# A WOMAN'S WORK IS NEVER DONE:
# CHANGING LABOR AT GRASSHOPPER PUEBLO

by

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## APPROVAL BY THESIS DIRECTOR

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# TABLE OF CONTENTS

TABLE OF CONTENTS - *Continued*

TABLE OF CONTENTS - *Continued*

## LIST OF FIGURES

# LIST OF TABLES

# ABSTRACT

After being a dominant decorated ware in the northern Southwest for centuries, Cibola White Ware ceased to be produced in the Grasshopper region of Arizona within a single generation, sometime between A.D. 1300-1325. The demise of Cibola White Ware and the increase in locally-produced Roosevelt and Grasshopper red wares coincided with the transition to full dependence on agriculture in this region. This study draws on feminist theory, theories of technological change, and an extremely robust archaeological record to construct an explanatory model of this ceramic transition by exploring one critical feature of the context in which it occurred: the labor of Grasshopper women. The model proposes that Roosevelt and Grasshopper red ware pottery were less labor-intensive than Cibola White Ware pottery to produce and that their adoption was related to women's scheduling constraints associated with the rapid transition to agriculture.

# CHAPTER ONE: INTRODUCTION

If there is one attribute of the archaeological record of the American Southwest that distinguishes it from other regions, it is the ceramic assemblage. Not only are ceramics abundant, but they are also incredibly varied, with an impressive range of raw materials, technologies, vessel forms, and designs. This has led to a long history of archaeological interpretation, beginning with ceramic typology and chronology and leading to more recent attempts to link ceramic attributes with human behavior.

The production of ceramics in the prehistoric Southwest has generally been attributed to women, but few scholars have explored ceramic manufacture in the context of women's lives. Such exploration promotes greater understanding both of the lifeways of prehistoric women and of the factors leading to the creation of the archaeological ceramic assemblage. The intention of this study is to explain a well-documented instance of ceramic change by looking at the circumstances of the lives of those women whose production choices caused its occurrence.

After being a dominant decorated ware in the northern Southwest for centuries, Cibola White Ware was replaced by red wares, including Roosevelt Red Ware and White Mountain Red Ware, over a broad region of central Arizona at the end of the 13th century. Cibola White Ware ceased to be produced in the Grasshopper region within a single generation, sometime between A.D. 1300-1325. The demise of Cibola White Ware and the increase in locally-produced Roosevelt and Grasshopper red wares was simultaneous with agricultural intensification in this region. I argue that these latter ceramic wares were less labor-intensive than Cibola White Ware to produce and that their rapid adoption was related to women's scheduling constraints associated with the transition to agriculture.

The Setting

The Grasshopper region, located in the mountains of east-central Arizona, is an ideal locale for an examination of women's lives and ceramic transition. The site of the University of Arizona archaeological field school for thirty years, Grasshopper Plateau is home to archaeological resources that have been well-utilized by many scholars. More than one-fifth of the 500 room compound of Grasshopper Pueblo has been excavated, yielding a large assemblage of well-provenienced whole and reconstructible vessels. Seventeen of the eighteen rooms at neighboring Chodistaas Pueblo were excavated, providing complementary ceramic data for the period immediately preceding the occupation at Grasshopper Pueblo. These sites and others in the Grasshopper region have been the subject of a vast literature (see Reid and Whittlesey 1999 for a bibliography), and the ceramic assemblages are well-represented in these analyses. The large amount of work that has already been done on Grasshopper region lifeways sets the stage for further research. Ceramics in particular have been established as one of the most informative artifact classes; my research builds upon the extensive ceramic analyses performed by Montgomery and Reid (1990), Zedeño (1991, 1994), Triadan (1997), Van Keuren (1999), and others.

The contributions of this study are two-fold. First, a model is offered for a well-documented instance of ceramic change. While the specifics of the argument are particular to the Grasshopper region, this model, or at least portions of it, has the potential to be extended to other areas in which the same phenomenon of ceramic technological change has been documented. The causes of such a dramatic change, both in the Grasshopper region and elsewhere, are no doubt multivariate. Thus the applicability of the explanatory model offered here hinges on careful consideration of the many behavioral processes identified for each case study.

The second contribution of this study stems from its grounding in feminist social theory. While gender studies in archaeology are rapidly gaining in popularity, those which move beyond simplistic gender attributions to greater feminist social implications are few and far between. In this study, I employ the theory of technological change to understand the different factors motivating a particular shift in prehistoric ceramic technology. I draw heavily on the insights of Judith McGaw (1989), who uses a feminist perspective to inform the history of technology. McGaw notes that even in feminist scholarship, women are often treated as passive in regard to their relationship with technology. Scholars of technological change are more likely to ask how technology has affected women, rather than how women have affected technology (McGaw 1989:174). McGaw describes women not as victims of technology, but rather as active technological shapers through the meaningful choices they make. These choices may be made either as producers or consumers of technology, since both play an important role in technological change. The women of Grasshopper Pueblo were the producers and the consumers of ceramic technology (as will be discussed below), and thus would have been the primary, if not exclusive, shapers of ceramic change (Skibo and Schiffer 1995).

Choices affecting technological change are always bounded by social and economic constraints (McGaw 1989), and at Grasshopper, it was likely that specific social and economic constraints related to agricultural intensification provoked changes in ceramic technology. However, it is important to recognize that it was the ways in which these social and economic constraints affected women's lives, and the choices that women made to deal with these constraints, that are reflected in the ceramic assemblage. Ceramics have often been touted as being one of the most informative artifact classes in the Southwest, and it is commonly agreed upon that these ceramics were primarily made and used by women. Much less common, however, is the explicit recognition that the changes seen by archaeologists in this most informative artifact class reflect women's lives and their meaningful choices. Prehistoric women's agency in the creation of the archaeological record should inform archaeological interpretation. It is my intention with this study to contribute to feminist studies of technological change by exploring how the division of labor and its implications for women's scheduling constraints provoked an instance of dramatic change in ceramic technology.

## The Model

The explanatory model employed to help understand the white ware to red ware transition in the Grasshopper region consists of six major points, which are outlined here and will be discussed in greater detail below.

1. Ethnographic and archaeological investigation have suggested that women have been pottery producers in the Southwest since prehistoric times when production and consumption are at the household level.

2. The transition to full dependence on agriculture in the Grasshopper region

occurred between A.D. 1300-1325, simultaneous with the transition from Cibola White Ware to Roosevelt and Grasshopper red wares.

3. Agricultural dependence would have required additional labor for subsistence activities, including a large amount of corn grinding, an activity that has been associated with women both ethnographically and archaeologically.

4. The amount of time available for ceramic production competed with the amount of time available for food production in women's work schedules. Because women had a finite time budget, more subsistence-related time constraints would have meant that other activities had to be sacrificed.

5. Roosevelt and Grasshopper red wares were more expediently produced than Cibola White Ware.

6. The switch from production of Cibola White Ware to Roosevelt and Grasshopper red wares is related to women's scheduling constraints associated with agricultural intensification.

In Chapter Two, I briefly review some of the historical developments of gender and feminist studies in archaeology. I then look specifically at how archaeologists have dealt with questions of gender and ceramic production, with a particular focus on gender attributions. Chapter Three describes the decorated ceramic assemblage of the Grasshopper region. For each of the four wares discussed, this chapter includes a description of the technology, temporal occurrence, frequency, context, and manufacturing loci. The subsistence adaptations of Grasshopper region residents during the Pueblo III to Pueblo IV period transition are addressed in Chapter Four. Chapter Five draws on theories of technological change to examine the performance characteristics of several ceramic wares and the design compromises that occurred during the transition from Cibola White Ware to Roosevelt and Grasshopper red wares. Chapter Six provides a summary and conclusion. Appendix A is included as a more detailed report of the experiment on labor investment in black paint, and Appendix B is a statistical evaluation of changes in Cibola White Ware through time.

# CHAPTER TWO: ENGENDERING ARCHAEOLOGICAL RESEARCH

## Gender Studies in Archaeology

> In spite of the absence of serious methodological or theoretical discourse on the subject, the archaeological literature is not silent on the subject of gender. Rather, it is permeated with assumptions, assertations, and statements of 'fact' about gender. This is a serious problem (Conkey and Spector 1984:2).

In 1984, Conkey and Spector put forth a call for a new, gendered approach to archaeology, one which would evaluate and reconstruct current assumptions about gender in light of feminist research and theory. They exposed the prevalent androcentric bias in archaeological research, defined the obstacles that have prevented the field from adequately dealing with issues of gender, and proposed task-differentiation as a specific framework from which to approach gender in the archaeological record.

By 1991, when Gero and Conkey's edited volume *Engendering Archaeology: Women and Prehistory* was published, few archaeologists had heeded this call, despite nearly two decades of women-focused research by cultural anthropologists (Rosaldo and Lamphere 1974; Reiter 1975). The articles in Gero and Conkey's (1991) volume made great advances in demonstrating that it is possible and productive to approach archaeology from the perspective of feminist social theory. The goals of this volume, which were successfully achieved, were to expose gender bias in archaeology, to "find" women in the archaeological record, and to challenge assumptions about gender and difference (Conkey and Gero 1991). The editors conceptualize the archaeology of gender as emphasizing social theory, agency, and interpersonal relations. Gender is viewed as being connected with all other aspects of existence, and any treatment of the past that does not take gender into consideration is seen as a partial account.

Gender research may take place on several different levels, which are sometimes conceptualized as developmental stages, though they are not mutually exclusive and need not be performed in a particular order (Wylie 1991). First, gender research may confront the androcentric biases of previous research. Second, "remedial" research may be conducted, with a concentration on "finding" women in prehistory where they had previously been ignored. This often involves making gender attributions to artifacts or activities. Conkey and Gero (1991) insist that the archaeology of gender is not limited to gender attributions, a statement that was likely provoked by the undeserved emphasis on this aspect of gender studies by archaeologists. Third, research may focus on the integrative theories of sex/gender systems. This last stage moves beyond an exclusive equation of gender with women to a focus on the people of prehistory, whether they be women or men, and their interpersonal relations.

*Feminist Archaeology versus Gender Archaeology*

There is an important distinction to be made between gender archaeology and feminist archaeology. While gender archaeology recognizes gender as an important variable in archaeological research, feminist archaeology takes gender research to a new theoretical level by employing feminist social theory. With regard to sexual divisions of labor, those who engender archaeology merely establish that such divisions did exist and explore the nature of the activities involved. While this is a valuable first step, it does not involve the recognition that there is a difference between the actual characteristics and activities of women and men and the status and value that are attached to them by a given society. The accompanying status and value must be analyzed contextually, and this is where the archaeology of gender often falls short of feminism. Many gendered accounts of prehistory fail to address this issue at all, but those that do often rely on Westernized ideals. For example, archaeologists in the Southwest have been able to associate prehistoric women with certain domestic activities, such as corn-grinding, cooking, and ceramic production, while prehistoric men are associated with certain public and ritual activities and spaces, such as hunting and ceremonial activities. The links made between gender and specific activities are sometimes questionable, but more important for this discussion are the values placed on these activities by archaeologists. There is often an implicit assumption that public and ritual activities were more highly valued in prehistoric societies of the Southwest than were domestic activities. Such assumptions should be recognized as products of Western culture and explicitly stated. A feminist archaeological approach would take into account the specific (pre)historical context and analyze the values placed on different activities by the people performing the activities rather than rely on values held by Western archaeologists. This is not always possible for archaeological contexts, but the recognition of impossibility is preferable to inaccurate interpretations.

Another aspect of prehistoric society frequently investigated by gender archaeologists is hierarchies of gender (or more often, sex). Whether a gender hierarchy existed in a prehistoric society is often inferred on the basis of mortuary context (Neitzel 2000; Crown and Fish 1996; Howell 1995). If there is a significantly greater amount or higher quality of grave goods in a burial, or if an individual is buried in what is determined to be a prestigious location, high status is inferred. Statistical comparisons of female versus male burials are used to make interpretations about possible gender hierarchies. This method of interpretation is again subject to the imposition of value judgments, since the relative quality of grave goods and the prestige of burial locations are being determined by archaeologists. One study in particular (Neitzel 2000) indiscriminately rates all ritual and ornamental grave goods higher than any utilitarian goods, which is inherently biased against women due to their frequent participation in household activities. A feminist archaeology would not assume that the values placed on goods by prehistoric peoples are the same as those of the archaeologist without empirical evidence to support this assertation.

Such inferences of sexual divisions of labor and gender hierarchies have implications for the interpretation of prehistoric power relations. Mohanty (1991b:71), a feminist scholar writing about third world women, notes that the problem with many definitions of power is the over-simplification to a binary variable, where the only options are to be powerful or powerless. This does not reflect the reality of power relations, as there are different degrees as well as various types of power (Wolf 1990; Crown 2000a). Definitions of power have been problematic in archaeological interpretation as well. Archaeologists and other anthropologists (Crown 2000a) generally define power as coming from political, ritual, and economic sources. While these are legitimate sources of power, they are primarily sources of public power. Power from domestic, reproductive, and socializing (of children) sources is often ignored, and it is these sources of power that were most likely to have been available to women in many prehistoric societies (Crown 2000a). Inferences about the sexual divisions of labor frequently associate women with domestic activities and men with public activities, and thus women are seen as being powerless because domestic power is largely unrecognized by archaeologists. Interpretations of prehistoric gender hierarchies may have power implications as well. While the literature usually reports its investigations as finding differences in status (rather than power), it is generally recognized that high status is instrumental in achieving power (Earle 1994).

Thus, it is not uncommon for archaeologies of gender to find prehistoric patterns that duplicate those found in many Western societies: men as powerful and women as powerless. The goal of feminist archaeology is to investigate gender in prehistory without mapping-on Western values to prehistoric societies. While some feminist archaeology exists (see in particular Spector 1993), it is too often overshadowed by the more common archaeology of gender. It also tends to be somewhat discounted by archaeologists with more "traditional" theoretical tendencies.

A feminist revision of prehistory is an important endeavor for several reasons. Mohanty (1991a:21) notes that feminist struggles take place on two different levels, "an ideological, discursive level which addresses questions of representation (womanhood/femininity), and a material, experiential, daily-life level which focuses on the micropolitics of work, home, family, sexuality, etc." A feminist archaeology would constitute a struggle on the ideological level by challenging current representations of women in reconstructions of prehistory. How prehistoric women are represented may not seem as vital to the feminist movement as how modern women are represented, but in fact the former has implications for the latter. Reconstructions of prehistoric gender relations can and have been used to justify current gender relations by citing the "natural" and universal dominance of men over women (Hager 1997). Thus, interpretations of prehistory constitute an important aspect of the feminist ideological struggle.

The multiplication of voices is a means by which the decentralization of power may take place (Minh-Ha 1991:123). The existence of an alternative (feminist) archaeology is within the postmodern tradition of decentralizing the voice of "scientific/academic" authority by promoting multivocality. Like any other archaeology, feminist archaeology can never be entirely without bias, but by creating alternative interpretations it can draw attention to the biases inherent in all prehistorical accounts. The rewriting of prehistory from a feminist perspective not only challenges the Western androcentric bias that exists in other versions of prehistory, but also promotes a reanalysis of the generalizations and value judgments placed on modern women (see Mohanty 1991b for a discussion of rewriting the history of third world women). If feminist archaeologists are to challenge Western androcentric biases imposed on prehistoric women, we must recognize the historical particularities of their existence.

*Gender Studies in the Southwest*

While the literature on gender in archaeology has steadily increased since the publication of the initial summons to engender the field, research in the American Southwest has been relatively silent on these issues (Whittlesey 1999). Whittlesey argues that this lack of attention is a result of the intimidating nature of the task, as well as the detrimental effects of some archaeologists having embraced a feminist approach while abandoning the rigors of scientific method. Regardless of the causes for the sluggish adoption of engendering techniques for Southwest archaeology, the last six years have seen a significant increase in the use of such approaches. Although this literature is still not plentiful, it is diverse, dealing with such issues as divisions of labor (Hegmon and Trevethan 1996; Shaffer and Gardner 1998; Shaffer et al. 1997), technology and craft production (Crown and Wills 1995b; Mills 1995, 2000), subsistence (Fish 2000; Szuter 2000), food processing and preparation (Spielmann 1995; Crown 2000b), exchange (Spielmann 2000), spatial organization (Hegmon et al. 2000), ideology and ritual (Hays-Gilpin 2000), conceptions of body and gender (Crown 2000a), mortuary context (Simon and Ravesloot 1995; Whittlesey 1999; Neitzel 2000), health and nutrition (Martin 2000), and status, power, and prestige (Howell 1995; Crown and Fish 1996).

With this thesis, I hope to contribute to the engenderment of Southwest prehistory through a discussion of sexual divisions of labor, technological change, and agency as they relate to women and ceramic production. The term "engenderment" is used here to refer to the inclusion of gender in the matrix of variables that must be considered to account for the variability in the archaeological record and the human behavior that created it. In this respect, gender is treated similarly to other, more commonly addressed variables such as ethnicity/culture, function, and formation processes. The history of archaeological theory has witnessed the gradual recognition of the importance of certain variables, such as function and formation processes, that had not previously been routinely considered in archaeological interpretation. Gender, though commonly recognized as a social category with significant implications for human behavior, has not yet been fully incorporated into the matrix of variabies conventionally employed to address variability in the archaeological record. Thus, by considering the implications of gender for an archaeological phenomenon of interest, in this case a particular instance of ceramic change, this study contributes to the engenderment of Southwest prehistory. By employing a gender-as-agency model to explore the contexts of women's technological choices, this study evaluates the archaeological record from a feminist perspective.

Gender and Ceramic Production

One of the ways in which systems of sex and gender may be addressed is through the exploration of gender as a construct for production. The prevalence of gendered divisions of labor makes this an arena in which we may be able to make inferences about "the productive roles and contributions of women" (Conkey and Gero 1991:10). Because female labor has been systematically devalued by archaeologists (Conkey and Gero 1991:18-19), this is an area in which "remedial" archaeology focusing on women may occur simultaneously with a reframing of how we think about gender relations. Too often in archaeological literature, the passive voice is used to describe change in prehistory with no recognition of the human agency involved in promoting change (i.e. "Cibola White Ware was replaced by red wares"). Changes in material culture, when viewed through a feminist perspective, "emerge as the result of conscious and deliberate actions with intended outcomes" (Conkey and Gero 1991:19). The adoption of models of "gender-as-agency" is promoted as a means for understanding change in prehistory.

Although the literature on ceramic production in the Southwest is vast, one aspect that has not been adequately addressed is its gendered implications (but see Mills 1995, 2000; Crown and Wills 1995b). Gender is often used as an organizational principle along which divisions of labor are made and social inequalities based. It is therefore an important social construct which gives us insights into human behavior, and because the tasks being divided often have material correlates, this is a natural place for archaeologists to begin looking at gender. Research on the division of labor can be as simple as making gender attributions for certain tasks and the artifacts associated with them, or as complex as exploring the intricate relationships of gender in multifaceted activity spheres. In terms of ceramics, gender may have determined who produced pottery, who consumed it, and what social significance it held. In this section, I explore the first of these topics, ceramic production, and its gendered implications, drawing on both ethnographic and archaeological evidence.

The archaeological record is often ambiguous, and archaeologists frequently look to living societies to make analogies for prehistoric groups. This may be done cross-culturally, to show the range of possible human behavior, or using the direct historical approach, which employs as analogs the extant societies in close proximity to the prehistoric population in question. Because gender can be extremely difficult to "find" in the archaeological record, there has been an uncritical dependence on ethnographic analogy for determining prehistoric gender relations (Conkey and Spector 1984). Ethnographic analogy should be used as a model to assist in the development of testable hypotheses, not as evidence for archaeological inference. Because it has been so widely used to make inferences about the gender of prehistoric potters, the following is a brief review of what gendered trends have been documented for ethnographic societies.

### *The Gender of Potters Cross-Culturally*

Cross-culturally, there is evidence for both female and male participation in pottery production (Arnold 1985; London 1991; Kramer 1991). A statistical analysis of technologies performed by Murdock and Provost (1973) was interpreted as demonstrating that pottery-making is a "swing activity," meaning that it is not strongly correlated with either gender. However, a clear majority of the societies studied had predominantly or exclusively female production (80 out of 105; 76%), and the possibility that female participation was underreported has been raised (Wright 1991). It has been well established that when pottery production and consumption are at the household level, ceramic manufacture is a primarily female activity (Arnold 1985; Murdock and Provost 1973; Rice 1991; Wright 1991). In fact, "it is difficult to find a stronger cross-cultural correlation" than that of female potters predominating when pottery is produced at a non-specialized household level (Skibo and Schiffer 1995:86). Greater male participation has been associated with intensification and higher technology (Murdock and Provost 1973), although this has been found objectionable as the association may have been promoted by androcentric biases in ethnographic reporting (Wright 1991). Even when the organizational level of pottery production (household, part-time specialization, or full-time specialization) is disregarded, pottery is still predominantly made by women in non-industrial societies (Skibo and Schiffer 1995).

Potters may work in groups, often with different individuals performing different stages of production (Kramer 1985; Wright 1991; Mills 1995). This leads to the "hidden potter" problem, in which more than one individual helps to create the finished product but only one individual is credited. The household is a common unit of production in which this phenomenon occurs. Even though many people may be involved in the process, usually only one person is *responsible* for creating a pot, and it is this person who is defined as the "potter" (Skibo and Schiffer 1995).

*The Gender of Potters in the Ethnographic Southwest*

Societies that provide direct historical evidence for pottery production are not lacking in the Southwest. Unfortunately, many early ethnographers did not specifically address the gender of potters, although some do make statements indicating that female participation was quite common (Bunzel 1929; Cushing 1920; Baxter 1882; Stevenson 1904; Curtis 1926). More recent ethnographers (and archaeologists referencing their work) describe ceramic production as being a predominately female activity (LeBlanc 1983; Fontana *et al.* 1966; Batkin 1987; Hardin 1991), although instances of male participation in the process are noted (Fontana *et al.* 1966). Male participation is well-documented for modern times (Batkin 1987; Mills 1995; Lange 1959), and evidence for male participation has been found to go back several generations (Dillingham 1994) or for at least a century (Frank and Harlow 1974). Decoration of pottery by men has been noted as early as the late 19th century (Batkin 1987; Hardin 1991) and for more recent times (Bunzel 1929; Fontana *et al.* 1966; Brody 1977). Family participation in pottery production is described by Baxter (1882) in the late 19th century, although the gender of those participating is not noted.

In short, the ethnographic record indicates that while there may have been occasional male participation, particularly in pot decoration, ceramic production was predominantly a female task in the Southwest. The result has been an overwhelming assumption by archaeologists that the same was true prehistorically. As noted above, ethnographic analogies for prehistoric peoples must be supported with archaeological evidence.

*The Archaeological Evidence*

Mortuary contexts have provided the primary archaeological evidence for female participation in pottery production. Social roles are often symbolized by certain ritual mortuary behaviors (Howell 1995:129). In Shafer's (1985) investigation of Mimbres site LA 15049 in Grant County, NM, excavations uncovered a "potter's grave" in room 14, which was designated "Burial 86." The skeleton was determined to be female and was associated with a '"potter's tool kit," including a coiled basket, several ceramic vessels (some smashed, some not, some unfired, some not), worked potsherds, pot-polishing stones, and red pigment. Burial 86 was interpreted as that of a craft specialist whose achieved status as a potter was preserved in death, and is cited as evidence that there were female pottery producers in the Mimbres culture.

Ravesloot (1992) has also found mortuary evidence supporting women's participation in pottery production. He reports a historic burial of an adult female at a Pima cemetery with a "potter's tool kit" which contained chunks of white clay, red ocher, and three polishing stones. However, at least one male burial at the cemetery contained chunks of white clay and pigments, which were not interpreted as being associated with pottery production. This evidence is perhaps less directly applicable to the prehistoric Southwest because it is a historic site, but it supports the idea that the social role of a potter may be represented in mortuary evidence.

Male participation in pottery production, and decoration in particular, has been suggested for the Mimbres Classic period based on representational designs found on ceramic vessels. Depictions of hunting scenes, "details of esoteric, male-oriented ceremonies," females portrayed as passive figures, and males portrayed as "actively dominating" figures have been interpreted as indicating that men were decorating pottery (Brody 1977:116). Whether women would not have been likely to paint such "male-oriented" designs is subject to interpretation. Designs of marine fish obtainable only at great distances (presumably procured only by men) have been interpreted similarly (Jett and Moyle 1986). A depiction of an anatomically incorrect birth has been used as evidence for male participation in vessel decoration (Hegmon and Trevethan 1996), but this has been subject to heavy criticism (Shaffer et al. 1997; Whittlesey 1999). One Mimbres vessel has been interpreted as depicting a woman painting a pot (Jett and Moyle 1986), although this has also been contested (Mills 2000).

The gendered division of labor is a social mechanism for the complementary allocation of tasks within the household (Netting 1993). Thus, while divisions of labor constructed along sex and gender boundaries may be somewhat flexible, it is reasonable to presume that within a given society, many tasks would have been performed primarily by either women or men. The extent of adherence to this gendered division is perhaps best exemplified by ethnographic descriptions of anatomical males who assumed the feminine gender and were thus able to participate in pottery production. Such individuals have been documented in early historic times among the Zuni (Stevenson 1904, Roscoe 1991), Laguna (Bunzel 1929:57), and Tewa (Bandelier 1966-1984, I:326; cited in Batkin 1987:40). This phenomenon, in which men are able to participate in women's activities only by gender-reversal, demonstrates the social importance of gendered divisions of labor. In summary, while there is some suggestion that men may have played limited and occasional roles in ceramic production in the prehistoric Southwest, the preponderance of evidence points to women as the primary manufacturers of pottery.

# CHAPTER THREE: GRASSHOPPER REGION DECORATED CERAMICS

While the women of the Grasshopper region focused their ceramic production efforts primarily on the manufacture of pottery for household cooking and storage (Reid and Whittlesey 1999), decorated ceramics, some imported and some locally produced, are also present in the ceramic assemblage. Four ceramic wares constitute the majority of the decorated ceramics in the Grasshopper region: Cibola White Ware, White Mountain Red Ware, Roosevelt Red Ware, and Grasshopper Red Ware (Zedeño 1994; Triadan 1997; Reid and Whittlesey 1999). In this chapter, I describe the technological aspects of each ware and the details of their occurrence in the Grasshopper region.

## Cibola White Ware

Cibola White Ware was the dominant decorated ware from approximately A.D. 700-1300 over a large region of eastern Arizona and western New Mexico (Zedeño 1994:72). It was manufactured in numerous regions of the Colorado Plateau and there is evidence for its long-distance circulation as early as A.D. 800 (Zedeño 1994:72). This ware was predominately made with a white-firing kaolinitic clay that is commonly found on the Colorado Plateau but not elsewhere in the Southwest (Reid and Whittlesey 1999:134). While the Grasshopper Plateau has several sources of clay, virtually none of these are white (Zedeño 1994:79). The paste was tempered with fine quartz sand and often crushed sherds (Zedeño 1994:79). The same white clay was used for the slip; the decorative designs were applied with a mineral-based paint made of either manganese or iron oxide (Reid and Whittlesey 1999:135). Cibola White Ware was fired at moderately high temperatures in a non-oxidizing atmosphere that would have required specific technical firing knowledge, the acquisition of which could have only occurred through the direct interaction of potters (Zedeño 1994:42). Those white ware vessels fired under different conditions are identifiable by the presence of fire clouds (Zedeño 1994:82).

Most of the Cibola White Ware vessels at Grasshopper Pueblo are storage ollas decorated in Pinedale style, though some small jars and pitchers are found as burial offerings (Reid and Whittlesey 1999:135). The assemblage at Chodistaas is larger and more varied; ollas still predominate, but pitchers, bowls, and a single canteen are also present (Zedeño 1994:Appendix A). The ollas are decorated in the Pinedale style, but other forms have greater stylistic variation, and many are not readily identifiable (Zedeño 1994:29).

Zedeño (1994) has reconstructed the manufacturing loci of pots found at Chodistaas using a tridimensional approach which considers style, technology, and compositional makeup as independent lines of evidence to distinguish local versus non-local ceramics. Although all ceramic wares were considered, Zedeño makes a particularly detailed assessment of variation in Cibola White Ware, as it was the dominant decorated ware at Chodistaas. Cibola White Ware originated on the Colorado Plateau, to the north of the Grasshopper region. Technological analysis confirms that Cibola White Ware found in the Grasshopper region during the late Pueblo III period was not manufactured locally. This non-local ware is distinguished by its white paste from later Cibola White Ware vessels produced at Grasshopper Pueblo with a local, brown paste. The Grasshopper Pueblo Cibola White Ware design styles also show a blending of northern and southern stylistic criteria.

As part of her study, Zedeño (1994) selected representative samples of Cibola White Ware vessels and Grasshopper region clays to be subjected to compositional analyses including Instrumental Neutron Activation Analysis (INAA), Inductively Coupled Plasma Emission Spectroscopy (ICP), and qualitative petrography. The results were then subjected to cluster analysis, and 95% of the samples were unequivocally assigned to one of four compositional groups. ICP clearly separated the brown paste (group 4) from the gray/white paste samples (groups 1, 2, 3). Neither INAA nor ICP were able to find exact matches between the white paste samples and the light-firing clay samples, but they did reveal a match between the brown paste sample and two clay samples found in room 113 at Grasshopper Pueblo. This indicates that the two brown paste vessels from Chodistaas and at least some of the brown paste vessels from Grasshopper were made with local clays. The situation reconstructed by Zedeño (1994) for the Grasshopper region is that Cibola White Ware was introduced through reciprocal exchange with groups to the north, which reinforced inter-community ties and buffered against environmental unpredictability. The local production of this ware was probably due to introduction by immigrants, who continued making their ware with local materials and were emulated stylistically by local residents, producing vessels with a similar style but different technology.

Van Keuren (1999) has used ceramic design execution as a means to further explore the social environment of Cibola White Ware manufacture in the Grasshopper region. He relies on the ethnoarchaeological finding that brushstroke sequence and division of the design field are strongly linked to learning frameworks and interaction networks. Using Zedeño's (1991; 1994) classification of local and non-local vessels, Van

Keuren's expectation is that consistency of design execution for local and non-local vessels would indicate that white ware was being made by immigrant potters, while inconsistency in design execution would suggest the sharing of technology with locals. He finds through design execution analysis that the locally produced white ware has variable execution organization, which is interpreted as indicating manufacture by local mountain potters emulating immigrants from the Colorado Plateau.

## White Mountain Red Ware

White Mountain Red Ware is similar to Cibola White Ware in the raw materials used, the technology employed, and the quality of the resulting vessels (Reid and Whittlesey 1999:135). This ware also originated on the Colorado Plateau, where it was produced using a light paste and a finely ground temper (Triadan 1997:14). Vessels were slipped with limonite, which fires in an oxidizing atmosphere to an orange-red color, and painted with black and sometimes white designs, both of which derive primarily from mineral pigments with added organic material (Triadan 1997:14). At Grasshopper Pueblo, most of the White Mountain Red Ware vessels are bowls, but a few jars occur as well. Earlier vessels tend to be decorated in Pinedale style, and Fourmile style becomes more prevalent later (Reid and Whittlesey 1999:136).

Triadan (1997) has done an extensive study of the production and distribution of White Mountain Red Ware in the Grasshopper region. Most of this ware found at Grasshopper Pueblo has a light paste that was chemically identified as coming from two different sources above the Mogollon Rim. After A.D. 1320, some vessels were produced with two distinct recipes of a locally-sourced brown paste with an igneous diabase temper, indicating local manufacture. The non-local White Mountain Red Ware was of high technological quality, while the local vessels evidenced lower technological quality. The ceramic data indicate a shift from the import of White Mountain Red Ware to its local production, which is interpreted as supporting the established migration into the Grasshopper region.

Roosevelt Red Ware

This ware has also been called Salado Polychrome due to its association with the Salado "culture" of central and southeastern Arizona. Roosevelt Red Ware is a more inclusive term, as it encompasses certain bichromes as well as the three polychromes characteristic of "Salado Polychrome": Pinto, Gila, and Tonto (Crown 1994). This ware is widely distributed throughout the Southwest (Crown 1994); this technological description focuses on those vessels found in the Grasshopper region. The clay used was coarse and contained enough iron to fire to a brown color; such clays are common in the mountains of Arizona and New Mexico (Reid and Whittlesey 1999:137). The paste was tempered with sand, ground sherds, or both (Zedeño 1994:30). The exteriors of the vessels were slipped red, often a "raspberry red," and the interior slip was most often white but occasionally salmon. Designs were added with a carbon-based black paint, to which ground minerals may have sometimes been added, though this seems to have been an uncommon occurrence in the Grasshopper region (Zedeño 1994:30).

Roosevelt Red Ware vessels were fired in an atmosphere with sufficient oxygen to maintain the red color of the slip (Reid and Whittlesey 1999:135). The firing temperatures were low (probably 600-700° C), and vessels were fired for a relatively short period of time (Crown 1994). The lower temperatures were necessary to avoid burning off the organic-base paint, but the resulting vessels would have been less durable than Cibola White Ware or White Mountain Red Ware (Reid and Whittlesey 1999:137; Reid et al. 1992:214). The majority of Roosevelt Red Ware vessels in the Grasshopper region were bowls, which were usually found in mortuary contexts (Reid and Whittlesey 1999:137). The design styles are very diverse, and while many vessels were locally made, there is enough variability to suggest the possibility of additional manufacturing loci (Reid and Whittlesey 1999:137).

### Grasshopper Red Ware

Grasshopper Red Ware is so named due to its almost exclusive occurrence in the Grasshopper region (Reid and Whittlesey 1999:138). It was manufactured locally with technology and materials similar to those used in the production of Roosevelt Red Ware, including the coarse brown paste and the low firing temperature. The design style, however, is similar to that of White Mountain Red Ware (Pinedale and Fourmile), which has led to the suggestion that it is a locally-made imitation of this ware (Whittlesey 1974). Bowls are the most common form, but jars also occur (Triadan 1997:15). Many of these vessels are heavy with thick walls and are generally not made or decorated as well as Roosevelt Red Ware or White Mountain Red Ware. This is the only red ware that occurs frequently on room floors at Grasshopper Pueblo (Reid and Whittlesey 1999:139).

### The Ceramic Assemblage at Chodistaas Pueblo

In central Arizona, the last quarter of the 13th century witnessed a broad trend of replacement of Cibola White Ware by Roosevelt Red Ware and White Mountain Red Ware (Montgomery and Reid 1990). Chodistaas Pueblo was occupied during this time (A.D. 1263-1300), and its ceramic assemblage attests to this pattern.

Cibola White Ware is the dominant decorated ware in the ceramic assemblage at Chodistaas, and was found on the vast majority of excavated room floors (Zedeño 1994; Figures 1 & 2). Roosevelt Red Ware makes its appearance rather suddenly in the 1280s (Montgomery and Reid 1990), around the same time as the shift to residential stability. The two types of Roosevelt Red Ware present at Chodistaas, Pinto Polychrome and Pinto Black-on-red, comprise 35.4% of the decorated assemblage and 12.1% of the total whole vessel assemblage (Zedeño 1994:95). A comparison of vessels on room floors and surface sherds indicates that within the space of a few years, near the end of the occupation at Chodistaas, Cibola White Ware bowls were almost entirely replaced by Roosevelt Red Ware bowls (Montgomery and Reid 1990; Figures 1,2, & 3).

The ceramic assemblage at Chodistaas contains only two White Mountain Red Ware bowls; the same quantity occurs in the whole vessel assemblage of contemporaneous Grasshopper Spring Pueblo (Zedeño 1994:30). Grasshopper Red Ware is not present at Chodistaas.

## The Ceramic Assemblage at Grasshopper Pueblo

The replacement of Cibola White Ware by red wares continued to be reflected in the ceramic assemblage at Grasshopper Pueblo. The percentage of excavated room floors with Cibola White Ware vessels decreased markedly from that of Chodistaas (Triadan 1997; Zedeño 1994; Figures 1 & 2). The prevalence of all three red wares, Roosevelt,

**Figure 1: Room Floors Containing Decorated Wares**
**adapted from Zedeno (1994) and Triadan (1997)**

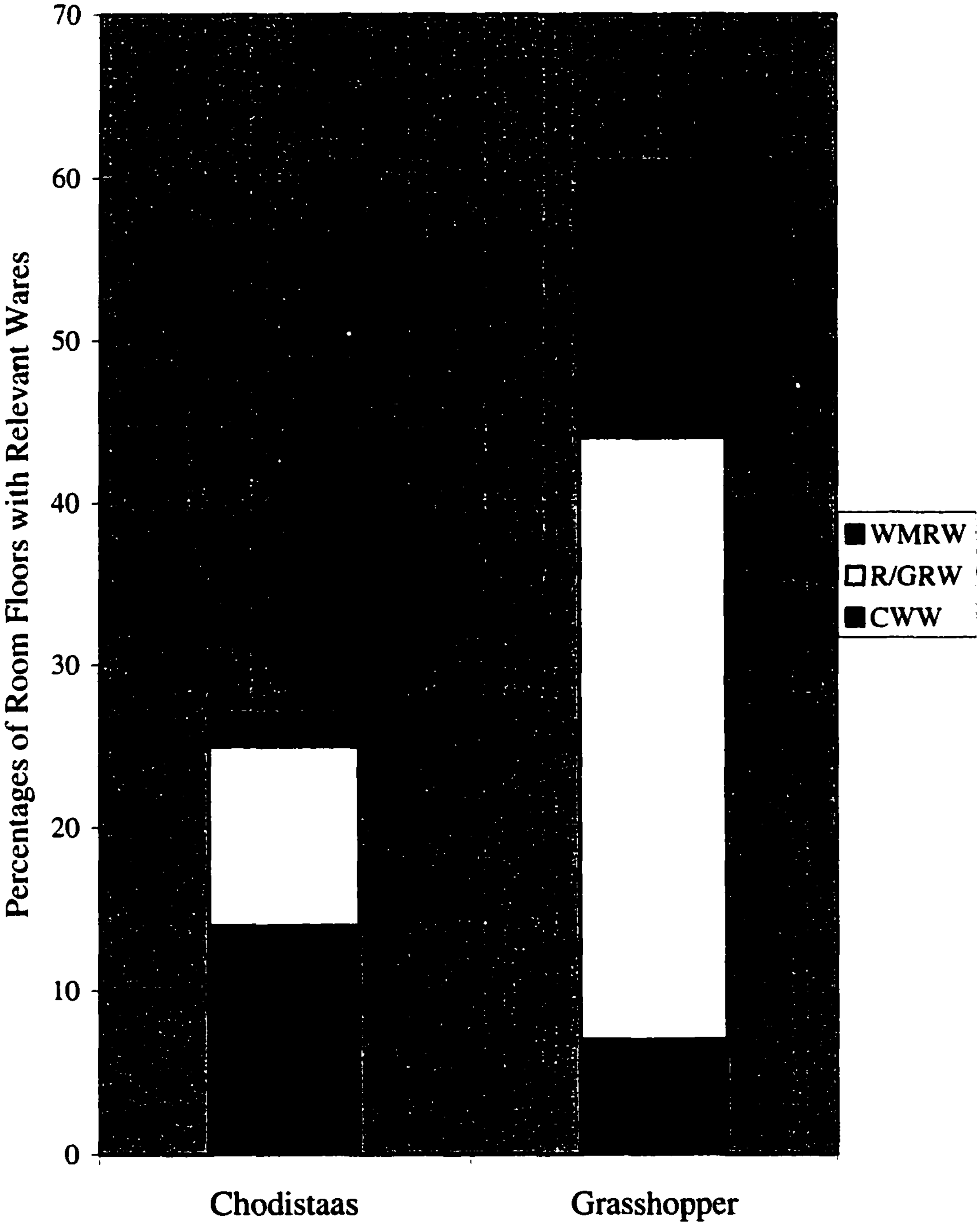


**Figure 2: Number of Decorated Vessels on Room Floors**
**adapted from Zedeno (1994) and Triadan (1997)**

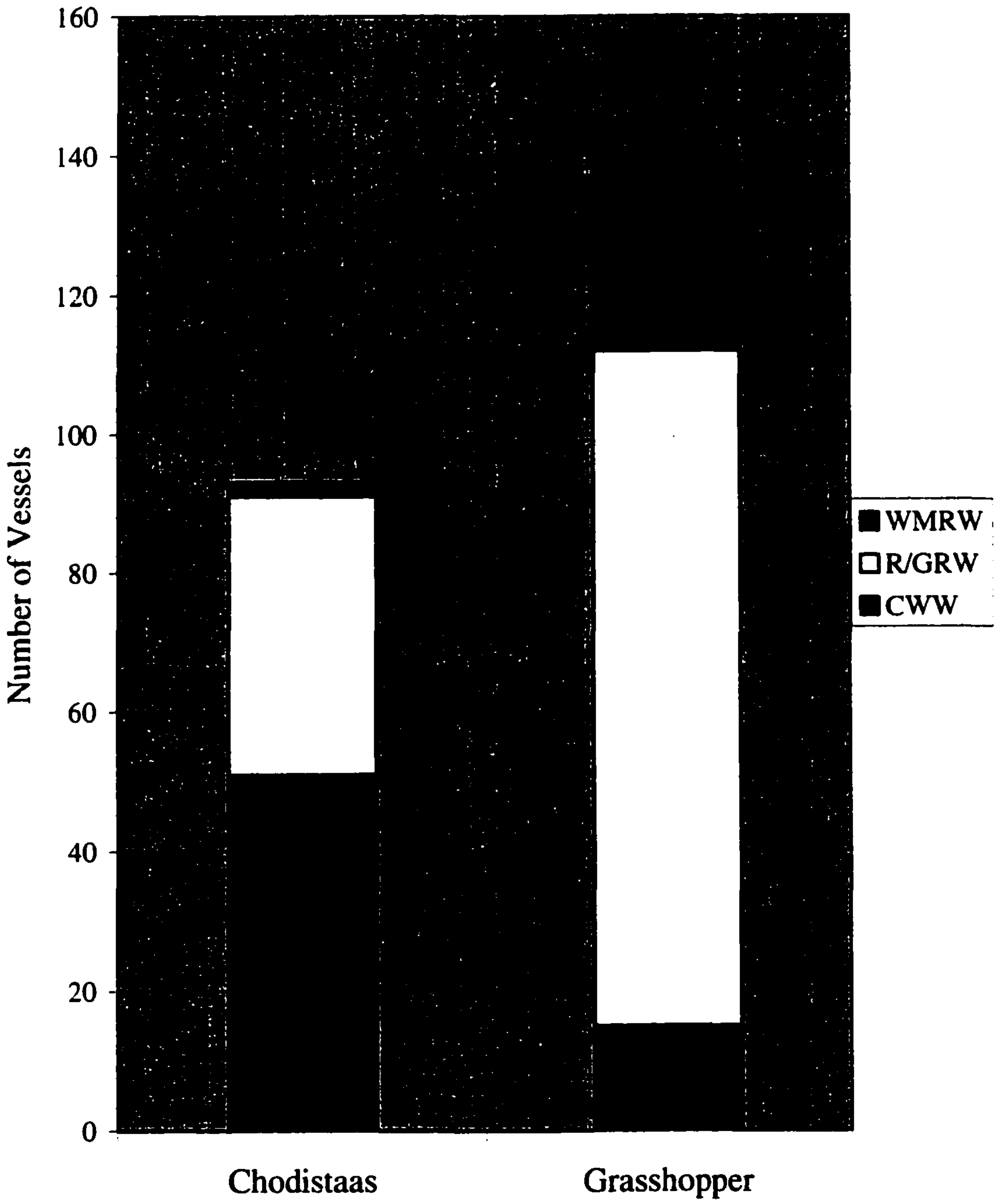
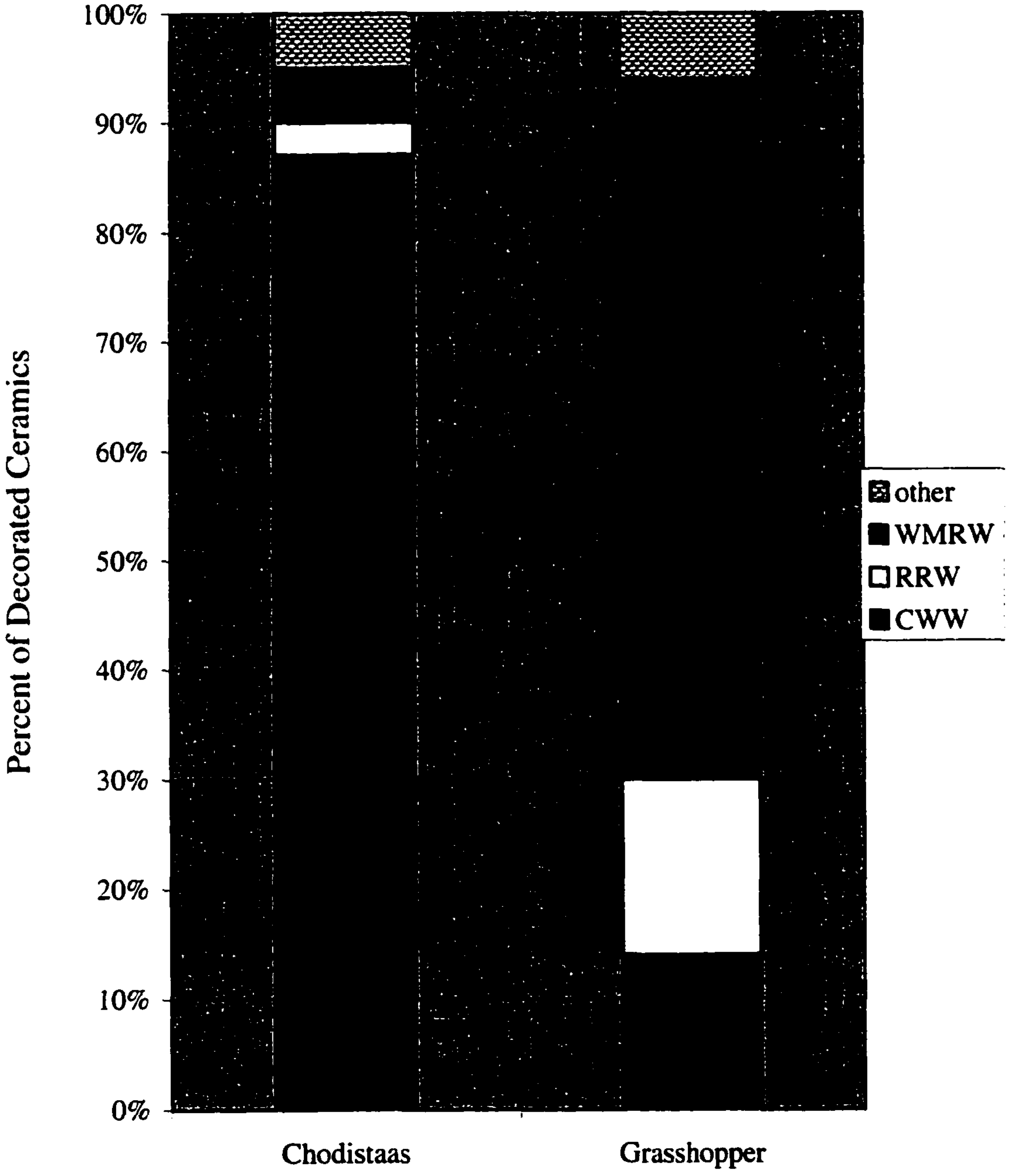


**Figure 3: Comparison of Decorated Ceramic Percentages as Surface Sherds**
**adapted from Montgomery and Reid (1990:93)**



Grasshopper, and White Mountain, increases substantially (Triadan 1997). The occurrence of each ware differs by context (room floor, room fill, surface collection, burial), making the overall proportions difficult to express as a single figure. Data on the relative occurence of decorated wares in burials is not currently available; such information would likely increase the overall proportion of Roosevelt Red Ware vessels (J. Reid, pers. comm. 2001).

Vessel Function

To address the question of whether Roosevelt and Grasshopper red wares replaced Cibola White Ware, these wares must be considered in terms of functional equivalence. This issue is problematic because the functions of most decorated vessels in the Grasshopper region assemblages have not been securely determined. Perhaps one of the most informative indicators of vessel function is use-wear. Schiffer (1989) has created a thorough research design for the study of use-wear on the Grasshopper ceramic assemblage, but thus far very little research on use-wear patterns has been undertaken. The notable exception is the study of White Mountain Red Ware by Jones (1989), which supports non-utilitarian use and non-cooking functions for the 74 bowls analyzed. "Results of this study support the general contention that decorated bowls functioned as stirring, mixing, and serving vessels, and possibly as short-term storage receptacles" (Jones 1989:359).

Cibola White Ware and Roosevelt and Grasshopper red wares have not been subjected to use-wear analysis, and thus any assertations about their functional equivalence must rely on vessel form. In addition to a relatively small number of bowls, the Cibola White Ware assemblage includes many large ollas that may have been used for water storage. Roosevelt Red Ware most frequently manifests itself in bowl form in the Grasshopper region. There are no large ollas, but Salado Red vessels, an undecorated form of Roosevelt Red Ware, include a number of medium-size ollas (J. Reid, pers. comm. 2001). Some Grasshopper Red Ware jars also occur, though this ware is primarily made up of bowls (Triadan 1997). The size of obliterated corrugated storage jars increased around the Pueblo III to Pueblo IV period transition, indicating another possible functional substitute (J. Reid, pers. comm. 2001). While the proportions of vessel forms found in Roosevelt and Grasshopper red wares are not identical to those of Cibola White Ware, similar forms are represented. There is the additional possibility of a shift in the functional requirements of ceramic vessels. The source of water is somewhat closer at Chodistaas than it is at Grasshopper. Due to higher annual rainfall and migration patterns evidenced during the Great Drought, it is likely that water was more readily available in the Grasshopper region than on the Colorado Plateau, where the largest Cibola White Ware ollas were produced. The need for large water storage vessels may have decreased under these new environmental conditions, making the medium-size Salado Red ollas or corrugated storage jars of sufficient size to serve as an acceptable functional substitute.

Provenance

The manufacturing locus of each ware is relevant to this analysis. Detailed studies by Zedeño (1994), Triadan (1997), and Van Keuren (1999) have addressed this issue for Cibola White Ware and White Mountain Red Ware. These studies have indicated that there is a general correlation between paste color and provenance. Those vessels made with a light-colored paste were likely manufactured on the Colorado Plateau. The lack of white to gray clay sources in the Grasshopper region supports the non-local manufacture of all light-paste vessels. Brown-firing clays are common in the Grasshopper region, and chemical composition analyses have linked many brown-paste vessels to these clays (Zedeño 1994). Thus, the assumption can be made that light-paste vessels were non-locally produced, while brown-paste vessels were more likely produced in the Grasshopper region.

The majority of Cibola White Ware at Chodistaas was of non-local production, but at Grasshopper, locally produced vessels make up a larger percentage of this ware. There is a statistically significant relationship between the site at which an olla was found and its locus of manufacture, with more non-local vessels in the Chodistaas assemblage and more local vessels found at Grasshopper (Appendix B). As noted above, this is interpreted as indicating introduction by immigrants, who continued production with local materials and were emulated by local residents (Zedeño 1994; Van Keuren 1999). A similar interpretation is offered for the White Mountain Red Ware assemblage at Grasshopper Pueblo, with the small percentage of locally-produced vessels attributed to immigrants (Triadan 1997).

While likely originating to the north, Roosevelt Red Ware exhibits technological and compositional continuities with local Grasshopper region ceramics, suggesting that this ware was readily adopted by local potters (Reid et al. 1992:213). The brown to orange paste of Roosevelt Red Ware suggests local manufacture, and the majority of samples from Chodistaas for which a provenance was determined through chemical composition analysis were of local origin (Zedeño 1994:101, Fig. 9.1), although some vessels appear to be of non-local manufacture (Zedeño 1991). In the Grasshopper region, most Roosevelt Red Ware was probably manufactured locally (Reid et al. 1992:214). Although chemical composition analyses have not been performed on the Roosevelt Red Ware assemblage from Grasshopper Pueblo, an assumption that the majority of vessels were made locally can be made based on the technological similarity to both the locally-produced Roosevelt Red Ware from Chodistaas and the locally-produced Grasshopper Red Ware from Grasshopper Pueblo. The possibility remains that some Roosevelt Red Ware at Grasshopper was produced non-locally and exchanged with Grasshopper residents. The reduced portability of this ware, due to its relative heaviness and lack of nestability, argues against Roosevelt Red Ware as a major trade ware. Even if some Roosevelt Red Ware arrived at Grasshopper through exchange mechanisms, this does not detract from the labor-based model presented here. If Grasshopper women found it necessary to supplement their household ceramic assemblages with some imported vessels, this may further attest to the presence of scheduling conflicts resulting in less labor allotment for ceramic production.

Grasshopper Red Ware seems to have been primarily, if not exclusively, produced in the Grasshopper region (Triadan 1997).

In summary, only small amounts of Cibola White Ware and White Mountain Red Ware were being locally produced in the Grasshopper region. In contrast, the majority of Roosevelt and Grasshopper red wares present in the assemblage was produced by local potters using local materials. The locus of manufacture is an important variable for the following analysis of scheduling conflicts because it is essential to know which of the ceramic wares were being produced by the women living in the Grasshopper region and were thus subject to their time constraints. This topic is discussed in greater detail in Chapter Five.

# CHAPTER FOUR: THE COMMITMENT TO AGRICULTURE

Ceramic manufacture was only one productive activity of the many that shaped the lives of Grasshopper women and men. This chapter focuses on the subsistence strategies employed by residents of the Grasshopper region, and how shifts in these strategies would have had implications for other aspects of people's lives.

Although knowledge of agriculture was present in the American Southwest as early as 1500 B.C., among many groups plant cultivation was initially used merely as a supplement to the hunting and gathering lifestyle (Wills 1988; Plog 1997; Tuggle 1970). In the mountains of east-central Arizona, the transition to full dependence on agriculture did not occur until much later, and was usually simultaneous with increased sedentism. Although cultigens such as maize would have been more aggregated, predictable, and easily stored than the less reliable wild grasses and plants available in the region, the switch to a maize-dependent diet had significant nutritional drawbacks. Maize has low protein and iron contents and does not provide as many essential vitamins, minerals, and nutrients as wild plant foods (Martin 1994). Because full dependence on agriculture had significant tradeoffs, the factors leading to this dramatic subsistence change would likely have been multivariate.

## Subsistence Change in the Grasshopper Region

In the Grasshopper region, subsistence began to shift from horticulture to full dependence on agriculture during the first quarter of the 14th century and was coincident with the migration of substantial numbers of Anasazi from the Colorado Plateau to the mountains of east-central Arizona, which had previously been occupied by the Mogollon. Reid and Whittlesey (1999:93-4) offer several reasons why this migration would have prompted the residents of the Grasshopper Plateau to adopt a sedentary lifestyle that was largely dependent on agriculture. First, the increase in population associated with this migration would have restricted the seasonal movement of the local Mogollon and their access to wild food resources. This significant population growth would have also increased the competition for these resources. Smaller groups would have been more vulnerable to attack, which provoked Grasshopper residents to reside in more aggregated settlements. Additionally, the Anasazi brought with them their dry farming expertise, which they were able to transmit rather quickly to the Mogollon. The beginning of the 14th century was a period of increased rainfall for the Grasshopper region, and this would have assisted farming endeavors.

While the residents of Chodistaas Pueblo engaged in some agricultural pursuits, they maintained a lifestyle that continued to exploit the abundant natural plant and animal resources of the area (Welch 1991, 1996). At the beginning of the site's occupation in A.D. 1263, the Chodistaas Mogollon were residentially mobile, only living in the pueblo for certain portions of the year (Reid and Whittlesey 1999:39). During the 1280s, at the height of the Great Drought, their settlement pattern shifted to full-time occupation, perhaps indicating increased dependence on cultivated foods. At the turn of the century, Chodistaas residents were almost certainly among the numerous groups who aggregated at Grasshopper Pueblo. During the first generation of occupation at Grasshopper Pueblo (A.D. 1300-1325), a rapid transition occurred from the hunting, gathering, and gardening lifestyle such as that practiced at Chodistaas to one that was fully dependent on agriculture. This transition is documented by multiple lines of evidence.

*Archaeobotanical Evidence*

Through archaeobotanical analyses of Grasshopper region sites, Welch (1996) finds an increasing reliance on cultivated foods through the 1300s. While there is evidence for the cultivation of beans, squash, and cotton, the only cultigen abundantly and consistently present in the samples is maize. Palynology and flotation sample analyses were used to assess the relative reliance on maize through time, and it was found that 14th century aggregation and population growth were accompanied by an increased reliance on cultivated foods. While 50% of the pre-aggregation samples from the Grasshopper region contained maize remains, this figure increased dramatically for samples from the aggregation period, with 70% containing maize. Welch also found archaeobotanical indications of increasing deforestation and ground disturbance, which would be consistent with a pattern of increased reliance on agriculture.

*Osteological Evidence*

This shift from a forager-farmer adaptive strategy to one of village agriculture has been independently documented by Ezzo (1991, 1992). Through multi-element and stable carbon isotope analyses of skeletal remains from Grasshopper Pueblo, Ezzo has differentiated dietary trends which reflect patterns of subsistence change. During the early period of occupation (A.D. 1275-1325), there were notable dietary differences by sex, with females consuming more wild plant foods and males consuming more meat and cultigens, including corn, beans, and squash. These differences may have been due to a sexual division of labor or to the existence of a social hierarchy. However, in the later period of occupation (A.D. 1325-1400), female and male diets were equalized, with both experiencing decreases in meat and wild plants and increases in cultigens. Ezzo attributes this change to increased subsistence stress, which led to more corn production and a pooling of resources.

*Site Locations*

Tuggle, Reid, and Cole (1984) have inferred high agricultural investment in the Grasshopper region during the 14th century based on the proximity of sites to arable land and the high ratio of agricultural-related sites to all sites. The distribution of agricultural soils correlates strongly with the location of agricultural features (check dams and contour terraces), field houses, and the ten large pueblos occupied in the region during this period. Thus, several lines of evidence indicate that the subsistence strategies of Grasshopper residents underwent rapid and dramatic changes during the first quarter of the 14th century, resulting in an adaptation which was fully dependent on agriculture.

## Agricultural Divisions of Labor

When agricultural intensification occurs, it is often accompanied by changes in the gendered division of labor. Tuggle (1970) compares the situation in the Grasshopper region to that of nearby Carter Ranch Site, where the coincidence of aggregation and environmental stress promoted greater cultivation efforts and changes in technology and social organization. One of the implications for the social organization of agricultural pursuits was "the intensification of the female role in this activity" (Tuggle 1970:44). Netting (1993) provides further ethnographic insight into how gendered divisions of labor are social mechanisms for the complementary allocation of tasks within the household. Food production as a subsistence activity requires a greater time investment than foraging for wild plants and animals, and for smallholder agriculturalists it is the household which is the key productive unit that mobilizes and allocates this additional labor. Gender is a key social category used by households to differentially allocate labor and thus deal with constraints on space and time.

*Women's Labor Contributions to Agriculture*

Ember (1983) describes a *relative* decline in women's contribution to agriculture with intensification, but this is because while women's *overall* contribution actually increases, men's contribution increases even more. Compared to men in horticultural societies, men in agricultural societies are less likely to have as much interference from hunting, warfare, and trade, thus freeing more time for agricultural work. In contrast, women have less time for the fieldwork tasks of agriculture because they are responsible for more domestic work associated with intensification, such as processing crops, preparing food, and caring for the greater number of children which result from the increased parity accompanying intensification and sedentism. Ember's classification of "fieldwork" or "outside work" as the "real" agricultural work is important for this discussion. While she claims that men's agricultural work increases more than women's, she is referring only to the "outside" or non-domestic tasks. Men's outside work does increase with intensification, but, as mentioned above, this is a result of the decrease in other types of labor. Women's outside agricultural work remains constant before and after intensification, and their household work increases, resulting in the contribution of more total work time for women. Increased labor input by women is less a result of their increased participation directly in crop production, but rather a result of the increase in household tasks related to agricultural intensification (Ember 1983; Netting 1993).

The increase in women's domestic tasks is partly a result of the greater dependence of intensive agriculturalists on cereal crops, which require increased processing and preparation (Ember 1983). In the Southwest, increasing reliance on cultigens meant an increase in women's food preparation, particularly that of corn (Crown 2000b). As mentioned above, maize has a low nutritional value relative to that of wild plants and grasses, and much of the processing of corn served as nutritional enhancement. The processing of plant foods is a potential way of intensifying subsistence without changing the resource base (Stahl 1989), and thus the economic success of a group may be determined less by the abundance of the harvest yield than by the postharvest processing efficiency (Barlow 1997). The soaking of maize with lime or wood ash improves the availability of protein and niacin (Arnold 1985; Stahl 1989). Grinding corn reduces the food particle size and increases the surface area which allows greater exposure of the food to digestive enzymes (Stahl 1989). Additionally, the minerals present in grinding stones may contribute to the corn's mineral content (Stahl 1989).

To facilitate grinding, the dried kernels of corn may first be subjected to additional processing, such as parching, soaking, or cooking (Barlow 1997). Maize may be further prepared into tortillas or hominy, both of which are documented ethnographically for many southwestern groups, including the Pueblos (Beck 2000). Schiffer (1975:108) has described 14 maize preparation tasks performed historically by Hopi women, only two of which were the responsibility of both women and men. I have reproduced Schiffer's behavioral chain here (Table 1) to demonstrate the many processes involved in maize agriculture.

There is ample evidence, both ethnographic and archaeological, suggesting that the task of grinding corn was likely performed by women in the prehistoric Southwest. Through cross-cultural comparison of foraging/horticultural societies, it has been found that corn grinding is a female activity (Crown and Wills 1995b) and that the use of grinding implements by men is rare (Fish 2000). In the Southwest, there are no ethnographic cases of men grinding corn daily or for economic reasons (Ortman 1998); food preparation, and grinding in particular, was historically the responsibility of women (Adams 1994:85). Ethnographic work among the Hopi describes women spending several hours per day grinding corn (Dorsey 1899); this was also a female activity historically at Gran Quivira, New Mexico (Hawkey 1988).

The gendered division of labor is often difficult to recognize archaeologically, but certain habitual activity patterns can be determined by osteological analysis. Forces put on the skeleton during particular activities cause the bone to redistribute itself to counteract these forces (Spielmann 1995). Additionally, bony lesions (enthesopathies) can develop at the sites of insertions of muscles, tendons, or ligaments as a result of repetitive action. These skeletal modifications may be used to relate certain tasks to the sex of the individuals performing them. Benson (1986) studied prehistoric degenerative joint disease by sex in the skeletal population of Grasshopper Pueblo and compared her

# Table 1: Partial Behavioral Chain of Maize for the Hopi, circa A.D. 1900, reproduced from Schiffer (1975:108)

| ACTIVITY | ENERGY SOURCES: SOCIAL UNITS | ENERGY SOURCES: NON-HUMAN | CONJOINED ELEMENTS | TIME AND FREQUENCY | LOCATION | OUTPUTS | INTERSECTIONS: ADDITIONS | INTERSECTIONS: DELETIONS |
|---|---|---|---|---|---|---|---|---|
| HARVEST | ABLE VILLAGERS OF BOTH SEXES 3,4 | | BASKETS 4 | SEVERAL DAYS IN SEPTEMBER 4 | FIELDS OF H.H. 3,4 | STALKS, WASTED OR UNHARVESTED MAIZE | | |
| TRANSPORT | ABLE VILLAGERS OF BOTH SEXES 3,4 | | BASKETS BLANKETS 3,4 | ONCE IN SEPTEMBER | FROM FIELDS TO ROOF OF H.H. AREA | POLLEN | | |
| HUSK | WOMEN OF H.H. AND OTHER FEMALES 3,4 | | WOODEN OR BONE PEG 6 | ONE OR SEVERAL DAYS IN SEPTEMBER | ON ROOF OF H.H. AREA 3,4 | POLLEN | | HUSKS |
| DRY | | SUNLIGHT 4 | ROOF OF H.H. AREA 4 | SEVERAL DAYS IN SEPTEMBER | ON ROOF OF H.H. AREA 3,4 | POLLEN | | |
| TRANSPORT | WOMEN OF H.H. | | BASKETS | ONCE IN SEPTEMBER | FROM H.H. AREA TO STOREROOM | OCCASIONAL KERNELS, POLLEN | | |
| STORAGE | | | STOREROOM 3,4,6 | 1 TO 100 WEEKS 6 | STOREROOM 3,4,6 | OCCASIONAL KERNELS, POLLEN | | |
| TRANSPORT | WOMEN OF H.H. | | BASKETS | SEVERAL MORNINGS WEEKLY | FROM STOREROOM TO HABITATION ROOM | | | |
| REMOVE KERNELS | WOMEN OF H.H. 3 | | SHORT STICK YUCCA BASKET 3 | SEVERAL MORNINGS WEEKLY | HABITATION ROOM | OCCASIONAL KERNELS, POLLEN | | COBS |
| COARSE GRIND | WOMEN OF H.H. 1 | | MEALING BIN, STICK, COARSE MANO AND METATE, YUCCA BASKET 1,2 | SEVERAL MORNINGS WEEKLY | HABITATION ROOM 1 | WASTED KERNELS AND MEAL POLLEN | | |
| REMOVE CHAFF | WOMEN OF H.H. | WIND | YUCCA BASKET 3 | SEVERAL MORNINGS WEEKLY | OUTSIDE OF STRUCTURE | CHAFF | | |
| MEDIUM GRIND | WOMEN OF H.H. 1 | | MEALING BIN, STICK, MEDIUM MANO AND METATE, BOWL 1,2 | SEVERAL MORNINGS WEEKLY | HABITATION ROOM 1 | WASTED MEAL | | |
| FINE GRIND | WOMEN OF H.H. 1 | | MEALING BIN, FINE MANO AND METATE STICK, BOWL 1,2 | SEVERAL MORNINGS WEEKLY | HABITATION ROOM 1 | WASTED MEAL | | |
| TRANSPORT | WOMEN OF H.H. | | BOWLS 2 | SEVERAL MORNINGS WEEKLY | HABITATION ROOM TO STOREROOM | WASTED MEAL | | |
| STORAGE | | | BOWLS 2 | SEVERALS DAYS TO A WEEK | STOREROOM | WASTED MEAL | | |
| TRANSPORT | WOMEN OF H.H. | | BOWLS 2 | TWICE DAILY | STOREROOM TO HABITATION ROOM | WASTED MEAL | | |
| MAKE DUMPLINGS | WOMEN OF H.H. | | COOKING JAR, BOWL | TWICE DAILY | HABITATION ROOM | WASTED MEAL | WATER, OTHER INGREDIENTS | |
| COOK | | FIRE | JUNIPER TWIGS COOKING JAR FIRE PIT 6 | TWICE DAILY 3 | HABITATION ROOM | SPILLAGE-WASTE | | |
| SERVE | WOMEN OF H.H. | | SERVING BOWLS COOKING JARS LADLES 5 | TWICE DAILY 3 | HABITATION ROOM | SPILLAGE-WASTE | | |
| EAT | ENTIRE H.H. | | BOWLS 5 | TWICE DAILY 3 | HABITATION ROOM | WASTE | | |
| DIGEST TRANSPORT | ENTIRE H.H. | | | ALMOST CONTINUOUSLY | LOCATIONS OF H.H. MEMBERS | | OTHER FOODS | |
| DEFECATE DISCARD | ENTIRE H.H. | | A BROAD LEAF | ONCE DAILY | AWAY FROM OCCUPIED ROOMS | A BROAD LEAF, RESIDUES | | |

KEY

1 · BARTLETT (1933) 4 · STEPHEN (1936)
2 · BARTLETT (1936) 5 · TURNER AND LOFGREN (1966)
3 · BEAGLEHOLE (1937) 6 · WHITING (1939)
H.H. HOUSEHOLD

findings to the activity patterns reconstructed for this site. She found that female skeletons evidenced osteoarthritic patterns that correlate with grinding meal and several other activities distinct from those patterns found on male skeletons. A similar study was done on the presence and location of enthesopathies in the skeletal population from Gran Quivira (Hawkey 1988), which were also found to be consistent with female corn grinding. An additional indication of gender roles in prehistoric populations is the repeated occurrence of certain burial goods with a particular sex. In the Southwest, no men have been associated with corn grinding tools in any mortuary population during any period (Ortman 1998), but the same cannot be said for women.

Food preparation and processing would have undergone substantial alterations with agricultural intensification, and the increase in corn grinding alone would have meant a significant labor commitment. Dorsey's (1899) ethnography of the Hopi describes women spending three hours each day grinding corn. Barlow (1997), employing an experimental archaeological approach, has shown that shelling corn and grinding it using a metate and mano requires just under two hours per kilogram of corn. Corn was ground dry at a rate of 1.73 hours per kilogram, while wet grinding required slightly more time at 1.9 hours per kilogram. These figures include shelling and grinding only, although corn may first be parched, soaked, or cooked to facilitate milling.

Zedeño (pers. comm. 2001) notes that even in the absence of full dependence on agriculture, aggregation increases the amount of labor required for subsistence activities because it increases the food requirements for a particular settlement. Aggregation and agricultural intensification occurred simultaneously in the Grasshopper region, making causal relationships somewhat difficult to determine. The transition to full dependence on agriculture occurred at drastically different times in different areas of the Southwest, and part of the reason that it was not always accompanied by shifts in ceramic technology may be related to social and economic contexts that were distinct from those of the Pueblo III to Pueblo IV transition in the Grasshopper region. The temporal intersection of aggregation and agricultural dependence in the Grasshopper region likely contributed to the substantial increase in women's labor required for subsistence activities and the scheduling conflicts that resulted.

*Women's Scheduling Conflicts*

Women's increased labor investment with agricultural intensification and aggregation would have created scheduling conflicts. Crown and Wills (1995a, b) provide a comprehensive list of the many responsibilities often assigned to women in foraging/horticultural societies such as the prehistoric Southwest. These responsibilities include gathering, farming, food processing and preparation, laundering, weaving, basket-making, and child care. Crown and Wills (1995b:177-8) also point out that pottery production requires intensive labor, including collecting clay and firewood, manufacturing tools, and forming, finishing, and firing vessels. They use this argument to support their assertation that women would have needed extra incentive to adopt the practice of pottery production. With the noted constraints on women's time, it could also be argued that the additional tasks associated with agricultural intensification would have necessitated alterations in other activities requiring intensive labor commitments, such as the production of pottery.

Arnold (1985) notes that the warm, dry weather necessary for pot production is the same weather ideal for agricultural activities, thus creating potential scheduling conflicts. However, women's labor, at least as it has been constructed for Grasshopper Pueblo, is more complex than would allow a simplistic application of Arnold's seasonal conflict observation. I have focused on corn grinding in particular as an activity that would have increased substantially with agricultural intensification and for which a strong case can be made attributing the labor to women. Because corn grinding would have occurred on demand, it would have taken place year-round and does not conform to Arnold's seasonal expectations for agricultural labor. As noted above, however, there are many other household activities associated with maize processing that are ethnographically attributed to women, some performed seasonally, others year-round (Schiffer 1975:108; Table 1). Additionally, the seasonality of pottery production has not been securely determined for the prehistoric Southwest. The temporal resolution of archaeological studies of pottery production is not fine enough to indicate seasonality.

Women can be viewed as having a total energy budget that is not completely governed by seasonal conflicts. Added labor requirements to this budget would have necessitated the subtraction of labor from elsewhere in the budget. Such a shift would likely be accompanied by many reconfigurations of women's schedules and labor allocations. As part-time potters who were also involved in subsistence activities, the women living at Grasshopper Pueblo would have experienced substantial scheduling conflicts and labor reconfigurations with the transition to agricultural dependence.

# CHAPTER FIVE: CERAMICS AND TECHNOLOGICAL CHANGE

The women of Grasshopper Pueblo had to find a way to deal with the scheduling conflicts they faced at the transition to full dependence on agriculture. A reduction in the amount of time dedicated to ceramic production would have been a potential solution, but this would have had implications for the quality or quantity of ceramics produced. In this section, I will discuss the characteristics of decorated ceramic wares and the details of ceramic change that may have made this a feasible option for lessening the time constraints of Grasshopper women.

## Theories of Change

Archaeologists tend to concentrate on stable states or time periods rather than on transitions (Rice 1984; but see Hill 1977). Ethnographers studying pottery production have reported that potters and pottery are "conservative and unchanging" (Rice 1984:234). Additionally, "many scholars have concluded that change in pottery does not reliably and predictably accompany other kinds of cultural change" (Rice 1984:234). This lack of obvious reflection of sociocultural context and the generally slow pace of ceramic change have led to "a hypothetical general ethic of 'conservatism' on the part of potters," an idea rejected by Rice (1991:441). Indeed, a conservative ethic does not go far in explaining the ceramic assemblage of the Pueblo III to Pueblo IV period transition in the Grasshopper region. Such a well-documented instance of rapid and dramatic ceramic change necessitates an exploration of the cultural context in which it occurred.

Because ceramics are embedded in a larger cultural context, the specific factors impacting ceramic change are difficult to isolate (Rice 1984). In addition, cultural change was historically explained by single factors or "prime movers"; more recently, multicausal explanations have become increasingly favored by archaeologists. While these multivariate explanations are likely more accurate reflections of the prehistoric situation, they contribute to the difficulty in isolating the factors promoting ceramic change.

Rice (1984) appeals to systems theory to inform the processes of ceramic change. Systems theory holds that a system (or culture) exists in equilibrium with its surroundings. When this equilibrium is disturbed, the system adjusts to achieve a new equilibrium. The source of disturbance may be internal or external, and it may be quantitative or qualitative in nature. A system experiencing stress (such as population increase) may respond by increasing its variety and making itself more adaptable. Rice (1984) applies this principle to changes in ceramic technology, which reflect the context of sociocultural interaction, although "a ceramic sub-system responds variably, indirectly, and slowly to change in the larger system with which it is associated" (Rice 1984:274).

Rice (1984) views population growth as one of the principle factors motivating ceramic change. Population growth changes the relationship between people and their environment, which creates stresses within the system that eventually may provoke changes in ceramics. The Pueblo III to Pueblo IV period transition witnessed substantial population growth with aggregation in the Grasshopper region. As discussed above, this was one of the primary causes of the shift to full agricultural dependence. In turn, this agricultural intensification created increased workloads for women which competed with the demands of pottery production. Theories of technological change are useful in explaining the ceramic choices made by women in response to these scheduling conflicts.

"A technology is a corpus of artifacts, behaviors, and knowledge for creating and using products that is transmitted intergenerationally" (Schiffer and Skibo 1987:595). Schiffer and Skibo (1987) have created a theoretical framework for explaining changes in technological processes and products. They note that changes in ceramics have previously been treated by archaeologists as if they only had social functions, partly due to the common assumption that nonindustrial technologies have a relatively unsophisticated scientific basis. Ceramics in particular have often been viewed by archaeologists as being primarily a form of artistic expression, such that "any changes in technology [are treated] as a reflection of the social dimension, not something done for utilitarian purposes" (Skibo and Schiffer 1995:81). Variation in ceramic temper is an example of this; formerly thought to be a function of social factors, experiments have found temper to influence utilitarian functions as well (Schiffer and Skibo 1987). Schiffer and Skibo (1987) emphasize the necessity of identifying those aspects of artifact variation which are attributable to technological functions.

Changes in all functional aspects of artifacts, whether they be technological, sociological, or ideological, may be in response to changes in lifeways and social organization (Schiffer and Skibo 1987). Additionally, change may be caused by feedback from the use of artifacts or by pressure put on producers, such as changing availability of raw materials. "Understanding how pots perform is the key to exploring change and the decisions potters make as they struggle to produce vessels under ever-changing environmental and social conditions" (Skibo and Schiffer 1995:90). Performance characteristics must be considered when explaining technological change because they illuminate patterns of design compromise. Schiffer and Skibo (1987:601) promote the creation of a "performance matrix" for each artifact which lists the performance characteristics relevant to all the activities of an artifact's life history, including raw material procurement, manufacture, use, and maintenance. Their next step is to build a model to explain the compromises of the performance matrix as an outcome of technological choices resulting from the context of lifeways and social organization. Essential to this model are the social units of activity performance, in other words, the membership of the task group as defined by categorical identities such as gender, age, class, etc. (Schiffer 1995). For the instance of ceramic change described here, it has already been determined that it was women who comprised the social unit of the activity.

Following the lead of Schiffer and Skibo (1987), I have created a performance matrix comparing the characteristics of Cibola White Ware to those of Roosevelt and Grasshopper red wares (Table 2). Table 2 designates which characteristics would be important to the producer versus the consumer. In the case of Grasshopper ceramic production, where pottery was manufactured at the household level, the producer and consumer were likely the same individuals, or at least belonged to the same social category. The evidence for pottery production as a task performed by women is outlined above; the use of pottery, particularly in cooking, is also usually within the female domain (Skibo and Schiffer 1995). Murdock and Provost (1973) identify the three activities with the highest cross-cultural female participation as water fetching, cooking, and preparing vegetal foods. The first two of these usually require the use of ceramic vessels (when available), and the third often requires pottery as well (Skibo and Schiffer 1995). Thus, while the performance matrix is divided into characteristics of production and characteristics of consumption, the two of these share the same social units of

**Table 2: Performance Matrix for Cibola White Ware and Roosevelt Red Ware/Grasshopper Red Ware**

| Performance Characteristic | CWW | RRW/GRW |
|---|---|---|
| **Important to Producer:** | | |
| Availability of Paste | - | + |
| | white paste not locally available on Grasshopper Plateau | brown paste locally available on Grasshopper Plateau |
| Ease of Manufacture | | |
| 1. Black paint | - | + |
| | mineral, greater production cost | organic, less production cost |
| 2. Fuel collection | - | + |
| | high fired, more fuel | low fired, less fuel |
| 3. Firing technology | - | + |
| | high fired, more technological knowledge | low fired, less technological knowledge |
| | non-oxidizing atmosphere, more control required | oxidizing atmosphere, less control required |
| **Important to Consumer:** | | |
| Portability | + | - |
| | high fired, stronger, lighter, more useful in context of high mobility | low fired, friable, not important in sedentary community |
| Durability | + | - |
| | greater impact resistance | less impact resistance |

Plus and minus symbols indicate the relatively high (+) or low (-) priority assigned to each characteristic by the technology (Schiffer and Skibo 1987:607).

activity performance. Compromise is key in understanding relationships between performance characteristics (Skibo and Schiffer 1995), and the compromises between production characteristics and consumption characteristics are both understood within the context of women's lives.

## Performance Characteristics

### *Availability of Clay*

Through cross-cultural comparison of ceramic-producing societies, Arnold (1985) has defined the catchment area for collection of clay as being within a 7-10 km radius of the site of production. Clay sources in the Grasshopper region have been thoroughly surveyed by Zedeño (1994). First, she performed a preliminary reconnaissance within the clay catchment area (7-10 km radius of Chodistaas Pueblo) in an attempt to identify potential sources of clay and temper. Known clay sources in the larger region were then sampled for comparative purposes, including the closest known source of white-firing clay and 8 additional deposits beyond the target area. Intensive survey and clay collection within a radius of 4.5 km from the site was also performed. In total, 32 clay exposures were sampled, and these data were supplemented by later samplings during subsequent excavations in the Grasshopper region. Zedeño (1994) found that white-firing clays are not located on the Grasshopper Plateau or within the primary clay catchment area. The closest sources were near sites occupied contemporaneously with Chodistaas, and there is no evidence for the trade of clay, especially not in the large quantities that would have been required to supply the production of a prominent decorated ware.

Thus, the white paste that was a hallmark of Cibola White Ware technology was not available in the Grasshopper region. As noted above, however, some Cibola White Ware was produced at Grasshopper Pueblo using locally available brown paste (Zedeño 1994; Van Keuren 1999). This occurrence indicates that despite the lack of the preferred paste, the production of Cibola White Ware could have continued, as some of the residents of Grasshopper Pueblo had the technological knowledge to do so.

*Black Paint*

The black paint used on Cibola White Ware is mineral-based, while that used for Roosevelt and Grasshopper red wares is carbon-based. I have experimentally replicated each type of paint in an attempt to determine which is more labor-intensive, measured by the variable of production time. A detailed description of this experiment is in Appendix A. The replicative process prompted a qualitative comparison which I found to be more behaviorally relevant than quantitative methods. Paint production involves two different types of time, which I have identified as *active participation time* and *passive production time*. *Active participation time* is the time during which the production process requires constant attention. The entire process of making mineral-based paint consists of active participation time. *Passive production time*, in contrast, does not require the attention of the producer; simmering water or food left unattended in its pot is an example. While producing carbon-based paint requires a greater amount of total time, the vast majority of this time is passive production time, leaving women free to attend to other responsibilities in the general vicinity of production. Thus, mineral-based paint production is considered more labor-intensive and more likely to have created scheduling conflicts with other activities.

Other characteristics of the two black paint types should also be discussed. Esthetically, the mineral-based paint produces crisper, darker designs, while the carbon-based paint soaks into the vessel wall, resulting in fuzzier edges and a lighter color. It is impossible to judge how these visual performance characteristics would have been evaluated by the makers and users of these pots.

The type of paint used also affects firing technology. Successful use of carbon-based paints requires careful control of firing conditions (Blinman 1993). If carbon-based paint is fired at high, oxidizing temperatures, it can burn off the vessel, thus erasing the design. This problem was solved by Grasshopper potters by firing at relatively low temperatures (Reid et al. 1992). Another solution would be to fire vessels in two separate episodes: one before painting and one after. Zedeño (pers. comm. 2001) has noted in her observations of vessel cores that this was potentially the case for some Roosevelt Red Ware vessels. This tentative finding may have implications for the model presented here, but needs to be substantiated further.

Certain mineral pigments, in contrast, have less sensitivity to firing conditions; this is particularly true of manganese paints. The color of iron oxide pigments is affected by firing temperature, duration, and atmosphere (Shepard 1965). To maintain a black color, iron oxide paints must be fired in a non-oxidizing atmosphere. Iron oxides were also used as a slip for many red wares and polychromes; these wares would have been fired in a neutral to oxidizing atmosphere to achieve the red color (Blinman 1993). While this requirement eliminates the possibility of using an iron oxide for the black paint on a red ware, the availability of manganese as a pigment (both manganese and iron oxide were used on Cibola White Ware [Zedeño pers. comm. 2001]) indicates that producers of red wares had other options for mineral-based paint.

Daniela Triadan (pers. comm. 2001) has suggested that the minerals required to produce mineral-based black paint were not available in the Grasshopper region. She argues that this may have caused the switch to carbon-based black paint, thus producing change in the firing technology for the logistical reasons stated above. I am not aware of any literature on the topic of mineral availability in the Grasshopper region and thus cannot specifically address the availability of manganese or specular hematite appropriate for making ceramic paints. However, even assuming that such minerals are not present in the Grasshopper region, this does not necessarily detract from the model proposed here. Arnold (1985) argues that while the procurement of clay and temper is constrained by distance, the procurement of materials for slips and paints is not subject to such constraints, due to the small quantities of these materials and their less frequent procurement. Arnold's (1985:52) cross-cultural studies of traditional societies show that materials for slips and paints may be obtained from sources that are 10s to 100s of kilometers away, much farther than the 7-10 km clay catchment area. Schiffer and Skibo (1997:35) note that "people might expend considerable effort in acquiring such materials when, for example, visual performance during post-manufacture activities depends on vessels having a certain color or a particular painted decoration." Additionally, the switch from mineral-based to carbon-based black paint is a pan-Southwestern phenomenon (Crown 1994), and cannot be solely explained by mineral availability in the Grasshopper region.

*Fuel Collection*

Firing ceramics at high temperatures or for long durations requires more fuel than firing at lower temperatures or for shorter amounts of time. This factor becomes particularly important in relatively fuel-scarce environments. Although the Grasshopper Plateau is not a fuel-scarce environment, increased fuel requirements also necessitate increased amounts of labor for fuel collection. Experimental refirings of sherds have suggested that Roosevelt Red Ware firing temperatures were probably no higher than 500°C, while Cibola White Ware was likely fired at temperatures between 750-950°C (Zedeño 1994:82, 97). As low-fired wares, Roosevelt and Grasshopper red wares would have required less fuel than the relatively high-fired Cibola White Ware.

*Firing Technology*

The manufacture of Cibola White Ware would have required a relatively great amount of technological knowledge in order to produce pots that were uniformly fired, unsmudged, and un-oxidized (Reid et al. 1992). There are no ethnographic analogs for this technology (Shepard 1965), and attempts at experimental replication have had only limited success (Blinman and Swink 1997). Roosevelt Red Ware, as a low-fired and incompletely oxidized ceramic ware, would not have required specialized technology and could thus be easily incorporated into any technological tradition (Reid et al. 1992). The same is true for Grasshopper Red Ware.

*Portability/Durability*

The drawback of a low-fired ware is decreased durability. Experiments have shown that as the temperature at which a vessel is fired increases, its resistance to impact breakage also increases, at least to a point (Skibo et al. 1989). Strength tests conducted on Cibola White Ware and Roosevelt Red Ware have shown that the latter is 30% weaker than the former (Reid et al. 1992:214). Strength has implications for ceramic transportability, as mobile societies have a greater probability of breaking pottery (Arnold 1985), and would thus require a more durable ware. Additionally, casual inspection suggests that Cibola White Ware vessels are of notably lighter weight than Roosevelt Red Ware vessels of comparable size, which contributes to their improved portability (J. Reid, pers. comm. 2001). In sedentary communities such as Grasshopper Pueblo and the later occupation of Chodistaas, the movement of pots is reduced, thus relaxing the importance of lightness and strength as ceramic characteristics. Whittlesey's (1974) study of ceramic nestability found Roosevelt and Grasshopper red wares bowls to be less nestable than White Mountain Red Ware bowls, supporting the argument that the former two wares were less likely manufactured for extended transport due to trade or residential mobility. To my knowledge, no studies of nestability have considered Cibola White Ware bowls.

Because Roosevelt and Grasshopper red wares were less durable than Cibola White Ware, they likely had a shorter use-life, perhaps necessitating increased rates of manufacture despite the sedentary nature of the Grasshopper community. This is a complicating factor as it may have affected women's decisions about technical choices. It is unclear whether differences in such long-term labor investments were evident to pottery producers or sufficient to outweigh the short-term benefits of expedience.

*Visual Performance*

Visual performance has already been discussed in regard to the characteristics of black paints. However, the visual performance of the wares as a whole should also be addressed. In general, Cibola White Ware seems to conform to a higher aesthetic standard than Roosevelt and Grasshopper red wares, though this evaluation is subjective. Grasshopper Red Ware in particular has been described as a poorly-made imitation of White Mountain Red Ware, specifically with regard to design execution (Whittlesey 1974; Triadan 1997).

The regional phenomenon of the replacement of white ware suggests that this may have been part of a stylistic trend that rendered red wares more visually acceptable than white wares. Crown (1994:7) views the visual aspect of Roosevelt Red Ware, with its "ubiquitous and redundant suite of icons" as indicating the spread of a regional cult. She argues that the inclusive ideology of this cult would have served to stabilize social relations during a period of widespread change. Van Keuren's (1999:50-1) study counters the expectation of a shared design scheme that would support the presence of a regional cult at Grasshopper Pueblo. Although Crown's (1994) scenario is not empirically demonstrable, neither is it mutually exclusive with the more functional model offered here.

## Labor Input

One of the principal differences between the two ceramic technologies highlighted by this performance matrix is the amount of labor input required for manufacture. This variable may differ in each production stage for the wares being compared, making the determination of overall relative expediency somewhat problematic. Feinman, Upham, and Lightfoot (1981) propose an ordinal measure of labor input for ceramic manufacture, which they call the "production step measure." This index is designed to provide empirically-based characterizations of relative labor costs of different pottery vessels. The production step measure focuses on the number of steps required in the production process. All manufacturing steps are weighed equally, which is a serious flaw because certain steps are vastly more time-consuming than others.

I do not find the production step measure useful for comparing the two ceramic technologies discussed here. The number of distinct steps required to produce a Cibola White Ware vessel would have likely been extremely close, if not identical, to those necessary for the manufacture of a Roosevelt or Grasshopper red ware vessel. As was shown in the discussion of performance characteristics, it is in the time required for each step where the differences lie. For Cibola White Ware, black paint production, fuel collection, and firing would have required greater amounts of time than would have been necessary for the equivalent steps in the manufacture of Roosevelt or Grasshopper red ware. The variable of time is a behaviorally relevant measure of labor input, as it is a factor that would have been evident to prehistoric potters and would have influenced their scheduling constraints (see above and Appendix A for discussion of the types of time relevant to black paint production).

*Cibola White Ware vessel size*

I have suggested that the amount of time that women were able to dedicate to pottery production decreased around the turn of the 14th century. It is possible that these increased time constraints are visible in the ceramic assemblage, particularly in

Cibola White Ware, which experienced a rapid decline in relative frequency leading to its ultimate demise. This might be evidenced by decreasing vessel size through time, as larger vessels require more time to manufacture. This assertation is somewhat intuitive, as greater surface area requires greater amounts of time for production processes such as coiling, scraping, polishing, and painting, but this has also been evidenced by ethnoarchaeological observation (DeBoer and Lathrap 1979:120-1). I have attempted to support the postulation of decreasing vessel size through time using statistical methods, the details of which can be found in Appendix B.

The vessel size difference is not statistically significant between Chodistaas and Grasshopper, possibly due to small sample size and outliers. The comparison of vessel size by manufacturing locus was statistically significant, with locally produced pots smaller than non-locally produced pots. This result is intriguing because it supports the idea that size decreased through time and that the people producing Cibola White Ware locally may have had less time for pottery production than did non-local producers. Zedeño (1994) and Van Keuren (1999) have indicated that locally produced Cibola White Ware was probably manufactured both by immigrants from the Colorado Plateau and by locals learning directly from these immigrants. If the Cibola White Ware in the Grasshopper region was being made by some of the same people (lineages) both locally and non-locally, a decrease in size indicates a choice on the part of the producers. The trend toward smaller ollas may have been due to scheduling conflicts induced by agricultural dependence, although functionally-specific factors may also be implicated. The olla is sometimes interpreted as a water storage vessel, in which case particular water requirements may have changed through time, affecting size requirements. It may be impossible to determine the exact causes of decreasing olla size, but it is consistent with the move toward ceramic expediency.

Additional statistical procedures were performed to help quantify some of the patterns seen in the production of Cibola White Ware in the Grasshopper region. No significant relationship was found between vessel size and design style. However, those pots found at Chodistaas and those produced non-locally (many of which are the same vessels) are found to be more size-standardized than Grasshopper and local pots. The implications of this finding are complex, but suggest that learning frameworks may have shifted through time (following Van Keuren 1999). A more detailed description and analysis of this statistical evaluation can be found in Appendix B.

## Design Compromise

"Any change in the vessel design can affect many performance characteristics and possibly set into motion a series of vessel changes," which may occur very rapidly (Skibo and Schiffer 1995:90). Because not all characteristics can be simultaneously optimized, compromise is key in understanding relationships between performance characteristics (Schiffer 1995). The point of creating a performance matrix is to show how "factors of lifeway and social organization *condition the acceptability of particular design compromises*" (Schiffer and Skibo 1987:600, emphasis in original). A model must be built to explain these compromises as the outcome of technical choices resulting from the particular context in which change occurred. What follows is a model explaining one particular instance of ceramic change in the Grasshopper region.

Diffusion and migration may introduce new ideas, styles, techniques, and resources into the local ceramic tradition (Rice 1984). It was likely one or both of these processes that caused the initial introduction of Roosevelt Red Ware into the Grasshopper region, as a trade ware or as a technology brought by immigrants. The adoption of this ware represents a significant technological innovation in comparison to the already existing ceramic traditions (Crown 1994; Montgomery and Reid 1990). Such a rapid and dramatic change in ceramic technology is rare; the technological package of Roosevelt Red Ware must have presented significant advantages to have been so enthusiastically adopted into the local ceramic tradition.

The greatest advantage of Roosevelt Red Ware was its expediency of production. The type of black paint used, the fuel requirements, and the technological knowledge necessary for successful firing all contributed to making Roosevelt Red Ware more easily manufactured than Cibola White Ware. Relative expedience of production, in addition to the availability of raw materials, would have made Roosevelt Red Ware more appealing to pottery producers. Additionally, the visual performance of red wares and polychromes may have been more desirable at this time. The design compromises are seen in characteristics that would have been important to the consumers of the pots, such as durability and portability. Vessel strength and lightness were reduced in this technological shift, although this would not have been as essential in a sedentary community such as the one into which this technology was adopted.

As noted above, the manufacture of ceramics at the household level meant that producers and consumers were essentially the same individuals. However, it is significant that the consumption-related characteristics were sacrificed for improvement in characteristics of production. This suggests that the context of pottery manufacture experienced stresses, which made the adoption of a more expedient technology desirable despite the compromised vessel performance. The adoption of Roosevelt Red Ware technology, and the subsequent creation of Grasshopper Red Ware, a new ceramic ware with essentially identical technological characteristics, occurred in the social and economic contexts of aggregation and agricultural intensification. Both of these processes would have directly affected the amount of labor available for ceramic manufacture by imposing constraints on the work loads of Grasshopper women. The preference for ease of manufacture at the expense of certain functional characteristics of pottery strongly suggests that constraints on women's time were a key factor promoting the adoption of this new technology. Agricultural intensification, as reflected in the greater amount of time required for maize processing, was a variable introducing greater demands on women's time which made the more expedient ceramic technology acceptable despite noted compromises of design. Although the technological knowledge necessary to produce Cibola White Ware was possessed by some of the residents of the Grasshopper region, women's scheduling constraints made the relatively expedient Roosevelt and Grasshopper red wares more acceptable in the social and economic context of the Pueblo III to Pueblo IV period transition.

## White Mountain Red Ware

Although White Mountain Red Ware was one of the primary decorated wares at Grasshopper Pueblo, it has been conspicuously absent from my argument thus far. White Mountain Red Ware experienced a similar trajectory to Cibola White Ware in the Grasshopper region, though it occurred somewhat later. These two wares were produced with a similar technology originating on the Colorado Plateau. In Grasshopper region assemblages, the majority of vessels from each of these wares were produced non-locally (Zedeño 1994; Triadan 1997). Some vessels were produced using local materials, suggesting the immigration of bearers of these ceramic traditions onto the Grasshopper Plateau, and also indicating that the technological knowledge to continue production of these wares was present locally. The community of women, both locals and immigrants, who manufactured decorated ceramics in the Grasshopper region chose to focus their production efforts on the distinct ceramic technology of Roosevelt and Grasshopper red wares. White Mountain Red Ware was replaced by Grasshopper Red Ware in the same way, and probably for many of the same reasons, that Cibola White Ware was replaced by Roosevelt Red Ware.

Specialization

The combination of agricultural dependence and aggregation may lead to inequalities of arable land, with relatively late-arriving immigrants having less access to prime agricultural land than previously established immigrants. This situation can have the effect of directing the efforts of relative late-comers toward non-agricultural activities, such as craft production or specialization (Netting 1993:113). Such a scenario has been proposed for ceramic production in the Silver Creek area of Arizona (Stinson 1996). Ceramic specialization is another route to manufacturing expediency (Schiffer and Skibo 1997:36), and should be evaluated as an alternate explanation for ceramic change in the Grasshopper region.

As noted above, the social and economic contexts of Grasshopper Pueblo were shaped by aggregation and agricultural intensification. The pueblo grew in spurts, indicating subsequent waves of immigration (Reid and Whittlesey 1999:66). But although there may have been some resident craft specialists, there is no evidence for ceramic specialization at Grasshopper (Reid and Whittlesey 1999:81). Ceramic manufacturing rooms have been identified, but they are attached to single households, supporting the assertation that ceramics were produced at the household level (Reid and Whittlesey 1999:81). Further, no current method of statistical evaluation of standardization supports ceramic specialization at Grasshopper (though such methods may be seriously flawed; Pizza 1999). Thus, ceramic specialization as an alternative explanation for the increase in ceramic expediency can be discounted with some certainty.

# CHAPTER SIX: CONCLUSION

The feminist theory that has informed this research encouraged the contextualization of specific behaviors within the particular circumstances of women's lives. It also provoked a departure from viewing women as passive recipients of technological change, and rather promoted a focus on women as agents of ceramic change. In so doing, feminist theory has proved useful as a tool for the exploration and interpretation of the archaeological assemblage, particularly for those artifact classes attributable to women. Feminist research, as shown in this investigation of ceramic change, can make unique and valuable contributions to archaeology.

One of the techniques promoted by feminist research is the engenderment of prehistory. Gender is commonly recognized as a social category with significant implications for human behavior, and this has been shown to be the case for divisions of labor in the prehistoric Southwest. By employing gender as a variable to be considered in investigations of archaeological variability, this study creates a model for ceramic transition that accounts for a previously unexplored factor: women's labor. This study is a preliminary step toward the full incorporation of gender into the matrix of variables conventionally employed to address variability in the archaeological record.

The replacement of Cibola White Ware by red wares is well documented, both for the Grasshopper region (Montgomery and Reid 1990) and for a broader area of the northern Southwest (Crown 1994). While more sociological and ideological explanations have been offered for the rapid spread of some of these wares (Crown 1994), Montgomery and Reid (1990) have indicated that the technology required to produce certain red wares was not specialized and thus would have been easily incorporated into any technological tradition. I have built on this latter, more functionalist interpretation to offer an model for this phenomenon of replacement, at least as it was evidenced in the Grasshopper region, with a focus on labor investment in the context of women's lives.

## Summary

Cibola White Ware was produced primarily with a light-colored paste which chemical composition analysis has shown to be non-local to the Grasshopper region (Zedeño 1994). Some Cibola White Ware, however, was produced locally, indicating that Grasshopper region residents did have the necessary knowledge and technology to continue its manufacture. The black paint used for decoration is a mineral-based pigment that would have required the labor-intensive grinding of either an iron oxide or manganese ore. Experimental evidence indicates that the production of mineral-based paint is more labor-intensive than carbon-based paint (Appendix A). The conditions in which Cibola White Ware was fired would have required specialized technological knowledge and relatively large amounts of fuel.

Roosevelt and Grasshopper red wares are considered together due to their technological similarities. In the Grasshopper region they are both produced with a brown paste; chemical composition analyses (Zedeño 1994) and technological comparisons have determined the majority of vessels to be of local manufacture. They were decorated with carbon-based black paint which is produced with relative expedience (Appendix A). Additionally, they were fired at low temperatures, requiring less fuel, and with a technology that did not require specialized knowledge. The drawback of low-fired vessels is their reduced strength due to less complete sintering. However, vessel strength as a performance characteristic would have been less important for residentially stable groups that did not need to transport their ceramics as frequently or over such great distances as did more mobile groups (Arnold 1985).

The residents of Chodistaas Pueblo (A.D. 1263-1290s) practiced only limited amounts of agriculture to complement their hunting and gathering activities. They were residentially mobile at the beginning of the occupation of this site, but in the 1280s moved toward full-time occupation. The household was the basic unit of social organization and pottery production. Cibola White Ware is the dominant decorated ware in the ceramic assemblage from Chodistaas, and was found on the vast majority of excavated room floors. Roosevelt Red Ware makes its appearance rather suddenly in the 1280s, around the same time as the shift to residential stability.

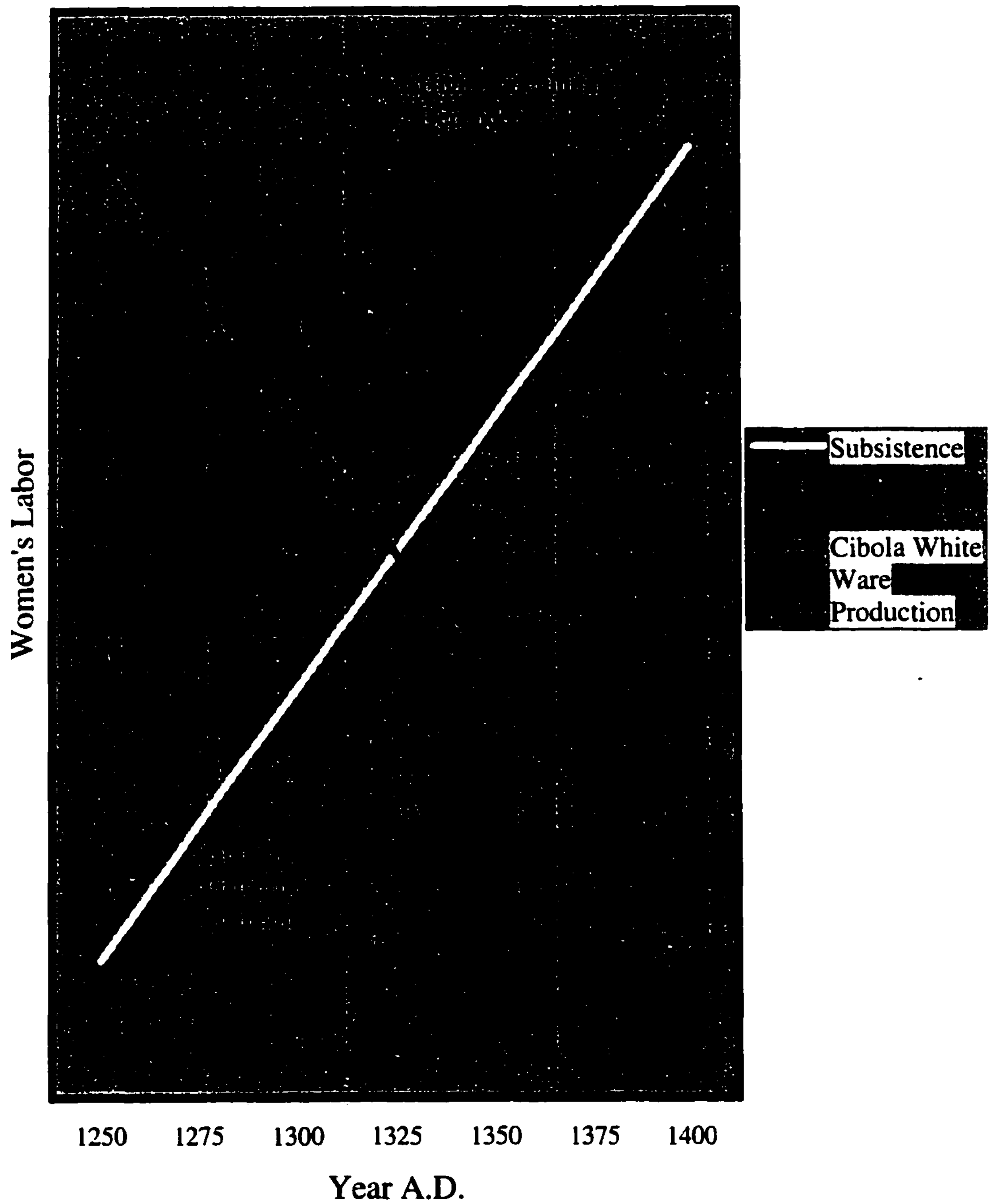
Grasshopper Pueblo was occupied during the 14th century, immediately following the occupation at Chodistaas. The beginning of Grasshopper's occupation was marked by the rapid transition from a mixed hunting, gathering, and gardening subsistence strategy to one of full dependence on agriculture. The people living there were residentially stable, and like Chodistaas, the household was the basic unit of social organization and ceramic production. Quantities of Cibola White Ware decreased markedly from those found in the ceramic assemblage of Chodistaas, while the occurrence of Roosevelt and Grasshopper red wares increased.

The first quarter of the 14th century saw both the demise of Cibola White Ware and the transition to full agricultural dependence in the Grasshopper region. Historically in the Southwest, women were the primary pottery makers when ceramic production and consumption were at the household level. Archaeological evidence supports the argument that the same was true in prehistoric times. The rapid transition to full dependence on agriculture would have raised some scheduling problems that would have had implications for how women allocated their time, since time spent producing ceramics would have competed with time spent on agricultural activities, as well as the many other activities that occupied women's time.

Agricultural dependence, with maize as the primary crop, would have necessitated increased labor input for food preparation, including large amounts of corn grinding. Corn grinding is an activity performed by women, both ethnographically and archaeologically. Analysis of osteological remains from Grasshopper Pueblo determined that the specific pathologies evidenced on women's skeletons were consistent with the motions involved in grinding corn (Benson 1986). Every kilogram of corn flour produced by grinding requires two hours of labor (Barlow 1997), making this a labor-intensive task. The agricultural transition and accompanying changes in food processing would have required that women spend more time on subsistence-related activities than was previously necessary, and because women had a finite time budget, time spent on other activities had to be reduced. The model that I propose here suggests that the production of decorated ceramics was one such activity. Ceramic production may not have been the only activity which was altered; it is quite possible that there was a large-scale reconfiguration of women's daily and seasonal activities. The production of decorated vessels is an activity for which the proposed reconfiguration is highly visible to archaeologists.

Figure 4 is a very simplified graph of the general trend that likely occurred, with

**Figure 4: Hypothetical Scheduling Constraints for Women**



the time spent on agricultural and subsistence-related activities increasing during the beginning of the 14th century, and time spent on ceramic production decreasing as a result. Cibola White Ware was relatively time-consuming to produce, and one of the reasons for the switch to Roosevelt and Grasshopper red wares may have been the ability to produce the latter wares more expediently. Women's scheduling constraints associated with the transition to agriculture would have made less labor-intensive ceramic wares more appealing, and this likely contributed to their adoption in the Grasshopper region.

## Further Research

There are several additional avenues of study that would help clarify the proposed model but have not been pursued here. Sourcing the minerals used for black paint on both local and non-local Cibola White Ware and White Mountain Red Ware would address questions regarding mineral availability and procurement. A more behaviorally-based assessment of ceramic visual performance and an inter-ware comparison of relative aesthetic standards would be informative, as would an exploration of the labor required for laying out and executing designs on each ware. Vessel weight is employed as an indicator of portability, but the relative weights are based only on casual observation; more precise measures comparing the weight of each ware would strengthen this model. The Roosevelt Red Ware assemblage from Grasshopper Pueblo has yet to be chemically sourced; such analysis would establish more precisely the proportions of locally and non-locally produced vessels. Additionally, many details of the conditions under which Cibola White Ware and Roosevelt and Grasshopper red wares were fired remain unclear. Replicative firing experiments would help bridge this gap in our knowledge of prehistoric ceramic technology.

By exploring the context of women's lives and their constraints as pottery producers and agriculturalists, this research has offered a model for an instance of well-documented ceramic change. At present, this model is limited to the Grasshopper region; applicability to other areas where similar ceramic transitions occur has yet to be demonstrated. Another potential direction for future research is a similar consideration of the circumstances of women's lives and pottery production in other areas of the Southwest.

In summary, Roosevelt and Grasshopper red wares were less labor-intensive than Cibola White Ware to produce and their adoption was related to women's scheduling constraints associated with agricultural intensification. This functionalist interpretation is not necessarily at odds with more social and ideological explanations (Crown 1994). The causes for such a dramatic and widespread ceramic transition were likely multivariate, and alternative explanations need not be mutually exclusive. The rapid spread of red wares at the beginning of the 14th century may have been initiated for social or ritual reasons, but their enthusiastic adoption by the women who were producing them was likely promoted by the technological characteristics, such as ease of manufacture, that made them fit well into the larger context of their lives.

# APPENDIX A: LABOR-INVESTMENT IN PAINT PRODUCTION TECHNIQUES

The black paint used for ceramics in the Mogollon Rim area of Arizona and New Mexico can be divided into two basic types: carbon-based and mineral-based. Prehistoric potters were largely consistent in using only one of these types of paint for a given ceramic ware, and this consistency has led archaeologists to incorporate paint type into the definition of certain wares.

With the intention of exploring the production of black ceramic paint types, I designed an experiment to compare the labor investment required for each one. Based on information from ethnographic accounts of paint manufacture in the Southwest and interviews with a contemporary potter who replicates prehistoric wares, I have attempted to recreate some of the processes involved in paint production. Carbon-based paint was made by boiling down Rocky Mountain bee plant and mesquite pods, and mineral-based paint was made by hand-grinding hematite and manganese ores. Each trial of the experiment was timed in an attempt to quantify the amount of effort required to make each paint type. A simplistic comparison of the total times recorded is not behaviorally relevant due to differences between active participation time and passive production time (defined below). Thus, the results are necessarily of a more qualitative nature. Based on my own experience and that of the potter interviewed, I conclude that while carbon-based paint requires a greater amount of total time to produce than does mineral-based paint, the latter is in fact more labor-intensive due to increased amounts of active participation time and physical exertion. Most of the time required to produce carbon-based paint is passive production time, which, while necessitating the producer's presence in the general vicinity, allows for concurrent participation in other activities, thus lessening the possibility of scheduling conflicts.

Background to the Experiment

This experiment is part of the larger attempt to explain the demise of Cibola White Ware in the Grasshopper region of Arizona. I have proposed that Roosevelt and Grasshopper red wares were less labor-intensive to produce than Cibola White Ware and that their adoption was related to women's scheduling constraints associated with the transition to agriculture. In addition to differences in the amounts of technical knowledge and fuel required to produce the necessary firing conditions for each ware, one facet of this argument involves the different types of black paint used, as Cibola White Ware vessels were decorated with mineral-based paint while Roosevelt and Grasshopper red wares were painted with carbon-based pigment. An experimental investigation of the amount of time required to produce each type of paint is relevant to the argument of expediency in ware production.

While there is a fair amount of ethnographic literature dealing with ceramic paint production, the question of labor investment required for different types of paint is not addressed. In order to better explore the production process, I use two approaches: interviewing a potter who makes both types of paint, and trying to replicate the process myself. Although the interview supported my hypothesis that the production of mineral-based paint is more labor-intensive than that of carbon-based paint, I believe that the best way to collect quantitative data and to better understand the qualitative experience was to make the paint myself. By doing this I was able to record the times required for multiple trials of paint production and get a better sense of how the processes involved might fit into the work day of prehistoric women.

I am assuming that it was women who were producing ceramic paints, based on both ethnographic (Bunzel 1929; Cushing 1920; Baxter 1882; Stevenson 1904; Curtis 1926; LeBlanc 1983; Fontana *et al.* 1966; Batkin 1987; Hardin 1991; Skibo and Schiffer 1995) and archaeological (Shafer 1985; Ravesloot 1992; Mills 2000) evidence that women were the primary potters in the Southwest. Additionally, women are associated with the specific tasks that are required in paint production, including cooking or boiling (Dorsey 1899; Wyckoff 1990; Crown and Wills 1995b; Crown 2000b) and grinding (Dorsey 1899; Benson 1986; Hawkey 1988; Crown and Wills 1995b; Fish 2000).

For the purposes of this experiment, I assume that the ethnographically documented techniques of Pueblo paint production are largely similar to techniques used by the Ancestral Pueblo potters (Anasazi and Mogollon). This assumption appeals not only to the direct historical approach, but also to indications that the types of black paint used prehistorically are compositionally similar to those used in historical times (Hawley 1929; Shepard 1965). Thus, the first type of data I will employ are ethnographic accounts documenting the processes of paint manufacture.

Guthe (1925) describes the process employed at San Ildefonso to manufacture black paint using organic materials. Rocky Mountain bee plant (*Cleome serrulata*) was gathered during April and May, when the shoots were 6-10 inches high and tender. It was boiled over an open fire until the unpleasant flavor had disappeared, usually requiring half to a full day. The liquid was then drained into wide-mouthed ceramic vessels and placed in the sun until it hardened into a solid, sticky mass. It was stored for one year before use to improve the color. A chunk of the mass was broken off for use and dissolved in water until it reached a syrupy consistency like thin molasses. Similar processes have been described for the Pueblo potters of the Rio Grande Valley (Shepard

1965), the Zuni (M.C. Stevenson 1904, 1915), the Cochiti and Santa Clara (J. Stevenson 1883), and the Tewa (Robbins et al. 1916). The Hopi use tansy mustard rather than bee plant, but the procedure is otherwise similar (Hawley 1929).

Shepard (1965) describes the manufacture of mineral-based paints in the Southwest during prehistoric and historic times. She notes that certain types of Pueblo black-on-white pottery were decorated with black iron oxide paints, which may be produced by either using magnetite and preventing it from oxidizing during firing or using hematite in a reducing atmosphere. Shepard also describes manganese and iron-manganese paints, which were the principal minerals used for the black paint of the oxidized wares in the Pueblo area. Manganese paint does not require the special conditions of the firing atmosphere that carbon and iron oxide paints require. At Zia Pueblo, concretions of manganese ore that had weathered out from a sandstone cliff were collected at the base of the cliff, and the Zuni and Hopi are described as collecting bog ores as their source of manganese. For the manufacture of mineral-based paints, the mineral was ground to a fine particle size so that it would be less grainy and less likely to settle when mixed with water. A general practice was to mix the ground mineral with an organic substance to improve the spreading quality and bind the paint to the surface. This practice, and the types of organic material mixed with minerals, have been described ethnographically for the Yuma, who used mescal or cane sugar (Rogers 1936), the Hopi, who used tansy mustard (Colton 1931), and the Zuni, who used yucca fruit or Rocky Mountain bee plant (M.C. Stevenson 1904).

My other source of information on black ceramic paint production was from an interview with Paul Thornburg, who was referred to me by J. Jefferson Reid at the University of Arizona. Paul and his wife Laurel are artists who live in Sonoita, Arizona and try to replicate prehistoric ceramic wares as closely as possible. They have developed their procedures by reading texts such as those by Shepard (1965) and Rice (1987) and through years of experimentation. Paul emphasized that he was an artist, not a scientist, and had no way of knowing how close his paint-making procedures are to indigenous methods. He would not impart to me his exact paint recipes, but he did give me enough detail to be extremely helpful.

For mineral-based paint, the Thornburgs use an iron ore which they collect in the vicinity of Silver City, New Mexico but which is also available around Patagonia and in other Arizona locales. At a rock shop, one would ask for hematite, but the hematite is of varying quality and differs in the paint characteristics it produces. A metate and mano are used to crush the iron ore to a powder which at this stage is not particularly fine. A ceramic mortar and pestle is then used (though he noted that stone implements would also work) to grind the iron ore to a fine powder. The powder is mixed with water, and the larger particles sink to the bottom and are discarded. This straining process is repeated several times. The powder is then dried and mixed with other irons or dry clay according to the Thornburgs' paint formulas. Organic material is added to the mineral paint, presumably to give it binding properties. The Thornburgs' organic binder of choice is mesquite sap, which can be collected in the form of golden drops that form on the trees in the spring and fall. Paul noted that other organic material, such as boiled-down bee plant, may be used.

The Thornburgs also make carbon-based paint, though not as often because replicas of Salado Polychromes (i.e. Roosevelt Red Ware) do not sell as well as some of their other wares. Paul listed a number of organic materials that can be used for black paint, including cottonwood leaves, bee plant, mesquite sap, tansy mustard, corn, beans, squash, and prickly pear roots. His material of choice is mesquite pods, which he breaks up and boils in water. He has no formula for the amount of water he uses, but rather goes by feel. During the boiling process, Paul occasionally breaks up the pods (not the seeds) with a kitchen implement such as a potato masher. He pours off the water and boils it down to the consistency of honey. When he is ready to use the pigment, water is added to achieve a desirable paint consistency.

When I informed Paul of the intent of my experiment, he noted that in terms of labor, much more effort is required to make mineral-based paint than carbon-based paint. This admission is an important line of evidence, as it comes from someone who has been producing such paints for years. It should be noted, however, that the technology he uses for paint production is much closer to prehistoric technology for the mineral-based paint (metate and mano, mortar and pestle) than it is for the carbon-based paint (stove).

## Experimental Procedures

The variable I use as indicating expediency is the time required to produce each paint type, as this is a factor that would have been evident to prehistoric potters and would have influenced their scheduling constraints.

Using the ethnographic descriptions and interview material described above, I set out to produce both types of paint. For organic-based plant I decided to use Rocky Mountain bee plant (*Cleome serrulata*) due to its frequency of occurrence in the ethnographic literature. I was able to identify bee plant from a trip to The Arboretum at Flagstaff, where the horticulturalist gave me a specimen. The remainder of the bee plant was collected by the railroad tracks in Flagstaff on October 1, 2000. The fact that it was collected so late during the growing season may have had some effect on the results, as it was historically collected in the late spring or early summer. The bee plant was divided into ten batches weighing approximately 75 grams each (an arbitrary weight used only for consistency). The bee plant was placed in a large pot (5 quart capacity) and covered with cold water (this required 15 cups of water, and this amount was kept consistent for each trial). The pot was then placed on the right front burner of my Hardwick gas stove with the heat at its maximum level. The bee plant was occasionally mashed or stirred with a kitchen implement. When the water reached such a level that it was no longer covering most of the bee plant, the woody parts of the plant were removed. At the point when the water was just barely covering the bottom of the large pot, the mixture was strained through a colander into a smaller pot (1 quart capacity). It continued to boil in the smaller pot, but the heat had to be reduced to about 3/4 of full heat (my archaic stove does not have any kind of temperature markers) to maintain a rolling boil. When the mixture was just barely covering the bottom of the small pot, the stove was turned off and the liquid was poured into a small plastic Gladware container to dry. At this point it had not reached the desired consistency of honey, but I found that boiling it any longer resulted in much of the pigment sticking to the bottom of the pot. The honey-like consistency was achieved during the air-drying process. This procedure was repeated for 10 trials, with the times being recorded for each step of the process. The finished dry weights of the paint were also recorded, with the exception of the first trial which was poured into a ceramic vessel and not able to be removed and weighed. These final weights seemed to depend mostly on the point at which I decided to turn the heat off (how much liquid was left at this point), and are thus not particularly relevant to the results of the experiment.

I also performed five trials of carbon-based paint production using mesquite pods. Although I found no mention of mesquite pods in the ethnographic literature (this may be due to my concentration on peoples of the northern Southwest), Paul Thornburg had noted that they were his organic material of choice. Additionally, J. Jefferson Reid pointed out that while Rocky Mountain bee plant would have been available in the Grasshopper region, it would not have been available in the Sonoran Desert, which is part of the range in which Roosevelt Red Ware was produced (Crown 1994). Mesquite pods would have been available to the potters of the southern Southwest. The mesquite pods (genus *Prosopis*) were collected in Tucson in early October; by this time they had already fallen off the trees. They were divided into batches weighing 75 grams each to maintain consistency with the bee plant. The procedure I used for boiling mesquite was largely the same as that used for the bee plant, with a few exceptions. The mesquite pods are much more compact than is an equal weight of bee plant. Thus, they were put into a medium-sized pot (1.5 quart capacity), and the water required to cover them was only 4 cups. The reduced amount of water meant that the time required to boil the mesquite down to the same level as the bee plant was cut approximately in half. The pieces of mesquite pod were also relatively large and easily removed from the pot without straining. The resulting paint appeared to be much the same as that of the bee plant.

My original intention for the mineral paint was to use manganese ore, due to its seemingly greater prevalence in the ethnographic literature. I collected manganese ore concretions from the banks of the Santa Cruz river, based on identification by Mike Heilen, who had previously identified the deposit in a geology class. Upon grinding 50 grams of this material to a powder using a metate and mano excavated from Grasshopper Pueblo, it became evident that while the outsides of the pebbles and sand collected were black, this was just a coating of manganese---the insides of most pebbles were gray, as was the resulting powder. Doubting the manganese content of this sample, I decided to look elsewhere for manganese ore. I went to Zee's Gallery, a rock shop in downtown Tucson, and asked for "manganese ore," which is the term used in the ethnographic literature. I learned that this is a very general term which can apply to a number of different substances. The man at the rock shop was nice enough to give me some sugilite with high manganese content. Sugilite is a purplish rock from South Africa, and those pieces having greater amounts of manganese were identified by their blackish color. I ground two trials of sugilite weighing 50 grams each. It was my impression that sugilite is an extremely hard material, and those pieces with more manganese were easier to grind. The color of the resulting powder was a light purplish-gray.

Unsatisfied with my quest for manganese ore, I followed Paul Thornburg's suggestion and obtained hematite from a rock shop. The man at Discount Agate House informed me that all his hematite had been collected from Arizona and is common throughout the state. Using the metate and mano, I ground up seven trials of hematite with start weights of 50 grams each. I settled on the number seven to make the total number of mineral-grinding trials an even ten. While the start weights of all ten trials were around 50 grams, some material was inevitably lost during the grinding process, resulting in lower end weights (the same was true for the manganese ores). The hematite powder was dark black.

The final experimental procedure I performed was a cursory test to assess the comparability of the dry weights of both paint types. Before comparing them by weight, it was necessary to gauge whether equal weights of each paint type would go equally far in painting a ceramic vessel. I used a small ceramic vessel that I had made with untempered clay from the Silver Creek region and fired in an open pit. I weighed out two grams each of bee plant pigment and hematite powder and added enough water to achieve desired paint consistency (2 grams and 2.3 grams, respectively). I divided the ceramic vessel in half and painted each half with each paint type. I then reweighed the remaining paint and calculated how much paint had been required to cover half of the vessel. Of the carbon-based paint, 1.9 grams was used; 1.5 grams of the mineral-based paint was used. While these figures are not exactly equal, they are reasonably close considering I only performed this exercise once. I conclude from this cursory comparison that the dry weights of each paint are approximately comparable in how much surface area they will cover.

## Results

The data on weights and times are recorded in Tables 3, 4, 5, and 6. The total times of each trial for each material are demonstrated graphically in Figures 5 and 6. I present them in this fashion to explore the possibility of a learning curve. The total times for the carbon-based paints remain relatively stable throughout the trials, suggesting the absence of a learning curve. This is not surprising considering that the technology used for this process was one that I was already familiar with (my stove). It appears that there may be a learning curve for the mineral-based paint production, which involved the use of a technology that was new to me (metate and mano). The different types of mineral are not comparable due to possible differences in hardness, but even within the hematite trials, the total times gradually decrease and then level out. Thus there appears to be a learning curve for the grinding equipment, but I feel that I performed a sufficient number of trials to achieve familiarity with this technology. The means for the total production times of the mineral-based paints might be slightly high because of the learning curve, suggesting that the median time may be a more representative value.

**Table 3: Bee Plant Processing Times**

| bag # | start wt. (g) | end wt. | wt. Difference | start time | stop time | total time |
|---|---|---|---|---|---|---|
| 6 | 75.1 | n/a | n/a | 4:48:30 PM | 7:39:35 PM | 2:51:05 |
| 7 | 74.6 | 12.2 | 62.4 | 7:57:05 AM | 10:50:00 AM | 2:52:55 |
| 8 | 75.0 | 8.8 | 66.2 | 12:40:40 PM | 3:32:40 PM | 2:52:00 |
| 9 | 75.1 | 7.3 | 67.8 | 10:33:30 AM | 1:26:20 PM | 2:52:50 |
| 10 | 75.0 | 8.5 | 66.5 | 7:00:00 PM | 9:58:35 PM | 2:58:35 |
| 11 | 74.4 | 8.3 | 66.1 | 5:55:00 PM | 8:39:10 PM | 2:44:10 |
| 12 | 80.0 | 11.6 | 68.4 | 7:22:10 PM | 10:13:14 PM | 2:51:04 |
| 13 | 76.3 | 13.7 | 62.6 | 9:23:45 AM | 12:17:30 PM | 2:53:45 |
| 14 | 75.5 | 11.4 | 64.1 | 8:44:03 AM | 11:32:41 AM | 2:48:38 |
| 15 | 75.6 | 12.8 | 62.8 | 6:42:50 AM | 9:31:30 AM | 2:48:40 |
| mean | 75.7 | 10.5 | 65.2 | | | 2:51:22 |

**Table 4: Mesquite Processing Times**

| bag # | start wt. (g) | end wt. | wt. Difference | start time | stop time | total time |
|---|---|---|---|---|---|---|
| 1 | 74.9 | 13.2 | 61.7 | 6:40:00 PM | 8:22:55 PM | 1:42:55 |
| 2 | 74.8 | 2.6 | 72.2 | 6:59:45 PM | 8:20:20 PM | 1:20:35 |
| 3 | 74.7 | 3.0 | 71.7 | 5:45:25 PM | 7:10:55 PM | 1:25:30 |
| 4 | 74.2 | 19.3 | 54.9 | 7:51:00 PM | 9:25:15 PM | 1:34:15 |
| 5 | 72.8 | 19.3 | 53.5 | 7:25:25 PM | 8:56:05 PM | 1:30:40 |
| mean | 74.3 | 11.5 | 62.8 | | | 1:30:47 |

**Table 5: Manganese Ore Processing Times**

| bag # | start wt. (g) | end wt. | wt. Difference | start time | stop time | total time | x 1.5 |
|---|---|---|---|---|---|---|---|
| 1 | 49.8 | 44.8 | 5.0 | 2:27:30 PM | 3:39:45 PM | 1:12:15 | 1:48:22 |
| 2 | 50.0 | 45.7 | 4.3 | 3:00:00 PM | 4:16:15 PM | 1:16:15 | 1:54:22 |
| 3 | 50.3 | 45.8 | 4.5 | 2:30:15 PM | 3:41:05 PM | 1:10:50 | 1:46:15 |
| mean | 50.0 | 45.4 | 4.6 | | | 1:13:07 | 1:49:40 |

**Table 6: Hematite Processing Times**

| bag # | start wt. (g) | end wt. | wt. Difference | start time | stop time | total time | x 1.5 |
|---|---|---|---|---|---|---|---|
| 1 | 50.9 | 45.6 | 5.3 | 2:16:30 PM | 3:09:30 PM | 0:53:00 | 1:19:30 |
| 2 | 50.1 | 45.6 | 4.5 | 3:03:15 PM | 3:59:40 PM | 0:56:25 | 1:24:37 |
| 3 | 51.3 | 43.8 | 7.5 | 1:48:00 PM | 2:29:10 PM | 0:41:10 | 1:01:45 |
| 4 | 49.9 | 41.9 | 8.0 | 2:43:15 PM | 3:24:30 PM | 0:41:15 | 1:01:53 |
| 5 | 48.5 | 36.8 | 11.7 | 12:55:10 PM | 1:30:00 PM | 0:34:50 | 0:52:15 |
| 6 | 50.8 | 40.2 | 10.6 | 2:11:30 PM | 2:43:25 PM | 0:31:55 | 0:47:53 |
| 7 | 49.8 | 39.9 | 9.9 | 2:58:20 PM | 3:39:40 PM | 0:41:20 | 1:02:00 |
| mean | 50.2 | 42.0 | 8.2 | | | 0:42:51 | 1:04:16 |

**Figure 5: Carbon-based Paint Production Times**

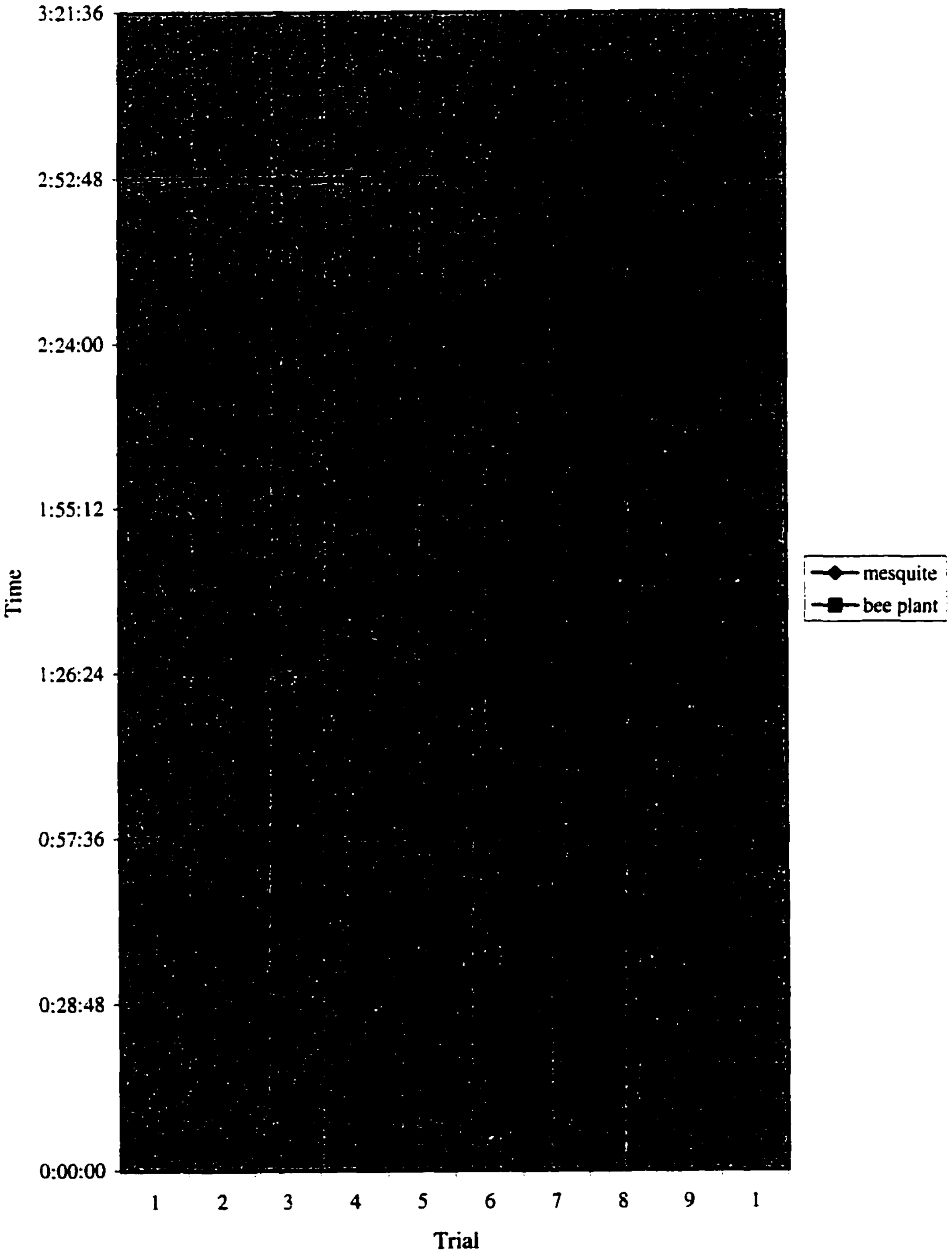
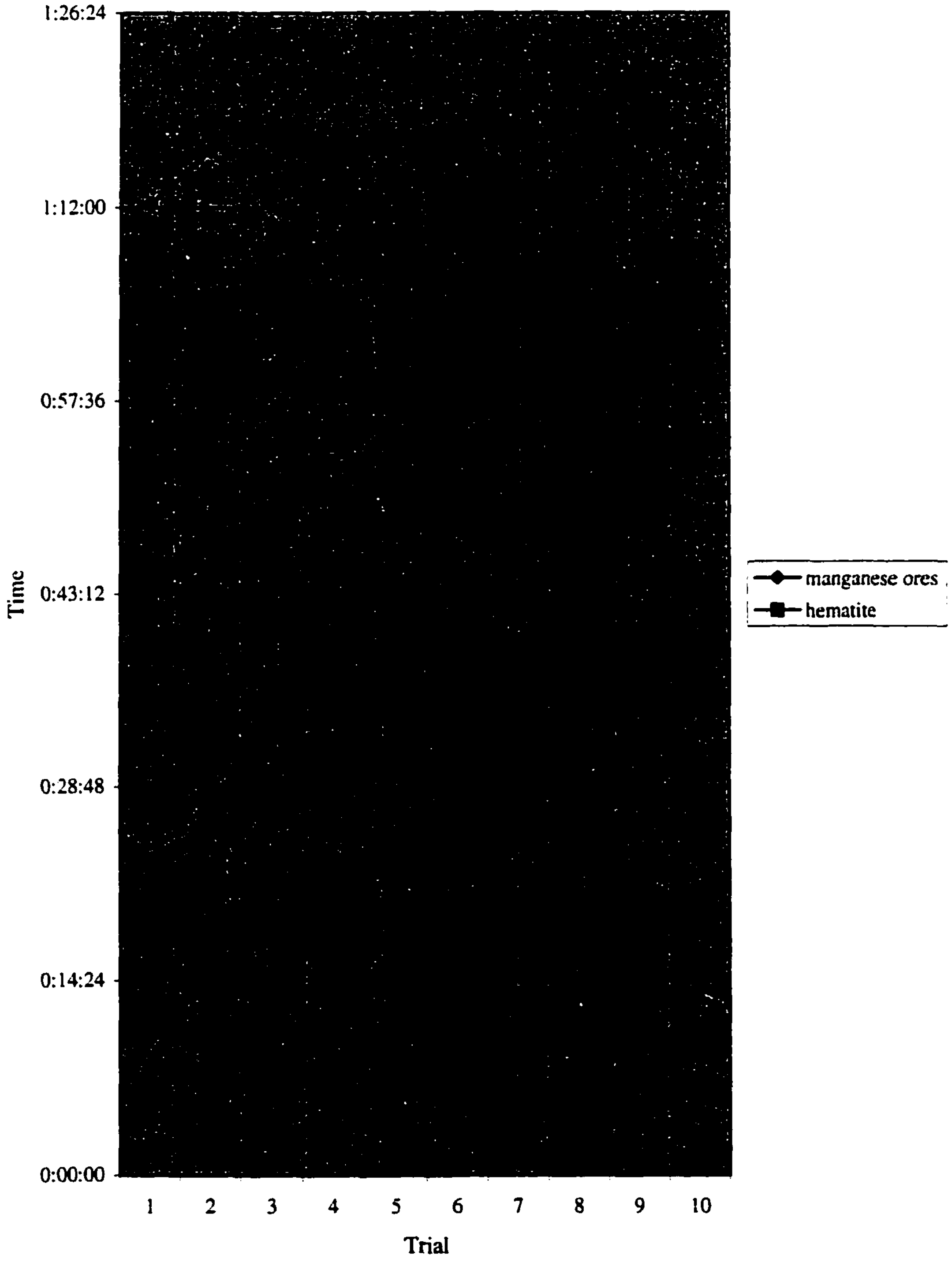


**Figure 6: Mineral-based Paint Production Times**



A comparison of the two paint types is problematic despite the comparability test I performed. I found that the dry weights (end weights) are approximately comparable, but even with constant start weights, the dry weights vary considerably within each paint type. For the mineral-based paint, the weight difference, or the amount of material lost in the grinding process, increases throughout the course of the experiment. This is probably a result of my increasing carelessness with regard to how much rock flew off the metate while I was grinding it. The weight differences for the mineral paints range from 4.3 grams to 11.7 grams, which is not too great considering that the mean end weight is 43.7 grams. The differences in the end weights for the carbon-based paints are more significant, ranging from 2.6 grams to 19.3 grams with a mean of 11.0 grams. As mentioned above, this difference in end weight is largely (if not entirely) a result of how much liquid was remaining in the bottom of the pot when I decided to turn off the stove. Thus, I believe that the median value more accurately represents the end weights for the carbon-based paints, although the median is only slightly higher than the mean.

Because the end weights were determined to be comparable, and the mean end weight for the mineral-based paints is 3.5 times greater than the median end weight for the carbon-based paints, an accurate comparison of time would require multiplication of the total times of the carbon-based paints by 3.5. This would make the mean total time for bee plant around 10 hours and the mean total time for mesquite over 5 hours, which is approximately 5 to 10 times the amount of time required to produce comparable amounts of mineral-based paint. An estimate of 5-10 hours for total production time for carbon-based paint is in accordance with Guthe's (1925) estimates of a half day to a full day for this process.

A comparison of total production time for each paint type shows that mineral-based paint requires much less time. However, total time is not an accurate indicator of labor-investment for this comparison. First, it must be recognized that the time recorded for the mineral-based paints only included one session of grinding with the metate and mano. The additional steps of further grinding with a mortar and pestle and extensive size-sorting and straining, as suggested by Paul Thornburg, and the addition of boiled-down organic material, as documented ethnographically (Shepard 1965; Rogers 1936; Colton 1931; M.C. Stevenson 1904) were not performed. The times for the mineral-based paints are thus artificially low. The same could certainly be said of the carbon-based paints, as the time required for collecting firewood and water is not considered (perhaps it may be assumed that the collection of plants and minerals would be approximately equal in length of time required, though I have no evidence to support this claim). Additionally, my gas stove is most definitely a more intense and more reliable source of heat than were the cooking technologies available in prehistoric times. It is difficult to gauge the extent of this difference without accurately reproducing prehistoric cooking technology. The season in which the plants were collected may also have an effect on how much paint they produce.

Due to these difficulties with quantitative data comparison, I believe that a more qualitative approach is warranted. It is interesting to note that despite the marked differences in production time between the paint types (with the carbon-based paint requiring much more time than the mineral-based paint), Paul Thornburg, who has had much experience producing both paint types, claims that considerably more effort is required to produce the mineral-based paint than the carbon-based paint. Having participated in both types of paint production, I would have to agree. While this seems to be at odds with the data, I am arguing that total time is not an accurate gauge of labor-investment, even if all of the aforementioned problems with technology replication were eliminated. The total production times cannot be directly compared due to the issue of *active participation time* versus *passive production time*. I am defining *active participation time* as the time during which the production process requires constant attention. For the mineral-based paints, the total time is comprised entirely of active participation time. *Passive production time*, in contrast, does not require the attention of the producer; a boiling pot that can be left unattended is an example of this. The majority of the time required to produce carbon-based paint is passive production time because it does not require the attention of the producer. Carbon-based paint production does include some active production time as it requires that the producer occasionally check on the progress and perhaps mash or stir the mixture. This inhibits the activities of the producer to those that can be performed within reasonable proximity to the production location.

I was not able to measure the amount of active participation time I spent in producing carbon-based paint because it mostly consisted of a few seconds here and there. It is my distinct impression, however, that it was substantially less time than that required for mineral-based paint production. The level of physical exertion required for each paint type is another factor that I was not able to quantify, but it does not seem too presumptuous to assume that constant grinding requires a significantly greater amount of physical exertion than does checking on a boiling pot.

These different types of time have different implications for women's scheduling constraints. Active participation time equals time away from other activities. During passive participation time, however, other activities may be scheduled, as long as they take place within a reasonable proximity. Fish (2000) notes that anthropologists have generally seen patterns of sexual divisions of labor in which women tend to participate in activities near habitations while men are more often seen traveling long distances. Crown and Wills (1995b) list the many responsibilities often assigned to women in foraging/horticultural societies such as the late prehistoric Southwest. These responsibilities include many activities which were likely performed near habitations, including ceramic production, food processing and preparation, laundering, weaving, basket-making, and child care. Such activities could have been performed simultaneously with the production of carbon-based paint. Thus, carbon-based paint production would have created fewer scheduling conflicts for women than did the shorter total time but greater labor-investment required to produce mineral-based paint.

## Summary

While this study does not succeed in producing a definitive quantitative comparison of the production of carbon-based and mineral-based ceramic paints, it has prompted a qualitative comparison which may in fact be more behaviorally relevant. Paint production involves two different types of time, which I have identified as *active participation time* and *passive production time*. The entire process of making mineral-based paint consists of active participation time. While producing carbon-based paint requires a greater amount of total time, the vast majority of this time is passive participation time, leaving women free to attend to other responsibilities in the general vicinity. Thus, mineral-based paint production was more likely to have created scheduling conflicts with other activities.

This finding has implications for the demise of Cibola White Ware in the Grasshopper region during the early 14th century. One of the characteristics that distinguishes Cibola White Ware from the decorated red wares that replaced it is the use of mineral-based black paint rather than carbon-based black paint. Because production of carbon-based paint required less active participation time, it may have been more easily scheduled around other household activities. Some of these activities, corn-grinding in particular, would have increased substantially with the rapid shift to full agricultural dependence. Switching to the production of a ceramic ware that would have been less labor-intensive, due to both the paint type and the firing technology, makes sense in the context of women's increased work-loads and scheduling constraints.

# APPENDIX B: A STATISTICAL EVALUATION OF CIBOLA WHITE WARE IN THE GRASSHOPPER REGION

This project was designed to quantify and explore certain trends that have bearing on the cessation of the manufacture of Cibola White Ware in the Grasshopper region of Arizona. I have argued that the shift from Cibola White Ware to Roosevelt and Grasshopper red wares is related to women's agricultural time constraints. I will here attempt to support this idea using statistical methods. If, as I have suggested, the amount of time that women were able to dedicate to pottery production decreased through time around the turn of the 14th century, it is possible that increased time constraints may be visible in the ceramic assemblage. I would expect this to be evidenced by decreasing vessel size through time, as larger vessels require more time to manufacture (DeBoer and Lathrap 1979:120-1; see Chapter Five of this paper).

## Data Set

The data set employed for these analyses is the entire assemblage of whole or reconstructed Cibola White Ware (hereafter CWW) ollas from Chodistaas (n=17) and Grasshopper (n=21) Pueblos. The dimensions of maximum diameter, height, neck height, and circumference were all measured by myself, thus eliminating inter-observer error. Each of the vessels was determined to be either of local or non-local manufacture by chemical and mineralogical analyses performed by Zedeño (1994) or by paste and temper comparisons to these sourced vessels by Van Keuren (1999) and myself. The design style of each vessel was determined for Chodistaas vessels by Zedeño (1994) and for all Grasshopper and some Chodistaas vessels by Van Keuren (1999). This is somewhat problematic because the two researchers seem to have used slightly different classification schemes, as is evident from the differential classification of particular vessels described by both. I will retain Zedeño's type classifications for Chodistaas ollas. Van Keuren has assigned all Grasshopper ollas to the Pinedale type; Zedeño (pers. comm. 2000) agrees that the clear majority of these pots were decorated in the Pinedale style, and I will thus cautiously use Van Keuren's classification for Grasshopper pots, recognizing the possibility of some inter-observer error.

The variables I use in these analyses are site, provenance, type (all nominal variables), and size (ratio scale variable). The purpose of analyzing size is to approximate the amount of time required to produce each vessel, assuming that larger vessels would require more time both to form and to decorate (DeBoer and Lathrap 1979:120-1; see Chapter Five of this paper). Surface area would likely be the size measure most relevant for operationalizing the amount of time spent on vessel production, as greater surface area would increase formation and decoration requirements. Due to the irregular shape of the ollas, however, surface area is difficult to measure, and I instead use maximum height multiplied by maximum diameter (h x d) as a proxy of surface area.

This data set is used to investigate the circumstances of ceramic production and circulation in the Grasshopper region during the 13th and 14th centuries A.D. Some of the quantitative methods are employed to ask specific questions about the ceramic assemblage; others are intended to explore possible relationships between different variables. In this appendix, I will separately outline each research problem, the statistical means for addressing it, and the results and interpretations.

Vessel Provenance at Chodistaas and Grasshopper Pueblos

*Problem:* Chodistaas was occupied immediately prior to Grasshopper, and it is likely that the residents of the former migrated to the latter (Reid and Whittlesey 1999). There are more non-locally produced pots at Chodistaas and more locally produced pots at Grasshopper. Is this relationship statistically significant? If so, this will show that through time, there was a significant shift from using non-locally produced CWW to using locally produced CWW.

*Test:* The chi square test looks at relationships between categorical variables, and will determine whether membership in one category is related to membership in another. Site and provenance are both categorical variables and thus their co-incidence is measurable through the chi square.

*Null Hypothesis:* The site at which a CWW olla was found has no relationship to its locus of manufacture. (alpha = 0.05)

*Results:* The pattern (seen in Table 7) is fairly evident: there are more non-local pots at Chodistaas and more local pots at Grasshopper. The P value is < 0.001, which is significant at the alpha level of 0.05.

**Table 7: Chi-square Frequencies (Provenance by Site)**

| | Chodistaas | Grasshopper | Total |
|---|---|---|---|
| Non-local | 16 | 7 | 23 |
| Local | 1 | 14 | 15 |
| Total | 17 | 21 | 38 |

Pearson Chi-square: value = 14.528 df = 1.000 prob = 0.000

*Conclusion:* The null hypothesis that site and provenance are unrelated can be rejected, and the presence of more non-local pots at Chodistaas and more local pots at Grasshopper is found to be statistically significant. This indicates that through time, the residents of the Grasshopper region shifted from using CWW ollas manufactured elsewhere to producing their own using local materials. The purpose of this quantitative test is to demonstrate statistical significance for an already established pattern.

Vessel Size Comparison by Site and by Provenance

*Problem:* Does vessel size differ significantly by site or provenance? I have argued that through time, women have more agricultural responsibilities and thus less time for ceramic production. Because smaller vessels require less time to produce, decreasing vessel size through time would support this argument. This test will compare the mean CWW olla size by site, which directly correlates with time. It will also look at differences by provenance, which indicates where the potters were living at the time of production.

*Test:* The Kruskal-Wallace test looks at similarity between samples and is thus appropriate for comparing Chodistaas to Grasshopper and non-local to local pots. The Kruskal-Wallace is the non-parametric version of the t-test; the vessel sizes are not normally distributed, which mandates the use of a non-parametric test. The mean size of ollas from each sample will be compared to determine the likelihood that the samples came from populations with the same mean. This will indicate whether the vessels in each category were being produced using the same size criteria.

*Null Hypothesis:* The vessels from each site (or provenance) come from parent populations with the same mean size. (alpha = 0.05)

*Results:* For the inter-site comparison the P value is 0.097 (Table 8), which is not significant at the previously determined alpha level of 0.05. The means of the two samples are fairly different, and I suspect that the lack of statistical significance may be due to the small sample size or to outliers in the Grasshopper distribution. The null hypothesis that the parent populations for each site had different mean sizes cannot be rejected.

**Table 8: Kruskal-Wallace Analysis of Variance by Site**

| Site | Count | Rank Sum |
|---|---|---|
| Chodistaas | 17 | 388.000 |
| Grasshopper | 21 | 353.000 |

Mann-Whitney U test statistic = 235.000

Probability = 0.097

Chi-square approximation = 2.751 with 1 df

For the provenance comparisons, the P value is 0.006 (Table 9), which is significant at the set alpha level of 0.05. This indicates that the two samples come from populations with different mean sizes. The means and distributions indicate that locally produced vessels are significantly smaller than the non-local vessels.

*Conclusion:* The olla size difference is not statistically significant between Chodistaas and Grasshopper, possibly due to small sample size. The statistical significance of the provenance comparison is intriguing because it supports the idea that

**Table 9: Kruskal-Wallace Analysis of Variance by Provenance**

| Provenance | Count | Rank Sum |
|---|---|---|
| Non-local | 23 | 541.000 |
| Local | 15 | 200.000 |

Mann-Whitney U test statistic = 265.000

Probability = 0.006

Chi-square approximation = 7.631 with 1 df

size decreases through time and that the people producing CWW locally may have had less time for pottery production than did non-local producers. Zedeño (1994) and Van Keuren (1999) have indicated that locally produced CWW was probably manufactured both by immigrants from the Colorado Plateau and by some locals learning directly from these immigrants. If the CWW in the Grasshopper region is being made by some of the same people (lineages) both locally and non-locally, a decrease in size indicates a choice on the part of the producers. The trend toward smaller pots may be due to scheduling conflicts induced by agricultural dependence; alternatively, it may be a response to consumer demand or different environmental constraints (see Chapter Five of this paper).

## Vessel Size and Design Style

*Problem:* Is there a relationship between design style (type) and vessel size? More specifically, does membership in a type category determine the size of an olla? This question is mostly exploratory; I have no reason to believe that there will be a relationship between these two variables. However, ceramic style may be a temporal marker or an indicator of social groups (Zedeño 1994). The Pinedale design style, for example, is temporally later than the other four types of CWW in these assemblages. Zedeño (1994) has shown that style does not correlate with manufacturing locus, so an exploration of the relationship between type and size should yield different results than tests of the relationship between size and provenance.

*Test:* Analysis of Variance (ANOVA) looks at the relationship between a nominal variable (type) and one or more ratio scale variables (size). The test determines whether membership in a category determines the level of the continuous variable.

*Null Hypothesis:* Membership in a type category has no effect on vessel size. (alpha = 0.05)

*Results:* The P value is 0.749 (Table 10), which is not statistically significant. The $R^2$ value is 0.055, indicating that only 5.5% of the variation in size is explained by variation in type, making this relationship of little practical significance.

**Table 10: Analysis of Variance (Size by Type)**

| Source | Sum-of-Squares | df | Mean-Square | F-ratio | Prob. |
|---|---|---|---|---|---|
| Type | 473114.223 | 4 | 118278.556 | 0.482 | 0.749 |

n = 38

Multiple R = 0.235

Squared Multiple R = 0.055

*Conclusion:* The null hypothesis cannot be rejected, and thus the possibility that there is no relationship between type and size cannot be discounted.

Size Standardization

*Problem:* Is there a difference in the amount of size standardization by site or by provenance? The standardization of certain attributes of CWW has been suggested as an indicator of direct versus indirect knowledge transfer (Van Keuren 1999), the idea being that greater standardization would indicate more direct learning networks. By applying this theory to the standardization of size, I hope to gain additional insight on the mechanisms of knowledge transfer of CWW technology in the Grasshopper region. Through a comparison of both site and provenance, four scenarios are possible:

1.) Result: Vessels from Chodistaas are more standardized than vessels from Grasshopper.

Interpretation: CWW ollas become less standardized through time, possibly indicating a shift from direct to indirect knowledge transfer (see Van Keuren 1999 for a discussion of learning frameworks).

2.) Result: Vessels from Chodistaas are less standardized than vessels from Grasshopper.

Interpretation: CWW ollas become more standardized through time, possibly indicating a shift from indirect to direct knowledge transfer (though a scenario that would cause this is difficult to imagine).

3.) Result: Non-locally produced vessels are more standardized than locally produced vessels.

Interpretation: Colorado Plateau producers of CWW had more direct learning frameworks than Grasshopper region producers. This may indicate that the locally produced pots were being made both by immigrants from the north and by local mountain people (the latter learning the technology through indirect frameworks and thus introducing greater variation) or by local mountain people emulating the imported vessel technology.

4.) Result: Locally produced vessels show equal (or greater) standardization as non-locally produced vessels.

Interpretation: The technology used in the local production of pots was transferred through more direct learning frameworks, possibly indicating that Colorado Plateau immigrants continued producing CWW with local materials and/or directly taught locals the ceramic technology.

The comparison of provenance is anticipated to be more informative about mechanisms of knowledge transfer. Knowing whether local CWW was produced by Colorado Plateau immigrants or local mountain people would help to determine whether the temporal size change in CWW was due to different production criteria caused by indirect learning networks or by scheduling constraints imposed on potters with similar technological criteria passed on through direct learning networks. Local (non-immigrant) participation in CWW production is more likely under scenario 3 than scenario 4.

*Test:* For comparative studies of standardization, the coefficient of variation is a more useful measure than the standard deviation because the latter may be sensitive to the overall size of measurements, while the former describes relative variation (Longacre et al.

1988). I have followed the methods of Kvamme, Stark, and Longacre (1996) by using the jackknife to measure ceramic standardization. I used the jackknife to produce a sampling distribution of the coefficient of variation for each of the four categories (Chodistaas, Grasshopper, non-local, local). The standard error was calculated and confidence intervals created for each to check for overlap; box plots were also used for a visual comparison of variability (Kvamme et al. 1996).

*Results:* The 95% confidence intervals are presented in Table 11. There is no overlap between sites or provenances, suggesting different levels of standardization.

**Table 11: Jacknifed Coefficients of Variation**

| | Mean CV | Stand. Dev. | Stand. Error | 95% Confidence Interval |
|---|---|---|---|---|
| Chodistaas | 0.348 | 0.016 | 0.004 | $0.344<CV<0.352$ |
| Grasshopper | 0.451 | 0.015 | 0.003 | $0.448<CV<0.454$ |
| Non-local | 0.359 | 0.011 | 0.002 | $0.355<CV<0.363$ |
| Local | 0.379 | 0.032 | 0.008 | $0.371<CV<0.387$ |

*Conclusion:* While these results are statistically significant, it is difficult to determine whether they are practically significant. Previous statistical studies of ceramic standardization (Longacre et al. 1988; Kvamme et al. 1996) have compared relative standardization but do not designate an absolute value for what may be considered "standardized." Because I am interested in comparisons of knowledge transfer rather than determination of specialization, these relative measures are sufficient. I conclude that the Chodistaas assemblage is relatively more size-standardized than that of

Grasshopper and that non-locally produced ollas are relatively more size-standardized than local vessels. This indicates that CWW ollas became less standardized through time, perhaps due to a shift from direct to indirect learning networks, which accords with the idea that the locally produced pots were being made by both immigrants from the north and local mountain people (the latter learning the technology through indirect frameworks and thus introducing greater variation) or by local mountain people emulating the imported vessel technology. The temporal decrease in size may thus be due to shifts in learning frameworks. This possibility detracts somewhat from the thesis that decreasing vessel size was caused by time constraints, although this statistical analysis should be considered very preliminary.

Summary

These statistical procedures have helped to quantify some of the patterns seen in the production of Cibola White Ware ollas at Chodistaas and Grasshopper Pueblos. There is a statistically significant relationship between the site at which an olla was found and its locus of manufacture, with more non-local vessels in the Chodistaas assemblage and more local vessels found at Grasshopper. Locally-produced vessels are significantly smaller than non-local vessels, supporting the idea that the people producing CWW locally may have had less time for pottery production than did non-local producers, perhaps due to agricultural scheduling constraints. No significant relationship was found between vessel size and design style. Lastly, those pots found at Chodistaas and those produced non-locally (many of which are the same vessels) are found to be more size-standardized than Grasshopper and local pots. The implications of this finding are complex, but suggest that learning frameworks may have shifted through time.

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