrumentation and protocol are described in Appendix D:271).

Results

Differentiating small from large mammals and plants from animals was possible, but pinpointing specific foods (e.g., maize) was not possible. Four sherds, all from Mitchell Ridge (41GV66) yielded no residue. Three sherds had lipid signatures which resemble the experimental "medium-low fat plant" category. Two sherds had lipid signatures which resemble the "low fat content plant" category (Table 7.6). Sherds from Honeycomb (41LB4) yielded a "large herbivore" signature, a "medium fat content food" signature, two "medium-low fat content plant" and two "low fat content plant" signatures. Five sherds had "medium fat content food and plant" signatures (Table 7.6). Little Bethlehem (41AU38) has two sherds with "large herbivore" signatures, one with a "high fat content" signature, two "low fat content plant" signatures, and one sherd with a mixture of plant and large herbivore residues (Table 7.6).

Discussion

The only sherds without lipid signatures are from Mitchell Ridge. These samples consisted of one rim sherd, two body sherds, and one base sherd. Thus, the lack of residue does not appear to correspond to a particular part of the vessel. The sherds come from various horizontal locations on the site: N2E0; N6E0, and N0E2. The vertical provenience of the sherds is in both levels of the cultural layer (Ricklis field notes 1992). Thus, the lack of residue on these sherds does not appear to be correlated with a particular location on the site. Furthermore, other sherd samples from these locations on the site did yield residues. Perhaps lipids were oxidized when vessels were subjected to direct heat. Only a small portion (less than 25 percent) of the exterior of the base sherd has any marks which can be interpreted as sooting. Two of the Mitchell Ridge sherds without residues have exterior colors suggesting that their clays were oxidized at some point during manufacture or use. Yet two other sherds have exterior colors which indicate non-oxidized surfaces. Furthermore, two other sherds from Honeycomb which yielded residues have exterior colors associated with oxidized surfaces. Perhaps these sherds from Mitchell Ridge were used for tasks other than food preparation, or were used for "back-loaded" storage.

All of the "medium fat content food and low fat plant" signatures are found on sherds from Honeycomb. While all of the Honeycomb sherds are grog-tempered, the five sherds with this particular category of residue do not appear to be limited to a particular portion of the vessel body, as three rim sherds and two body sherds were linked with this particular signature. One of the rims was incised. Honeycomb also has one sherd with a "large herbivore" signature. Yet large herbivore processing in pots at these three sites appears to be a rarity. Some differences in types of resources processed in pots appear between sites. Honeycomb sherds have a "medium fat content food and low fat content plant" signature not found on sherds from the other two sites. Little Bethlehem has two sherds with "large herbivore" residues and the only "high fat content food" signature in the entire sample. As previously stated, foods in this category consist of rendered animal fat (including grease and marrow) and nuts, both of which would have been available in the vicinity of the site. Grog temper, given its experimental links with proficiency over direct heat, might be linked with particular food categories which are best processed with prolonged simmering or boiling over direct heat, such as starchy seeds. Yet there appears to be no correlation between grog temper and a particular residue signature. Two sherds with tar on their exteriors—both from Mitchell Ridge—were included in this study. One sherd had no residue and the other had a "medium-low fat content plant" signature, suggesting that if tarred vessels were in fact used for storage, they may have been used to store water (which would leave no signature) and plant foods.

Previously reported faunal data indicate that at Mitchell Ridge (41GV66), high frequencies of small mammal and shellfish are present. In addition, dietary data from human remains in the area suggest that individuals interred at Mitchell Ridge consumed high amounts of marine foods. At Honeycomb (41LB4), the majority of the faunal assemblage is comprised of fish and medium/large mammal remains. Nut fragments, possibly related to human consumption, were found at the site. The Little

Bethlehem (41AU38) faunal assemblage has high frequencies of freshwater fish and large mammal. Dietary data from human remains suggest that people living inland primarily focused on large-bodied mammals such as deer, as well as nuts. In some cases, organic residues from the sherds sampled in this study reflect the frequency of resource types in the faunal record. This is not the case at Mitchell Ridge where organic residues from the sherds do not correlate with the faunal record, suggesting that even if diets of individuals living at this site consisted predominantly of marine foods, the pottery assemblage appears to be strongly correlated with processing or storing plant foods such as prickly pear, greens, roots, berries, and starchy seeds. Future studies can benefit from more work on the nature of marine food residues in lipid analysis to make certain that the plants consumed by marine species are not reflected in the residue assemblage.

Organic residues from sherds in the Honeycomb (41LB4) assemblage resemble the faunal assemblage to an extent. Medium fat content foods—possibly freshwater fish and turtle—are common in the assemblage, while large herbivore residues are rare. While plant foods such as prickly pear, greens, roots, berries, and starchy seeds are present in the Honeycomb samples, nut residues are not. This is interesting considering that nut remains were found at Honeycomb, a hypothesized nut-processing site (Ensor et al. 1995). Perhaps pottery was not the chosen tool in processing or storing nuts. Residues from the Little Bethlehem (41AU38) sherds agree with what is known about diets in the inland portion of the UTCP: large herbivores (such as deer), and plant foods such as nuts and grasses.

While limited in size, the data set allows initial assessment of the food processing, storage, and prestige hypotheses. Sherds with grog temper have a variety of residues, not just the low-fat content plant residues we would expect to see if these pots were being used to process starchy seeds. Six of eight sherds with some evidence of sooting yielded plant residues, suggesting that these plant foods may have been processed over direct heat. While analysis of sherds in these assemblages indicates that pots may not have been specifically engineered as storage containers, it can be said that if pots were being used for storage, then this storage was predominantly "front-loaded". Such a mode is theoretically predicted to be favored by hunter-gatherers with relatively low residential mobility. If tarring is linked convincingly linked with storage functions in future studies, then further sampling of tarred sherds might yield more information on what kinds of items are stored in these vessels. Identification of residues from the small sample of decorated sherds is not specific enough to determine if maize was actually in the pots. One sherd from Honeycomb (41LB4) does have "medium fat content food", a residue category which includes maize, but also includes a many other types of foods. All three decorated sherds sampled have residues associated with plants. These may be non-local resources, or local plants used for ceremonial purposes. Decorated pots may simply have plant residues associated with everyday food processing, storage, and serving activities. In future studies, residues from additional samples of decorated sherds will need to be extracted to further assess the prestige hypothesis.

Conclusions

While small in scope, this preliminary study indicates that there is promise for future organic residue studies in the upper Texas coastal plain. Work on refining the categories of foods identified by residue analysis continues, and future studies in the UTCP can benefit from it. Further isotopic work along the lines of Sherriff et al. (1995) may help distinguish between maize and fish signatures from one another, a distinction very much of interest when testing hypotheses about diet in the UTCP. However, chemical signatures of maize may not be as detectable as has traditionally been thought (Reber and Evershed 2004, 2006).

As previously discussed, theoretical links between diet and residential mobility enable us to use organic residue data to address questions concerning the residential mobility, storage strategies, and prestige behavior of hunter-gatherers. This study provides some preliminary information on vessel use and subsistence and mobility practices.

Table 7.1 Regional food resources. * indicates seasonal availability of certain parts.

Species	**Location**	**Availability**
Bison (*Bison bison*)	Inland/sometimes Coast	fall/all seasons
Whitetail deer (*Odocoileus virginianus*)	Inland/Coast	fall/all seasons
Raccoon (*Procyon lotor*)	Inland/Coast	all seasons
Turtle (various species)	Inland/Coast	all seasons
Alligator gar (*Lepisosteus tristoechus*)	Inland	all seasons
Brackish and saltwater shellfish (*Rangia cuneata, Crassostrea virginica*)	Coast	all seasons
Black drum (*Pogonias cromis*)	Coast	January-April
Red drum (*Sciaenops ocellata*)	Coast	August-November
Spotted sea trout (*Cynoscion nebulosis*)	Coast	all seasons
Atlantic croaker (*Micropogonius undulatis*)	Coast	October-February
Cattail (*Typha anusstifolia, T. dominguensis, T.T.T. latifolia)* seeds, roots, and stalks	Inland/Coast	all seasons*
Water lily (*Nymphaea odorata*)	Coast	all seasons
Berries (various species)	Inland/Coast	late summer

Table 7.1 continued. Regional food resources.* indicates seasonal availability of certain parts.

Species	Location	Availability
Pecan (*Carya illinoiensis*)	Inland	fall
Oak (*Quercus* sp.)	Inland	fall
Hickory (*Carya texana*)	Inland	fall
Amaranth (*Amarantus* sp.)	Inland	summer-fall
Bulrush (*Scirpus californicus*)	Inland/Coast	all seasons
Cane (*Arundinaria* sp.)	Inland/Coast	all seasons*
Chenopodium (*Chenopodium* sp.)	Inland	all seasons*
Pickerelweed (*Pontederia cordata*)	Inland	all seasons*
Reed (*Phragmites communis*)	Inland/Coast	all seasons
Blue camass (*Camassia scilloides*)	Inland	spring/all seasons
Honey mesquite (*Prosopis glandulosa* var. *glandulosa*)	Inland	summer
Prickly pear (*Opuntia engelmanni* and many other sp.)	Inland	all seasons*

Table 7.2 NISP of Mitchell Ridge (41GV66) fauna, with all gar and turtle elements (left) and without (right).

	All elements		Minus selected elements	
Animal	**NISP**	**Percentage**	**NISP**	**Percentage**
large mammal	179	3	179	6
medium/small mammal	1039	16	1039	34
birds	14	<1	14	<1
reptile	182	3	108	3
amphibian	0	0	0	0
fish	3975	61	531	18
shell	1142	17	1142	38
total	6531		3013	

Table 7.3 NISP of Honeycomb (41LB4) fauna, minus v*ertebrata* .

Animal	**NISP**	**Percentage**
large/medium mammal	2831	30
medium/small mammal	137	1
birds	6	<1
reptile	454	5
amphibian	0	0
fish	5740	61
shell	not counted	N/A
total	9348	

Table 7.4 NISP of Little Bethlehem (41AU38) fauna, with all gar and turtle elements (left) and without (right).

	All elements		Minus selected elements	
Animal	**NISP**	**Percentage**	**NISP**	**Percentage**
large mammal	227	8	227	14
medium/small mammal	189	6	189	12
birds	5	<1	5	<1
reptile	824	28	429	27
amphibian	100	3	100	<1
fish	1504	51	618	38
shell	77	3	77	<1
total	2926		1611	

Table 7.5 Diagnostic catgories of lipid isomers used to identify residues in UTCP sherds (after Malainey 1999).

Fatty Acids	**Category**	**Foods**
high levels of C16:0, C18:1, C18:0	large herbivore	deer, bison, pronghorn
high levels of C18:1; low levels of C18:0	high fat content food	rendered animal fat, hickory, pecan, acorn nuts
low levels of C18:0 and relatively high levels of C18:1	medium fat content food	mesquite, corn, fish, turtle, snail
low levels of C18:0; slightly higher levels of C18:1 than low fat content plants	medium-low fat content plant	prickly pear
low levels of C18:1, C18:0 and high levels of medium chain fatty acids	low fat content plant	greens, roots, berries, starchy seeds

Table 7.6 Residues in sherds from Mitchell Ridge, Honeycomb, and Little Bethlehem.

Food residue	**41GV66**	**41LB4**	**41AU38**
Large herbivore	0	1	2
high fat content food	0	0	1
Medium fat content food	0	1	0
Medium-low fat content plant	3	2	0
low fat content plant	2	2	2
Plant and large herbivore	0	0	1
Medium fat content food and plant	0	5	0
no residue	4	0	0
total sherds	9	11	6

CHAPTER 8: CONCLUSIONS AND FUTURE RESEARCH

Goals of the study

The purpose of this dissertation is to evaluate three possible explanations of the circumstances under which some hunter-gatherer groups choose to make and use ceramic vessels. This is accomplished by analyzing three Late Prehistoric period hunter-gatherer pottery assemblages on the upper Texas coastal plain. Pottery can play critical roles in contexts of subsistence, mobility, and social complexity, but the role(s) of pottery on the UTCP are not currently understood. Explanations for the continued use of pottery on the UTCP implicate intense use of plant foods, including starchy seeds and/or cultigens. Pottery may have become more attractive to UTCP foragers as their territories became packed through time and group mobility declined as a result of limited home ranges. Pottery may have also been a useful ceremonial or symbolic object in yet undocumented social and political contexts. I have used theoretical tools derived from human behavioral ecology to create models which address the interplay between physical and social environments and pottery production which I then tested. Learning more about the functions of UTCP pottery will contribute to our understanding of UTCP hunter-gatherer diet and mobility, as well as our understanding of pottery and its context in hunter-gatherer adaptations.

Explanation of hunter-gatherer pottery function: general insights

Manufacturing attributes and use-wear characteristics of ceramic assemblages from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38) give a picture of predominantly locally-made, plainware assemblages engineered for processing foods over heat with low amounts of water, such as starchy seeds or cultigens. Organic residue and use wear data suggest that pots may have been used for different tasks at each site. Results indicate that wall thickness of sherds in all three assemblages was highly uniform within and between sherds. Like Honeycomb (41LB4), the Mitchell Ridge (41GV66) assemblage has a high amount of grog temper, an attribute associated with vessels used in direct heating tasks (Table 8.1).

Honeycomb (41LB4) sherds exhibit a high correlation between non-variable wall thickness and grog temper, suggesting that pottery at this site was engineered to be used over direct heat (Table 8.1). Yet while attributes associated with vessel construction (especially in the case of Honeycomb) suggest that vessels were engineered for use over heat, other aspects of the manufacturing process—most likely coping with unforgiving raw materials—are effectively masking evidence of construction for use over direct heat.

Generally, assemblages from the three sites show little evidence of use wear characteristics associated with use over direct heat, suggesting that vessels were rarely used in this manner (Table 8.1). Small portions of the assemblages from each site have use wear patterns consistent with observed use wear caused by simmering and boiling in ethnographic assemblages. Low frequencies of spalling on sherd interiors in all assemblages suggest that vessels used in direct heating tasks may have been used for processing foods over heat by boiling rather than simmering. Thus, UTCP vessels do not seem to be used to process large quantities of cultigens or wild starchy seeds very frequently. The Mitchell Ridge (41GV66) assemblage is a possible exception. Unlike assemblages from other sites, the Mitchell Ridge sherds sampled had plant residues—or none at all (Table 8.1). The high frequency of plant residues, combined with the high frequency of interior sooting relative to the other two sites, suggests that pottery at Mitchell Ridge may have been mainly used to process plant foods over direct heat. Yet this aspect of the diet is not reflected in isotopic signatures derived from human remains from the site. Perhaps at Mitchell Ridge pots were used for cooking plants (starchy or otherwise) while other cooking methods were used for fish and other foods. Nontheless, the significance of plants—possibly starchy plants—in the daily diet of people at coastal margin sites such as Mitchell Ridge remains unclear.

In contrast, sherds from the Honeycomb (41LB4) assemblage have relatively fewer plant residues than Mitchell Ridge (Table 8.1). Honeycomb sherds commonly have plant and medium-small mammal foods, with some large herbivore, reflecting both the upland and swamp environments surrounding the site. Given the residue and use wear evidence, it is more difficult to make a case for intensive plant processing over direct heat at Honeycomb than at Mitchell Ridge. The Little Bethlehem (41AU38) assemblage is distinctive from the other two in that the frequencies of sooting and grog temper are comparatively lower (Table 8.1). Residues suggest that large mammals were more important here than at other sites, not surprising considering the location of the site is inland, where such resources are expected to be plentiful. Plant residues are present in some sherds, which could reflect local plant foods that are available in this area (Table 8.1).

Given the lack of use-wear attributes associated with use over direct heat, it is possible that vessels were used for storage purposes, although vessel assemblages have a low frequency of surface treatments associated with storage. If some of the vessels from these assemblages did function in storage capacities, then the fact that organic residue data are present on 22 out of the 26 sherds sampled suggest that a "front-loaded" strategy was used, in which most of the food processing costs were assumed up-front. The expectations developed specifically for UTCP pottery assemblages state that if hunter-gatherers in this region were utilizing pots for so-called "front-loaded" storage, then they would have low degrees of residential mobility. Paired with the "front-loaded" storage expectations, the organic residue data from these three sites suggest that at least some UTCP groups were fairly sedentary and possibly stored food. The current methodology does not find support for the idea of vessels as storage containers. The great majority of sherds analyzed do not fit the traditional structural profile of storage vessels, but again this may simply be the result of coping with unforgiving raw materials (making thin-walled pots to prevent failure during firing). Petrographic data have the potential to provide an understanding of the extent of residential mobility in the region although the high homogeneity of gulf coastal plain mineral assemblages should be taken into account when interpreting these results.

Petrographic sourcing indicates that the vessels are locally made (Table 8.1), and suggests that people on the UTCP commonly did not move or trade with adjacent cultural areas. However, mineral assemblages over a large portion of the Texas coastal plain are homogenous. Therefore it is still possible that people were moving extensively throughout the upper coastal plain but this movement cannot be detected by sourcing. While additional information on vessel construction and geologic source of UTCP pottery would be helpful in assessing the hypotheses, initial work using these methods indicates that future work may not add much more information. While other sherd assemblages in this area can and should be investigated in terms of vessel construction, it is highly probable that the nature of the raw materials in this area will continue to obscure our understanding of how vessel construction relates to function. Local source materials are very homogenous in this region, and future sourcing studies should take this into account.

The hypothesis that pottery on the UTCP was used as part of social aggrandizing and other prestige behavior is not well supported by the data. Pottery assemblages have low amounts (five percent or less) of decorative surface treatments (Table 8.1). Sourcing data indicate local geological sources for raw materials, indicating that these are not exotic trade wares. Nonetheless, pottery could have been used to process substances in ceremonial activities which could be implicated with accruing or maintaining social or economic prestige. Food identifications were not specific enough to determine if exotic foods (such as maize) were present in the vessel assemblages.

Evaluating models of settlement and subsistence using these three UTCP pottery assemblages was based on the premise that they were contemporaneous. Sherds from the Mitchell Ridge and Little Bethlehem assemblages have earlier dates than Honeycomb, suggesting that some ceramics from each site are from the Late Prehistoric, but maybe not all. While only some dates correlate well with previously obtained radiocarbon dates, other younger dates on sherds from Mitchell Ridge and Little Bethlehem suggest that radiocarbon dates from both of these sites could not accurately date ceramic use on the sites (Table 8.1). In the cases of Mitchell Ridge the radiocarbon dates obtained from the block excavation do not appear to reflect the timing of all prehistoric activity in this area of the site. Despite the homogenous stratigraphy and lone radiocarbon date at Little Bethlehem, the luminescence dates from sherds in this study indicate there is apparently a much longer span of time than originally thought, or that older ceramics were curated and brought to newer occupations. Since radiocarbon and thermoluminescence methods date different events, this might also explain some of the discrepancies.

Assessing the Akokisa model

While the results of these analyses do not unequivocally disprove any other of the three vessel function hypotheses, they do provide more insight on mobility patterns and diet. Assuming that at least some of the portions of the sites are contemporaneous, I suggest that there were two separate populations on the upper Texas coastal plain, a relatively sedentary coastal population relying primarily on small-bodied, r-selected resources, and a more mobile inland population using greater amounts of large-bodied resources.

Residue data from this study indicate that the UTCP diets differ between sites in different environmental zones. Some morphological and use wear data indicate that pots at coastal margin sites were used differently than those at inland sites. Organic residues from coastal margin sherd samples indicate a reliance on small-bodied resources. Large mammal residues are not present in the Mitchell Ridge samples. Sherd samples with plant residues may indicate use of starchy seeds and/or cultigens, but the general nature of lipid residues makes this idea difficult to evaluate. Nonetheless, the high frequency of r-selected resource residues on sherds from coastal margin sites does lend support to the idea that coastal margin populations were experiencing some territorial constraint and were broadening their diet as the result of their inability to pursue large-bodied resources frequently. However, residue analysis of more sherds from coastal margin and inland sites needs to be done before these conclusions can be accepted. Given that the UTCP coastal margin was a highly consistent and productive environment, coastal margin groups may have had incentive to be sedentary even without territorial constraints and/or resource depression. Whether sedentism at these sites is actually the result of environmental circumscription due to environmental packing needs to be further evaluated using other archaeological data, such as dietary and disease stress data from human remains.

Organic residue data from samples of Little Bethlehem (41AU38) sherds suggest that pots were not being used to process small-bodied resources or starchy seeds in the inland portion of the UTCP. In terms of the Akokisa model, inland groups could have been experiencing territorial constraints during the late Prehistoric or earlier. Ceramic vessels among inland groups suggests resource depression of large mammals—the result of larger populations, more constrained territories, or both. Looking more closely at the faunal record may provide insight on the question of resource depression (e.g, Densmore et al. 2007; Fullerton et al. 2007). The suitability of pottery for processing plant foods suggests its utility to coastal margin populations. The function of pottery for inland groups with apparently higher degrees of residential mobility needs to be investigated further. Future research on upper Texas coastal plain pottery and faunal assemblages can be used to evaluate the idea of two distinct populations using ceramic vessels as a part of two different adaptations.

Future research

Experimental work

Additional knowledge of particular cooking techniques will be useful in assessing hypotheses of vessel function and use (Sillar 2003). More experimental work needs to be done in this area to determine if cooking methods using low amounts of liquid are truly useful in processing starchy plant materials, particularly native edible plants in the upper Texas coastal plain region. Existing experimental studies have produced useful but conflicting information about whether boiling is particularly suited to processing starchy plants and seeds or breaking down the connective tissue in meat (Reid 1990; Skibo 1992). Skibo obtained use wear data on pots used to cook rice using low amounts of liquid, and observed that other plant materials were boiled using higher amounts of water. Reid's statements that pots were used to boil meat are based on ethnohistoric data. Yet Hally points out that pot walls frequently spall when liquid used to cook starchy seeds to a gelatinous consistency evaporates.

The nature of porosity of UTCP wares should be further investigated as well. Porosity of vessel walls affects both heating and storage properties of the vessel, but specific information is lacking. Future studies could focus on how long it takes water to boil in experimentally replicated vessels with differing amounts of porosity. Pore structure and frequency of these vessels could then be examined in thin section. Some surface treatments (namely tar) indicate that pots from UTCP sites may also have been used for storage, but it is not clear from the non-destructive data what fraction of the vessel assemblages were used for storing foodstuffs. Future experimental investigations could develop baselines for porosity, and determine if tar is effective in limiting porosity on cooking vessels, or if it simply melts off the pot surface when the vessel is heated.

Investigating other cooking technologies

Further investigation of cooking techniques—with pots and other technologies— is also warranted. Clay balls have been documented in the UTCP, suggesting that other cooking technologies in addition to pottery were used in this area. The age and of clay balls is not well documented. Their distribution appears limited to the southern inland portion of the UTCP (Patterson 1993), although workers in the region have only recently begun to systematically document their presence. Currently their function is assumed to be related to cooking, but this is uncertain. The presence of clay balls at some inland sites has been interpreted to mean that indirect boiling methods were used (Ellis 1995; Patterson 1993). Additional information about clay balls, such as whether they were used instead of or in addition to pottery could be useful in understanding the evolution and function of pottery on the UTCP. Future research on cooking technology in the UTCP should include closer examination of the regional distribution and functions of clay balls. Organic residue studies and luminescence dating may enable us to learn more about the function and spatial and temporal distribution of these possible cooking implements.

Refining methods introduced in this study

Further work with organic residues and temper may improve our understanding of vessel use and function on the UTCP. Organic residue analysis is a promising technique that can greatly contribute to knowledge of UTCP diet. While initially successful, this method needs to be refined for further application in the region. Developing standards for marine foods is a logical next step, and work has already begun (Malainey personal communication 2006). Detecting maize does not appear as promising (Reber and Evershed 2004, 2006). Further work on the performance properties of bone temper will also be useful. It is not clear what specific qualities of bone might have been of value to prehistoric potters. Perhaps bone was simply plentiful and therefore useful in increasing the workability of highly plastic local clays. The frequencies of bone and grog non-plastics in the sherds from all three assemblages often occur in amounts well below 50 percent. Cross sections of some sherds show only one or two pieces of bone or grog, apparently far too little to have any appreciable affect on vessel performance. Different types of inclusions often co-occur in a single sherd, suggesting that the specific properties of a particular inclusion may not have been so important. Rather, the presence of *any* non-plastics may have been sufficient to insure optimal performance during manufacture or use.

Ceramic origins

Although this study did not focus on ceramic origins, why UTCP hunter-gatherers chose to make and use pottery when they did can provide more information on hunter-gatherer evolution. The information on function provided in this study is a start in this direction. Further investigation of the faunal record in pre-ceramic and ceramic period occupations is currently underway and may provide information on why pottery became attractive to UTCP hunter-gatherers when it did (Nagaoka personal communication 2006). More information on the timing and pace of pottery adoption is also desirable. Luminescence dates in this study suggest an earlier arrival of pottery in the inland portion of the UTCP than previously known. The fact that luminescence dates obtained in their study are few and that some have large error terms actually supports the idea that more UTCP ceramics should be dated in order to provide more data points and thereby increase our ability to interpret dates on pottery.

The premise that pottery use relates to social and economic behavior enables studies of pottery function to provide information on the variability in organization in hunter-gatherer societies. The work presented here is a step toward understanding the functions and uses of hunter-gatherer ceramics in order to address questions of more general anthropological interest concerning hunter-gatherer economic and social adaptations.

Table 8.1 Summary table of wall thickness, vessel morphology, porosity, source, decorative treatment, use wear, and lipid data from three Late Prehistoric sites on the upper Texas coastal plain. Luminescence dates on sherds from each site are reported as a range next to the site name.

Mitchell Ridge (41GV66) 123BC-AD1357

Wall thickness	Vessel morphology	Porosity	Source of asplastics	Decorative treatment	Heating use wear	Food residue
thin, uniform	round base, smooth wall curvature; orifice diameter 16-41 cm	low	local; grog and sand	low	high on interior bases	5 sherds with residues, 4 without. prickly pear, greens, roots, berries, starchy seeds. Exotic foods? Unknown

Honeycomb (41LB4) AD 1168-1457

Wall thickness	Vessel morphology	Porosity	Source of asplastics	Decorative treatment	Heating use wear	Food residue
thin, uniform	round base, smooth wall curvature; orifice diameter 8-26 cm; conical jars	low	local; grog and sand	low	low	mostly mesquite, corn, fish, turtle, snail, prickly pear, greens, roots, berries, starchy seeds. Exotic foods? Unknown

Little Bethlehem (41AU38) 90/7BC-1177

Wall thickness	Vessel morphology	Porosity	Source of asplastics	Decorative treatment	Heating use wear	Food residue
thin, uniform	round base, smooth wall curvature; orifice diameter and morphology unknown	low	local; bone and sand	low	low	mostly large animals, rendered fat or nuts. Exotic foods? Unknown

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APPENDIX A: LUMINESCENCE DATING OF POTTERY FROM THE UPPER TEXAS COASTAL PLAIN

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Ten ceramic sherds from three sites on the Upper Texas coastal plain were submitted for luminescence dating by Larkin Hood, as part of her dissertation work on ceramic production and use. Pertinent data on the sherds are given in Table A.1. Laboratory procedures are given in the appendix.

Internal radioactivity (from the sherds themselves) did not vary much among sherds from the same site, but did vary among sites. If other compositional information follows the same pattern, it could mean the pottery was manufactured from local materials. Internal dose rate constituted from 65-85% of the total dose rate. External dose rate was measured from one sediment sample for each site, and also included the cosmic contribution. Radioactivity values are given in Table A.2. Also given are the beta dose rates as derived from beta counting and as calculated from alpha counting and flame photometry, assuming secular disequilibrium. No significant differences in beta dose rate were discernable. Final dose rates are given in Table A.3. These include correction for moisture content. The environment is fairly moist and the sherds were assumed to have retained on average 80 ± 20 % of their absorbed water capacity.

Equivalent dose was determined both by thermoluminescence (TL) and by optically stimulated luminescence (OSL). The OSL measurements included an infrared exposure (IRSL) prior to blue light stimulation, but only five of the sherds showed an IRSL signal and it is not considered further. Various data are given in Table A.4.

The TL plateau regions on all sherds were relatively broad (>60°C), except for UW1338, but this one was constrained mainly by alpha efficiency. After the slide procedure (moving the additive dose curves into near coincidence with the regenerative curves by best fit), the growth curves for all samples passed through the origin, indicating no anomalous behavior.

The OSL behavior was a little more peculiar. On two samples (UW1335 and UW1336), the natural signal was much, much higher than the signal from the highest regeneration dose. Even if we used higher regeneration doses and were able to capture the natural signal, the resulting ages would be older than reasonable (pre-pottery). On one other sample, UW1333, the natural signal intersected the regeneration growth curve, but still produced a large equivalent dose with a correspondingly unreasonably old age. On all three of these samples, the equivalent dose was only determined by TL. On two more samples, UW1330 and UW1331, the OSL also produced fairly old ages, but not outside the realm of reason. I do not understand at this point the unreasonably high OSL signals. Possibly the OSL signal was not reset in antiquity, leaving a geologic residual, but all of these sherds had broad TL plateaus, which would not be expected for a poorly heated sample. For now they must be considered anomalous.

TL fading tests were performed on all but three samples. The OSL signal is not expected to fade significantly. Four samples (UW1331, UW1336, UW1338, and UW1339) exhibited significant TL fading, and the TL age was subsequently corrected using the method of Huntley and Lamothe (2001). On two samples (UW1332 and UW1334) fading was not significant, and on one sample (UW1335) the data were too scattered to make a judgment. On one of the samples where fading was not tested (UW1337), the TL and OSL ages were in agreement, so it is assumed fading is not significant. On the other two (UW1330 and UW1333), fading cannot be discounted, so the TL ages must be considered minimum.

The b-value, used to adjust for lower efficiency of alpha radiation in producing luminescence, was determined for all samples using TL and for six of the samples using OSL. The b-value for OSL varied little among samples so an average (0.669 ± 0.119 Gy μm^2) was taken as the best estimate for the samples not measured.

Table 5 gives the derived ages. Because of the high OSL, the TL was taken to be the best estimate of age for UW1332, UW1335, and UW1336. The TL ages (corrected for fading where appropriate) and OSL ages agreed on five sherds (UW1331, UW1334, UW1337, UW1338, and UW1339) and a weighted average was taken as the best estimate. Because the TL can only be considered a minimum age (because of possible fading) on UW1333, the OSL age is considered the best estimate for that sample. UW1330 is problematic. The TL age must be considered a minimum because of possible fading, but it falls within the same general range as UW1332 and UW1333 from the same site. Plus it is in the right stratigraphic order. The OSL is much older, but is in agreement with the age (from both TL and OSL) of UW1331. Both ages are given in Table 5.

Interpretation of the ages is not straightforward. The ages of five of the samples are close to expectations. The TL age of UW1330 is also close to expectations if the OSL result can be considered anomalous. The other three samples (UW1331, UW1335 and UW1336) are much older than expected. These cannot be dismissed because of anomalous OSL, because for UW1331 the OSL and TL ages agree and for the other two samples, the ages are based on TL only. Perhaps consideration should be given to the possibility that the two sites from which these samples were taken have an earlier component (or at least older ceramics). Sand-tempered ceramics have been made on the Texas coast for two millennia. Should it be completely out of the question, that some older ceramics have found their way into sites that were generally occupied at a later date?

Appendix: Procedures for Thermoluminescence Analysis of Pottery

Sample preparation -- fine grain

The sherd is broken to expose a fresh profile. Material is drilled from the center of the cross-section, more than 2 mm from either surface, using a tungsten carbide drill tip. The material retrieved is ground gently by a corundum mortar and pestle, treated with HCl, and then settled in acetone for 2 and 20 minutes to separate the 1-8 μm fraction. This is settled onto a maximum of 72 stainless steel discs.

Glow-outs

Thermoluminescence is measured by a Daybreak reader using a 9635Q photomultiplier with a Corning 7-59 blue filter, in N_2 atmosphere at 1°C/s to 450°C. A preheat of 240°C with no hold time precedes each measurement. Artificial irradiation is given with a ^{241}Am alpha source and a ^{90}Sr beta source, the latter calibrated against a ^{137}Cs gamma source. Discs are stored at room temperature for at least one week after irradiation before glow out. Data are processed by Daybreak TLApplic software. For feldspars, a blue-green Schott BG39 filter is used for emission.

Fading test

Several discs are used to test for anomalous fading. The natural luminescence is first measured by heating to 450°C. The discs are then given an equal alpha irradiation and stored at room temperature for varied times: 10 min, 2 hours, 1 day, 1 week and 8 weeks. The irradiations are staggered in time so that all of the second glows are performed on the same day. The second glows are normalized by the natural signal and then compared to determine any loss of signal with time (on a log scale). If the sample shows fading and the signal versus time values can be reasonably fit to a logarithmic function, an attempt is made to correct the age following procedures recommended by Huntley and Lamothe (2001).

Equivalent dose

The equivalent dose is determined by a combination additive dose and regeneration (Aitken 1985). Additive dose involves administering incremental doses to natural material. A growth curve plotting dose against luminescence can be extrapolated to the dose axis to estimate an equivalent dose, but for pottery this estimate is usually inaccurate because of errors in extrapolation due to nonlinearity. Regeneration involves zeroing natural material by heating to 450°C and then rebuilding a growth curve with incremental doses. The problem here is sensitivity change caused by the heating. By constructing both curves, the regeneration curve can be used to define the extrapolated area and to correct for sensitivity change by comparing it with the additive dose curve. This works where the shapes of the curves differ only in scale (i.e., the sensitivity change is independent of dose). The curves are combined using the "Australian slide" method in a program developed by David Huntley of Simon Fraser University (Prescott et al. 1993). The equivalent dose is taken as the horizontal distance between the two curves after a scale adjustment for sensitivity change. Where the growth curves are not linear, they are fit to quadratic functions. Dose increments (usually five) are determined so that the maximum additive dose results in a signal about three times that of the natural and the maximum regeneration dose about five times the natural. If the regeneration curve has a significant negative intercept, which is not expected given current understanding, the additive dose intercept is taken as the best, if not fully reliable approximation.

A plateau region is determined by calculating the equivalent dose at temperature increments between 240° and 450°C and determining over which temperature range the values do not differ significantly. This plateau region is compared with a similar one constructed for the b-value (alpha efficiency), and the overlap defines the integrated range for final analysis.

Alpha effectiveness

Alpha efficiency is determined by comparing additive dose curves using alpha and beta irradiations. The slide program is also used in this regard, taking the scale factor (which is the ratio of the two slopes) as the b-value (Aitken 1985).

Radioactivity

Radioactivity is measured by alpha counting in conjunction with atomic emission for ^{40}K. Samples for alpha counting are crushed in a mill to flour consistency, packed into plexiglass containers with ZnS:Ag screens, and sealed for one month before counting. The pairs technique is used to separate the U and Th decay series. For atomic emission measurements, samples are dissolved in HF and other acids and analyzed by a Jenway flame photometer. K concentrations for each sample are determined by bracketing between standards of known concentration. Conversion to ^{40}K is by natural atomic abundance. Radioactivity is also measured, as a check, by beta counting, using a Risø low level beta GM multicounter system. About 0.5 g of crushed sample is placed on each of four plastic sample holders. All are counted for 24 hours. The average is converted to dose rate following Bøtter-Jensen and Mejdahl (1988) and compared with the beta dose rate calculated from the alpha counting and flame photometer results.

Both the sherd and an associated soil sample are measured for radioactivity. Additional soil samples are analyzed where the environment is complex, and gamma contributions determined by gradients (after Aitken 1985: appendix H). Cosmic radiation is determined after Prescott and Hutton (1988). Radioactivity concentrations are translated into dose rates following Adamiec and Aitken (1998).

Moisture Contents

Water absorption values for the sherds are determined by comparing the saturated and dried weights. For temperate climates, moisture in the pottery is taken to be 80 ± 20 percent of total absorption, unless otherwise indicated by the archaeologist. Again for temperate climates, soil moisture contents are taken from typical moisture retention quantities for different textured soils (Brady 1974: 196), unless otherwise measured. For drier climates, moisture values are determined in consultation with the archaeologist.

Procedures for Optically Stimulated or Infrared Stimulated Luminescence of Fine-grained pottery.

Optically stimulated luminescence (OSL) or infrared stimulated luminescence (IRSL) on fine-grain (1-8μm) pottery samples is carried out on single aliquots following procedures adapted from Banerjee et al. (2001), and Roberts and Wintle (2001). Equivalent dose is determined by the single-aliquot regenerative dose (SAR) method (Murray and Wintle 2000).

The SAR method measures the natural signal and the signal from a series of regeneration doses on a single aliquot. The method uses a small test dose to monitor and correct for sensitivity changes brought about by preheating, irradiation or light stimulation. SAR consists of the following steps: 1) preheat, 2) measurement of natural signal (OSL or IRSL), L(1), 3) test dose, 4) cut heat, 5) measurement of test dose signal, T(1), 6) regeneration dose, 7) preheat, 8) measurement of signal from regeneration, L(2), 9) test dose, 10) cut heat, 11) measurement of test dose signal, T(2), 12) repeat of steps 6 through 11 for various regeneration doses. A growth curve is constructed from the L(i)/T(i) ratios and the equivalent dose is found by interpolation of L(1)/T(1). Usually a zero regeneration dose and a repeated regeneration dose are employed to insure the procedure is working properly. For fine-grained ceramics, a preheat of 240°C for 10s, a test dose of 1.8 Gy, and a cut heat of 160°C are currently being used, although these parameters may be modified from sample to sample.

The luminescence, L(i) and T(i), is measured on a Risø TL-DA-15 automated reader by a succession of two stimulations. First 100 s at 125°C of IRSL (880nm diodes), and second 100s at 125°C of OSL (470nm diodes). The OSL is also called blue stimulated luminescence (BSL). Detection is through 7.5mm of Hoya U340 (ultra-violet) filters. The two stimulations are used to construct IRSL and OSL growth curves, so that two estimations of equivalent dose are available. Only feldspars are sensitive to IRSL, but they are also sensitive to blue light, but current data suggest that most of the feldspar signal is removed by the IRSL stimulation, so that the OSL signal arises predominantly from quartz. This may mean that the OSL signal does not suffer from anomalous fading, but the procedure is still undergoing study and may be modified in the future.

Alpha efficiency differs among IRSL, OSL and TL on fine-grained materials. The b-value was measured for OSL and IRSL by adding two alpha irradiations to the SAR sequence (still maintaining a test dose with beta radiation) and using the difference in slopes between the beta and alpha growth curves to determine as the b-value. The b-value for OSL has been found not to vary much and seems to center around 0.6-0.7 for most samples.

Table A.1.* These sherds were covered by an additional meter of alluvium, which is thought to have been deposited within the last 20 years.

Lab #	*Sample #*	*provenience*	*Depth of burial (cm)*	*Sherd type*
		41AU38 "Little Bethlehem"		
UW1330	2 D	Test pit #1 N108 W99	10-20	Sand-tempered
UW1331	4 A	Test pit #1 N108 W99	30-40	Sand-tempered
UW1332	3 M3	Test pit #1 N108 W99	20-30	Sand-tempered
UW1333	3 K3	Test pit #1 N108 W99	20-30	Sand-tempered
		41GV66 "Mitchell Ridge"		
UW1334	355 I6	N030	5-10	Grog-tempered, asphaltum body
UW1335	356 A4	N030	10-15	Sand-tempered
UW1336	358 J12	N030	15-20	Sand-tempered
		41LB4 "Honeycomb"		
UW1337	123 693-9	Unit 1 N524 E680.5	10-20*	Sand-tempered
UW1338	132 693-18	Unit 1 N525 E681.5	0-10*	Grog-tempered
UW1339	136 729-3	Unit 1 N525 E680	0-10*	Sand-tempered

Table A.2 *As of this writing, radioactivity for UW1339 has only been measured by beta counting. The table will be updated when the other measurements are completed, but no significant difference in the age is expected.

Sample	^{238}U *(ppm)*	^{232}Th *(ppm)*	*K (%)*	*Beta dose rate (Gy/ka)* ß-counting	α-counting/flame photometry
		41AU38 "Little Bethlehem"			
UW1330	3.09±0.22	9.77±1.10	1.00±0.01	1.36±0.13	1.52±0.04
UW1331	3.83±0.22	3.30±0.80	1.05±0.01	1.41±0.14	1.50±0.04
UW1332	2.85±0.19	5.03±0.93	0.87±0.03	1.21±0.10	1.25±0.05
UW1333	2.17±0.16	7.42±0.93	0.82±0.02	1.08±0.08	1.18±0.04
Sediment	2.11±0.20	11.68±1.44	0.70±0.02		
		41GV66 "Mitchell Ridge"			
UW1334	1.67±0.15	8.14±1.16	1.33±0.02	1.38±0.11	1.53±0.04
UW1335	2.34±0.17	6.55±0.95	1.42±0.05	1.61±0.15	1.66±0.05
UW1336	2.46±0.17	4.77±0.89	1.32±0.02	1.59±0.16	1.55±0.04
Sediment	0.80±0.09	3.50±0.72	0.45±0.02		
		41LB4 "Honeycomb"			
UW1337	2.59±0.22	11.66±1.44	0.50±0.01	0.98±0.08	1.09±0.05
UW1338	2.98±0.23	10.44±1.37	0.57±0.04	1.07±0.07	1.18±0.06
UW1339*				0.85±0.12	
Sediment	1.50±0.23	19.94±1.94	1.05±0.04		

Table A.3 * dose rates for UW1339 are approximations based on beta counting.

Sample	*Dose rate (Gy/ka)* alpha	beta	gamma	cosmic	total
		41AU38 "Little Bethlehem"			
UW1330	2.95±0.40	1.38±0.05	0.77±0.07	0.21±0.04	5.31±0.41
UW1331	1.81±0.23	1.35±0.05	0.81±0.07	0.19±0.04	4.15±0.25
UW1332	1.54±0.16	1.15±0.05	0.78±0.07	0.20±0.04	3.67±0.19
UW1333	1.63±0.16	1.08±0.04	0.79±0.07	0.20±0.04	3.69±0.18
		41GV66 "Mitchell Ridge"			
UW1334	1.16±0.13	1.32±0.06	0.31±0.03	0.22±0.05	3.01±0.15
UW1335	1.18±0.12	1.46±0.07	0.33±0.03	0.21±0.04	3.18±0.15
UW1336	0.96±0.08	1.31±0.06	0.33±0.03	0.20±0.04	2.80±0.11
		41LB4 "Honeycomb"			
UW1337	1.99±0.28	0.99±0.05	1.24±0.11	0.24±0.05	4.46±0.31
UW1338	2.08±0.19	1.05±0.06	1.05±0.27	0.26±0.05	4.44±0.34
UW1339*	1.14±0.11	0.77±0.05	1.024±0.27	0.26±0.05	3.19±0.30

Table A.4 * For "fit", L= linear, Q=quadratic. "Scale" is the ratio of additive dose and regeneration growth curves.

Sample	*Equivalent dose (Gy)*		*TL parameters**			*b-value (Gy μm^2)*	
	TL	OSL	Plateau (°C)	fit	scale	TL	OSL
			41AU38 "Little Bethlehem"				
UW1330	4.35±0.71	8.58±1.90	250-340	L	0.73±0.12	3.28±0.40	0.66±0.06
UW1331	5.28±0.36	5.08±0.40	260-360	L	1	2.48±0.28	0.58±0.02
UW1332	3.48±0.40	6.25±0.56	260-360	L	0.79±0.10	2.32±0.20	0.74±0.05
UW1333	2.84±0.10	2.54±0.13	300-360	L	1	2.47±0.20	
			41GV66 "Mitchell Ridge"				
UW1334	2.00±0.28	1.71±0.15	280-370	L	1.51±0.15	2.05±0.18	0.87±0.09
UW1335	6.77±0.71		280-340	L	0.59±0.06	1.92±0.16	
UW1336	3.47±0.19		300-370	Q	1	1.78±0.09	
			41LB4 "Honeycomb"				
UW1337	4.07±0.38	2.30±0.11	250-330	L	1	2.23±0.28	
UW1338	2.06±0.09	1.82±0.06	280-310	L	1	2.35±0.17	0.58±0.03
UW1339	1.59±0.34	1.47±0.05	250-350	Q	1.65±0.21	2.02±0.17	0.57±0.03

Table 5 * Minimum age because of possibility of fading

Sample	*Age (ka)*	*% error*	*Calendar age*	*Basis for age*
		41AU38 "Little Bethlehem"		
UW1330	0.818±0.147	18.1	AD 1188 ± 147	TL*
	2.120±0.204	9.6	AD 114 ± 204	OSL
UW1331	1.858±0.155	8.4	AD 148 ± 155	OSL-corrected TL
UW1332	0.949±0.120	12.7	AD 1057 ± 120	TL
UW1333	1.017±0.076	7.5	AD 989 ± 76	OSL
		41GV66 "Mitchell Ridge"		
UW1334	0.708±0.059	8.3	AD 1298 ± 59	OSL-TL
UW1335	2.130±0.247	11.6	124 ± 247 BC	TL
UW1336	2.271±0.437	19.2	265 ± 437 BC	Corrected TL
		41LB4 "Honeycomb"		
UW1337	0.787±0.051	6.5	AD 1219 ± 51	OSL-TL
UW1338	0.646±0.062	9.6	AD 1360 ± 62	OSL-corrected TL
UW1339	0.625±0.076	12.2	AD 1381 ± 76	OSL-corrected TL

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Table B.1 Orifice diameters of selected sherds.

Lot #	Sherd #	orifice diameter (cm)
	Mitchell Ridge	
360	41GV66 360 Z5-1	26
385	41GV66 385F	22
392	41GV66 392B2	25
393	41GV66 393R2	25
416	41GV66 416 G2	16
431	41GV66 431 A	17
435	41GV66 435 B	41
436	41GV66 436 L4	24
436	41GV66 436 K4	27
437	41GV66 437 D	32
474	41GV66 474 D2-3	20
	Honeycomb	
6	41LB4-6 91-17	10
7	41LB4-7 92-3	12
7	j/t 41LB4-7 92-3	12
7	41LB4-7 735-5	19
11	j/t 41LB4-11 838-10	12
118	41LB4-118 406-1	10
135	41LB4-135 752-27	10
135	j/t 41LB4-135 752-27	10
143	41LB4-143 529-87-Q	15
143	41LB4-143 529-87-O	15
143	41LB4-143 529-87-P	15
143	41LB4-143 529-87-C	15
143	41LB4-143 529-D	15
143	41LB4-143 529-E	15
143	41LB4-143 529-H	15
143	41LB4-143 529-I	15
143	41LB4-143 529-J	15
143	41LB4-143 529-L	15
143	41LB4-143 529-87-N	15
143	41LB4-143 529-87-A	15
143	41LB4-143 529-87-B	15
143	41LB4-143 529-F	15
143	41LB4-143 529-G	15
143	41LB4-143 529-K	15
143	41LB4-143 529-M	15
143	41LB4-143 529-104-A	26
148	41LB4-148 700-P	8

Table B.2 Body diameters of selected sherds.

Lot #	Sherd #	chord length (mm)	body diameter (mm)
	Mitchell Ridge		
355	41GV66 355 E6	20	74.89
355	41GV66 355 I6	30	173.07
358	41GV66 358 J2	20	69.95
360	41GV66 360 L7	20	88.48
360	41GV66 360 Z5-1	20	312.82
360	41GV66 360 K7	20	312.82
360	41GV66 360 H7-1	20	101
360	41GV66 360 Q6	25	92.82
360	41GV66 360 V6	20	244.31
361	41GV66 361 H3	20	126.58
362	41GV66 362 A9-1	20	74.63
362	41GV66 362 N7	20	102.51
376	41GV66 376 S	20	113.88
376	41GV66 376 A2	25	138.8
379	41GV66 379 Y2	20	84.88
379	41GV66 379 S3	20	104.59
380	41GV66 380 N2	20	82.21
385	41GV66 385D	20	88.07
386	41GV66 386L	20	116.47
386	41GV66 386Q	20	84.53
387	41GV66 387M2	30	97.31
389	41GV66 389W5	20	253.56
389	41GV66 389B6	20	75.16
393	41GV66 393E	25	115.01
395	41GV66 395A2	20	81.57
395	41GV66 395V2	20	339.28
399	41GV66 399B4	20	85.93
399	41GV66 399D4	20	164.54
401	41GV66 401R	20	136.79
405	41GV66 405H	20	500.2
408	41GV66 408 S2	20	63.72
408	41GV66 408 G2	25	193.71
410	41GV66 410 J3	20	74.89
418	41GV66 418 O	25	77.73
419	41GV66 419 G2	25	70.52
419	41GV66 419 J	25	82.08
423	41GV66 423 R2	20	81.25
433	41GV66 433 B3	20	109.04
434	41GV66 434 E	20	56.62
435	41GV66 435 A	30	133.67
436	41GV66 436 E4	20	103.54
436	41GV66 436 A3	25	112.61
437	41GV66 437 O2	25	140.14
452	41GV66 452 M5	20	62.44
453	41GV66 453 J4	25	111.46
475	41GV66 475 F4	20	163.22
475	41GV66 475 V3	20	88.86
475	41GV66 475 C4	25	117.94
475	41GV66 475 I4-4	25	248.65
475	41GV66 475 H4	30	87.25

Table B.2 continued. Body diameters of selected sherds.

Lot #	Sherd #	chord length (mm)	body diameter (mm)
506	41GV66 506 B	20	80.32
510	41GV66 510 A	20	114.52
511	41GV66 511 D	20	148.82
512	41GV66 512 A	20	114.52
	Honeycomb		
5	41LB4-5 918-19	20	74.63
6	41LB4-6 91-22	25	1116.21
7	41LB4-7 735-11	20	317.78
7	41LB-7 735-8	25	186.85
14	41LB4-14 332-1	25	118.81
90	41LB4-90 416-4	25	137.61
122	41LB4-122 102-12	20	168.66
122	41LB4-122 102-11	20	122.77
123	41LB4-123 693-19	25	109.58
132	41LB4-132 718-15	20	128.2
133	41LB4-133 663-8	25	219.25
135	41LB4-135 752-18	25	102.36
136	41LB4-136 729-4	20	124.27
140	41LB4-140 657-32	20	158.115
140	41LB4-140 641-2	20	128.99
140	41LB4-140 657-23	20	225.16
140	41LB4-140 657-27	20	130.64
140	41LB4-140 657-29	25	140.63
141	41LB4-141 547-5	25	-529.96
141	41LB4-141 538-82	25	111.84
142	41LB4-142 280-1	20	121.31
142	41LB4-142 280-2	20	119.89
143	41LB4-143 529-239	20	57.21
143	41LB4-143 529-244	20	105.67
143	41LB4-143 529-250	20	138.66
143	41LB4-143 529-206	20	110.2
143	41LB4-143 529-1	20	161.91
143	41LB4-143 529-209	25	316.15
143	41LB4-143 529-235	25	209.08
143	41LB4-143 529-243	25	184.67
143	bag w/ 41LB4-143 529-250	25	121.96
143	41LB4-143 529-252	25	1644.83
143	41LB4-143 529-245	30	132.17
143	41LB4-143 529-249	30	134.44
144	41LB4-144 668-16	25	168.05

APPENDIX C: GRAIN COUNTS

Table C.1 Grain counts of thin sections of selected sherds from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

Sample ID	Paste type	Vessel part	Surface treatment	Qm	Qu	Qp	Li	Fk	Fp	F	Po	Gr	B	loc	Unk	N
Mitchell Ridge																
41GV66-452-Y4	shell	body	plain	39	3	2	1	_	_	1	18	_	18	7	1	90
41GV66-362-G6	grog	rim	aspahltum exterior	87	10	9	10	1	_	3	52	25	_	11	10	219
41GV66-413-A	shell or bone	body	punctate	136	7	10	8	_	_	2	46	2	7	6	4	228
41GV66-399-D	sand	rim	incised ticks on lip	6	2	1	1	_	_	1	1	_	_	_	_	12
41GV66-389-I5	sand	body	burnishing exterior	74	8	4	4	_	_	3	14	_	_	2	_	109
41GV66-508-C	sand	body	plain	13		1	1	7	1	_	20	_	_	1	1	45
41GV66-511-G	sand	body	dark spots exterior	65	6	3	5	_	_	1	29	1	_	7	6	123
41GV66-394-10	grog	body	resin exterior	28	6	5	9	1	_	7	6	1	_	3	1	67

Table C.1 continued.Grain counts of thin sections of selected sherds from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

Sample ID	Paste type	Vessel part	Surface treatment	Qm	Qu	Qp	Li	Fk	Fp	F	Po	Gr	B	loc	Unk	N
Honeycomb																
41LB4-127-769-8	grog	body	sooted interior, combed exterior	8	_	_	1	_	_	1	2	2	_	6	_	20
41LB4-135-752-O2	grog	rim	incised; red film	14	2	1	3	_	_	1	7	8	_	3	_	41
41LB4-144-519-2	grog	body	burnishing exterior	46	5	2	_	_	_	1	13	13	_	1	_	86
41LB4-151-802-5	grog	body	incised	63	12	5	2	_	_	5	34	17	_	12	_	148
41LB4-8-93-7	bone	body	plain	35	5	4	3	_	_	2	14	50	50	4	_	117
41LB4-76-397-15	sand	body	plain	54	8	6	8	4	_	_	30	10	_	4	1	125
41LB4-143-529-227	grog	body	dark spots interior	31	7	2	2	_	_	2	28	8	_	2	1	86

Table C.1 continued.Grain counts of thin sections of selected sherds from Mitchell Ridge (41GV66), Honeycomb (41LB4), and Little Bethlehem (41AU38).

Little Bethlehem																
41AU38-54-N	bone	rim	incised	50	7	4	_	_	1	_	11	_	35	9	_	117
41AU38-16-Y	sand	body	pitting interior	31	7	4	3	9	_	_	10	_	_	1	_	63
41AU38-72-A2	sand	body	dark spots interior	81	27	14	2	18	4	_	50	_	1	7	_	204
41AU38-74-B	sand	body	plain	31	6	4	4	2	_	_	10	_	_	3	_	58

APPENDIX D: ANALYSIS OF THE FATTY ACID COMPOSITIONS OF ARCHAEOLOGICAL POTTERY RESIDUES FROM SITES 41AU38, 41GV66, AND 41LB4.

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Introduction

A total of 23 potsherds from three sites 41AU38, 41GV66 and 41LB4, were submitted for analysis; where possible, subsamples were taken from larger sherds. Exterior surfaces were ground off to remove any contaminants and samples were crushed. Absorbed lipid residues were extracted with organic solvents. Fatty acid components of the lipid extracts were analyzed using gas chromatography. Residues were identified using criteria developed from the decomposition patterns of experimental residues. The first section of this report outlines the development of the identification criteria. Following this, analytical procedures and results are presented.

Fatty Acids and Development of the Identification Criteria

Introduction and Previous Research

Fatty acids are the major constituents of fats and oils (lipids) and occur in nature as triglycerides, consisting of three fatty acids attached to a glycerol molecule by ester-linkages. The shorthand convention for designating fatty acids, Cx:yωz, contains three components. The "Cx" refers to a fatty acid with a carbon chain length of x number of atoms. The "y" represents the number of double bonds or points of unsaturation, and the "ωz" indicates the location of the most distal double bond on the carbon chain, i.e. closest to the methyl end. Thus, the fatty acid expressed as C18:1ω9, refers to a mono-unsaturated isomer with a chain length of 18 carbon atoms with a single double bond located nine carbons from the methyl end of the chain. Similarly, the shorthand designation, C16:0, refers to a saturated fatty acid with a chain length of 16 carbons.

Their insolubility in water and relative abundance compared to other classes of lipids, such as sterols and waxes, make fatty acids suitable for residue analysis. Since employed by Condamin *et al.* (1976), gas chromatography has been used extensively to analyze the fatty acid component of absorbed archaeological residues. The composition of uncooked plants and animals provides important baseline information, but it is not possible to directly compare modern uncooked plants and animals with highly degraded archaeological residues. Unsaturated fatty acids, which are found widely in fish and plants, decompose more readily than saturated fatty acids, sterols or waxes. In the course of decomposition, simple addition reactions might occur at points of unsaturation (Solomons 1980) or peroxidation might lead to the formation of a variety of volatile and non-volatile products which continue to degrade (Frankel 1991). Peroxidation occurs most readily in fatty acids with more than one point of unsaturation.

Attempts have been made to identify archaeological residues using criteria that discriminate uncooked foods (Marchbanks 1989; Skibo 1992; Loy 1994). Marchbanks' (1989) percent of saturated fatty acids (%S) criteria has been applied to residues from a variety of materials including pottery, stone tools and burned rocks (Marchbanks 1989; Marchbanks and Quigg 1990; Collins *et al.* 1990). Skibo (1992:89) could not apply the %S technique and instead used two ratios of fatty acids, C18:0/C16:0 and C18:1/C16:0. He (1992) reported that it was possible to link the uncooked foods with residues extracted from modern cooking pots actively used to prepare one type of food; however, the ratios could not identify food mixtures. The utility of these ratios did not extend to residues extracted from archaeological potsherds because the ratios of the major fatty acids in the residue changed with decomposition (Skibo 1992:97). Loy (1994) proposed the use of a Saturation Index (SI), determined by the ratio: SI = 1-[(C18:1+C18:2)/C12:0+C14:0+C16:0+C18:0)]. He (1994) admitted, however, that poorly understood decompositional changes to the original suite of fatty acids make it difficult to develop criteria for distinguishing animal and plant fatty acid profiles in archaeological residues.

The major drawback of the distinguishing ratios proposed by Marchbanks (1989), Skibo (1992) and Loy (1994) is they have never been empirically tested. The proposed ratios are based on criteria that discriminate food classes on the basis of their original fatty acid composition. The resistance of these criteria to the effects of decompositional changes has not been demonstrated. Rather, Skibo (1992) found his fatty acid ratio criteria could not be used to identify highly decomposed archaeological samples.

In order to identify a fatty acid ratio unaffected by degradation processes, Patrick *et al.* (1985) simulated the long-term decomposition of one sample and monitored the resulting changes. An experimental cooking residue of seal was prepared and degraded in order to identify a stable fatty acid ratio. Patrick *et al.* (1985) found that the ratio of two C18:1 isomers, oleic and vaccenic, did not change with decomposition; this fatty acid ratio was then used to identify an archaeological vessel residue as seal. While the fatty acid composition of uncooked foods must be known, Patrick *et al.* (1985) showed that the effects of cooking and decomposition over long periods of time on the fatty acids must also be understood.

Development of the Identification Criteria

As the first stage in developing the identification criteria used herein, the fatty acid compositions of more than 130 uncooked Native food plants and animals from Western Canada were determined using gas chromatography (Malainey 1997; Malainey *et al.* 1999a). When the fatty acid compositions of modern food plants and animals were subject to cluster and principal component analyses, the resultant groupings generally corresponded to divisions that exist in nature (Table D.1). Clear differences in the fatty acid composition of large mammal fat, large herbivore meat, fish, plant roots, greens and berries/seeds/nuts were detected, but the fatty acid composition of meat from medium-sized mammals resembles berries/seeds/nuts.

Samples in cluster A, the large mammal and fish cluster had elevated levels of C16:0 and C18:1 (Table D.1). Divisions within this cluster stemmed from the very high level of C18:1 isomers in fat, high levels of C18:0 in bison and deer meat and high levels of very long chain unsaturated fatty acids (VLCU) in fish. Differences in the fatty acid composition of plant roots, greens and berries/seeds/nuts reflect the amounts of C18:2 and C18:3ω3 present. The berry, seed, nut and small mammal meat samples appearing in cluster B have very high levels of C18:2, ranging from 35% to 64% (Table D.1). Samples in subclusters V, VI and VII have levels of C18:1 isomers from 29% to 51%, as well. Plant roots, plant greens and some berries appear in cluster C. All cluster C samples have moderately high levels of C18:2; except for the berries in subcluster XII, levels of C16:0 are also elevated. Higher levels of C18:3ω3 and/or very long chain saturated fatty acids (VLCS) are also common except in the roots which form subcluster XV.

Secondly, the effects of cooking and degradation over time on fatty acid compositions were examined. Originally, 19 modern residues of plants and animals from the plains, parkland and forests of Western Canada were prepared by cooking samples of meats, fish and plants, alone or combined, in replica vessels over an open fire (Malainey 1997; Malainey *et al.* 1999b). After four days at room temperature, the vessels were broken and a set of sherds analysed to determine changes after a short term of decomposition. A second set of sherds remained at room temperature for 80 days, then placed in an oven at 75°C for a period of 30 days in order to simulate the processes of long term decomposition. The relative percentages were calculated on the basis of the ten fatty acids (C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1w9, C18:1w11, C18:2) that regularly appeared in Precontact Period vessel residues from Western Canada. Observed changes in fatty acid composition of the experimental cooking residues enabled the development of a method for identifying the archaeological residues (Table D.2).

It was determined that levels of medium chain fatty acids (C12:0, C14:0 and C15:0), C18:0 and C18:1 isomers in the sample could be used to distinguish degraded experimental cooking residues (Malainey 1997; Malainey *et al.* 1999b). These fatty acids are suitable for the identification criteria because saturated fatty acids are stable and the mono-unsaturated fatty acid degrades very slowly, as compared to polyunsaturated fatty acids (deMan 1992). Higher levels of medium chain fatty acids, combined with low levels of C18:0 and C18:1 isomers, were detected in the decomposed experimental residues of plants, such as roots, greens and most berries. High levels of C18:0 indicated the presence of large herbivores. Moderate levels of C18:1 isomers, with low levels of C18:0, indicated the presence of either fish or foods similar in composition to corn. High levels of C18:1 isomers with low levels of C18:0, were found in residues of beaver or foods of similar fatty acid composition. The criteria for identifying six types of residues were established experimentally; the seventh type, plant with large herbivore, was inferred (Table D.2). These criteria were applied to residues extracted from more than 200 pottery cooking vessels from 18 Western Canadian sites (Malainey 1997; Malainey *et al.* 1999c; 2001b). The identifications were found to be consistent with the evidence from faunal and tool assemblages for each site.

Work has continued to understand the decomposition patterns of various foods and food combinations (Malainey *et al.* 2000a, 2000b, 2000c, 2001a; Quigg *et al.* 2001). The collection of modern foods has expanded to include plants from the Southern Plains. The fatty acid compositions of mesquite beans (*Prosopis glandulosa*), Texas ebony seeds (*Pithecellobium ebano Berlandier*), tasajillo berry (*Opuntia leptocaulis*), prickly pear fruit and pads (*Opuntia engelmannii*), Spanish dagger pods (*Yucca treculeana*), cooked sotol (*Dasylirion wheeler*), agave (*Agave lechuguilla*), cholla (*Opuntia imbricata*), piñon (*Pinus edulis*) and Texas mountain laurel (or mescal) seed (*Sophora secundiflora*) have been determined. Experimental residues of many of these plants, alone or in combination with deer meat, have been prepared by boiling foods in clay cylinders or using sandstone for either stone boiling (Quigg *et al.* 2000) or as a griddle. In order to accelerate the processes of oxidative degradation that naturally occur at a slow rate with the passage of time, the rock or clay tile containing the experimental residue was placed in an oven at 75°C. After either 30 or 68 days, residues were extracted and analysed using gas chromatography.

The results of these decomposition studies enabled refinement of the identification criteria.

Methodology

Descriptions of the samples are presented in Table D.3. Exterior surfaces were removed by grinding off exterior surfaces with a Dremel® tool fitted with a silicon carbide bit. Immediately thereafter, the sample was crushed with a hammer mortar and pestle and the powder transferred to an Erlenmeyer flask. Lipids were extracted using a variation of the method developed by Folch *et al.* (1957). The powdered sample was mixed with a 2:1 mixture, by volume, of chloroform and methanol (2 X 30 mL) using ultrasonication (2 X 10 min). Solids were removed by filtering the solvent mixture into a separatory funnel. The lipid/solvent filtrate was washed with 16 mL of ultrapure water. Once separation into two phases was complete, the lower chloroform-lipid phase was transferred to a round-bottomed flask and the chloroform removed by rotary evaporation. Any remaining water was removed by evaporation with benzene (1.5 mL); 1.5 mL of chloroform-methanol (2:1, v/v) was used to transfer the dry total lipid extract to a screw-top glass vial with a Teflon®-lined cap. The sample was flushed with nitrogen and stored in a -20°C freezer.

A 400 μL sample of the total lipid extract solution was placed in a screw-top test tube and dried in a heating block under nitrogen. Fatty acid methyl esters (FAMES) were prepared by treating the dry lipid with 5 mL of 0.5 N anhydrous hydrochloric acid in methanol (68°C; 60 min). Fatty acids that occur in the sample as di- or triglycerides are detached from the glycerol molecule and converted to methyl esters. After cooling to room temperature, 3.5 mL of ultrapure water was added. FAMES were recovered with petroleum ether (2.5 mL) and transferred to a vial. The solvent was removed by heat under a gentle stream of nitrogen; the FAMES were dissolved in 75 µL of *iso*-octane then transferred to a GC vial with a conical glass insert. Because the FAME concentration was so high, it was necessary to dilute residue WSH 9 in 1 mL *iso*-octane in order to obtain a suitable chromatogram.

Solvents and chemicals were checked for purity by running a sample blank. The entire lipid extraction and methyl esterification process was performed and FAMES were dissolved in 75 µL of *iso*-octane. Traces of contamination were subtracted from sample chromatograms. The relative percentage composition was calculated by dividing the integrated peak area of each fatty acid by the total area of fatty acids present in the sample.

The step in the extraction procedure where the chloroform, methanol and lipid mixture is washed with water is standard procedure for the extraction of lipids from modern samples. Following Evershed *et al.* (1990), who reported that this step was unnecessary for the analysis of archaeological residues, previously the solvent-lipid mixture was not washed. This step was recently adopted to remove impurities so that clearer chromatograms could be obtained in the region where very long chain fatty acids (C20:0, C20:1, C22:0 and C24:0) occur. It was anticipated that the detection and accurate assessment of these fatty acids could be instrumental in separating residues of animal origin from those of plant (Malainey *et al.* 2000a, 2000b, 2000c, 2001a).

In order to identify the residue, the relative percentage composition was determined first with respect to all fatty acids present in the sample (including very long chain fatty acids) (see Table D.4) and secondly with respect to the ten fatty acids utilized in the development of the identification criteria (C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1w9, C18:1w11 and C18:2) (not shown). The second step is necessary for the application of the identification criteria presented in Table D.2.

It must be understood that the identifications given do not necessarily mean that those particular foods were actually prepared because different foods of similar fatty acid composition and lipid content would produce similar residues. It is possible only to say that the material of origin for the residue was similar in composition to the food(s) indicated.

Gas Chromatography Analysis Parameters

The GC analysis was performed on a Varian 3800 gas chromatograph fitted with a flame ionization detector connected to a personal computer. Samples were separated using a DB-23 fused silica capillary column (30 m X 0.25 mm I.D.; J&W Scientific; Folsom, CA). An autosampler injected a 1 μL sample using a split/splitless injection system. Hydrogen was used as the carrier gas with a column flow of 1.0 mL/min. Column temperature was held at 80 °C for 1 minute then increased to 140 °C at a rate of 20 °C per minute. It was then programmed from 140 to 230°C at 4°C per minute. The upper temperature was held for 5 minutes. Chromatogram peaks were integrated using Varian MS Workstation® software and identified through comparisons with external qualitative standards (NuCheck Prep; Elysian, MN).

Results of Archaeological Data Analysis

The fatty acid compositions of nineteen residues are presented in Table D.4. Four residues, WSH 5, WSH 6, WSH 19 and WSH 20, contained insufficient fatty acids for analysis. The term, Area, represents the area under the chromatographic peak of a given fatty acid, as calculated by the Varian MS Workstation ® software minus the solvent blank. The term, Rel%, represents the relative percentage of the fatty acid with respect to the total fatty acids in the sample. Hydroxide or peroxide degradation products can interfere with the integration of the C22:0 and C22:1 peaks; these fatty acids were excluded from the analysis.

A total of six residues, WSH 8, WSH 9, WSH 18, WSH 22, WSH 23 and WSH 25, appear to reflect the preparation of low fat content plants. These residues are characterized by elevated levels of medium chain fatty acids and relatively low levels of

C18:0 and C18:1 isomers. Foods known to produce similar residues include plant greens, roots, certain berries and low fat starchy seeds. The lipid recoveries from WSH 9, WSH 23 and WSH 25 were very high, which may suggest the vessels were intensely used.

Five other residues, WSH 3, WSH 4, WSH 7, WSH 15 and WSH 16, appear to reflect the preparation of medium-low fat content plants. These residues are similar to those described above except that the level of C18:1 isomers is slightly higher. Foods known to produce similar residues include prickly pear tunas and Spanish Dagger pods.

Medium fat content foods appear to occur in six residues. A variety of plant and animal foods are known to produce these residues including mesquite beans, corn, cholla, freshwater fish, terrapin, *Rabdotus* snail and fat-depleted elk. The decomposed cooking residues of these foods are characterized by slightly elevated levels of C18:1 isomers and relatively low levels of C18:0. Amounts of medium chain fatty acids are very high in five of these residues, WSH 10, WSH 11, WSH 12, WSH 14 and WSH 21, which suggests that the medium fat content foods were prepared in combination with low fat content plants. Residue WSH 13 likely reflects the preparation of a medium fat content food alone.

Three samples, WSH 2, WSH 17 and WSH 24 have elevated levels of C18:0, which occurs in residues produced from large herbivore meat. Bison, deer and moose are examples of large herbivores that produce similar residues. Other foods known to produce similar residues include javelina meat and the seed oils of certain tropical plants, such as sotol.

One sample, WSH 1, has elevated levels of both C18:0 and medium chain fatty acids. This residue most likely reflects a combination of low fat content plants and large herbivore meat.

One sample, WSH 26, has high levels of C18:1 isomers and low levels of C18:0. The most probable source of this residue is locally available high fat content seeds and nuts. The rendered fat of animals is very similar in fatty acid composition. Levels of medium chain fatty acids of about 10% slightly favor a plant origin for this residue.

Table D.1. Summary of average fatty acids compositions of modern food groups generated by hierarchical cluster analysis.

Cluster	**A**				**B**						**C**				
Subcluster	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**XIII**	**XIV**	**XV**
Type	Mammal Fat and Marrow	Large Herbivore Meat	Fish	Fish	Berries and Nuts	Mixed	Seeds and Berries	Roots	Seeds	Mixed	Greens	Berries	Roots	Greens	Roots
C16:0	19.90	19.39	16.07	14.10	3.75	12.06	7.48	19.98	7.52	10.33	18.71	3.47	22.68	24.19	18.71
C18:0	7.06	20.35	3.87	2.78	1.47	2.36	2.58	2.59	3.55	2.43	2.48	1.34	3.15	3.66	5.94
C18:1	56.77	35.79	18.28	31.96	51.14	35.29	29.12	6.55	10.02	15.62	5.03	14.95	12.12	4.05	3.34
C18:2	7.01	8.93	2.91	4.04	41.44	35.83	54.69	48.74	64.14	39.24	18.82	29.08	26.24	16.15	15.61
C18:3	0.68	2.61	4.39	3.83	1.05	3.66	1.51	7.24	5.49	19.77	35.08	39.75	9.64	17.88	3.42
VLCS	0.16	0.32	0.23	0.15	0.76	4.46	2.98	8.50	5.19	3.73	6.77	9.10	15.32	18.68	43.36
VLCU	0.77	4.29	39.92	24.11	0.25	2.70	1.00	2.23	0.99	2.65	1.13	0.95	2.06	0.72	1.10

Table D.2. Criteria for the identification of archaeological residues based on the decomposition patterns of experimental cooking residues prepared in pottery vessels.

Identification	**Medium Chain**	**C18:0**	**C18:1 isomers**
Large herbivore	≤ 15%	≥ 27.5%	≤ 15%
Large herbivore with plant OR Bone marrow	low	≥ 25%	$15\% \leq X \leq 25\%$
Plant with large herbivore	≥ 15%	≥ 25%	no data
Beaver	low	Low	≥ 25%
Fish or Corn	low	≤ 25%	$15\% \leq X \leq 27.5\%$
Fish or Corn with Plant	≥ 15%	≤ 25%	$15\% \leq X \leq 27.5\%$
Plant (except corn)	≥ 10%	≤ 27.5%	≤ 15%

Table D.3. List of pottery samples analyzed.

Lab No.	**Sherd Number**	**Characteristics**	**Sample Size (g)**
WSH 1	41AU38 16 Z	Sandy paste rim sherd	11.189
WSH 2	41 AU38 2 B2	Sandy paste body sherd	10.270
WSH 3	41GV66 362 A5	Sandy paste rim sherd	8.275
WSH 4	41GV66 362 I6	Sandy paste base sherd with asphaltum	8.308
WSH 5	41GV66 362 L7	Grog paste body sherd with asphaltum	7.066
WSH 6	41GV66 360 L7	Sandy paste rim sherd	7.437
WSH 7	41GV66 360 B7	Sandy paste body sherd	10.713
WSH 8	41GV66 412 A	Sandy paste incised rim sherd	8.251
WSH 9	41GV66 416 G2	Rim sherd with asphaltum	7.217
WSH 10	41LB4-123-693-12	Grog paste rim sherd	8.994
WSH 11	41LB4-124-595-1	Grog paste incised rim sherd	6.503
WSH 12	41LB4-123-713-23	Grog rim sherd	6.046
WSH 13	41LB4-139-638-6	Grog rim sherd	7.473
WSH 14	41LB4-139-638-8	Grog body sherd	11.550
WSH 15	41LB4-151-813-2	Grog rim sherd with missing lip	6.719
WSH 16	41LB4-147-793-34	Grog rim sherd	8.619
WSH 17	41LB4-139-652-5	Bone incised rim sherd	7.180
WSH 18	41AU38 3 O3	Sandy paste body sherd	8.210
WSH 19	41GV66 380 N2	Sandy paste base sherd	5.969
WSH 20	41GV66 376 A2	Grog paste body sherd	6.700
WSH 21	41LB4-122-102-5	Grog paste body sherd with mending hole	8.100
WSH 22	41LB4-124-723-8	Grog body sherd	8.226
WSH 23	41LB4-132-718-15	Sandy paste body sherd	10.286

Table D.4. Fatty acid composition and identification of pottery residues.

Fatty acid	**WSH 1**		**WSH 2**		**WSH 3**		**WSH 4**	
	Area	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**
C12:0	119198	3.03	110297	1.20	1014	0.34	1601	0.65
C14:0	267796	6.82	334668	3.65	15533	5.16	27019	11.01
C14:1	53849	1.37	30074	0.33	3188	1.06	1048	0.43
C15:0	210977	5.37	238464	2.60	8769	2.91	6426	2.62
C16:0	1813627	46.16	3485777	37.98	188031	62.47	121271	49.44
C16:1	6078	0.15	11171	0.12	3294	1.09	3204	1.31
C17:0	256988	6.54	406666	4.43	15424	5.12	2752	1.12
C17:1	238	0.01	7529	0.08	244	0.08	0	0.00
C18:0	999668	25.44	4292412	46.77	15397	5.12	40798	16.63
C18:1s	33758	0.86	129154	1.41	37762	12.55	29703	12.11
C18:2	6515	0.17	10255	0.11	4081	1.36	2408	0.98
C18:3w3	102183	2.60	52896	0.58	2332	0.77	3299	1.34
C20:0	30399	0.77	38361	0.42	924	0.31	1942	0.79
C20:1	1999	0.05	1171	0.01	2162	0.72	1667	0.68
C24:0	25706	0.65	28317	0.31	2853	0.95	2167	0.88
Total	3928979	100.00	9177212	100.00	301008	100.00	245305	100.00
Identification	**Plant + Large Herbivore**		**Large Herbivore**		**Medium-low fat content plant**		**Medium-low fat content plant**	

Table D.4. continued Fatty acid composition and identification of pottery residues.

Fatty acid	WSH 7		WSH 8		WSH 9		WSH 10	
	Area	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**
C12:0	0	0.00	39667	7.70	0	0.00	7425	2.55
C14:0	23643	9.00	85124	16.52	44270	5.86	30823	10.59
C14:1	1313	0.50	2061	0.40	2868	0.38	4488	1.54
C15:0	15507	5.91	35645	6.92	34365	4.55	26798	9.21
C16:0	154462	58.82	240615	46.69	565261	74.85	90388	31.06
C16:1	2516	0.96	7293	1.42	2272	0.30	5051	1.74
C17:0	5990	2.28	11165	2.17	21883	2.90	31972	10.99
C17:1	447	0.17	431	0.08	0	0.00	1089	0.37
C18:0	19266	7.34	35532	6.90	79373	10.51	34271	11.78
C18:1s	31449	11.98	45201	8.77	1040	0.14	49220	16.91
C18:2	4279	1.63	4966	0.96	0	0.00	3710	1.27
C18:3w3	2896	1.10	4414	0.86	0	0.00	1361	0.47
C20:0	813	0.31	3196	0.62	3899	0.52	4403	1.51
C20:1	0	0.00	0	0.00	0	0.00	0	0.00
C24:0	0	0.00	0	0.00	0	0.00	0	0.00
Total	262581	100.00	515310	100.00	755231	100.00	290999	100.00
Identification	**Medium-low fat content plant**		**Low fat content plant**		**Low fat content plant**		**Medium fat content food + low fat plant**	

Table D.4. continued Fatty acid composition and identification of pottery residues.

Fatty acid	**WSH 11**		**WSH 12**		**WSH 13**		WSH 14	
	Area	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**
C12:0	6944	1.57	7578	3.10	460	0.16	4964	3.07
C14:0	65715	14.84	35280	14.42	22051	7.63	24841	15.34
C14:1	6531	1.48	3811	1.56	3168	1.10	2516	1.55
C15:0	38848	8.78	21216	8.67	16034	5.55	14020	8.66
C16:0	188760	42.64	88915	36.35	127210	44.02	49856	30.79
C16:1	7784	1.76	4224	1.73	6785	2.35	5733	3.54
C17:0	5420	1.22	3260	1.33	20308	7.03	12936	7.99
C17:1	1476	0.33	1412	0.58	1923	0.67	2647	1.63
C18:0	26937	6.08	12900	5.27	31174	10.79	2702	1.67
C18:1s	82698	18.68	56425	23.07	48741	16.87	34694	21.43
C18:2	4615	1.04	4203	1.72	3913	1.35	1579	0.98
C18:3w3	0	0.00	1289	0.53	2039	0.71	1231	0.76
C20:0	6951	1.57	4083	1.67	5192	1.80	4199	2.59
C20:1	0	0.00	0	0.00	0	0.00	0	0.00
C24:0	0	0.00	0	0.00	0	0.00	0	0.00
Total	442679	100.00	244596	100.00	288998	100.00	161918	100.00
Identification	**Medium fat content food + low fat plant**		**Medium fat content food + low fat plant**		**Medium fat content food**		**Medium fat content food + low fat plant**	

Table D.4. continued Fatty acid composition and identification of pottery residues.

Fatty acid	WSH 15		WSH 16		WSH 17		WSH 18	
	Area	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**
C12:0	4082	2.63	2101	0.63	29914	0.49	26285	2.99
C14:0	24347	15.67	45071	13.58	227921	3.70	96857	11.03
C14:1	1756	1.13	5260	1.59	4757	0.08	19580	2.23
C15:0	13995	9.01	40804	12.30	193250	3.13	44513	5.07
C16:0	43773	28.18	137723	41.51	3014970	48.89	452855	51.57
C16:1	3032	1.95	4308	1.30	14544	0.24	4694	0.53
C17:0	21129	13.60	32005	9.65	270379	4.38	29634	3.37
C17:1	2090	1.35	1290	0.39	4732	0.08	1036	0.12
C18:0	11747	7.56	19498	5.88	2129832	34.54	153469	17.48
C18:1s	19974	12.86	34446	10.38	192625	3.12	40771	4.64
C18:2	3387	2.18	4730	1.43	17327	0.28	5338	0.61
C18:3w3	2404	1.55	0	0.00	0	0.00	0	0.00
C20:0	3614	2.33	4550	1.37	66592	1.08	0	0.00
C20:1	0	0.00	0	0.00	0	0.00	0	0.00
C24:0	0	0.00	0	0.00	0	0.00	3116	0.35
Total	155330	100.00	331786	100.00	6166843	100.00	878148	100.00
Identification	**Medium-low fat content plant**		**Medium-low fat content plant**		**Large Herbivore**		**Low fat content plant**	

Table D.4 continued. Fatty acid composition and identification of pottery residues.

Fatty acid	**WSH 21**		**WSH 22**		**WSH 23**	
	Area	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**
C12:0	8531	4.26	7949	1.46	14761	1.13
C14:0	32761	16.38	62084	11.40	90209	6.88
C14:1	1822	0.91	4229	0.78	2617	0.20
C15:0	15708	7.85	47032	8.64	80652	6.15
C16:0	64514	32.25	277520	50.97	792123	60.40
C16:1	4224	2.11	5236	0.96	5424	0.41
C17:0	13124	6.56	23898	4.39	46482	3.54
C17:1	989	0.49	1154	0.21	2435	0.19
C18:0	12749	6.37	67292	12.36	192316	14.66
C18:1s	44470	22.23	44048	8.09	59728	4.55
C18:2	0	0.00	4063	0.75	4870	0.37
C18:3w3	0	0.00	0	0.00	2942	0.22
C20:0	0	0.00	0	0.00	16845	1.28
C20:1	0	0.00	0	0.00	0	0.00
C24:0	1165	0.58	0	0.00	0	0.00
Total	200057	100.00	544505	100.00	1311404	100.00
Identification	**Medium fat content food + low fat plant**		**Low fat content plant**		**Low fat content plant**	

Table D.4 continued. Fatty acid composition and identification of pottery residues.

Fatty acid	WSH 24		WSH 25		WSH 26	
	Area	Rel%	Area	Rel%	Area	Rel%
C12:0	20574	1.11	104301	6.39	98024	2.45
C14:0	93460	5.05	267602	16.40	201565	5.03
C14:1	8515	0.46	66277	4.06	68545	1.71
C15:0	71194	3.85	136148	8.34	107811	2.69
C16:0	817524	44.20	713456	43.73	954829	23.82
C16:1	5603	0.30	18193	1.11	17194	0.43
C17:0	115486	6.24	91652	5.62	122885	3.07
C17:1	0	0.00	13615	0.83	9665	0.24
C18:0	628068	33.96	92047	5.64	395910	9.88
C18:1s	54606	2.95	90899	5.57	1954617	48.75
C18:2	4902	0.27	0	0.00	11573	0.29
C18:3w3	15234	0.82	6967	0.43	49850	1.24
C20:0	5366	0.29	8015	0.49	5420	0.14
C20:1	0	0.00	5012	0.31	0	0.00
C24:0	8926	0.48	17475	1.07	11272	0.28
Total	1849457	100.00	1631658	100.00	4009159	2.45
Identification	Large Herbivore		Low fat content plant		High Fat Content – nuts/seeds/rendered fat	

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APPENDIX E: CHARACTERISTICS OF SHERDS ANALYZED FOR ORGANIC RESIDUES

Table E.1 Characteristics of sherds selected for organic residue analysis.

1 *	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Other
lg. herbivore+plant	16	41AU38 16 Z	11	34.78	30.14	7.97	Y		10YR 5/1	1	3	0	0	0	4	0	0	0	1	3	scratches interior
lg. herbivore	2	41AU38 2 B2	10	37.94	29.99	7.11	N		10YR 7/1	2	2	0	0	0	1	0	0	0	4	3	
low fat content plant	3	41AU38 3 O3	8.2	37.63	24.15	8.69	Y		10YR 7/4	2	2	0	0	0	2	0	0	0	4	3	scratches exterior
medium-low fat content plant	360	41GV66 360 B7	11	38.98	33.29	6.32	N		5YR 5/3	2	1	0	0	0	1	0	0	0	4	3	
none	360	41GV66 360 L7	21	49.14	37.16	9.57	N	8.848 cm	7.5YR 5/2	2	1	0	0	0	1	0	0	0	1	3	spalling interior

*1=Residue type(s), 2=lot number, 3=sherd number, 4=weight of sherd, 5=length of long axis in mm,
6=length of short axis in mm, 7= sherd thickeness in mm, 8= variability in thickness (Yes or No), 9= curvature,
10=color of sherd exterior, 11= firing core (1=oxidized, 2=reduced),
12=sand abundance (0= none, 1=<25%, 2=50%, 3=>50%), 13=grog abundance,
14=bone abundance, 15=abundance of other inclusions, 16= sand size, 17=grog size, 18=bone size,
19=size of other inclusions, 20=location of sherd on vessel,
21=culture historical "type" "Other"=use wear characteristics and surface treatments.

Table E.1 continued. Characteristics of sherds selected for organic residue analysis.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Other
none	362	41GV66 362 L7	14	53.56	29.64	7.8	N		10YR 5/3	1	2	1	0	0	2	3	0	0	4	13	resin exterior
low fat content plant	412	41GV66 412 A	8.3	31.61	30.21	6.69	Y		10YR 5/3	1	3	0	0	0	1	0	0	0	1	5	burnished interior
low fat content plant	416	41GV66 416 G2	33	61.54	49.89	6.74	Y	16 cm	10YR 4/2	2	3	0	0	1H	2	0	0	3	1	13	resin exterior
medium fat content food+low fat plant	122	41LB4-122 102-5	16	47.01	38.77	6.01	N		10YR 5/2	2	3	1	0	0	1	3	0	0	4	8	scratches interior, scratches exterior, mending
medium fat content food+low fat	123	41LB4-123 693-12	9.1	31.25	29.08	7.08	Y		7.5YR 6/4	2	3	1	0	0	4	3	0	0	1	8	
low fat content plant	124	41LB4-124 723-8	8.3	37.97	31.73	5.74	N		10YR 3/1	2	3	1	0	0	1	3	0	0	4	8	scratches exterior

*1=Residue type(s), 2=lot number, 3=sherd number, 4=weight of sherd, 5=length of long axis in mm,
6=length of short axis in mm, 7= sherd thickeness in mm, 8= variability in thickness (Yes or No), 9= curvature,
10=color of sherd exterior, 11= firing core (1=oxidized, 2=reduced),
12=sand abundance (0= none, 1=<25%, 2=50%, 3=>50%), 13=grog abundance,
14=bone abundance, 15=abundance of other inclusions, 16= sand size, 17=grog size, 18=bone size,
19=size of other inclusions, 20=location of sherd on vessel,
21=culture historical "type" "Other"=use wear characteristics and surface treatments.

Table E.1 continued. Characteristics of sherds selected for organic residue analysis.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Other
medium fat content food+low fat plant	128	41LB4-128 713-23	13	49.25	33	6.86	Y		10YR 4/1	1	3	1	0	0	1	3	0	0	1	8	scratches interior, scratches exterior
medium fat content food	139	41LB4-139 638-6	13	37.83	33.41	7.34	N		10YR 5/1	2	3	1	0	0	1	3	0	0	1	8	
medium fat content	139	41LB4-139 638-8	11	35.54	35.38	6.76	N		10YR 6/1	1	3	1	0	0	1	3	0	0	4	8	
lg. herbivore	139	41LB4-139 652-5	15	51.53	31.1	7.97	N		10YR 5/2	1	3	1	1	0	1	3	3	0	1	15	
medium-low fat content plant	147	41LB4-147 793-34	8.7	31.43	29.98	6.04	N		10YR 2/1	1	3	0	0	1H	1	0	0	3	4	3	

*1=Residue type(s), 2=lot number, 3=sherd number, 4=weight of sherd, 5=length of long axis in mm,
6=length of short axis in mm, 7= sherd thickeness in mm, 8= variability in thickness (Yes or No), 9= curvature,
10=color of sherd exterior, 11= firing core (1=oxidized, 2=reduced),
12=sand abundance (0= none, 1=<25%, 2=50%, 3=>50%), 13=grog abundance,
14=bone abundance, 15=abundance of other inclusions, 16= sand size, 17=grog size, 18=bone size,
19=size of other inclusions, 20=location of sherd on vessel,
21=culture historical "type" "Other"=use wear characteristics and surface treatments.

Table E.1 continued. Characteristics of sherds selected for organic residue analysis.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Other
medium-low fat content	151	41LB4-151 813-2	13	38.96	35.77	7.7	N		10YR 7/2	2	3	2	0	0	1	3	0	0	4	10	punctate
high fat content nuts/seeds/re	54	41AU38 54TT	12	38.96	34.62	6.57	N		10YR 6/4	2	3	0	1	0	1	0	3	0	1	15	scratches interior
medium fat content food+low fat	124	41LB4-124 595-1	13	53.7	32.96	7.17	Y		10YR 7/2	1	3	1	0	0	1	3	0	0	1	10	sooting interior, incising
low fat content plant	55	41AU38 55D	33	46.6	42.5	9.42	Y		5YR 6/6	2	3	0	0	0	2	0	0	0	4	3	sooting interior, cordmarking interior

*1=Residue type(s), 2=lot number, 3=sherd number, 4=weight of sherd, 5=length of long axis in mm,
6=length of short axis in mm, 7= sherd thickeness in mm, 8= variability in thickness (Yes or No), 9= curvature,
10=color of sherd exterior, 11= firing core (1=oxidized, 2=reduced),
12=sand abundance (0= none, 1=<25%, 2=50%, 3=>50%), 13=grog abundance,
14=bone abundance, 15=abundance of other inclusions, 16= sand size, 17=grog size, 18=bone size,
19=size of other inclusions, 20=location of sherd on vessel,
21=culture historical "type" "Other"=use wear characteristics and surface treatments.

Table E.1 continued. Characteristics of sherds selected for organic residue analysis.

medium-low fat content plant	362	41GV66 362 A5	13	48.99	37.69	6.14	Y		10YR 5/3	1	1	0	0	0	1	0	0	0	1	3	sooting exterior, scratches exterior
medium-low fat content plant	362	41GV66 362 I6	75	88.38	62.54	10.18	Y		10YR 5/3	1	2	0	0	0	2	0	0	0	5	13	sooting exterior, scratches interior, scratches exterior, resin exterior
none	380	41GV66 380 N2	13	44.24	32.18	6.36	N	8.221	5YR 5/4	1	2	0	0	0	1	0	0	0	5	3	sooting exterior
lg. herbivore	70	41AU38 70A	14	42.82	38.18	7.15	N		10YR 6/6	2	2	0	0	0	1	0	0	0	4	3	sooting exterior
low fat content plant	132	41LB4-132 718-15	21	57.04	43.47	6.42	N	12.82	10YR 5/2	1	3	0	0	0	1	0	0	0	4	3	sooting interior
none	376	41GV66 376 A2	21	57.08	32.15	8.84	Y	13.88	10YR 5/4	1	2	1	0	0	2	3	0	0	4	9	sooting exterior, scratches exterior

*1=Residue type(s), 2=lot number, 3=sherd number, 4=weight of sherd, 5=length of long axis in mm, 6=length of short axis in mm, 7= sherd thickeness in mm, 8= variability in thickness (Yes or No), 9= curvature, 10=color of sherd exterior, 11= firing core (1=oxidized, 2=reduced), 12=sand abundance (0= none, 1=<25%, 2=50%, 3=>50%), 13=grog abundance, 14=bone abundance, 15=abundance of other inclusions, 16= sand size, 17=grog size, 18=bone size, 19=size of other inclusions, 20=location of sherd on vessel, 21=culture historical "type" "Other"=use wear characteristics and surface treatments.

VITA

Larkin Hood was born in Lincoln, Nebraska. She received her Bachelor of Arts in English Language and Literature from the University of Michigan, Ann Arbor. She earned a Master of Arts in Anthropology at the University of Washington in 1998, and a Doctor of Philosophy in Anthropology in 2007. Her research interests include hunter-gatherer settlement and subsistence, ceramic archaeometry, the social and economic contexts of pottery production and use, and the archaeology of the American Southeast. Larkin began her archaeological career in the Chihuahuan Desert in 1991, and has since participated in academic and private contract work in the north-central, eastern, coastal, and southern portions of Texas, as well as projects in the San Juan Islands and western Washington.

Larkin has been involved in numerous community outreach projects, from visits to K-12 classrooms to the design and implementation of outreach programs in archaeological education for all ages. She has presented her research to the citizens of Texas and Washington. In both her classroom and informal teaching, she emphasizes the connections of archaeology to modern communities and to liberal arts education.