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Exploring the Social Dimensions of Grog-Temper Use at the Ink Bayou Site (3PU252): A Plum Bayou Culture Site in Central Arkansas

Eric Chadwick Drake
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EXPLORING THE SOCIAL DIMENSIONS OF GROG-TEMPER USE AT THE INK BAYOU SITE (3PU252): A PLUM BAYOU CULTURE SITE IN CENTRAL ARKANSAS

by

Eric Chadwick Drake

A Thesis
Submitted to the Faculty of The Graduate College in partial fulfillment of the requirements for the Degree of Master of Arts Department of Anthropology

Western Michigan University Kalamazoo, Michigan June 2001
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I would like to dedicate this thesis to my grandparents, Frank Dirk and Abbie Dean Stolting, who instilled in me the significance of history and the value of family and community. Their love, wisdom, and life histories shall forever remain a source of personal strength and inspiration. Words alone cannot begin to express the appreciation I have for them. I can only hope they know the extent of my love and gratitude.

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She has endured more conversations about ceramic technology and Plum Bayou
archaeology than anyone I know, and yet her love, encouragement, and support has
never faltered. I owe her my deepest and most heart-felt words of appreciation.
Without her, this thesis would have ended long before it began.

Eric Chadwick Drake
EXPLORING THE SOCIAL DIMENSIONS OF GROG-TEMPER USE AT THE INK BAYOU SITE (3PU252): A PLUM BAYOU CULTURE SITE IN CENTRAL ARKANSAS

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Western Michigan University, 2001

This thesis explores the social implications involved with the technological decision to use grog (crushed potsherds) as a ceramic tempering agent by potters affiliated with the Plum Bayou culture of central Arkansas. The analytical technique of point-counting ceramic thin sections is used to search for patterns of grog-temper use at a single Plum Bayou culture site, the Ink Bayou site (3PU252). While the thermal properties of grog-temper may help to explain the variability of use observed at the Ink Bayou site, the social implications of producing grog-tempered pots are best illuminated by the sequence of productive operations employed by the Ink Bayou potters themselves when constructing grog-tempered pots of the type, Baytown Plain. The results of this study suggest that the practice of constructing Baytown Plain ceramics constitutes a technically versatile, socially flexible, and easily taught ceramic technology.
TABLE OF CONTENTS

ACKNOWLEDGMENTS........................................................................................................... ii

LIST OF TABLES................................................................................................................... vii

LIST OF FIGURES................................................................................................................ viii

CHAPTER

I. INTRODUCTION TO THE STUDY .................................................................................. 1

II. ARCHAEOLOGY OF THE PLUM BAYOU CULTURE AND THE INK BAYOU SITE (3PU252) .................................................................................................................. 10

   A General Description of Material Culture, Subsistence, and Settlement.................. 10

   The Ink Bayou Site (3PU252)..................................................................................... 26

III. TOWARD A SOCIAL FRAMEWORK FOR INTERPRETING CERAMIC DESIGN .............................................................................................................. 35

   Introduction.................................................................................................................. 35

   On the Concept of a Mode of Production: Placing Tools in Their Social Contexts .... 41

      Temper Choices and Technical Compromises: The Materiality of Ceramic Vessels 51

      Placing the Pot in the Hand of the Potter: Ceramics and the Organization of Labor 62

IV. RESEARCH METHODOLOGY...................................................................................... 69

   Introduction.................................................................................................................. 69

   Sample Choice and Description.................................................................................. 70

   Description of Macro-Physical Attributes.................................................................. 73

      Orifice Diameter...................................................................................................... 75

      Color......................................................................................................................... 75

      Hardness.................................................................................................................... 78
Table of Contents—continued

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Finish and Texture</td>
<td>79</td>
</tr>
<tr>
<td>Rim Mode</td>
<td>80</td>
</tr>
<tr>
<td>Vessel Form</td>
<td>83</td>
</tr>
<tr>
<td>Petrographic Analysis of Ceramic Thin Sections</td>
<td>84</td>
</tr>
<tr>
<td>Thin Section Preparation</td>
<td>87</td>
</tr>
<tr>
<td>Preliminary Analysis</td>
<td>90</td>
</tr>
<tr>
<td>Point-Count Analysis</td>
<td>94</td>
</tr>
<tr>
<td>V. ANALYSIS AND RESULTS</td>
<td>96</td>
</tr>
<tr>
<td>Introduction</td>
<td>96</td>
</tr>
<tr>
<td>Analysis of Ceramic Paste and Body Characteristics</td>
<td>97</td>
</tr>
<tr>
<td>Attribute Correlations</td>
<td>109</td>
</tr>
<tr>
<td>Comparing the Ink Bayou and Toltec Mounds Samples</td>
<td>119</td>
</tr>
<tr>
<td>The Social Dimensions of Grog-Tempered Ceramics</td>
<td>126</td>
</tr>
<tr>
<td>VI. SUMMARY AND CONCLUSION</td>
<td>141</td>
</tr>
<tr>
<td>APPENDICES</td>
<td></td>
</tr>
<tr>
<td>A. Baytown Plain Rimsherd Sample From the Ink Bayou Site (3PU252)</td>
<td>148</td>
</tr>
<tr>
<td>B. Macro-Physical Attribute Documentation Form</td>
<td>150</td>
</tr>
<tr>
<td>C. Point-Count Analysis Documentation Form</td>
<td>153</td>
</tr>
<tr>
<td>D. Table of Point-Count Values and Macro-Physical Attributes For the Ink Bayou Ceramic Sample</td>
<td>155</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>159</td>
</tr>
</tbody>
</table>
LIST OF TABLES

1. Radiocarbon Dates From the Ink Bayou Site, 3PU252 ........................................ 30

2. Ceramic Paste Values for the 51 Thin Sections Analyzed in the Ink Bayou Sample ................................................................. 99

3. Ceramic Body Values for the 51 Thin Sections Analyzed in the Ink Bayou Sample ........................................................................ 106
LIST OF FIGURES

1. Map of Central Arkansas and the Plum Bayou Culture Study Area .................. 3
2. The Toltec Mounds Site (3LN42) ................................................................. 11
3. The Ink Bayou Site (3PU252) ................................................................ 27
4. Vessel Forms From the Ink Bayou Site ....................................................... 33
6. Ceramic Body Ternary Diagram Showing Volumetric Percentages of Grog-Temper, Sand, and Clay Matrix (With Silt) for Each Thin Section in the Sample .......................................................... 108
7. Regression Analysis Graph Plotting the Number of Grog-Temper Particles Against the Volumetric Percentage of Grog-Temper, per Thin Section ........................................................................ 112
8. Regression Analysis Graph Plotting the Average Size of Grog-Temper Particles Against the Volumetric Percentage of Grog-Temper, per Thin Section ........................................................................ 113
9. Analysis of Variance Test Results Comparing the Average Size of Grog-Temper Particles by Vessel Form ............................................................... 116
10. Analysis of Variance Test Results Comparing the Volumetric Percentage of Grog-Temper Particles by Vessel Form ............................................... 117
11. Analysis of Variance Test Results Comparing the Volumetric Percentage of Grog-Temper Particles by Provenience ............................................. 118
12. Results for Student's T-test Comparing the Volumetric Percentage of Grog-Temper by Site Number ................................................................. 122
13. Results for Student's T-test Comparing the Volumetric Percentage of Quartz by Site Number ................................................................. 124
14. Operational Sequence For Producing Grog-Tempered Ceramics of the Type, Baytown Plain ................................................................. 129
15. A Generalized Operational Sequence For Producing Shell-Tempered Ceramics ...................................................................................... 130
CHAPTER I

INTRODUCTION TO THE STUDY

Technology embraces all aspects of the process of transforming matter into a socially usable and identifiable form, from the organization of labor to the design and use of tools (Lemonnier 1992:1). As such, the study of technology holds great potential as an entry point for anthropological inquiry into the social, political, economic, and even ideational dimensions of past and present societies (Ingold 1997; Lemonnier 1992; Pfaffenberger 1992). This is especially intriguing for the field of archaeology where the material record itself consists largely of the products and precedents of technological activities and practices (Lechtman and Steinberg 1979:140; Wobst 1978:303). The challenge for the archaeologist, however, is to explore the various ways in which technology articulates with other aspects of social life and to determine how this articulation finds material expression in the formal, temporal, and spatial dimensions of artifact variability in the material record (Lechtman and Steinberg 1979:136-139).

In the process of material culture design, individuals and social groups make technological decisions concerning several recurrent sets of activities relating to the production, use, maintenance, and discard of material objects (McGuire and Schiffer 1983). For example, in the process of ceramic design, potters may choose to use different combinations of raw materials and manufacturing techniques to produce pots intended for different social and/or mechanical functions (Arnold 1971; Schiffer and Skibo 1987, 1997). Post depositional processes aside, the results of
such decisions are realized in the formal attributes of artifacts, as well as their frequencies and distributions through time and space in the material record (Schiffer 1972). Determining the range and degree of artifact variability, therefore, constitutes a necessary and unavoidable first step in any attempt to better understand a particular technology and the social, political, economic, historical, and environmental contexts within which past technological decisions were made.

This research project has been designed to take such an initial step toward the greater goal of better contextualizing the technological choice to use grog (crushed potsherds) as a ceramic tempering agent by potters associated with the Plum Bayou culture of central Arkansas. The Plum Bayou culture represents a late Baytown-Coles Creek cultural pattern which occupied the Arkansas River Lowland region (Figure 1) between approximately A.D. 600 and A.D. 1000 (Nassaney 1991, 1992, 1994, 1996c; Rolingson 1982, 1990, 1998). This study involves the preparation and point-count analysis of a sample of grog-tempered ceramic thin sections from a single Plum Bayou culture site, the Ink Bayou site (3PU252). All of the thin sections were removed from rimsherds of the most predominant Plum Bayou pottery type, Baytown Plain, which has been described as a "super type" in need of further geographical and chronological refinement (Phillips 1970; Rolingson 1978, 1998).

This study is guided by four primary goals. The first goal is to determine the range of variation in the size and amount of grog-tempered particles within the Ink Bayou sample. The second is to identify specific technological strategies of grog-temper use; for example, selecting a certain size of temper to be used in constructing a specific vessel form, such as a cooking jar (e.g., Steponaitis 1983). Addressing
Figure 1. Map of Central Arkansas and the Plum Bayou Culture Study Area (Redrawn from Nassaney 1992a:Figure 3.3, 3.4).
this goal will involve looking for patterned correlations between the size and amount of temper particles, and other more obvious ceramic attributes, such as vessel form, surface finish, and wall thickness, to name only a few (see Chapter IV for more details). A third goal of this study is to determine whether such correlations will facilitate breaking down the type, Baytown Plain, into temporally sensitive and/or formally specific varieties. Finally, in addition to providing direction for future research concerning the manufacture and use of grog-tempered pots, the results of this study will illuminate a number of possible reasons--social and economic--for the persistent use of grog by the Plum Bayou potters, as opposed to other available tempering materials, such as shell, bone, sand, or grit, which many scholars view as being mechanically superior (see Dunnell and Feathers 1991; Feathers 1989a, 1989b; Hoard et al. 1995; Osborn 1988).

The manufacture and use of grog-tempered ceramics figures prominently in the ceramic history of the Lower Mississippi Valley (Phillips 1970; Phillips et al. 1951). Introduced during the early Marksville period (ca. 100 B.C.), the use of grog persisted until it was eventually eclipsed by the manufacture and use of shell-tempered ceramics in many parts of the region more than a thousand years later (Jeter et al. 1987; Morse and Morse 1983; Nassaney 2001; Steponaitis 1986). Archaeologically speaking, shell-tempered pottery is considered a hallmark of the Mississippian culture (ca. A. D. 1000-1700), in which the major river valleys and tributaries of the Mississippi River witnessed the development of ranked, hierarchical social formations underwritten by intensive maize-based agriculture, the construction of large pyramidal earthen mounds, and the establishment of long-distance exchange networks (Morse and Morse 1983; Smith 1986; Steponaitis 1986). Although linked to the increased reliance upon maize as a food staple, the
factors leading to the invention and widespread adoption of shell-tempered pottery are as poorly understood as the reasons for the persistent use of grog as a ceramic tempering agent (Dunnell and Feathers 1991; Feathers 1989b; O'Brien et al. 1994; Steponaitis 1986). An attempt to better understand the technology of grog-temper use, therefore, is needed, not only in the context of Plum Bayou culture archaeology, but in order to address social and historical processes of ceramic technological change on a regional scale, as well.

Over the past few decades studies of ceramic technological variation and change have increasingly been conducted from an engineering-design approach emphasizing: (1) the manufacture, use, discard, and recycling of clay pots; (2) the relationship between raw materials, manufacturing techniques, ceramic attributes, and the mechanical performance characteristics of vessels; (3) the environmental impacts on ceramic technology; and (4) the physical, chemical, and economic constraints structuring the technological choices and behaviors of potters (Arnold 1971, 1985; Bronitsky 1986; Nicklin 1971; O'Brien et al. 1994; Schiffer and Skibo 1987, 1997; Van der Leeuw 1993). Through this research archaeologists have become quite adept at reconstructing ceramic manufacturing sequences and determining how different raw materials and ceramic variants can effect the overall mechanical performance of a vessel as in the effects of size, amount, and type of temper on the properties of vessel strength and thermoconductivity (Bronitsky 1986; Rice 1987:207-243). The knowledge acquired from such re-search has provided archaeologists with the empirical links necessary for making inferences about the productive activities of past pottery-using societies. Unfortunately, however, the theoretical foundations for addressing the social dimensions of past
ceramic technologies, and technology in general, have not been developed as far as the methodological ones (Dobres and Hoffman 1994:211-212).

Most of the research conducted under the engineering-design rubric has been guided by a behavioral or a Darwinian theoretical orientation. While these two perspectives differ in a number of ways (see Jones et al. 1995:18; Schiffer 1996), they share an evolutionary, instrumentalist view of technology, which sees necessity as the mother of invention and technology as a means of solving problems posed by both the physical and social environments (Pfaffenberger 1992:494-495). From this perspective, the persistence of a specific technology is often explained as the most efficient solution to a given problem within the limitations imposed by a particular set of environmental conditions (O'Brien and Holland 1992; Schiffer 1996). By viewing ceramic pots as tools designed to fulfill a specific need, the conditions of the physical and social environments (i.e., the selection environment) are assumed to favor one or more ceramic variants from a range of possible choices. Specific traits are selected, therefore, by virtue of their material properties and their effect on the overall mechanical performance characteristics of the finished vessel (Braun 1983; Feathers 1989a; O'Brien et al. 1994; O'Brien and Holland 1992; Schiffer 1996:647; Schiffer and Skibo 1987, 1997).

Underlying this evolutionary view of technology is the assumption that form follows function (Pfaffenberger 1992) and that a tool's primary function is that which directly enhances the fitness, or adaptability, of the populations within which the tool was used (Dunnell 1978). Consequently, explanations for ceramic variation and change from an engineering-design approach involve determining and comparing the techno-functional advantages and disadvantages that different ceramic designs could provide a population within a given selection environment (Nicklin 1972:26;
Schiffer 1996:647). In the case of shell tempering, such studies have shown that the addition of burned shell to clay increases not only the workability of the clay, but also a vessel’s toughness and ability to resist thermal shock (Feathers 1989a, 1989b; Million 1975; O’Brien et al. 1994). Furthermore, some scholars have suggested that the physical and chemical properties of burned shell, when mixed with clay, may even reduce the firing time needed to produce a successful pot (Dunnell and Feathers 1991:31).

Given the technical advantages offered by the adoption of shell-tempered pottery, one is led to ask a series questions concerning the archaeological evidence for the adoption of shell tempering. First, why did the use of grog and other tempering materials (e.g., sand, grit, or limestone) persist for so long in the face of such a technological breakthrough? Second, why was the adoption of shell tempering not a homogeneous process across the cultural landscape of the Lower Mississippi Valley (Feathers 1989b)? What were the social and/or political factors underlying the heterogeneous adoption of shell-tempered pottery? Finally, how should one begin to approach such questions?

Engineering-design studies have provided nothing short of a bounty of practical knowledge concerning the manufacture and use of low-fired ceramics. However, can technological choices, such as the decision to continue producing grog-tempered pots as opposed to shell-tempered pots, be explained entirely in terms of the performance characteristics of different ceramic variants and their behavioral implications relative to vessel function? Should not the conscious actions of human agents be entered into the discussion of technological change as well?

This study employs a political-economic framework in arguing that technology not only serves as a means of solving problems in the physical world, but consti-
tutes a process of human labor that presupposes a web of social relations and sym-
bo
colic meanings structuring the technological choices and productive activities of in-
dividuals and social groups (McGuire 1992:103-104). In and of themselves, tools
like ceramic pots have no value until they are entered into the relations of produc-
tion, where they serve to increase the capacity of agents to transform matter into a
socially usable and identifiable form (Marx 1906:198-201). Technological choices
concerning the design and use of tools, therefore, are not made inside a social and po-
litical vacuum but are, instead, structured by various social logics, both technical
and non-technical, that serve to organize the labor process and determine the goals of
production (Lemonnier 1992, 1993). This view of technology does not deny the
importance of understanding the materiality of tools in explaining ceramic variation
and change. On the contrary, a vessel's function and performance are understood to
effect its placement in various classification systems that serve to organize labor and
establish the context for social action and interaction within a particular labor pro-
cess (Lemonnier 1993:3). As such, new techniques, ideas, or strategies of techno-
logical production must be compatible with, and part of, other social logics and re-
lations structuring a group's technological activities before they can be adopted into
the labor process (Lemonnier 1992). Consequently, multiple reasons may exist for
the heterogeneous spread of shell tempering, as different social groups may have ac-
cepted or rejected the technology of shell temper for reasons pertaining to their own
paricular histories. Better contextualized studies of local ceramic industries are
needed, therefore, before more general processes of ceramic variation and change can
be explored.

The epistemological assumption from which this research is based contends
that through studies of technological variation and change, archaeologists can access
the social conditions structuring the productive activities of past societies, as well as the economic constraints and ecological imperatives under which such labor processes were carried out. Again, this study has been designed to take the initial steps toward this greater goal by distinguishing technological strategies of grog temper use at the scale of a single Plum Bayou culture site. Based upon empirical evidence, I argue that the manufacture and use of grog tempered ceramics constitutes a versatile, flexible technology that can be easily taught to others in the social group. Such versatility might explain this technology's persistence, as well as its appeal to a loosely integrated population of dispersed sedentary horticulturalists, like the Plum Bayou culture.

In Chapter II, I provide a brief overview of the Plum Bayou culture, its ceramic industry, and the archaeology of the Ink Bayou site (3PU252). In Chapter III, I discuss in detail the major assumptions and tenets of the political-economic framework guiding this study, as well as the physical and chemical properties of ceramic temper and its effects on mechanical performance. Chapter IV provides a description of the Ink Bayou sample and the methods and procedures used to generate the data for this study. In Chapter V, I present the results of my analysis and compare these results to those of a similar petrographic analysis of ceramic pots recovered from the paramount religious-political center of the Plum Bayou culture, the Toltec Mounds site (3LN42). From this, I explore the social dimensions of grog-temper use, and discuss these implications in the context of Plum Bayou archaeology. I conclude this study in Chapter VI by reviewing the significance of this analysis and providing direction for future research concerning the manufacture and use of grog-tempered ceramics within the context of Plum Bayou culture.
A General Description of Material Culture, Subsistence, and Settlement

The archaeology of the Plum Bayou culture is best known from investigations conducted at the Toltec Mounds site (3LN42), a multiple mound and plaza complex located on an oxbow lake associated with the abandoned Plum Bayou channel of the Arkansas River (Figure 1; Nassaney 1992b:122; Rolingson 1990:27). Standing as one of the earliest and largest pyramidal mound and plaza centers in the Lower Mississippi Valley, Toltec is believed to have functioned as the paramount religious and political center for a large dispersed population of sedentary horticulturalists known collectively as the Plum Bayou culture (Nassaney 1992a, 1994, 1996b, 1996c; Rolingson 1988:6; Steponaitis 1986:385-386). At the height of occupation around A.D. 900, the Toltec Mounds site contained 18 earthen mounds, 10 of which were organized around a large rectangular plaza area (Figure 2; Rolingson 1990:31-34; 1998:96). In total, the Toltec Mounds site covers an approximate area of 42 ha, all of which is enclosed within a semi-circular earthen embankment measuring 1.6 km in length and 2.5 m in height (Rolingson 1990:33). The actual function of the embankment remains elusive: no evidence for the existence of a palisaded wall (i.e., post holes) has been identified so far, suggesting that the embankment may have served the more symbolic function of delineating sacred and secular space (Rolingson 1990:33).
The religious/sacred function of the Toltec Mounds site is further implied by the alignment of some of the mounds in accordance with seasonally-important solar positions and celestial bodies. Mounds A, G, and H, for example, are aligned east-west with the sun’s position at the equinoxes, while Mounds A and E are oriented north-south with the North star (Sherrod and Rolingson 1987:21-32). Moreover, a number of the site’s features were arranged on the landscape according to some in-
crement of a standard unit of measure equaling 47.5 m (Sherrod and Rolingson 1987:35-41). The central plaza area, for example, measures 380 m in length, a distance eight times the standard unit of measure, while its width equals a distance four times the unit of measure (190 m). Likewise, the location of Mound A is four times the unit of measure away from Mound D, which in turn was constructed three times the standard unit (143 m) away from the semi-circular embankment. Even the length of the embankment corresponds to this pattern, measuring 1,615 m long, which is equal to thirty-four times the 47.5 m module. The sheer size of the Toltec Mounds site, along with its formalized construction suggests a degree of labor mobilization and sociopolitical integration previously unknown in central Arkansas.

Only 6 of the 18 mounds at Toltec have undergone archaeological excavations-Mounds B, C, D, E, G, and S. Mounds A and B are the largest of the platform mounds, towering 15.0 m and 11.5 m high, respectively (Rolingson 1990:31-33). Mound B was investigated with an excavation profile of an erosional cut located in its south-eastern corner. A constructional sequence consisting of at least three occupational surfaces and midden deposits with intermittent stages of mound fill were identified (Miller 1982:36-41, Figure 27). Materials recovered from the midden deposits suggest the presence of domestic activities despite the lack of positive evidence for the construction of household structures on top of these mounds (Rolingson 1990:32). In the succeeding Mississippi period (ca. A.D. 1000-1700) platform mounds like Mounds A and B are known to have supported both elite domiciles and charnel houses for the dead (Knight 1989; see contributions to Lewis and Stout 1998). Indeed some scholars have suggested that the stages of mound construction at Toltec may have corresponded with the tenure of individual lineage heads and the succession of leadership, as the practice of sealing off the old occupation surface
served to "renew" the mound platform by covering up the residues of the former structure and possibly its former occupants as well (Nassaney 1996b:32; Rolingson 1994:8). The question of whether a population of incipient elites resided at Toltec, however, remains unanswered.

Evidence for multiple construction stages have also been identified in Mounds D, E, G, and S (Rolingson 1990, 1992, 1998). In the case of Mound D, however, construction efforts were focussed on expanding the area of the platform rather than increasing the overall height of the mound (Rolingson 1994:2-3, 1998:10-26). Four stages of mound construction and two concentrations of midden on the off plaza side of the mound have been identified in profile (see Rolingson 1998:10-25). Similar to Mound B, the contents of the middens indicate the performance of a number of domestic activities on top of and/or around the mound area. Mounds E, G, and S also represent low quadrilateral platform mounds, but the artifactual remains from these mounds imply that they may have been constructed with different functions in mind. Mound S, for example, may have served as a platform for conducting ceremonial feasts based upon the location of a dense concentration of animal bone and associated artifacts on the off-plaza side of the mound. The relatively well preserved state of the bone reflects a short period of activity as the midden was quickly covered after deposition--behavior not necessarily representative of domestic activity (Rolingson 1992:25).

The occupational sequence for the Toltec Mounds site has been well established as a result of extensive excavations of both mound and nonmound contexts at the site (Rolingson 1990:31-34, 1992, 1998:24-25). However, the paucity of deeply stratified sites in the surrounding Toltec environs, coupled with a lack of chronologically sensitive artifact types, has constrained efforts to refine the
chronological development of the Toltec Mounds and the Plum Bayou culture in general, through relative dating techniques (Nassaney 1996c). A series of radiocarbon and archaeomagnetic dates recovered from numerous submound and mound stage deposits at Toltec, however, indicate that mound building activities took place during the Coles Creek period (ca. A.D. 700-1000), with an intensive period of earthen construction between A.D. 800 and 1000 (Rolingson 1998:24-25, 101). Recently, two provisional phases of mound construction have been proposed for the Toltec Mounds based upon the stratigraphic distribution of the radiocarbon and archaeomagnetic dates across the site: the Dortch Bend phase (A.D. 650-800) and the Steele Bend phase (A.D. 800-1030) (see Rolingson 1998:101). Within this chronological scheme, the construction and use of Mound S is assigned to the Dortch Bend phase, while Mounds D, E, and G are unequivocally assigned to the Steele Bend phase. Mound B, on the other hand, appears to have been constructed and used over a long period of time spanning both temporal phases (Rolingson 1998:101).

Concurrent with the period of mound construction at Toltec was an increase in the size and density of Plum Bayou culture sites within the surrounding Toltec environs (Nassaney 1991:199-211). Toltec stands as the largest Plum Bayou culture site in a four-tiered settlement hierarchy consisting of over 40 Baytown-Coles Creek period components within a 20-km radius of the paramount center (Nassaney 1992a:244-251, 1994). Plum Bayou culture sites range in size and character from single (< 0.2 ha) and multiple households (> 0.2 ha), to small mound centers where one mound is present, to large multiple mound centers like Toltec and the neighboring Coy Mound site (3LN20)—a smaller mound and plaza center (ca. 12.0 ha) located approximately 20 km southeast of Toltec (Nassaney 1996c:26). The settlement data from the surrounding Toltec environs indicates that the majority of
the Plum Bayou population inhabited a number of small, dispersed habitation sites consisting of one, or only a few dwellings. It was from this population of loosely integrated horticulturalists that the labor needed to construct and maintain the Toltec Mounds site was mobilized.

Population densities in the Arkansas River Lowland were extremely low, prior to the establishment of Toltec and the Baytown-Coles Creek period occupation of the natural levees of lakes and bayous in the region (Nassaney 1991:200). Only seven late Marksville period (ca. A.D. 200-400) sites have been recorded within the 20-km radius zone around Toltec (Nassaney 1992a:246). This is due, in part at least, to the political geography of the Lower Mississippi Valley and the Trans-Mississippi South during the late Marksville period (see Nassaney 1991:199-202), and the fact that the region only became desirable for occupation after local groups decided to incorporate native cultigens into their subsistence economy (Nassaney 2001).

The incorporation of indigenous cultigens into the Plum Bayou subsistence economy (Fritz 1988), together with the exploitation of a wide diversity of aquatic and terrestrial animal species (R. Hoffman 1982; Styles et al. 1985) represents a subsistence strategy focused on intensifying food production (Nassaney 1987, 1992b:126). The pattern of Plum Bayou faunal exploitation is not unlike that proposed for later Mississippian cultural groups occupying meander belt zones in the northern lower Mississippi Valley, with an emphasis on deer, turkey, raccoon, and fish (House 1985:103; Nassaney 1991:190; B. Smith 1975). However, in addition to a variety of nuts and wild plants, floral assemblages from Toltec and surrounding Plum Bayou culture sites are typical of a “Woodland” horticultural complex consisting almost entirely of cultivated starchy seeds, such as sumpweed, chenopod,
maygrass, and little barley (Fritz 1988; House 1985:102-103; King 1987; C. Smith 1996). Curiously, the most abundant type of charred seed identified in the archaeobotanical inventory from Mound D at Toltec, is an as-of-yet unidentified grass seed (Fritz 1988). Maize, while present in several Coles Creek period contexts at Toltec and the Ink Bayou site, does not appear in any great quantity and did not constitute a significant portion of the Plum Bayou diet (King 1987; C. Smith 1996). The recovery of maize from a midden associated with Mound S at Toltec, however, does establish its presence in the Arkansas River Lowland by the middle of the eighth century A.D. (C. Smith 1996:69-71).

Paralleling the changes in Plum Bayou culture settlement and subsistence were a number of changes in stone tool production and lithic raw material use, as well. Chert, novaculite, and quartz crystals served as the raw materials for producing a variety of chipped stone tools, including both arrow points and atlatl dart points (Nassaney 1996a; Nassaney and Pyle 1999). Small, bifacially-chipped projectile points were introduced into the region around A.D. 600 from the west, signifying the adoption of the bow and arrow and possibly an increased threat of warfare (Nassaney and Pyle 1999). The transition to the bow and arrow is marked by a change in lithic reduction techniques, from a core-tool reduction sequence to a more expedient flake-tool strategy (T. Hoffman 1982; Nassaney 1996a:205-208). Flake tool manufacturing is oriented toward producing a diversity of specified tool types (e.g., arrow points, drills, and flake tools) as opposed to the production of multi-purpose hafted implements, characteristic of core-tool reduction strategies. This technological shift correlates with changes in lithic raw material use, a decrease in mobility inferred from the Plum Bayou settlement data, and changes in subsistence strategies (see Nassaney 1992a:216-221, 1996a).
Changing raw material frequencies from the late Marksville through Mississippi periods, and their spatial distributions throughout the Plum Bayou locale, demonstrate the increased exploitation of local chert sources over time, at the expense of high quality bedded novaculite from the Ouachita Mountains to the west and other nonlocal lithic materials, such as Pitkin and Boone chert from the Ozark Plateau to the north. The use of stone tools produced from locally available cherts would have certainly supported the shift to a more sedentary way of life (Parry and Kelly 1987). However, from a more political-economic perspective, such a strategy would also remove individuals and social groups from the social and economic demands associated with maintaining exchange networks needed to supply non-source areas with chipped stone--networks which could be manipulated and controlled by individuals and groups vying for power and status (Nassaney 1996a:215). Moreover, empirical evidence from the Marksville through Mississippi time periods indicates a high incidence of thermal alteration (i.e., heat treatment of cherts) during the Baytown-Coles Creek period, suggesting that "local groups chose to improve the flaking characteristics of lower quality, and perhaps less costly, raw materials" (Nassaney 1992a:216).

While the use of novaculite and non-local cherts decreased through time, the frequency of quartz crystal use reached a height of popularity during the peak period of mound construction at Toltec (Nassaney 1992a:Figure 7.7, 2001). Crystals may have functioned as items of prestige imbued with symbolic power by individuals of rank (Nassaney 2001). The ethnographic record indicates that quartz crystals played a variety of roles in the social and ideological domains of Native American life, from divination to physical and spiritual protection (Hudson 1976; see Nassaney 1992a:316-319). While crystals may have been implicated in processes of social
ranking, their relatively even distribution throughout the Plum Bayou locality suggests that attempts to control access to this material were tentative at best (Nassaney 1996a:204).

Despite significant changes in social organization, settlement, subsistence, and lithic technology, the ceramic industry of the Plum Bayou culture represents the continuance of a long standing tradition in the ceramic history of the Lower Mississippi Valley, the manufacture and use of grog-tempered pots. The study of ceramics has long played a significant role in archaeologically defining the concept of Plum Bayou culture. Plum Bayou culture ceramic assemblages are characterized by an overwhelming occurrence (over 90%) of undecorated, grog-tempered, plainware pots of the type, Baytown Plain (Rolingson 1982:87, 1990:35-36; Stewart-Abernathy 1982). Initially, the ceramics recovered from the Toltec Mounds site puzzled archaeologists as to the actual period of occupation. While the design of the site suggested a Mississippi-period occupation, the ceramics were thought to be characteristic of the earlier Baytown and early Coles Creek time periods (Phillips 1970:916). It was not until the establishment of the Toltec Mounds Research Project in the mid-1970s that radiocarbon and archaeomagnetic dates from mound and submound contexts were soon recovered, which verified the Coles Creek period of mound construction (Rolingson 1990:30).

Unfortunately, concerns with chronology continue to plague Plum Bayou archaeological research. The paucity of deeply stratified sites in the region has made the search for sealed, discrete artifact assemblages, as well as temporally sensitive artifact traits, imperative for constructing local occupational sequences (Nassaney 1996c:44). The problem has been further compounded by the relatively low frequency of decorated ceramic types useful for seriation and necessary for constructing
fine-grained ceramic chronologies. While the high incidence of Baytown Plain pottery has helped to archaeologically distinguish the Plum Bayou culture from other Coles Creek period groups in the Lower Mississippi Valley (Davis 1966; Rolingson 1982), the inability to distinguish discrete varieties of this type on the basis of temporally and spatially sensitive attributes has stymied attempts to refine local chronologies beyond the macro-temporal scale. There is simply too much variation and not enough patterning in the way distinct attributes are combined together on Baytown Plain pots to warrant the definition of new varieties (Martha Rolingson, personal communication 1996). As Phillips admits, “until technological studies can provide criteria on the paste and manufacture of grog-tempered plainware (i.e., Baytown Plain), geographical location stands as one of the primary sorting criteria for defining various varieties of Baytown Plain” (1970:48).

Two other types of plainware ceramics occur in Plum Bayou assemblages, as well; Morris Plain and Mississippi Plain. Both are distinguished from Baytown Plain by their temper. The temper in Morris Plain vessels consists of a mixture of grog, clay particles, and fine particles of calcined bone. The amount of bone can vary considerably within this category, although it is “generally sufficient [enough] to consider it a deliberate addition rather than a casual inclusion” (Rolingson 1998:37).

Vessels of the type, Mississippi Plain, on the other hand, are tempered with particles of finely crushed shell. Shell-tempered sherds have been recovered in small amounts from both mound and submound deposits at Toltec where no evidence of animal or human mixing exists (Rolingson 1990:36). Shell tempering is typically considered a hallmark of the later Mississippi period (ca. A.D. 1000-1700; Steponaitis 1986). However, the production of shell-tempered pots is known to have oc-
curred in the Western Lowland of northeastern Arkansas by the ninth and tenth centuries A.D. (Morse and Morse 1990:159-161) and possibly even earlier in the Ozark foothills of southeastern Missouri (Price 1986). Likewise, bone tempering is a technological trait most often associated with the Fourche Maline and Caddoan cultures of southwestern Arkansas and the Trans-Mississippi South (Schambach 1982:162). The social, political, and economic conditions under which the Plum Bayou peoples were exposed to these two different ceramic traditions are poorly understood. Nevertheless, the presence of shell and bone-tempered sherds in Plum Bayou ceramic assemblages suggests that the Plum Bayou potters had knowledge of other construction techniques, but chose not to imitate them to any great extent.

Decorated ceramic types also occur in Plum Bayou ceramic assemblages, though in relatively low frequencies. The most common decorated type is Larto Red-although this may be due to the placement of red filming over both the body and rim of the vessel (Rolingson 1990:36). When present, other modes of decoration are often restricted to the lip and rim portions of vessels and take the form of incised lines or punctations (Rolingson 1978, 1990:35-36, 1998:26-53; Stewart-Abernathy 1982). Grog-tempered rim sherds with one or more incised lines in the lip and around the rim are typed as Coles Creek Incised (Phillips 1970:69). While this decorative motif is found throughout the Lower Mississippi Valley, several varieties of this type have been defined for the Plum Bayou locality based upon the number and unique arrangement of incised lines (Rolingson 1978, 1998:38-43; Stewart-Abernathy 1982). Stratigraphically, the multiple line and rim strap varieties occur in higher frequencies in the later deposits at Toltec Mounds (Rolingson 1990:36).
A new type, Officer Punctate, has been defined to recognize the application of punctations on the lip and rim of some grog-tempered vessels. Four varieties have been defined for this type based upon the location and form of rows of punctations (see Rolingson 1998:48-49). In the past, rows of punctations were subsumed under the type, Baytown Plain (Phillips et al. 1951:79). However, given the low occurrence of decoration in the Plum Bayou ceramic tradition, the presence of any decorative attribute is considered to be significant (Rolingson 1990:36).

There are a number of well established Lower Mississippi Valley ceramic types which occur in Plum Bayou culture pottery assemblages, as well (House 1987; Nassaney 1992a:150-202; Rolingson 1990:36, 1998:26-53). These types include Alligator Incised, Evansville Punctate, French Fork Incised, Indian Bay Stamped, Mulberry Creek Cord Marked, Salomon Brushed, Yates Net Impressed, Harrison Bayou Incised, and Withers Fabric Impressed (Phillips 1970; Phillips et al. 1951). Sherds of these types usually occur in such small amounts, however, that the significance of their presence is difficult to assess (Rolingson 1990:36).

Both plain and decorated vessels were fashioned into a variety of forms from hemispherical to shallow bowls, cylindrical to barrel shaped jars, to jars with flaring rims. Jars were produced with flat bases, that were either square or circular in shape. Flat bases occasionally appear on bowls as well, although rounded bases are much more common (Rolingson 1998:30-34). Jars are assumed to have been used for cooking and storing foods, while bowls were for serving and consuming prepared meals (Martha Rolingson, personal communication, 1997). Unfortunately, evidence for vessel use (e.g., sooting and cooked on food residues) has only occasionally been documented in studies of Plum Bayou ceramics, and never systematically analyzed in relationship to specific vessel forms or ceramic attributes. So far, very
few complete or nearly complete vessels have been recovered from Plum Bayou culture assemblages. Until archaeologists learn to accurately identify specific vessel forms from small sherds in the archaeological record, the search for correlations between vessel form and use will remain highly subjective.

Only two technical studies of Plum Bayou ceramics have been undertaken prior to this study. The first provided the inspiration for the current work, and involves the petrographic analysis of a collection of ceramic thin sections from the Toltec Mounds site (Bennett 1980). The objective of Bennett’s (1980) study was to provide qualitative and quantitative information on the type, size, and volumetric amount of nonplastic inclusions in the Toltec ceramics. A collection of 98 grog-tempered rimsherds (69 of them were Baytown Plain) and 2 shell-tempered rim sherds from five proveniences at the site were analyzed. Of the 98 grog-tempered rims, grog, quartz, muscovite mica, and feldspar represent the four constituent categories identified in the analysis. No significant variation in the volumetric percentages of these four categories were identified between the five proveniences, although the Mound D sample did possess the greatest range of volumetric percentages of grog-temper.

The amount of grog per thin section, however, varied considerably within the Toltec Mounds sample. Grog amounts ranged from 4% to 66%, with an average of 21% (Bennett 1980:Table 6). The amount of quartz, on the other hand, demonstrated a smaller range of variation with an average of 6% (Bennett 1980:Table 4). From this, Bennett concluded that common clay sources were most likely selected for use, but that preparation of the clays differed (Bennett 1980:28-39).

The second technical study of Plum Bayou ceramics (Stewart-Abernathy 1985) used the technique of X-ray diffraction to compare the mineralogical compos-
itions of bone-tempered ceramics and clays from Toltec and two Fourche Maline culture sites located in the Quachita River floodplain, near Arkadelphia, Arkansas. One of the study's primary objectives was to discriminate between locally produced and imported ceramics at Toltec. Grog-tempered sherds were not analyzed because the degree of mineralogical variability produced by the addition of crushed potsherds of unknown sources could not be controlled. Unfortunately, the results of the study showed that the vessels were fired at a high enough temperature that differences in clay mineralogy could not be accurately distinguished through X-ray diffraction (Stewart-Abernathy 1985:98). However, important information on the effects of heat on clay mineralogy and the minimum firing temperature of bone-tempered ceramics were collected. First of all, the study determined that temperatures above 500°C negated the mineralogical characteristics of illite and montmorillonite clays and that the addition of bone to the clays increased the temperature of the ceramic body by an additional 50°C. As such, a firing temperature of 500°C would have produced a bone-tempered ceramic body temperature of 550°C. From this comparison of temperature and clay mineralogy, therefore, the author concluded that the bone-tempered sherds in the sample must have been fired at a minimum temperature of 450°C (Stewart-Abernathy 1985:104). Unfortunately, while the results of this study might suggest a minimum firing temperature of 500°C for grog-tempered ceramics, without direct evidence this assumption will continue to exist as a hypothesis in need of testing.

Exactly how the manufacture and use of grog-tempered ceramics were implicated in the emergence and dissolution of the Plum Bayou culture is not yet fully understood. What is clear, however, is that after A.D. 1100 the population which had built and maintained the mounds at Toltec packed up their pots and other belongings,
and abandoned the region, leaving an occupational hiatus which con-tinued until the later half of the Mississippi period (Nassaney 1991, 1992a:246). Where the peo-
ple of the Plum Bayou culture left the region for is unclear, although it is assumed that they may have been embraced by the newly integrated Mississ-ippian, Caddoan, and Plaquamine polities emerging on the peripheries of the Plum Bayou culture a-round A.D. 1000 (see Nassaney 1991:199-211).

The data on settlement change, subsistence intensification, and technological organization present a contradictory view of Plum Bayou social-political organi-
ization. On the one hand, the formalization of the cultural landscape at Toltec, to-gether with its size and labor requirements, implies the emergence of social ranking and the existence of an incipient elite population within the Plum Bayou society (Nassaney 1992b, 1997, 2001). On the other hand, the evidence for social ranking is brought into question by a lack of burials in the region with lavish grave offerings indicative of high ranking individuals (Miller 1982; Nassaney 1994:7; Rolingson 1982:90; Waddell et al. 1987). Indeed, evidence for elite accumulation of goods ob-
tained through long-distance exchange is limited in the material record of the Plum Bayou culture. While the distribution of finished objects of copper, galena, mica, and conch shell appear confined to the Toltec Mounds site, they occur in such small quantities that the extent to which these objects may have served to mark positions of social rank seems tenuous and ephemeral at best (Nassaney 1997:8). Compliance with labor demands and the reproduction of hierarchical social relations within Plum Bayou society, therefore, were most likely reinforced through per-iosic and highly ritualized behavior, involving the sponsoring of communal feasts and the dis-
trubution and exchange of goods and services (Nassaney 1997:8-9).
Described as an experiment in social ranking (Nassaney 1992a), the failure of the Plum Bayou culture to reproduce itself beyond A.D. 1100 suggests that its leaders were unable to successfully transform the logic of communalism which shaped the day-to-day interactions and practices of the greater Plum Bayou population (Nassaney 1992b). Bonds of reciprocity, the need for consensus in political decisions making, and the maintenance of local autonomy all represent communal traditions resistant to the political and economic machinations and activities of incipient elites (Nassaney 1992b, 1996a, 1997, 2001). While the social and political organization of the Plum Bayou culture may have tested the rules of communalism, its decline was due, in part at least, to the intended and unintended consequences of actions taken by non-elites to secure access to resources deemed necessary and vital for social and biological reproduction within a communal mode. Indeed, the shift to a more expedient lithic technology, the increased use of locally available chert resources, and the intensification of the subsistence base, all represent practices which may have served to maintain a critical degree of household and village autonomy, despite their possibly destabilizing tendencies (Nassaney 1991, 1992b, 1996a). More work is needed, however, before the social, political, and economic implications of daily household and village activities can be fully assessed in the context of Plum Bayou cultural history.

Recent archaeological scholarship has insisted on the importance of integrating multiple scales of analysis into explanations for social process and change (Cobb and Nassaney 1995; Marquardt 1992). Within this framework, the archaeology of single and multiple household sites gains further significance as a unit of analysis for examining variability in the material record. Indeed, what may appear homogeneous at one level of analysis, may appear quite heterogeneous at another, and such
discrepancies, or continuities, need to be examined and interpreted. Since the late 1980s a considerable effort has been made to recover and examine archaeological assemblages from the numerous Plum Bayou culture habitation sites located in the region surrounding the Toltec Mounds site (Nassaney 1992a, 1996c). Despite the significant amount of information regarding changes in settlement, demography, subsistence and technology, only one habitation site within a 20 km radius of Toltec has undergone intensive excavations of its subsurface deposits, the Ink Bayou site (Rollingson 1998:102; Waddell et al. 1987). The focus of this discussion will now turn to a description of this important Plum Bayou culture site.

The Ink Bayou Site (3PU252)

The Ink Bayou site is located 20 km north of Toltec on the natural levee of Ink Bayou, an oxbow lake associated with an abandoned channel of the Arkansas River (Figure 1; Waddell et al. 1987). It was first discovered and recorded in 1983 by the Arkansas Highway and Transportation Department during a cultural resource management survey for the Northbelt Expressway in Pulaski County (McClurken 1983). The site first appeared as a surface scatter of lithic debris and ceramics covering an area of approximately 1.4 ha in size. Preliminary investigations identified two concentrations of material culture at the east and west ends of the site and exposed a number of subsurface deposits (Figure 3; McClurken 1983).

More extensive testing of the area to be impacted by highway construction was conducted in 1984 by the Arkansas Archeological Survey (Waddell et al. 1987).
Figure 3. The Ink Bayou Site (3PU252) (redrawn from Waddell et al. 1987).
Survey personnel implemented a three-step evaluative program to locate, assess, and excavate undisturbed subplowzone deposits within the right-of-way. First, a controlled surface collection of the area was made from six dog-leash surface collection units (DLSC) measuring 5 m in radius in order to identify concentrations of material on the site surface (Figure 3). Based upon this information, six 2 x 2 m excavation units were then placed near areas yielding high, medium, and low artifact densities to see whether surface distributions correlated with the locations of specific types of subsurface features (e.g., middens, house structures, pit features).

Each unit was excavated by natural stratigraphy and by 10 cm arbitrary levels when strata exceeded 10 cm in depth. The plowzone, however, was excavated as a single stratigraphic unit. Generally speaking, the stratigraphic profile for each unit exhibited a high degree of uniformity. A double plowzone was identified in profile with the upper plowzone consisting of a dark, yellowish brown silty loam extending approximately 7 cm to 13 cm below the surface. The second plowzone consisted of a dark brown silty loam extending between 5 cm and 15 cm below the bottom of the first plowzone (Waddell et al. 1987). Below the entire plowzone was a discontinuous material culture bearing stratum of dark, yellowish brown silt loam mottled with a dark brown loam and brown midden deposits. The thickness of the stratum measured as much as 13 cm in some areas, while being completely absent in others. Only in the area of DLSC 5 did survey personnel identify a thin (between 1 cm and 3 cm thick) stratum of discontinuous, but undisturbed dark brown midden deposits. Beneath the material culture bearing strata existed a stratum of dark grayish brown sandy silt, that was generally devoid of cultural material, except for a number of intrusive pit features and post-molds which continued downward from the base of the plowzone (Waddell et al. 1987).
Based upon the results of this initial stage of investigation, the Arkansas Archeological Survey designed a multidisciplinary research program to systematically expose a substantial amount of the site’s subplowzone deposits in order to obtain information on Plum Bayou culture settlement and subsistence (Waddell et al. 1987). First, a series of 50 x 50 cm test units were placed across the site on a 5 m grid system in order assess the horizontal distribution of artifacts within the plowzone and disturbed midden deposits. Next, the plowzone and midden deposits were stripped away using a back-hoe to expose subsurface features. A total of 323 subsurface soil anomalies were identified within an area measuring 60x65 m (Waddell et al. 1987). Of these, 121 pit features, 3 burials, and a habitation structure were excavated.

Pit features were classified as a postmolds (n=44), medium pits (n=56), or large pits (n=21) based upon their diameter size. Postmolds were the smallest with diameters measuring less than or equal to 25 cm. Medium pit features measured from 25 cm up to 50 cm, while features larger than 50 cm in diameter were classified as large pits (Waddell et al. 1987). Pit functions appear to have varied from suspected “smudge pits” to fire pits, earth ovens, and large storage pits. Four radio-carbon dates were retrieved from charred vegetable material found in four of the pit features (see Table 1).

The radiocarbon dates suggest that the primary component of the site represents a late Baytown-Coles Creek period occupation. An additional Late Mississippi-period occupation is also suggested by the A.D. 1551 date from Feature 301, although the artifactual remains from the site indicate a less substantial occupation during this period (Waddell et al. 1987).
The habitation structure is represented by a rectangular arrangement of postmolds, enclosing an area measuring 6 x 4.5 m. The structure is oriented east-west along its longest axis, with an entrance on the east side (Waddell et al. 1987). Almost no pit features or postmolds were located inside the structure, although a number of small, shallow features were located behind and along its sides.

Table 1
Radiocarbon Dates From the Ink Bayou Site, 3PU252

<table>
<thead>
<tr>
<th>Sample</th>
<th>Provenience</th>
<th>Sample Material</th>
<th>Calander Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMU 1524</td>
<td>Feature 662</td>
<td>Hickory Nut Shell</td>
<td>A.D. 925 ± 140</td>
</tr>
<tr>
<td>SMU 1525</td>
<td>Feature 361</td>
<td>Wood Charcoal</td>
<td>A.D. 897 ± 129</td>
</tr>
<tr>
<td>SMU 1526</td>
<td>Feature 301</td>
<td>Wood Charcoal</td>
<td>A.D. 1551 ± 98</td>
</tr>
<tr>
<td>SMU 1531</td>
<td>Feature 641</td>
<td>Wood Charcoal</td>
<td>A.D. 680 ± 177</td>
</tr>
</tbody>
</table>

Adapted from Waddell et al. (1987)

In the northwest corner of the structure, however, a burial consisting of a single extended adult of unknown sex was identified. The remains of two other adults of unknown sex were also found at the site, but not in association with the habitation structure. Like the burials from Mound C at the Toltec Mounds site, none were found in association with any grave goods.
Two Plum Bayou culture components were identified at the Ink Bayou site based upon radiocarbon assays and the spatial distribution of discrete artifact categories and their associations with one another (Waddell et al. 1987). The earlier component represents a late Baytown-early Coles Creek period occupation that was spatially restricted to the southern boundary of the site, along the top of the levee overlooking Ink Bayou. This is the location of Feature 641, which yielded a radiocarbon date of A.D. 680 ± 177 (see Table 1). Artifact assemblages associated with this portion of the site suggest seasonal occupation with an emphasis on hickory nut processing.

The primary occupation of the site corresponds to the Coles Creek period, as indicated by the radiocarbon dates recovered from Features 361 and 662 (see Table 1) and associated ceramic types (e.g., greater percentage of Coles Creek Incised sherds). The presence of the habitation structure suggests the shift to a year-round occupation of the site. This shift to a more sedentary lifestyle is further marked by the presence of large storage pits, the high incidence of native cultigens, and the sheer density of chipped-stone tools and ceramic forms affiliated with a broad range of domestic activities (Waddell et al. 1987).

The Ink Bayou ceramic assemblage exhibits an exceptional degree of similarity to the ceramic collections from Toltec Mounds (Rolingson 1978, 1998:26-52; Stewart-Abernathy 1982). Both Baytown and Coles Creek period pottery types are represented in the Ink Bayou assemblage (House 1987). The type, Baytown Plain, of course, predominates, comprising over 90% of the total assemblage. Decorated sherds of the types, Coles Creek Incised, var. Keo, Larto Red, Officer Punctate, and
Mullberry Creek Cordmarked, however, are also present in frequencies comparable to the Toltec collections (House 1987). Sherds of bone-tempered (Morris Plain) and shell-tempered (Mississippi Plain) plain wares occur as well, but in very small amounts (less than 1%).

A variety of vessel shapes are also present in the Ink Bayou sample which compare to those identified at Toltec, including large flaring rim jars, cylindrical jars or beakers, hemispherical bowls, and shallow bowls with sloping walls (Figure 4; House 1987). Such functional diversity suggest that the inhabitants conducted a variety of domestic activities. While, this range of past activities likely included the manufacture of low-fired earthenware pots, no direct evidence for this practice (e.g., ceramic wasters and firing pits) was recorded at the Ink Bayou site (House 1987).

The chipped stone assemblage from Ink Bayou is comparable to that of Toltec and other Plum Bayou culture sites in the region, as well (Nassaney 1992a:137; Waddell et al. 1987). Local chert gravels comprise the bulk of lithic raw material (79.9%), followed by novaculite (16.9%) and quartz crystal (3.2%). Although a concentration of quartz crystal debitage was identified behind the habitation structure, only three formal tools made from quartz crystal were found at the site. This suggests that unlike tools fashioned from chert or novaculite--of which there were many--tools knapped from quartz crystal may have been produced at the Ink Bayou site for exchange with other members of the Plum Bayou culture; perhaps even during ceremonial events held at the Toltec Mounds.
Figure 4. Vessel Forms From the Ink Bayou Site: Cylindrical Jar or Beaker (a); Flaring Rim Jars (b) and (c); Hemispherical Bowl (d); and Shallow Bowl (e) (adapted from House 1987).

Subsistence data from the site indicate that a broad range of animal species were exploited (e.g., deer, turkey, raccoon, turtle, and fish), with an emphasis on aquatic fauna (Colburn 1987). Moreover, plant remains include a variety of wild and domesticated species. Hickory nuts and acorn represent wild species, while chenopod (Chenopodium sp.), sumpweed (Iva annua), little barley (Hordeum pusillum), and maize represent the cultivated species recovered from the site (King
All of these plants, with the possible exception of maize, are associated with the Plum Bayou culture components.

In summary, the archaeological record of the Ink Bayou site demonstrates the social and economic transformation from seasonal to year-round occupation during the late Baytown-Coles Creek time period. Subsistence was based upon foraging supplemented by the cultivation of native and tropical plants. Formal and stylistic similarities between the artifact assemblages from Ink Bayou and the Toltec Mounds sites suggest both contemporaneity and close cultural affiliation. Indeed, the Ink Bayou site probably represents one of the many Plum Bayou culture household and multi-household units which supplied the labor necessary for mound construction at Toltec.
CHAPTER III
TOWARD A SOCIAL FRAMEWORK FOR INTERPRETING CERAMIC DESIGN

Introduction

Ceramic pots are tools, and as such one would expect their design to somehow correlate with their intended use (Braun 1983:107). On the other hand, as objects produced by humans in society, pots are also social products; thus they represent the objectification of technical knowledge as well as socio-cultural understandings of what constitutes appropriate technological practices and manufacturing techniques (Lemonnier 1990, 1992, 1993). Consequently, technological strategies resulting in the material design of a pot cannot be solely explained in terms of the mechanical performance characteristics of a vessel, and their corresponding behavioral implications, alone. Instead, we need a framework which allows us, or at least challenges us, to situate the process of ceramic production, and the materiality of ceramics, within a broader web of social relations and systems of meaning that structure the work and technological strategies of potters.

In a recent critique of behavioral archaeology, Randall McGuire (1995:168) pointed out that technological studies could benefit from considering two observations made by V. Gordon Childe. First of all, tools reflect the social and economic conditions in which they were produced and that we can learn about those conditions through the analysis of tool production and use (Childe 1944:1). Second, that archaeologists should treat tools "always and exclusively as concrete expressions and em-bodiments of human thoughts and ideas--in a word, knowledge" (Childe 1956:1,
Tools, therefore, do more than just embody human behavior; in their production and through their use they also objectify human relations, actions, and knowledge of the social and physical worlds (McGuire 1992:102-103, 1995:169; Wolf 1982:75). Tools are, therefore, more than just passive reflections of social, political, and economic relations, but active constituents involved in the production and reproduction of social life.

The term "objectification" was used by Karl Marx (1959:69) to refer to the process by which objects become components of social relations (McGuire 1992:103). In the process of objectification, individuals and productive groups transform matter through social labor into objects of material culture that are practical as well as socially recognizable. The process of social labor in production, therefore, ends in the creation of something, which already existed in an ideal form in the imagination of the producer before the process began (Marx 1906:198). As Marx famously observed, "what distinguishes the worst architect from the best of bees is this, that the architect raises his structure in imagination before he erects it in reality" (1906:198). In other words, it is the conscious planning of human agents existing within which differentiates human production from that of non-human, tool producing and tool using animals (Ingold 1986:40-78, 1988:270-271).

The social consciousness of human producers is expressed through their technological choices, which create and reproduce the human labor process, while at the same time determining the material design of the finished product in question (Lemonnier 1992, 1993). Methodologically speaking, a focus on explaining the technological choices of potters, implies the existence of two or more possibilities, which must be compared in order to determine how they differ from or resemble each other, how these
dissimilarities and similarities are to be explained, and what their material as well as social consequences may be” (Lemonnier 1993:7).

Material science studies of ceramics have contributed much to our understanding of the material consequences of certain technological choices, such as the effects of temper choice on vessel strength and thermoconductivity (e.g., Braun 1983; Bronitsky 1986; Schiffer and Skibo 1987). However, very few studies have actually addressed the social consequences of such decisions (see for example Sassaman 1992). As a result, we now know a great deal about the range of manufacturing techniques and production sequences involved with different ceramic industries, but little about the social relations of ceramic production, distribution, consumption, and use affiliated with such industries. In order to place pots back into the hands of the potters, so to speak, we need to take heed of Childe’s two observations, and acknowledge the dialectic which exists between the mental and the material dimensions of social life (McGuire 1995).

In this study I employ the concept of a mode of production in order to examine the social basis for using grog as opposed to other ceramic tempering materials. The mode of production model serves as a heuristic device for visualizing how the technical transformation of raw clay and associated materials into a ceramic pot is conjoined with the organization of human sociality. The concept illuminates the manner in which a given set of technical forces of production are articulated with the social relations of production to produce and reproduce the material and ideational ties of human social life (Trigger 1993:163; Wolf 1982:75).

The concept of a mode of production makes it possible to conceptualize different ways in which humans socially, politically, and economically organize their production (Wolf 1982:75). While Marx spoke of a number of different modes of production in his writings (e.g., a capitalist mode, a feudal mode, an Asiatic mode, and an
antique, communitarian mode), neither he, nor his confidant, Frederick Engels, ever explicitly outlined a theory of the concept. This has resulted in much debate among Marxist scholars over the precise definition of a mode of production, as well as wrangling over the identification of different types, or modes of production in human history (Trigger 1993:163; Wolf 1982:75).

Marx felt that history needed to be explained in primarily materialist terms (Wilk 1996:85). To demonstrate how the material basis of society moved history, he envisioned each society as being comprised of two primary components; (1) the economic base, and (2) the superstructure (Trigger 1993:163). For Marx, the economic base consisted of the tools, technologies, skills, and labor for production, as well as the specific relations of inequality, which organize the distribution of wealth in society. On top of the base was the superstructure consisting of two parts: (1) a legal and political system that orders and regulates society; and (2) a system of ideas, including religion, cosmology, and philosophy, which rationalizes and explains the economic system (Wilk 1996:86). Together, the base and superstructure formed a society’s mode of production.

For Marx, the dynamics of a society, as well as its historical development, were determined by its mode of production (Trigger 1993:162-171; Wilk 1996:87).

The mode of production in material life determines the general characteristics of the social, political and spiritual processes of life. It is not the consciousness of men that determines their existence, but, on the contrary, their social existence determines their consciousness (Marx 1904:11-12, quoted in Harris 1968:229).

While Marx acknowledged the inter-relationship that exists between a society’s superstructure and its base, he saw the economic base as the determinitive element in each mode of production, and this framework shaped his understanding of
historical process. Marx's emphasis on the economic base has led some to accuse him of being a mechanical materialist, espousing a philosophy of economic determinism (Wilk 1996:87). Such an accusation, however, holds little merit. Marx always argued that human social relations were an integral component of a society's economic base. Furthermore, Marx did not envision society as constituting a well integrated seamless system. Instead, he argued that conflicts and contradictions between the various components of society were always in existence, threatening order and lending a dynamism to history, which often played itself out in the context of social struggle (Marx and Engels 1965; Wilk 1996:85-87). For Marx, qualitative, social changes resulted from contradictions between the forces and relations of production in society--especially contradictions resulting from technological developments (see Trigger 1993:165).

Marx rejected the enlightenment view of technological change, however, which claimed that new technologies resulted from the use of human reason to control nature in a more economically efficient and successful manner. While new technologies were seen as creating circumstances which brought on social, political, and economic changes, such changes were said to be the product of specific social and historical contexts (see Marx and Engels 1965; Trigger 1993:165). It was here that the historical significance of the superstructure was acknowledged as a factor facilitating, directing, and inhibiting social process and change. Repressive political regimes and religious beliefs, for example, were considered to have historical power in the sense that they could thwart technological change and, therefore, prevent or delay social development (Trigger 1993:165; Tringham 1983:95-96).
Despite his rejection of the Enlightenment view of technological change, Marx and Engels were still social products of their time. Indeed, Marx's knowledge of historically and ethnographically known societies was limited by the, then, current state of research on the subjects. As such, the writings of Lewis Henry Morgan and his evolutionary scheme had a significant influence on Marx's writings. He conceptualized different aspects of Morgan's pre-civilized (i.e., pre-capitalist) evolutionary stages as constituting different modes of production in human history; each characterized by qualitative changes in the forces of production (Bernbeck 1995:3). Consequently, embedded within Marx's view of change lies an ideology of progress (with evolutionary undertones) that is primarily based on technological developments—an ideology which directly links a reduction in the limitations imposed by nature upon society to progressive changes in the forces of production (Bernbeck 1995:3).

Technology and technological changes in-and-of-themselves, however, are neither good nor bad, but they are also never neutral (Kranzberg 1979:xxiv). In order to steer around the methodological and epistemological trappings of an evolutionary or progressive vision of technology, I follow the lead of Reinhard Bernbeck (1995), by drawing inspiration from a structural Marxist model for modes of production. Bernbeck's approach is based upon Balibar's model, which he presents in his section on "The Basic Concepts of Historical Materialism" in Reading Capital (Althusser and Balibar 1979:199-308). As Bernbeck points out, Balibar's approach "consists of a generalization of the structure of modes of production . . . through which the modes of production in a particular society can be analyzed and compared to those of other societies" (1995:5; emphasis added). This approach offers the possibility of identifying previously unrecognized modes of production.
Moreover, it permits the analysis of quantitative and qualitative transformations in the economic base of a particular society without having to decide whether each element of that society's economy is more characteristic of one or more previously defined, and idealized modes of production. Certainly, similarities in social, political, economic, and ideological structures exist across societies through time and space, but pigeon-holing different aspects of a society into a previously defined and idealized scheme runs the risk of overlooking significant variations in production at finer scales of analysis. In this study, for example, I am less concerned with analyzing transformations in the overall mode of production of the Plum Bayou culture, than I am with analyzing the labor process involved with the production of a specific instrument of labor, grog-tempered ceramics. I now turn my attention to the modes of production concept guiding this research.

On the Concept of a Mode of Production: Placing Tools in Their Social Context

As mentioned earlier, all modes of production consist of a set of forces and social relations of production (Ingold 1988: 274; Trigger 1993:163). According to Balibar's reading of Capital (Marx 1906), the forces of production are comprised of two components: (1) the organization of labor, or labor power; and (2) the means of production (Bernbeck 1995:5). The organization of labor refers to all persons involved in production; more specifically, the number of persons involved in the production process as well as the different kinds of cooperative arrangements. Productive labor can be organized through a number of cooperative arrangements involving one or more individuals. If we consider the scheduling of activities, for example, then we can speak of cooperative arrangements in terms of linear and simul-
Simultaneous tasks (see Wilk and Rathje 1982:622). Linear tasks can be accomplished by a single person performing a sequence of operations, such as in the production of simple chipped stone tools (e.g., utilized and retouched flakes). Simultaneous tasks, on the other hand, are performed by a number of people acting at the same time, as in the communal construction of large earthworks like those found at the Toltec Mounds site.

Simultaneous activities can be further subdivided into the categories of complex and simple simultaneous tasks (Wilk and Rathje 1982:622). A simple simultaneous task involves many people conducting the same task at the same time, as in a large planting group where each person is responsible for planting a single row of crop. Bernbeck (1995:5) calls this type of cooperative arrangement "nonhierarchical", and cites Malinowski's (1961:159-162) description of communal work in gardens on the Trobriand Islands as an example. Complex simultaneous tasks often involve specialization, as different members of the working group carry out different parts of the same job at the same time (Wilk and Rathje 1982:622). Such activity often times results in a hierarchical structure of cooperation where not all individuals involved have equal say in the labor process (Bernbeck 1995:5).

Many activities, however, can be accomplished in either a linear or simultaneous manner. A single potter, for example, can dig their own clay, form a pot, and fire it all by themselves in a linear sequence, or the different tasks involved in ceramic production could be divided among the available labor force and carried out simultaneously. As such, two different cooperative arrangements within the same society--and therefore different labor processes--could feasibly produce ceramic pots with similar, if not identical, material designs. Likewise, identical cooperative arrangements could potentially yield completely different material results, based
upon the social and historical context of ceramic production in each society (Cobb 1993).

I do not intend to imply that the organization of labor is not influenced and shaped by technological and environmental conditions, only that such elements of the production process do not determine the way labor is to be organized (McGuire 1992:104-105). Within the mode of production framework, technological and environmental conditions are reconfigured as the objects and means of labor. Objects of labor include all matter, which is transformed through human labor into an artifact for social use. This could be raw clay extracted from the environment, or a broken Baytown Plain pot that is being crushed into grog for ceramic tempering. Objects of labor may be immediately consumed (e.g., unprocessed foods), or they may be used to produce other artifacts, in which case they become means of labor (Marx 1906:198-199).

Included in the means of labor are the tools produced and used by humans, as well as water, wind, land and other naturally occurring means of labor not produced by humans (Bernbeck 1995:5; Marx 1906:199). Water, for example, becomes a means of labor when the energy of a flowing river is used to drive the turbine engines of a hydroelectric dam. Likewise, the apparatus and techniques of the human body can also serve as a means of labor (Ingold 1988:273, 1990:7). Take, for example, the process of preparing a clay body, where the hands and feet are often used to blend and kneed a mixture of raw clay, water, and temper before a ceramic pot can be formed (see Rye 1981:18-19).

The triad of the organization of labor, objects of labor, and the means of labor, constitute the three elemental factors of what Marx referred to as the "labor process" (Marx 1906:198). Bernbeck points out that within this triad, the means
of labor play a prominent role in determining to a certain extent the organization of labor and the character of the objects of labor, as well (1995:6). He uses the example of the shift to fully mechanized farming practices as a transformative force in reshaping the organization of the family operated farm to one organized by economic structures of employer and employee (see Bergmann 1990:52-55; cited in Bernbeck 1995:6). Likewise, the shift changed the nature of the plants themselves; as plants produced on such farms require more standardization in order to be cared for and harvested with the use of mechanized machines.

Another example of how the means of production can shape the organization of labor is exhibited in the way earthen mounds were constructed at the site of Toltec. An excavation cut made into the upper two-thirds of Mound B at Toltec indicates that the 11.5m tall platform mound was built in a series of construction stages (see Miller 1982:Figure 27; Rolingson 1990:Figure 8). A total of five fill zones and three intermittent midden deposits were identified in the excavation profile (Miller 1982:36-41; Rolingson 1990:32). Present in the profile wall of each fill zone were multicolored elliptical and amorphous “blobs” of soil (see Miller 1982:Figure 26). Each blob represents a single basket-load of soil that was carried to the mound locality and dumped by hand. The soil was most likely dug by hand as well, using a wooden digging stick, or some form of hoe.

Given the hand-held nature of the tools, mound construction efforts would have required the mobilization of a substantial workforce in order to complete the project in a timely manner. As such, one can assume that the labor force was organized in a simple simultaneous or complex simultaneous fashion (Wilk and Rathje 1982). In the first scenario, each individual in the group would have been responsible for digging and hauling their own basket loads of earth. However, in the later
scenario two distinct work parties would have performed the tasks, the diggers and the haulers. Nassaney (1992b) has even suggested that the careful planning behind the placement and construction of the earthworks at Toltec indicates a third occupational role held by the elite of the Plum Bayou culture; that of labor mobilizer, organizer, and construction director. Following the work of Krause (1985), Nassaney posits that construction episodes may have corresponded with changes in leadership and were initiated by “elite members of a descent group who, by reasons of their rank, could mobilize the labor of their kin toward particular goals” (1996b:32). In such a scenario, the hierarchically organized process of mound construction not only symbolized the rank of the elite organizers, but also served to reproduce—and possibly challenge—the social alliances, which underwrote the labor process to begin with.

Stating that the means of production can shape the overall character of the labor process, however, runs the risk of being misread as an argument for technological determinism. Such a misunderstanding is characteristic of a standard view of technology which regards tools and techniques as the linchpins of human adaptation, and treats the organization of human labor as a passive response to changes in these two elements of the production process (Pfaffenberger 1992). The fact remains, that in most preindustrial societies, tools and techniques are secondary to the social coordination of labor in structuring human adaptations (Pfaffenberger 1992: 497; Sahlins 1972:81). This suggests that technological choices concerning the design and use of particular objects as instruments of labor do not arise from technical knowledge alone. Technological choices are also shaped by non-technical logics (e.g., gender constructions) that structure the social coordination of labor, as well as the

Lemonnier states that any technical act, such as the manufacture of ceramic vessels, may be "poly-determined"; that is, the act "may [simultaneously] respond to, illustrate, and be compatible with, several social logics, each of a different order" (1990:29). At times, the physical purpose of an instrument of labor, what is often referred to as the tool's primary function (e.g., Dunnell 1978; Schiffer and Skibo 1987, 1997), may be separate from its communicative purpose. The custom paint-job on one's car, for example, in no way interferes with the aerodynamics of the car or the quality of its acceleration--I am thinking here of the lavish paintings found on the sides of vans during the 1970s. At other times, a certain aspect of an artifact or a particular technique may possess both purposes at once. One example is provided by the persistent use of the horse and buggy by contemporary Amish groups in the Midwestern United States. While the horse and buggy allows the Amish to travel to and from the market place, it also signifies their identity as members belonging to a specific religious community distinguished apart from a greater nation of automobile users.

The patterning of material culture and technological practices, therefore, lends reality to social structure. That reality, however, may in fact, misrepresent the social structure by reinforcing and reproducing beliefs that mask relations of power structuring the labor process (McGuire 1992:105). Likewise, the patterning of material culture and technological practices may also serve as the vehicle whereby relations of power can be resisted, as in the case of the Amish. In this way, the technological production and use of material culture serves as an arena of social interaction, contestation, and control, as the forces of production become embedded
within a broader context of social, political, economic relations (Dobres 1995; Wright 1996).

Social relations of production constitute the other primary component of any mode of production. In classical Marxism, the social relations of production are reduced to property relations and distributions of wealth. They denote specific patterns in the ownership and control of the forces of production (Trigger 1993:163). According to Balibar, however, the social relations of production include the relations between all persons involved in the production, distribution, and consumption of a product (Althuser and Balibar 1979:232-233; cited in Bernbeck 1995:6). As a result, considerable overlap occurs between the organization of labor and the social relations of production, as both elements involve relations between human agents involved in technological production (Bernbeck 1995:6).

To get around this conceptual problem, Bernbeck (1995:6) suggests that cooperation in work (see above) should be kept separate from other relations of production in our analyses. Examples of such relations are those intertwined with relations of class, ethnicity, or gender, which not only structure who controls and has access to the forces of production, but who performs the actual work involved in the production process, as well. Here, the concept of work is distinguished from that of labor, in that work refers to the specific actions and techniques of an individual, or group of individuals, using energy to create energy (McGuire 1992:103; Wolf 1982:74). Labor, on the other hand, is social, conscious, and meaningful, and thus, "presupposes a web of social relations and meanings that structure work" (McGuire 1992:103). Humans never create or use energy outside of this web, the character of which, is socially and historically contingent.
Consequently, cooperation can be understood in two different ways: (1) as "the functioning of a complex mechanical system composed of an aggregate of relatively autonomous working parts" (Ingold 1988:278); and (2) the cooperation of persons acting together in the labor process (Ingold 1988:280). The latter speaks more to the sharing of activities between socially conscious individuals in society. The former, however, more closely conforms to the above definition of work, by referring to the technical arrangement of persons involved in the exploitation of a certain environmental setting by means of a particular technology. As such, I restrict the meaning of cooperation to the first, more instrumental, definition, for only in this sense can the cooperative arrangements involved in technological production be compared between different social groups, and between different productive activities within society. However, it is important to remember that while cooperation constitutes a primary element of the organization of labor, it also serves as an analytical entry point into the social relations of production in society (Bernbeck 1995:6).

Archaeologists, of course, do not uncover modes of production in the course of their excavations. Instead, they uncover and recover the products and precedents of human activities and technological practices (Wobst 1978). Therefore, if a mode of production framework is to have utility for archaeological investigation, then the archaeological correlates for the different elements of a mode of production need to be identified.

Objects recovered from the ground largely belong to the sphere of the means of production (i.e., the objects and means of labor). Instruments of labor, such as ceramic pots or stone tools, are used by humans to enhance their ability to transform matter into socially identifiable and useful forms; that is, to satisfy their wants and
achieve their established goals of production. Such instruments are themselves the result of matter being transformed. All intentionally produced means of labor, therefore, must go through a stage in which they are the objects of labor, as well (Marx 1906:197-220). Acknowledging this double aspect of all humanly produced objects is crucial for the archaeological analysis of variation and patterning in the material record. As such, one goal of archaeological investigation should be to reconstruct as much of the means of production in society as possible (Bernbeck 1995:6).

Experimental reconstructions and material science studies of various instruments of labor from different cultures and social groups over time have contributed greatly toward the achievement of this goal. In the case of low fired, earthenware pottery, certain attributes of ceramic vessels allow us to ascertain the means of labor involved in ceramic production. Take, for example, the paddle-and-anvil formation technique which has been well documented ethnographically around the world as one of the primary manufacturing techniques used by potters to shape and finish coil-built vessels (Fewkes 1941; Rice 1987:136; Rye 1976:109). Cordmarking on the exterior surface of Late Woodland period pots throughout the Eastern Woodlands attests to the use of a hand-held, cord-wrapped stick or paddle to draw and shape the vessel walls, while strengthening the bonds between individual coils of clay used to construct the pot. Likewise, circular divots, or even fingerprints, on the interior of the vessel walls speak to the use of an anvil, or the human hand, to support the wall while being paddled and shaped.

On plainware ceramics like the type Baytown Plain, however, the use of a paddle and anvil is more difficult to infer, because evidence of cordmarking is removed when the surface of the pot is smoothed and finished. On the other hand, cord-marked vessels do appear in Plum Bayou ceramic assemblages as the type Mulberry
Creek Cord Marked (Rolingson 1978; Stewart-Abernathy 1982) and potsherds fractured along coil lines confirm that Baytown Plain vessels were constructed using a coil-building technique (House 1987). Taken together, these two independent lines of evidence suggest that the Plum Bayou potters were, at the very least, familiar with the paddle-and-anvil construction technique.

Certain attributes of ceramics can also inform us on the intended use of a vessel (i.e., the pot as a means of labor). Different attributes of vessel morphology and composition have been shown to effect the mechanical performance of ceramics in both positive and negative ways which depends upon the intended use of the vessel and the specific kinds of stresses developed during manufacture and use (Braun 1983:109; Bronitsky 1986; Rice 1987:347; Schiffer and Skibo 1987, 1997). The mechanical performance characteristics of pots can be understood as the behavioral capabilities which a vessel must possess in order to fulfill its function within a specific activity (Schiffer and Skibo 1987:599).

Performance characteristics are affected by the formal properties of ceramics, which in turn are the result of technological decisions made by the potter at each stage in the production sequence (Braun 1983; Schiffer and Skibo 1987, 1997). Generally speaking, each technical choice effects multiple formal properties and performance characteristics. In fact, as Schiffer and Skibo (1987, 1997) point out, technical choices are renowned for having polar effects on the mechanical performance characteristics of ceramics: while some are enhanced, others are degraded. For example, while thinner walls can improve the thermal conductivity and thermal shock resistance of cooking pots, they simultaneously reduce the pot's ability to withstand impact stresses. In addition, a single performance characteristic can also be affected by multiple technical choices. Thermal shock resistance, for example,
can be manipulated and altered by the shape of the vessel, as well as the size, amount, and type of temper added to the paste (Braun 1983; Bronitsky 1986; Feathers 1989a).

Consequently, the polar effects of technical choices promote compromises in ceramic design as they relate to the intended use of a vessel and the availability of raw materials, degrees of technical knowledge, the skill of the potter, and their repertoire of available manufacturing techniques (Schiffer and Skibo 1987, 1997). For the sake of brevity, I will limit my discussion of mechanical performance to the effects of temper on the formal properties and performance characteristics of ceramics as an example of some of the technical compromises involved with ceramic production.

Temper Choices and Technical Compromises: The Materiality of Ceramic Vessels

The intended goal of this discussion is to provide an example of how technological choices--in this case, temper choices--can shape the process of ceramic production and effect the material properties of clay pots. The act of tempering refers to the mixing of additives (including other clays) with raw clay to produce a ceramic body for pottery construction (Arnold 1974; Rye 1976:109). The addition of ceramic temper constitutes one strategy for modifying the properties of ceramic pastes and fired clay pots. The addition of temper can: (1) vary the workability of the paste (i.e., the mixture of raw clay and natural inclusions); (2) reduce stresses resulting from shrinkage during drying; (3) reduce the stresses caused by rapid heating and cooling; and (4) increase the flexural (rupture) strength of low fired earthen pots (Braun 1982:183-184, 1983:122-123; Rye 1976:109). Potters can control--to a certain degree--the material effects of their temper by choosing
to use different tempering materials, the size of the temper particles, and the amount added to the paste.

Temper choices are executed early on in the production sequence and can, therefore, potentially affect technical choices later on in the sequence (Schiffer and Skibo 1997:31). Initially, the addition of temper alters the workability of a ceramic body. Workability is a subjective term that refers to the suitability of a clay body for ceramic production. Materially speaking, workability is derived from the blend of clay minerals and nonplastic inclusions—those naturally occurring and those added by the potter (Rye 1981:31). To understand how the addition of temper to a ceramic paste improves its workability, we need to first address some of the physical and chemical properties of naturally occurring clays.

Soil scientists use the term “clay” to denote a specific particle-size grade whose fraction consists of the smallest particles. The term is also used in reference to a fine-grained earthy material comprised predominantly of clay minerals, which develops plasticity when mixed with a limited amount of water (Copeda 1994:79; Grim 1968:1-2; Rice 1987:36). Clay minerals are hydrated aluminophyllosilicates which form as alteration products of silicate minerals—primarily feldspars—during the initial weathering of rocks forming the earth’s crust (Lewis and McConchie 1994:153-154; see Grim 1968:31-50 for a detailed description of the chemical, structural, and physical characteristics of the various clay mineral types). Naturally occurring clays are usually composed of several clay minerals (Copeda 1994:79), as well as a number of naturally occurring, non-clay minerals and organic materials (Rye 1976:29). The actual composition of a clay is determined by the chemistry of the weathering or diagenic environment (Boule et al. 1973:84-86; Lewis and McConchie 1994:157), as well as the depositional environment (Rye
Clays that form near the parent material are called primary clays. These clays are generally coarser grained and more uniform in composition than secondary clays. Secondary clays are finer grained and more complex in composition, with a higher organic content, owing to their being deposited some distance from the parent material through erosion, lacustrian, aeolian, and other geological processes (Rice 1987:36-37; Rye 1981:29). By virtue of their variable geological origins, clays tend to vary greatly in their physical and chemical properties (Boule et al. 1973:84-86) and thus, vary in their suitability and selection as raw materials for ceramic production, as well (Arnold 1971; Nicklin 1979).

One of the most salient properties of clay effecting its suitability as a ceramic raw material is its plasticity. Plasticity refers to the ability of the moistened clay to be deformed under pressure and retain its shape even after the deforming force is removed (Grim 1968:1; Rice 1987:58; Rye 1981:31). Plasticity is influenced by such factors as organic content and mineral composition, but the primary factors controlling plasticity is the shape of the clay particles, their size, and the electrical relationship between water and the colloidal particles (Bronitsky 1986:213; Rice 1987:58). Clay particles have a flat lamellar or plate-like shape, measuring 0.004 mm or less in diameter (Grim 1968:2; Lewis and McConchie 1994:115, Figure 5-1). Generally speaking, the smaller the particle size, the greater the total surface area per unit volume, and thus, the more plastic the clay (Rice 1987:59). When clay is mixed with water a thin film of absorbed water surrounds the clay particles and acts as a lubricant allowing the platelets to slide over one another. At the same time, however, the surface tension of the water coating the particles also tends to weakly hold them together (Rice 1987:59). The net effect is similar to that of two plates of glass being stuck together by a thin film of water: although they can
still be separated, it is much easier to slide them along one another than it is to pull them apart. Finer grained clays like those found in back water swamp areas, therefore, are usually more plastic than coarser grained clays (Rice 1987:60).

Clay becomes plastic when the amount of water added reaches a definite point called the yield point (Shepard 1995:15). Up to this point the clay exhibits elastic flow when subjected to shearing forces. Once the yield point is passed, a plastic clay will allow a considerable amount of extension until cracking begins (Shepard 1995:15). Generally speaking, a workable clay body is one with a high enough yield point so as to prevent accidental deformation, or sagging before drying, and a large enough extensibility to facilitate formation without cracking (Shepard 1995:15). An inverse relationship exists between the yield point and the extensibility of the clay, however. A moderate yield point and extensibility, therefore, is considered ideal for pottery manufacture. As such, the addition of temper to a highly plastic ceramic paste serves to decrease the overall surface area per unit volume of the plastic clay particles. This decrease essentially raises the amount of water needed to bring the clay to a plastic state (i.e., raises the yield point of the paste), while maintaining a suitable degree of extensibility.

Not all tempering materials will effect the workability of a given ceramic paste in the same way. Calcium carbonate (CaCO₃) based tempers, such as burned shell, limestone, and bone, for example, are said to greatly increase the workability of highly plastic clays over that gained through using other tempering materials (Million 1975:202; O’Brien et al. 1994:283; Stimmell et al. 1982:220). Chemically speaking, when clays are wetted, an identical ionic charge occurs on the surface of the clay particles, keeping them slightly repelled from one another. This ionic repulsion is negated when burned calcium-carbonate-tempers are added to the paste.
(see Million [1975:202] and Stimmell et al. [1982:220] for details). The addition of burned shell, limestone, or bone produces a flocculation process whereby the clay particles tend to stay together and form larger clay particles. As a result, the total surface area per unit volume of the plastic clay particles is substantially decreased and the clay becomes more "workable" (Million 1975:202; Stimmell et al. 1982:220).

Despite an improvement in paste workability, one of the compromises involved with using calcium-carbonate tempers is the risk of lime spalling during firing. When heated to temperatures well within the range of non-kiln firing techniques (600-900°C), \( \text{CaCO}_3 \) decomposes into \( \text{CaO} \) and \( \text{CO}_2 \) (Rice 1987:98; Rye 1976:120; Stimmell et al. 1982:219). Upon cooling, the \( \text{CaO} \) takes up water from the paste and readily combines with water vapor in the air forming \( \text{Ca(OH)}_2 \). There is a significant difference in the volumes of \( \text{CaO} \) and \( \text{Ca(OH)}_2 \), with the volume of the calcium hydroxide being much greater. As such, the formation of calcium hydroxide can create considerable pressure in the vessel body, causing cracking and spalling (Rice 1987:98; Rye 1976:120-121). The rehydration of the \( \text{CaO} \) gives the pot a very low strength (i.e., the ability to resist crack initiation and propagation), and in extreme cases may cause the entire clay body to crumble into a pile of grains (Rice 1987:98; Rye 1976:121).

Several solutions exist for dealing with the problem of lime spalling (Laird and Worcester 1956). Potters can fire their vessels at temperatures below the critical temperatures of \( \text{CaCO}_3 \) degradation (Rice 1987:98), or at higher temperatures, but in a reducing atmosphere (Feathers 1989a:580; Laird and Worcester 1956:555). A reduced atmosphere is one where carbon dioxide is present because insufficient oxygen is available for fuel combustion (Rye 1981:146). Thirdly, the
addition of salt (NaCl) to the clay mixture also retards spalling by inhibiting the transition of calcium carbonate to calcium oxide (Hoard et al. 1995:830; Laird and Worcester 1956; Rye 1976; Stimmell et al. 1982:222). Potters may also employ a procedure called docking to control spalling, which involves wetting the newly fired vessel with water before it cools (Laird and Worcester 1956; Rice 1987:98). Finally, the material consequences of rehydration and of CaO and the subsequent expansion of Ca(OH)$_2$ are less seriously damaging when very fine-grained particles of calcium carbonate-temper are added to the clay (Hoard et al. 1995:830; Rice 1987:98).

The choice of which strategy or strategies to use, of course, depends on a number of factors ranging from the potter's knowledge of the various techniques to the natural properties of the raw clay. Arnold (1971:29-30) reports, for example, that the Ticul potters of the Yucatan prefer to use clay that has a salty "taste" when preparing calcite-tempered cooking ware vessels. Regardless of which technique one uses, the fact remains that there are consequences involved with the choice to use shell, bone, or limestone as a ceramic tempering agent--consequences that must be dealt with later on in the production sequence.

In addition to improving workability, temper choices can also effect a vessel's ability to withstand thermally and mechanically induced stresses. The ability to withstand such stresses relates to a more specific effect of tempering on a ceramic body--the ability to resist cracking (Braun 1983:123). Resistance to cracking can be divided into two categories: resistance to crack initiation and resistance to crack propagation (Braun 1983:123; Bronitsky 1986:232). Resistance to crack initiation involves the ability to prevent cracks from forming in the clay matrix (Braun 1983:123). Prevention depends upon the clay molecules being able to form a con-
tinuous and homogenous crystalline matrix (Braun 1983:123). The chemical bonds between clay particles are relatively weak compared to the bonds formed after firing. Even so, pots fired in open pits rarely reach temperatures above 1000°C, and therefore, never become fully vitrified (Rice 1987:5; Rye 1981:25, 108). Consequently, resistance to crack initiation is typically low in open pit fired pottery, and less critical than controlling the propagation of cracks through the vessel body once they have formed. However, as a general rule of thumb, a vessel’s ability to resist crack initiation will increase as the overall grain size of the ceramic body decreases (Braun 1983:123; Shepard 1995:131). In short, pots produced with finer-grained clays and tempered with smaller-sized temper particles should have a greater bending strength (increased resistance to crack initiation) than pots tempered with coarse-grained temper particles (Steponaitis 1983:37).

Cracks can be initiated by mechanically and thermally induced stresses. Ceramic materials crack and break in thermal shock due to the development of tensile stresses that exceed the strength of the ceramic body (Lawrence 1972:174). Such stresses are caused by two thermally induced situations. Thermally induced stresses can result from the development of a thermal gradient through the vessel wall. Fired clay is not a good conductor; therefore, when a vessel is placed on a fire the exterior surface will become hotter and experience a greater degree of expansion than the interior surface of the vessel wall. As a result, the vessel wall will bend unevenly, causing cracks to form on the cooler interior surface in order to relieve the tensile stresses caused by the thermal gradient (Braun 1983:123; Lawrence 1972:175-178; Steponaitis 1983:37-45).

Cracks and internal stresses can also arise from the different thermal expansion and contraction rates of the temper particles relative to the clay matrix (Braun
Different kinds of tempers have different thermal expansion characteristics, making some materials more suitable for constructing pots for use over an open fire. Calcite, and other calcium carbonate-tempers, for example, have thermal expansions similar to those of many naturally occurring clays, whereas quartz has a much greater thermal expansion (see Rye 1976:Figure 3). Pots made of ceramic bodies with tempers that have thermal expansion characteristics close to that of the clay matrix typically have a higher resistance to thermally induced stresses than those, like quartz, which have much greater volumes when heated. Again, grain size becomes an important variable here. The smaller the average grain size of the temper particles, the higher the flexural strength of the vessel walls and the more resistant it will be to crack initiation under thermal stress.

Resistance to crack propagation, on the other hand, increases with the increasing grain size (within limits) of irregularities included in the ceramic body (Braun 1983:123; Lawrence 1972:181-182). While temper particles may serve as sources of cracks, they also function as points of arrestment for cracks expanding through the ceramic body. As a result, materials with numerous crack sources per unit volume show a greater resistance to crack propagation than to crack initiation (Bronitsky 1986:232-233). This means that pots tempered with coarse particles would most likely have a lower initial strength value than fine-tempered vessels, but would retain most of their strength even after being subjected to extreme thermal stress.

In his study of shell-tempered ceramics from Moundville in Alabama, for example, Steponaitis (1983:17-45) concluded that the Moundville potters manipulated the composition of their ceramic pastes in order to fulfill certain functional
needs. He observed that cooking jars tend to be tempered with greater amounts of coarse-sized temper particles than other vessel forms, such as bottles and bowls, which would usually not be subjected to conditions of rapid heating and cooling. Steponaitis (1983:45) suggests that through a gradual process of trial and error, the Moundville potters discovered that tempering with coarse particles of shell would increase the longevity of cooking vessels.

In addition to the size and amount of temper, the material type, shape, and orientation of the temper particles can also effect a vessel's ability to resist crack propagation (Braun 1983:123; Feathers 1989a:581; Shepard 1995:131). In his study of the transition to shell-tempered pottery in southeast Missouri, Feathers (1989a) determined that shell-tempered ceramics were stronger and tougher than sand-tempered wares. Toughness, in this case, is defined as the time between crack initiation and failure. Feathers attributes the strength of the shell-tempered ceramics to the plate-like structure of the calcite grains. As he points out:

When viewed under high magnification (160x), the particles appear as bundles of longitudinal fibers. When these fibers are aligned parallel to the direction of stress, they increase strength because of the greater force required to break them as compared to the force required to break the clay matrix (Feathers 1989a:586).

Sand grains, on the other hand, are not plate-like, but rounded in shape. As such, one would not expect sand-tempered wares to be as crack tolerant as the shell-tempered wares. In fact, according to Feathers' (1989a:585) study, sand tempered wares are not only weaker than shell tempered wares, but test bars tempered with only 25 percent by volume of sand grains performed better under a three-point bend test than those tempered with 45 percent sand. This inverse relationship between the amount of sand tempering and vessel strength, is most likely related to the rounded shape of the sand grains, and the differences in thermal expansion charac-
teristics between quartz sand and the clay matrix (see Rye 1976:117). Under such conditions, therefore, the potential for crack initiation, propagation, and vessel failure in sand-tempered pots would increase with an increase in the amount of temper added to the paste.

The opposite was true for the sample of shell-tempered test bars. Feather's results mirrored those of Steponaitis (1983), as test bars tempered with 45 percent course-sized particles of burned shell proved to be tougher than those tempered with 25 percent and 45 percent fine-grained shell, and 25 percent of the coarse-grained shell, as well (Feathers 1989a:Figure 2). Based upon his findings, Feathers (1989a:587, 1989b:78) suggests that the selective force favoring the increased production and use of shell-tempered ceramics after ca. A.D. 900 may be related to a growing need for tougher and more thermally resistive pots. Exactly what these needs encompassed, however, is never fully addressed. Instead, Feathers' (1989a, 1989b) explanation for the shift from sand- to shell tempering relies upon his assumption that the relationship between a vessel's design and its intended function is direct and rational.

I do not deny that in some societies there exist technological choices, which are, or were, made and rationalized in predominantly techno-functional terms. I argue, however, that such cases need to be socially contextualized and demonstrated, rather than merely assumed. Indeed, if one initially assumes a clear and rational connection between artifact form and function, then one will always be able to find (create) a techno-functional reason for an artifact's existence. The question is whether such explanations will be able to address the social complexities underwrit-
ing processes of technological production, invention, adoption, and change (Dobres and Hoffman 1994).

While the polar effects of technical choices may allow archaeologists to analyze the mechanical performance capabilities and potentials of ceramic pots (Schiffer and Skibo 1987, 1997), the nature of their use is not given in their formal attributes and composition alone (Lemonnier 1993). An artifact's design may limit its range of possible functions within the labor process, but it does not determine what those functions should be. Things become means and objects of labor (i.e., tools) only when they are entered into the social relations of labor—the web of relations and systems of meaning structuring work (Marx 1906). To state it differently, the architect not only envisions the building before he/she constructs it in reality, but envisions the manner in which the building is to be constructed as well, including who, how, where, when, and with what (Cresswell 1990; Lemonnier 1992, 1993). As such, the organization of labor constitutes an integral component of the forces of production in society, and must be addressed in the course of explaining variations in artifact design and corresponding processes of technological development and change (Pfaffenberger 1992).
Placing the Pot in the Hand of the Potter: Ceramics and the Organization of Labor

The task of ceramic production does not constitute a single moment in the life of an individual potter, but rather a moment in the social life of potters existing within a broader community. Work—the act of using energy to create energy—is as much about social interaction and reproduction as it is material production (Applebaum 1984a; Cresswell 1990). As a topic of anthropological inquiry, productive activities (i.e., work) can be analyzed in terms of the physical transformations of matter, social transactions, economic activities, and forms of personal identity (Wallman 1979:1). Over the past few decades, anthropology has witnessed a growing interest in developing a comparative framework for analyzing the organization of labor, the results of work, and the embeddedness of productive activities within the social institutions of different societies (see contributions to Applebaum 1984b).

The organization productive tasks (i.e., the act of work) in society involves a number of interrelated components (Applebaum 1984a; Rapoport 1990; Wallman 1979). First, the resources, or matter, being transformed through the labor process shapes the nature of work. Issues of accessibility, as well as the physical and chemical properties of the raw materials, apply in this case. A second component is the manner in which the activity is carried out, including the tools, techniques, and sequence of associated tasks. The scheduling of activities and their spatial arrangements over the landscape constitute two more significant components of labor organization. Both, of course, are inextricably linked to a fifth component of labor organization; the way specific productive activities are associated with other activities (productive and non-productive, alike) and combined to form activity systems (Lemonnier 1992:4-11; Rapoport 1990:12-13). Related further still, is the issue of who performs and controls the work in question—keep in mind that under
certain social and economic conditions, those who perform the work are not necessarily synonymous with those controlling the labor process (Braverman 1974). Included in this component are: (1) the number of people involved in the activity; (2) the division of labor in society (be it along the lines of gender, age, class, and/or ethnicity); and (3) the forms of cooperation (e.g., number of linear or simultaneous tasks). Finally, the meanings and values socially ascribed to a specific activity also play a significant role in the organization of labor. Some tasks are valued more than others are and this often times effects whom, how, when, where, and for what purpose an activity is performed. An important aspect of addressing this component of labor organization is to ask how and by who the work is being evaluated (Wallman 1979:1). The androcentric evaluation of women's domestic work as unpaid, unproductive labor serves as one example of how gender ideologies, and a corresponding division of labor in society, can shape the nature and organization of work (Moore 1988:42-72).

These different components of labor organization are in no way mutually exclusive of one another. Together with the objects and means of labor, the different components of labor organization form a causal nexus shaping, if not determining, technological choices. Consequently, the analysis of labor organization provides a powerful entry point into the dynamic relationship between the forces of production and the social relations of production in society. According to Bernbeck (1995:5), however, our analysis of labor organization--for analytical reasons--needs to be limited to questions regarding cooperation in work (see above). This does not mean, of course, that cooperation in work cannot be indirectly addressed by examining the other components of labor organization. The challenge for the archaeologist, therefore, is to investigate how the various components of labor organization can shape,
and be shaped by, the materiality of the means and objects of labor involved with a specific activity, or set of activities.

Consider, for example, the following scenario: Hudson (1976:309), citing Swanton (1911:78,90), mentions that the Southeastern Indians did not eat regular meals together, but rather ate their meals on an ad hoc basis whenever they were hungry. Apparently, the Southeastern Indians normally ate at their own leisure, with ceremonial feasts serving as the primary context for communal consumption events. Even then, however, as Hudson points out, consumption may have been separated along the lines of gender and rank (1976:309).

By focusing on the social organization of work a number of significant questions can be proposed in reference to the above scenario. First of all, how might the different contexts of eating (i.e., casual and ceremonial) have effected the scheduling of food production among the Southeastern Native American groups? In what ways could the scheduling of food preparation influence, and be effected by, the scheduling of other daily tasks in society (e.g., working in gardens or hunting game, to name only two)? How might labor have been organized, or reorganized, in order to ensure the availability of food throughout the day, in different contexts? Was labor organized into a series of linear and/or simultaneous tasks? Would simmering as opposed to boiling have been the preferred method of food production under these circumstances? How might a cooking pot have been designed to fulfill the labor demands and mechanical requirements imposed by such situations? Can the engineering principles of ceramic design discussed above help us interpret the way a particular vessel was used, as well as the social and physical conditions surrounding its use? Finally, do our empirically based inferences regarding ceramic production and use corre-
spond with the use-wear data itself? If not, then how do they differ, and could this difference relate to a particular labor arrangement not initially considered?

While not entirely unique to a social approach to technology, these are the types of questions fostered by an emphasis on the relationship between working people, their tools, techniques, transformed materials, and the social structures determining the allocation and articulation of productive tasks. What is needed, however, is a systematic method for analyzing the relationship between the organization of labor and the products of labor. Likewise, this method must provide a means for comparing data concerning the socialized actions on the material world.

The French anthropologist Pierre Lemonnier (1992:25-37) has suggested that observing and recording the sequence of operations involved with a particular activity provides an empirical means for analyzing and comparing the work of individuals and productive groups within and between societies. The concept of “operational sequence” was first used by Leroi-Gourhan to “systematize work by considering the mechanical aspects of the means and objects of labor” (Bernbeck 1995:7). Later, Cresswell (1990) employed the concept in formulating a social approach to the study of technological production (i.e., work). He defines an operational sequence as a series of sequential or simultaneous operations through which raw materials are transformed into a socially usable and identifiable form. At each stage in the sequence, individuals and productive groups make technical decisions which serve to reproduce existing, or create new, social relations within the matrix of a technological process—a process that is simultaneously social and practical (Cresswell 1990:46; Lemonnier 1992:25-37, 105-115).

All three elements of the forces of production play a significant role within the concept of the operational sequence (Bernbeck 1995:8). The object of labor, for
example, constitutes the item whose operational sequence is being reconstructed through the course of archaeological inquiry. The means of labor (including the human body) are, of course, important in all such operational sequences. Certain means of labor have to be produced in advance of, or simultaneously with, specific tasks in the operational sequence, and therefore can shape the overall length, or complexity of the sequence.

The organization of labor effects such sequences in several ways. In addition to the number of individuals involved in each task within the sequence, the number of tasks, and the degrees of repetitiveness and simultaneity of tasks also characterize the organization of labor in society (Bernbeck 1995:8). Indeed, the number of different steps involved with bringing an object from a raw form to a finished product gives a first approximation of the organization of technological production.

Ideally, one would want to analyze the various components of work organization at each step in the operational sequence in order to address the social basis for specific technological choices relating to ceramic design (Lemmonier 1992:18-19). It is impossible, however, to address all the organizational components through archaeological evidence alone. The engendering of specific tasks within a gendered division of labor, for example, requires the recourse to ethnographic analogies for examining the dialectic between gender ideologies and technological practices (Brumfiel 1991; Conkey and Cero 1991; Costin 1996).

Furthermore, archaeologically analyzing the organization of labor in society is often limited by analyses of only one kind of material object (e.g., ceramics, lithics). Indeed, one long-term goal for archaeological research should be to recreate as much of the means and objects of labor as possible and examine their interrelationships. Such knowledge leads to a richer description and explanation of different
operational sequences, which in turn facilitate the search for general trends in cooperation.

Even more problematic than analyzing the organization of labor is the reconstruction of the social relations of production in society. Here too, recourse to ethnographic studies is often relied upon in order to impose a certain form of social-political organization upon the archaeological data (e.g., kinship, tributary, or capitalist forms of productive, distributive, and consumptive relations; see Wolf 1982). However, as Bernbeck points out, "if archaeological correlates for social relations of production cannot be devised, the whole concept of modes of production loses its value" (1995:9). Again, one of the advantages to the structural model of modes of production is that it allows us to discuss the dialectic between the forces and relations of production without having to treat the relationship as an invariant one. Surely by analyzing different patterns of work cooperation, some informed inferences about the relations of production in society can be put forward in the course of archaeological inquiry, without having to rely upon evolutionary frameworks. While certain forms of archaeological evidence can inform us on relations of social ranking (e.g., mortuary data, prestige goods, and monumental constructions), heterarchical forms of sociopolitical integration and interaction should also be addressed, such as relations of gender, age groups, lineage groups, and political factions (Brumfiel 1992; Crumley 1987). Indeed, it is within the dialectical relationship between the forces and relations of production where one finds the non-technical social logics, which influence technological choices and shape the character of artifact design variability in the past and present.

In summary, the technological production of the material world constitutes a form of human labor that is inherently social, as well as practical. As such, the
study of technology provides a unique entry point into the social relations, systems of
meaning, and environmental constraints, which influence and determine technical
choices relating to artifact design. The present study employs a structural Marxist
model for modes of production in order to analyze variations and patterns of grog-
temper use within a single sample of Baytown Plain pots from the Ink Bayou site in
central Arkansas. Again, the goal of this study is not to reconstruct the mode of pro-
duction for the entire Plum Bayou society, but rather to use the mode of production
framework in order to take the first steps toward analyzing the social organization of
ceramic production in the Plum Bayou culture.
CHAPTER IV

RESEARCH METHODOLOGY

Introduction

As a segue into a discussion of the methodological procedures employed in this study, I would like to briefly describe a very useful analytical framework provided by Owen Rye (1981:4-5) for addressing variation and patterning within and between particular ceramic industries. Rye identifies four inextricably linked units of analysis which serve to guide inquiries into the process of ceramic production. The four units of analysis are: 1) attributes; 2) techniques; 3) process sequences; and 4) technological traditions. Ceramic attributes include the observable, repetitive, physical phenomena of ceramic pots, such as their color, surface texture, shape, decoration, and the type, size, and amount of temper particles, to name only a few. Such attributes are viewed as the material result of repetitive human actions, or techniques, as Rye (1981:4) refers to them. The particular order in which such techniques are carried out forms a distinct process sequence, or technical strategy, the character of which reflects the social and economic conditions shaping technological choices.

The fourth unit of analysis in Rye's (1981:5) framework is that of technological tradition, which can also be thought of as the operational sequence for ceramic production. The identification of a particular technological tradition, such as the use of grog-tempered plainware, refers to the existence of a high correlation between distinct process sequences; for example, the use of coarse-grained temper to
produce one form of vessel, and fine-grained temper to produce another (Rye 1981:5). The degree of correlation between distinct process sequences is a rather subjective measure indicated by the similarity in manufacturing techniques at comparable stages of production, which, of course, might be inferred from the presence or absence of specific attributes, or combinations of attributes, on individual vessels (Rye 1981:4-5). Consequently, pots belonging to different types and/or varieties can be classified as belonging to the same technological tradition. Likewise, the identification of different process sequences within a single technological tradition can serve as the basis for further subdividing established pottery types and varieties in terms of the specific technological practices through which the attributes of a vessel were produced.

The methods and techniques employed in this study have been chosen in order to look for distinct process sequences (i.e., technical strategies) of grog-temper use by empirically testing for correlations between the attributes of temper size, amount of temper used, and various macro-physical attributes of Baytown Plain pots from the Ink Bayou site (3PU252). Two broad categories of methodological procedures will be discussed in this chapter: 1) macro-physical attributes; and 2) ceramic petrography. The details of each category will be discussed independently below following a brief description of the Ink Bayou ceramic sample and the factors influencing sample choice.

Sample Choice and Description

The first hurdle to jump in choosing an appropriate sample is the identification of a specific problem (Rice 1987:321). The details surrounding the research questions driving this study have already been discussed in the opening chapters. For
the purpose of this section, however, the different research goals previously outlined can be condensed into one question: Can one or more process sequences, or technical strategies, of grog-temper use be identified for the pottery type, Baytown Plain, whose overwhelming presence is characteristic of Plum Bayou culture ceramic assemblages?

Ceramic temper can vary according to a number of attributes, most notably, the type of material used, the amount of temper, and the size and shape of the temper particles (Arnold 1974; Rice 1987:379-380; Shepard 1995:156-165). In the context of analyzing grog-tempered ceramics, the attributes of material type and particle shape are not as significant as the size and amount of temper used. There are a couple of reasons why. First of all, the overwhelming use of grog as a ceramic tempering agent by the Plum Bayou potters has already been firmly established through a previous thin section analysis of Baytown Plain sherds from the Toltec Mounds site (Bennett 1980). Second, recording particle shape relates more to studies of sand, rock, and grit tempered ceramics, where the degree of roundness of individual grains can indicate whether the temper was collected from naturally occurring deposits formed through geological processes, or produced from the grinding of weathered, friable rocks by the potters themselves. For the purposes of this study, the shape of the temper particles is considered to be less significant since grog, by definition, is the result of humans crushing and pulverizing potsherds and other objects of baked clay (Rye 1981:33).

Numerous material science studies of ceramic temper have shown that the size and amount of temper used can effect the mechanical performance of ceramic vessels (Bronitsky 1986; Bronitsky and Hammer 1986; Feathers 1989a, 1989b;
Schiffer and Skibo 1987). The ability to determine vessel form, therefore, becomes essential for interpreting patterns of grog temper use. Plum Bayou ceramic assemblages are notorious for yielding few complete, or partially complete ceramic pots (Michael Nassaney, personal communication, 1994). Rim sherds, therefore, provide the most accurate means of distinguishing basic vessel forms (e.g., jars, bowls, and beakers). Furthermore, with the exception of red-slipped pottery, the decoration of Plum Bayou pots is often restricted to the lip and rim, making the identification of pottery types, like Baytown Plain, dependent upon rim sherd analysis (Rolingson 1990:35-36, 1978; Stewart-Abernathy 1982). Consequently, only Baytown Plain rims will be used in this study in order to control for variation in vessel form and pottery type, and to ensure that each rim came from a different vessel (cf. Bennett 1980:12).

A total of 227 Baytown Plain rims were recovered by the Arkansas Archaeological Survey (AAS) during their 1984 excavation of the Ink Bayou site. Only 57 of these rims, however, were of an analytically useful size, the majority consisting of small lip and rim fragments (House 1987). Of the 57 rim sherds, 56 were chosen for analysis (Appendix A), but only 51 were thin-sectioned for this study.

Rim sherds originating from the same context, and therefore assigned to the same FSN number, were further distinguished by adding an additional specimen number. For example, the rim sherds from FSN number 205, are labeled 205+1 through 205+10. The 5 rims not considered for thin sectioning, therefore, are 84-712-14+1, 84-712-32+1, 84-712-205+5, 84-712-308+3, and 84-712-873+1. These five rims were not chosen for thin sectioning, because they were either too fragile to begin with, or they broke during the process of making the thin
sections. Of the remaining 51 rims, attributes such as rim orientation, interior and exterior color, thickness, and rim mode (see Rolingson 1978, 1998:30) were analyzed in order to make sure that no two rims came from the same pot. Fortunately, all 51 of the rim sherds proved to be derived from individually distinct vessels.

Unfortunately, controlling for temporal variation within the collection is a much more difficult task than controlling for the uniqueness of each rim sherd. Only 9 of the 56 rims are from dated contexts. The seven rims from feature 662 are associated with a radiocarbon date of A.D. 925 ± 140, while the two rims from feature 641 are associated with an earlier date of A.D. 680 ± 177 (Waddell et al. 1987). While this study takes into account the possibility of temporal variability, the search for chronologically sensitive changes in grog-temper use would benefit more from a point-count analysis involving multiple pottery types recovered from deeply stratified deposits.

Description of Macro-Physical Attributes

The goals of this study are centered around the point-count analysis of ceramic thin sections in order to empirically assess variation in the amount and size of grog-temper particles. The production of ceramic thin sections is a destructive process. As such, a detailed description and photographic documentation of each rim sherd in this study was deemed mandatory and conducted prior to thin section production.

The photographic documentation of the Ink Bayou rim sherds involved a two-stage process. First, I made photocopies of the interior and exterior of each rim in
the collection. Rims from the same provenience were photocopied together. Photocopying rim sherds has both financial and functional benefits. Financially, it is an inexpensive way to get around the high costs of making black and white photos for publication, whose quality can never be totally insured. Photocopying also provides an actual size image of each rim sherd, which makes identifying misplaced or broken rims an easy task of matching a rim sherd to its own image. Furthermore, most modern copy machines have the ability to make photo copies lighter or darker. By playing with the lighting controls, surface features such as pitting, cracking, or even tool marks can be drawn out to give an impression of surface texture and finish.

Photocopies, of course, are no substitution for color slides when it comes to documenting the macro-physical features of an artifact. Using a 35 mm Nikon camera, a camera stand with artificial lighting, and Ectochrome 160T color slide film, I took detailed, close-up shots of the interior and exterior of each rim sherd in the collection. In addition to the storability of color slides, the projection of the slide image onto a screen affords other researchers the opportunity to examine the rims and verify, or contest, my observations of the macro-physical features for each specimen.

A two page documentation form (Appendix B) was used to record the macro-physical attributes of each rim sherd in the collection. The length, width, orifice diameter, thickness, and weight of each rim were measured in metric units (e.g., centimeters, millimeters, and grams). The weight of each rim was measured to two decimal places using an electronic balance. Sherd length refers to the maximum horizontal measurement of the rim when oriented as if it were attached to the original pot. The width of each sherd, therefore, refers to the maximum vertical extent of
the rim. Sherd thickness, on the other hand, was measured using bow calipers along the most posterior edge of the rim. In addition to the general information mentioned above, extensive notes were taken on each rim describing any possible use-wear evidence (e.g., sooting, discoloration, pitting and scratching), as well as any tool marks or distinguishing characteristics indicative of vessel production. Procedures used to record and document the more standard macro-physical attributes of ceramic pots will be discussed in detail below.

Orifice Diameter

The orifice diameter of individual vessels represented in the collection was determined by comparing the arc of each rim to a chart containing a series of concentric circles of known diameters. Orifice diameter provides one means of estimating the relative size and shape of vessels within known vessel form categories (e.g., large bowls vs. small bowls) (Rice 1987:222-224). The problem with the Ink Bayou sample is that many of the rims are too short to accurately measure their orifice diameters. Consequently, a maximum and minimum diameter measurement was provided for some rims in the collection, while others were not measured at all. Of the initial 56 rims chosen for this study, only 17 were long enough to achieve an accurate measurement of orifice diameter. For the analytical purposes discussed in Chapter V, however, an average orifice diameter was used for those specimens with a minimum and maximum orifice diameter.

Color

There are three primary variables effecting the color of low fired ceramic vessels: 1) the size, amount, and distribution of iron and organic materials present
in the raw clay; 2) the duration, temperature, and atmospheric conditions of the original firing; and 3) the rate and conditions of cooling the pot after firing (Rice 1987:333-336, 343-345; Rye 1981:114-118). Under oxidizing conditions (i.e., oxygen rich firing environment) iron-rich compounds present in the clay will be brought to their highest state of color development (oxidation), which gives a yellow, or more commonly, a red or reddish-brown color to the fired clay (Gibson and Woods 1990:208; Rice 1987:335). The presence of iron compounds in the raw clay act as the primary determinate of the final color of low-fired clay pots. Iron oxides, however, do not begin to play an active role until the organic materials in the clay have been oxidized or eliminated (Rice 1987:334).

The amount of organic matter in clay is highly variable and dependent on the way in which the clay was deposited (Rice 1987:334). When clays containing carbonaceous materials (organics) are heated, the carbon begins to char and oxidize. Clays fired for a long time in a highly oxidized environment will often times have most, if not all, of their organic matter eliminated or oxidized. When viewed in cross-section, such a pot will likely have a core area that is yellow, red, or reddish-brown like its exterior and interior surfaces. However, if the pot is fired rapidly or in a reduced environment (i.e., low oxygen), a black or gray ceramic core may be produced (Rye 1981:114-116). A pot that has been entirely reduced, producing a black core with black exterior and interior surfaces, therefore, may be the result of intentionally firing a vessel in a heavily reduced environment—a process called “smudging”, in which an open fire is smothered with a dense layer of organic matter, such as manure or sawdust or grass, in order to significantly reduced the a-

The rate of cooling can also have an effect on the color of fired clay. Like the process of heating a clay pot, the rate of cooling can contribute significantly to the removal or deposition of carbonaceous materials (Rye 1981:117). In open pit firing, pots can be cooled by either leaving them in the fire as it slowly burns out, or removed from the fire and left to cool in the open air. If a pot is left in the fire to cool, then the exterior and possibly the interior surfaces of the vessel will most certainly be covered with ash, charcoal, and unfired fuel, producing a reducing atmosphere whereby carbonaceous materials will be deposited on the surfaces of the pot (Rye 1981:117). Open air cooling, on the other hand, oxidizes the vessel surfaces and produces a sharp margin inside the ceramic core (Rye 1981:116, Figure 104).

In summary, the color of a vessel's interior and exterior surfaces, as well as the interior core of the vessel wall, are important attributes to record in order to gain insights into the initial firing and cooling conditions affiliated with the production history of a particular pot. For this reason, the color of the exterior and interior surfaces of each rim were described and recorded, as well as the color and thicknesses of oxidized and reduced zones in the vessel wall interior. All color descriptions were based upon the Munsell color system (Munsell Color Company 1975), and all observations of ceramic cores were made on fresh breaks.
Hardness

The hardness of a ceramic material is effected by a number of different factors, including firing temperature and atmosphere, porosity of the clay, the size and type of natural inclusions present, and the type of surface treatment, to name only a few (Rice 1987:354-355). As such, the term “hardness” has many meanings, such as resistance to penetration, abrasion, scratching, and crushing (Shepard 1995:113). For the purposes of this study, the hardness of the exterior and interior surfaces of each rim was described according to Moh’s mineral hardness scale. This scale uses a series of minerals of increasing hardness, which are ranked from 1 to 10, with talc having a hardness of 1 and diamond having a hardness of 10 (see Shepard 1995:Table 4). Moh’s test measures the ease with which a mineral of known hardness will produce a scratch when drawn across the surface of the rim sherd. The hardness of a particular rim, therefore, will be less than the that of the first mineral to produce a scratch on its surface, and greater than or equal to the hardness of the preceding, softer mineral in the sequence. As Rice (1987:356) points out, one of the advantages of using the Moh’s test is that it reflects the actual use and serviceability of a pot. The procedure of scratching the surface of a vessel is analogous to the practice of stirring or scraping, which can abrade the interior surface of low fired earthen wares.
Surface Finish and Texture

Surface finish refers to the operations which effect the reflectance of light (luster) and the texture, or "feel" of the vessel surface (Rye 1981:60). Surface texture varies in three ways: 1) smooth; 2) rough; and 3) granular (Shepard 1936:445). A smooth texture is one that is slick to the touch, while a rough texture implies a gritty feeling surface, resulting from the poor compaction of the paste during finishing. A granular texture, however, is characterized by protruding inclusions, resulting from the finishing of a vessel while it still exists in a yielding state. Consequently, as the paste dries, inclusions and temper particles within the paste will remain in place and begin to protrude from the vessel body as the rest of the vessel body shrinks around them.

Surface texture, along with luster, and the evenness of the vessel surface (i.e., its contour) form the basic criteria for defining the three types of surface finishes described in this study (plain-smoothed, burnished, and polished). Pots with a "plain-smooth" surface finish are uneven and rough, or granular to the touch, with numerous irregularities, although some areas of the surface may be smooth (Rolingson 1998:29). Tool marks, such as those affiliated with the scraping, or wiping of the vessel surface, are a common characteristic of plainsmoothed pots.

The second finish type, burnishing, is characterized by a fairly even surface with a lustrous, or matte-like appearance. Burnishing refers to the process of rubbing the surface of vessel with a pebble or hard tool while the paste is in a leather hard state (Shepard 1995:190-191). The process of burnishing produces a hard
compact surface with numerous parallel, flat facets, that have a lustrous or matte-like appearance. The overall appearance of the surface finish, therefore, is a combination of lustrous and matte finished areas, or non-uniform luster (Rye 1981:90). Polished surfaces, on the other hand, are even with no tool marks present, and a uniform luster (Rye 1981:90).

The surface finish for each rim sherd in the Ink Bayou collection was described according to the above criteria for plain-smooth, burnished, and polished surfaces. In doing so, however, it became apparent that considerable variability existed in the degree of smoothing and burnishing, with much overlap in the presence and absence of specific attributes between the three categories. The same problem was identified by Rolingson (1998:28-29) in her analysis of the Mound D ceramics from the Toltec Mound site. Consequently, although an initial effort was made to distinguish all three surface finishes in the collection, burnished and polished rims were lumped together under the category of "burnished" during the final analysis.

Rim Mode

In the initial analysis of the Ink Bayou ceramic assemblage, House (1987) described the 57 Baytown rims in the collection according to the 10 rim modes defined in Rolingson's (1978) description of the Chowning ceramic collection from the Toltec Mounds site. Although the total number of rims pertaining to each mode was provided in the Ink Bayou report (House 1987), specific information relating individual specimens to a particular rim mode was absent. Consequently, I had to re-classify each of the 56 rims analyzed in this study. As one would expect, significant differences exists between House's analysis and my own, and this should be taken into
account when looking for correlations between rim mode and other ceramic attributes.

In order to systematically describe the Ink Bayou rims, I relied heavily on the seven rim modes defined by Rolingson (1998:30) for the Mound D ceramic sample from Toltec as the primary basis for comparison. Six of Rolingson’s (1998:30) seven rim modes are represented in the Ink Bayou collection: unmodified rims, tapered rims, wedge rims, and rims with an exterior strap, an interior strap, or an exterior fold (see Rolingson [1998:Figure 32] for a visual representation of the different rim modes).

Unmodified rims have rounded or flat lips, or a combination thereof, with little or no change in thickness. In some cases, however, a slight thinning of the rim towards the lip may occur, with a difference in thickness of 0.15 cm. Forty-one percent of the sample (n=23) are characterized by unmodified rims.

Tapered rims, on the other hand, are thinned toward the lip with a decrease in thickness from 0.15 cm to 0.4 cm. Rounded lips are more common on tapered rims, but flat lips do occur and may vary on individual sherds. Twenty-seven percent of the sample (n=14) are characterized by tapered rims.

Exterior strap rims are characterized by the addition of a coil or strap of clay to the exterior or the lip, forming a collar. The added strap may have a smooth juncture with the vessel wall, or form an abrupt juncture that is sometimes accentuated by a shallow incised line. Both variations are usually characterized by flat, as opposed to rounded, lips. Only 5% of the rim sherds in the collection (n=3) exhibit an exterior strap.

Wedge rims have flat lips as well, with the lip representing the thickest portion of the rim. The rim and lip may thicken gradually, with a symmetrical increase
on both surfaces, or only the lip may thicken abruptly out from the vessel wall. Out of the 56 sherds analyzed in this study, only 9% (n=5) are representative of the wedge rim mode.

Interior strap rims are produced in the same manner as the exterior strap rims, only the strap of clay is added to the interior of the lip. Unlike the exterior strap rim mode, however, the juncture of the strap is always distinct from the vessel body. Only 1 rim (2% of sample) in the collection is representative of this mode.

Exterior fold rims have a fold of clay on the exterior surface, below the lip. The thickening of the lip is produced by folding the lip outward onto itself while the paste is still in a yielding state, and may be the result of "careless work in the finishing process" (Rolingson 1998:30). The thickened area is usually thin and narrow, and extends between 0.1 cm to 0.3 cm from the vessel wall. This rim mode constitutes 16% (n=9) of the sample.

One rim sherd in the collection (2% of sample) did not compare with the criteria for any of the seven Mound D rim modes (Rolingson 1998:30). Specimen 84-712-205+5 is an outward flaring rim with a rounded, but faceted, lip that is thickened by an exterior fold which is smoothed down the rim approximately 1.5 cm below the lip. The thickened area has been accentuated by a series of bending creases resulting from the outward flaring of the rim while the paste was in a semi-leather hard state. At best, this rim most closely resembles Rolingson's (1978) "rim mode 7" as described in her analysis of the Chowning ceramic collection from the Toltec Mounds site.
Vessel Form

Vessel forms of the Plum Bayou culture consist of jars, beakers, shallow bowls, hemispherical bowls, and bowls with restricted orifices (Rolingson 1982:87, 1990:36, 1998:32). No complete ceramic pots were recovered from the Ink Bayou site (House 1987). As such, a certain degree of conjecture can be expected in the process of identifying specific vessel forms within the sample. Vessel shapes were identified on the basis of rim orientation, rim mode, and orifice diameter, as well as the comparison of Ink Bayou rim profiles with published drawings of rims from known Plum Bayou culture vessel forms (see Figure 4; House 1987; Rolingson 1998:32-35). A profile of each rim in the sample was drawn in order to document their orientation and shape.

Baytown Plain jars are subglobular, or subconoidal in shape with flat circular or square bases (House 1987; Rolingson 1990:36, 1998:30-31). The category of jars includes a number of variations upon a common theme: a constricted neck and an externally flaring rim (Rolingson 1998:32). Variations on this theme correspond to the degree of flare in the rim. Jar rims range from being nearly vertical to having a deep, wide flare, 4 to 6 cm tall, to a short flaring rim measuring only 2 to 4 cm in height (Rolingson 1978:10, 1998:32). A total of 28 jars were identified in the Ink Bayou sample.

There are three basic bowl forms which can be found in Plum Bayou ceramic assemblages: hemispherical; sloping; and restricted bowls (House 1987; Rolingson 1982:87, 1998:34). Only hemispherical and outward sloping bowls were identified in the Ink Bayou sample. Hemispherical bowls (n=4) have nearly vertical upper walls which may begin to flatten out slightly toward the base instead of maintaining a continuous hemispherical curve, although none appear to have flat bases (Rolingson
1998:34). The same is true for most bowls with outwardly sloping walls, although some sloping bowls may have had flat circular bases (Rolingson 1998:34). Four rims in the sample are representative of sloping bowl forms.

Beakers are defined as vertical wall, cylindrical jars, with flat bases (Rolingson 1998:34). Beakers are difficult to distinguish from hemispherical bowls, because many rim sherds are too small to discern a nearly vertical wall. Nonetheless, four rims in the collection were large enough and vertical enough to warrant their classification as beakers.

Unfortunately, 16 of the initial 56 rim sherds in the Ink Bayou sample were not large enough, or distinct enough to be accurately classified. For analytical purposes, therefore, I used the general categories of jars, bowls, and beakers in order to look for correlations between vessel form and temper use. As one can imagine, the relatively small number of bowls and beakers in the collection poses a significant limitation for this study. The direction of future research concerning temper use and vessel form will be discussed in the final chapter of this thesis.

Petrographic Analysis of Ceramic Thin Sections

Ceramic petrography entails the description, classification, and interpretation of ceramic pastes, employing techniques derived from those used in geology (e.g., Chayes 1956, 1954; Griffiths 1967) to describe the composition and characteristics of rocks (Freestone 1995:111). Petrographic analysis is considered to be invaluable for the study of paste preparation techniques, manufacturing methods, and firing parameters (Freestone 1995:111; Shepard 1995:139-140). Most studies, however, have used ceramic petrography to address issues of provenience, for example, determining the location of pottery production, and/or seeking evidence for
trade and cultural interaction (e.g., Garrett 1986; Shepard 1936; Stoltman 1991; Stoltman et al. 1992).

Currently, the petrographic technique most widely used by archaeologists to analyze ceramic pastes and bodies is point counting, or modal analysis. Point counting is a systematic sampling procedure by which the volumetric amounts and size distributions of temper particles and naturally occurring inclusions (sand and silt size particles) are estimated from a series of observations made at fixed intervals (e.g., 1 mm) across the entire area of a ceramic thin section (Stoltman 1989:148, 1991:104). To conduct a point count analysis of ceramic thin sections, one must have access to a polarizing microscope equipped with a measuring eye piece that has a central crosshair, and a rotating stage with a device that allows one to move up and down the thin section in fixed increments beneath the crosshairs (Stoltman 1989:148). At each stop, the observer identifies the mineral, or particle type beneath the crosshair. The total number of points per thin section, therefore, is dependent upon the counting interval selected (i.e., increment size) and the total area of the thin section.

The rationale for point counting ceramic thin sections is founded upon the Delesse relation, which declares that "area proportions of minerals in thin section are equivalent to volumetric proportions of minerals in rocks" (Stoltman 1991:103-104). Since sherds can be regarded as metamorphosed sedimentary rocks (Williams 1983:301, cited in Stoltman 1991:104), the basic principles of point counting apply equally to both rocks and sherds. As such, the percentage of counted points pertaining to each constituent category (e.g., temper, or quartz) is equivalent to the total percent volume of each paste constituent category. Thus, for example, if 25% of the total number of points counted on an individual thin section were identified as
grog-temper particles beneath the crosshairs of the scope, then the ceramic paste with which the original vessel was constructed can be said to have contained a mixture of 1 part grog per every 3 parts clay-rich matrix.

While the analysis of temper (the size, shape, amount, and type of particles) has remained the primary focus of ceramic petrography, recent petrographic studies have emphasized the significance of analyzing the clay-rich matrix, especially the amount of naturally occurring silt and sand size particles, in order to distinguish between different paste types (Porter 1984) and address questions of provenience (Stoltzman 1989, 1991). Grain size analyses provide an effective means of interpreting depositional conditions, and relatively distinguishing clays originating from different source areas (Lewis and McConchie 1994:119).

The ability to quantify the amount of sand and silt size inclusions through point counting procedures acquires a special significance when analyzing grog-tempered ceramics in the context of Plum Bayou culture. First of all, unlike grit or sand tempered ceramics, grog (crushed potsherds) cannot be linked to a specific geological source area. Furthermore, grog temper renders various methods of chemical analysis, such as neutron activation or X-ray diffraction, virtually useless, as the analyst cannot control for the possibility that nonlocal pots may have been crushed up and used as a ceramic tempering agent (Stewart-Abernathy 1985:3). A grain size analysis of the clay-rich matrix, therefore, provides one means of getting around such methodological hurdles to empirically address questions concerning cultural interaction and exchange.

The process of point counting involves three main steps: 1) the preparation of a ceramic thin section; 2) a preliminary analysis of grain types and the determination of an appropriate contour interval; and 3) the quantitative assessment of
paste constituent amounts and grain size distributions. The particulars of each step will be individually discussed below.

**Thin Section Preparation**

Preparation of the 51 thin sections analyzed in this study followed the procedures recommended by the director of the geological laboratories at Western Michigan University, Robert Havira. All thin sections were prepared by myself with the help of two petrographic laboratory assistants, Ben Sincler and Mary Savillo. A horizontal cross section (chip) was removed from the most distal end of each rim in order to preserve the integrity of the lip and upper portions of the rim. Chips were removed using a precision cutoff saw, and cut to a width of at least 1/4 inch to facilitate holding of the sherd during the initial grinding of the mounting surface.

After removing the chip from the rim sherd, the saw marks on the surface to be mounted were removed by grinding the surface smooth on a rotating 220 mesh diamond lap (grinding wheel), and then on a 45 micron lap for about one minute (Robert Havira, personal communication, 1994). Next, the chip was washed with warm, soapy water and left to dry. Once dried, the chip was ready for mounting onto a glass slide.

Before mounting, each glass slide was cleaned with alcohol and graded with a micrometer. The tolerance in thickness from one end of the slide to the other is .01 mm. Slides with a differential thickness greater than 0.1 mm should not be used. Also, a corner of each slide was scored with a grinding wheel so that the specimen number of each chip could be written in pencil and covered with epoxy to preserve the identity of the thin section.
Chips were fixed to slides using a prepared mixture of Hillquist D and C epoxy—one part D for every four parts C. A thin film of epoxy was applied to both slide and chip immediately before placing them together, by first joining one long edge of a chip to a slide, and slowly lowering the other edge until flat. Next, the glass and chip were firmly pushed together with a rotating motion to squeeze out any air bubbles in the epoxy and set on a flat surface to cure overnight. The curing process can be sped up by placing the sandwich on a hot plate set at 175 degrees Fahrenheit. However, even though the hot plate process only takes 30 minutes to cure, the risk of air bubbles increases substantially (Robert Havira, personal communication, 1994).

After the epoxy had cured, a precision cutoff saw was used to remove most of the chip from the slide. The remainder of the chip was then ground using a thin section diamond grinder to a standard thickness of .03 mm—the thickness at which quartz grains appear gray to pale yellow when viewed between “crossed polars” under the polarizing microscope (Mackenzie and Adams 1994:22).

The polarizing microscope differs from the usual biological microscope in that it is equipped with a rotating stage and two polarizing filters, one above and one below the stage (Mackenzie and Adams 1994:9). The filter below the stage is called the polarizer while the one above is the analyzer. Polarized light, unlike ordinary light, vibrates in only one direction—the plane of polarization. When ordinary light passes through a polarizing filter, only the light waves which are vibrating along the same plane as the orientation of the filter are allowed to pass through, producing polarized light. The two filters on the microscope are set at right angles to each other, such that when the analyzer is removed, the thin section can be viewed in plane polarized light. When the analyzer is inserted, however, the thin section is said to be
observed with "crossed polars", or "crossed nickels" (Mackenzie and Adams 1994:9).

When polarized light enters most crystals, it is divided into two components, each having different velocities. As the two light waves travel through the crystal they become out of phase and interfere with one another upon emerging from the mineral, producing interference, or birefringence colors that can be viewed between crossed polars through the polarizing microscope (Mackenzie and Adams 1994:22).

Many minerals have more than one refractive index—a property known as double refraction. The birefringence of a mineral refers to the difference between its maximum and minimum refractive indices. As such, minerals with different refractive indices will display different birefringence colors when viewed between crossed polars, providing an accurate means of identifying specific mineral species.

There are three factors which effect the birefringence colors of minerals in thin section: 1) the birefringence of the mineral; 2) the orientation of the mineral when cut; and 3) the thickness of the section (Mackenzie and Adams 1994:22). Grinding the thin sections to a standard thickness, therefore, removes the third dimension of variability from the process of identifying minerals in thin section. Consequently, the birefringence of quartz is often used as an index for determining when the thin section has reached the proper thickness and the grinding process is complete.

Finally, once the thin sections had been ground to the proper thickness, they were covered with a No. 1 glass slide to protect them from being scratched. The glass slides were fastened to individual thin sections using the same epoxy and procedures mentioned above for fastening a ceramic chip to a slide. In the end, 51 thin sections
were prepared in such a way that all are well protected and preserved for future analyses.

**Preliminary Analysis**

Each thin section in the sample was examined prior to point counting to determine the appropriate counting interval and to conduct a preliminary assessment of the different types of minerals and nonplastic inclusions to be found in the ceramic body, as well as the range of particle sizes. For statistical purposes, it is necessary to have at least 100 counted points (open pores do not constitute points) for each thin section in order to quantify the volumetric amounts of each paste constituent category (Stoltman 1991:108). The interval at which the cross hairs are moved across an individual thin section, therefore, is determined by the need to count a minimum of 100 points and the overall area of the individual thin section. Thin sections taken from small sherds, or ceramics with thin walls, for example, may require a shorter counting interval in order to obtain the required number of points. In this study a standard counting interval of 1 mm was used to point count the entire area of most thin sections in the sample. Of the 51 thin sections analyzed, only 4 were too small to point count using a 1 mm interval, and were point counted at an interval of 0.5 mm, instead.

A preliminary analysis of the mineral types and nonplastic inclusions is necessary to determine the constituent classes to be counted during point counting. The establishment of constituent classes requires that the classes be mutually exclusive, such that each point can be assigned to a specific class without ambiguity (Griffith 1967:178). Consistency, however, is far more important than accuracy, for it is impossible to accurately identify all constituents in a single specimen (Griffith
1967:176). As such, the constituent classes established for this study pertain not only to what other analysts have identified in their studies of Plum Bayou ceramics (Bennett 1980; House 1987; Rolingson 1978, 1998), but the ability of the author to identify different mineral species and nonplastic inclusions, as well.

Most residual clays are deposited along with other minerals originating from several sources. The most common mineral inclusions are quartz, feldspars, micas, carbonates, iron oxides, and several forms of titanium (Shepard 1995:18). In her petrographic analysis of ceramic thin sections from the Toltec Mounds, Bennett (1980) established and point counted three mineral classes (quartz, feldspar, and muscovite mica), all of which occurred naturally in the clays used by the Plum Bayou potters. Quartz was the most common mineral class encountered with an average volumetric measure of .06 (Bennett 1980:29). This comes as no surprise, since quartz is the most common and abundant mineral inclusion occurring naturally in most ceramic bodies, with grain sizes ranging from colloids to silt and sand size particles (Rice 1987:94, Shepard 1995:18).

Although inclusions of muscovite mica and feldspar minerals were also recorded by Bennett, their volumetric percentages were so small (0.5% and 0.3%, respectively) that their significance as inclusions in the Toltec pottery was considered negligible (Bennett 1980:29). For comparative purposes, however, I still maintained these two mineral types, along with quartz, as established constituent classes to be point counted in this study.

Under crossed polars, individual muscovite mica grains are characterized by interference colors which range from yellow to blue. Feldspars, on the other hand, like quartz, are gray to yellow in color under crossed polars. Plagioclase feldspar crystals are distinguished from quartz by the presence of twinning and zoning on the
crystal surface. Twinning appears as parallel lines, or bands of different birefringence colors across the plane of the crystal surface, while zoning denotes a change in birefringence or extinction angle between the core of the crystal and its outer rim (Mackenzie and Adams 1994:28-29). Unfortunately, twinning and zoning are not typical characteristics of orthoclase feldspars, which makes it more difficult to distinguish them from quartz under the polarized microscope. Fortunately, while silt and sand-sized grains of feldspar are known to occur in clays, all feldspar minerals are easily altered into clay sized minerals, rendering them unidentifiable under the microscope.

As a general rule of thumb, if the point under the cross hairs goes in and out of extinction as the stage is rotated, then the point is most likely a distinct mineral grain, and should be properly classified. This is important for establishing and counting the fourth constituent class in this study, that of clay matrix. Clay particles are too small (<0.002 mm) and far too thin--thinner than the thickness of the thin section--to be individually analyzed in thin section. Under plane polarized light and crossed polars, clay particles appear as a reddish-brown mass, or matrix with no distinguishable particle grains. Therefore, all points that were not distinct mineral grains, voids, inclusions, or temper particles, were counted as clay matrix.

Grog-temper, the fifth class established for point counting, is defined as any pre-fired clay product which is crushed or ground into small sized particles to be added to clay and used as temper (Porter 1964:521; Rice 1987:476). Crushed potsherds and particles of burnt clay are included in this definition. In thin section, crushed potsherds appear as angular, internally heterogeneous inclusions which often differ in color from the surrounding clay matrix (e.g., Shepard 1936:Figure 305b, 1995:Figure 12d). When the boundaries of the temper particles are diffuse,
the mineral grains and inclusions inside the boundaries of the temper particle can often be discerned by their different orientation relative to that of the surrounding clay matrix (Porter 1964:521). The same is true for particles of baked clay, which tend to be more rounded than angular in shape.

During the grinding process, particles of grog temper are often torn from the ceramic body of the chip, leaving open spaces in the clay matrix called temper voids. Temper voids are distinguished from naturally occurring voids by their shape and size. Naturally occurring voids are often irregular in shape (Rice 1987:350). Temper voids, on the other hand, are angular in shape, or rounded, like the temper particles that once sat inside them. Furthermore, remnants of temper will often remain adhered to the outside edges of the temper void, providing an additional clue to their origin.

Naturally occurring voids are formed by a wide variety of processes (see Rice 1987:350-351). One process is the burning out of macrobotanicals during firing, which leaves an open space, or "cast" of the original material. Not all organics are removed during firing, however. Remnant organics have been identified in Baytown Plain pastes (House 1987). Consequently, organics constitutes an eighth class to be point counted.

Finally, all points which could not be unambiguously assigned to one of the above eight constituent classes were assigned to an unknown category. Many of the "unknown" inclusions were more than likely various species of iron oxide minerals, or manganese concretions, which I could not positively identify. House (1987) reports that "buckshot" inclusions (i.e., iron oxide minerals and manganese concretions) were present in the Ink Bayou sample, but infrequent as ceramic paste constituents. The results of this study confirm House's observation (see chapter 5).
Point-Count Analysis

The method of point counting employed in this study closely follows the basic procedures outlined by Stoltman (1989, 1991), which are designed to calculate the volumetric amounts of clay, silt, sand, and gravel size particles in ceramic bodies, including those of ceramic temper. Stoltman (1991:109-110) maintains the distinction between the body and paste of ceramic pots. Paste refers to the raw clay with all of its naturally occurring silt, sand, and gravel sized inclusions. The term body, on the other hand, refers to the bulk composition of ceramic vessels, consisting of the ceramic paste and any other inclusions added by the potter as temper (Stoltman 1991:110-111).

Distinguishing between what does and does not constitute temper in a ceramic body is not always an easy task (see Arnold 1974:34-35). This is especially true for ceramics tempered with materials which can appear naturally in clays, such as sand, organic fiber, or mica, to name a few. In such situations, the size and shape of individual grains are often recorded in order to look for distinct groupings within specific paste constituent categories. Fortunately, with a grog-tempered ceramic industry, the problem of distinguishing temper particles from other inclusions in ceramic bodies is substantially lessened.

All thin sections in this study were analyzed under a magnification of 100X. Each point directly beneath the cross hairs was assigned to one of the nine constituent classes mentioned above, while each individual grain—mineral, temper, or otherwise—was measured using a measuring eyepiece, and assigned to a specific size class. Individual grains were assigned to one of six size classes: silt (<0.0625
mm); fine sand (0.0625 mm-0.249 mm); medium sand (0.025 mm-0.49 mm); coarse sand (0.5 mm-0.99 mm); very coarse sand (1.0 mm-2.0 mm); and gravel (>2.0 mm) (Stoltman 1989:149, 1991:108). Again, clay minerals are too small to identify petrographically and, therefore, were classed as clay matrix (Appendix C shows the point-counting documentation form).

Particles larger in size than the chosen counting interval run the risk of having multiple points inside their boundaries. This is not a problem for volumetric estimates, where each point is counted equally. For grain-size estimates, however, all counts greater than one on any individual grain must be excluded in order to ensure the independence of the grain-size measurement (Stoltman 1989:149, 1991:108). Keeping track of all multi-count grains can be time consuming, but the positive side to this approach is that a reliable estimate of grain sizes and volumetric amounts of inclusions in ceramic bodies can be provided within a single point-counting procedure (Stoltman 1991:108).

The data resulting from the above procedures will allow each thin section to be characterized by the kind of temper, the size of temper particles, the amount of temper, and the relative amounts of clay matrix and naturally occurring inclusions (i.e., paste). All of these data categories can be compared with those of the macrophysical attributes to search for individual process sequences that could further divide the pottery type, Baytown Plain, into more refined varieties. Furthermore, the Ink Bayou data, along with Bennett's (1980) petrographic study of rimsherds from the Toltec Mounds, will provide a comparative database for addressing questions of intersite interaction and exchange within the Plum Bayou locality as future point-count analyses are conducted on sherds from other Plum Bayou culture sites.
CHAPTER V

ANALYSIS AND RESULTS

Introduction

The point-counting data from the Ink Bayou site will be presented and assessed in three consecutive stages of analysis. In the first stage of the analysis the ceramic paste and body characteristics of the Ink Bayou sample will be presented and discussed. In the second stage, statistical methods are employed to search for significant correlations between the attributes of temper, paste composition, and the macro-physical attributes of Baytown Plain ceramics. The goal is to empirically distinguish specific operational sequences of ceramic manufacturing (i.e., technical strategies) that may help to define new varieties of the type, Baytown Plain. Finally, in the last stage of the analysis, the temper and paste characteristics of the Ink Bayou sample will be statistically compared to Bennett's (1980) point-count data from the Toltec Mounds to assess regional patterns of grog temper use in the Plum Bayou locality.

Before each stage of analysis can be discussed individually, a single assumption underlying all three stages needs to be brought to the foreground and clarified. This underlying assumption has to do with the amount of within-vessel variability one would expect to find in the amount and size of temper particles. In other words, are the paste and body characteristics of a rimsherd representative of the rest of the vessel? Stoltman (1989) has recently addressed this question in his petrographic analyses of grit-tempered jars from southwestern Wisconsin.
Comparing the point-count data of four thin sections removed from the rim, body, and base of a single vessel, Stoltman (1989:151) determined that any two thin sections from the same vessel can be expected to differ from one another by less than seven percent. Unfortunately, no complete, or nearly complete Baytown Plain pots were recovered from the Ink Bayou site (House 1987), making it impossible to estimate the amount of within-vessel variability for this study. I am hesitant to use Stoltman's estimation of seven percent for fear that the amount of within-vessel variation may itself vary by vessel, site, or region. Consequently, the analyses conducted in this study will be based on the assumption that during the process of kneading the clay and temper mixture, particles of grog temper were uniformly distributed throughout the clay body (see Rye 1981:39-40).

Analysis of Ceramic Paste and Body Characteristics

The distinction between paste and body is important for assessing the relative provenience of ceramic vessels within and between discrete samples. The most successful and convincing ceramic provenience studies are those which compare and contrast data derived from both chemical and petrographic analyses (Bishop et al. 1982). Despite their accuracy, however, chemical composition studies, such as neutron activation, cannot distinguish between the chemical composition of a vessel's temper and that of its paste--both of which will typically have independent origins. As such, the scale of accuracy for most chemical analyses is often restricted to the identification of ceramics produced within primary river valley systems on a macro-regional scale (see Steponaitis et al. 1996). By distinguishing paste from body, therefore, a more fine-grain assessment of paste mineralogy can be determined. Furthermore, measuring the volumetric amounts of naturally occurring silt,
sand, and gravel-sized inclusions in the paste can also facilitate the identification of different clay-rich sediments within major river systems (Stoltman 1991). Unfortunately, when studying grog-tempered ceramics one cannot assume that the potsherds crushed to make grog temper were manufactured from the same untempered raw material as the paste the grog was added to. Chemical analyses are rendered inaccurate in such circumstances (Stewart-Abernathy 1985), leaving petrographic analysis as the most reliable approach to analyzing the paste composition of grog-tempered pots.

The point-count data pertaining to the paste and body characteristics of the Ink Bayou sample will be presented in tabular form (Tables 2 and 3) as well as in separate ternary diagrams (Figures 5 and 6). The paste diagram provides a visual representation of the relative volumetric proportions of clay (matrix), sand, and silt in the untempered raw materials from which each Baytown Plain vessel was manufactured. The body diagram, on the other hand, is intended to provide a visual representation of the volumetric proportions of matrix (silt included), sand, and temper. It is important to note that the temper values throughout the analysis included the combined point-counts of temper and temper voids.

Returning to the ceramic paste values for the Ink Bayou sample, the compositional average volumes for matrix, silt, and sand are 80.01%, 18.43%, and 1.62%, respectively (Table 2). The paste diagram (Figure 5) shows a relatively tight clustering of data points around this compositional average, with a few outlier values as well. The outliers can be organized into two groups: a sandy-paste group and a clayey-paste group. The sandy-paste group consists of two specimens (84-712-662+4 and 84-712-897+1) each containing a volumetric sand content of over 5% (see Table 2). Both specimens were recovered from Feature 662, a large refuse pit con-
taining five additional Baytown Plain rims included in the Ink Bayou sample (see Appendix A). The volumetric proportions of sand sized particles for these five specimens ranged from 0% to 2.40%--values well within the range of the primary compositional group.

Table 2

Ceramic Paste Values for the 51 Thin Sections Analyzed in the Ink Bayou Sample

<table>
<thead>
<tr>
<th>Specimen No.</th>
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<th>Silt</th>
<th>Sand</th>
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</tr>
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<td>2.40</td>
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</table>

Mean = 80.01 ± 1.31  18.43 ± 0.72  1.62 ± 1.34

A Silt sized particles not included

While the paste composition of the two sandy-paste specimens are distinguishable from the rest of the Ink Bayou sample, the difference between their individual percent-sand values is substantial. Specimen 84-712-662+4 contains nearly twice as much sand as specimen 84-712-897+1. This difference in sand content is even noticeable to the touch. During the initial macro-physical description
Figure 5. Ceramic Paste Ternary Diagram Showing Volumetric Percentages of Sand, Silt, and Clay Matrix for Each Thin Section in the Sample.
of the Baytown Plain sherds, specimen 84-712-662+4 was described as having a "gritty, sandy" feel to its interior and exterior surfaces—the only sherd in the sample to receive such a textural description. It is entirely possible that specimen 84-712-662+4, alone, was brought to the Ink Bayou site from another site in the Plum Bayou locality. However, while intriguing, not enough supporting evidence exists at this point to substantiate such a claim.

Three thin section specimens (84-712-7+2, 84-712-12+2, and 84-712-308+13) comprise the clayey-paste group viewed as only two data points in the paste diagram (see Figure 5). Each specimen is composed of over 90% matrix (see Table 2). Again, the possibility of an additional clay source is realized, but unverifiable with such a small sample size. Moreover, unlike the sandy-paste group, none of the clayey-paste specimens share a common spatial-temporal provenience, suggesting that if an additional clay source was exploited by the Ink Bayou potters it was on an infrequent basis.

Variation in the paste composition of the Ink Bayou sample can be accounted for in three ways: (1) the exploitation of discrete clay-rich sediments; (2) exchange or interaction with individuals from other sites in or around the Plum Bayou culture area; and (3) the exploitation of a single, local clay source, within which the range of sand and silt size particles indicated in the paste diagram occur naturally. Obviously, the third possibility needs to be addressed before the other two hypotheses can be tested.

According to the soil survey of Pulaski County, Arkansas (Haley et al. 1975:sheets 29-32), the bottom land soils present within a 1.5 km radius of the Ink Bayou site are known to contain deposits of clay-rich sediments. The Ink Bayou site itself is located within an area of silt loam identified as belonging to the Keo soil
series (Waddell et al. 1987). The Keo series consists of well drained, level soils formed in loamy alluvium deposited by the Arkansas River as natural levees (Haley et al. 1975:14).

On the backside of the Ink Bayou levee, however, there exist a variety of bottom land soils belonging to the Perry and Rilla soil series (see Haley et al. 1975:sheets 29-32). Of special interest to this study are the large deposits of Perry clays, which are formed in thick beds of clayey slack-water deposits laid down by the Arkansas River. Perry clays are very fine grained, plastic clays characterized by a high shrink-swell potential (Haley et al. 1975:20-21, Table 11). In examining the soil profile for the Perry series, the different layers of clay sediment range in color from dark grey to grey, to dark reddish brown as one moves down the profile. In two of the seven clay layers (layers B2Ig and IIIB25) black concretions are reported (Haley et al. 1975:20-21). These are most likely manganese concretions, which occasionally occur in clays from swampy areas as reddish-brown or blackish-brown colored flecks or nodules (Rice 1987:336; Sheppard 1995:40-41).

House (1987) recorded the rare occurrence of such nodular, or “buckshot” concretions in his examination of Baytown Plain paste characteristics from the Ink Bayou site. Likewise, the infrequent occurrence of reddish-brown concretions measuring 0.5 mm to 2.0 mm in diameter were identified in the present study as well. For the sake of consistency, however, such concretions were point-counted as temper particles and not buckshot concretions. Although the larger concretions were easily identified in thin section, the smaller flecks of manganese (fine sand to silt sized particles) were not as easy to differentiate from temper particles of the same size: both can appear rounded, reddish-brown to black in color, and opaque under the polarized light. The occasional presence of manganese concretions in the Ink
Bayou sample certainly places the exploitation of local Perry clays well within the realm of possibility.

While Perry clays predominate in the area, isolated deposits of Latanier silty clay and Moreland silty clay may also have been exploited by the Ink Bayou potters, as well. Both Latanier and Moreland silty clays are known to occur in isolated spots within soils of the Perry and Rilla series surrounding the Ink Bayou site (Haley et al. 1975:21, 23). Similar to the Perry clays, both clays are very plastic, with a high shrink-swell potential (Haley et al. 1975:Table 11). Perry clays are finer grained than the Latanier and Moreland silty clays; hence the qualifier, "silty." A mechanical grain size analysis of Latanier and Moreland silty clays indicates that both contain substantial amounts of silt-sized particles in their natural state (see Haley et al. 1975:Table 12). Furthermore, Latanier silty clays are known to contain sand-sized particles as well, with percentages ranging from 1% to 22% of the total paste composition. Unfortunately, a mechanical grain size analysis was not conducted for the Perry clays. Comparatively speaking, however, one could certainly expect Perry clays to contain a smaller percentage of silt size particles (i.e., a greater percentage of matrix) given its description as being a "very fine" grained paste, as opposed to only a "fine" grained paste (Haley et al. 1975). Consequently, the variation found in the paste composition of the Ink Bayou sample could be explained in terms of the exploitation of local Perry clays with the opportunistic and/or occasional use of Latanier and Moreland silty clays occurring in the vicinity of the Ink Bayou site.

The addition of grog temper to the highly plastic clay-rich sediments of the Ink Bayou locality, would have improved their workability for the manufacture of Baytown Plain pots. Looking at the body diagram for the Ink Bayou sample (Figure...
6) One, again, finds a relatively tight cluster of data points around a compositional average of 78.26% temper, 20.51% matrix, and 1.33% sand (Table 3). The two sandier outliers in the body diagram are the same two sandy-paste specimens discussed earlier. As such, only one possibly significant clustering of specimens with a higher percentage of temper appears in the body diagram. This group consists of seven specimens (84-712-12+2, 84-712-22+1, 84-712-205+6, 84-712-205+9, 84-712-641+2, 84-712-656+1, and 84-712-705+1), all of which were manufactured with over 30% grog-tempering (see Table 3).

Aside from their shared abundance of grog temper, however, these seven rims have no other attributes in common. Three of the rims are identified as belonging to jars, while the rest are classified as unknown vessel forms, which means that they have vertical, or nearly vertical rim profiles. As such, they could potentially be from beakers (i.e., cylindrical jars) or hemispherical bowls (Rolingson 1998:Figures 37, 40). I suspect that instead of correlating with a specific vessel function or activity, these seven specimens represent discrete cases where the individual potter added the appropriate amount of temper to the paste in order to achieve a desired degree of workability. Workability, remember, is a subjective quality (see Chapter III) defined by the potter's judgement of how well a particular clay body is suited for the manufacturing processes envisioned to be used (Rye 1981:20-21). Workability, therefore, may have been the primary physical property effecting the amount of grog temper each Ink Bayou potter added to their paste. If this is the case, then the degree of variation represented in the ceramic body diagram may very well be explained in terms of the subjective quality of workability and the preferences of individual potters which occupied the site during the late Baytown-Coles Creek time period.
Table 3

Ceramic Body Values for the 51 Thin Sections Analyzed in the Ink Bayou Sample

<table>
<thead>
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<th>Temper B</th>
<th>Sand</th>
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Mean = 78.26 ± 1.57 20.51 ± 1.47 1.33 ± 0.63

A  Silt sized particles included
B  Temper voids included

In summary, two hypotheses have been offered to account for the variation observed in the ceramic paste and body compositions from the Ink Bayou site. The first argues for the preferred use of local Perry clays for ceramic production, with the occasional exploitation of local, isolated deposits of Latanier and Moreland silt clay clays. The second hypothesis suggests that individual Ink Bayou potters added grog temper in variable amounts to their ceramic pastes with the goal of improving and modifying the workability of the ceramic body toward individual preferences.
Figure 6. Ceramic Body Ternary Diagram Showing Volumetric Percentages of Grog-Temper, Sand, and Clay Matrix (With Silt) for Each Thin Section in the Sample.
While convincing, both hypotheses are in need of independent lines of corroborating evidence. In the case of the first hypothesis, for example, the paste compositions of the Ink Bayou sample should be compared to samples of locally collected Perry, Latanier, and Moreland clays, as well as the paste compositions of ceramic samples recovered from other Plum Bayou culture sites (see Stoltman 1989). For the second hypothesis, correlations between the size and amount of grog temper and other physical properties (e.g., vessel strength, thermoconductivity, and toughness) need to be identified before one can claim that improved workability constituted the primary technical strategy governing the amount of grog added to the paste. If such patterned correlations exist between such attributes as temper size and vessel form, for example, then these patterns will serve to direct more specific tests for mechanical performance criteria, such as thermal conductivity, or vessel wall strength.

Further corroboration of the first hypothesis is beyond the scope of the present study. However, the search for patterned correlations between the paste and macrophysical attributes of Baytown Plain pots will be the focus of the following stages of this analysis.

Attribute Correlations

This stage of the analysis involves quantitatively assessing and describing variations and patterns found in the use of grog as a ceramic tempering agent by the Ink Bayou potters. Statistical methods are employed to search for significant correlations and differences between the attributes of grog-temper, the macro-physical attributes of the ceramics, and the various constituent categories defined in Chapter IV.
The oneway ANOVA and student's t-test were used to search for significant differences in the size and amount of temper, between variables comprised of nominal data (e.g., types of vessel forms, modes of surface finish, and provenience). In regards to surface finish, for example, each specimen was organized into two categories; those with plain-smooth surfaces and those with burnished surfaces—the one polished rim was included in the burnished category. In this particular case, no statistically significant variations at the .05 alpha-level were detected between plain-smooth and burnished surfaces in terms of the amount (p=0.38) and the average size (p=0.32) of grog-temper used. These results indicate that the Ink Bayou potters did not manipulate the size or amount of their grog temper in reference to the intended surface finish of their pots. Nor, did they decide to use a specific surface finishing technique as a result of the size of temper used.

When temper values were plotted against attributes involving continuous data (e.g., wall thickness, or the volumetric percents of specific constituent categories), a linear regression analysis was used to test for significant correlations between the variables. The significance of each statistical test used in this study was evaluated at the .05 alpha-level. All statistical analyses were conducted using a computer software package called JMP IN, version 3 for Macintosh, which presents the results of the analysis in both graphic and tabular form.

The attributes of average temper size and temper amount were each plotted against the categories of intra-site provenience, wall thickness, surface finish, rim mode, vessel form, orifice diameter, hardness, the number of temper particles counted, and the volumetric percentages of sand, silt, matrix (not including silt), mica, and feldspar. Only two of the twenty-six possible correlations were found to be statistically significant: (1) the amount of grog-temper by the number of temper
particles \( (r^2=0.49) \); and (2) the amount of temper between Feature 641 and Feature 662 \( (n=9, F=19.42, p=0.0031) \).

At first glance, the significant correlation between the amount of grog and the number of grog particles point-counted during the analysis may not appear to be all that surprising (see Figure 7). If we consider the possibility that the greater amounts of temper could be the result of a larger average particle size, however, then the significance of this correlation could be the result of adding more temper to the paste, or just adding larger temper particles (Figure 8). To test these two possibilities, a linear regression analysis was run plotting the amount of grog-temper against the average size of the grog-temper particles. The correlation was found to be insignificant \( (r^2=0.0046) \), suggesting that the higher percent-temper values tend to correlate with the addition of more grog to the paste. Furthermore, this pattern of grog-temper use suggest an initial concern with the workability and prefiring characteristics of the ceramic body (e.g., the degree of shrinkage during the initial drying of the vessel) (see Rye 1976:115-116).

No significant correlations were found to exist between the amount, or size of grog-temper particles and the different techno-functional attributes previously mentioned (e.g., wall thickness or vessel form, to name only two). This suggests that, in practice, temper choices were not made in reference to any specific attribute, or set of attributes, resulting from choices made later on in the operational sequence. The lack of statistically significant correlations does not mean, however, that the Ink Bayou potters were not concerned with the mechanical performance characteristics of their vessels.
Figure 7. Regression Analysis Graph Plotting the Number of Grog-Temper Particles Against the Volumetric Percentage of Grog-Temper, per Thin Section.
Figure 8. Regression Analysis Graph Plotting the Average Size of Grog-Temper Particles Against the Volumetric Percentage of Grog-Temper, per Thin Section.
Controlling the size and amount of grog-temper was not the only means available to potters for effecting vessel performance. A number of material science studies concerning the thermal properties of ceramics, for example, have established a direct relationship between the thermal conductivity of fired ceramic pots and a number of macro-physical features, like wall thickness and vessel shape (e.g., Braun 1983; Hally 1986; Henrickson and McDonald 1983). Vessels with thin walls, conical bases, and rounded contours are said to be better suited for cooking over open fires. The thin walls provided faster heat transfer and the rounded contours improve the vessel's resistance to thermally induce stresses caused by the uneven transfer of heat through the vessel body. The results of this study, therefore, suggest that the Ink Bayou potters controlled the mechanical performance characteristics of their pots through the manipulation of vessel shape, size, surface finish, and wall thickness, rather than adjusting the size and amount of grog-temper used to prepare a versatile ceramic body.

The apparent leeway which the Ink Bayou potters had in choosing the size and amount of grog-temper particles to be added to their ceramic pastes relates, at least in part, to the thermal properties of the grog itself. As crushed particles of previously fired pots, the use of grog would increase a vessel's resistance to thermally induced stresses, which often result from different thermal expansion and contraction rates between the temper and the surrounding clay matrix (Braun 1983:123; Rye 1976:117; Steponaitis 1983:37-45). In the case of grog-tempered ceramics, the thermal properties of the grog would be similar, if not identical, to the clay matrix. Consequently, as Rye (1976:115) suggests, the use of grog would allow a considerable degree of variability in the amount and size of temper added to the paste.
Sample size, on the other hand, may be partially responsible for the statistically insignificant relationship between vessel form and the size and amount of grog, as well. While the Ink Bayou sample contained point-count data for twenty-five jars, only four beakers and six bowls were available for comparison. Yet, as Figures 9 and 10 indicate the range of temper values (average temper size and volumetric percent of temper) for both beakers and bowls fit well within the range of variation recorded for Baytown Plain jars. Likewise, no significant variation exists between the mean temper values for each vessel form. I suspect, therefore, that despite the analytical problems caused by the small sample size, the Ink Bayou potters did not differentiate between vessel forms in terms of grog-temper size or amount. Future studies comparing larger samples of different vessel forms are needed, however, to further test this hypothesis.

An unfortunate outcome of this analysis is the lack of any significant patterning in the microscopic and macroscopic attributes of the Baytown Plain pots which might have allowed the type to be broken down into distinct varieties for chronological purposes. The closest this study has come to determining any significant chronological differences in ceramic production has been the identification of a statistically significant decrease (p=0.0031) in the amount of grog-temper between the rim-sherds associated with Feature 641 (n=2) and Feature 662 (n=7) (see Figure 11). Both features have associated radiocarbon dates that situate them within the late Baytown and Coles Creek time periods, respectively (see Table 1). However, in addition to the statistical problems associated with a small sample size, I suspect that this chronological difference in the amount of temper used relates more to the individual preferences of potters separated in time by 250 plus years, rather than an actual chronological trend in grog-temper use. As a result,
Figure 9. Analysis of Variance Test Results Comparing The Average Size of Grog-Temper Particles by Vessel Form.
Figure 10. Analysis of Variance Test Results Comparing The Volumetric Percentage of Grog-Temper Particles by Vessel Form.
Figure 11. Analysis of Variance Test Results Comparing The Volumetric Percentage of Grog-Temper by Provenience.
differences in the volumetric percentage of temper should not be relied upon to designate discrete archaeological components as early or late in the occupational sequence of the site.

In summary, the results of this stage of the analysis support the hypothesis that the Ink Bayou potters emphasized the importance of producing a workable clay body that could be manipulated through a number of manufacturing and finishing techniques into vessels of different shapes, sizes, surface finishes, and textures. While variation in the average size of temper exists, the data suggest that the Ink Bayou potters adjusted workability by adding different amounts of grog-temper, as well as water to the dry paste. Consequently, the reasons underlying the persistent use of grog tempering by the Ink Bayou potters may very well be linked to the obvious versatility and flexibility afforded by this ceramic tradition. Before the technological choices of the Ink Bayou potters can be discussed as a culture-wide tradition, however, the pattern of grog-temper use mentioned above must be examined on a regional scale of analysis. In the final stage of this analysis, therefore, I will compare the results of this study to those of Bennett's (1980) petrographic analysis of Bay-town Plain sherds from the Toltec Mounds site.

Comparing the Ink Bayou and Toltec Mounds Samples

The Toltec Mounds site is believed to have functioned as the paramount religious-political center of the Plum Bayou culture (Rolingson 1988:6). As such, one can imagine families and even whole villages periodically traveling to the site for ceremonial and social gatherings, bringing with them clay pots for the transportation, preparation, and consumption of communal feasts. Ceramic pots, of course, are
known to break, so it is entirely possible for ceramic assemblages from refuse areas at the Toltec Mounds site to be comprised of vessels originating from a variety of Plum Bayou culture settlements, perhaps including Ink Bayou. Consequently, comparing the paste and body compositions of ceramics from Toltec Mounds with those from surrounding sites, like Ink Bayou, provide an empirically grounded line of inquiry for identifying patterns of grog-temper use on a regional scale of analysis.

Unfortunately, Bennett's (1980) petrographic analysis of 100 sherds from the Toltec Mounds site is only partially comparable to the data derived from the present study. First of all, 2 of the 100 sherds were shell-tempered, and only 69 of the remaining 98 grog-tempered sherds were of the type, Baytown Plain. Secondly, while the volumetric amounts of individual ceramic body constituents were recorded (e.g., grog, quartz, mica, and feldspar), only the smallest and largest particle sizes observed for each constituent category were noted and tabulated (see Bennett 1980:Appendix 5). As a result, I was unable to conduct an accurate grain-size analysis (%matrix, %silt, %sand) of the Toltec Mounds assemblage, nor a comparison of average temper size between the two assemblages.

In looking over the particle size ranges tabulated for grog and quartz, however, the size distributions for both appear to compare with the Ink Bayou data. For the Ink Bayou sample, grog ranges from silt to fine gravel (> 2.0 mm) sized particles, with an overall mean value of just less than 1 mm (.98 mm) in size, while silt-sized particles of quartz grains appear more numerous than sand-sized particles. I will assume, therefore, that in the Toltec sample a similar lack of significant correlations exists between average temper size and the other paste, body, and macro-physical attributes discussed above for the Ink Bayou sample.
In order to look for statistically significant differences in the amount of
grog-temper used between the two sites, I conducted a student's t-test comparing the
mean volumetric percentages of grog-temper for both samples. The degree of vari-
ance between the two samples was found to be insignificant at the .05-alph level
(p=0.4528). This suggests that the Ink Bayou pattern of grog-temper use—with the
emphasis on producing a workable clay ceramic body—is characteristic of the Plum
Bayou ceramic industry as a whole (see Figure 12). Indeed, the range of grog-tem-
per amounts for the Ink Bayou site (from 9% to 34%) fits well within the range of
values for the Toltec Mounds sample (from 6% to 66%). Furthermore, their mean
values are nearly equal with the average amount of grog for the Ink Bayou sample
being 21%, and 22% for the Toltec Mounds sample. Read another way, the pattern of
grog-temper use appears to be the same in both samples.

The greater range of temper amounts recorded for the Toltec Mounds sample
is not surprising given the site's perceived function as the paramount aggregation
center of the Plum Bayou culture. Further evidence suggesting the transportation of
Baytown Plain pots to Toltec from other Plum Bayou culture sites in the area is pro-
vided by a comparison of the quartz percentages recorded for each thin section in the
Toltec and Ink Bayou samples. For both samples, the amount of quartz serves as a
rough estimate of the amount of sand and silt size particles occurring in the raw
pastes. While the presence of mica and feldspar inclusions were noted in the Toltec
Mounds sample, mica was recorded in only 6 of the 69 Baytown Plain thin sections,
and only 2 thin sections had minute amounts of feldspar minerals (Bennett
1980:Table 2).
Figure 12. Results For Student's T-test Comparing the Volumetric Percentage of Grog-Temper by Site Number.
For the Ink Bayou sample, however, the frequency of both minerals per thin section increased (49 thin sections out of 51 for mica and 6 out of 51 for feldspar), but their volumetric percentages remained less than that for quartz (see Appendix D). Differences in the frequency of mica alone might suggest that the Ink Bayou ceramics were produced from a more micaceous clay than many of the pots from the Toltec Mounds site. On the other hand, a student's t-test comparing the mean percentages of quartz for each sample shows a mildly significant amount of variation (p < 0.0001, r^2=0.34) between the two samples (Figure 13). What this relationship suggests is that on average the Ink Bayou pots were produced from pastes containing a higher amount of quartz than a majority of the pots deposited at the Toltec Mounds site. The range of variation in the Toltec Mounds sample, however, is not only greater than, but also includes, the distribution of quartz percentages for the Ink Bayou sample (Figure 13). As a result, while it is entirely possible that some of the pots in the Toltec sample were made from ceramic pastes similar to the Ink Bayou pots, most of the vessels deposited at Toltec appear to have been manufactured using clays not readily available to the Ink Bayou potters.

Obviously, the results of this analysis in no way prove beyond a reasonable doubt that the inhabitants of the Ink Bayou site traveled with their pots to the Toltec Mounds site. The results do, however, physically establish the possibility of such a practice taking place. Again, the comparison of quartz percentages between the Ink Bayou and Toltec samples, only serves as a rough estimate for the relative amounts of silt- and sand-size inclusions one might expect to find occurring naturally in the locally exploited clays. Likewise, problems attributed to observer bias (e.g., failure to distinguish between quartz and orthoclase minerals) could have potentially inflated the percentage of quartz grains recorded for each thin section.
Figure 13. Results for Student's T-test Comparing the Volumetric Percentage of Quartz by Site Number.
Even so, given the near absence of feldspar minerals in the Toltec Mounds sample, the use of quartz as a relative measure of grain size distributions would have rendered this error virtually meaningless. Future point-count analyses of Plum Bayou culture ceramic assemblages, however, should follow the methodological procedures outlined by Stoltman (1989, 1991), and reproduced in this study. Only then will the comparison of spatially discrete ceramic assemblages from surrounding Plum Bayou culture sites facilitate the study of local and regional interactions.

In summary, comparisons with Bennett's point-count data from the Toltec Mounds site suggests that the use of grog-temper by the Ink Bayou potters to produce a "workable" and versatile clay body was a culturally recognized practice reproduced beyond the scale of the individual site. Furthermore, significant differences between the two samples in regards to the percent-volume of quartz grains per thin section, lends support, in the form of a materially grounded hypothesis, to the long held belief that the Toltec Mounds served as the paramount religious-political center of the Plum Bayou culture. Social groups from the surrounding environs would have periodically congregated at the site for a variety of social reasons, namely the preparation and consumption of communal feasts associated with ceremonial activities and the exchange of goods and services. The question which remains to be addressed, however, concerns how the production and use of grog-tempered pots were integrated into the organization of labor in Plum Bayou society?
The Social Dimensions of Grog-Tempered Ceramics

Analyzing the relationship between technology and the organization of labor begins with the study of differences and variations in the technological actions observed within and between social groups through time and space (Lemonnier 1992:19). Differences and variations in the technological actions of potters speak to the range of recognized alternatives from which specific technological choices are made (Van der Leeuw 1993:241). As such, the decision not to use a particular raw material or manufacturing technique is just as socially, politically, and economically significant to the study of ceramic technology and society, as the actual choices brought to bear on the ceramic production sequence.

In the course of this study, variations and differences involving the use of grog as a ceramic tempering agent by potters of the Plum Bayou culture have been addressed on a number of analytical scales, from a regional scale to the level of a single site. At the macro-regional scale of analysis, the much higher frequency of plain, grog-tempered ceramics, as opposed to shell- or bone-tempered plainware pots, has long served to distinguish the spatial and temporal distributions of the Plum Bayou culture from neighboring groups throughout the Lower Mississippi River Valley and Trans-Mississippi South (see Rolingson [1998:113-132] for an in depth discussion of the geographical expanse of the Plum Bayou culture and its neighbors). The recovery of shell-tempered and bone-tempered sherds from numerous Plum Bayou culture sites, however, indicates that the Plum Bayou potters possessed knowledge of other ceramic tempering materials, and even experimented with these materials on occasion. At the Soc site, for example, sherds tempered with grog and minor amounts of shell were recovered along with two shell-tempered sherds with decorative motifs identical to two distinct varieties of the ceramic type
Coles Creek Incised (Figley 1968; Rolingson 1998:117). Despite the occasional production and use of bone- and shell-tempered ceramics, the archaeological record for the Plum Bayou culture clearly demonstrates the preferential decision to use grog over other tempering materials.

The question is why? What was it about grog that made its use as a ceramic tempering agent so appealing to the Plum Bayou potters? In Chapter III I made the argument that in order to fully address the question of temper choice we need to place one foot outside of the laboratory and recognize that the process of ceramic design is as much a social endeavor as it is a practical one (Dobres 1995; Ingold 1988; Lemonnier 1992; Pfaffenberger 1988, 1992). While tools, like pots, may be designed to solve problems and satisfy specific needs (Schiffer and Skibo 1987, 1997), the nature of their design and use must be compatible with the various social logics that form the backdrop against which the actual material actions of ceramic production and use are preformed. One cannot simply assume that the predominant goal of technological production is to maximize one's "efficiency" and utility (satisfaction gained through consumption) under a given set of physical, chemical, and economic constraints (Wilk 1996:150-151). As a result, the goals of production cannot be divorced from the broader web of social relations and systems of meaning which structure work and the processes of material culture design (Ingold 1988; Lemonnier 1992, 1993; McGuire 1992:103, 1995). Understanding how the labor process of ceramic production was organized, therefore, becomes the keystone for explaining temper choice.

Reconstructing the number, type, and sequence of steps involved with the manufacture of Baytown Plain vessels serves as a first approximation of the way ceramic production may have been organized (cf., Cresswell 1990:46-48; Lemonnier
The results of the above analysis provide the necessary evidence for reconstructing a provisional sequence of operations for the manufacture of Baytown Plain vessels (Figure 14). By comparing the operational sequence for grog-tempered ceramics to that for other types of tempered wares, we can begin to systematically address the social and material factors influencing temper choice among the Ink Bayou potters (cf. Lemmonier 1992:19; Van der Leeuw 1993:241). For the purposes of this analysis, I focus on comparing the operational sequences for grog- and shell-tempered ceramics (see Figure 14 and 15).

The operational sequence presented for the construction of Baytown Plain pots (Figure 14) corresponds with the argument that the Ink Bayou potters emphasized the importance of attaining a "workable" and versatile ceramic body that could be used to manufacture a variety of vessel forms (see above). As a result, there are only two steps involved with the initial preparation of the grog-temper—the collection and pulverization of previously fired pots into temper particles. The lack of patterned correlations between the temper and macro-physical attributes of Baytown Plain ceramics indicates that the Ink Bayou potters did not sort the grog particles by size or amount prior to mixing the raw materials. Such a practice would have added additional steps to the operational sequence and changed the organization of the labor process during the initial stages of production.

The practice of separating temper by size prior to mixing has been well documented among some Middle and Late Mississippian cultural groups in the southeastern United States, however. At the Moundville site in Alabama, for example, Steponaitis (1983:Figure 5) observed that cooking jars were tempered with coarse (> 2 mm) particles of burned shell, while bottles and bowls were tempered with finely (≤ 2 mm) crushed shell particles.
Figure 14. Operational Sequence For Producing Grog-Tempered Ceramics of the Type, Baytown Plain.
Collect clamshells

Open clams and remove meat

Burn clamshells

Crush burnt shells

(?) Sift and sort by size

Fine

Coarse

MIX RAW MATERIALS

VESSEL FORMATION

FINISHING

FIRE VESSELS

Consume Meat

Figure 15. A Generalized Operational Sequence For Producing Shell-Tempered Ceramics.
Likewise, ceramics associated with the Nodena phase (ca. A.D. 1400-1700) of northeast Arkansas, were also constructed from two primary types of ceramic bodies. Not unlike the Moundville case, Nodena phase jars were manufactured with coarse particles of burnt shell ranging in size from powder to pieces 6 mm in diameter, and averaging between 3 mm and 4 mm in diameter (Million 1975:202). Nodena bottle and bowl forms, on the other hand, were tempered with a finely pulverized mixture of burnt shell and grog particles measuring less than 1 mm in diameter (Million 1975:203).

For both of these examples, the decision to differentiate between fine and coarse tempered wares is clearly related to a technical distinction between specific vessel forms and their intended functions and manners of use (e.g., cooking jars vs. serving bowls). However, the practice of producing fine and coarse tempered wares is not inherent to the use of burned shell as a ceramic tempering agent, and can be left out of the production sequence. Even without the added step of sorting the temper by particle size the process of acquiring and preparing the shell for ceramic production is more involved than the production of grog-tempered ceramics (Figure 15).

While the tasks of collecting, opening, and burning the shells are not difficult in-and-of-themselves, they are time consuming. Burning the shells alone would add a substantial number of hours to the labor process. The amount of time involved with a particular task, of course, effects the scheduling of other productive activities within the operational sequence, and thus shapes the organization of the entire labor process (Rapoport 1990; Wallman 1979). As such, the initial tasks involved with preparing the shell temper would have to be scheduled well in advance of the actual process of sorting and mixing the raw materials for vessel construction.
Such scheduling concerns are less an issue with the production of grog-tempered ceramics, however. Every time an Ink Bayou potter successfully, or unsuccessfully, completed a pot of the type, Baytown Plain, they were simultaneously producing a future source for grog temper. As such, the final stage of firing doubles as the first step involved with preparing the grog for use as temper (Figure 14). This technical loop in the operational sequence effectively reduces the degree to which the labor process is socially and materially constrained by the organization and scheduling of other activities related to the production of grog-tempered pots.

The task of gathering shellfish to make temper serves as one example of how the organization of ceramic production might be effected by the scheduling of related activities. In his comprehensive review of the ethnographic literature on shellfish gathering societies, Waselkov (1987:109-114) observed that the scheduling of shellfish gathering events depends on more than just resource availability. Instead, scheduling decisions are based upon a complex nexus of social, economic, and environmental factors, such as the ease of procurement, seasonal availability of resources, changing estimates of group needs, and the constant reassessment of other potentially available food resources (Waselkov 1987:111). In other words, the decision to make a shell-tempered pot involves a certain amount of forethought and planning, regarding the timing of activities materially linked to the sequence of productive tasks.

Granted, shell middens can always be exploited, and crushed particles of burned shell could always be stored for future use. However, while there is no single “right” way to organize the production of shell-tempered pots, there are some tasks, which by necessity, need to be completed before the sequence can be followed through from start to finish. The point is that the decision to adopt and use burned
shell as a ceramic temper entails the recognition and acceptance of the rhythms and tempos of work embedded within the operational sequence itself.

Comparatively speaking, the production of grog-tempered ceramics not only affords a considerable degree of technical versatility and flexibility (see above), but constitutes a more expedient ceramic technology as well, with fewer possible scheduling constraints imposed by interrelated activities. Together, these three characteristics combine to establish a fourth characteristic of making grog-tempered pots; that is, the ease with which the skills, manufacturing techniques, and technical knowledge involved with the labor process—especially the early stages of the production sequence—could have been taught to other members of the social group.

As the Ink Bayou data indicates, virtually no technical restrictions concerning the appropriate amount or size of grog-temper particles were imposed on the ceramic production process by the Ink Bayou potters. Instead, the motivation for adding grog-temper to a ceramic paste was to obtain a “workable” ceramic body from which a variety of vessel forms could be produced (see above). Workability is a subjective quality, irreducible to any objective form of measurement (Rye 1981:20). As such, a technical neophyte could have learned what constitutes a “workable” ceramic body through a simple process of imitation and hands-on learning, with little verbal instruction. The initial tasks of ceramics production, therefore, could have been effortlessly delegated to other members of the household or extended family group, including children, the elderly, or even across social divisions of gender.

Embedded within the practice of making and using grog-tempered pots, therefore, exists a considerable degree of social flexibility in terms of the range of cooperative work arrangements supported by the nature of the production process.
With the pool of available labor presumably opened up to include all members of a household or extended family unit, the process of pottery production could have been organized as either a set of simultaneous tasks performed by a group of individuals, or as a linear sequence of activities carried out by a single potter (cf. Wilk and Rathje 1982). As such, if scheduling conflicts between the organization of pottery production and other activities were to arise, then at least the task of preparing a workable ceramic body could have been allocated to other members of the social group without becoming subject to the temporal constraints which a steep learning curve can impose upon the organization of labor.

This discussion raises an important point: The mode of instruction constitutes a principle component of all technological systems, and can therefore effect the organization of production (Schiffer and Skibo 1987:597). How people are taught, and the social contexts in which they receive instruction, have significant implications for the reproduction of technological style, and for the spatial-temporal patterns of artifact variability in the material record, as well (Herbich 1987; Hill 1970; Longacre 1970; Wallaert 1988). In her ethnoarchaeological study of Luo potters in western Kenya, for example, Herbich (1987) found that the existence of localized ceramic "micro-styles" could be attributed to a post-marital pattern of learning, a patrilocal residence system, strong pressures for the post-marital resocialization of women, and the interactions of individual potters within communities.

In Luo society, a woman learns to make pots from her mother-n-law after being married and moving into her husband’s house. The Luo are strongly patrilineal and rigorously follow ideals of patrilocality and polygamy. As a result, tensions relating to issues of seniority and authority between the husband’s mother and the co-wives of a household, generate considerable pressures to socialize new wives into the
social hierarchy (Herbich 1987:200). The process of learning to make pots in the local fashion, therefore, serves as one context for the resocialization of new wives into the household. In addition to the interactions between individual potters of a community, the social context for learning to pot directly correlates with the emergence of localized technological practices and decorative motifs (Herbich 1987).

The Luo study serves to illuminate the significance of identifying who in society is involved with ceramic production, and the nature of their social relationships in other technical, and non-technical realms of social life. For the Plum Bayou culture, this task involves exploring who was potentially involved with the making and using grog-tempered pots, as well as who may have been in charge of organizing the process of ceramic production.

In kinship-based societies gender, along with age, serve as the primary factors structuring the allocation and organization of productive activities (Claussen 1992:3-4; Conkey 1991:66-71; Costin 1996:113; Sahlins 1972:78-79). Likewise, the activities and productive roles one performs in society constitute a primary means for defining one's personal and gendered identity within the social group (Costin 1996:113). Following Costin (1996:113), I view gender as a set of learned practices and culturally communicated symbols of distinction that materialize constructions of masculinity and femininity, while shaping the nature of social interaction and reproduction. Employing an interest in understanding the gendered relations of production in society, therefore, becomes an important issue--both theoretically and methodologically--for probing the dialectic between the materiality of human life and the social construction of human life in the context of technological production (Conkey and Gero 1991, 1997; Wylie 1991).
There exists a long held assumption among many North American archaeologists that women were the primary producers and users of low-fired, earthenware vessels. In the archaeological literature concerning the Native American populations of the southeastern United States, this assumption has been largely founded upon the existence of ethnohistoric accounts describing women and young girls in the process of making and using clay pots (see Swanton 1946:549-555). While I do not deny the historically significant role of women in the development and transformation of ceramic technologies among the southeastern Native American groups, the social flexibility inherent to the process of manufacturing grog-tempered ceramics at the Ink Bayou site raises the possibility of male involvement with the production process, as well. Indeed, as the evidence suggests, it would be difficult for any adult in this case, to refuse their labor on the grounds of technical ignorance. Perhaps, therefore, we should consider the role of women potters as the primary organizers of ceramic production, rather than as the sole producers and users of grog-tempered pots. From this perspective we can still maintain the feminine association with ceramic production, while simultaneously considering the practice of making grog-tempered pots as constituting a dynamic arena of social interaction involving women, men, the young, and the old (cf. Dobres 1995).

To fully appreciate the significance of this perspective for addressing the social implications of using grog-temper, we need to consider the specific context(s) of ceramic production in Plum Bayou society. As Childe (1944:1; cited in McGuire 1995:168) observed, tools reflect the social and economic conditions (i.e., contexts) of their production and use. Determining where those conditions exist in time and space, therefore, constitutes one line of inquiry for discerning the social context of ceramic production and use.
Conkey (1991:67), for example, has suggested that in order to locate contexts where sexual and age-based distinctions may have been more visibly “at work,” we need to analyze sites of social interaction beyond the level of the household. For Conkey (1991:67-68), sex and age-based distinctions function to create social order beyond the level of the household and, therefore, would most likely be rigorously adhered to in the context of “aggregation” sites, where a gendered division of labor would serve to create the sphere of social interaction between individuals and social groups. In the context of daily life and labor, however, distinctions of gender and age become blurred as a result of the face-to-face dynamics of household social interactions (Conkey 1991; Stine 1992). As such, the household context is understood to produce methodological problems for identifying the archaeological correlates of gendered practices (Conkey 1991:67). Yet, the individual household serves as one of the primary contexts in Plum Bayou society where technological decisions concerning the production and use of grog-tempered pots were made. Is not the reproduction of a technically versatile and socially flexible ceramic technology reflective of such social and economic conditions?

As the results of this study suggest, the majority, if not all, of the Baytown Plain rims analyzed in the Ink Bayou sample were produced from locally available clays (see above). According to the settlement hierarchy established by Nassaney (1992a), however, the Ink Bayou site—measuring 1.3 ha in size—is classified as a multiple household site, representing an aggregation of distinct, contemporaneous household units (Nassaney 1992a:245). While a single habitation structure with associated features and activity areas has been identified at the site, less than half of the entire area of the artifact scatter has been excavated (Waddell et al. 1987). As a consequence, the question we are forced to ask is whether ceramic production at the
Ink Bayou site should be addressed in the context of a household level of production, or in the context of an “aggregated” village setting?

Obviously, the problems of settlement contemporaneity and spatial congruence loom large in this case (Dewar 1986, 1991; Schacht 1981). Settlement types for the Plum Bayou culture range from single household sites (< 0.2 ha) to large multiple mound and plaza centers, like the Toltec Mounds site, with multiple household settlements being the most common site type in the survey area (Nassaney 1992a:244-245, Figure 6.8). While the faunal and floral data from the Ink Bayou site are indicative of a year-round occupation (Colburn 1987; King 1987), the actual cycle of occupation remains a question in need of resolution. In other words, the site may have been continuously occupied throughout the late Baytown-Coles Creek time period by one or more household units (ca. A.D. 600-1000), or only periodically for intervals of more than a year. Either case may have significant implications for the social organization of productive activities at the site.

Conceptually speaking, the archaeological problems associated with examining the social relations of household production at the Ink Bayou site can be transcended by regarding the household as a basic economic unit in Plum Bayou society (cf. Muller 1986, 1997). The productive activities of the “household”, from this perspective, are assumed to be virtually the same wherever they occur in society (e.g., Muller 1997:286). Consequently, by imposing this model on the Ink Bayou data, the habitation structure and its associated features and artifacts could be analyzed as representing the activities of a single Plum Bayou culture household unit.

However, implied within this model for the household is the assumption that the organization of domestic activities, such as the production of ceramic pots, remain unchanged in the village context. As Pfaffenerberger points out, “It is not mere
technology [i.e., tools and techniques], but technology in concert with the social coordination of labor, that constitutes a human population's adaptation to its environment" (1992:497). Differences in Plum Bayou settlement size, design, and function, therefore, may correspond as much with processes of labor organization and reorganization, as with the related issues of rank and ritual. Further excavations at the site are necessary before the problems of settlement contemporaneity and spatial congruence can be properly addressed.

Despite the significance of these conceptual and methodological problems, one fact remains clear, the practice of making grog-tempered pots could have easily promoted and reproduced cooperative work arrangements within and between individual households, or extended family groups, living at the Ink Bayou site. As such, the practice of making ceramic pots of the type, Baytown Plain, does not represent a single moment in the life of an individual Ink Bayou potter, but rather a moment in the social life of a community. Within the arena of ceramic production, social actors could have come together as autonomous agents, under a variety of cooperative work arrangements, to share their labor in pursuit of a common productive goal—a social characteristic which Ingold (1988:282-283) attributes to a hunter/gatherer (i.e., communal) mode of production.

The persistent decision of the Ink Bayou potters to use grog instead of shell or bone as a ceramic temper, therefore, may have embodied a shared desire—rooted in tradition—to maintain a certain degree of social flexibility in the organization of ceramic production. Indeed, perhaps the practice of producing and using grog-tempered ceramic reflects one of the social logics of "communalism", which the incipient elite of the Plum Bayou culture were unable to transform through the
strategies of surplus accumulation and labor mobilization (see Nassaney 1992b:131-132).
CHAPTER VI

SUMMARY AND CONCLUSION

In this thesis, I have attempted to analyze the social dimensions of ceramic production in the context of a single Plum Bayou culture habitation site, the Ink Bayou site (3PU252). In doing so, I addressed the social and material implications involved with the technological decision to use grog (crushed potsherds) as a ceramic tempering agent when producing pots of the type, Baytown Plain. I argue that while the thermal properties of grog may help to explain the technical versatility observed in the Ink Bayou sample (see Rye 1976:115), the social implications of producing grog-tempered pots are best illuminated by the sequence of productive operations employed by the Ink Bayou potters themselves when constructing grog-tempered vessels (Figure 14).

According to the results of this study, few technical restrictions were placed on the Ink Bayou potters regarding the appropriate size and amount of grog-temper to be used in vessel construction. Instead, the Ink Bayou potters stressed the importance of obtaining a “workable” ceramic body from which a variety of vessel forms could be produced. Likewise, when compared to the operational sequence for producing shell-tempered ceramics (see Figure 15) the organization of grog-tempered ceramic production appears less dependent upon the scheduling and organization of other related activities, making the process more expedient in character.
Taken together, the characteristics of expediency and technical versatility suggest that at least the initial stages of making Baytown Plain pots could be easily taught and delegated to other members of the social group. As a result, the pool of available labor could potentially be expanded, with little resistance, to include women, men, the young, and the old alike--especially at the household scale of production (cf. Conkey 1991). Embedded within the practice of making Baytown Plain pots, therefore, exists a considerable degree of social flexibility in terms of the various cooperative work arrangements facilitated by the operational sequence itself. My goal in comparing the operational sequences for grog- and shell-tempered ceramics was to demonstrate that the organization and scheduling of ceramic production, as well as the process of learning each operational sequence, was not only different, but socially and historically contingent. As such, I argue that part-and-parcel of the Ink Bayou potter's decision to use grog as a ceramic tempering agent is the culturally shared productive goal to reproduce a socially flexible ceramic technology that is technically versatile, expeditious, and easily taught to others.

In the process of addressing the social dimensions of ceramic production, this thesis also set out to identify specific patterns of grog-temper use (i.e., technical strategies) that would facilitate breaking down the type, Baytown Plain, into chronologically sensitive and/or formally specific varieties. The pottery type, Baytown Plain, dominates Plum Bayou culture ceramic assemblages (Rolingson 1982:87, 1990:35-36; Stewart-Abernathy 1982) and has been described as a ceramic super-type in need of further chronological and spatial refinement (Phillips 1970).

Unfortunately, the only pattern of grog-temper use identified in the Ink Bayou data was one of considerable variability, with no apparent guidelines struc-
turing the amount or size of grog-temper to be used in vessel construction. However, while the search for patterned correlations between the temper attributes and macro-physical features of Baytown Plain pots proved intangible, a number of directions for future research concerning this line of inquiry emerged during the analytical process.

To begin with, the issue of sample size proved to be problematic when looking for differences in the volumetric amount and average size of temper particles between distinct vessel forms. Despite the problem of sample size, I concluded that the Ink Bayou potters did not differentiate between bowls, beakers, and jars in terms of adding different amounts and sizes of grog-temper particles to their ceramic pastes. My interpretations of the Ink Bayou data were based upon the degree of overlap observed in the temper values associated with all three vessel forms (see Figures 9 and 10). Clearly, further statistical comparisons employing the use of larger samples of specific vessel forms are required before my conclusions can be empirically validated.

Indeed, given the rather fragmented state of many Plum Bayou ceramic assemblages (e.g., the Ink Bayou ceramic assemblage), part of the challenge involved with searching for distinct patterns of grog-temper use is the task of obtaining statistically significant samples sizes from individual Plum Bayou culture sites. While certain aspects of this study fell subject to the problem of sample size, the comparison of the Ink Bayou and Toltec Mounds data (Bennett 1980) provided an unforeseen solution to this problem for future investigations. In comparing the temper values for the two samples, the average amount of grog-temper added to a paste (see Figure 12) and the range in temper particle sizes, were found to be nearly the same for
both. This shared pattern of grog-temper use suggests that the potters responsible for making the pots in the Toltec Mounds and Ink Bayou samples followed the same technological practice of ceramic production—that is, without actually specifying the nature of that practice. As a result, if we can assume a regionally shared technological practice of grog-temper use, then we should be able to increase the sample size for each vessel form by using rimsherds selected from a variety of Plum Bayou culture ceramic assemblages. This would not be the case, however, if the temper values for the Ink Bayou and Toltec Mounds samples were found to be significantly different from one another. At the very least, this analysis has served to establish the empirical justification for obtaining statistically significant sample sizes in the search for patterned correlations between the attributes of grog-temper and specific vessel forms of the Plum Bayou culture ceramic tradition.

Sample size proved to be a problem when addressing chronological differences in grog-temper use at the Ink Bayou site, as well. A statistically significant decrease in the average amount of grog-temper used over time was identified between the ceramic samples from two pit features at the Ink Bayou site—Feature 641 (n=2) and Feature 662 (n=7) (see Figure 7). Both pit features have associated radio-carbon dates that situate them within the late Baytown and Coles Creek time periods, respectively (see Table 1). In light of the variable pattern of grog-temper use identified in the Ink Bayou sample, I suggested that this chronological difference could just as easily be attributed to the subjective preferences of individual potters separated in time, as to an actual chronological trend in grog-temper use.

While I suspect that my conclusions in this case are correct, they are based upon a statistically significant variation involving only nine specimens from two
different proveniences. The possible existence of chronologically sensitive practices of grog-temper use, therefore, should not be entirely ruled out for the Plum Bayou culture. A useful course of study for the future would be to conduct a comparative, point-count analysis of ceramic thin-sections recovered from chronologically discrete contexts. The analysis of samples recovered from the mound and submound deposits at the Toltec Mounds site would serve as a likely starting point for such a study (e.g., ceramics from Mound S and Mound D deposits). Archaeological deposits with associated radiocarbon, or archaeomagnetic dates are preferable, and the sample size from each context should be large enough to conduct statistical comparisons.

Technological trends in the average size and amount of grog-temper used by the Plum Bayou potters could be identified by chronologically ordering all of the samples and comparing their median values for both grog-temper attributes. In this case, the median value would be more indicative of a tendency to add a particular amount or average size of grog-temper to a ceramic paste. If such trends exist, then the results of such a study may aid in cross-dating archaeological deposits and occupational areas, with no associated radiocarbon dates or diagnostic artifacts.

Finally, a related topic for future research concerns the contemporaneity problem in Plum Bayou settlement and the question of spatial congruency at the intra-site level of analysis. Both issues pose a fundamental problem for determining the number and size of contemporaneous settlements, which in turn serve as the basis for estimating population densities, describing demographic trends, and addressing issues of social-political process and change (Dewar 1986, 1991; Schacht 1981). Obviously, more archaeological excavations of single and multiple household
sites within the Plum Bayou culture area are necessary before these problems can be fully addressed.

For the purposes of this study, however, simply asking the right questions in light of the settlement contemporaneity issue, constitutes an important first step toward examining the dialectic between the social relations of production in Plum Bayou society and the technological practices of the Plum Bayou potters. Future studies of Plum Bayou culture settlement need to resolve the question of whether sites classified as multiple household settlements are truly comprised of contemporaneous and contiguous "household" units, or whether they represent the periodic abandonment and reoccupation of a specific locality by a single extended family group. Likewise, should we expect the organization of labor in the context of a single household site to be different from that of a multi-household, village context? And finally, how might the organization and scheduling of ceramic production have been articulated with other aspects of social life and labor within these different social settings?

Investigating the social dimensions of ceramic production—and other technological practices, as well—holds great potential as an entry point into the social, political, economic, and environmental processes which underwrote the development and dissolution of the Plum Bayou culture during the late Baytown-Coles Creek period. The failure of the Plum Bayou society to reproduce itself beyond A.D. 1100 has been attributed to the inability of incipient elites to successfully transform the traditions of communalism, which shaped the day-to-day interactions and productive activities of the greater Plum Bayou population (Nassaney 1992a, 1992b). The production of Baytown Plain ceramics constitutes one such productive activity,
shaped by the shared, traditional goal of reproducing a socially flexible ceramic technology. While not a means to an end, this study has presented a provisional framework for taking the initial steps toward placing the pots back into the hands of the Plum Bayou potters, and further situating their technological choices into a broader web of social, political, and economic relations.
Appendix A

Baytown Plain Rimsherd Sample From
The Ink Bayou Site (3PU252)
Sample Description of Baytown Plain Rimsherds Used in this Study From the Ink Bayou Site (3PU252)

<table>
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<th>Acc-FSN no.</th>
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<th>Bowls</th>
<th>Beakers</th>
<th>Unknown</th>
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Appendix B

Macro-Physical Attribute Documentation Form
Plum Bayou Culture
Ceramic Thin Section Project

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<td>variety:</td>
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<td>Use-wear:</td>
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State of Clay when Finished: ____________________________

Description of the Lip and Rim: ________________________

Macrophscopic Description of Paste (texture, fracture, relative abundance): ____________________________

 Comments: ______________________________________

Drawings: ________________________________________
Appendix C

Point-Count Analysis Documentation Form
Plum Bayou Culture
Ceramic Thin Section Project

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Date __________________________

Site name (number) __________________________

Recorder __________________________

Provenience __________________________

Counting interval __________________________

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Total
Appendix D

Table of Point-Count Values and Macro-Physical Attributes
For the Ink Bayou Ceramic Sample
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<th>Specimen No.</th>
<th>Procvenience</th>
<th>Width (cm)</th>
<th>Length (cm)</th>
<th>Thickness (mm)</th>
<th>Orifice Diam. (cm)</th>
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Applebaum, H.

Arnold, D.

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Bergmann, T.

Bernbeck, R.

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Wylie, A.