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The Origins of Pottery among Late Prehistoric Hunter-Gatherers in California and the Western Great Basin

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Abstract

As shown by cross-cultural studies, pottery-making is rare among mobile hunters and gatherers. Many factors, including the heaviness of pots, their susceptibility to breakage, small population size, and time and scheduling conflicts work against such groups to engage in pottery-making. In this regard, the late prehistoric hunter-gatherers of California and the Western Great Basin, who began making earthenware vessels some 500-700 years ago, are unusual. This dissertation seeks to understand why these Numic people began making and using pottery, and how the technology was embedded within the constraints of high residential mobility and a simple social organization.

To address this question it was necessary to understand how pottery was used and produced. Five main analyses were undertaken. Chapter 3 surveys the ethnographic literature on California Great Basin pottery-making. Chapter 4 presents a technological study of whole pots and potsherd attributes. Chapter 5 analyzes the distribution of pottery in the study area across different ecological zones and valley systems. Chapter 6 examines pottery use more directly through Gas Chromatography-Mass Spectrometry analysis of organic residues in a sample of potsherds. Chapter 7 discusses an Instrumental Neutron Activation Analysis of a large sample of potsherds to better understand the production and movement of ceramics.

Results are manifold and show, first, that California and Great Basin pots are not crude and unsophisticated tools, as they are often described, but were modified to suit the constraints of particular environments and social systems. Second, pots are primarily associated with valley bottom locations and especially lakeside environments. Third, pottery was primarily used to process plant resources, particularly seeds and nuts. Fourth, pottery-making was organized on a small family-level or individual scale and vessels were rarely moved between valley systems.

In the final analysis, I suggest pottery was adopted by women to resolve time and labor demands created by a diet increasingly focused on small seed resources and the need to feed and care for larger families. At the same time, I suggest that pots were an instrumental tool in the shift to a more privatized economy. Pots were an efficient tool for processing large volumes of small seeds. Seed resources could be owned and consumed by individual families and were not subject to public sharing rules that governed other resources and cooking technologies.

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CHAPTER I

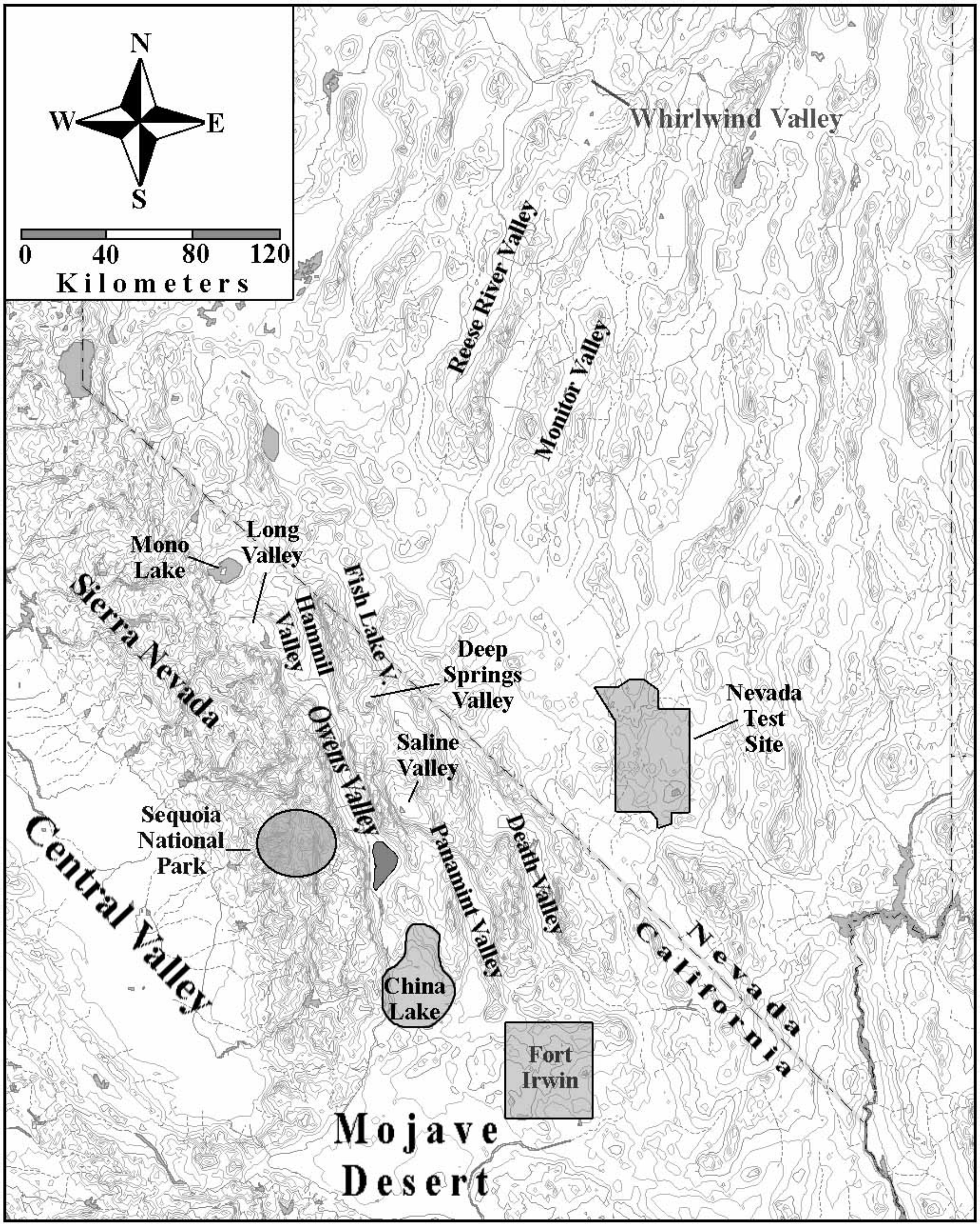
INTRODUCTION

Pottery-making is common in sedentary, agricultural, and complexly organized societies. Indeed, such societies often have large-scale and well developed ceramic traditions, occasionally with attached or independent craft specialists producing pots for both elite and common consumption (Rice 1996). Although known from ethnographic, ethnohistoric, and archaeological studies (e.g., Aikens 1995; Bollong et al. 1997; Close 1995; Gayton 1929; Osgood 1940; Rudner 1968, 1979; Steward 1938), pottery-making among mobile hunters and gatherers appears to be uncommon (Arnold 1985). One end result of this work has been an assumed implicit inverse relationship between pottery-making and degree of residential mobility (though see Arnold 1999; Hoopes and Barnett 1995; Rice 1999 for recent attempts to disassociate these factors). Under what circumstances, then, do more simple and mobile hunter-gatherer groups engage in pottery production and what is the impetus behind such a transition?

As discussed below, a mobile lifestyle makes incorporation of pottery production and use difficult. Clearly, most hunter-gatherers lack the social organization necessary for the development of large and elaborate ceramic technologies. Thus, the craft specialists and elaborate distributional systems that characterize pottery production in many other societies are lacking in hunter-gatherer cases. A complex and sedentary lifestyle may promote the use of pottery, by facilitating large scale production to take advantage of economies of scale, by the development of markets for the exchange of pottery and ideas (in many cases promoting experimentation and development of the craft), and by allowing potters to be in one place long enough to adequately finish all production steps, which may take up to several weeks. In addition, pots are heavy and fragile relative to baskets and other containers, making their addition to material culture difficult under residentially mobile conditions. Moreover, time conflicts may exist for women if they are responsible for pottery manufacture, food gathering, meal preparation, and child rearing. All these factors conspire against most mobile hunter-gatherer groups from engaging in the production of earthenware vessels (Arnold 1985; Brown 1989: 200; Close 1995; Welsby 1997).

The North American Great Basin presents something of an anomaly in this respect, as pottery making is known archaeologically and ethnographically among many of the highly mobile hunting and gathering groups that occupied the region (e.g., Drucker 1937; Steward 1933; 1938, 1941; Stewart 1942), people often cited for their extreme "simplicity" on the social complexity yardstick (Thomas 1981). Although ceramic artifacts are never a dominating aspect of the archaeological

Figure 1: Map of California and Western Great Basin, and places mentioned in text.



record and do not occur in the densities typically found among sedentary and complex groups (though also note that population densities were much lower), they are common enough in Great Basin sites to suggest that pots played an important role in aboriginal lifeways.

This dissertation explores the reasons why hunting and gathering groups in parts of California and the Western Great Basin started making and using pottery, despite their mobile lifestyle and relatively simple social organization. The study area centers on Owens Valley, in central-eastern California and includes analysis of surrounding regions to the north, south, east, and west, including the Western Sierra Nevada, Deep Springs Valley, the Nevada Test Site, Death Valley, and the Mojave Desert. Figure 1 gives the locations of regions and places discussed in the text.

For thousands of years people living in interior California and the Western Great Basin made a living without pots, and indeed, some groups never adopted the craft. However, it is clear from the archaeological record that many of these people knew about pottery long before they adopted it. The adoption and development of this technology in other parts of North America, including nearby areas such as the Southwest (Cordell 1997; Doyel 1991:236) and Coastal California (Drover 1975; Drover et al. 1979), begins *at least* 1500 years earlier than the Great Basin (although Coastal Californians subsequently abandoned the craft). Contact with Coastal California during the time pottery was made is evident by the presence of temporally diagnostic marine shell beads. Similarly, contact with the Southwest is also evident based on small numbers of pot sherds native to that area collected in various regional surveys within the study area (e.g., Chapter 7; Gilreath et al. 1987; A. Hunt 1960). As well, an Owens Valley site dated to 1200 BP contained a small number of sherds made from local clay (Eerkens et al. 1999). Though not in the traditional brownware style, these rare sherds do demonstrate a familiarity with the technology. Thus people in the study area, especially Death Valley, the Mojave Desert, and Owens Valley, knew about pottery at least 500-700 years before they actually began making it in earnest themselves.

Approximately 500 years ago, locally-made brownware pottery appears in the archaeological record in fairly significant numbers. From this point in prehistory forward, pottery is a common element of domestic sites, suggesting that the craft spread quickly and widely across the study area. This dissertation seeks to understand why this shift took place when it did and with such apparent ubiquity and speed. What happened at this point in prehistory that suddenly made pottery so attractive to native people?

Studies of and Attitudes Towards Pottery

Relative to other artifact types such as flaked and ground stone, analysis of brownware ceramics has not figured prominently in archaeological interpretation in the Great Basin. Unfortunately pottery is usually relegated the role of footnote or appendix and constitutes only a minor part of most excavation and survey reports. Thus, we know little about the role of pottery in prehistoric adaptations to the steppe and desert environments of the Great Basin, and even less about the relative importance of pottery to different Numic groups (i.e., the branch of languages spoken by most peoples within the region). Similarly, we know little about how ceramic technology was introduced to the area, that is, if it was an independent invention or an introduction from another area, or whether it was adopted simultaneously in all regions of the Great Basin or spread slowly. Although some research suggests ceramics developed *in situ* in some parts of the Great Basin (Eerkens et al. 1999), additional research is needed in other areas to corroborate or refute this position.

The reasons for this lack of interest and knowledge are many and include both historical, typological, and practical issues. First, pottery only occupies a relatively small window of time. Thus, while archaeologists study over 10,000 years of prehistory, pottery only becomes significant in the last 500 years. Much archaeological work and interest has focused on understanding pre-pottery phases of prehistory.

Second, archaeologists working the region have stressed flaked stone as the major arena in which to understand prehistoric behavior. This is as true today as it was over 50 years ago. Lithic studies, indeed, have been very successful. Many theoretical and methodological developments in lithic research, that have subsequently been adopted worldwide, were originally developed by Great Basin archaeologists. This historical success probably pulls time, effort, and resources away from potential ceramic research and continues directing it towards the analysis flaked stone (i.e., why risk something new when lithics are a tried and true method for understanding the prehistoric record). Similarly, stone tools, rather than ceramics, have formed the backbone of California and especially Great Basin chronology. This is in opposition to areas like the Southwest and Southeast United States where ceramics play a critical role in dating sites. Since dating sites is such an important part of our work, the failure of ceramics to add much in this respect probably contributes to a lack of interest.

Third, the number of pot sherds typically encountered in archaeological sites is often small, usually less than 200 sherds per site. Combined with the small time frame in which pots were made, hence the small number of sites containing pottery, archaeologists do not often get the chance to study ceramics in large numbers, particularly on a large multi-regional scale. Because ceramics have not traditionally been important in our studies, California and Great Basin archaeologists are not often trained in ceramic analysis. Moreover, they do not acquire these skills through their experiences in the field and lab, owing to the small numbers of sherds typically encountered during a project. In this sense, the lack of interest in pottery propagates itself, each archaeologist implicitly learning that ceramics tell us little about prehistoric behavior and are unimportant (since they are not studied).

Fourth, archaeologists in California and the Great Basin have been unable to develop a consistent and meaningful typology or classification of pot sherds. Brownware sherds from the region are externally highly variable (i.e., in lip and rim form, size, overall shape, color, surface finish, etc.) and are usually undecorated. Ceramic studies in other areas have often emphasized decoration as means for addressing topics such as interaction, exchange, and world view, and for creating more detailed typologies and finer chronologies. Hence, many of the theories and methodologies successfully applied to ceramics elsewhere do not lend themselves to California and Great Basin brownwares. Although most archaeologists recognize the high degree of internal variability in brownware, this variability seems to have thwarted rather than encouraged analysis. That is, brownware is often viewed as so variable and lacking of central tendencies that there is nothing of interest to say. Because much Americanist archaeology has focused on the analysis of types and central tendencies, rather than variability within and across categories, the lack of a workable ceramic typology has discouraged the study of pottery.

As a result, we know very little about the role of pottery in California and Western Great Basin Native American societies. For example, little is known about how pottery varies from region to region, and whether pot-making traditions in different valley systems are similar or different. No systematic comparisons between valleys has been undertaken. Nor is much known about how pottery fits into the mobile lifestyle of people living in the area, that is, whether pots were carried around during the seasonal round or were cached in particular locations. Similarly, very little is understood about the scale of pottery production and how it was organized in various areas, that is, whether everyone made pots or only certain people specialized in this activity. In fact, we do not even know what pots were used for.

The Current Project

It is clear from studies in other areas that the study and analysis of ceramics can tell us much about prehistoric behavior. Unfortunately, such research has not been carried out in California and the Western Great Basin. Thus, to fill in this large gap, an analysis of pottery from the region was started. The study focuses only on brownware ceramics, and does not consider pottery associated with either Anasazi or Fremont cultures (despite the fact that such sherds are occasionally found within the study area). As mentioned above the ultimate goal is understanding why hunters and gatherers began making and using pottery in the area. However, to begin answering this question it was necessary to collect a broad range of background data. This dissertation presents the results of this data collecting and analysis project.

Chapters in this dissertation are organized to present different aspects of this research program. Chapter 2 presents a discussion of pottery-making behavior among mobile hunter gatherer groups and the problems of incorporating the craft into such cultural systems. In addition the chapter presents theoretical models that have been proposed to explain the origins of pottery making. Chapter 3 presents background data for the study area, including a discussion of existing ethnographic data on pottery-making and the current state of archaeological understanding of ceramics. Chapter 4 compares attributes of whole pots and pot sherds across the study area, with the primary aim of understanding how pot design may have been linked to potential function and how sherds vary environmentally and regionally. Chapter 5 examines the distribution of pottery across the region, using the context and location of pottery finds to infer the use of pots. Chapter 6 presents the results of an organic residue analysis of a sample of pot sherds to more directly determine the types of functions and foods that may have been associated with pots. Chapter 7 presents the results of Instrumental Neutron Activation Analysis on nearly 400 sherds and clay samples from the region to better understand the production of pottery and how pots moved about the landscape. Finally, Chapter 8 pulls together the data to evaluate the different theoretical models presented in Chapter 2 to gain a better understanding of the origins of pottery-making in the study area.

CHAPTER II

THEORETICAL ORIENTATATION

Pottery-making among Mobile Hunters and Gatherers

A review of the ethnographic and archaeological literature suggests that pottery-making is rare among residentially mobile hunting and gathering groups (e.g., Arnold 1985). Although part of the reason for our thinking this way may result from a focus on other technologies in hunter-gatherer studies, mainly lithics, it is almost certainly a real phenomenon. For many reasons pottery-making simply does not fit in with a mobile hunting and gathering way of life.

First, pottery is fragile and heavy. Bringing pots along during the seasonal round is not only an expensive task in terms of energy expenditure (due to weight constraints), it is a risky endeavor as well, given the vulnerability of pots to breakage from impact stress. Although pottery can be cached in certain locations, limiting the need for transport, mobile peoples may not be able to predict exactly where they will be from year to year. This is especially true in the Great Basin, where the availability of certain resources, such as piñon nuts, is unpredictable spatially and temporally (Thomas 1972) and families were often in different locations from year to year (Steward 1938). Moreover, suitable ceramic resources such as clay may not have been readily available in locations where pots were desired or needed. Even caching can be a risky endeavor, as unattended and cached pots may break during the off-season when a site is not in use (i.e., due to thermal stress or animal scavenging). In sum, baskets are lighter, more durable, and more amenable to caching, and though cooking with them (i.e., stone boiling) may be more labor and time intensive, they may have been preferred for this task under many circumstances.

Second, because pottery making, like gathering, is a often gendered activity performed by women, there often exist organizational and scheduling conflicts between child rearing, gathering activities, and ceramic production (Crown and Wills 1995). In most societies, women are responsible for both ceramic production and the collection and processing of vegetable foods (Arnold 1985: 102; Murdock and Provost 1973). Gathering requires much mobility, even while a temporary camp is established, and requires being out in the field much of the time away from the base camp where pottery production would normally occur. Moreover, pottery production must take place during the dry season (Arnold 1985: 61-63), which often conflicts temporally with the availability of plant resources, unlike basketry manufacture, which can take place during the rainy season when fewer plants are available for harvest. Thus, in mobile foraging societies heavily dependent upon plants, women may simply not have the time, at the right time, to produce pottery.

Third, pottery-making requires the manufacturer to be settled in a single location for at least as long as it takes to complete the process of making a single pot. The amount of time this takes varies, but includes time needed to collect the clay, process it (pound, sour, and temper, if necessary), form a pot, dry it, fire it, and let it cool down. As discussed below, it is not economical to fire a single pot, and usually many are fired at once. The length of time it takes to complete these steps is reviewed by Arnold (1985) for various ethnographic groups. Clearly, a potter who is familiar with resources in a given area will not need much time to collect raw materials, including clay, water, temper, and fuel for firing. As indicated by Arnold (1985:38-51) the distance traveled to collect these resources can vary from one to 50 kilometers, with the majority of societies travelling less than seven km. Collecting resources in most cases, then, probably amounts to less than one day of time. The time required to process clay in preparation for forming varies depending on what is necessary. Pounding and tempering the clay probably take no more than one or two hours (within the study area Gayton 1929:241 gives a duration of about 30 minutes). However, souring clay, or letting it sit buried, can take up to several weeks, though during this time it does not need to be attended. Likewise, forming a pot does not take much time, probably less than an hour per pot for an experienced potter. On the other hand, much more time is required to dry and fire pots. In drying, Arnold (1985) gives values ranging from one to 30 days, and Gayton (1929) in the study area gives a value of one day. Firing can take anywhere from less than one day to several days, and Gayton (1929:244) suggests Yokuts women fired their pots between 24 and 48 hours. In total, the time it takes to produce a pot from raw material collection to first use can vary anywhere from two to three days to several months. Potters must be present during much of this time and the weather must be favorable, limiting the ability of residentially mobile groups to manufacture pots.

Finally, pottery-making is often worthwhile only when the number of pots needed is large. This is mainly due to the economy of scale and the organization of ceramic production when compared to other substitute cooking technologies, such as basketry and stone boiling (Brown 1989). In technologies where items are made individually (e.g., basketry), each item takes a unit amount of time and the production of 30 items takes 30 times as long as making a single one. In such a process, time spent manufacturing and the number of items produced are linearly correlated. However, in technologies where steps of the production process can be combined for multiple items the relationship between time and the number of items produced is altered (Brown 1989). In the case of pottery, firing can be performed for approximately the same amount of time and energy whether one or 30 pots are fired. Firing and the economy of scale, then, make the organization of ceramic technology significantly different than basketry. If only small numbers of cooking vessels are needed, basketry is an optimal technology. The basket will probably last longer than the pot, particularly relative to the resources invested. On the other hand, if large numbers of cooking vessels are needed, pottery is more economical. For many hunting and gathering groups (especially mobile ones), the population base and demand for containers may not be high enough to warrant production of pots. In these cases the costs of production in terms of time and energy expenditure (especially combustible fuel) outweigh the benefits of ceramic manufacture (Brown 1989).

In spite of these conflicts and drawbacks, some mobile hunting and gathering groups regularly made and used pottery. It is clear that in these contexts the temporal conflicts between ceramic production and foraging were resolved, settlement patterns were stable enough that pots could be made and either carried along or cached in locations where they were needed, and the demand for cooking implements was high. Unfortunately, no synthetic work examines the production and intensity of pottery use across different foraging groups to see how these conflicts were resolved in different contexts.

Innovation or Adoption?

As discussed in the previous chapter, it is fairly clear that groups in California and the Great Basin were at least aware of pottery-making by 1200 BP, though they did not start producing it until much later (ca. 500 BP). Due to this awareness, it is unlikely that groups invented pottery completely independent of any external influence. At the very least, the idea that clay could be molded in a plastic state and fired into a hardened one would have been transmitted to the study area from the outside. At the most, people already using pottery could have migrated into the study area forcing out pre-pottery inhabitants, suggesting that no innovation took place.

How much of the process in California and the Western Great Basin was innovation and how much was adoption has been a question of some interest to archaeologists. Some, such as Touhy (1973, 1990:94) and Gunnerson (1969:191) have suggested the craft diffused, apparently wholesale, from the Southwest culture area, though in an earlier paper, Touhy (1956:69) suggested pots from the Great Basin were derived by diffusion from Woodland peoples on the northern Plains. Steward (1940:479) suggested pottery-making in the central Great Basin was largely borrowed from groups in Southern California and Arizona along the Colorado river. Still others have suggested a diffusion of pottery from Inuit cultures to the north (Coale 1963).

Most of these early studies, then, do not attribute California and Great Basin pottery to any kind of indigenous development. Diffusionist explanations, of course, were quite popular within the dominant theoretical paradigms in Americanist archaeology during the 1940's – 1950's (Willey and Sabloff 1980), and in this respect the authors cannot be blamed for seeking external origins for the development of ceramic technologies in the region. Many of these early studies, then, see pottery in California and the Great Basin as largely wholesale adoption of technologies developed elsewhere.

However, it is clear that there are large differences in the size, shape, method of construction, production, and overall appearance of ceramics in the study area and other nearby areas, such as the Arctic, Plains, Southwest, and Southern California. Based on these dissimilarities, Kroeber (1922, 1925) long ago felt that the craft was independently invented in the study area and unrelated to the Southwest and Southern California. Indeed, comparison of pottery from the study area and any other nearby region would lead most to note differences rather than similarities, and more recent research with pottery in the study area tends to support these notions (Pippin 1986). In fact, few modern studies even mention diffusion as an explanatory framework in discussing Great Basin pottery, and many focus on aspects of indigenous innovation (e.g., Eerkens et al. 1999; Pippin 1986).

These differences suggest that people in the study area did not copy or borrow the craft wholesale from other areas. Thus, while people were clearly aware of pottery before they started making it, the craft underwent much experimentation and modification before being incorporated into the local material culture. This suggests that borrowing (i.e., diffusion) and innovation are *both* important in the ultimate origins of pottery in the study area. Exactly how much of the process can be attributed to borrowing and how much to innovation is not known, nor is an answer likely to present itself in the near future (due to both lack of interest in the topic and non-systematic comparison of pottery from this area to nearby regions).

Theories on the Origins of Pottery

The beginnings of ceramic technology in various prehistoric cultures has piqued much archaeological interest in the last decade (e.g., papers in Barnett and Hoopes 1995; Brown 1989; Crown and Wills 1995; Sassaman 1993; Rice 1999). This interest has resulted in a number of interesting and innovative theories on why groups adopt pottery, whether by innovation or diffusion.

Rice (1999) has recently summarized research on the origins of pottery, primarily as a process of innovation rather than adoption. She divides theories into four categories: architectural theories; culinary hypotheses; resource intensification models; and social/symbolic elaboration theories. Although discussing essentially the same body of literature and theories, the section below divides theories along slightly different lines, including functional or ecological reasons (including resource intensification), population size or demand hypotheses, models about competitive feasting and symbolism, reasons related to political and gender issues, and migration theories.

Functional Models

The first of these classes includes models that interpret pots as serving people to better adapt to their environment. In this sense, pots are seen as an innovation allowing people to process foods in a different manner or provide access to new sources of food. Pottery, then, simply provides a functional advantage over non-ceramic technologies.

Foremost among these theories suggests that pottery provides a means to exploit a wider range of foods through detoxification of food and increasing palatability (Arnold 1985; Braun 1983; Ikawa-Smith 1976). For example, Ikawa-Smith (1976) suggests that boiling shellfish, especially bivalves, causes the muscles binding the valves to lose elasticity and the shell to open, giving access to the meat. As well, exposure to sustained heat in water helps to detoxify and sterilize foods (Stahl 1989; Wandsnider 1997), allowing people to exploit new foods. Pottery would have permitted direct application of fire to foods allowing complex organic compounds to break down prior to digestion, including toxins. Although there are other ways to do this (as most readers familiar with acorn processing and tannic acids in California are aware), pots offer an easy and accessible method that can be applied to a wide range of foods, that is, pots offer an all-purpose detoxifying tool. Furthermore, because of their inorganic nature pots themselves are not subject to decomposition when exposed to these toxins and acids as are other organic containers (see, for example, Katz et al. 1974).

Gebauer (1995) envisions a similar explanation for the adoption of ceramics in Mesolithic Ertebølle cultures of Southern Scandinavia. Potsherds there are associated with domestic contexts and appear to have been used primarily in cooking, and possibly storage. Many of these pointed-bottom and undecorated vessels have thick encrustations of carbonized material on their inner surfaces. Gebauer believes these early ceramics were adopted mainly to expand the range of resources processed and to maximize nutritional return in a way that was "less energy- and work-consuming" (Gebauer 1995:103).

Others have suggested that a mobile system of storage and ease in packaging and transportation goods was the driving force behind the adoption of pottery, though these studies usually recognize other functions of pottery as well (Matson 1972). Storage is suggested to have been an important function of the earliest pottery in the Middle East (Moore 1995), South America (Damp and Vargas 1995), and the Southeastern United States (Peterson 1980:368-369), and a strong influence in the adoption or innovation of pottery. Sedentism is often seen as a necessary precondition for, or in some cases a byproduct of, pottery-making in these models.

Still other researchers see pots as functional, as above, but feel that certain prerequisites must be met to spur the production of pots. Resource intensification has been an important part of these models, and in this sense, pots are seen as tools that allow people to more intensively extract or use resources from the environment. Oyuela-Caycedo (1995), for example, suggests that the origins of pottery are related to changes in the population-resource base. He suggests that such changes are often the byproduct of changes in the productivity of environmental resources due to climatic change (1995:134). Pottery is one way to cope with such changes by allowing people to extract more calories and nutrients from the resources they collect when faced with a diminished resource base. Braun (1983) proposes a similar model. While not suggesting the earliest adoption of pottery was related to resource intensification, Braun (1983) suggests that many of the technological changes that are apparent in Woodland ceramic assemblages soon after they are adopted are related to this process. Braun suggests that changes in temper, wall thickness, and shape are all consistent with a shift to more intensive boiling of small seeds as a way to extract more from the environment. Pots filled this niche in a way that baskets and gourds could not.

Bettinger et al. (1994) and Bettinger (1999) suggest a similar resource intensification model for the adoption of ceramics, but relate its inception not to food, but to intensification on fuel resources. In central Mongolia, Bettinger et al. (1994:95) believe a restriction in mobility led to an increase in diet breadth. Combined, these two processes created an increased demand on combustible fuel. Pottery is interpreted as filling this gap, to not only widen the range of foods exploited, but to more efficiently make use of fuel resources to cook foods. Similarly, in one of the few models applied to the study area, Bettinger (1999:63) proposes that the adoption of pottery in California and the Great Basin may be related to "making more efficient use of scarce fuel and extracting more nutrients from traditional meat-seed stews."

Population Levels and Demand

The third major class of theories, again revolves around optimality and economics, but in this instance involves population levels. The main work fitting into this category is that by Brown (1989), briefly summarized in the preceding section of this chapter. In many ways Brown's ideas are similar to intensification models. However, rather than representing an intensification on resources, pots are seen as an intensification relating to the population base and demand for containers. Brown (1989) suggests that pottery is only adopted once demand reaches a certain level, such that people can benefit from the economy of scale afforded by ceramic production. This demand is often initiated by an increase in population, though changes in subsistence practices, food processing, storage, or food serving behavior could also play a role. In this sense, Brown (1989) suggests that pottery is inherently superior to other types of containers in an economic sense, that is, they are cheaper to make when they are made in bulk. Thus, Brown's model represents more of a prerequisite for the adoption of pottery, calling for a certain level of demand for watertight containers before they are produced in earnest.

Competitive Feasting/Symbolic Models

Hayden (1990, 1995) offers a similar intensification explanation in the adoption of pottery. However, the cause of this intensification is not from ecological, dietary, or population-level sources, but from political competition between emerging elites. Hayden feels that pottery often plays a significant role within prestige economies, as opposed to practical economies or technologies (as in models discussed above), and is prominently used during competitive feasts between status-seeking males (i.e., aggrandizers). In this respect, ceramic vessels have many properties that facilitate and encourage use in competitive feasts, including that pots are good for rendering oils and fermenting beverages, they are good for storing valuable goods in anticipation of a feast, they can be elaborately decorated to inflate their social value, they can be shaped into almost any form, and they can be dramatically broken at feasts to demonstrate the wealth and status of the feast-giver.

To test the competitive feasting model as applied to pottery, Hayden (1995) provides a list of archaeological expectations. He suggests that the earliest pottery in an area should commonly be in the shape of serving vessels and come in labor-intensive (i.e., well-decorated) and specialized forms. As well, there should be evidence for competitive feasting in other aspects of the archaeological record, and elaborately decorated pottery should also be common in burials.

Hoopes (1995) follows this model in explaining the origins of pottery in Central America. Hoopes argues that pottery was critical in the extraction of oils, and fermentation of beverages for feasting. In this sense, pottery was not used to prepare staple food items for basic subsistence, but valuable and luxury foods and beverages used during feasts. As these competitive feasting activities intensified and grew larger the demand for efficient extraction of these resources increased as well, which was eventually met by the adoption of ceramics. Hoopes further suggests that pottery was important in the transition of many groups into an agricultural lifestyle, as hunting and gathering people interacted with their agricultural neighbors.

Social Models

Social factors comprise the fourth major category of theories. Many of these models relate to demands on time and labor and gender issues. A main assumption by many of these studies is that women alone are responsible for the manufacture and use, and hence, adoption of pottery. Although this notion has been reexamined to show that both men and women participate in the overall production of pots (when all steps are considered from gathering clay to the eventual use; e.g., Wright 1991), it seems to be true that women in most societies are responsible for forming pots and cooking with them (Arnold 1985; Rice 1999).

Thus, Crown and Wills (1995) suggest that pots were adopted in the Southwest to minimize demands on the time and labor of women. They see an increased reliance on agricultural food products in the Southwest as an outgrowth of a sedentary lifestyle. Sedentism, in turn, decreased birth spacing and increased family size, forcing women to spend more time engaged in domestic activities, particularly breast feeding and food preparation. These added demands on the time and labor of women changed the demand for cooking containers.

A shift to cooking with pottery, rather than baskets, helped ease time and labor demands in two main ways. First, cooking using baskets and heated stones requires the cook to constantly move stones about so they don't burn a hole through the basket, and to replace stones when they have cooled. Pots, on the other hand, can sit directly over the fire, unattended, while cooking. Thus, cooking with pots frees time (Arnold 1985:128; Ikawa-Smith 1976:514; Van Kamp 1979:74). Although this might not be a problem if one has ample free time, as the popular image of small-scale hunter-gatherers suggests, in societies where time is in high demand pottery has clear advantages. Second, the use of pots facilitates gelatinazation of foods such as maize. Crown and Wills suggest that corn gruel may have been a nutritionally adequate substitute for breast milk allowing women to wean their children earlier and freeing more of their time (though who would look after all these weaned children with all the demands on women's time is unclear). Finally, Crown and Wills also suggest that since women were occupying more time in the domestic sphere in these societies, they may have had less access to meat. To control their own caloric and nutritional intake, women may have turned to pots to cook a wider variety of foods and extract more nutrition from starchy foods such as maize.

In many ways the ideas proposed by Crown and Wills (1995) are similar to those of Brown (1989) above. Changes in subsistence practices and/or settlement strategies are seen to change the demand for certain types of containers. However, rather than the economy of scale that Brown felt was so important, Crown and Wills suggest the major advantage of pots is their ability to gelatinize corn and withstand direct heat. Although Crown and Wills apply their model to the Southwest and the origins of maize agriculture, their ideas can just as easily be applied to hunters and gatherers, who surely faced similar time and labor restrictions. A major assumption of this model, of course, is that women are responsible for the majority of food preparation and are tethered to the domestic realm. Based on ethnographic data collected in California and the Western Great Basin (see Chapter 3), these assumptions seem to hold for the study area.

Sassaman (1993) uses a similar approach to explain the origins of the earliest pottery in coastal Southeast United States around 4500 years ago. He suggests that increasing demands on the time, and especially labor, of women may have prompted them to adopt pottery. Sassaman notes that the beginnings of pottery-use in many areas coincides with the use of large shell-ring sites and heavy dependence upon shellfish in the diet (1993:215-217). These shell mounds are seen as ceremonial and ritual structures, equivalents of the earthen mounds constructed by inland and more northerly Woodland and Mississippian groups. Sassaman argues that women were heavily involved in the process of shellfishing and creation of shell mounds, and that these added demands prompted them to pursue and experiment with alternative cooking technologies, including pottery.

At the same time, Sassaman (1993) also gives a convincing argument about the resistance to pottery manufacture in more inland locations. He argues that established elites (males), who were engaged in elaborate soapstone exchange networks, resisted the adoption of pottery. Earthenware pots were seen as a threat by these elites that could potentially undermine the success of their prestigious soapstone economy. In this case, the delayed adoption of pottery in inland locations is less related to function than it is to the social climate. In essence, Sassaman argues that the ultimate adoption of pottery in inland locations is related to the eventual breakdown of exchange systems based on an important element of an alternative cooking technology, namely soapstone.

Armit and Finlayson (1995) present yet another social model for the adoption of pottery. Although they recognize various functional advantages of pottery that may have attracted interest, they argue that a primary driving force in Scotland was that pots are convenient vehicles for expressing ethnicity and identity. They recognize this largely through the well-defined and discrete spatial distribution of various decorative styles seen on pot sherds. Because clay is a plastic medium, artisans could easily mold it into a diversity of shapes and add decoration to express ideas and convey information. Thus, in their model pots play an important symbolic role as a vehicle for individual and group-level expression.

Finally, Vitelli (1989) does not believe that early pottery from Greece was used in any capacity related to food, neither storage, processing, nor cooking. Although she does not offer any other hypotheses as to the function of these objects, social or symbolic roles would seem to be likely candidates. Exactly how social or symbolic processes played out in the adoption of pottery in Greece, however, will require further analysis.

Migration Models

The final set of models that have been used to explain the adoption of pottery in an area are related to migrations. In this case, either a population is replaced by a new population that uses pottery (perhaps violently, or slowly pushed out), or a group of people using pottery comes to occupy a region that was previously abandoned. In this model, assimilation is not part of the answer. If the resident population decides to use pottery as a result of such contact, one of the above models is more applicable (i.e., to explain why people adopted pottery).

Thus, in explaining the origins of ceramics, migration models suggest simply that a new population moved in possessing a developed and workable ceramic technology. Little further analysis is needed. Although the question of why the migrating population began using ceramics in the first place is still ultimately valid, for the region into which they migrated, the question is of little relevance.

Summary

Many different models purporting to explain the origins of ceramic technologies have been proposed in the archaeological literature. In most cases, the theories and models are developed to explain the process in a single region, rather than on a general level (though the works by Brown 1989 and Hayden 1990, 1995 are more general). In attempting to use these models to explain the origins of ceramics in California and the Great Basin, it is important to recognize this fact. Each region, of course, is different environmentally and witnessed a different historical and social development.

Table 2.1: Major models on the origins of ceramics.

Explanation/Model	**Expectations**	**Main References**
Functional: Detoxifying foods & Diet Breadth Increase-Intensification.	Pot design consistent with cooking, Sooting on exterior. Diet change.	Ikawa-Smith 1976; Oyuela-Caycedo 1995
Functional: Storage	Design consistent with storage; Cooking of minor importance.	Moore 1995; Peterson 1980
Functional: Fuel Intensification	Pots designed to maximize thermal transfer. Increase in demand for fuel (often in arid environment).	Bettinger et al. 1994
Economic: Population or Demand	Increase in population size. Diet relatively unchanged.	Brown 1989
Social: Competitive Feasting	Pots decorated & usually for serving. Found in burials & usually broken.	Hayden 1990, 1995; Hoopes 1995
Social: Women's Time and Labor	Change in diet to more vegetable products. Increased sedentism.	Crown and Wills 1995; Sassaman 1993
Social: Symbolic value	Pots decorated. Clear spatial distributions in styles.	Armit and Finlayson 1995
Social: Migration/Diffusion	Population replacement, or abandonment and re-occupation. Earliest pottery is already a well developed technology.	

Moreover, although I have classified the models into discrete categories here, many researchers, in fact, recognize multiple causes and prerequisites in the development of ceramic technologies. I have tried to pick out the (seemingly) most important or unique aspect of each work that differentiates it from the others. Thus, most models recognize the potential for pots to serve both cooking and storage purposes and clearly see this as one of the important functions of pots. At the same time, most models seem to weigh one factor more than others. In the discussion above, I tried to classify different works by what the author(s) seemed to be stressing as most important in the transition to pottery.

Unfortunately, many of the models do not explicitly discuss how they can be applied to other regions and cultures. Thus, few give specific expectations about what should be seen in the archaeological record if the model is valid (though see Brown 1989 and Hayden 1995). I have tried to summarize what information is available, as well as derive some obvious expectations, in Table 2.1 above. Although the table is probably incomplete and other archaeological correlates could be proposed, the table does provide a starting point for the discussions that appear in the following chapters. This information will also be used in Chapter 8 to summarize the results of this dissertation and evaluate different models in explaining the transition to pottery in California and the Western Great Basin.

CHAPTER III

ENVIRONMENT, ETHNOGRAPHY, AND HISTORY OF STUDY

This chapter provides the background to the study. To place the use of pottery in a broader context, the environment and ethnographic pattern in California and the Western Great Basin are reviewed. The ensuing section provides a discussion of previous ceramic studies in the region, focusing first on ethnographic and then on archaeological data. Reviewing these topics provides a greater context to data that are presented in the remaining chapters, and eventually, to evaluate the reasons why hunter-gatherers in the Western Great Basin began making and using pottery.

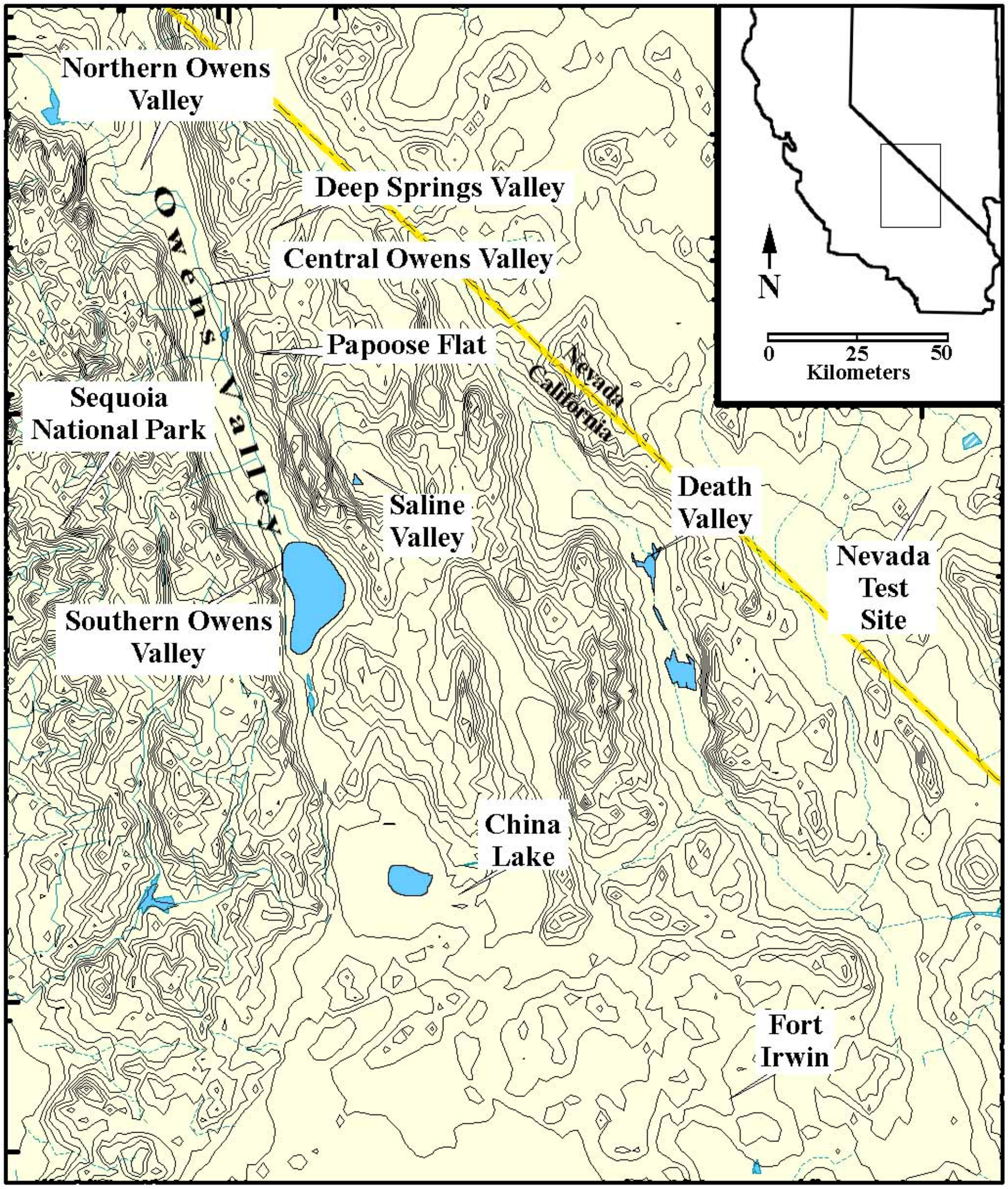
Environment

The region of interest in this dissertation, including the Western Sierra Nevada, the Northern Mojave Desert, and Western Great Basin, is an area of extremes. The region displays extremes in elevation, extremes in precipitation, extremes in temperature, and as a result, extremes in bioproductivity and biodiversity. These extremes make summarizing the environment into a few paragraphs extremely difficult. Information below is summarized from discussions by Grayson (1993), Fiero (1986), Cronquist et al. (1972), Lanner (1984), and from historic precipitation data available from the Western Regional Climate Center and the National Oceanic and Atmospheric Association (on the internet see www.wrcc.dri.edu). Information on environmental aspects of clays is summarized from Arnold (1985), Keller (1970), Lawrence and West (1982), Mason (1981), and Shepard (1968).

General description

The dominant geographic feature of the landscape in this area is the presence of tall mountain ranges separated by deep valleys. This is particularly true in regions outside the Mojave Desert. The formation of these mountain ranges began some 17 million years ago as the continental crust was stretched apart, thinned, and uplifted. Faulting of the thin crust in large blocks ensued, resulting in the uplift of mountains and dropping of basins in between. This faulting gives much of the Western Great Basin its classic basin and range topography. Figure 3.1 shows the study area, including major ranges and valleys and places referred to in the chapters that follow.

Figure 3.1: Map of study area.



The mountain ranges that were formed have a profound effect on nearly all other aspects of environment and ecology in the study area. Precipitation in the region is winter dominant, and derives from storms in the Pacific Ocean. As these storms move east they run into successive mountain ranges causing air to rise, cool, condense, and precipitation to fall. This removes moisture from such weather systems. Thus, each mountain range casts a cumulative rain shadow on regions to the east, and areas become more arid as one moves from west to east. This process begins with the Sierra Nevada, the tallest range in the study area and the one that has the largest effect on precipitation patterns throughout the study area. For example, compare historic precipitation at the following five weather stations moving from west to east: Yosemite Park headquarters on the western side of the Sierra Nevada at 95 cm per year; Bishop in Owens Valley at 13.4 cm per year; Dyer in Fish Lake Valley at 12.3 cm per year; Silverpeak in Clayton Valley at 11.4 cm per year; Sarcobatus Flat at 9.1 cm per year. All five weather stations are at similar elevations (1200-1300 m above sea level) and latitudes (37.25 – 37.75 degrees north) and show how precipitation decreases from west to east.

The height of mountain ranges to the west and distance from the Pacific Coast, then, play an important role in the aridity of different regions. However, precipitation is also heavily influenced by elevation, increasing with height above sea level. For example, in Death Valley historic precipitation varies from less than 5 cm per year in the valley bottom at -86 meters elevation, with some years receiving no measurable rainfall at all, to over 30 cm per year in the adjoining Panamint Range at 3300 m. Similarly, near Bishop in Owens Valley, the valley bottom at 1250 m above sea level receives just 13.4 cm of precipitation per year while the White Mountains at 3800 meters just to the east receive over 40 cm per year.

This inverse correlation between temperature and altitude has many important effects on biotic communities. Decreasing temperature with increasing elevation causes plants to bloom first in the warmer and lower regions, and gradually over the course of several weeks, in higher elevations, within the temperature and precipitation limits each species can tolerate. Many animal species follow these shifts and seasonally migrate up and down the mountains with growing and ripening plants. As well, dramatic shifts in the communities of plants and animals can be seen with increasing elevation. Typically, most regions range from desert scrub, including creosote, saltbush, and/or sagebrush on the valley bottom, to more wooded areas including piñon and juniper trees in mid-elevations (ca. 2200-2700 m), to upper sagebrush or conifer woodland in higher elevations, to subalpine and alpine environments in the highest reaches of mountain ranges. Major exceptions to this pattern occur around springs, rivers, washes, and lakebeds, where plants more adapted to wetland and marshland environments are readily found.

The Death Valley case is a good example to illustrate the extremes in elevation, precipitation, and temperature experienced in the study area. In this region, the valley rises from below sea level to over 3000 m in less than 25 linear km (i.e., as the crow flies). As mentioned, precipitation also rises from less than 5 cm per year to over 30 cm per year in this same distance. Similarly, temperatures are extreme. While winters are generally mild on the valley bottom, daily maximum temperatures in the summer commonly reach 50 C or more. At the same time, snow can be found in the surrounding mountains for much of the year, and summer temperatures in montane environments rarely reach 25 C. These differences in precipitation and temperature also create extreme environmental zonation in plant and animal communities, each adapted to different climatic regimes. Thus, in a matter of a few kilometers one can travel from desert scrub communities to piñon-juniper woodland to subalpine communities. While the Death Valley case is somewhat extreme for the study area, it does serve to represent an important point, namely, that arid valleys separated by tall mountain ranges create rugged terrain with high biodiversity in relatively small spatial areas.

The overall height and longitude of surrounding mountain ranges also determines the permanence of creeks within each area. Higher mountains and those further west capture more snow, which runs off during late spring and summer. In some areas, such as Owens Valley, these creeks run year-round. Moreover, prior to water diversions by the city of Los Angeles in the early 1900's, these creeks fed into a large permanent lake in the Southern end of Owens Valley. In other areas, creeks are less permanent and run only in late spring and summer. In these areas, seasonal lakes are created with marshy playas present during other seasons. Because most of the study area is internally draining (with the exception of the Western Sierra Nevada), salts and minerals tend to accumulate in these lakes (i.e., runoff dissolves minerals from the surrounding mountains, which are left behind when the water evaporates). As a result lakes in the study area are alkaline and saline, limiting the range of plants and animals that can survive in them. Except during periods of rapid freshwater influx (i.e., flooding), fish are absent from these lakes, though they are present in most adjacent perennial streams.

Overall, then, the study area is relatively arid, ranging from Mediterranean environment in the Western Sierra, the western part of the study area, to steppe environment in the central and northern part of the study area, to true desert in the northern Mojave Desert in the southern part of the study area. Meteorological studies suggest that, in general, as average precipitation decreases that variability increases as measured by the Coefficient of Variation (Trewartha and Horn 1980). Thus, like most arid regions, the study area experiences high variability in precipitation in both a spatial and temporal sense. This is particularly true of areas that are lower in elevation and those further towards the east. The availability of many food resources in these places, then, are unreliable and unpredictable, a fact that had great effects on the people living here. Notable exceptions include riverine and lacustrine environments, which are certainly predictable in a spatial sense and, depending on the permanence of creeks and water, probably more predictable temporally as well.

Environment and the production of pottery: Resources

A number of aspects related to climate and environment would have been important to prehistoric potters in the area. First, and most obvious, is the availability of raw materials to make and produce pots. Clay, temper, water, and fuel are all essential in the process of pottery production. In almost any environment these basic materials will be available in one form or another. Thus, clay can be found almost everywhere rocks are decomposing, sediment is accumulating, or water is pooling and settling. Temper in one form or another is nearly ubiquitous (e.g., what environment does not have sand, grass, pebbles, obsidian flakes, or rocks that could be crushed?). Water is widely available and almost any organic matter can be burned to achieve heat. However, the quality of these materials for making pots is not equal between different areas. Thus, some clays require extremely high firing temperatures and others contain chemical impurities that will cause them to spall and crack unless measures are taken to counteract this effect. Some tempers will cause pots to crack upon firing and others will cause them to break easily from impact stress. Water with dissolved salts and minerals may cause unwanted side effects, and different fuels may burn too hot, too cold, too unevenly, or may crackle and explode if oils and resins are present. In other words, not just any raw materials will do. The right types, in the right combinations, and treated in the correct fashion (e.g., with the right technology), are necessary to make a pot that satisfies certain functional and social constraints.

Clays come in two general types, residual and sedimentary. Residual clays are those which are still in contact with the rocks from which they were formed. They often contain rocks and minerals characteristic of the parent material and form relatively slowly through chemical weathering. As a result they are generally unavailable in hillside settings where they are easily washed away. Instead, residual clays are most often found deeply buried under soils (which are indicative of landform stability). In this respect, they are often more difficult to access, unless creeks have cut through beds of sediments to expose more deeply buried clay-bearing strata or tilted or faulted strata have been exposed through geologic processes. The degree of resistance to decomposition of the parent material is also critical to the development of residual clays. Some materials, such as quartz, are very resistant and do not weather into clay minerals, while others such as feldspar readily decompose. Thus, one is unlikely to find residual clays in locations where the parent rock is composed primarily of quartz and/or a steep slope exists. Residual clays often have ample and poorly sorted fragments of the parent material still embedded within them. Removing the larger of these fragments may require some processing on the part of the pottery.

Sedimentary sources of clay represent clays that have been transported to new locations, usually by water. Because of their smaller particle size, clays tend to stay suspended in moving water longer than silts and sands, and only settle in very slow moving water. As a result, clay particles tend to collect in places where water has pooled and stands still. Lakes, oxbows, and overbank river deposits are common places to find sedimentary sources of clay. Because they are found in low energy depositional environments, erosion of sedimentary deposits of clay is minimal. How well-sorted sedimentary clays are depends on the conditions under which they were deposited, particularly the speed of the water which carried them, and clays formed in higher energy environments may be too silty. Oftentimes the use of sedimentary clays requires the addition of a binding or tempering agent. As well, the process of transportation can change the chemistry and structure of the clay minerals.

Within the study area, residual clay deposits are typically available in the higher reaches or foothills of mountain ranges. Places near active faults also can provide access to residual sources of clay, either by exposing buried sediments that have already been weathered to clay or by promoting grinding of rocks and allowing water to access new strata encouraging chemical weathering. Residual clays exposed in strata are often dry and require much processing, including removal of larger pieces of parent rock, grinding, the addition of water, and working the clay into a plastic form. Occasionally, washing, leaching, or souring (letting the clay sit buried for several days or weeks) are also necessary. Granitic rocks commonly weather to kaolinite, a good clay mineral for making pottery due to its relationship with water. Kaolinite does not swell when water is added or removed, and is less prone to crack during drying. These properties make it a popular choice among potters today. Residual clays that have been formed more recently and are exposed in river cuts may already be wet and plastic. Use of such clays could save much time in processing and drying.

Sedimentary clays within the study area are available in many locations. Lakes and playas are the most obvious location. However, these clays suffer from two main problems. First, they are often composed of montmorillonite (or bentonite, which is often formed from decomposing volcanic ash or basalt), which, due to its molecular structure tends to swell when water is added and shrink when it evaporates. As a result, cracking during drying is a typical problem with such clays. Second, clays in dry-lake playas typically contain high levels of salt minerals and sometimes calcium carbonates. Chemical reactions with these minerals during and after firing can cause spalling and cracking. However, these problems can be overcome by the addition of the right amount of either salt water or calcite to the clay (Rye 1976). Thus for pottery purposes, dry lakebeds may not be ideal places to collect clay within the study area, though the quality of such clays will vary by region depending on local chemistry, hydrology, and geology.

Old lakebeds that have been tectonically raised, chemically altered, and are now exposed, however, may provide better opportunities for collecting sedimentary clays in the region. Salts and carbonates may be leached out of such beds and additional chemical weathering may change the mineralogy of the clays making them more suitable for pottery. The author has observed several such beds of clay around Owens Lake that appear to have pottery-quality clay. In addition, locations near rivers may have oxbow and/or overbank deposits with pottery-quality clay, although these sources are often too silty. Smaller and more ephemeral depressions where water pools may also provide locations to collect high quality clays, as they tend to be lower in salts and carbonates than playa clays. Some of the best clays I collected in the study area come from these locations (see Chapter 7).

Sedimentary clays are usually already wet and plastic. Use of these clays rather than dried residual sources would have accelerated the manufacturing process, obviating the need to crush, process, and rehydrate the clay. On the other hand, these clays are sometimes too wet and require extra drying time. However, Skibo et al. (1989) demonstrate that the use of organic (fiber) temper could offset this problem by increasing porosity and absorbing water. Indeed, they equate the use of organic temper with expediency and the need to produce pottery cheaply and quickly in more mobile societies. The use of sedimentary clays from wetland areas, with roots and other organic matter embedded within the clay, then, may have been an attractive feature promoting the use of such clay sources.

The availability of fuel to fire pots would also have been an important consideration of prehistoric potters. This is especially true in more arid regions of the study area where firewood is less abundant. Unfortunately, little experimental work has been done with different sources of fuel and firing qualities in California and the Great Basin. It is likely that many potential sources, such as sagebrush, saltbush, and other shrubs, burn too hot and too quickly, and contain oils that tend to snap and explode, preventing even and consistent firing. Dung from larger herbivores such as sheep, deer, and antelope may have provided a better source of fuel for firing pots. Experiments by Shepard (1968: 79) suggest that dung fires achieve higher temperatures than wood fires, but do not leave behind charcoal and quickly cool, as opposed to wood fires which maintain lower heat over a longer period. Such quick firing at high temperatures results in a reduced atmosphere and an unoxidized core within the pot. A similar result, though, is achieved by longer firing where the pot is covered by ashes and coals.

To the best of my knowledge, there are no archaeological data from California or the Great Basin that bear on the issue of firing and the types of fuels used in pottery production. No kilns or other pottery firing features have been discovered or described in the archaeological literature. Similarly, ethnographic data are scant. Interestingly, Steward (1933) reports the use of sagebrush in Owens Valley, despite the fact that it has low wood density, burns quickly, and contains many oils and resins. In Sequoia National Park, one of the better watered regions within the study area, Gayton (1929: 244) reports the use of “any convenient variety” of wood that comes in long poles (i.e., from trees), as well as bark from oaks. Gayton (1929) suggests that pots were fired anywhere from 24 to 48 hours, requiring significant quantities of fuel. The use of dense woods that create charcoal upon burning would have been advantageous in this regard. By doing so potters would not have to constantly add fuel to the fire, but could let the coals slowly and evenly release heat and burn out on their own.

Importantly, it seems likely that the use of fuel to fire pottery would have competed with other needs for fuel, such as cooking and heating. In more arid regions where firewood and dung are more scarce, the need for efficient fuel use would have been heightened. This may have been compensated by changing pottery technology. For example, potters could make thinner or smaller pots such that they require less firing time. Alternatively they could reduce demand for pots by making fewer but stronger and longer-lasting pots or by trading for them. Another option still may have been to reduce fuel consumption in other activities such as cooking and heating. Some of these expectations are borne out in the study area, as discussed in Chapter 4.

The availability of fuel on the landscape is also uneven. Within the study area, higher elevation areas that receive more rain would have had more fuel available, and may have promoted firing of pots in these regions (although as discussed in Chapter 5 the distribution of pottery in lowland areas does not support this). Alternatively, firewood brought to lowland areas by flooding creeks may have been collected in washes, or firewood could have been carried to lower elevations from mountains.

Environment and the production of pottery: Climate

The second important effect of environment in the production of pottery relates to climate and weather. As discussed extensively by Arnold (1985: 61-98), weather has important effects on the scheduling of pottery-making, including affecting when raw materials can be gathered, the length of time it takes to make a pot, the degree and length of drying, and firing conditions.

For example, certain sources of clay may not be accessible during certain times of the year. Clays normally available in lakebeds may be inaccessible during winter or spring when water has inundated these areas. Similarly riverine sources of clay, such as oxbows and overbank deposits may be inaccessible during periods of high water. The inability to collect the right types of clay during these seasons would certainly have limited the ability of California and Western Great Basin potters to practice their craft.

Weather has important implications for drying pots as well. Drying prior to firing is a crucial production step and is often accomplished through air drying. Drying usually takes on the order of several days to several weeks (see table in Arnold 1985: 68-70). Pots that dry unevenly as a result of being differentially exposed to wind or sun, are also subject to warping and cracking. Pots that are not adequately dried also tend to crack and break during firing as water trapped in the clay turns to steam and expands. Similarly, pots that have only been partially dried and are then re-exposed to moisture are at significant risk of deformation and breakage. Complete, even, and unbroken drying is difficult during the windy and/or rainy seasons. This may effectively limit pottery production to summer and fall months in California and the Great Basin.

Similarly, cold and/or rainy weather increases the time it takes to make a pot, by increasing drying time and making firing more difficult. Wet sources of fuel are not only difficult to light, but they also lower the effective temperature that can be achieved. Lower firing temperatures reduce the strength of a finished vessel to resist mechanical stress (such as impact from falling to the ground), creating an inferior product. For these reasons and others (see Arnold 1985) drying and firing during cold or rainy conditions is undesirable.

Thus, pottery making is mainly a dry weather activity. In many ways, California and the Western Great Basin provide ideal settings for making pots with a relatively arid climate and warm temperatures. This is especially true if we compare this region with others in North America, such as the Pacific Northwest or the Southeast. However, these activities still had to be scheduled within seasonal weather and mobility patterns. Production during a mobile phase of the year may have been difficult, as the production of a pot from start to finish usually takes 4 or more days. As discussed below, in many areas the period of highest mobility appears to coincide with the dry season, while relative sedentism coincides with the cold and rainy season. Moreover, it is often necessary for a potter to at be present during all production steps (i.e., the potter must rotate vessels during drying when wind is present, s/he must feed the fire at intervals, s/he must take care that they do not cool too quickly, etc). Having to be present at the base camp to perform these activities, particularly during summer when seeds were ripening, likely created scheduling conflicts for prehistoric groups in the production of pots. However, it is one that they clearly solved.

Ethnographic Pattern

General Review

As in summarizing the environment for such a large area, it is also difficult to summarize ethnographic patterns in a neat and concise fashion across an area as diverse as the Western Sierra Nevada, Owens Valley, the Northern Mojave Desert, and the Western Great Basin (outside of Owens Valley). Of course, each group was independent and probably had different practices within these regions. Indeed, practices probably varied in the same group from year to year, depending on local conditions. Rather than summarizing the entire area, each of these four areas is briefly discussed below.

Unfortunately, ethnographic research among Native Californian groups has been patchy in both spatial coverage and detail. The majority of academic work was undertaken during the first half of the 1900s, after native lifeways were significantly altered through direct (e.g., removal, missionization, and sedentarization) and indirect influences (e.g., disease and disruption of trade patterns) of European immigrants, and has been criticized as such (Heizer 1978; Service 1964; see also Preston 1996). Indeed, much research was based on salvage and memory ethnography, where tribal elders were asked to inform anthropologists about how it was in the old days before the arrival of whites. Work was also focused in areas where Europeans were more actively interacting with and disrupting native lifeways, while less is known of regions more sparsely populated and infrequently visited by early settlers, such as the Mojave Desert. As a result, the reconstruction of aboriginal patterns in these latter areas has relied on other sources of information, such as archaeology, analogy with similar groups, and theoretical arguments, rather than first-hand ethnographic data (Eerkens 1999).

Western Sierra Nevada

Of interest here is the region surrounding Sequoia National Park, which historically included primarily the Monache (or Western Mono) and Foothill Yokuts. Unfortunately, ethnographic information is scant. Main sources for the area include works by Gayton (1945, 1948), Gifford (1932) and Kroeber (1925). Steward (1935) provides a cursory review of much of the early information, while Spier (1978a, 1978b) provides a more recent review.

The hunter-gatherers of this area apparently lived in higher population densities and more permanent villages than groups in any other part of the study region. This is particularly true for regions closer to the Central Valley of California, where the Foothill Yokuts lived, than regions higher up in the Sierra Nevada mountains, traditionally occupied by Monache people. Steward (1935) attributed this mainly to the greater precipitation and increased abundance of plants (i.e., food) in the region.

Several distinct groups, identified by linguistic dialects, occupied the region. People organized themselves by patrilineal lineages, and occasionally, moieties. Relatively permanent villages were occupied and set up in certain strategic and centrally located places, such the confluence of major streams and rivers. However, some degree of mobility was afforded through seasonal movements within a defined home territory. Some lands were jointly owned and used by neighboring groups (Gifford 1948:213) and much latitude seems to have been given to others travelling through and making use of home territories.

Male chiefs headed villages and were responsible for contributing to communal undertakings (such as seasonal ceremonies), feeding the poor, and hosting visitors. Decisions regarding revenge killings, trading, and setting dates for events were generally carried out by chiefs. Chiefs inherited their positions by blood, and gathered status through moiety or lineage affiliation and wealth. Villages often had more than one chief.

Although much has been made of the dependence on acorns, several ethnographic accounts are quite explicit on the diverse nature of the diet that focused on numerous resources and not primarily acorns. Deer, rabbit, quail, duck, fish, freshwater mussel, insects, pine nuts, grass seeds, roots, and manzanita berries are all mentioned as important sources of food and nutrition. These resources were harvested by a number of means using a variety of implements. The use of bow and arrow, often tipped with obsidian projectile points derived from Owens Valley, was common. Yokuts people also used weirs seasonally to trap salmon and other species of fish.

Acorns were often ground into a flour using a mortar and pestle and leached on a raised flat surface covered with sticks and sand. These elevated structures were often used to store acorns as well (prior to leaching), occasionally with pine nuts. These storage granaries were usually outdoors and in the open such that everyone within a village could view their contents. Apparently, theft of unprocessed acorns was not a major concern. This may have much to do with the fact that acorn processing is back-loaded, whereby large volumes of nuts can easily be collected and stored raw (see Bettinger 1999). Processing acorns is usually performed at the base camp and the amount of time spent collecting the nuts is small relative to time spent processing them. After leaching, acorn mush was typically cooked in baskets using heated stones.

Little specialization in terms of craft-workers is known among the Monache and Yokuts. In general, then, independent family units were able to produce the full range of material objects used in day-to-day activities. In this respect, trade and exchange can be seen primarily as social activities revolved around gathering information about the environment, the acquisition of prestigious goods, the formation of alliances and marriage partnerships, and simply having fun, rather than acquiring staples necessary for survival.

Owens Valley

The primary source of ethnographic information on the Owens Valley Paiute comes from Julian H. Steward's work in the area. In addition to his classic “Ethnography of the Owens Valley Paiute” (1933), he published a number of other works based on data collected from informants who could remember life as it was prior to the severe changes resulting from contact with European culture (Steward 1934, 1936, 1938a, 1938b). Other sources of ethnographic information come from Chalfant (1933), Wilke and Lawton (1976) on the travels of J.W. Davidson in 1859, Lawton et al. (1976) on the surveying work of Von Schmidt in 1855-1856, Grosscup (1977) on ethnic boundaries, and Liljeblad and Fowler's review of the literature (1986). This information provides a relatively rich record of historic and proto-historic living conditions.

Sources indicate that late prehistoric Owens Valley people were not typical of the Great Basin as a whole. In many respects they resembled the more socially complex Californian groups to the west, such as the Monache and Yokuts, than those further east, their linguistic Shoshone cousins. The basic sociopolitical unit in Owens Valley was the autonomous “district”, which was made up of a single large or several smaller villages (Steward 1933, 1938). District territories were large rectangular regions running from the Sierra Nevada down across the valley bottom and back up into the Inyo-White range, thereby crossing all major vertical biotic zones, from valley bottom riverine to alpine. Villages ranged in size from 25 to over 200 individuals and were predominantly located on or near Sierran creeks in the valley bottom, along the western side of the valley. Each village was headed by a hereditary chief whose duty was to redistribute goods (Bettinger 1983; Bettinger and King 1971), settle disputes, and organize events such as the construction and maintenance of irrigation systems and sweathouses, annual fandangos, and rabbit and antelope drives (Steward 1933). Families within villages were land-owning units and laid claim to distinct seed plots, irrigation plots, and piñon groves.

Lowland villages were fairly permanent and seem to have been occupied for much of the year, with logistically organized task groups occasionally making forays into the surrounding region to secure resources such as piñon, acorn, and large game. These resources were usually brought back to the valley bottom village for consumption or storage; however, when piñon nuts were especially plentiful, families would move into the mountains during the late fall and stay throughout the winter. As such, the settlement system has typically been classified as semi-sedentary and village-oriented, and approximates a collector-type system as defined by Binford (1980).

The practice of irrigation, first discussed by Steward (1930), has attracted some attention from archaeologists (Lawton et al. 1976; Bouey 1979), although perhaps owing to the difficulty in discovering and dating irrigation systems, interest seems to have waned in recent years. Irrigation appears to have been an indigenous development in Northern Owens Valley to help the propagation of natural seed and bulb stands. Sierran run-off was diverted through an intricate system of ditches and canals to flood specific lowland areas. The bountiful seed harvests were used as over-wintering food and were stored in valley bottom villages. Such a system apparently provided a more reliable alternative to unpredictable piñon harvests, a common winter-stored food resource in other parts of the Basin, which produce good crops on average only once every 7 years (Thomas 1972a). Lawton et al. (1976) attribute the practice of irrigation as heavily contributing to and allowing for the semi-sedentary residential pattern recorded ethnographically, at least in the northern half of the valley. They suggest that the brine fly larvae, or kutsavi, which wash up in thick windrows during the summer may have played this role along the shores of Owens Lake in Southern Owens Valley, allowing a similar semisedentary lifestyle to develop.

In sum, Owens Valley Paiute were probably less sedentary socially complex than their Monache and Foothill Yokuts neighbors to the west, but more so than groups to the south, north and east. These people also seem to have lived in smaller villages, had lower population densities than Monache and Yokuts people. Owens Valley Paiute appear to have been highly reliant on small seed resources. These resources are At the same time, a diversity in the diet is also evident in the mention of meat, freshwater mussel, fish, waterfowl, insects, greens and roots, acorns, and other plant products in the ethnographic record. Bettinger (1975) suggests that dryland seeds and roots provided the bulk of subsistence intake, followed by riparian seeds and roots, pine nuts, and irrigated plants in decreasing order of importance.

Little work has been done to examine differences in settlement and social organization patterns within the valley, despite the fact that the region is quite differentiated in terms of environment. Steward's work focused mainly on Central and Northern Owens Valley, and little information is available from the Southern end of the valley along the shores of Owens Lake. Grosscup (1977) indicated that the Western shores of Owens Lake were occupied by Owens Valley Paiute, and Bettinger (1982a) believed that these groups were probably more mobile than their neighbors in the north of the valley. However, additional research is necessary to support these hypotheses.

Northern Mojave Desert

It is clear that a number of different ethnographic groups occupied the Northern Mojave Desert (Eerkens 1999). For example, different ethnographers have attributed Fort Irwin to a minimum of four different Native American groups: the Kawaiisu, Chemehuevi, Las Vegas Paiute, and Vanyume. While Julian Steward (1937:Figure 1; 1938:76) ascribes the area to the Kawaiisu and Zigmond (1938, 1981) includes it within their range of seasonal trips, Kroeber (1925:593) believes the region to be a westward extension of Chemehuevi territory, and Kelly (1934) locates the Las Vegas Paiute on the eastern side, with logistical hunting in and south of the study area. Other information indicates that the Vanyume may have owned and used the area, though little is known of this group (Bean and Smith 1978; Euler 1966:105. The proximity and high residential mobility of Shoshone groups living in Panamint and Death valleys (Bettinger 1982; Coville 1892; Steward 1938) makes it possible that they too made use of the area. Together with archaeological, historical, and other ethnographic data, this information suggests that much of the area may have been only sparsely and likely seasonally occupied. Indeed I have used this data to argue that parts of the Northern Mojave, and Fort Irwin in particular, were part of an intertribal common pool resource system, whereby many groups jointly owned the land and only occasionally made use of its resources during times of relative scarcity (Eerkens 1999).

Although differences exist between the groups purported to have occupied the Northern Mojave Desert, they are similar in many aspects of settlement and subsistence relative to the discussion below (Kroeber 1925; Steward 1938). Groups appear to have maintained a flexible settlement pattern, following food resources as they became available in different locations. Gathering information about the state and harvest potential of resources was integral to this system. Information could be gathered directly through monitoring rainfall and plant growth or indirectly through communication with other groups (Bettinger 1982; Steward 1938; Thomas 1972b, 1981). Due to the sparse and variable nature of food resources, people maintained relatively low population densities (Eggan 1980:177; Euler 1966:51; Kroeber 1925; Zigmond 1938: 638). Exact figures are difficult to determine due to Euroamerican disruption (i.e., disease and displacement), high mobility, flexible social boundaries, and inaccurate census data (King and Casebier 1976: 195; Preston 1996). However, as a rough gauge for two groups that may have used the area, Steward (1938a) estimated Las Vegas Valley densities at .04 and Death Valley at .03 people per square mile.

A generalized seasonal round for groups such as the Kawaiisu, Southern Paiute (Las Vegas and Chemehuevi groups), and Western Shoshone (Panamint and Death Valley groups) includes a late fall/winter aggregation, followed by a spring/summer dispersal. People were highly mobile and residential movements of over 80 kilometers in a single direction were not uncommon (Steward 1938). In general, people would begin the year (January) in aggregated winter villages, usually in upland areas, eating stored resources. Villages would break up when food stores were low, during late spring in good years and early spring in poor ones. At this point nuclear families would disperse and begin a cycle of successive short-term occupations at temporary camps (Bettinger 1982). Subsistence activities would have focused on low bulk and patchy resources, such as greens, grass seeds, insects, and small game (Thomas et al. 1986). Springtime settlement would typically focus on warmer low elevation areas, where plants would bloom and ripen first. In summer, as various seeds, berries, and roots would ripen, first on the valley floor and then into upland areas, groups would follow the availability of resources into higher elevations. Fall was typically a time of plenty as bulk staple resources such as piñon, acorn, and mesquite became harvestable. There was much travel between valley lowlands, where communal hunting of rabbit and antelope would take place, and uplands, where gathering activities were focused, and between different villages, which would hold their annual fandangos or feasts (Kelly and Fowler 1986). Following these events in the late autumn, extended families would reconvene at villages to begin preparation for the winter, including construction of lodges and caches for storage of overwintering food resources.

Western Great Basin (outside of Owens Valley)

Many aspects of Western Great Basin groups, including people living in areas such as the Nevada Test Site, Death Valley, and Panamint Valley, are probably similar to those of the Northern Mojave Desert. People appear to have been highly mobile, living in small kin-based groups (Eggan 1980; Steward 1938, 1941). For example, seasonal transhumance between ecological zones to take advantage of locally abundant resources was probably the rule rather than the exception in Death Valley (i.e., in opposition to the transport of food resources to a central base). This mobility likely included travel to and between different Great Basin valley systems and the Northern Mojave Desert.

The high degree of residential mobility seems to have played an important role in social and material culture. For example, the range of material goods was not extensive given the need to carry the majority of implements around during the seasonal round. Similarly, structures and camps were typically small, temporary, and simple, and were lived in and occupied by an extended family. These elements of native culture prompted many early explorers and anthropologists to regard Western Shoshone and Southern Paiute people as primitive, backwards, and deprived. However, current interpretations see these people as remarkably complex and resourceful, exquisitely adapted to a rather harsh environment (Fowler 1996; Thomas et al. 1986: 265). Knowledge of when and where various resources, including water, were likely to be plentiful throughout the year was critical to survival. It is believed that annual fandangos held in the fall, where multiple families would gather to socialize, meet potential spouses, and conduct rabbit and antelope drives, was also critical as a place to disseminate important environmental information on the state of resources in various parts of the region (Thomas 1972b:146-148). Much of the annual round appears to have been synchronized to the availability of different resources, particularly grasses and small seeds during the spring and summer and piñon in the fall.

Unlike the Northern Mojave, regions in the Western Great Basin likely offered a greater range of resources by providing more immediate access to higher elevations in local mountains. An important resource in this regard would have included piñon nuts, by many accounts the staple resource of the region. Other important resources include small seeds such as blazing star (*Mentzelia* sp.), goosefoot (*Chenopodium* sp.) and other chenopods, Rice Grass (*Achnatherum hymenoides*) and other grasses, salvia seeds, cactus, agave, bighorn sheep, rabbit, deer, antelope, small rodents, and insects. Fish and waterfowl, where they were available, also formed an important part of the diet. Mesquite also seems to have been a staple resource in areas where it grows, such as Death Valley.

Summary of Ethnographic Pattern

Although mostly covering generalizations and glossing over intra-regional differences, the preceding discussion allows from some gross comparisons of mobility and diet across the study area. The data suggest that populations in the western part of the study area in the western Sierra Nevada were slightly more dense and more sedentary than those to the east, south, and north. These populations were highly reliant on acorn, but did make use of a wide array of other food resources including small seeds and various animal products. Owens Valley Paiute populations were slightly less dense and more seasonally and residentially mobile than their Western Sierra neighbors. These groups were highly dependent on small seeds and roots from both dryland and wetland areas, but again, made use of other resources as well, occasionally including acorn, piñon, and large and small game. Although parts of the Mojave may not have been permanently occupied, groups making use of the Mojave region were surely more mobile and sparse than those in Owens Valley, particularly during the periods when they were making use of the region. These peoples were likely highly reliant on small dryland seeds and small game, while piñon, acorn, and large game were relatively unimportant. Finally, Western Great Basin groups east of Owens Valley appear to have been more mobile than Owens Valley Paiute, but less so than Mojavean populations. These Shoshone groups were dependent on a mix of small seeds and piñon, but also made extensive use of mesquite where it was available. In general these statements are supported by archaeological data from the late prehistoric (600-200 BP) and protohistoric (roughly 200-100 BP) periods.

Review of California and Great Basin Pottery-Making

Unfortunately, ethnographic information on the production and use of pottery in California and the Western Great Basin is scant. More disheartening, several lines of evidence suggest that many of these reports are not accurate reflections of pre-contact ceramic practices. For example, Steward (1933: 269) reports that archaeological sherds in Owens Valley differ significantly from pots made on request by informants. In fact, when discussing different native technologies in Owens Valley, Steward (1933: 267) resorts primarily to archaeological collections to describe the range of pot shapes that were made, unlike discussions of other native crafts such as flintknapping, basket weaving, wood-working, and house construction, where primary ethnographic data are used. Similarly, reports by Driver (1937) state that the native style of pottery making in Big Pine and Independence, Owens Valley, included painting decorations on their pots (sometimes in ways reminiscent of classic Southwest black-on-white styles). Yet no painted pots have ever been reported in prehistoric contexts (other than the extremely rare Southwest exchange piece).

My own experience with Death Valley pots (see Chapter 4) also supports this notion. In shape, color, and even chemical composition (see Chapter 7; Eerkens et al. n.d.), many “ethnographic” specimens are completely different than pots and sherds recovered from archaeological sites. This suggests that the art of ceramic manufacture had been largely discontinued and forgotten by the time ethnographic work commenced. Moreover, these historic Shoshone and Paiute informants who did make pots may simply have been producing items that ethnographers and other whites were expecting or wanting (i.e., painted “traditional native” wares for the tourist or artifact collecting industry). The connection of ethnographically reported practices with prehistoric ones, then, must be questioned.

Indeed, at the time they conducted their fieldwork (1920’s – 1930’s) many ethnographers noted that in some regions most of their informants could not remember *ever* having made pots, despite the presence of potsherds in the region demonstrating they were made in prehistoric times (e.g., Steward 1933; Voegelin 1941). As a result, ethnographic studies often give pottery only cursory treatment, mainly noting the presence or absence among different groups. In fact, it appears that the presence or absence of this trait was often based on the presence or absence of archaeological sherds in an area, rather than on responses from or discussions with informants.

By the 1920's and 30's, most groups were using metal containers for storage, transport, and cooking. Photographs from the late 19th and early 20th century show that while baskets, millingstones, and metal pots are common, ceramic pots in and around house structures are absent. For example, a study of 16 historic photographs of houses in Owens Valley taken between 1900 and 1924 did not reveal a single ceramic container in any domestic context (Milliken et al. 1995). Metal containers, including large cast iron pots, large serving pans, and smaller milk cans and tins, are quite common in these photographs. These objects often seem to be lying haphazardly in and around many of the domestic structures. At the same time, several photographs show large cast iron metal pots in use, sitting on centrally located hearths.

That many native crafts such as basketry, milling, and flintknapping were still practiced in the early 1900's but pottery was absent, suggests that this craft was quickly dropped from the cultural inventory following contact with Euroamericans. Moreover, that metal containers are so common and can serve many of the same purposes, suggests that ceramic vessels were likely replaced with metal ones. Metal containers may have had several advantages over ceramic ones, including increased strength, greater heating efficiency, and, in the case of tin cans (but not cast iron pots) being lighter in weight. Moreover, many metal containers, such as milk cans and tins may have been discarded as trash by white settlers. By collecting these implements from trash dumps, Native groups would not have had to undergo the rather time consuming and energy demanding task of making and firing earthenware pots. Sedentarization and homesteading by Whites may also have reduced access to traditional clay sources and/or distribution networks. If ceramic technology was expedient to begin with (see Chapter 4), collection of discarded metal cans would certainly have made the process even more expedient, presenting an efficient replacement for the native craft. If this is true, then many of the tasks undertaken using metal pots in proto-historic times may have been done with earthenware pots in prehistoric times.

However, in many other societies where ceramic-using people have been introduced to metal vessels, ceramic containers continue to be made and used (Arnold 1985). One of the main reasons cited by informants for keeping the traditional craft alive is that foods cooked and stored in earthenware pots taste better than those in metal ones. Religious reasons are also occasionally given.

One major exception to the scanty nature of ethnographic data on pottery is the work by Gayton (1929, 1948). Gayton goes into considerable detail on the steps taken to produce pottery among the Monache (Western Mono), in the Western Sierra Nevada. The study is one of the few in the region that gives more than cursory treatment to pottery manufacture. For example, related to the discussion on climate above, Gayton mentions that early summer was the preferred time to make pottery (although clay was occasionally collected in winter and left to sour until early summer; see Gayton 1948: 265). Unfortunately she pays less attention to subsequent uses of pottery, but does suggest that larger vessels were used for cooking, especially meat and greens, and occasionally acorn mush, and smaller vessels were often used as individual serving dishes or as cups or scoops (Gayton 1948: 226). Her studies also suggest that storage was not a major function of pots in this area.

Given these comments and reservations for using ethnographic data on pottery, a cursory review of the range of uses for pots mentioned by ethnographic informants is given below. Table 3.1 reviews six ethnographies where pottery is discussed and food preparation details are given. The table lists cases where pottery is explicitly mentioned as being involved in food preparation, as well as foods where detailed preparation data are given but pottery is not mentioned. Cases where the foods are mentioned as being “boiled” or “cooked”, but no reference to the boiling or cooking implement is given (e.g., basket, pot, pit), are not included. The table also lists other uses for pots outside of cooking when they are mentioned.

Table 3.1: Ethnographic accounts of food preparation and the use of pottery.

Reference	**Group/ Region**	**Foods Cooked in Pots**	**Foods not Cooked in Pots**	**Other Uses for Clay Pots**
Gayton 1929, 1948	Western Mono, Yokuts / Central Sierra Nevada	Deer Meat, Greens, Acorn Mush (rarely)	Small Rodents, Fish, Manzanita, Grasshopper	Serving
Steward 1933	Owens Valley Paiute / Owens Valley	Seeds, Piñon, Berries, Acorn, Rabbit, Water Fowl, Sheep, Pandora Moth, Brine Fly	Fish, Deer, Rodents	Trade item to Sierra Nevada groups.
Steward 1941	W. Shoshoni / W. Nevada	Seeds, Roots, Animal internal organs	Meat Flesh, Piñon, Acorn	
Voegelin 1941	Tubatulabal / Southern Sierra Nevada	Piñon, Elderberries, Yucca, Buckeye, Acorn, Meat Flesh	Small Game, Fish, Freshwater Mussel, Roots	Processing of salt grass and tobacco stalks
Kelly1964	Southern Paiute / SW Nevada	Meat	Berries, Roots, Small Game	
Irwin 1980	Shoshoni / Inyo County, Ca.	Seeds, Rabbit	Piñon, Blue Dick, Joshua Tree	Temporary Storage

There is no clear pattern evident from the data presented in Table 3.1. Pots seem to have been used to cook a variety of foods. Seeds seem to be commonly cooked in pots as a mush, but an equally diverse range of plants and animals are also represented. Interestingly, piñon and acorn are mentioned as being cooked in pots for some groups and explicitly not in others. Ethnographic accounts suggest that piñon was often roasted in fires or eaten raw, rather than boiled, and acorn was often mentioned as having been boiled in baskets rather than pots. Small game, other than rabbits, are also rarely mentioned as having been prepared in pots. Surprisingly absent from much of this material is mention of how greens were prepared.

Points in Common from Ethnographic Data

Despite the minimal description given to pottery and pottery-making behavior, the ethnographic work is consistent on a number of points. First, pottery-making was clearly a gendered activity. Although men occasionally helped by collecting clay and bringing it back to the camp, women were exclusively responsible for the production of pots, including processing the clay, and shaping, drying, and firing vessels (Gayton 1929, 1948; Steward 1933, 1938, 1941; Stewert 1941). Women also appear to be primarily responsible for the use of pottery, particularly as it related to cooking.

Second, the ethnographic accounts are also in synchrony as to the construction techniques employed. Pots were formed by coiling to create the basic form, with the interior and exterior surfaces scraped with a brush or some other implement to finish it. The paddle and anvil technique does not seem to have been used, as it was in Southern California (see Kroeber and Harner 1954 and Van Camp 1979). This accords well with archaeological data that shows coil-and-scrape to be the exclusive technique of pot formation in the study area.

There is less information about the scale of production. Steward (1933) suggested that some women in Owens Valley were specialists and owned specific clay sources (although he noted also that few informants could remember much about pottery-making). These women made large numbers of pots and exchanged them for shell bead money. Bettinger (1989:266) has suggested that this specialization may have developed as a response to spatial variability in the availability of food. Shell bead money could later be exchanged for food resources in times of resource shortfall. Unfortunately, this account has not been corroborated or studied by archaeologists. Among the Monache in the Western Sierra Nevada Gayton (1929:240) also suggested that some women specialized in pot making while others were unfamiliar with the craft. These women sold their goods to others who were "stupid or too lazy" to make pots (Gayton 1929:240). Other ethnographic works do not mention the scale or nature of pottery production. Thus, the scale and organization of production is not well known for the region at large, but may have been rather specialized in Owens Valley and the Western Sierra Nevada.

Third, although pots were occasionally embellished with fingernail incisions or punctate holes made with the end of a small twig around the neck or rim (usually on the exterior), the majority of pots were left undecorated. This practice is surprisingly similar across the ethnographic accounts, and no major variations on this theme are mentioned. Painting and glazing are described for some groups, but the presence of this practice in prehistoric times is doubtful.

Fourth, pots were usually fired in small brush fires with whatever fuels were conveniently available. No mention is made about a desire to conserve fuel resources. The maximum temperatures of these fires were low (ca. 600-800 C), and the firing technique created an uncontrolled atmosphere for the pots.

Finally, pots were used primarily as cooking implements. The range of foods boiled in pots is diverse, but plants, and especially seeds, are commonly mentioned. Storage is never explicitly mentioned as a function, and serving only occasionally. Some pots appear to have been the object of trade with neighboring groups. Unfortunately the motivation for trading pots, and whether the pots were simply the vehicle for trading some other item of worth, such as salt or food, is not known. Thus, the use of pots in transportation is also a distinct possibility.

In sum, with the exception of Anna Gayton's work, much of California and Great Basin ethnographic work related to pottery-making is not to be entirely trusted, particularly in regard to finer details as to how pots were made and used. Steward (1943: 274), in fact, stated as much when discussing the Northern and Gosiute Shoshoni, suggesting that pottery-making had been abandoned so long ago that statements by informants were of "doubtful worth." Although the accounts provide important starting points in the study of pottery, the warnings should be heeded, and hypotheses checked using archaeological data.

In terms of the current research objective, understanding the origins of pottery-making, the ethnographic data provide two important points that are worth repeating. First, outside of Sequoia, cooking seems to have been the primary function of pots, whereas in Sequoia serving is distinctly mentioned. The origins of pottery, then, are likely to relate to these objectives. Second, if Steward's account of specialization and exchange in Owens Valley is correct, the beginnings, spread, and proliferation of pottery may have been encouraged by certain enterprising women in their desires to reduce the risk of resource shortfall. Convincing others to use pottery for cooking (and serving) various foods, rather than pits, baskets, gourds, or stone or steatite bowls, may have been a motivating factor for these women, and may account for the origins of pottery-making.

Archaeological Studies of California and Great Basin Brownware

Archaeological study of brownware in California and the Great Basin is still in its infancy. Although long recognized as a common but minor component of late prehistoric sites in the region, its main role in archaeological interpretation has been as a chronological marker. The section below reviews archaeological discussions of pottery in California (outside of the Patayan area in and around San Diego in extreme Southern California and Siskiyou Utility Ware in Northern California) and the Western Great Basin.

The history of ceramic study is relatively long, but its role in understanding prehistoric behavior has been almost negligible. Early work was concerned primarily with describing pottery, defining different wares and types, and reconstructing the diffusion and spread of the trait among Native peoples (Pippin 1986). The earliest work is by Alfred Kroeber (1922, 1925) during the 1920's, who began to describe pottery from different parts of California, including Eastern California in the Western Great Basin and the Western Sierra Nevada. Although his descriptions were cursory and general, they did establish the general distribution of pottery-making across the state. Citing the divergent styles of manufacture, decoration, and overall appearance, Kroeber felt that pottery-making in this region was not related to agriculture and was not an extension or diffusion of the Southwestern style, but was an indigenous development (although he did relate pottery from the Colorado River and San Diego area as influenced by Southwestern styles). Kroeber found this pottery to be very crude and "wanting" and did not discuss the craft further, such as considering potential functions of pots or how the technology fit in with a mobile lifestyle.

Similarly, Steward (1928) briefly described pottery from Deep Springs Valley, with the goal of extending the known distribution of pottery making. Steward also felt that the craft did not diffuse from the Southwest or Colorado River into Deep Springs Valley, but instead likely diffused from west of the Sierra Nevada region in the San Joaquin Valley where it was an indigenous development. Steward (1933: 266-269) continued this work a few years later with a study of pottery from Owens Valley, again suggesting that the craft did not have relations to the Southwest. Steward (1929, 1933) did suggest the pots probably served as general cooking vessels, but judging by his comments and extent of his discussion was not particularly impressed with the craft.

This concern with diffusion, description, definition of wares and types continued during the ensuing decades, when several wares and types were defined by different archaeologists. In the 1950's Riddell (1951) formally defined Owens Valley Brownware as a category. Later Riddell (Riddell and Riddell 1956) considered possible geographic origins for the technology and how it diffused across the region. To the west Fenenga (1952) defined Tulare Plain Ware to describe pottery from the South-Central Sierra Nevada. However, he did little else than describe the pots sherds, and interestingly, did not propose an origin or direction of diffusion for the craft. To the south and east Baldwin (1945, 1950) defined Southern Paiute Utility Ware to describe pottery from Southwest Nevada. To the east of the study area, Shoshoni Ware has often been discussed. Early descriptions of this pottery type come from a paper read by Prince in 1959 (and reprinted in 1986), Rudy (1953: 94-96), and Touhy (1956). A study of Shoshonean pottery by Coale (1963) also sought to differentiate late prehistoric Great Basin from Southwestern pottery. Based on thin section comparisons to pottery from Inuit cultures of North America, Coale felt the craft probably diffused to the Great Basin from regions to the North. Finally, Mulloy (1958) collapsed many of these categories and defined Intermountain Ware as flat-bottomed pots attributable to the Shoshone people.

Slightly earlier, and further south and east, Colton (1939) defined Tizon Brownware and 15 different sub-types for pottery from western Arizona. These terms were eventually adopted and used to describe much of the pottery from the Mojave Desert (King and Casebier 1976; Lyneis 1988) and the surrounding area. For example, Hunt (1960) used these categories to describe much of the pottery from Death Valley. In addition, Hunt added new categories such as Death Valley Brown Ware to define pottery tempered with schist from the Johnnie formation.

A concern for the identification of ethnicity and diffusion of pottery has been a continuing theme in pottery studies from the 1960's to the present. For example, Elsasser (1960) used Riddell's description of Owens Valley Brownware to discuss possible contact between Owens Valley groups and Western Sierra ones, and the diffusion of the craft from eastern Nevada and Utah to the Western Great Basin and eventually the Western Sierra. In the 1970's, using different ware types, Madsen (1975) examined the distribution and temporal affinity of ceramics to date the expansion of Paiute-Shoshonean speakers in the prehistoric Great Basin. Madsen felt that pottery marked the spread of these people around AD 1000-1300 and that resource stress and competition between Numic speakers and Fremont agriculturalists was an important factor in the disappearance of the latter. Rhode (1994) continued this line of study with a pilot thermoluminescence study to date more directly brownware from the region. Although he ultimately relates the dates back to the timing of the Numic spread, his study does demonstrate that pottery-making is a late phenomenon in the region. Outside of one sherd dating to AD 1080 ± 100, all other potsherds date after AD 1400. In a similar manner, Marceau (1982) examined the distribution of steatite bowls and Intermountain pottery in Utah, Wyoming, and Idaho. He used these data to argue that the two artifact classes were made by distinct cultures occupying different parts of the prehistoric landscape. Wright (1978) has also visited these issues with brownware in Wyoming to examine the movement of ethnic groups into the region.

Although there are important exceptions, the late 1970's and 1980's witnessed a continuation of the ware and type discussions. Many papers in the important Great Basin ceramics volume edited by Suzanne Griset (1986), still concern themselves with providing descriptions of pottery from different regions. Outside of one article concerned with Fremont ceramics, seven of the remaining ten articles describe assemblages or the distribution of ceramics in different regions. Similarly, May (1978, 1980) has discussed different types and wares from Sierra

Nevada and Southern California, Johnson (1990) described and defined a Cosumnes Brown for pottery from the Sacramento area in California, and Plew (1979) proposed a Southern Idaho Plain category for pottery from that area. Though outside the study area, Mack (1986, 1990) defined Siskiyou Utility Ware in Northern California and Southern Oregon. However, in Mack's case (particularly the 1990 article), the analysis of the pottery has gone well beyond merely defining the pottery, to discussing possible uses. Mack (1990) suggests that pottery from this area was used mainly to serve fish oils and other foods, rather than to cook foods or store things.

It seems that by the mid 1980's, many archaeologists were becoming increasingly confused by the definition of all the different ware and type categories, and at least some authors (e.g., Pippin 1986, Prince 1986) felt that the field was in serious need of revision. It had been suggested at times (e.g., Mulloy 1958) and extensively discussed by Pippin (1986), that the definition of all these different types created more problems than understanding. A number of publications in recent years reflect this frustration (e.g., Bettinger 1986; Butler 1981; Dean 1992; Eerkens et al. n.d.; Pippin 1986; Touhy 1990; Touhy and Strawn 1986). Many of these studies suggest that as more data on individual assemblages have been collected, more variability within defined wares or types has been recognized than exists between these categories. These researchers suggest that either the typologies are useless and should be abandoned, or more rigorous comparative data needs to be collected before the typologies can be applied.

Indeed, recent attempts to move ceramic research away from the confines of traditional ware and type categories have met with much success. For example, research employing thin section analysis (Lyneis 1989; Touhy 1990; Touhy and Strawn 1986) has not only questioned the basic ware categories mentioned above, but also demonstrates that much pottery appears to be locally made within regions. This information, of course, is directly relevant to settlement strategies and how ceramics are incorporated into residentially mobile cultures. Several studies also attempt to study function of ceramics within these settlement strategies (e.g., Lockett and Pippin 1990; Mack 1990; Plew and Bennick 1990; Touhy 1990). Although not arriving at any concrete and widespread answers, the studies suggest boiling and serving may have been important functions of Great Basin pots.

A study by Simms and Bright (1997) in the Eastern Great Basin is an excellent recent example of not only recognition of inherent variability in brownware ceramics, but interpretation of it in behaviorally meaningful ways as well. Simms and Bright examine several attributes of hunter-gatherer pottery in northwestern Utah, including temper size and composition, wall thickness, and surface smoothing, and compare these to pottery from more sedentary Fremont agriculturalists from same the region. They find significant differences in temper size and wall thickness and relate these differences to the amount of time invested in ceramics. Although their model does not accord well with data produced in this dissertation (see Chapter 4), their study is significant in that it moves beyond the typological issues discussed above and takes ceramic analysis in a new and informative direction.

Finally, dating ceramics has been a topic of some concern in recent years. Unfortunately in most regions the number of dates associated with ceramics is either small or zero. Outside of the study by Rhode (1994) mentioned above, direct dating of ceramics is nonexistent. Rhode's study suggests a relatively late date for the inception of brownware pottery use, certainly after 1000 BP, and likely after 600 BP for most regions.

These data are supported by a number of studies. Pippin (1986) reviews radiocarbon data from the Central Great Basin and concludes that the data are minimal. After discounting a number of tenuous older dates, Pippin finds that the only securely dated contexts with pottery include those postdating 500 BP. The earliest of these accepted dates occurs at Hogup Cave at 480 ± 80 BP, while a number of sherd assemblages are firmly associated with later dates between 450 and 200 years ago. Wright (1978) arrived at a similar conclusion in Wyoming where the oldest secure contexts are dated to 450 ± 80 BP, and many assemblages postdate this figure.

The most thorough review comes from Delacorte (1999) in Owens Valley. A reproduction of his data is produced in Table 3.2 below, which examines radiocarbon dated house floor features in the region and the number of pot sherds unequivocally associated with each. His data show that brownware pottery is not associated with any feature dating earlier than 780 radiocarbon years BP. Although a single sherd from Iny-3806 is associated with a house floor feature dating to 1180 BP, this sherd is unlike brownware from the region and suggests early experimentation with the craft (Eerkens et al. 1999). On the other hand, every house floor feature dating after 780 BP is associated with pottery. An important point here concerns Structure 13 at Iny-30, which has been dated to 710 BP. This feature has an intrusive pit containing pottery overlying, and dug into, the floor deposit, suggesting a later age. I have personally examined the artifact collection from this feature, and several sherds which are attributed to the undisturbed floor context are identical in color, form, paste, and temper composition to sherds clearly associated with the intrusive pit. These findings suggest that the sherds associated with Structure 13 are likely to be intrusive and of a later age than the dated floor.

Thus, Delacorte's review shows that pottery-making in Owens Valley dates no earlier than 700 BP, and most likely was introduced around 500 BP. However, outside of Structure 13 at Iny-30, there are very few excavated structures that have been dated to the interval 500-700 BP. Thus, it remains to be seen whether a ceramic technology was introduced earlier (around 700 BP) and we have not yet excavated such sites, or whether the craft was introduced later, around 500 BP, as the data hint.

Table 3.2: Pottery from Owens Valley and associated radiocarbon dates

Features with Pottery		
Site	**Context**	**^{14}C Date**
Iny-30	Structure 9	180 ± 60
Iny-5207-2	Structure 1	270 ± 60
Iny-30	Structure 10	390 ± 90
Iny-30	Structure 5	410 ± 80
Iny-1700	Structure 16	425 ± 100
Iny-3769-13	Structure 1	430 ± 40
Iny-30	Structure 1	470 ± 70
Iny-30	Structure 7	480 ± 60
Iny-30	Structure 13	710 ± 70

Features without Pottery		
Site	**Context**	**^{14}C Date**
Iny-3769-5	Structure 1	780 ± 110
Mno-2197	Structure 2	870 ± 50
Iny-3806	Structure 1	1160 ± 60
Mno-2194	Structure 2	1190 ± 70
Iny-4646	Stratum II	1190 ± 70
Iny-3806	Structure 2	1400 ± 80
Iny-30	Structure 15	1460 ± 60
Short Stop	Structure 3	1565 ± 100
Iny-3812	Structure 1	1600 ± 60

Notes: Data from Delacorte 1999: 63. Iny-5207-2 refers to Locus 2 at Iny-5207.
Dates are in uncorrected radiocarbon years BP.

Unfortunately, dates on brownware pottery are lacking in a number of regions, including many considered later in this dissertation. A single date of 580 BP from the basal stratum of Tul-2132 in Sequoia National Park (Tom Burge, personal communication) is worth mentioning in this regard, and indicates a maximum age depth of the craft at that site. However, dates from regions including the Northern Mojave Desert and Death Valley are lacking. Thus, the majority of information indicates that although occasional experimentation with the craft exists slightly earlier, large scale adoption of pottery only takes place after approximately 500 years ago. Of course, it is likely that the exact timing of the introduction of pottery varies from region to region, and may, in fact, have been adopted and abandoned several times in different areas.

In sum, a division of western Great Basin pottery into more meaningful temporal or spatial categories has thus far eluded archaeologists working in the area (Bettinger 1986; Lyneis 1988; Pippin 1986). Part of the problem is the inherent variability in California and Great Basin brownware. Moreover, the existing ware and type categories are difficult to use in practice. Descriptions as they exist in printed text are especially hard to apply to new assemblages without direct visual comparisons of assemblages to one another. The fact that pottery is scant at most Great Basin sites, usually less than 200 sherds per site, and that collections from particular regions are often spread across a number of different museums throughout the country, certainly does not make cross-comparison any easier. As a result of these problems and others, the ware or type division has not been successful. I suggest archaeologists should probably abandon this approach, or at least suspend it until better techniques can be used to create new and more robust typologies (as discussed in Chapter 7). Instead, studies that focus on variability within assemblages, rather than central tendencies as the ware or type approach requires, are likely to be more successful. Focus on variability, as Simms and Bright (1997) demonstrate, can be quite fruitful, and is the approach followed in this dissertation.

Frustrated with the lack of a working typology, many researchers have not pursued pottery studies further than basic counts and occasional descriptions of sherd assemblages. As a result, study of California and Great Basin pottery has really lagged behind that undertaken in other parts of the country. However, as discussed in Chapter 7 (see also Eerkens et al. 1998, n.d.), pottery *can* be grouped into informative types relating to original locus of manufacture using chemical methods. This line of inquiry offers the potential to help in the division of pottery into finer categories, but is more expensive and slower than visual identification. This study also provides new avenues of research by making a cross-regional comparison of pottery technology, form, shape, and use.

CHAPTER IV

TECHNOLOGICAL ANALYSIS OF WHOLE POTS AND POTSHERDS

Archaeologists working with ceramics in many parts of the world are increasingly interested in determining pot function based on formal attributes of vessels (e.g., Braun 1980, 1983; Hally 1983; Juhl 1995; Linton 1944; Skibo 1992; Smith 1985). This research is an outgrowth of the desire to move beyond chronology building and determination of ethnicity, common in most early ceramic analysis, to a research program that retrieves more information about prehistoric behavior from the artifacts we study. Recent ceramic research aims to interpret pots as tools, made with specific ideas as to how they were to be used and subject to physical laws that determine their suitability for different functions. These studies assume that potters were aware of the advantages and disadvantages of different pot attributes and were able to manipulate them without too much trouble to serve their needs. The field includes two main foci, studying alteration of vessels based on use, such as scratches due to ladling or carbonization due to sitting over an open fire, and studying shape, composition, and size attributes, such as wall thickness, temper types, or mouth opening diameter. I focus mainly on the latter.

This chapter has two goals. First, I describe the range of pottery made ethnographically and prehistorically in the area to gain a better understanding of the types of pots made and construction techniques used. This goal is approached through a study of California and Great Basin ethnographic pots and archaeological pot sherds housed in various museums. In particular, the study focuses on whole pots and rim sherds.

Second, I apply some of the theories on pottery function to the database assembled to learn more about how pots were used. It is hoped that a better understanding of both central tendencies as well as regional variability of vessel attributes will speak to the role that ceramics played in the study area. The analysis is geared mainly towards understanding the economic (or technonomic) aspects of pottery use, rather than ideological or symbolic (ideotechnic or sociotechnic as per Smith 1985) aspects, that is, the analysis is concerned with how pots are used to transform, transmit, transport, or store matter and energy.

Theory and Significance of Attributes

Archaeological studies of vessel morphology frequently divide pots into a number of different functional categories. Categories most often recognized include storage (often divided into short-term and long-term, and/or wet and dry storage), transport (often subdivided into vessels for liquid vs. solid transport), serving (usually subdivided into vessels used by individuals vs. groups), mechanical processing, and cooking. Although different types of cooking exist (e.g., boiling, broiling, roasting, parching) and different products are cooked in pots (e.g., meat, seeds), the effects of these different techniques and products on pot morphology have not been well studied by archaeologists (Smith 1985; though see Bennison 1999; Braun 1983, 1987; Linton 1944; Reid 1990). The following section considers how different pot attributes relate to these activities and how archaeologists have used them to infer vessel function.

Vessel volume and orifice size are most often related to different functional categories. For example, ethnoarchaeological work suggests that long-term storage vessels have the largest volumes, while serving vessels have the smallest. This stems from the fact that it is more economical (in terms of ceramic raw materials as well as time spent making pots) to make a single large pot for storage than several smaller ones. Moreover, weight is usually not a concern since storage vessels are rarely moved. At the same time, orifice size, particularly relative to volume, tends to be minimized in storage vessels (i.e., narrow mouth, big body) and maximized (i.e., large mouth, small body) in serving containers (Juhl 1995; Smith 1985). This stems from the desire to restrict access to contents in storage vessels, that is, to keep out pests, water, and sunlight that might consume or spoil stored resources, and to provide easy access to contents in serving vessels, so that they can be freely consumed. The intersection of these two design constraints often leads to storage vessels that have large bodies but narrow necks and mouths, often resulting in incurved or recurved rims, and serving vessels that have smaller bodies but large mouths, resulting in direct rims. These attributes are especially pronounced in liquid storage and transport containers. Here, the need to prevent evaporation and spillage leads to the smallest mouth diameters relative to volume for any class of pot. These containers, then, have large bodies with extremely narrow openings (Henrickson and McDonald 1983; Smith 1985).

An important consideration in the case of cooking pots relates to method of cooking and rim and neck shape. When heated from the lower region of the vessel, heat generally escapes from the pot through the mouth by the evaporation of water. Constricting the mouth with an incurved or recurved rim conserves heat within the pot and maximizes heating efficiency. However, if the contents are to be boiled, constricting the rim will cause heat to build up at the mouth, and likely result in explosive overboiling (Juhl 1985). In addition incurved or recurved rims restrict access to the pot interior, and inhibit activities such as stirring and scooping out contents that are part of the cooking process. Thus, pots used to boil foods should display relatively direct and unrestricted rims.

Wall thickness is also often discussed by archaeologists. Thickness is a relative attribute (to the overall size of a pot) and represents a compromise between strength, particularly resistance to mechanical shock (or impact stress), heating efficiency, total vessel weight, and the amount of raw materials needed. Thicker pots are stronger and less prone to cracking and breaking, but they are also heavier, do not transfer heat as effectively, and require more clay to make (Braun 1983; Smith 1985). Where weight is an important consideration of the overall function of the pot, such as long-distance transport, thickness will tend to be minimized. On the other hand, where resistance to mechanical stress is most important, such as in processing and serving, pots should be thicker. In the case of cooking, however, vessel thickness is modified by the need to conduct heat and increase resistance to thermal stress. Thinner pots conduct heat more efficiently by bringing contents into more direct contact with the source of heat. As well, thin pots are more resistant to thermal shock since the temperature difference between the inner and outer surface is minimized, causing less tensile stress due to thermal expansion (Lawrence and West 1982: 226). Thus, pots intended to be used over higher cooking temperatures should be thinner. Storage pots, since they are not exposed to heat and do not need to conduct it, tend to have thicker walls. Ethnographic data suggest that dry storage pots have thicker walls than wet storage vessels (Henrickson and McDonald 1983).

Surface treatment is also recognized by archaeologists as an attribute affecting function. The heating efficiency of cooking pots can be modified by maximizing the surface area of the pot exposed to heat. Leaving the exterior surface unfinished, or actually roughening it, increases the surface area relative to a smoothed surface, and increases the amount of heat absorbed and transferred (Juhl 1995; Lischka 1978: 227). On the other hand, burnishing or glazing the surface prevents liquid from escaping and evaporating and also minimizes heat transfer. Liquid storage and transfer pots, then, should display intentionally smoothed or glazed surfaces (Henrickson and McDonald 1983; Reina and Hill 1978). At the same time, liquid contents can be kept cooler by promoting evaporation (Rye 1976: 113; Shepard 1965: 126). Thus, depending on the product and the need to keep contents cool, some storage vessels may be made extra porous by leaving an unfinished or roughened surface. Smoothing the interiors may also make extraction of contents more efficient and also reduces wear that would introduce grit into a food product. This is especially valid for cooking and storage pots.

Rye (1976: 113) discusses the advantages of heat retention, as measured by pot color, for different purposes. Rye suggests that in arid areas white or light colored pots are particularly well suited as water storage vessels due to their ability to reflect rather than absorb heat. Cooking pots, on the other hand, need to be darker in color in order to retain and absorb heat. As Rye points out, carbon staining from fires can partially serve this process, but the overall beginning color is important as well. Unfortunately, the original color of a pot is difficult to determine from archaeological sherds alone. Sherds are particularly prone to post-depositional alteration of color, and as refitting often shows, conjoining sherds are frequently of different color.

Finally, much has been written about the effects of temper on vessel function (e.g., Braun 1983: 122-125; Bronitsky and Hamer 1986; Feathers 1989; London

1981; Reid 1984; Rye 1976; Sampson and Vobel 1996; Shepard 1968: 24-31; Skibo et al. 1989). The most commonly recognized role of temper includes counteracting excessive shrinkage during drying and firing and increasing resistance to cracking (particularly due to thermal stress). The larger the temper, the less prone pots are to breakage during drying and firing (Shepard 1968). Temper can also help increase resistance to thermal stress by creating pores within the walls to help stop the propagation of cracks (Braun 1983: 123; Lawrence and West 1982: 225; Shepard 1968: 27). This is particularly true of organic temper (such as grass or dung) that burns off during firing, leaving vugs within the vessel walls. Similarly, the driving off of water adsorbed to mineral temper during firing also leaves vugs, and experiments suggest that organic and mineral temper have similar thermal shock resistance (Skibo et al. 1989). Moreover, the addition of temper also seems to increase heat transfer efficiency and accelerates the drying process (Skibo et al. 1989). On the other hand, the addition of temper weakens resistance to mechanical stress, such as impact from falling on the ground (Bronitsky and Hamer 1986; Skibo et al. 1989). This seems to be especially true of overly dense or overly large temper. Increasing firing temperature also seems to have a positive correlation to resistance to mechanical stress (Skibo et al. 1989).

The type of temper added is also important. Addition of temper with different thermal expansion qualities than the fired clay, such that the temper expands at a different rate during cooking or firing, can cause spalling and breakage (though Woods 1986 disagrees, and cites several ethnographic examples where potters purposefully add temper with quite different thermal expansion properties than the fired clay). Quartz is particularly poor in this regard, expanding much faster than most fired clays. Feldspar, hornblende, calcite, and crushed sherd are much better (though calcite has other problems, see Rye 1976). Thus, a compromise must be reached between adding temper with the right thermal expansion properties to increase resistance to thermal stress and minimizing temper to increase resistance to mechanical stress. Resistance to thermal shock, or repeated cycles of heating and cooling, is particularly important for cooking pots.

Organic temper is particularly effective at reducing the weight of pots, while still providing increased resistance to thermal shock (London 1981; Reid 1984; Skibo et al. 1989). Organic temper is also good for absorbing water in overly wet clay which may speed up the production of pottery by eliminating the time-consuming steps usually taken in drying clay. However, organically tempered pots are less resistant to impact stress and abrades easier. In addition, experiments suggest that while organic temper is efficient at transferring low-temperature heat, it is difficult to get water to boil (Skibo et al. 1989). Consequently, organic pottery is usually associated with expedient ceramic technologies (Skibo et al. 1989). Shell temper seems to be particularly effective for a number of the properties mentioned above. However, as it is unknown in California and the Western Great Basin it is not considered further.

In sum, the addition of temper of any type is particularly important for cooking pots. For cookpots, large, but not too large, mineral temper with similar thermal expansion properties as the clay is preferable. Organic temper is a decent substitute to speed up the manufacturing process and to lighten vessel weight, and is certainly better than untempered clay, but suffers from decreased impact strength. For other types of pots not regularly exposed to heat, such as storage, transport, or serving vessels, the addition of temper should be minimized to just above the level where cracking during drying and firing are avoided. Since thermal shock resistance is unimportant, firing temperature should be maximized and temper minimized. This suggests that storage, transport, serving, and processing vessels should, in general, have less temper than cooking pots. The results are summarized in Table 4.1.

Table 4.1: Summary of expectations for pot functions.

	Volume/ Orifice	**Rim Forms**	**Wall Thickness**	**Surface Finish**	**Temper Density, Size, and Type**
Dry Storage	Large	Incurved Recurved	Medium	None	Small S&D. Mineral.
Dry Transport	Medium	Incurved Recurved	Small	None	Very small S&D. Organic.
Liquid Storage	Largest	Incurved	Small-Medium	Waterproof-None	Small S&D. Mineral.
Liquid Transport	Largest	Incurved	Smallest	Waterproof-Smooth	Very small S&D. Organic.
Serving	Smallest	Direct	Medium - Large	Decorated	None - Small S&D. Mineral.
Processing	Small	Direct	Large	Variable	None - Small S&D. Mineral.
Cooking	Small - Medium	All	Medium - Small	Rough	Medium S&D. Mineral or Organic.

Notes: S&D – Size and Density.

Sample

Data were collected from two main sources for this study. First, whole or near-complete pots housed in various museums were studied. This data set includes both archaeological and ethnographic specimens. Unfortunately, there are not very many complete pots and they are spread over a large number of museums. As a result, the data set includes mainly pots from Sequoia National Park (18), Death Valley (15), Owens Valley (nine – mostly from the central and northern parts), Rose Valley (six – collected in the Olancha dune fields to the south of Owens Lake), and the Coso-China Lake area (five) with a few additional pots scattered across different regions. Many more pots surely exist in various collections (including private ones) and future study could expand the database manifold.

The second and more complete source of data for this study comes from archaeological sherds. For this study, only rim sherds that were large enough to estimate a number of attributes of interest were used. Although restricting the study to rim sherds decreases the potential pool of available data points (i.e., many collections contain only body sherds), these sherds contain more information about vessel form than do body sherds and also provide a degree of standardization across the data set. For example, Great Basin pots often vary in thickness across the height of a pot so that sherds near the rim are generally thinner than those near the base. Since it is impossible to tell from where a body sherd is derived, using only rim sherds provides some standardization to the study. An attempt was made to ensure that each rim sherd represents a distinct and unique pot. Thus, many potential specimens were omitted from the study because they were from the same site and were either found near one another or were similar in formal appearance, suggesting they might have been from the same broken pot. Such a sampling scheme will tend to overestimate diversity by eliminating certain pots that were made in the same fashion and from similar sources of clay as others within the same site.

In total, 318 rim sherds from 11 different regions were included in the study. For the most part, this sample reflects the range of rim sherds analyzed by INAA in Chapter 7 (although the INAA sample includes 137 body and base sherds as well). However, in the case of Southern Owens Valley and Death Valley the rim sherd sample is greatly enlarged over the INAA sample.

The whole pot and rim sherd data sets have both advantages and disadvantages. Obviously, different characteristics are visible in each. For example, it is difficult or impossible to estimate vessel height or total volume from rim sherds alone. Similarly, it is difficult to determine the type, size, and density of temper used as well as construction techniques from whole pots without breaking them. The best situation is when archaeological sherds have been refitted to *nearly* reconstruct an original pot, for then attributes of the whole pot as well as construction and temper can be recorded and measured. Unfortunately, it is rare in California and Great Basin archaeology to attempt full excavation to recover all sherds of a pot, or even to undertake large-scale refitting studies, due probably to time and money constraints.

On the other hand, most "ethnographic" specimens have poor locational information. For example, many whole pots were found by casual collectors in the first half of the 20th century and do not have precise spatial information. In fact, some pots had to be omitted from the study because they were only labeled as coming from "Inyo Country" or "California", a scale too broad for this study. Moreover, there is the danger that many of the ethnographic pots were not at all intended to be used by the producer (e.g., made to be sold in the tourist industry).

Such pots, then, could be made in manners alternative to the “traditional” way, giving data at odds with archaeological collections. Given the fact that by the early 1900’s few Paiute and Shoshone knew how to make pots, ethnographic specimens seem particularly prone to this problem. Indeed, analysis of some ethnographic pots from Death Valley shows that they are wholly unlike any archaeological pot in form or in chemical composition (Eerkens et al., n.d.). In fact, Steward (1933: 268) reported in 1933 that a Death Valley man had recently revived the art for commercial purposes. A similar situation has been described for Death Valley baskets (Sennett 1988, 1992). These clearly aberrant Death Valley pots were not included in the analysis discussed below.

The rim sherd sample derives from samples collected in a range of locations, including valley bottom areas and more upland locations (Papoose Flat and the White Mountains are good examples of the latter). However, the vast majority are from valley-bottom locations (not surprisingly, the area where sherds are most common, see Chapter 5). Although it would have been nice to standardize across different regions by a single environmental zone, the nature of the sample available for study (which itself is patchy in spatial coverage) dictated more of a “take what you can get” sampling design. Where possible, apparent differences related to environmental zone are discussed.

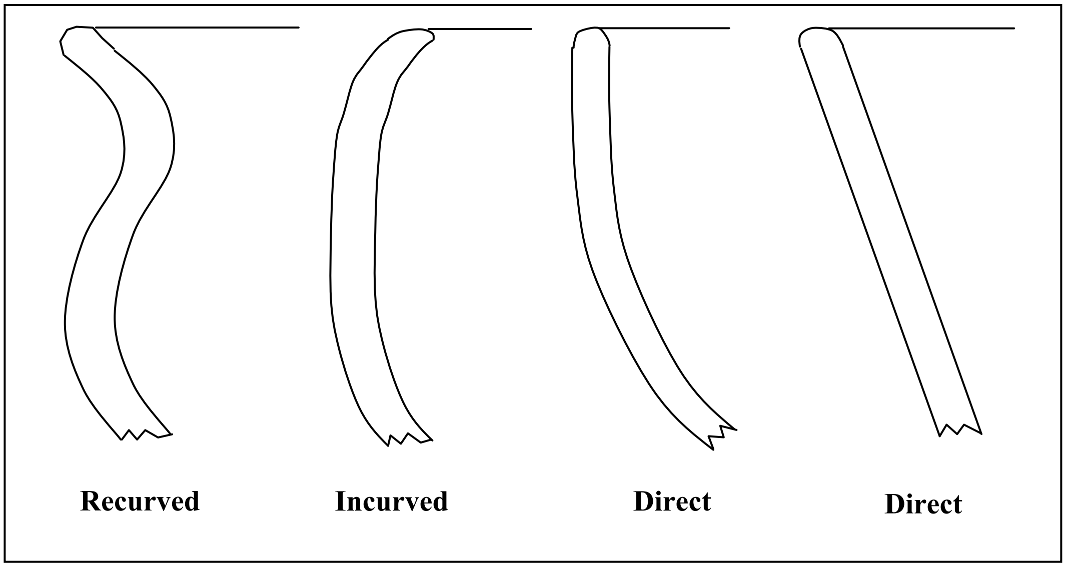
Measurements Taken

Where they could be determined, a number of different attributes were measured on each pot or sherd. As discussed below, these attributes are often thought to relate to overall pot function. Using digital calipers, *thickness* was measured to the nearest tenth of a millimeter at a location 1cm below the lip of the pot or sherd. Occasionally pot thickness appeared variable across the piece and in these cases a number of thickness measurements 1cm below the lip were taken and averaged. Mouth, or *orifice diameter*, was measured either by caliper, if more than half the mouth was present, or using a rim gauge by placing the sherd on a piece of paper with concentric circles and matching the sherd curvature to circles of known size. This measurement was taken to the nearest 2.5 cm. Both thickness and diameter are continuous attributes.

In addition, a number of nominal and ordinal measurements were taken. *Rim form* describes how the vessel wall behaves near the mouth. Five categories were originally recognized: incurved; slightly incurved; direct; slightly recurved; and recurved (or outflaring). Subsequently the slightly incurved and slightly recurved classes were collapsed into the direct rim category. Direct rims have their maximum diameter at the lip of the pot giving unrestricted access to vessel contents, while all incurved and recurved pots have more restricted mouth openings and maximum diameters below the lip or neck. Pots with recurved rims have necks and inflection points along the walls, while those with direct and incurved rims lack such features.

Incurved pots represent simple restricted vessels (Shepard 1968: 229). Figure 4.1 shows examples of the three different rim forms.

Figure 4.1: Rim and neck shapes recognized.



The method of interior and exterior *surface finish* was also recorded. Bettinger (1986; see also Griset 1988) recorded joint interior-exterior surface finish combinations for pot sherds and used this to examine inter-site differences in Central Owens Valley. Although this analytical approach was not followed, most of the same categories Bettinger used were recognized. Sherds were classified by their smoothness (rough vs. scraped vs. smooth) and the direction of surface finish or scraping, if one existed, including diagonal, vertical, horizontal, and random brush strokes.

The presence, type, and regularity of *decoration* was noted. Most decoration consists of fingernail impressions just below or on the lip of the exterior surface of the pot. Most often these impressions comprise a single row running around the pot parallel to the mouth opening. Occasionally a sharp tool rather than a fingernail was used to create the impressions. More rarely, fingernail impressions consist of several parallel columns oriented perpendicular to the mouth (i.e., each column running from the lip down the wall approximately 5-10 cm). Regularity of decoration was recorded by the Coefficient of Variation of the distance between design elements.

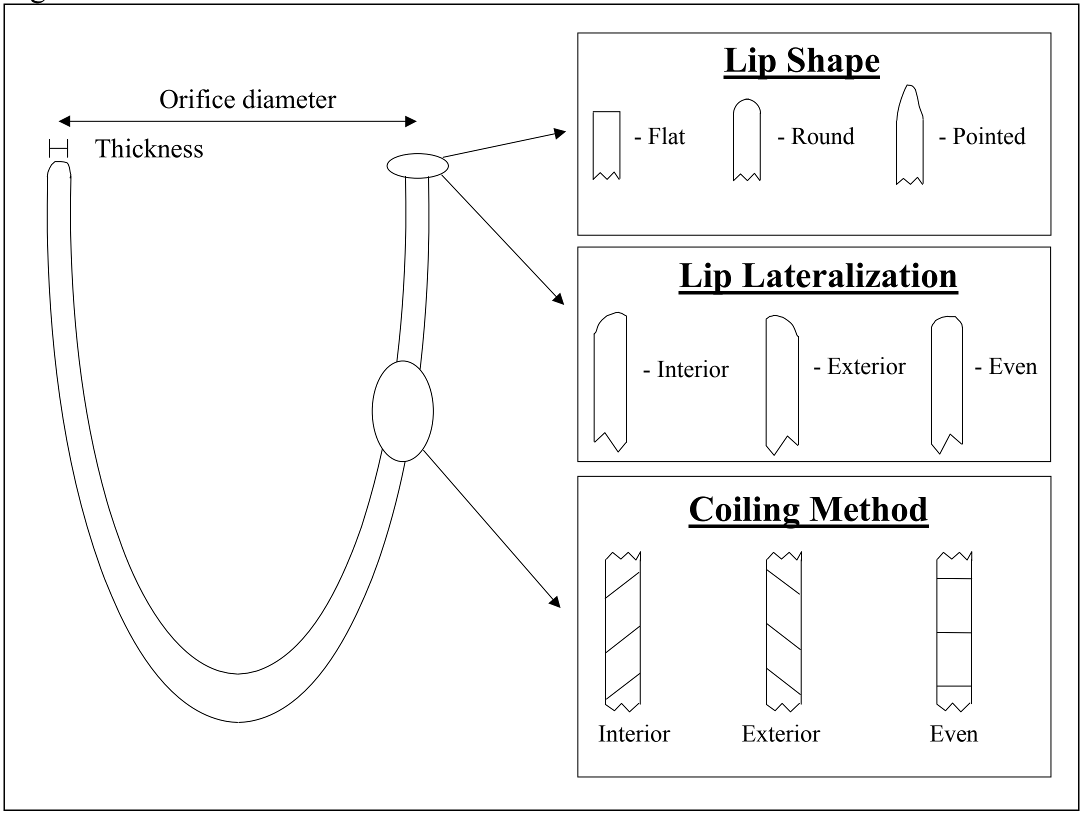
The *presence of handles* was also noted, as well as the length and size of such features. Only five complete ethnographic pots, all from Sequoia National Park, contained handles. Indeed, handles are generally unknown from other parts of the Great Basin, and were not observed on any archaeological pot sherds. These five pots, perhaps made and sold within the tourist industry, may represent cases where contact with Euroamericans influenced design and shape.

A fresh break on each archaeological sherd was also observed under low-power magnification (30 X) to determine *firing properties* and to examine the types, density, and average size of *temper* particles within each sample. Cores were noted for color and size, to estimate the firing atmosphere, whether reduced or oxidized. Cores with an orange to yellow color were coded as oxidized, while darker cores were coded reduced. However, it is conceded that core color may change depending on depositional conditions (for example if found on the floor of a house that was burned down). Estimates of temper type, size, and density are largely subjective in nature and were based on visual examination, hence only temper large enough to be seen through low-powered magnification was included. Sherds that appeared to contain less than 25% temper by total sherd volume were classified as low density, 25% to 50% temper was termed medium density, and greater than 50% temper by volume was classified high density. Apparent average temper particle size below 0.25 mm in diameter was considered fine, between 0.25 and 0.5 mm was classified medium, and larger than 0.5 mm was deemed coarse. The amount of organic temper and mica was also recorded. Organic temper, usually represented by vugs or empty spaces where organic material has been burned out of the sherd, was estimated by volume (0%, 10%, 20%, 30%, 40%, and 50% or greater), that is, the amount of space the vugs appear to contribute to total sherd volume. The density of mica was recorded on a more subjective scale from 0 (no mica present) to 5 (very large amounts of mica).

In addition to these categories often recognized as relating to vessel function, several other attributes were also recorded (see Figure 4.2). *Lip shape* was classified into five different categories grading from flat to pointed, which were later collapsed into three categories, including squared or flat, round, and pointed. The shape of the lip may relate to the rate of flow and/or drinking properties of the pot (if the pot was used for serving liquids). On the other hand, this trait may also simply be a stylistic preference of the potter or a result of construction technique. Lips that displayed clear lateralization to the interior or exterior were also noted, that is, orientation towards the interior or exterior of the pot, rather than being aligned in the same plane as the neck or wall. Again, this attribute may not have any functional significance, but could relate to the rate of flow and/or drinking properties.

The method of melding or attaching coils together was also recorded. As seen in wall profiles, some sherds have coils which overlap on the interior, where clay from the upper coil was pushed or extended down onto the lower coil from the interior side of the pot. This can be seen in the wall profile where the area between coils angles down from the exterior towards the interior. Other pots have coils that overlap on the exterior, where wet clay was pushed down on the exterior to overlap with lower coils. Still other pots display coils that were not overlapped and were stacked vertically on top of one another. These three coil melding styles were encoded as interior, exterior, and even, respectively. The functional significance of this attribute is not known.

Figure 4.2: Potsherd attributes recorded.



A number of attributes were only visible on whole pots. *Maximum diameter* and *height* were calculated by caliper or ruler to the nearest centimeter, and reflect the largest dimension of the pot in the horizontal and vertical direction respectively when the pot is standing upright. *Base shape* was recorded by three different classifications, flat, round, and pointed. Flat bases indicate a planar basal profile parallel to the mouth opening with walls coming off the base at well defined points. Rounded bases have no basal end points and the wall forms a continuous curve. Pointed bases indicate walls that come close to a point near the base. *Base diameter* represents the distance between basal end points, that is, the flatter basal area of the pot before the walls begin to significantly rise upward toward the mouth. On rounded pots this measurement represents the flatter area of the pot that appears to have been in regular contact with the ground (as evidenced by scratch marks and pitting). Pointed bases generally have very small base diameters.

Finally, not every attribute was measurable on every rim sherd. For example, although recurved rims are usually quite evident, some sherds did not extend far enough down the wall of the pot to distinguish between incurved and direct. Similarly, some sherds were not wide enough to reliably determine mouth diameter, particularly for sherds with large mouths. Overly small sherds where few attributes could be recorded with confidence were omitted from the study.

Results and Discussion

Description of Whole pots

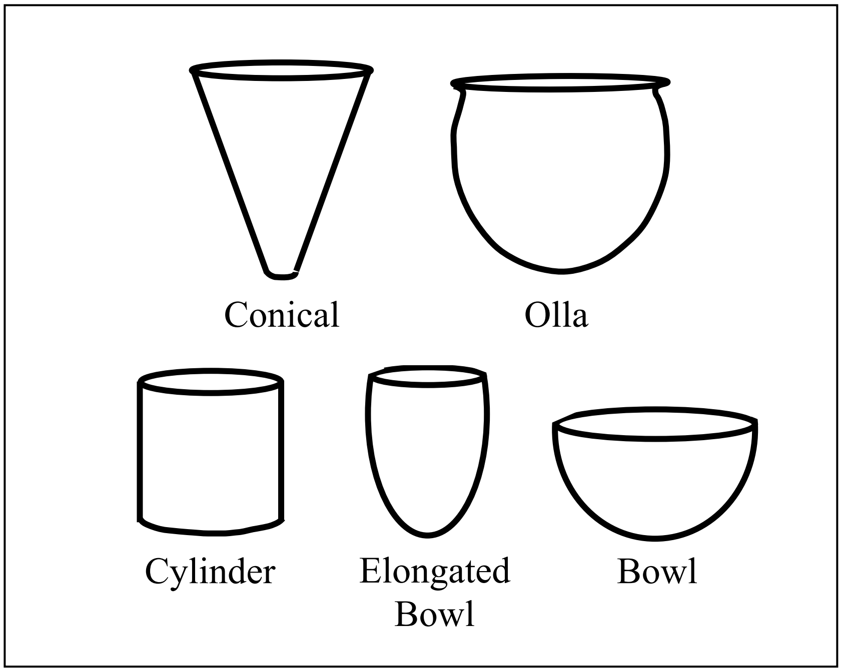
The whole pots provide an interesting data set to compare against archaeological sherds. As larger pots are less likely to survive whole into the present, this data set is likely biased towards smaller pots. Many of the whole pots appear to be distinctly burned on their exterior surfaces, suggesting they were used in aboriginal activities, likely cooking. As well, many pots contain carbonized residues adhering to the interior surface and four pots from Death Valley contained a thick layer of yellow organic residue of what appears to be mesquite.

Visual comparison of the whole pots suggested distinct differences in both shape and surface appearance between pots from Sequoia National Park and other areas. The Sequoia pots were often smoothed on their exterior and interior surfaces and appeared black in color, as opposed to the Death Valley, Owens Valley, and other Great Basin pots that were rougher on their surfaces and appeared more brown to orange in color. This smoothing may derive from the practice of burnishing described by Gayton (1928) for Yokuts pottery making. A number of the Sequoia pots also contained handles or lugs (5 of 17), a feature unknown for other parts of Central-Eastern California. Finally three Sequoia pots came in highly unusual shapes. Two pots had “boat-like” shapes, being greatly elongated along one axis, and a third water bottle had a very unusual outline with a very small mouth (approximately 10 cm in diameter). Due to their unusual forms, these three pots were not included in the study below.

The unusual pots removed, several basic shapes were recognized (see Figure 4.3). These basic shapes can be further modified by small changes in rim configuration or length to height ratios. The most common shape is the conical variety, with direct rims, flaring walls, and a small rounded to pointed base. This is the “typical” Great Basin form commonly depicted in archaeological texts and reports. Thirty-one of the 34 pots measured have this basic shape, including five of 14 Sequoia pots, ten of 15 Death Valley pots, three of six China Lake pots, eight of nine Owens Valley pots, and five of six Rose Valley pots. Conical pots range in height from 16 to 34 cm (average =21.3), have mouth orifice diameters ranging from 15 to 32 cm (average = 23.9), and have basal diameters ranging from 4 to 10 cm (average 7.7). Maximum diameter to height ratios range from 0.8 to 1.4 (averaging 1.2), and average wall thickness for these specimens is 5.6 mm. The majority of the pots are lightly tempered with smaller pieces of sand. Mica is occasionally present and organic temper is absent.

Classic bowl-shaped pots were next most common. Nine examples were measured, three from Sequoia, four from Death Valley, and one each from China Lake and Owens Valley. All bowls have direct to slightly incurved rims and rounded bases. Bowls walls average 5.0 mm, slightly thinner than conical pots. However, these examples have significantly smaller mouth openings (average = 17.7 cm), and are much shorter (average = 12.8 cm) than their conical counterparts. The diameters of the basal area on these pots are similarly small, averaging 8.2 cm. The ratio of maximum diameter to height ranges from 0.9 to 2.3 (averaging 1.6). Like the conical pots, these items tend to be lightly tempered with small pieces of sand, and mica is occasionally present and organic temper absent.

Figure 4.3: Common California and Western Great Basin pot shapes.



All six cylindrical pots were from Sequoia. However, two of the specimens have slightly flaring walls, like conical pots, but still have distinct and flat bases with angular corners. Also, the two flaring-walled specimens are distinctly shorter in height than most conical pots, suggesting they are more closely related to cylindrical vessels. These pots have direct to slightly incurving rims and large flat bases. Average height for these six pots is 12.7 cm, average mouth diameter is 18.4 cm, both significantly smaller than conical pots. However, as would be expected, basal diameters are significantly larger than either conical pots or bowls, averaging 15.3 cm, and walls are also significantly thicker, averaging 6.8 mm. Maximum diameter to height ratios range from 1.3 to 1.7, averaging 1.5. Temper among these pots is also different, being larger and more dense and containing more mica, than the other pots, even conical pots and bowls from Sequoia. This suggests these pots may have served a slightly different function.

Two pots were classified as elongated bowls with incurved rims and rounded bases (slightly egg shaped). Both pots are from the China Lake area and are relatively thin (4.8 and 5.2 mm). Small mouth openings (19.5 and 13.2 cm) relative to height (21 and 23.5 cm) and small basal areas (6.1 and 7.5 cm) characterize these pots. Ratios of maximum diameter to height are 0.8 and 0.9, suggesting a slightly elongated shape. I was unable to determine temper type, size, and density for one of the pots, while the second had low density and medium sized temper.

Finally, a single olla was examined from Death Valley. This pot type is bowl-shaped with a rounded base, but has a restricted and recurved rim. Interesting was that this was the only example of a recurved rim seen among whole pots, whereas a larger percentage of the archaeological rim sherds are recurved. This probably stems in part from the fact that the majority of the whole pots are from Sequoia, an area where recurved rims are rare. This single sample has a mouth opening of 18 cm and a maximum diameter of 24 cm below the neck. It is relatively squat at 14.5 cm high, and thick at 7.1 mm, and has a basal area of roughly 7 cm. The ratio of maximum diameter to height is 1.6. Temper is medium in size and density, and medium levels of mica are visible.

Table 4.2: Averages and CV's for regions with more than one whole pot.

Region	**No**	**Wall Thickness**		**Mouth Diameter**		**Height**		**Base Diameter**		**Median Temper Size**	**Median Temper Density**
		Avg.	**CV**	**Avg.**	**CV**	**Avg.**	**CV**	**Avg.**	**CV**		
ChinaLk	6	5.2	.13	176	.24	188	.31	70	.19	Medium	Low
Death V.	15	5.5	.16	215	.19	178	.32	68	.33	Medium	Medium
Owens V	9	6.1	.19	247	.25	226	.42	72	.18	Medium	Low
Rose V.	6	5.5	.22	221	.29	173	.46	75	.17	Low	Low
Sequoia	14	5.9	.23	192	.21	141	.39	123	.24	Medium	Low

Almost all the lips in the whole pot samples are rounded. Only three samples have flat rims, one conical pot from China Lake, one conical pot from Rose Valley, and one bowl from Sequoia, and two samples have pointed rims, an elongated bowl from China Lake and a conical pot from Owens Valley. Similarly, five pots have lips that are lateralized to the exterior, while the remainder are even. Thus, no apparent patterning in lip shape or lateralization is evident from the sample.

A comparison of whole pots to archaeological sherds is worthwhile in the Owens Valley, Death Valley, and Sequoia National Park cases, since a relatively large sample for each is available. As expected, average mouth diameter is smaller for the three sets of whole pots relative to sherds from the same region (since smaller pots are more likely to survive unbroken). In wall thickness and temper composition the Death Valley pots and sherds are similar. Similarly, the Owens Valley pots are slightly thinner but have similar temper constituents to archaeological samples. On the other hand, the Sequoia whole pots are slightly thicker than their archaeological counterparts and contain less mineral temper. This suggests that the Sequoia National Park whole pot sample may not be as representative of prehistoric pots as the Death Valley and Owens Valley samples. This conclusion is further supported by the unusual shapes mentioned earlier and apparent differences in surface finish between the whole pots and sherds. As mentioned, many of the Sequoia whole pots display a black and burnished finish on the exterior and often interior as well. Although sherds are often smoothed in Sequoia, the degree of smoothing is much less and rarely clearly burnished, and the surface color tends to be more brown than black.

Function of whole pots

Given the descriptions offered above, what can be made of the whole pot sample in terms of potential function? First, most pots have relatively accessible contents, with maximum diameters usually at or just below the lip and primarily direct rims (heavily incurved or recurved rims are rare, limited to three pots). These findings and the lack of fiber temper in the sample suggest that the pots were probably not used for liquid transport or storage (only two pots, both from Rose Valley, have any evidence of fiber temper). Such pots are usually much more restricted at their mouths. As well, except for the Sequoia pots, no pots show smoothed or waterproof surfaces as might be expected for liquid transport or storage vessels. Finally, the presence of dried foods in several of the Death Valley pots suggests they were used in association with solid foods rather than liquids.

Similarly, the overall large height and lack of decoration suggests that use as serving was probably not a major function of the pots. Henrickson and McDonald (1983) suggest that individual serving vessels have wide mouths, are usually decorated, range from 6 to 8 cm in height, and are often twice as wide as they are tall. Family serving vessels are often taller (averaging 14 cm in height) but are frequently even wider, over two and a half times as they are tall. Only three pots in the sample were decorated (unless smoothing is considered a decorative style). These include a bowl from Sequoia, which was decorated along the interior rim, a small bowl from Rose Valley, again decorated along the interior surface, and a larger conical pot also from Rose Valley decorated on the exterior below the lip. Similarly, only one pot was twice as wide as tall, the aforementioned decorated bowl from Sequoia, and only four pots were less than 10 cm high, two bowls from Sequoia, including the decorated one mentioned above, the decorated bowl from Rose Valley (also mentioned above), and a conical pot from Owens Valley. The lack of external burning on all three specimens also suggests they may have been used as serving vessels. Thus, of the total sample, only three pots really fit the description of serving vessels, the decorated Sequoia pot, the small decorated bowl from Rose Valley, and the small Owens Valley conical pot. Interestingly, two of these pots have decorations on the interior surface where only the user or consumer would be able to see them.

Dry transport is also an unlikely function of these pots. The near lack of fiber temper, presence of mineral temper, and large size of many of the pots suggests they were rather heavy and not efficient as transport vessels, particularly over large distances. As well, the large mouth openings and direct rims would have made the contents rather exposed and subject to spillage without some kind of cover. In this respect, baskets would have been much more efficient as transport vessels for dry goods.

Use as processing vessels is also not supported for most pots. In general, the majority of the pots are not built such that they would be especially resistant to impact stress. Most pots appear to be low-fired (although this may be more a product of technology) and have thin walls. However, the description of processing vessels in the archaeological and ethnographic literature, is limited and additional data is needed to more confidently reject this possibility.

Dry storage is a possibility for many of the pots, with the caveat that the contents of such storage vessels would have been relatively exposed without some type of cover. Dry storage vessels often have more restricted rims relative to the maximum diameter. As well, the relatively thin walls and temper types of many of these pots does not suggest particularly strong walls to withstand impact stress, as might be expected for storage vessels. On the other hand, if storage vessels are placed out of the way of traffic, resistance to impact stress might not be especially important to the function of such pots. Thus, provided that independent external covers were used and pots were stored out of the way of potential impact stress, these pots may have been used for storage.

However, the evidence at hand suggests primary use as cooking vessels. This comes from several lines of evidence. First, the relatively open mouths and unrestricted rims suggest ready access to contents was important. In cooking, access is important to occasionally stir and/or add foods. Second, the use of mineral temper suggests that resistance to thermal stress was an important consideration in the design of pots. Third, relatively thin walls combined with mineral temper also suggest that heat transfer was important. Fourth, many of the pots appear to be burned on their exterior as if they had been exposed to fire. In some cases sooting is extensive, suggesting repeated and long-term exposure to heat. Fifth, as mentioned, several pots contain remains of foods within them. These remains often form a congealed mass at the bottom and a horizontal line near the rim of the pot, a pattern that is typical of the boil line in pots. Finally, the Sequoia pots excepted, the pots were either rough or gently brushed on their interior and exterior surfaces. Such brushing marks and/or a rough exterior would increase the surface area, and hence, the potential heating efficiency of a pot. These patterns are all typical of ethnographically described cook pots.

One point deserves further discussion here. Cooking pots usually display rounded bottoms and lack sharp corners. Sharp corners tend to concentrate heat, causing thermal stress at these points, and inhibit even transfer of heat to the pot contents (Smith 1985; Rye 1976; Kingery 1955; though see Woods 1986 for a contrary discussion citing several ethnographic examples of cooking pots with flat bases and sharp corners). As discussed, the most common pot form is the conical pot shape, which consists of a relatively pointed base. If suspended over a fire, such a base might differentially absorb heat and eventually fail. However, it appears that the bases of these pots were rarely exposed to direct flame. Carbonization patterns on the exteriors of several conical pots suggests that flames hit the midsection of the walls rather than the base or rim, as if the base had been embedded in sand and a fire build around the pot. Indeed, this conical pot V shape may have made them unstable to stand on end, particularly when filled with food. Although most of the conical whole pots could stand upright unassisted on their small bases, a few were unable to do so. At the same time, many of the former did not appear particularly stable when standing upright and could have been knocked over with only a small amount of force applied to the rim. Partially inserting the base in a soft substrate may have given extra support to stabilize the pot, and this activity may explain the sooting patterns on the exterior surfaces. Bowls and elongated bowls, of course, contain rounded bases well adapted for cooking.

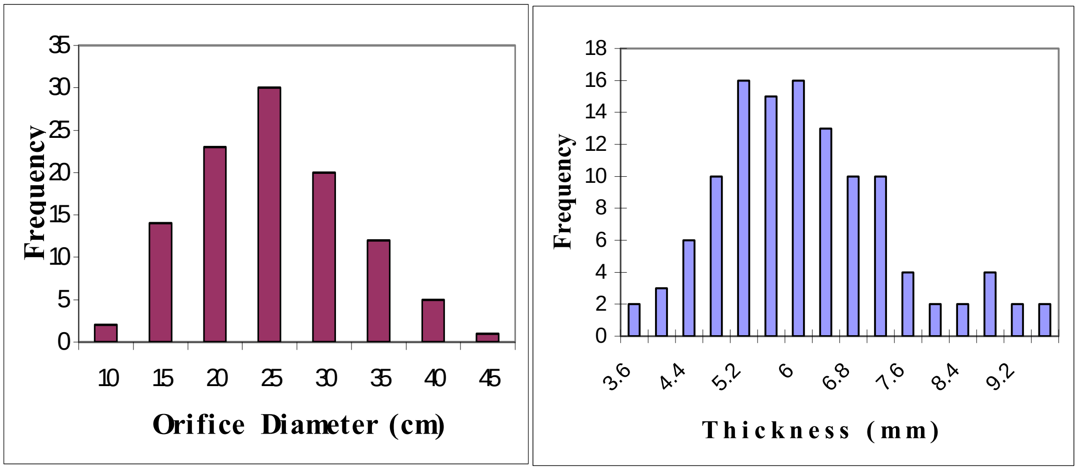
On the other hand, the cylindrical pots from Sequoia also display sharp corners that would have been exposed to heat had they been suspended over a fire. Such corners along the base may have been inefficient in heat transfer and a source of potential failure due to thermal stress. In terms of shape, then, these cylindrical pots may not have been particularly well suited to cooking. Moreover, as mentioned, the smoothed surfaces of these pots would also make them less heat efficient. It is likely then, that these cylindrical pots served other functions, such as dry storage and/or serving. As discussed in Chapter 2, serving is explicitly mentioned by Gayton (1948) as one of the main uses of smaller pots among the Western Mono in Sequoia National Park.

Description of Rim Sherds

The archaeological rim sherd sample is probably more representative of the range of pots made and used by prehistoric inhabitants of the area, not being biased by size. On the other hand, as mentioned, less information about overall pot shape is available from rim sherds alone. The section below describes the sample in greater detail, comparing sherds by region, and ultimately considers potential function based on patterns in sherd attributes.

Examination of histograms produced from the rim sherd data suggests that while mouth opening diameter is approximately normally distributed, wall thickness is less so. For example, Figure 4.4 gives histograms for rim thickness and mouth diameter for Southern Owens Valley rim sherds only (to standardize for a single region; n=117). A Kolmogorov-Smirnov test for normality on both distributions gives a value of 0.11 (p=.002) for mouth diameter, and 0.09 (p=.03) for thickness, suggesting that the former are more normal than the latter.

Figure 4.4: Histograms of thickness and rim diameter for Southern Owens sherds.



A similar result is obtained for Death Valley, as well as when all rim sherds in the study are combined and plotted together in histograms, suggesting the pattern is not peculiar to Southern Owens Valley. That mouth diameter is distributed in a normal fashion with a single mode and median, suggests that it is probably responding to single design constraint (whether imposed by social or functional restrictions). On the other hand, that thickness is not normally distributed and has more of a bi- or tri-modal distribution, suggests that this attribute is responding to more than one design constraint. Pots seem to be made with distinctly different wall thicknesses, some very thick with an average near 9 mm and others thinner with an average near 6 mm. The latter, in fact, seems to be spread over a large range, between 5 and 7.5 mm, suggesting that more than one optimal thickness may exist for pots responding to this design constraint(s).

Figure 4.5 plots thickness and diameter for all rim sherds and whole pots. A regression of these two attributes suggests no correlation ($r^2 = 0.01$). In an analysis of post-1550 BP rim sherds from west-central Illinois, Braun (1983: 121) found a similar pattern. On the other hand, earlier Illinois sherds displayed a much stronger correlation in the two attributes. Braun interpreted the earlier correlated pattern as indicating a concern for resistance to mechanical and thermal stress that was solved by increasing pot thickness. In this scenario, if potters wanted to make larger pots, as measured by the mouth opening, they had to increase the thickness as well. The later post-1550 BP uncorrelated pattern suggested to Braun that potters had developed new solutions to the size-thickness problem. Braun related these changes to the use of new temper recipes, in particular decreases in the density and size of temper that increased strength. In this way, potters could increase the heating efficiency of pots, by making them thinner, without sacrificing strength. Ultimately he correlated this change to the increased importance of boiling starchy seed foods in prehistoric diets.

Figure 4.5: Plot of thickness and diameter for all rim sherds and whole pots

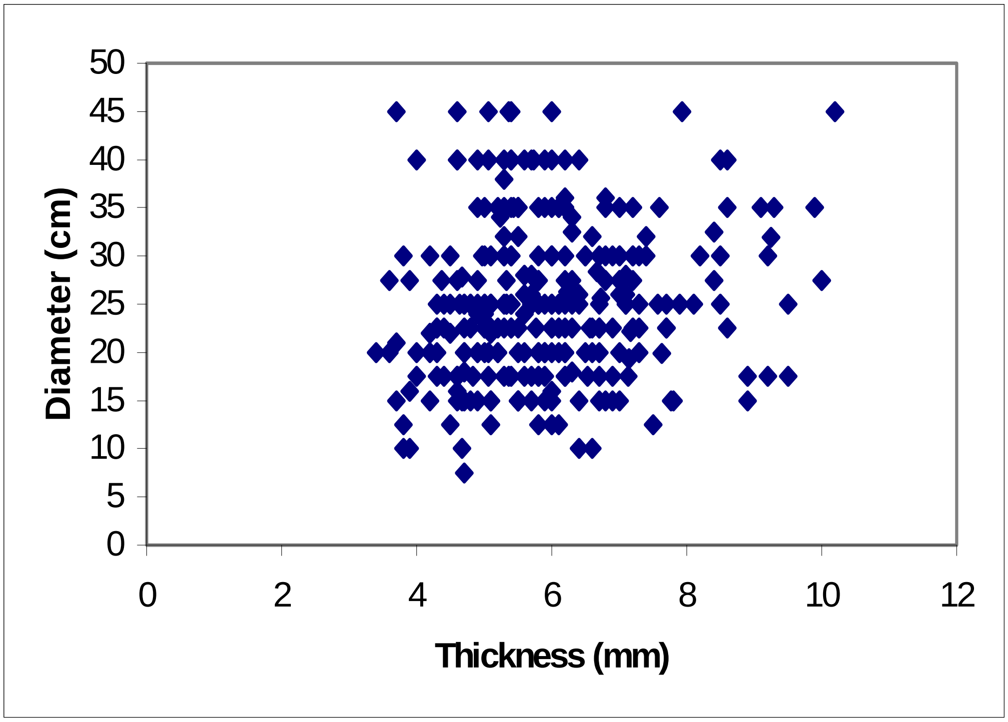
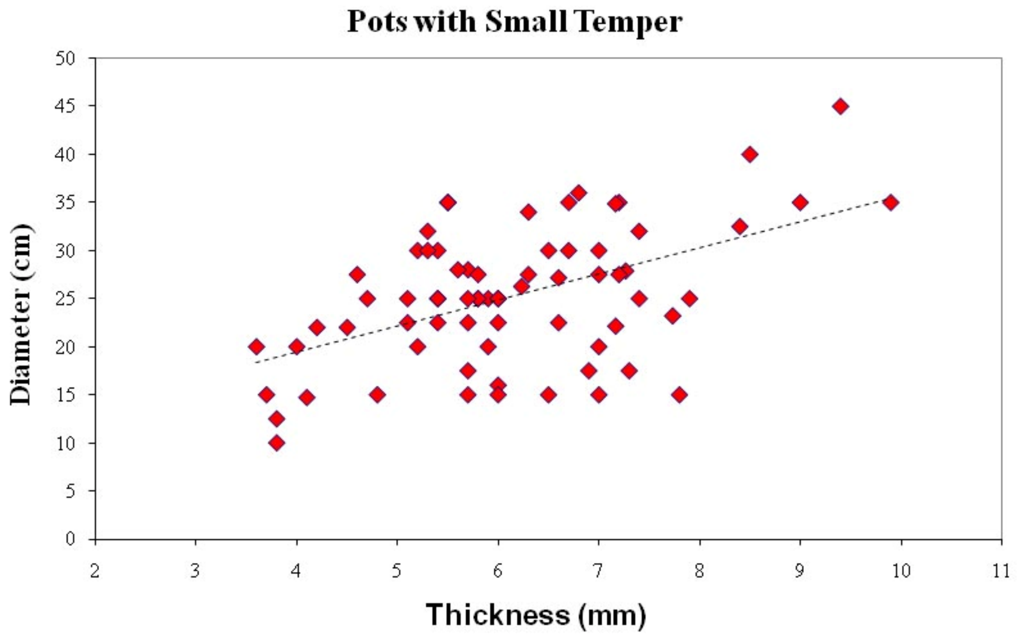
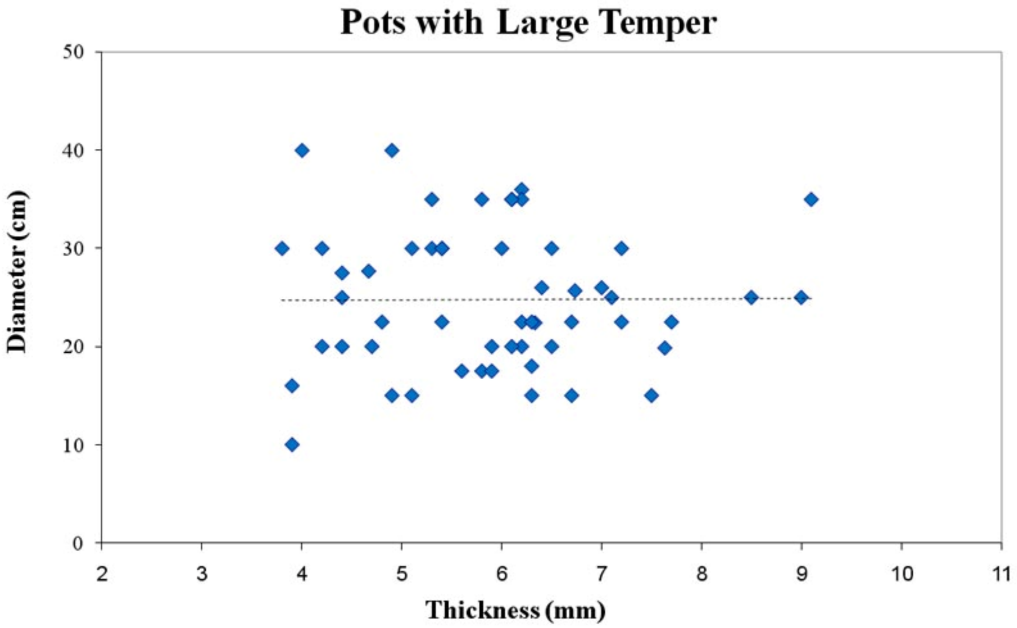


Figure 4.6: Comparison of thickness and diameter for rim sherds with small (fine) vs. large (coarse) temper. Data is the same as in Figure 4.5, but broken down here into small vs. large temper.





Based on Figure 4.5 and the poor correlation mentioned above, potters in California and the Western Great Basin also seem to have solved the size to wall thickness problem. Evidence that temper was the key to solving this problem comes from the graphs in Figure 4.6 which compare sherds with smaller-sized temper and larger temper. Sherds with smaller pieces of temper display more of a correlation between wall thickness and mouth opening ($r^2 = 0.40$), while those with larger temper do not display this pattern ($r^2 = 0.03$). This suggests that when it was necessary to make a larger pot (as measured by mouth opening) with thin walls, larger temper was used. This result is opposite that found by Braun, where later period sherds with smaller temper tended to be less correlated. However, the size of temper to which Braun refers is in the range of 1 – 3 mm or more, whereas most temper in the California and Great Basin sample is less than 1mm. Why the size-thickness relationship holds for pots with small temper but does not for pots with large temper is not entirely clear, and will require further research, but may be related to cooking and heating efficiency. Some larger pots may have been made purposefully thin to make heating more efficient (i.e., requiring less fuel). Similarly, large pieces of temper may have been added to increase heating efficiency and resistance to thermal shock. Such a concern may not have been as important for smaller pots.

Table 4.3: Attributes of Rim sherds.

	No.	Thickness		Diameter		Rim Shape			Smoothed	
		Avg.	CV	Avg.	CV	Inc.	Dir.	Rec.	Exter.	Inter.
Sequoia	34	5.15	0.23	237	0.36	9%	91%	0%	39%	64%
Fort Irwin	7	5.45	0.20	214	0.15	0%	86%	14%	0%	14%
China Lake	14	6.03	0.18	218	0.28	21%	71%	7%	14%	0%
Death Valley	73	5.57	0.18	251	0.25	3%	79%	18%	10%	11%
S. Owens	117	5.97	0.22	248	0.31	8%	90%	2%	19%	12%
Papoose Flat	5	6.68	0.31	263	0.33	0%	60%	40%	20%	20%
Deep Springs	15	5.55	0.11	237	0.28	27%	53%	20%	22%	27%
C. Owens	10	6.94	0.18	286	0.29	10%	80%	10%	11%	10%
N. Owens	20	6.49	0.16	267	0.38	0%	90%	10%	5%	20%
Saline Valley	3	6.40	-	270	-	0%	100	0%	0%	0%
Nevada TS	19	5.42	0.11	332	0.31	29%	59%	12%	18%	0%

Notes: Thickness and Diameter in mm; Inc. = Incurved; Dir. = Direct; Rec. = Recurved.

As seen in Table 4.3 the vast majority of sherds, like the whole pots, have direct rims and hence relatively unrestricted mouth openings, where this attribute could be recorded. In total, 257 of 312 or 82.9% of the rim sherds have direct rims.

Incurved rims account for 8.7% of the total sample, and recurved rims 8.3%. There is some variability between regions. For example, China Lake, Deep Springs Valley, and the Nevada Test site have higher numbers of incurved rims, while recurved rims are more common in Deep Springs Valley and Death Valley (and perhaps Papoose Flat, though the sample size is small). Sequoia National Park and Owens Valley are dominated by direct rims.

Significant differences in wall thickness between different regions are also evident (see Table 4.3). This trend has been noted by other archaeologists comparing pot sherds from Central Owens Valley, Southern Owens Valley, and Deep Springs Valley (Delcaorte 1990; Delacorte et al. 1995). Sherds from Central Owens Valley were the thickest of all regions, while Sequoia sherds were the thinnest. This difference was quite pronounced as sherds from the former are almost 40% thicker on average than those from the latter. Some trends in thickness are evident as well. Aside from the Sequoia samples, pots from more arid areas appear to be thinner. For example, sherds from the Nevada Test Site, Death Valley, and Fort Irwin, among the driest areas in the study area are among the thinnest, while Central and Northern Owens Valley and Papoose Flat sherds were the thickest and are the wettest areas. The Saline Valley sherds were also relatively thick, but only three specimens were analyzed.

Exactly why more arid areas would have thinner sherds is unclear. However, two possibilities come to mind. First, arid areas have less firewood available due to decreased precipitation and lower overall bioproductivity. To maximize fuel efficiency, groups living in these areas may have purposely made thinner pots to increase heating efficiency (see Bettinger et al. 1994). As mentioned earlier, a thin pot requires less fuel to heat the same mass of food or liquid than a thicker pot (Braun 1983). Although thinner pots would have been less resistant to mechanical and thermal stress, the increased heating efficiency may have been worth the decrease in strength.

Second, groups living in more arid areas were probably more residentially mobile (e.g., Steward 1938). Thinner pots would have been lighter in weight and would require less effort to carry during the seasonal round. However, as discussed in Chapter 5, the distinct possibility that pots were cached in particular locations on the landscape rather than carried around should have obviated the need for lightweight pots. Moreover, if lightweight pots were truly the objective, one would expect to see more widespread use of organic temper in California and the Great Basin. As discussed by Skibo et al. (1989), use of fiber temper can easily reduce the total weight of a pot by 20-40%. Although use of fiber temper is certainly evident in some pots, it is never the dominant temper type and rarely accounts for more than 20-30% of all temper by volume when it is present. Similarly, there seems to be little correlation between arid regions and increased use of fiber temper, as seen in Table 4.4. Likewise, a comparison of thickness and the amount of organic temper reveals little patterning (a linear regression produces a slope near zero, and $r^2 = 0.04$). Given these observations, the first explanation seems more likely.

An examination of Table 4.3 also suggests some regional differences in terms of average vessel rim diameter. Areas in the Mojave Desert (China Lake and Fort Irwin) appear to have the smallest diameters while the Nevada Test Site (NTS) has the largest. A T-test comparing means of the Mojave sample against the NTS sample is significant ($p<0.001$). Central and Northern Owens Valley have more intermediate values and are also significantly different than Mojave samples ($p=0.005$), but are not from NTS rim diameters ($p = 0.23$). Shapiro (1984) relates vessel size, as measured by rim diameter to site permanence and group size. If true in the Great Basin, it suggests NTS groups were the largest and most residentially stable and Sequoia groups the smallest and least mobile, clearly opposite what would be expected given discussions by Steward (1938). However, if the NTS and Sequoia samples are omitted, the relation between degree of residential mobility as described by Steward (1938) and mouth diameter is roughly correct. Northern and Central Owens Valley pots are the largest, Southern Owens and Death Valley less so, Deep Springs Valley even smaller, and China Lake and Fort Irwin the smallest. A similar ranking of mobility and population density would probably ensue, with perhaps Death Valley and Deep Springs Valley reversed (see Delacorte 1990). Why NTS pots are so large and Sequoia pots relatively small is not known.

Table 4.4: Temper and firing atmosphere attributes for rim sherds by region.

	Mineral Temper Density			**Mineral Temper Size**			**Organic ≥ 20% / ≥ 30%**	**Mica ≥ 3**	**Redu-ced Core**
	Fine	Med.	Crs.	Low	Med	High			
Sequoia	30%	30%	39%	15%	44%	41%	3.0% / 3.0%	45.4%	67%
Fort Irwin	0%	57%	43%	-	-	-	14.3% / 0.0%	0.0%	71%
China Lake	36%	57%	7%	-	-	-	21.4% / 7.1%	35.7%	86%
Death Valley	30%	52%	18%	19%	58%	23%	11.0% / 0.0%	23.2%	83%
S. Owens	51%	42%	7%	34%	50%	17%	21.7% / 6.9%	27.8%	74%
Papoose Flat	40%	60%	0%	25%	25%	50%	20.0% / 0.0%	0.0%	75%
Deep Springs	46%	32%	22%	22%	46%	32%	0.0% / 0.0%	36.4%	91%
C. Owens	50%	30%	20%	40%	40%	20%	0.0% / 0.0%	50.0%	90%
N. Owens	30%	65%	5%	10%	60%	30%	10.0% / 0.0%	40.0%	75%
Saline Valley	53%	44%	3%	67%	33%	0%	0.0% / 0.0%	33.3%	-
Nevada TS	47%	47%	5%	-	-	-	0.0% / 0.0%	31.6%	84%

The degree of surface smoothing is fairly constant between the different regions, with the exception of Sequoia National Park, where roughly twice as many sherds are smoothed on their exterior and three times as many on their interior surface. This result is similar to the observations of the whole pots, where Sequoia vessels were often finished smooth. The exact reasons for this difference are unclear but may relate to their function in capacities other than cooking or to aesthetics and/or display. The majority of pots in the Great Basin, then, are either left rough or are brushed. This brushing, which is occasionally done with a larger tool leaving deep grooves but usually with a small tool such as a bundle of leaves or a rough stone, is particularly useful if the pot is used for cooking. A rough surface or one with grooves serves to increase the surface area such that more heat can be absorbed through the walls of the pot and transferred to the contents.

Differences in the use of temper can also be seen in Table 4.4. Some regions, such as Central and Southern Owens Valley and the Nevada Test Site, appear to make greater use of fine and low density temper. In other regions, such as Fort Irwin, China Lake, Death Valley, and Sequoia, coarse and high density temper recipes are more common. Higher density and size of temper may indicate greater need to prevent cracking during drying and firing and/or the desire to increase heating effectiveness. As indicated above, the latter regions also tend to display thinner pots, suggesting an inverse correlation between pot thickness and size and density of temper.

Organic temper is more common in the southerly regions of the study area, including Southern Owens Valley, China Lake, and to a lesser extent Fort Irwin. However, as mentioned above, sherds with organic temper often contain ample amounts of mineral temper as well. Based on impressions on the surface and within the sherds, organic temper is often composed of blades of grass and other plant parts such as roots. It is possible that the grass and roots are naturally present in certain clays used for making pots, such as sedimentary sources in wetland marshes. Rather than picking out bits of grass and root matter prior to forming a pot, it may have been left within the clay and fired. The low percentage of sherds containing organic temper, particularly in levels over 20%, suggests that this style of tempering was not a very important part of the ceramic technology. Thus, minimization of vessel weight does not appear to have been a priority.

Opposite the distribution of organic temper, sherds with higher amounts of mica are slightly more common in the northern parts of the study area, including Central and Northern Owens Valley and Deep Springs Valley. However, China Lake and Sequoia also have higher levels of mica. Based on observations of clays collected from the region (see Chapter 7), mica is a common constituent of sedimentary sources of clay. However, sedimentary sources of clay also often have roots and other organic matter present. That the presence of mica and organic temper are not related hints that organic temper (or mica) may be intentionally added to or removed from some clays prior to making pots. It is possible, though, that drying and pounding clay would eliminate evidence of natural organic temper in sedimentary clays.

Finally, Table 4.5 lists the (apparently) non-functional attributes recorded within the rim sherd assemblage. The most pertinent to the questions considered here is the percentage of decorated sherds. The most common motif is a row of vertical fingernail incisions just below the lip on the external surface. Occasionally this motif is present on the lip itself, and less commonly on the interior surface just below the lip. Spacing between successive fingernail impressions is often irregular, suggesting somewhat haphazard and quick decoration.

In total, less than 10% of the rim sherds are decorated, suggesting that few California and Great Basin pots bore much in the way of decorative elaboration. Examples of serving vessels are usually highly decorated (Henrickson and McDonald 1983; Smith 1985), implying that few California and Great Basin pots were primarily used as serving vessels. Moreover, pots probably did not play an important role in ideological or symbolic aspects of life, such as religion, gift giving, and/or exchange. However, the percentage of decorated sherds varies somewhat by region. Although a chi-square test comparing region by decoration is not possible because many cells contain values less than five, some seemingly significant differences are evident. It appears that regions such as Death Valley and Deep Springs Valley have roughly twice as many decorated sherds as Owens Valley and the Mojave Desert, four times as many as the Nevada Test Site, and five to six times as many as Sequoia National Park.

Table 4.5: Non-functional attributes for rim sherds by region.

Region	%Decorated	Lip Shape			Lip Lateralization			Coil Type		
		Flat	Rnd	Pnty	Ext	None	Int	Ext	Even	Int
Sequoia	2.9%	9%	76%	15%	12%	85%	3%	30%	50%	20%
Fort Irwin	14.3%	29%	43%	29%	29%	71%	0%	0%	0%	100
China Lake	7.1%	21%	50%	29%	7%	86%	7%	0%	11%	89%
Death Valley	20.4%	19%	77%	4%	10%	84%	7%	5%	24%	70%
S. Owens	10.3%	21%	71%	8%	27%	70%	3%	45%	28%	28%
Papoose Flat	0.0%	0%	100%	0%	25%	75%	0%	0%	100%	0%
Deep Springs	22.2%	23%	77%	0%	8%	92%	0%	0%	40%	60%
C. Owens	0.0%	10%	90%	0%	10%	90%	0%	0%	60%	40%
N. Owens	10.0%	0%	100%	0%	35%	65%	0%	10%	30%	60%
Saline Valley	33.3%	0%	100%	0%	0%	100%	0%	-	-	-
Nevada TS	5.3%	26%	63%	11%	11%	74%	16%	17%	33%	50%

Table 4.5 also indicates that the vast majority of pots have rounded lips. Flat lips comprise approximately 20% - 30% of pots in most regions except Sequoia, Central Owens Valley, and Northern Owens Valley, where they occur in fewer numbers. Pointed lips are found in highest concentrations in the Mojave Desert and Sequoia National Park. There also appear to be slight differences in the

lateralization of lips. Pots from Owens Valley, especially Southern and Northern, appear to be often lateralized to the exterior. Interior lateralization is rare, except in the Nevada Test Site sample, where they comprise 16% of the rim sherds. These regional differences may simply indicate preferences by potters for different lip finishing styles.

The rim sherd sample also indicates slight regional differences in the style of coiling. Most areas had a predominance of pots where coils were stacked on one another on the inside and clay pushed down over lower coils from the interior, or where coils were stacked directly on top of one another (i.e., even). Two areas stand out in this regard, Southern Owens Valley and Sequoia National Park, where a significant number of pots were manufactured such that coils were stacked on top of one another on the outside and clay was pushed down over lower coils on the exterior. In Southern Owens Valley nearly half, and in Sequoia nearly one-third, of the sherds (where this attribute could be measured) have exterior melded coils. Most other areas have less than one-fifth, and in many cases this trait was not observed at all. The exact significance of this difference is unclear, but appears to relate more to individual or group manufacturing techniques than function.

Comparison of whole pots vs. rim sherds

In most respects, the rim sherd sample is similar to the whole pot sample. However, three points merit discussion. First, whole pots are noticeably smaller than their rim sherd counterparts. This likely stems from the greater likelihood of breakage among larger pots. Second, whole pots seem to have lower-density temper. This lower density may have contributed to greater resistance to impact stress and a greater likelihood of survival into the present. Third, Sequoia National Park whole pots are different in several respects from rim sherds recovered from the region. Several examples have handles, they are mostly black in surface color (occasionally appearing as if a slip or paste has been applied to the exterior), the majority have flat bases, and walls often extend from the bases at 90 degree angles, forming sharp corners. These attributes are uncommon in potsherds from the region and suggest historic pot making may have changed from proto- and prehistoric practices, perhaps due to Euroamerican influences.

Function of pots based on rim sherd attributes

Although there are notable differences by region, the overall assemblage is surprisingly conservative on a number of points. For example, the rim sherd sample contains a predominance of direct and unrestricted rims, most sherds have relatively thin walls (e.g., as compared to other regions and time periods in North America where pots are often in excess of 10 mm thick), there is a general lack of decoration on most sherds, the majority have roughened exterior surfaces, and there is a predominance of mineral as opposed to organic temper. These similarities may be the reason why archaeologists have tended to lump all Western Great Basin ceramics into a single typological category.

One region that stands out in this regard is Sequoia National Park. In this region pots are even thinner, are more densely and coarsely tempered, and are often smooth on their exterior and interior surfaces, though they are less often decorated. Like the conclusions reached in the analysis of whole vessels, this suggests that pots may have played a slightly different role in the lives of people living in this area. The origins of pottery in the Western Sierra Nevada is often attributed to Eastern Sierran influences, especially Owens Valley (Spier 1978a, 1978b; Steward 1935; though see Steward 1928). However, the notable differences between Eastern and Western Sierran pottery described above suggest that this assumption should be reexamined. That is, the data offer the possibility that ceramics may have been independently invented, may have been introduced to the Western Sierra region from somewhere other than Owens Valley, or if they were introduced from Owens Valley, that they followed a different developmental trajectory than other areas of the Western Great Basin. The latter seems especially plausible given the vastly different social climate and diet (i.e., based on acorn) that existed in the region and is described in the ethnographic literature.

The formal attributes described above for rim sherds from the Western Great Basin suggest that the majority of pots in the Western Great Basin were not built to be lightweight for transport or for storage of liquid, or to be highly visible. Instead, most pots were manufactured to transfer heat efficiently and evenly from an external source to the vessel contents, and to withstand repeated episodes of heating and cooling. These attributes suggest that cooking was one of the primary function of pots in this area. Supporting evidence comes from the frequent presence of sooting or blackening on the exterior of pots due to exposure to fire. Furthermore, the occasional presence of carbonized materials on the inside of pots near the rim also demonstrates association with food, likely cooking.

Summary and Conclusions

The evidence discussed above based on formal whole vessel and rim sherd attributes suggests that most pots in the Western Great Basin were best designed to operate as cooking vessels. Additional data based on blackening and sooting on the exterior and carbonized remains on the interior of a number of pots support this conclusion. Pots from Sequoia National Park, on the other hand, are slightly different and suggest alternative uses, though cooking still appears to have been an important function. These pots may also have been used as storage and/or serving vessels.

This is not to say that Great Basin pots served only as cooking vessels. Pots, like any tool, are likely to have served multiple functions as needs arose. For example, when not in use as a cook pot, vessels may have been used for other purposes, such as short distance transport of water (e.g., from a river or spring to the base camp) or food (e.g., to a neighboring fandango or as a gift) or short-term storage of various products. Unfortunately, it is difficult to detect or reconstruct these more sporadic uses.

These less common uses aside, what is of most importance to the study at hand is determining why pots were designed and constructed the way they were. Most tools are produced with a primary function in mind, and in the case of California and Western Great Basin pots, this function appears to have been cooking. While not a great surprise, it does suggest further avenues to explore when answering the main question raised in this dissertation, namely why did people in California and the Great Basin begin making and using pottery in the first place. Based on the data presented above, a concern for cooking and maximizing heating efficiency in arid areas are evident.

Finally, I wish to briefly compare these results to those of Simms and Bright (1997). In the Eastern Great Basin, they suggest that thinner walls, finer temper, and surface smoothing represent greater investment of time in ceramic production, and furthermore, that investment in ceramics should increase as residential mobility decreases. The current study clearly does not support these results. The model does seem to work to some extent in the Sequoia case. Hunter-gatherers there were probably the most sedentary in the study area and they seem to have made the thinnest and smoothest pots, though they tended to use quite large temper. However, outside of this region, pot thinness seems to vary positively with degree of mobility (rather than the opposite predicted by Simms and Bright), and there is no clear relationship between temper size, degree of smoothing, and degree of mobility.

Part of the problem here may be that the variables Simms and Bright (1997) use relate, in many cases, to the function of the pot, as well as to physical laws governing strength and thermal stress, rather than simply to degree of time and labor investment as dictated by mobility. Simms and Bright (1997:790) realize this, stating that they do not argue “for a simplistic and unwavering relationship between mobility and the particular variables used to measure ceramic investment.” However, I believe the problems run deeper than simply determining which variables should be used to measure degree of time and labor investment. I would argue that in some cases, higher residential mobility may actually lead to *increasing* investment in ceramics, since such a lifestyle may impose greater restrictions on how pottery had to be made and used. In fact, as argued above, restrictions relating to the availability of fuel and the weight of pots may have led to greater investment in pot design and production for more mobile people living in arid areas.

CHAPTER V

DISTRIBUTION OF POTTERY

This chapter examines the distribution of brownware ceramics across the Western Great Basin relative to a number of different dimensions and spatial scales. Where ceramics are found tells us much about where pots are being used within the landscape. When related to the ethnographic and archaeological record, we can compare places where late prehistoric people were living and undertaking various activities against those that contain pottery. Thus, an examination of the distribution and context of pottery relative to the resources available within a local environment and other artifact categories will help us to understand how pots are being used within the seasonal round and what sorts of activities they are associated with. Similarly, where pots are not found, particularly in areas that we know were habitually used by late prehistoric peoples, tells us where pots were not needed within the landscape. These two lines of evidence, where pots are and where they are not, have important implications for why pots were being made and used in the first place, and hence, the origins of pottery making in the Western Great Basin.

It is clear from even a cursory analysis of the archaeological record that ceramics are not evenly distributed across the Western Great Basin. For example, certain regions and valleys have large numbers of ceramics while others have few or lack them altogether. Several anthropologists and archaeologists working in the western Great Basin have noted such differences in the distribution of pot sherds (Coale 1963; Butler 1979; Elsasser 1960; Fowler 1968; Gayton 1929: 249; Gilreath 1995: 253; Touhy 1973; Thomas 1970; Weaver 1986). Few, however, have offered explanations for these differences beyond simply relating them to ethnicity and mobility. Moreover, even within valleys ceramics are unevenly distributed, being more common in certain locations such as low elevations near riparian and lacustrine environments than others, such as upland locations. Again, these differences surely relate to differences in the types of activities carried out within the landscape, but few archaeologists have explored or given behavioral significance to these patterns. This chapter deals with these issues.

Distribution at a Local Scale Within Regions

As early as 1922, Alfred Kroeber (1922) recognized a relationship between the distribution of pottery and wetland areas in Eastern California and the Mojave Desert, though unfortunately he did not attach meaning it. Subsequent archaeological investigation by several researchers in recent years has supported these early impressions. For example, surveys in many valleys in the central and western Great Basin demonstrate that the frequency of pottery is significantly higher in valley bottom riverine and lakeside locations (e.g., Bettinger 1975; Delacorte 1990; Elsasser 1960; Hunt 1960; Plew and Bennick 1990; Thomas 1972, 1983; Wallace 1986). That is, when pottery is found, the majority of it is found in lowland locations. Although Thomas (1970) suggested an association between the piñon zone and pottery, his later work (Thomas 1971:150; 1983) clearly refutes this hypothesis. Table 5.1 presents the density of pottery (per unit area, expressed as a percentage) in three environmental and elevation zones in several large Great Basin surveys. The table shows that when adjusted for the area surveyed, between 60% and 100% of pot sherds are found in lowland locations.

Table 5.1: Distribution of pottery by environmental zone (adjusted by area surveyed).

	Valley Bottom	**Piñon/ Juniper**	**Above Piñon**	**Reference**
C. Owens Valley	86%	12%	4%	Bettinger 1975
Deep Springs	64%	36%	0%	Delacorte 1990
Monitor Valley	76%	15%	9%	Thomas 1983
Reese River	100%	0%	0%	Thomas 1971
Coso area	63%	37%	N/A	Delacorte 1990; Hildebrandt & Ruby 1999; Gilreath & Hildebrandt 1997

The results listed in Table 5.1 are mirrored in several areas of the Western Great Basin. For example, a comparison of separate surveys performed in Panamint Valley on the valley floor (Davis 1970) and the adjacent Panamint Range (Oetting 1980) suggests that sherds are *significantly* more common in the former area. Similarly, sherds along the Pacific Crest Trail in the Sierra Nevada (Garfinkel et al. 1979; McGuire and Garfinkel 1980) and White Mountains (Bettinger, personal communication 1999) are present, but uncommon, while sherds on the Owens Valley floor abound. These patterns are also seen in areas in the Central Great Basin. For example, a comparison of the number of potsherds found in the Grass Valley uplands (Wells 1983) with those in the valley bottom (Beck 1981) suggests significantly higher densities in the latter. The pattern may not hold as well in the Eastern and Northeastern part of the Great Basin, where pottery is often found in upland meadow settings (e.g., Butler 1979). Part of this may relate to the availability of and dependence on different food resources such as roots in the latter area.

It is possible that the lowland pattern simply reflects the distribution of prehistoric activities in general; that is, people spend more time in lowland areas and therefore deposit more sherds there. A few of these studies (e.g., Bettinger 1975; Delacorte 1990; Thomas 1972, 1983) have attempted to control for this factor and have examined the density of pot sherds in different environmental zones standardized by overall density of artifacts. Even when the overall distribution of artifacts is accounted for, the distribution of pot sherds is still heavily weighted towards valley bottom locations.

Table 5.2: Distribution of late period projectile points (DSN & Cottonwood) and total sites, by environmental zone.

	Valley Bottom (Points – Sites)	**Piñon/Juniper** (Points – Sites)	**Above Piñon** (Points – Sites)
C. Owens Valley	31% - 44%	63% - 37%	5% - 19%
Deep Springs Valley	74% - 32%	16% - 60%	10% - 8%
Monitor Valley	69% - 41%	14% - 24%	17% - 35%
Reese River Valley[1]	38% - N/A	49% - N/A	13% - N/A
Coso area	22% - 30%	78% - 70%	N/A

Notes: [1] – Individual sites not reported by environmental zone for Reese River.

This can also be seen in the distribution of contemporaneous (to pottery) artifact types, namely late period projectile points (Desert Side-Notched and Cottonwood). Table 5.2 shows that these artifacts do not necessarily follow a similar valley-bottom dominant pattern. Several areas, including Central Owens Valley, Reese River, and the Coso area do not have the majority of late period projectile points in lowland areas. Although projectile points represent an activity different from that associated with pottery, most likely hunting, the distribution of this artifact category shows that late prehistoric populations were making significant use of all three environmental zones. In particular, the piñon-juniper zone is heavily represented in many regional surveys, something the ethnographic record would certainly support (Steward 1938). This suggests that the distributions of sites, projectile points, and ceramics follow different spatial distribution patterns.

Of course, to see whether pot sherds are truly distributed differently than the overall range of activities carried out in different environmental zones, it would be desirable to compare pottery against the distribution of late prehistoric sites, rather than projectile points (as a way to standardize relative use of upland vs. lowland environments). However, the main method of dating sites in the Western Great Basin *is* through chronologically sensitive projectile points and ceramics. Therefore, without independent excavation and radiocarbon or obsidian hydration dating for every site it is not possible to ascertain the distribution of all late period sites. Such data are not available for any region on a systematic basis (i.e., many sites discovered during survey contain only undiagnostic flaked stone). Unfortunately then, it is not possible to compare the distribution of pottery against late period sites only. However, Table 5.2 does give the distribution of all archaeological sites (irrespective of period), standardized by area surveyed, for the same regions (data for Reese River are not broken down by site in Thomas 1971). These data again suggests that pottery is distributed differently than the overall distribution of archaeological sites.

In sum, the relative distribution of ceramics, late period projectile points, and archaeological sites suggests that while late prehistoric period populations were making use of all environmental zones, they were using pottery mostly in low elevation areas. According to the ethnographic record, these areas were occupied primarily during spring and summer by Western Great Basin groups (Steward 1938; though see Steward 1933 for some exceptions with regards to Owens Valley).

That the majority of prehistoric ceramics is located in valley bottom areas suggests something about how they were used prehistorically. In particular, the distribution suggests use associated with resources that are processed, stored, and/or brought to those areas. Based on the association with valley bottom locations, riparian and lacustrine resources seem a likely candidate. As these areas were often used during spring and summer, the settlement pattern during those seasons may have been particularly conducive to the manufacture and use of ceramics. At the same time, the presence of small amounts of pottery in piñon-juniper woodland and even alpine areas speaks to the diversity of uses to which Numic peoples put ceramics. However, use and construction of ceramics in these upland areas may not have fit well within settlement strategies and/or the range of subsistence pursuits undertaken in these locations during the seasons they were occupied. Alternatively, the raw materials for ceramic production may not have been readily available in upland settings, and pots may even have been carried to these locations from lower elevations.

Distribution of pots on a regional scale

In a similar manner, when we keep environmental zone constant to lowland areas the distribution of ceramics across the Great Basin is also not uniform (i.e., between valleys and geographic regions). For example, large sections of the Northern Great Basin are lacking in ceramic materials (Madsen 1986; Fowler 1968; Tuohy 1973), while others contain large numbers of pot sherds (Basgall and McGuire 1988; Pippin 1986). Some researchers have attributed this to ethnic differences or a lack of knowledge about ceramic technology. Presumably non-ceramic-making groups used baskets and stone boiling as a substitute for whatever function pots served in ceramic-using areas or did not undertake these activities at all. However, the ethnic division between pottery-making and non-pottery-making peoples does not accord well with archaeological data that demonstrates the presence of occasional sherds found in supposedly non-pottery-making areas (Layton 1970; Mack 1990; Pippin 1986; Raven and Elston 1988; Riddell and Riddell 1986; Weaver 1986). These sherds suggest that even non-pottery-making groups occasionally experimented with pots, and whether they made these pots themselves or traded for them, they clearly had access to and knowledge of ceramic technology. Thus, the division seems to be more a matter of degree of reliance on pottery rather than absolute. This suggests that the decision to make and use pottery lay more in the usefulness or desirability of pots or the economics of the technology than simply a lack of knowledge or ethnicity and strict adherence to the ways of past generations.

How, then, is pottery distributed across different regions or valleys within the Western Great Basin? In which valleys is pottery common, and in which areas is it rare? Moreover, what do areas with ample pottery have in common with one another versus areas with little or no pottery? The sections below examine these questions to better understand how pottery is distributed across the Western Great Basin.

Methods

The ultimate goal of this study is to compare the degree of reliance on pottery in different areas. In other words, the aim is to determine where pottery was most important and where was it apparently superfluous. How to measure this depends on how one defines "reliance on" or "importance." Ideally, we would measure the average number of hours that people used pots in different areas. Areas where people spent more hours using pots (per person) should be regarded as more reliant upon pots in their daily lives. However, to estimate this based on archaeological data we would have to know the total number of pots produced in a region, divide this by the life span of each pot, and divide this by the total number of people living in an area during which pots were made.

Unfortunately, these numbers are nearly impossible to reconstruct from archaeological evidence alone, particularly in an area lacking writing. Instead, as a proxy measure of the degree of reliance on pottery I chose to examine the ubiquity and density of pot sherds in different areas. The number of pot sherds recovered or encountered is commonly noted in archaeological survey and excavation reports and in this manner is amenable to quantitative analysis and comparison. I make the assumption that larger numbers of sherds left behind in a region are positively correlated with a greater reliance on pottery in every day life in that area. Thus, people more dependent on pots should leave behind more broken pots, and consequently more sherds, than people less dependent on them.

Assumptions

This hypothesis is predicated on a number assumptions. First this position assumes that pot sherds and pots are roughly the same size in different areas. One hundred sherds found in one area should represent roughly the same number of pots as 100 sherds in a second area. Clearly, areas that have high levels of disturbance will have sherds broken into more pieces than undisturbed areas. Since the basic unit of analysis is the sherd, such areas might unfairly reflect a higher reliance on pottery than was present prehistorically. A possible solution to this problem might be to use the weights of sherds rather than raw counts, assuming pots are roughly the same thickness (which itself could be tested if thickness were regularly reported). However, sherd weights are rarely reported in archaeological reports. Based on the data presented in Chapter 4, pots in different parts of the Great Basin do not appear to be *drastically* different in size or thickness. Thus, it seems reasonable to assume that whole pots are represented by approximately the same number of sherds in different areas.

Second, the study assumes that the use life of pots is roughly equal in different areas. A pot that is made of more durable raw materials, is fired to a higher temperature, and/or is treated more carefully will probably last longer. In such a case a smaller number of sherds may represent a *greater* reliance on pots, when compared to an area where pots are softer, more friable, or disposable. Given the similarity of pot sherds in most areas, that is, almost all Great Basin brownware is low-fired, fairly friable, and constructed by a similar method (coil-and-scrape), this assumption also seems reasonable. It would be possible to perform further analyses by systematically comparing the hardness, firing temperature, and degree of use of sherds in different areas. Such analyses would clearly be informative and would probably highlight slight differences between areas. However, based on my experience examining sherds from many different valleys in the Western Great Basin, these differences do not appear to be extreme.

Third, the comparison assumes similar rates of recovery by archaeologists. Of course, areas in which archaeologists fail to recognize and systematically record pot sherds would be slighted in their perceived degree of reliance on pottery. Few archaeologists would admit that they miss (particularly in a systematic fashion) an entire artifact class. Other than resurveying tracts of land, little can be done to account for such potential biases. I assume that archaeologists using similar methods and trained under a similar paradigm with similar theoretical underpinnings (i.e., Americanist archaeology) will recover sherds in a similar manner at a similar rate. Again, this does not seem unreasonable. Rates of recovery can also be affected by differential collection by casual collectors or pot hunters in different areas. However, given the remoteness of many Great Basin areas, a lack of decoration on most brownware pots, and the general disinterest in broken artifacts by collectors (indeed, many casual collectors may not even recognize pot sherds as artifacts or be able to differentiate them from rocks), this bias is probably not too great.

These first three assumptions do not appear to be too significant within the context of this study. However, two final assumptions are more difficult to justify.

First, comparing sherds as a way to estimate reliance on pottery in an area requires that the number of people in each area to be roughly equal. Thus, an area with ten pots and 1000 individuals is far less reliant on pottery than an area where ten pots serve only ten people. However, if the pots decompose in a similar manner, break into equal numbers of sherds, and are recovered equally by archaeologists, the areas will be similar in terms of sherd density, and hence, the reconstructed reliance on pottery. One way to account for this would be to adjust by the estimated prehistoric population density. However, it is very difficult to reconstruct prehistoric population levels from archaeological evidence, particularly for mobile and small scale hunter-gatherer populations. A second and probably more reliable way to adjust for this is to standardize sherd counts by other data, such as the number of late period projectile points or by the number of sites recorded in an area. Doing so assumes that there are no dramatic differences between areas in the other data category, that is, that projectile point use or site formation is equal between areas. This is the approach followed here.

The final assumption is probably the most difficult to account for. This study assumes that pottery makes its appearance across the Western Great Basin at approximately the same time. Thus, if overall reliance on pottery were similar but was used for a longer period of time in one area, that area would appear to have greater reliance on pottery as a greater number of pot sherds would be found. It is quite clear from the archaeological record that pottery makes its appearance late in time in all areas, that is, within the last 1000 years. Unfortunately, archaeological data are not available to date the inception of ceramic technology in different parts of the Great Basin (Pippin 1986). A systematic study of dating pot sherds using a technique such as thermoluminescence (TL) would go far to address this issue. Indeed, preliminary studies by Rhode (1994) and Benedict (1989) using TL dating suggest that the beginnings of pottery-making may be slightly older in the Southeastern Great Basin. Based on other criteria, Lyneis (1982) has made similar suggestions, that ceramic technology spread from Southwestern Pueblo groups to groups living on the Basin-Southwest fringe, and then further north and west from this Southeastern corner of the Great Basin. If pottery-making spread from the Southeastern Basin to the Western Basin, it suggests that regions further east may have adopted pottery slightly earlier. A comparison of nine TL dates from the Nevada Test Site with two from Owens Valley (Rhode 1994) does support this notion. However, the sample size is *very* small and the difference in age is slight, on the order of 100-200 years. Overall, it is still unclear exactly when and how quickly pottery spread across the entire Great Basin, much less a smaller portion such as the Western section. Because pottery is unanimously late and the available evidence does not support a large temporal difference in the inception of pottery-making, I assume that any differences, if present, will have only negligible effects on the results of the current study, that is, on the estimated measures of prehistoric reliance on pots in different areas.

Estimating density

Five different measures were employed to estimate prehistoric reliance on pottery in Western Great Basin regions, each with advantages and disadvantages as discussed below. These five measures can be broken down into two categories, those that estimate density of pottery (measures 1, 2, and 5 below) and those that estimate the ubiquity of pottery (measures 3 and 4). Due to problems related to sampling strategy and intensity of investigation, measures 1 and 5 below use only data from surface survey, while measures 2, 3, and 4 combine surface survey and excavation data. To control for the differences relating to differential pottery distribution by environmental zone noted above (i.e., higher pottery density in lowland areas), all the data presented and analyzed below represent pottery recorded from lowland locations within each region (with the exception of Papoose Flat which is in the Inyo Mountains, and by definition, is all upland).

First, I sought to estimate the density of pottery per unit area. Measure 1 was calculated by computing the number of sherds recorded divided by the area surveyed. The main disadvantage of this measurement is that it fails to control for population density. As discussed, the density of pottery in an area should be positively correlated to the density of people living there; more people leave behind a higher density of sherds. Thus, this measure is appropriate only when comparing areas that have approximately equal population density. As Steward (1938) long ago noted, there are major differences in population density between different Great Basin valleys. To correct for this problem, I attempted to standardize the number of sherds in an area by a second artifact category dating to the same time period. Thus, the second measurement of pottery density relates the number of sherds to the number of late period projectile points, that is, desert series points, including Cottonwood Triangular and Desert Side-Notched (see Thomas 1981b; Bettinger and Taylor 1974 for a discussion of time sensitive projectile point types in the Great Basin). This measure assumes that the number of projectile points produced per person is approximately equal between different areas, and that changes in the sherd to point ratio primarily reflects differences in the rate of ceramic manufacture rather than projectile point manufacture. This information was tabulated separately for survey and excavation reports, but are combined in the presentation below.

Third, I calculated the percentage of sites within a region that contain pottery, under the assumption that groups more dependent on ceramics will leave behind a higher percentage of sites with sherds. This measure was calculated for excavated and surveyed sites combined, and has the added advantage that it focuses only on ceramics, irrespective of projectile points. However, disadvantages include a failure to control for different settlement strategies, since strategies involving frequent residential movement will leave behind a higher frequency of sites with pottery (if people use pottery), a failure to account for the quantity of pottery at individual sites (i.e., a site with 1 sherd is treated equally to one containing 1000 sherds), and an inability to control for earlier occupation, since areas with larger numbers of pre-pottery sites will have a lower percentage of pottery-bearing sites than areas with similar dependence on pottery but less intensive pre-pottery habitation. To account for this last factor, I created a fourth measure of pottery density by examining the percentage of sites containing late period material (i.e., Desert series points, radiocarbon dates, or pottery itself) that also contain pottery. This measure is somewhat circular, as the presence of pottery is one of the ways in which age is determined. In essence, this measurement describes the proportion of sites containing pottery relative to sites containing late period projectile points but no pottery. These two measures, then, relate the ubiquity of pottery in archaeological sites in an area.

Finally, from surface survey information only, I estimated the average number of sherds per site for sites with pottery in different regions. Advantages of this measure are that it attempts to account for the density of pottery within pottery-bearing sites, instead of just presence or absence (as above), and that it does not rely on projectile points either. Disadvantages, however, are that it fails to control for site reuse (i.e., areas where people frequently go back to the same location will have higher average numbers of surface sherds per site), population aggregation (i.e., areas where people tend to live in larger groups will have higher values for this measurement), and site recording methods (i.e., areas where people tend to lump sites together will have higher values than areas where sites are split into discrete loci). Excavated data are not amenable to analysis by this measure due to an inability to control for volume of material excavated and differential rates of sediment deposition, as well as differences in excavation strategy and screening methods (i.e., excavating several test units around the main part of a site to determine site boundaries will lead to vast differences in the density per unit volume of sherds recovered and use of different sized screens will lead to differential recovery rates).

Thus, each of the five measurements described above estimates the density of pottery in an area. However, each is affected by different cultural factors and is likely to express reliance on pottery in different ways. Rather than rely on a single measurement, I decided to incorporate all five measures into the current analysis with the hopes that they would, in general, tell a similar story with regard to the relative importance of pottery in different Great Basin regions. Unfortunately, the data needed to estimate these different measures were not always readily available in published form. Therefore some areas do not have values for certain pottery density measurements. Table 5.3 lists the references consulted to collect the data used in this study.

Table 5.3: References consulted for distributional study.

Region	**References**
Southern Owens Valley	Basgall and McGuire 1988; Bouey 1990; Delacorte 1999; Delacorte and McGuire 1993; Delacorte et al. 1995; Eerkens 1997; Gilreath 1995; Riddel 1951; Wilke 1983
Monitor Valley	Thomas 1983, 1988
Nevada Test Site	Drollinger 1993; Henton and Pippin 1991; Hicks 1990; Jones 1991, 1993; Lockett and Pippen 1990; McLane et al. 1993; Reno 1983; Simmons et al. 1991
Panamint Valley	McCarthy et al. 1984; Davis 1970
Death Valley	A. Hunt 1960; Wallace 1957, 1958, 1968, 1986
Sequoia	Von Werlhof 1960, 1961; Hale and Hull 1997; Parr 1997; Dillon 1992; Wallace 1993; Foster & Kauffman 1991; Fenenga 1952
Reese River	Thomas 1971; Thomas personal communication 1999
Fort Irwin	Gilreath et al. 1987
Hammil Valley	Halford 1998
Deep Springs	Delacorte 1990
Cent. Fish Lake	Clay 1994; Clay and Young 1994
Central Owens Valley	Bettinger 1975, 1989; Delacorte and McGuire 1993; Wickstrom et al. 1994
Northern Owens	Basgall and Giambastiani 1992; Delacorte and McGuire 1993
China Lake - Coso	Clay 1997; Gilreath 1987; Gilreath and Hildebrandt 1997; Botkin et al. 1997
Whirlwind Val.	Elston and Bullock 1994
Papoose Flat	Reynolds 1996
Mono Basin	Arkush 1995; Davis 1964; Hall 1990;Wickstrom and Jackson 1993
Long Valley[2]	Bettinger 1977

Results

Table 5.4 lists the results of the analysis. Regions are listed in approximate order of reliance on pottery (greatest reliance on top), as determined by the 5 measurements discussed above. Clearly there are significant differences between areas in terms of the density of pottery, and by inference, the importance of pottery in prehistoric lifeways. Indeed, areas quite close to one another, such as Southern and Central or Northern Owens Valley, and to a lesser extent Monitor and Reese River Valleys, are different in the commonness of pottery, despite the fact that at contact they were occupied by the same ethnographic and linguistic groups. These differences suggest that the importance of pottery varied not only by elevational zone (as discussed above), but by Great Basin valley system and even regions within a valley as well.

Table 5.4: Density and ubiquity of pottery Central and Western Great Basin regions.

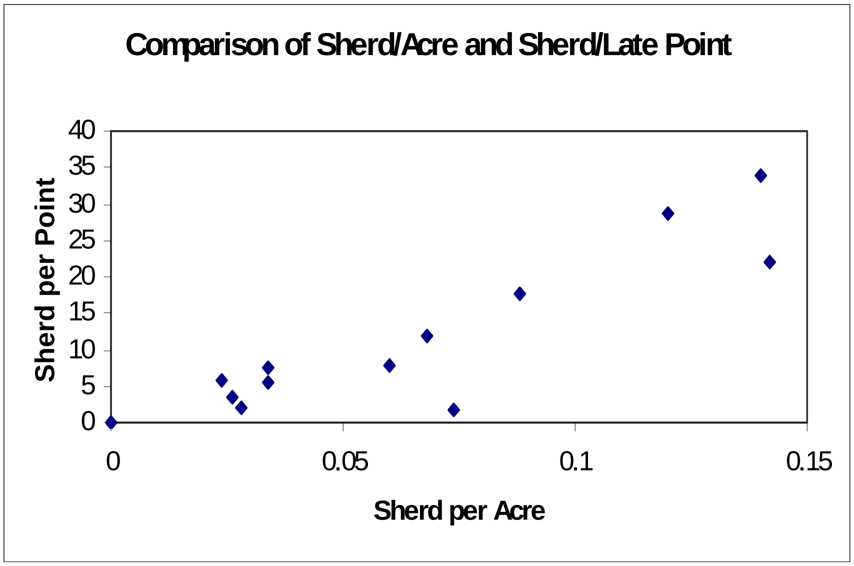
Region	Rank	Sherd/ Acre	Sherd/ Point	% All Sites	% Late Sites	Avg. No/ Site
Southern Owens	1	.140	33.9	54%	92%	35.2
Nevada Test Site	2	.120	28.6	9%	75%	16.8
Panamint Valley	3		26.4	27%	88%	20.4
Monitor Valley	4	.142	22.1	22%	57%	125.1
Death Valley	5	.088	17.7	48%	68%	25.1
Sequoia	6	-	11.9	10%[1]	-	-
Reese River	6	.068	11.9	-	-	-
Fort Irwin	8	-	9.4	20%	75%	37.3
Deep Springs	9	.060	7.9	38%	75%	28.8
Hammil Valley	10	.034	7.6	14%	62%	12.3
Central Fish Lake	11	.024	5.8	10%	50%	11.7
Central Owens	11	.034	5.4	7%	50%	21.8
Northern Owens	13	-	4.7	-	-	-
China Lake - Coso	14	.026	3.5	5%	20%	-
Whirlwind Valley	15	.028	2.1	7%	18%	-
Papoose Flat	16	.074	1.6	24%	62%	7.9
Mono Basin	17	-	1.5	6%	33%	16.7
Long Valley[2]	18	.000	0.0	0%	0%	0.0

Notes: [1] - This is an estimate by park archaeologist Tom Burge. [2] – No pottery was recovered in the single survey used to estimate density in Long Valley.

As Table 5.4 suggests, there are large differences between areas in terms of the reliance on pottery. Pottery is much more common in Southern Owens Valley, the Nevada Test Site, Panamint Valley, and Monitor Valley than in other areas such as China Lake, Whirlwind Valley, Mono Basin, and Long Valley (where it is absent). As the table shows, there are strong positive correlations between the sherds:point ratio and sherds per acre ($r^2 = 0.81$), sherds:points and the percentage of sites with sherds ($r^2 = 0.43$), and sherds:points and the percentage of late period sites with sherds ($r^2 = 0.54$). These four measures, then, seem to be tracking the same cultural phenomenon, what I would suggest is reliance on pottery.

On the other hand, the average number of sherds per site does not correlate to any of the former measures ($r^2 = 0.11$ with sherd:point by comparison). In part, this may be a result of site recording strategies, that is, the tendency of archaeologists to lump or split "sites" in different areas, lumped areas having higher numbers of sherds per site. For example, in Monitor Valley, Thomas (1988) recorded a single large site that covered nearly all the lakebed shoreline (i.e., artifacts covered the shoreline in a nearly continuous manner). At the same time, this variable probably also records the degree of clustering of pottery within an area. Thus, areas with similar overall densities of sherds but larger average numbers of sherds per site tend to have most of their pottery in particular locations, rather than more evenly spread across the landscape.

Figure 5.1: Plot of Sherd/Acre and Sherd/Point for regions in Table 5.4



The main question, then, is why the large differences in estimated reliance on pottery? To what can we attribute these differences? First, it is fairly clear that the difference is not simply due to overall degree of prehistoric residential mobility. Pottery is often considered a marker of increased sedentism. If this were true of the prehistoric Great Basin, Table 5.4 would suggest that Southern Owens Valley, Monitor Valley, Panamint Valley, and Nevada Test Site inhabitants were among the least mobile groups in the Western Great Basin, that Death Valley and Deep Springs Valley peoples were less mobile than those in Northern or Central Owens Valley, and that Monitor Valley people were more sedentary than Reese River groups. This is clearly not the case, as much anthropological and archaeological data indicate (e.g., Bettinger 1983; Delacorte 1990; Steward 1938; Thomas 1983).

Data in Table 5.5 support this conclusion. Estimates for population density (in square miles per person) are given for regions where these data are available. Steward (1938) felt that population density was closely related to degree of mobility, mobility increasing with decreasing population density. Unfortunately, many of the areas included here were not studied directly by Steward and/or populations were not estimated by ethnographers, and as a result, population density estimates (the best predictor of residential mobility) are not available. However, Steward also felt that population density and precipitation were correlated, a statistic that is more readily determined. Table 5.4 and 5.5 do not suggest a correlation between precipitation and any of the pottery density measures from Table 5.4. Nor does there appear to be a correlation between population density, where these data were available, and reliance on pottery, given the data that are available. Thus, reliance on pottery and degree of residential mobility do not appear to be correlated.

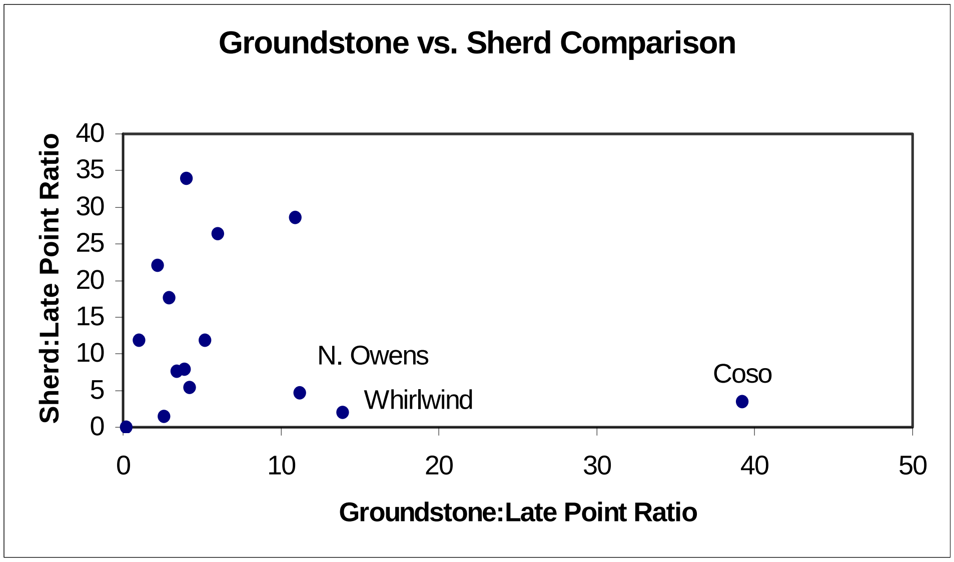
Table 5.5: Other attributes of regions in study area.

Region	**Population Estimate[1]**	**Average Annual Precip.[2]**	**Grndst/ Acre**	**Grndst/ Late ppt (total ppt)**	**%Sites w/ Grndst**	**Avg. # Grnstd /Site**	**Lake**
Southern Owens	2.1[3]	14.5	.050	4.0 (1.8)			Y
Nevada Test Site	32.1[4]	12.8	.011	10.9 (1.4)	23%	2.3	N
Panamint Valley	16.6	N/A		6.0 (0.7)	53%	3.6	Y
Monitor Valley		17.6	.005	2.2 (0.2)	24%	3.2	Y
Death Valley	30.0	5.3		2.9 (1.5)	21%	2.4	Y
Sequoia	0.5[5]	57.7		5.2 (2.8)			N
Reese River	3.6	19.6	.006	1.0 (0.1)			N
Fort Irwin		10.1					Y
Deep Springs	10.7	15.4	.020	3.9 (1.3)	24%	3.6	Y
Hammil Valley		20.4	.016	3.4 (1.6)			N
Central Fish Lake	9.9	12.0			32%		N
Central Owens	2.1	13.5	.034	4.2 (2.2)	22%	6.5	N
Northern Owens	2.1	16.0		11.2 (1.5)			N
China Lake-Coso		11.9	.110	39.2 (9.5)	50%	16.4	N
Whirlwind Valley		21.0		13.9 (2.0)	55%		N
Papoose Flat		N/A			59%		N
Mono Basin		35.0		2.6 (1.6)	67%	4.9	Y
Long Valley		N/A	.003	0.2 (0.1)	11%	1.5	N

Notes: Grndst = Groundstone. [1] – In square miles per person, data from Steward (1938) unless otherwise noted. [2] – In centimeters per year. [3] – Steward's (1933) gave this estimate for all of Owens Valley, but it probably applies more to Northern and Central Owens Valley where he conducted his ethnographic work. [4] – Estimate from Jones (1993). [5] – Data derived from Steward (1935).

Second, it appears initially that the density of pottery is also unrelated to the density of groundstone artifacts. Presented in Table 5.5 are data for the density of groundstone artifacts in lowland locations for the same 18 regions. In the table, groundstone artifacts include millingstones, metates, manos, pestles, bedrock mortars, and grinding slicks. Density was determined by the number of groundstone artifacts per acre, the number of groundstone artifacts relative to late period (and total) projectile points, the percentage of sites with groundstone, and the number of groundstone artifacts per site. The correlation between these figures and the pottery figures is decidedly insignificant (for example, between sherd:late point and groundstone:late point, $r^2 = 0.03$, between sherd:late point and groundstone/acre), suggesting $r^2 = 0.01$, and between sherd/acre and groundstone/acre, $r^2 = 0.03$). Figure 5.2 plots the sherd:point ratio against the groundstone:late point ratio. These data suggest that the relative distribution of ceramics between different areas does not mirror the relative distribution of groundstone artifacts and features.

Figure 5.2: Comparison of groundstone and pottery density (by late period points).



However, as indicated in Figure 5.2, three regions stand out in particular to make the correlation poor, namely China Lake-Coso, Whirlwind Valley, and the Tablelands of Northern Owens Valley. All three regions have very large numbers of groundstone relative to pottery, particularly China Lake-Coso. If these three regions are removed from the analysis, a much better correlation is achieved ($r^2 = 0.33$), suggesting that in most regions pottery and groundstone *are* to some degree positively correlated. This implies that these two artifact categories were used in similar sorts of activities.

Part of the reason for the poor correlation may lie in the fact that groundstone artifacts are not temporally diagnostic (unlike pot sherds and projectile points). Thus, by grouping groundstone together in the analysis, pieces from all of prehistory are being agglomerated, unlike the analogous comparison with pottery and projectile points described above, where only late period artifacts are included. This is particularly relevant in the Whirlwind Valley case, where a single site, 26La2387, contributes 64% of the 500+ groundstone artifacts recorded. This site appears to date predominantly to the Middle Archaic period (ca. 3000 BC – AD 650), long before pottery was in use. Together, the data suggest that some regions notwithstanding, reliance on pottery and higher density of groundstone are generally correlated. The possible significance of this correlation is discussed in greater detail in Chapter 8.

Finally, as indicated in Table 5.5, there appears to be an association between higher densities of pottery, the average number of sherds per site, and the presence of valley-bottom lakes or playas. Six of the nine highest pottery density areas have lakes while eight of nine of the lowest density areas do not. A logistic regression on lake/no lake and the sherd:point ratio gives a Nagelkerke R^2 value of 0.29 (this value is a logistic regression analogue for the R^2 strength-of-association statistic typically reported in linear regressions; see Nagelkerke 1991). This suggests that the presence of a lake is a fair (though far from perfect) predictor of increased density of pottery.

A higher degree of correlation is achieved through a logistic regression of lake/no lake and the average number of sherds per site. In this case the Nagelkerke R^2 value is 0.75, which suggests that the presence of a lake is a relatively good predictor of the average number of sherds per site. This suggests that sherds tend to pile up at sites in areas with lakes, while they are more dispersed in areas lacking these features. That lakes have higher densities of pottery and more sherds per site is supported by the discussions of Beck (1981) concerning Grass Valley, which appears to have high levels of pottery as well as a lake. Unfortunately, the unsystematic nature of artifact collection in Grass Valley made it incompatible for inclusion in this study.

Discussion

The analysis demonstrates that pottery is not evenly distributed across California and the Western Great Basin. In all regions it appears that pot sherds are more common in valley bottom locations than either piñon-juniper woodlands or higher elevation areas. This distribution surely relates to where on the landscape and with what types of resources and activities pottery was associated. Apparently pots were not often used to process and/or store piñon, juniper, or other winter resources in higher elevations.

At the same time, pottery is also unevenly distributed between different valley systems, some areas having high densities of pottery and others having very little. This distribution is apparently not related to degree of residential mobility, as might have been expected. Instead, the differential distribution may in part be related to the degree of milling that took place within an area, as represented by the density of groundstone artifacts and features and the presence of a lake. Although a few notable regions do not conform, there seems to be a positive linear correlation between the density of pottery and the density of groundstone. Groundstone is often interpreted as an indication of plant processing, though it is known to be used occasionally for processing animals (Fowler 1986; Steward 1941; Stewart 1941; see also Cummings and Puseman 1994). Increased milling activities and increased use of plants, then, may be associated with increased use of ceramics.

The archaeological record of the Western Great Basin would certainly imply an increase of groundstone during the late prehistoric period. Late prehistoric sites (post 1400 BP) usually contain ample groundstone while earlier period sites have much less. However, the exact timing of this increase in groundstone relative to the inception of pottery-making is difficult to determine owing to the difficulty in directly dating groundstone. Determining whether there is a one-to-one correlation or one slightly predates the other must await future research. In particular, the development of a chronologically sensitive typology of groundstone would go far towards this end (see Delacorte and McGuire 1993 and Delacorte et al. 1995 for a discussion of this in Owens Valley).

That pottery and mobility are not associated might have been anticipated based on the association of pottery with valley bottom and wetland areas. According to Steward (1938), use of the valley bottom often took place during spring and summer when groups were fairly mobile (see also Bettinger 1982 and Thomas 1983:591, 1986). An exception to this pattern may be in Owens Valley, where groups appear to have resided primarily in valley bottom villages throughout the year, only relocating to other areas, such as the piñon zone, during years with bountiful harvests (Steward 1933). For the rest of the western and central Great Basin, however, spring and summer usually involved dissipation of the larger fall and winter piñon zone villages into smaller family units that moved around on the valley floor in search of early ripening seeds and greens (Bettinger 1982a; Fowler 1986; Thomas 1981a). If this generalized settlement strategy is true of the study area at large, it suggests that pots were most often used during periods when groups were relatively mobile.

At first glance, this association appears something of a paradox. In order to make pottery, it is usually necessary to be in one place for a sizable period of time. One has to have time to gather resources and fabricate, dry, and fire the pots. Moreover, carrying heavy pots around during the seasonal round is expensive in terms of energy costs (relative to lighter baskets) and potentially dangerous due to increased chances of breakage.

However, upon further consideration, the distribution makes more sense. First, in California and the Western Great Basin summertime is the best time of the year to make ceramics due to decreased chances of rainfall (see Arnold 1985 for discussion of seasonality and pottery-making). Second, the raw materials necessary for making pots (e.g., clay, sand or fiber for temper, and firewood), are all readily available in valley bottom locations (e.g., see Mason 1981). Finally and most important, the riverine and lacustrine resources available in these areas are spatially fixed and reliable, much more so than either piñon or other montane seed resources which are notoriously variable spatially and temporally (Thomas 1972). Thus, despite the fact that residential mobility was higher during periods in which valley bottoms were exploited, people could have cached pots in these locations to which they knew they would be returning, obviating the need to transport heavy and breakable artifacts during the seasonal round.

In this manner, pottery could have been an attractive technology even to mobile groups, provided the resources pots were used to process were spatially fixed year after year. Furthermore, this also explains why fiber-tempered pottery is relatively uncommon (as discussed in Chapter 4). If pots were cached, rather than moved around during the seasonal round, there would have been little incentive to make pots lighter (but less strong) using fiber temper. Indeed, Beck (1981:13) has proposed that the hunter-gatherers of Grass Valley in Central Nevada cached their pots with their metates in lowland areas while they were elsewhere on the landscape. Archaeological evidence from a number of regions within and surrounding the study area support the notion that pots were cached for future use (e.g., Bayman et al. 1996; Murray et al. 1989; King 1976; Wallace 1965).

Along these lines, the average number of sherds per site (in Table 5.4) may record the relative spatial and temporal stability of resources in an area. For example, if resources are in a fixed location year to year, it is expected that reoccupation of this location through the years would lead to a large build-up of refuse, including broken pots. Provided “sites” are recorded in a similar and consistent manner, areas with large numbers of sherds per site should reflect such locations. Table 5.4 suggests that many of the regions displaying high average numbers of sherds per site, particularly Southern Owens Valley, Monitor Valley, and Deep Springs Valley, are located in areas containing either permanent or perennial shallow lakes. Likewise, many of the sites containing pottery in Fort Irwin, which also has a high average number of sherds per site, are located near lake beds. Two regions containing playas or lakes do not fit this pattern, Mono Lake and Death Valley. However, Mono Lake has little pottery in general, and sites around the lake seem to have higher numbers of sherds than sites more distant, hinting that the pattern may hold, just on a smaller scale. Death Valley simply does not fit and seems to have pottery more dispersed.

Similarly, pottery is much more dispersed (i.e., lower average numbers of sherds per site) in areas lacking lakes, such as Central Owens and Northern Owens Valley, Hammil Valley, Papoose Flat, and the Nevada Test Site. Finally, the sample from Fish Lake Valley, which does have a lake but pottery is dispersed, includes areas that are located in the middle of the valley, away from the playa on the north end of the valley. Accordingly, the average number of sherds per site in this area of the valley is relatively low. This part of Fish Lake Valley, then, may be akin to pottery-poor areas such as Central and Northern Owens Valley (relative to Southern Owens Valley which has a lake). If the pattern holds, lakeshore survey in Northern Fish Lake Valley should reveal a higher density of pottery.

Why lakeshore environments tend to have more pottery per site relative to riverine settings is unclear, but may stem from three factors. First, sedimentary clays may be more accessible to inhabitants living in these areas. This is particularly true of areas containing lakes that tend to dry or recede on an annual basis, exposing lake bottom sediments, or those that contain elevated Pleistocene clay deposits now exposed in arroyos. Second, depending on the slope of the shoreline and the depth of the lake, lacustrine environments may support larger marshland areas with wetland food resources than more narrow and linear riverine areas, especially if many streams empty into the lake. Finally, lacustrine environments offer unusual resources not available in other areas. For example, in addition to seeds, roots, and tubers that are also available in many riverine environments (especially *Typha*, *Juncus*, and *Scirpus*), many western Great Basin lakes and playa marshlands offer higher densities of waterfowl (particularly grebe and other migratory birds) and brine fly (*Hydropyrus hyans*). Moreover, many areas within and adjacent to such wetland regions boast a variety of shrubs and grasses, which presented native groups opportunities for harvesting large numbers of seeds. It is possible that pottery was particularly valuable in the preparation of these resources for consumption or storage.

Summary and Conclusions

The distributional data suggest that pottery is most common in lowland areas around rivers and lakes. Other areas, such as piñon woodland and alpine zones, display lower densities of pottery, despite the fact that people spent much time in these locations in semi-permanent villages (see Bettinger 1989; Thomas 1981). This suggests that most pots were probably 1) produced in lowland locations and 2) used to cook (or store) resources that are available in these areas. Such resources may have included water or other liquids, marshland plant seeds or roots, alkali plant seeds, brine fly, fish, shellfish, waterfowl and/or nearby dryland seed resources. The tentative association between higher densities of pottery and groundstone hints that plant products may be involved, *if* traditional interpretations of groundstone as a plant processing tool are correct. It does not appear, then, that pots were very important in the exploitation of upland resources such as piñon nuts, juniper berries, or alpine roots and tubers. This provides the first bit of evidence suggesting why people may have adopted ceramic technology, namely to facilitate more intensive exploitation of lowland resources.

Interestingly, these lowland areas were often exploited during times of higher residential mobility in the summer. The data also show that people described ethnographically as having high residential mobility are not necessarily less reliant on pottery. Indeed, areas known to display high mobility often have large numbers of ceramics relative to more sedentary areas. Together, these lines of evidence suggest that reliance on pottery and overall degree of residential mobility are not related in late prehistoric California and the Western Great Basin. Instead, the spatial stability of resources along rivers and lakes may have been more influential in the decision to make and use pottery. Mobile groups may have been able to cache pots in these locations, fixed points on the landscape they knew they would return to year after year.

The data also suggest that pot sherds tend to pile up differentially at lakeshore sites. Since lakes are somewhat like point sources, and in this sense provide a more concentrated and fixed focal point in the seasonal round (relative to rivers which are more two-dimensional and linear), sites in these areas may have seen more frequent reoccupation as groups came to harvest resources each year. As a result, cached pottery may have accumulated faster along lakeshores than at riverside sites. Alternatively, lakeshore resources may have been more efficiently processed or stored in bulk using pottery. This may explain the tendency of regions with lakes to have higher densities of pottery as well as an elevated number of sherds per site.

CHAPTER VI

GC-MS ANALYSIS OF ORGANIC RESIDUES

Introduction

The preceding chapters have examined the role and use of pottery in the Western Great Basin largely through indirect measures, such as ethnographic data on pottery use, vessel size and form, and the association of pottery with certain environments and resources. This chapter attempts to examine pottery use more directly through the analysis of organic residues absorbed and preserved within the walls of pot sherds. Such analyses have gained popularity in recent years, as witnessed by the number of published reports employing this technique (e.g., Charters et al. 1997; Deal and Skibo 1995; Dudd et al. 1999; Evershed et al. 1997; Fankhauser 1994, 1997; Gerhardt et al. 1990; Melainey et al. 1999a, 1999b, 1999c; Mottram et al. 1999; Skibo 1992; Stott et al. 1999). These studies demonstrate that a variety of organic compounds, including fatty acids, waxes, sterols, resins, tars, pitches, and proteins (though see Evershed and Tuross 1996) can be preserved in prehistoric pot sherds (see Evershed 1993).

To date, this approach has not been applied to Great Basin pot sherds. However, for a number of reasons such a program holds much promise in the analysis of Great Basin brownware. First, the technique offers the possibility to determine more directly the use of pots, particularly the types of foods, and in some cases the exact plant or animal species, cooked within vessels. This is particularly important in light of the lack of ethnographic information on pot use. Second, given the porous, unglazed, and unpainted nature of most Great Basin pottery, these sherds are good candidates for the absorption and retention of organic materials such as lipids. Finally, because pottery is a late phenomenon, occurring mostly within the last 500 years of prehistory, residues within sherds are more likely to be preserved and to have had less opportunity degrade and break down.

Given these observations, a small sample of 74 archaeological sherds were selected for fatty acid analysis by Gas Chromatography-Mass Spectrometry (GC-MS) at the University of California at Santa Barbara. Previous study has shown that fatty acids preserve quite well in ancient archaeological sherds (e.g., Condamin et al. 1976; Melainey et al. 1999a; Patrick et al. 1985) and are not contaminated by surrounding soil (Deal and Silk 1988; Heron et al. 1991). The sherds selected were also among the samples analyzed by INAA (see Chapter 7), allowing comparison of production location with use. In addition, a number of plants mentioned as important sources of food in the ethnographic literature were assembled, cooked in small test pots, and analyzed by GC-MS. These samples represent a reference collection against which the archaeological sherds were compared.

Numerous chemical methods currently exist to study and characterize organic compounds, and rapid progress is being made in the fields of biochemistry to expand the range and accuracy of analysis. Archaeologists have applied a number of techniques towards this end, including stable isotope analysis (Hastorf and DeNiro 1985; Morton and Schwarcz 1988), nuclear magnetic resonance spectroscopy (NMR) (Sherriff et al. 1975), infrared specroscopy (IR) (Badler 1990; Hill and Evans 1989; Hill et al. 1985), thin-layer chromatography (Kharbade and Joshi 1995; Ugent 1994), and identification by Scanning Electron Microscope (SEM) and energy dispersive X-Ray flourescence (EDXRF) (Bush and Zubrow 1986). However, the use of gas chromatography, particularly when coupled to a second spectrometric detector such as a mass spectrometer (MS) or an ion ratio monitoring mass spectrometer (irm-MS; to determine ratios of stable isotopes, including carbon and nitrogen), has also met with much success in archaeological applications. Indeed, future use of techniques such as GC coupled with IR or NMR spectroscopy, in addition to GC-MS, would go far to further the study of archaeological residues.

As discussed below, it was ultimately decided to attempt to extract and characterize lipids that have been absorbed *into* the walls of the pot (not carbonized deposits adhering to the surface of sherds). Lipids appear to be relatively well insulated and preserved within the fabric of ceramic pots (Deal and Silk 1988; Heron et al. 1991) and it is a simple matter to remove potentially contaminated and degraded material by burring away the top 1mm surface of the sherd on all sides to expose the interior. Analysis by GC-MS allowed for characterization of the preserved lipid profile.

Chemists and biochemists use several different methods to name and identify organic compounds such as fatty acids and other lipids (Christie 1989; Lobb 1992). Some texts use a systemic naming system that unambiguously identifies the chemistry and structure of a compound. For example, *cis-9, cis-12, cis-15-octadecatrienoic acid* describes a fatty acid molecule with 18 carbon atoms and 3 double bonds, all in the cis- configuration (i.e., a polyunsaturated fat). However, in other texts an abbreviation system is used, thus, C18:3, or for more detail, C18:3(n-3), C18:3ω3, or C18:3Δ9 refer to the same compound (the difference between the n or ω and Δ naming systems has to do with which side of the molecule the first or last double bond is counted from). In yet other texts this same molecule is referred to by its common name, linolenic acid. The use of these different systems makes for some confusing reading, particularly to those unfamiliar with the field of organic chemistry (e.g., archaeologists employing biochemical techniques). The systematic naming system gives the most clear and unambiguous information, but at the expense of space and readability. Most researchers prefer one of the abbreviated nomenclature systems.

Throughout the text below, I will use an abbreviation system. Fatty acids are referred to by their carbon length and number of double bonds (i.e., degree of unsaturation). C16:1 refers to a compound with 16 carbon atoms and 1 double bond (a monounsaturated fat). When more specificity regarding the location of double bonds is needed the ω system will be used, thus, C16:1ω7 and C16ω9 refer to two different isomers of C16:1, the first with a double bond seven carbon atoms from the terminal methyl carbon group (as opposed to the end with a carboxyl carbon group) and the second with a double bond nine spaces from this same end.

Goals, Assumptions, and Background

The ultimate goal of this study was to determine more accurately the range of food-stuffs cooked or stored within Great Basin brownwares through an analysis of preserved organic residues. While the analysis of DNA would provide the most direct evidence for the preparation of specific plants and animals in pots, DNA does not survive well under most conditions, is difficult to extract without contamination, makes up only a minor fraction of living tissue (Evershed 1993), and more importantly, no previously published studies have attempted to extract and identify DNA from prehistoric ceramics, giving little guidance for future work. On the other hand, carbohydrates, proteins, and lipids are much more common and form a major fraction of plant and animal products. For this reason, they are much more likely to be encountered and quantified in archaeological ceramics. Of these, lipids are most resistant to degradation (up to 400C) and can remain intact over long periods of time (Evershed 1993). This was particularly important in the current study, as the age of most sherds was unknown and a significant fraction are derived from site-surface contexts.

Lipids include a number of organic compounds such as fatty acids, sterols, diterpenoids and triterpenoids (resins, tars, and pitches), mono-, di- and tri-acylglycerols, and waxes, among others, each of which contain tens to thousands of distinct organic compounds or isomers. Of interest to archaeology is the fact that different plants and animals produce different types and quantities of these compounds, providing the opportunity to "fingerprint" different plants and animals according to their makeup of lipids. In fact, some lipid isomers are rare and only made by certain plant or animal species or families (referred to as biomarkers). In such a case, the identification of this compound in an archaeological sherd provides strong evidence that that particular plant was cooked, processed, stored, served, or transported within the vessel.

Fortunately most plants and animals produce a variety of lipids in different concentrations that can be used to aid identification of archaeological residues. For example, in an analysis of milk (using now outdated equipment), among the fatty acids alone, 437 distinct isomers were recorded (Patton and Jensen 1975). Of course, no single analysis or analytical technique can observe, differentiate, and quantify all 437 compounds. Instead the authors had to rely on a barrage of analyses, using different equipment and parameters (e.g., method of extraction, type of derivitization, type of column, and temperature regime; see below for examples and further explanation), to obtain this result. However, with modern GC equipment, particularly fused silica wall-coated open-tubular (WCOT) columns with narrow internal diameters, it is possible to measure and discriminate among a significant fraction (e.g., 15-20%) of isomers within a single analysis (Christie 1989).

Based on the greater density and likelihood of preservation I decided to examine a small sample of pottery sherds from the Western Great Basin for lipids, focusing particularly on fatty acids. Before discussing the results of the study a number of issues are first addressed, including lipid preservation, the use of lipids to identify foods, and the types of foods available in the Great Basin.

Changes in lipid profile from original food to archaeological identification

Unfortunately, fingerprinting residues based on their lipid profiles is not as simple and straightforward as it sounds. There are a number of processes that act to change the original lipid profile of a plant or animal to the profile obtained by the archaeologist from a prehistoric pot sherd, including cooking, variability within the food cooked, multiple uses of a pot and mixing of fatty acids, post-depositional change, and contamination.

First, cooking exposes lipids to heat, which causes degradation of organic compounds. Of course, in many instances this is the main goal of cooking in the first place, namely, to make foods easier to digest by breaking down complex compounds such as fatty acids. In other words, cooking begins the digestion process extrasomatically (Wandsnider 1997). Exactly how cooking foods in clay ceramic pots affects the lipid profile of a particular plant or animal has not been studied by archaeologists, and research along these lines would go far in advancing functional studies of ceramics. Nor is it understood how pots differentially absorb organic compounds. For example, it is likely that larger and heavier compounds are not as easily absorbed into the walls of a pot, but more research is needed to verify this point.

Of course, these two factors, exposure to heat and differential absorption, will change the profile of lipids from original plant or animal to those preserved within a pot. One way to circumvent these issues is to cook potential food items in test pots and use the resulting profiles as signatures or fingerprints of the original plants or animals, rather than the plants or animals themselves. However, different shapes of pots and cooking parameters (e.g., temperature, length of time exposed to fire) may create slightly different profiles of lipids. Moreover, even if it were known exactly how these potential cooking parameters affect lipids, it is extremely difficult to determine and replicate the original cooking conditions in archaeological sherds.

In short, cooking in ceramic pots changes the ratio and types of lipids absorbed and preserved. The construction and lipid analysis of test pots that mimic potential prehistoric cooking conditions can help to identify these changes, a tact that several archaeologists have explored (e.g., Evershed et al. 1991; Melainey 1999b; Skibo 1992). However, differences in cooking conditions are likely to introduce additional error that is difficult to account for.

Second, in ethnographic examples, foods are commonly prepared in stews where several different items are mixed and cooked together. Unless the foods were originally very similar, such mixing may make identification of the original foodstuff by the archaeologist difficult. Depending on the uniqueness of the compounds present in the two (or more) food items, it may or may not be possible to determine that the pot was used to cook multiple items. Most likely, the individual amounts of common compounds, such as C14:0 (myristic), C16:0 (palmitic), C18:0 (stearic), and C18:1 (oleic acid) will not be useful in the identification of mixed foods, especially when the foods are different in their makeup.

Similarly, different cuts from the same animal or parts of the same plant show variation in the percentage of different lipid compounds. For example, the kidneys of a pig have a slightly different lipid signature than the bone marrow or muscle. Likewise, plants collected from different soil types or harvested at different times of the season (particularly premature versus fully or over-ripe seeds, nuts or fruits) may have slightly different organic profiles. These differences introduce variability into the range and concentration of different lipids, making quantification and identification of specific foods based on absorbed residues difficult.

Third, and related to the point above, a pot is often reused over the course of its life, and may be used to cook quite different foods from cooking episode to episode. Research by Fankhauser (1997) with amino acids suggests that the first use of a pot essentially saturates the vessel walls and “seals” the pot from further amino acid contribution, that is, amino acid residues within a pot record the only first few uses of the pot. Although identical studies have not been carried out with lipids, a similar process may operate, whereby the lipids preserved in a pot record information primarily about the first few uses, rather than its entire use-life. If so, multiple uses may not introduce much complication to residue studies.

Fourth, while lipids are relatively stable, they do undergo degradation through oxidation and hydrolysis (Christie 1989). How extensive this is in archaeological contexts will depend on a number of factors, primarily the depositional context of the sherd, how well lipids are sealed within the sherd, and length of time since the pot was used. Hydrolysis is probably of less significance in the current context given the arid nature of most Great Basin environments and soils (though sherds from Sequoia National Park may undergo this process more extensively). Oxidation is likely to be more of a problem, though some suggest the effects are minimal or can be accounted for (Hill and Evans 1989; Melainey 1997: 109).

Particularly troublesome with oxidation is that not all lipids decompose at the same rate. Longer-chain compounds decompose more quickly than shorter-chained compounds, and unsaturated fats more quickly than saturated fats (the rate increasing two to three times for each double bond present). For example, it is estimated that the rate of oxidation between C18:0, C18:1, C18:2, and C18:3 at 100C is 1:100:1200:2500 (deMan 1992). Thus, not only do the absolute concentrations of lipids change with oxidation, but the ratios between compounds change as well, depending on the type of lipid. More importantly, this suggests that polyunsaturated lipids are unlikely to survive in archaeological samples, a result borne out by the current study and previous studies (e.g., Dudd and Evershed 1999; Melainey 1997). Unfortunately, it is difficult to estimate the amount of decomposition that has taken place. If this were possible, one might be able to account for decomposition and reconstruct the original amounts of different lipids based on known differences in the rate of decomposition between compounds. However, the decomposition process is very complex and there are few unique degradative products produced through oxidation of specific lipids (Frankel 1980, 1987; Hudlicky 1990: 222). The main byproducts of fatty acid oxidation are hydroperoxides and an assortment of volatile short-chain fatty acids with 9 carbon atoms or less (Frankel 1980, 1987; Frankel et al. 1981; Fritsch and Deatherage 1956; Porter et al. 1981). Many of these byproducts are lost prior to analysis during the extraction process, especially by the creation of methyl esters (Badings and de Jong 1983). Indeed, few of these compounds were detected in the current study.

Several archaeological studies have examined how fatty acids decompose by simulating long term decomposition in experimental cook pots (Marchbanks 1989; Patrick et al. 1985; Skibo 1992; Melainey 1997; Melainey et al. 1999c). These studies provide some direction to estimate and account for decomposition, and they suggest that the ratios of more stable compounds, particularly saturated and monounsaturated fatty acids, can be a useful indicator of the original foods cooked. However, determining the extent of decomposition in an archaeological sherd is ultimately an empirical problem; samples must simply be analyzed to see whether fatty acids have been preserved.

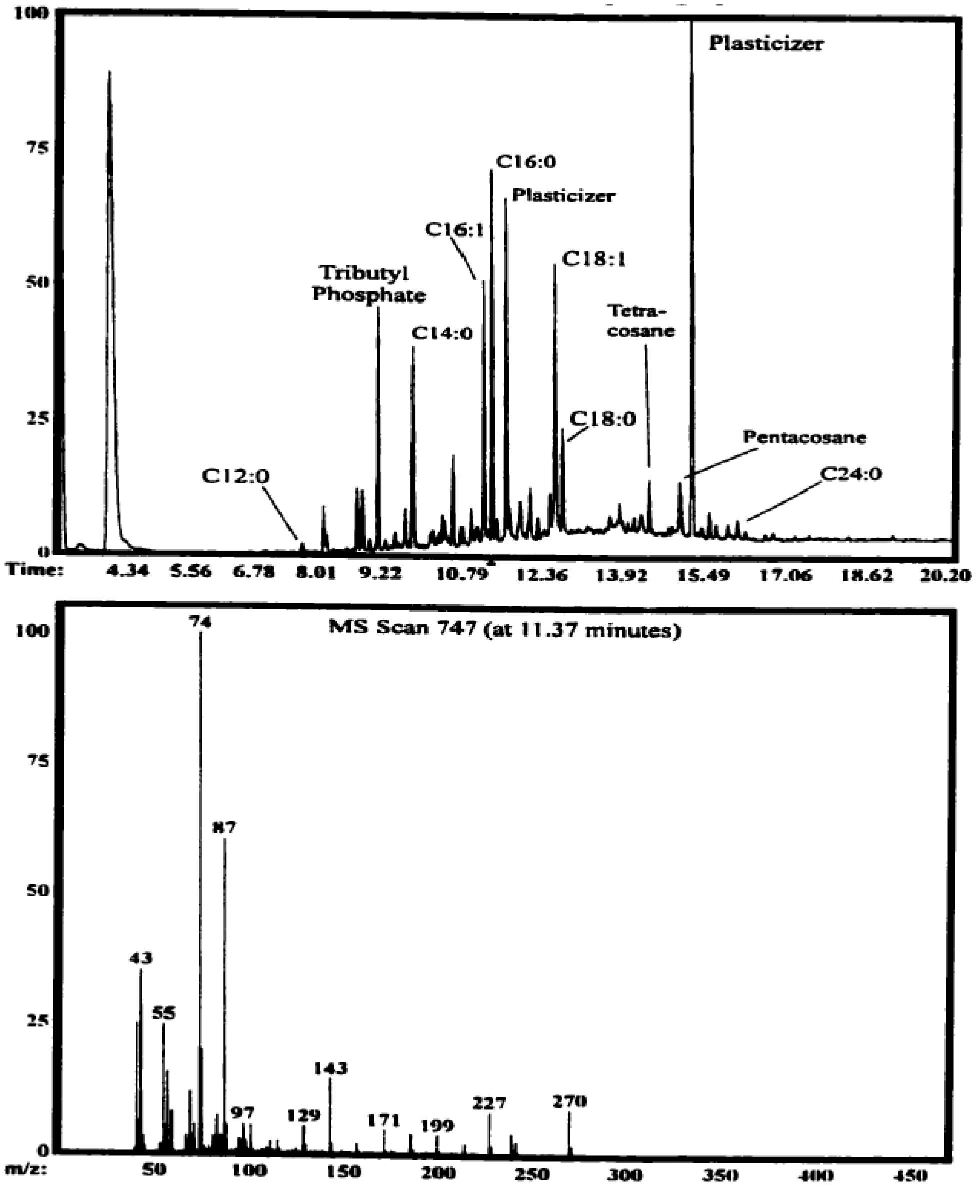
Finally, the archaeologist must be concerned with contamination. As human skin and oils contain various organic compounds, handling sherds without gloves is a potential sources of contamination during the extraction of lipids from sherds. Similarly, test tubes and caps or stoppers may have been handled by humans or exposed to other sources lipids. Plastics, which were encountered during the current study, are petroleum based and may contribute low levels of fatty acids to samples. In practice, it appears that low levels of non-food lipids are introduced during the course of archaeological analysis of ceramic residues. For example, Deal and Silk (1988), Melainey et al. (1999c), and Skibo (1992) all report low levels of fatty acids in blank control samples, a result also experienced in the current study (see below). These sources of contamination can modify the lipid profiles obtained, and of course, every attempt should be made to minimize them. Indeed, even chemists find low levels of fatty acids in blank samples (e.g., Alexander and Justice 1985), suggesting the problem is not related to archaeologists alone.

In sum, there are a number of potential problems that can lead to modification of lipid profiles from original plant or animal to archaeological recovery. This probably makes the use of quantitative techniques based on ratios of common lipids to identify specific plants and animals of limited value. This is unfortunate, as large databases exist documenting the profiles of lipids within various plant and animals species (though this is less so in the case of native foods commonly eaten in the Great Basin since they rarely have commercial value). While the analysis of test cook pots with native foods will go far towards the identification of lipids in prehistoric sherds, it is impossible to simulate every possible condition in such pots. Thus, combining every possible parameter, between cooking temperature, length of cooking, the cut of meat or part of the plant, the mixing of different food items together, pot reuse, as well as simulating different degradative conditions, presents a bewildering number of possibilities to duplicate in test cooking pots. For these reasons, it seems that the identification of lipids in sherds is more of a qualitative procedure than a strictly quantitative one. Identification of foods based on lipid profiles is likely to be valid only to a very general food category, family level or even more general. However, even if it is not possible to determine the exact species cooked within a pot, a general level of identification is quite informative, particularly in the Great Basin, as we know so little about what pots were used for. Any information of this sort will be of much use in determining why pottery was adopted in this area. Moreover, a comparison of lipid profiles between sherds from different geographic areas, between different pot types (e.g., thick vs. thin, narrow diameter vs. large diameter, recurved vs. direct rim profile, etc), and between locally made and imported sherds, will tell us not only about the diversity of uses to which pots were put, but also about the nature of pot movement or exchange in this area (as discussed below).

Methods

GC-MS was chosen as the analytical method for a number of reasons. First, GC-MS is a relatively standard technique and is particularly effective at separating and identifying many types of lipids. This was considered important as it was not known ahead of time which specific lipids would be encountered or which would be effective at discriminating different classes of foods. The greater the range of lipids, of course, the greater the likelihood of finding and identifying specific biomarkers of different plant or animal families and/or species. Moreover, the technique is relatively inexpensive (i.e., machine time), is easy to learn and use, and has been used by other archaeologists, facilitating comparison with other studies. Most importantly, of course, the machinery was available for use by graduate students in the Department of Chemistry at the University of California, Santa Barbara.

Figure 6.1: Gas Chromatogram and Mass Spectrogram of JEC047.



Equipment

The Gas Chromatography (GC) phase of this technique separates a complex mixture of compounds into its various lipid constituents. This is accomplished by injecting the mix of lipids as a liquid into a long narrow tube or column, in this case a fused silica wall-coated open-tube (WCOT) capillary column, with an internal diameter of .25mm and 30m long (J and W DB5). A carrier gas moves compounds down the column to separate them by their different molecular weights, sizes, and shapes. At the same time, the internal temperature is slowly raised, in this case from 100C to 325C at a rate of 12C/minute, causing different compounds to volatize and become gaseous at different times. The final temperature is then held for a period of five minutes. Finally, as different compounds volatize they are carried to the end of the column and passed by a flame ionization detector, which essentially measures the volume of gas eluting at different points in time. The plot of volume of gas eluted from the column against time creates a chromatogram. For example, the upper half of Figure 6.1 provides a chromatogram for sample **JEC047**, an imported (i.e., non-local; imported from Northern Owens Valley) sherd collected in Cedar Grove in Sequoia National Park. The x-axis plots time (beginning at three minutes and ending at 28 minutes) while the y-axis records levels of compounds coming out of the end of the column. The scale on the Y-axis is the percent of the most common compound.

Following measurement, the GC directs the eluting gases to a Mass Spectrometer (MS) which allows for identification of the compounds. Different compounds have unique mass spectral signatures due to their mass and how they fragment (Harrison and Tsang 1972). For example, the lower half of Figure 6.1 provides the mass spectrum of the peak occurring upper part of Figure 6.1 at 11.37 minutes. This particular mass spectrum happens to correlate with methyl palmitate (the methyl ester of palmitic acid, or C16:0). Thus, while the GC separates the organic compounds by size and shape, it does not identify which compound corresponds to a particular peak. The MS allows for identification of particular organic compounds. The scale of the Y-axis on the MS graph is percentage of most common mass.

Analyses were done on a 5890 Hewlett Packard Gas Chomatograph with splitless injection coupled to a 5790 Hewlett Packard Mass Spectrometer. A solution containing known amounts of methyl benzoate (internal standard) and HPLC-grade hexane (solvent) was prepared and added to each sample prior to injection. The use of an internal standard facilitates numerical comparison of lipid densities across different samples, particularly samples run on different days.

Extraction

To extract lipids from the pot sherds, a small fragment (approximately 1 cm^2, but varying depending on sherd thickness) of each specimen was broken off and prepared for analysis; thus the method is partially destructive. The outer 1 mm of all exposed surfaces of each sample was removed by burring, using an abrasive silicon carbide drill bit, to remove any potential contamination due to handling or contact with the surrounding soil. The fragment was then crushed to a powder in a small agate mortar and pestle and 400 mg was transferred to a test tube. The mortar and pestle were cleaned with solvent following grinding of each sherd. After transfer to the test tube, 200 ml of chloroform-methanol solvent (a 2:1 mixture of HPLC grade chloroform and protein-sequencing grade methanol) were added. The test tube was then gently agitated to mix the solvent and sherd powder, and sonicated for 15-20 minutes. This step brings the lipids into solution while leaving behind any inorganics (crushed clay and temper matrix). Following sonication, the test tube was placed in a centrifuge for ten minutes to separate the solvent mixture, now containing lipids, from the fine clay particles. The solvent was then pipetted from the first test tube and transferred to a second test tube. The second tube was then placed in a vacuum centrifuge to evaporate off the chloroform-methanol solvent, leaving behind dried lipids.

Finally, samples were derivatized to methyl esters. Derivitization serves several purposes, including improving the shape of resulting peaks during GC (i.e., making quantification easier), improving the chemical stability of compounds, increasing the volatility of compounds (thereby decreasing retention time within the GC column and reducing overall analysis time), and enhancing the sensitivity of compounds to the GC detectors (see Taguchi 1990 for a discussion). At the same time, esterification can cause the loss of shorter-chained volatile compounds (Badings and de Jong 1983). In the present analysis, dried samples were derivatized by the addition of 100 µl of methanolic HCl and placement in a heating block set at 60C for 1 hour, with the test tube capped. This step produced the Fatty Acid Methyl Esters (FAMEs) necessary for analysis. After heating, samples were dried within the vacuum centrifuge and stored in a freezer until ready for analysis by GC-MS (fatty acids stored at or below 0C are relatively stable, see Igene et al. 1981).

Unfortunately, while analysis of FAMEs is relatively standard and well studied, the use of this particular derivitization technique does not allow for the differentiation of isomers with the same carbon-chain length and degree of unsaturation but with double bonds in different positions (Christie 1989: 165). For example, mass spectra of C18:1ω7 and C18:1ω9 (two isomers of C18:1 with double bonds at the 7th and 9th position along the carbon chain respectively) are nearly identical when the fatty acids are derivatized to methyl esters. On the other hand, the use of pyrrolidine or picolinyl ester derivatives allows for recognition and separation of such isomers (Christie 1989). Indeed, Evershed (1992) uses pyrrolidide derivatives in an analysis of bog body abdomen remains. However, these techniques have other disadvantages, and are not used as often in fatty acid research, particularly in archaeological studies, making comparison to previous reports more difficult.

Contamination

Despite repeated (many times over!) attempts to remove the source of contamination, small levels of lipids and plasticizers were detected in runs that were supposed to be blank. It is suspected that the source of this contamination was from small plastic caps that were essential to the analysis. Due to the equipment available alternative glass or teflon caps were not a possibility. Ultimately the plastic caps were lined with small teflon disks, teflon tape, and aluminum foil to eliminate contamination. However, very low levels of fatty acids (C16:0 and C18:0) and plasticizers were still encountered, similar to reports in other archaeological (Deal and Silk 1988; Melainey et al. 1999c; and Skibo 1992) and chemical (Alexander and Justice 1985) studies.

However, the effect of the fatty acid contaminants is minimal and relatively standard from run to run. For example, levels of C16:0 in blank control samples were less than 2% of levels in the majority of sherds analyzed and varied less than 5% (as measured by the Coefficient of Variation) from control to control. Thus, in most archaeological samples, the levels of these contaminants is dwarfed by the presence of food-related fatty acids. In any event, the average levels of lipids in 12 controls were subtracted from all archaeological samples to remove the possible effects of contamination from the study. Levels of plasticizer were higher, but since these compounds are easy to identify and do not overlap with fatty acids, they are easily ignored and removed from the analysis.

Quantification

Organic compounds were identified by their relative retention time within the GC column, as well as by their mass spectra. The National Institute of Standards and Technology (NIST) 98 Mass Spectral Library was used to match obtained spectra in archaeological and test pot sherds to reference spectra. The NIST database contains over 100,000 standard reference spectra of high quality, including most FAMEs and sterols of interest (although in practice, as discussed below, many compounds observed in this study were not present in the NIST database).

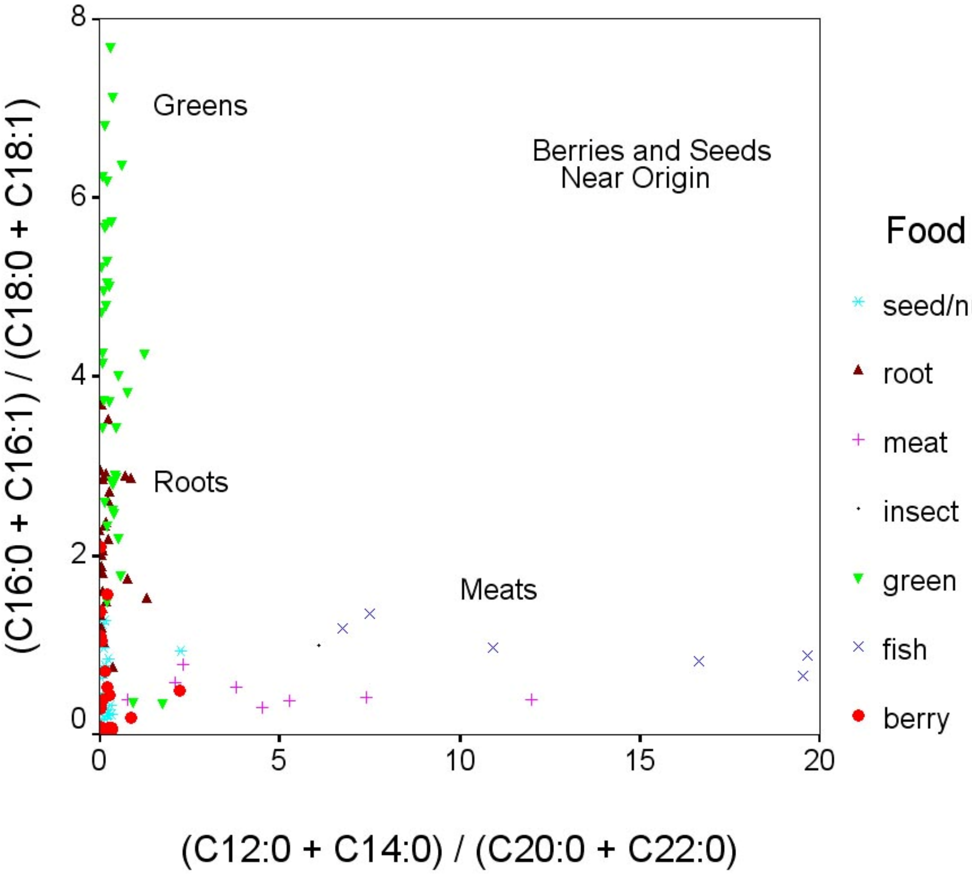
The amount of each organic compound present in a sample was computed using the Automated Mass spectral Deconvolution and Identification System (AMDIS), also provided by NIST. This program allows for rapid quantification of organic compounds observed during GC-MS analysis. A target reference library was created with the FAMEs, sterols, and other compounds of interest observed in the archaeological and test pot samples. The AMDIS program was then used to run a batch job, identifying and computing the amount of each compound in the target library in each archaeological or test pot sample. The quantity of a particular compound was determined by AMDIS by integrating the GC total ion current (TIC) curve for the peak associated with that compound (i.e., integration and calculating the area under a peak).

Biomarkers, Fatty Acid Ratios, and Discrimination of Food Types

As discussed by Malainey et al. (1999a) and Skibo and Deal (1995), there are different ways to identify foods based on absorbed residues. The clearest and most unambiguous way involves the identification of specific biomarkers that are produced only in certain plant or animal species, or classes of species. For example, pimaric and abietic acids, both resins or terpenoids, are synthesized only in coniferous trees, such as pine. Their presence in a sherd, then, would provide unequivocal evidence that resins from a species of pine were prepared or somehow incorporated into the fabric of that particular pot. On a similar but more general level, cholesterol, C20:4 (arachidonic acid), and C24:1 (nervonic acid) are produced almost exclusively in the animal kingdom, while sitosterol, stigmasterol, and citric acid (2-hydroxy-1,2,3-propanetricarboxylic) are produced primarily within plants, though traces can be found in the animals that eat these plants. Moreover, the distribution of these compounds within the animal and plant kingdom is not even. Thus, c24:1 is particularly common in marine fish but rare or absent in freshwater fish (Hilditch and Williams 1964; Patrick et al. 1985), and citric acid is present primarily in the fruits, berries, and seeds of certain plants (Bender 1997; Boland et al. 1968; Holland et al. 1992). Again, high levels of cholesterol and C24:1 in a sherd, then, would provide strong evidence that not only meat, but likely marine fish, had been prepared in that pot. Similarly, high levels of citric acid would suggest a fruit, berry, or seed had been prepared. Smith (1970) discusses several unusual fatty acids and their distribution in various plant species (see also Wolff and Miwa 1965 and Weber et al. 1995). Biers et al. (1994), Dudd and Evershed (1999), and Mills and White (1989) employ the biomarker approach to identify tars and resins in a variety of archaeological artifacts.

Less precise markers also exist. These compounds are found widely in nature, including plants and animals, but are particularly common in some species. For example, methyl-branched odd-chain fatty acids and unsaturated fatty acids with bonds in the *trans*- configuration are found in very low levels in many plants and animals. However, they are relatively common in ruminant animals, as well as their products, such as milk (Hartman 1957; Jensen 1992; Massart-Leen et al. 1981; Rhee 1992). Similarly, C22:1 (erucic acid) is present in minor amounts in many plant and some animal species, but is found in relatively high concentrations in the seeds of several species of Cruciferae (mustard family), particularly rapeseed and crambe, and the leaves of some plants, such as cabbage (Smith 1970). While the presence of such compounds in pottery specimens does not provide unambiguous evidence of a particular food product being cooked or stored within a pot, it does provide supporting evidence. Skibo and Deal (1995) regard such compounds as impure biomarkers. Evershed et al. (1997) use such an approach to identify the fats of ruminant animals in archaeological pot sherds.

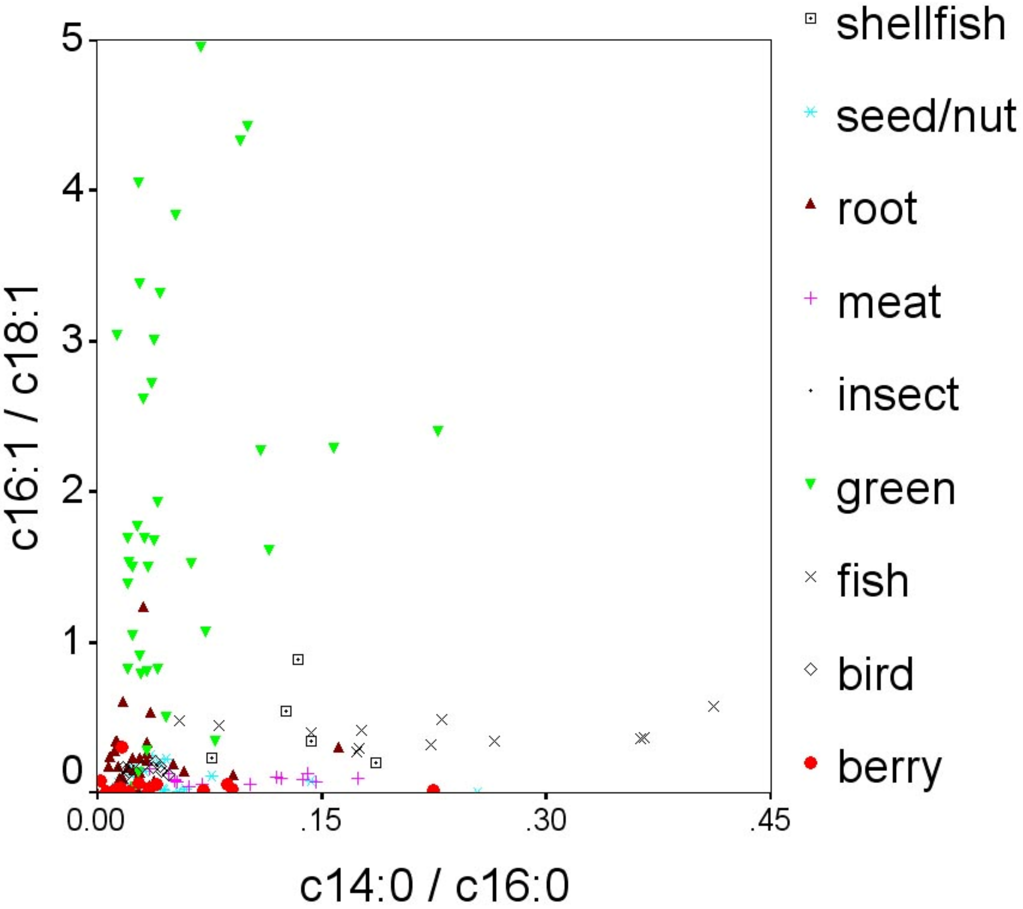
Figure 6.2: Comparison of fatty acid ratios for reference food collection.



Finally, certain classes of foods can be identified based on the ratio of more common organic compounds, including fatty acids (as used below). However, the use of such ratios leads to even less specificity in terms of identifying the original foods cooked or stored within a pot. For example, Figure 6.2 plots the ratio of short and long-chained unsaturated fatty acids [(c12:0 + c14:0)/(c20:0 + c22:0)] against the ratio of c16's and c18's [(c16:0 + c16:1)/(c18:0 + c18:1)] for several different types of foods (data from this study, Malainey 1997, and chapters in Chow 1992). The figure shows that meats (including fish but excluding birds) are usually higher in short-chained unsaturated fatty acids (relative to long-chained ones), while roots and greens are higher in C16's than C18's, and as a result the three classes of foods (meats, roots, and greens) are readily differentiated and identified based on the ratios of these common fatty acids. Further separation of food types using the ratio of common fatty acids is also possible. For example, in Figure 6.3, these two food types are separated by the ratio of C16:1 to C18:1, where greens generally have a value greater than one and roots have a ratio less than one.

Polyunsaturated fats are another type of fatty acid that can potentially be used to separate meats from plant products. Plants often contain high levels of C18:2 and C18:3 (particularly the latter), while meats, including fish and birds, contain lower quantities of these compounds. At the same time, meats contain higher levels of C20:2, C20:4, C20:5, C22:4, C22:5, and C22:6 than plants. However, these polyunsaturated fats, particularly those with more than 2 double bonds, are extremely susceptible to oxidation, and after hundreds of years of exposure are rarely found in archaeological pot sherds. However, the presence of even small amounts of these compounds in some sherds may provide supporting evidence for conclusions reached from the analysis of other fatty acids and their ratios.

Figure 6.3: Second comparison of fatty acid ratios for reference food collection.



Most archaeological studies have employed the ratio approach in some fashion to identify archaeological residues. Malainey (1997; see also Malainey et al. 1999a) used the results of a principal components analysis on the raw percentages of fatty acids (as a percent of total fatty acid content) to classify archaeological sherds into different food groups. Deal (1990), Mottram et al. (1999) and Rottlander (1990) employ a similar approach, but use primarily qualitative values of different fatty acids (e.g., absent, low, medium, high; though the Mottram study also uses the ratio of carbon isotopes as additional evidence). The approach used here is similar, but relies on ratios of specific fatty acids to one another, rather than the ratio (or percentages) of different fatty acids to total fatty acid content. Skibo (1992) uses this same approach but only employs two ratios, C18:0 to C16:0 and C18:1 to C16:0. I am somewhat hesitant to use ratios of saturated to unsaturated fatty acids, particularly when using the ratios of modern food samples to classify archaeological sherds. This seems problematical due the dramatic difference in rates of oxidation between saturated and unsaturated molecules, this process having probably been more extensive in archaeological samples than modern test pots. Having seen less oxidation, modern samples of the same food will have higher ratios of saturated to unsaturated fatty acids, and will not be good indicators of archaeological ratios. While it is also true that longer-chained fatty acids will oxidize faster than shorter-chained ones, the difference is only slight when compared to the difference between saturated and unsaturated (Hudlicky 1990). Therefore, it seems most reasonable to use ratios of saturated to saturated or unsaturated to unsaturated compounds.

Great Basin Foods

Unfortunately very little information exists regarding the chemical composition of specific plants and animals that were economically important in the prehistoric Great Basin and may have been cooked in pots. Most food chemistry studies focus on domesticated crops and other foods that are important today, and few archaeological studies have incorporated studies of raw foods, much less ones available in the Great Basin. A major exception is the study by Malainey (1997; see also Malainey et al. 1999b) who examined foods typically available in Western Canada, including several also present in the Great Basin. The current study draws heavily on her work to aid in the identification of fatty acid residues.

To supplement Malainey's study, a small number of test cook pots incorporating potential Great Basin foods were prepared and analyzed by the author. Test pots were purchased at a Santa Barbara nursery and are composed of high fired orange standard potters clay. The following food items were boiled in small ceramic pots over an open flame for approximately 1-2 hours: acorn (*Quercus agrifolia*), brine fly (*Ephydra hians*), buckeye (*Aesculus californica*), elderberry (*Sambucus melanocarpa*), baltic rush (*Juncus balticus*), piñon nut (*pinus monophylla*), prickly pear (*Opuntia basilaris*), rice grass (*Achnatherum hymenoides;* aka *Oryzopsis hymenoides*), rye grass (*Elymus cinereus*), bulrush seeds (*Scirpus maritimus*), screwbean mesquite seeds (*Prosopis pubescens*), and dropseed (*Sporobolus airoides*). Additional foods were sought, but many (particularly animals) proved difficult to acquire or represent endangered species (e.g., bighorn sheep, antelope, desert tortoise, native desert fish species, and freshwater mussel or *Anodonta* sp.). The test pots were then broken, a sherd removed from each, and prepared in a manner identical to the archaeological sherds (see below). Two samples, consisting of raw brine fly and raw elderberry were also analyzed to compare raw food composition to cooked food composition. Finally, several exotic foods, including catfish, maize, duck, and lamb were also cooked in test pots and prepared as standards for comparative purposes (i.e., between this study and Malainey's study).

Unfortunately a significant fraction of the test pots prepared proved to have little or no absorbed fatty acids and sterols. This is particularly true among pots in which small seeds, fruits, and berries were prepared. It may be that the species cooked in these pots have low levels of fats and need longer cooking times and/or multiple cooking sessions to achieve more significant levels of fatty acid residues. Alternatively, it is possible (perhaps likely) that the test pots are composed of clay that is too dense and has few internal vugs in which to absorb organic materials.

Table 6.1: Results of test pot GC-MS analysis.

Fatty Acid	Acorn	Buckeye	Piñon	Screwbean Mesquite	Dropseed	Raw Brine Fly	Raw Elderberry
C10:0	0.03%		0.03%			0.02%	
C12:0	0.12%					1.02%	
C14:0	0.54%	0.42%	2.32%	7.06%	1.74%	8.16%	0.88%
C15:0	0.06%		0.65%	0.87%	1.54%	4.33%	0.01%
C16:0	9.14%	18.7%	16.3%	27.8%	41.76%	12.25%	9.15%
C16:1	0.94%	0.4%	3.21%	0.1%	4.61%	17.84%	0.78%
C17:0	0.21%		0.94%			3.35%	0.20%
C18:0	7.14%	6.15%	4.78%	11.0%	26.05%	9.40%	7.22%
C18:1	37.2%	38.6%	40.4%	53.3%	23.54%	26.79%	0.04%
C18:2	42.2%	36.1%	18.6%			0.34%	28.49%
C20:0	1.56%		9.0%		0.77%	1.24%	25.32%
C22:0	0.33%		2.0%			0.26%	15.4%
C22:1							
C24:0	0.11%		0.65%			0.26%	10.94%
Branched FA						0.90%	0.05%
Other FA	0.24%	0.30%	1.1%	0.0%	0.0%	13.81%	1.56%
Citric Acid*			0.44%		56.80%		5.12%
Sitosterol*	0.07%					0.12%	
Stigmasterol*	0.13%					0.19%	0.10%
Cholesterol*						1.04%	
Campesterol*						0.56%	

Note: * - The values for these compounds reflect density relative to total fatty acid content.

Among the Great Basin foods, only acorn, buckeye, piñon, screwbean mesquite, and dropseed proved to have sufficiently high levels of lipids for quantitative analysis (catfish, maize, duck and lamb among the exotic species also had high levels of fatty acids). Results of the test pot analysis are given in Table 6.1.

Composition of different food types

The data from the test pots described above, as well as previously published data in Malainey (1997; see also Malainey 1999b and Chow 1992) form the background data that were used to help classify different food types based on ratios of various common fatty acids. These ratios were then used to classify archaeological sherds to food type. However, the food classes must remain rather broad at this stage due to the limited number of fatty acids available for statistical analysis (i.e., that were common to most sherds).

In terms of the potential range of food items that could have been cooked in pots in the prehistoric Great Basin, the background data set is lacking in two important classes of food, namely freshwater shellfish and insects. Although data for marine shellfish species are available, it is not known how similar they are to freshwater species in their fatty acid composition, and as such, they were left out of the study. On the other hand, data for one insect, brine fly, was collected and used as it occurred in the raw state. The background food data do cover a diverse range of plants, including numerous roots, greens, seeds, nuts, berries, and fruits; and animals, including birds, fish, small mammals, and large mammals.

Table 6.2: Distinguishing food types by fatty acid ratios.

	Mammal Meat/Fat	Fish	Bird	Roots	Greens	Seeds & Nuts	Berries
$\frac{(c12:0 + c14:0)}{(c20:0 + c22:0)}$	> 3.5	> 5	> 3	< 2	< 2	< 2	< 0.8
$\frac{(c16:0 + c16:1)}{(c18:0 + c18:1)}$	< 1	< 1.5	>0.5 & <0.8	> 1.5	> 2	< 0.5	< 0.5
$\frac{c16:1}{c18:1}$	< 0.4	> 0.2 & < 0.7	< 0.3	< 1	> 1	<0.1 OR >0.1 & <0.3	< 0.2
$\frac{c16:0}{c18:0}$	< 4	> 3	< 3	> 3	> 3	Mix*	< 4

Notes: * - Some seeds and nuts have values > 4, making this a worthwhile ratio.

Table 6.2 gives the general criteria by which archaeological sherds were classified. As discussed above, animal meats are defined by higher ratios of short-chain saturated fats to long-chain saturated fats, while roots and greens are defined by high C16 fats to C18 fats. The ratio of C16:1 to C18:1 and C16:0 to C18:0 are also useful in discriminating different foods. When available, biomarkers are also used to supplement this information. While the values listed for different food types usually hold, there are always exceptions or outliers. However, as a whole, the criteria seem to work fairly well at discriminating different food types, with the exception of separating berries from seeds and nuts.

Results

Fatty acids and other organic compounds were quite common in the majority of archaeological sherds analyzed. Of the 74 sherds selected for GC-MS study, four had levels too low to make quantitative analysis worthwhile (two from Fort Irwin, one from Southern Owens Valley, and one from Northern Owens Valley). These pots may not have been used for cooking or storing foods, or if they were, the foods may not have had high levels of fats initially, and few were absorbed, or the fatty acids may have been so heavily oxidized and degraded prior to analysis that few remain for detection. At any rate, these four samples are excluded from further analysis and discussion. The 70 sherds considered below consist of 17 from Southern Owens Valley, 15 from Sequoia National Park, 14 from Death Valley, 11 from Northern Owens Valley, six from the Nevada Test Site, six from Fort Irwin, and one from Deep Springs Valley.

Nine fatty acids were regularly encountered in the archaeological sherds analyzed, including C12:0, C13:0, C14:0, C15:0 (including iso-, ante-iso and other branched isomers), C16:0, C16:1, C17:0 (including iso-, ante-iso and other branched isomers), C18:0, andC18:1. As indicated in Table 6.3, these compounds were found in over three quarters of all samples. Other fatty acids (listed in Table 6.3) and organic compounds (Table 6.4) were also observed, though less frequently. In addition a number of compounds were encountered that could not be identified by their mass spectra and were not present in the NIST mass spectra database. These compounds were classified as unknown, and are not considered further. However, future work may help to identify the nature of these compounds, and they may be of use in pinpointing the exact nature of residues. Unfortunately, few biomarkers were encountered, making the ratios common fatty acid the most promising avenue to help match residues to original food type.

As can be seen in Tables 6.3 and 6.4 polyunsaturated fats, long-chained saturated fats, and sterols were uncommon. This result was expected, given the propensity for these compounds to oxidize. In fact, many of the dicarboxylic acids encountered (dibasic -dioic dimethyl esters; separated by short and long in Table 6.4) may be byproducts of the oxidation of unsaturated fatty acids (Hudlicky 1990: 226). Higher densities of these compounds, then, may indicate the former presence of significant quantities of unsaturated fatty acids. Similarly, the cholestane isomers encountered may represent the oxidative byproducts of cholesterol or cholestanol.

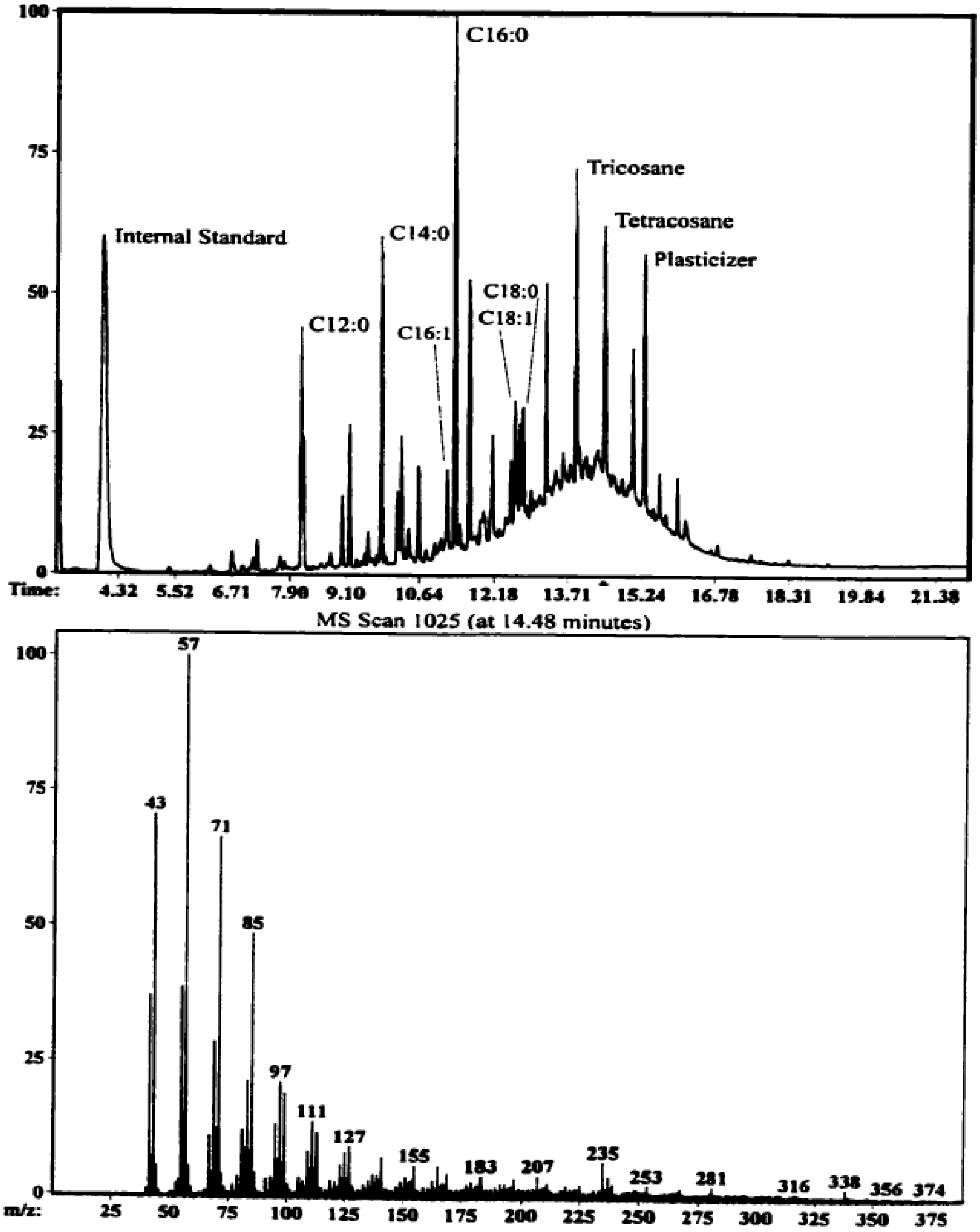
Table 6.3: Fatty acids encountered during analysis of archaeological sherds.

Compound	**Systematic Name**	**Common Name**	**Percent of sherds containing**	**Percent of Total Fatty Acids Recovered**
C9:0	Nonanoic	Pelargonic	7%	0.2%
C10:0	Decanoic	Capric	18%	0.2%
C11:0	Undecanoic	Undecylic	31%	0.2%
C12:0	Dodecanoic	Lauric	77%	4.6%
C13:0	Tridecanoic	Tridecylic	69%	0.6%
C14:0	Tetradecanoic	Myristic	97%	13.1%
C14:1	Tetradecenoic	Myristoleic	25%	0.3%
C15:0	Pentadecanoic	Pentadecylic	88%	3.0%
C15:0 br	Methyltetradecanoic	Isopentadecylic	66%	0.9%
C16:0	Hexadecanoic	Palmitic	100%	32.2%
C16:1	Hexadecenoic	Palmitoleic	85%	7.4%
C17:0	Heptadecanoic	Margaric	84%	1.5%
C17:0 br	Methylhexadecanoic	Isoheptadecylic	52%	0.3%
C18:0	Octadecanoic	Stearic	100%	11.8%
C18:1	Octadecenoic	Oleic	86%	18.0%
C18:2	Octadecadienoic	Linoleic	17%	0.3%
C19:0	Nonadecanoic	Nonadecylic	14%	0.03%
C20:0	Eicosanoic	Arachidic	33%	0.4%
C22:0	Docosanoic	Behenic	18%	0.1%
C22:1	Docosenoic	Erucic	5%	0.04%
C24:0	Tetracosanoic	Lignoceric	26%	0.06%

Table 6.4: Other compounds encountered during analysis of archaeological sherds.

Compound(s)	**Percent of sherds containing compound**	**Average density relative to total fatty acid content**
Citric Acid	7% (n=5)	18.0%
Short-Chain Alkane (C14-C19)	66% (n=47)	10.6%
Long-Chain Alkane (C20+)	85% (n=60)	39.0%
Short-Chain Dicarboxylic (C6-C10)	38% (n=27)	4.5%
Long-Chain Dicarboxylic (C11+)	3% (n=2)	0.4%
Epoxy Fatty Acids	21% (n=15)	1.9%
Hydroxyalkanoic Acids	6% (n=4)	1.3%
Cholestane isomer	11% (n=8)	0.1%
Pine Resin	1% (n=1)	> 100%

Figure 6.4: Gas Chromatogram and Mass Spectrogram for JEC011.



During analysis it was noted that sherds from some areas had quite different-looking gas chromatograms. This was due to the presence of high levels of straight-chain hydrocarbons (alkanes) in samples from Sequoia National Park (eight of the 15 analyzed) and Death Valley (seven of 14), causing a large hump with many peaks to appear around 12-15 minutes (after most fatty acids had eluted). In the former case, all eight sherds containing high levels of hydrocarbons are from a single site, Hospital Rock (Ca-Tul-24). In the latter, they were from a mixture of sites. Figure 6.4 gives an example of such a chromatogram for JEC011 from Death Valley. The mass spectrograph corresponds to the compound tetracosane.

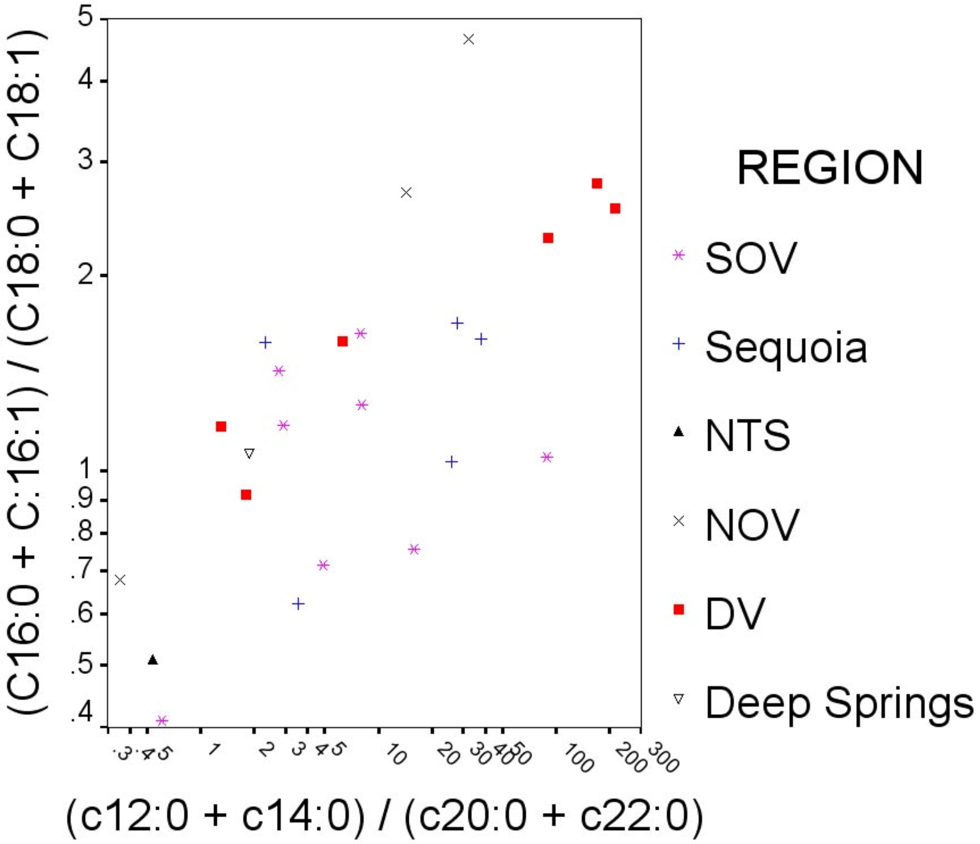
In all 15 cases, the sherds are from collections made in the 1940's and 1950's. While such hydrocarbons naturally occur in many animals and plants, particularly in leaf waxes (indeed, they were discovered in low levels in almost all of the test pots discussed above), among these sherds odd and even length alkanes occur in approximately equal proportions. Such a distribution is more typical of a petroleum product than a plant or animal where the odds usually dominate the evens (Biers et al. 1994; Charters et al. 1997; Evershed, personal communication 2000). In light of this observation, it is possible that the high levels of alkanes in these 15 sherds may be attributed to contamination by some petroleum product. This contamination may be from cleaning, handling, or storage of the artifacts after they were collected by archaeologists.

However, I note also that many of the plant test cook pots also had high levels of alkanes in similar proportions as above (i.e., odd- and even-length in nearly equal densities). As well, blank (i.e., empty) pots did not display any alkanes, suggesting they are indeed derived from the foods. This suggests that the alkanes observed in the sherds may be a natural component of foods cooked in the pots. Further work with alkanes will be necessary to establish their origin with greater certainty. As such, the alkanes are not considered further.

Figure 6.5 plots the archaeological sherds by the same two fatty acid ratios used in Figure 6.2. Unfortunately, not all sherds could be plotted as some were missing data to determine the ratios necessary. In particular many sherds lacked C22:0, and others also lacked C20:0. However, of the pots that could be plotted, Figure 6.5 suggests that few fall within the range of meats shown in Figure 6.2. This finding is strengthened by the fact that longer-chained compounds tend to decompose faster than shorter-chained compounds. Thus, values for the ratio of short- to long-chained saturated fats used in Figure 6.2 on the x-axis in archaeological sherds (i.e., {[C12:0 + C14:0] / [C20:0 + C22:0]}), where there has been more time for decomposition, would tend to be elevated for all food classes. The range of values for meats, then, should fall even further to the right of the graph in Figure 6.5. This suggestion is supported by the fact that many sherds have values for this ratio in excess of 50, while no food sample had a ratio over 25.

For the samples plotted in Figure 6.5, meat does not appear to have been a major component. Four samples stand out in this regard, three from Death Valley and one from Southern Owens Valley. All appear on the far right hand side of Figure 6.5, and may have been used to cook meats. Indeed, one of these samples also contained cholestanol, suggesting it had been used to prepare meat. At the same time, most of these samples show elevated levels of (C16:0 + C16:1) / (C18:0 + C18:1), above what is typical in meat products, and is more common of greens, and especially roots. This suggests that they may have used to process stews containing both meat and roots.

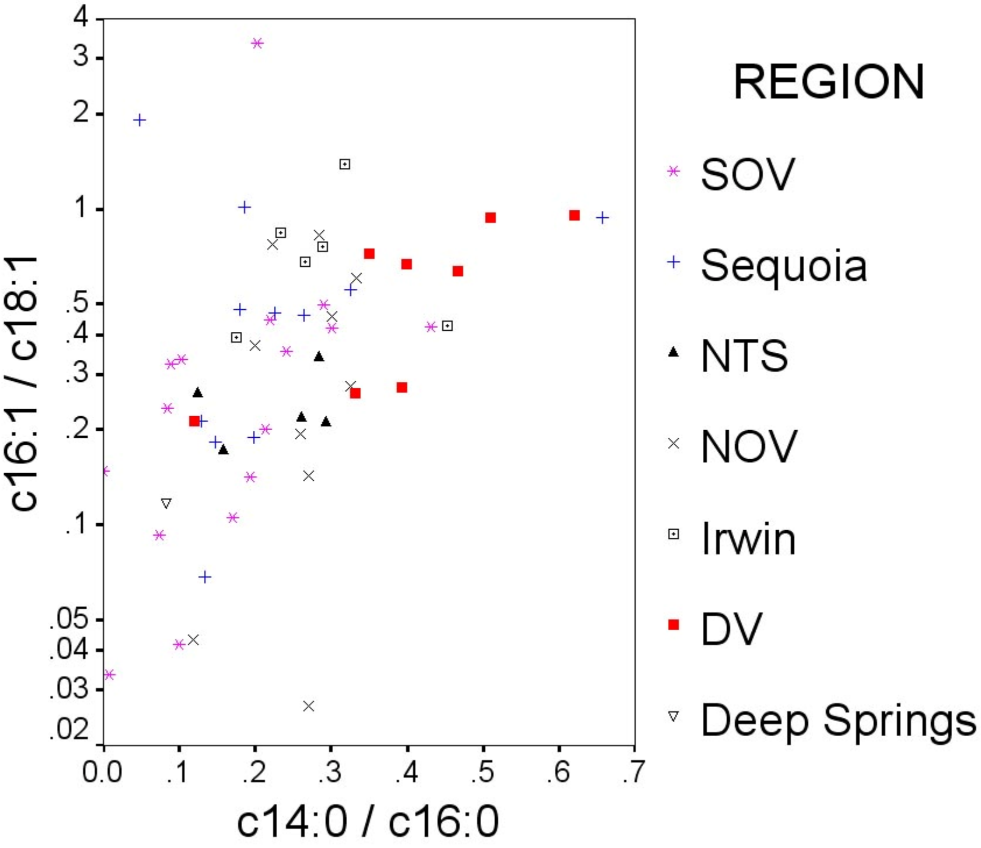
Figure 6.5: Archaeological sherds plotted by fatty acid ratios.



Notes: SOV = Southern Owens Valley; Sequoia = Sequoia National Park, NTS = Nevada Test Site; NOV = Northern Owens Valley; DV = Death Valley; and Deep Springs = Deep Springs Valley.

Figure 6.6 plots the archaeological sherds by the two fatty acid ratios used in Figure 6.3. Relative to Figure 6.5, a larger percentage of the sherds could be plotted due to the ubiquity of the four compounds used to create the ratios used in the figure. Moreover, the difference in carbon-chain length in the compounds used in the ratios is similar. Thus, C16:1 and C18:1, and C14:0 and C16:0, respectively should undergo decomposition at roughly similar rates, as opposed to short- and long-chained compounds, as used in Figure 6.2 and Figure 6.5, which likely decompose at more divergent rates.

Figure 6.6: Archaeological sherds plotted by two additional fatty acid ratios.



Notes: SOV = Southern Owens Valley; Sequoia = Sequoia National Park, NTS = Nevada Test Site; NOV = Northern Owens Valley; DV = Death Valley; and Deep Springs = Deep Springs Valley.

Unfortunately, the two fatty acid ratios plotted in Figure 6.3 and Figure 6.6, offer less discriminatory power among different food classes than the ratios used in Figure 6.2 and Figure 6.5. In particular, outside of fish, meats fall in the same general area of the graph as roots, berries, birds, and seeds/nuts. Nevertheless, a comparison of Figure 6.3 with Figure 6.5 is worthwhile, and suggests, first, that few greens were cooked in the archaeological pots. The ratio of C16:1 to C18:1 is very low (i.e., less than 1) for most samples, while the ratios of most greens is greater than 1. Greens, then, do not seem to form an important component of the range of foods cooked in these pots. Second, fish is an unlikely candidate for most sherds, based on the ratio of C14:0 to C16:0 (which is generally above 0.2 for most fish samples). Most of the archaeological sherds have values for this ratio less than 0.3.

Table 6.5: Results of classification of archaeological specimens.

Sample	Region	Result
JEC003	DV	seed
JEC011	DV	meat + plant
JEC015	DV	meat + green
JEC016	DV	meat + root
JEC020	DV	root/green
JEC021	DV	meat + root/green
JEC026	DV	meat + green/seed
JEC028	DV	meat + root
JEC031	DV	plant
JEC035	DV	seed/berry
JEC037	DV	plant
JEC038	DV	green
JEC039	DV	meat + plant
JEC041	DV	meat + root
JEC237	Irwin	meat + root/green
JEC238	Irwin	plant
JEC239	Irwin	seed
JEC240	Irwin	seed
JEC241	Irwin	meat
JEC242	Irwin	plant
JEC047	SqNP	meat + seed
JEC050	SqNP	meat + root
JEC054	SqNP	seed
JEC057	SqNP	seed/root
JEC058	SqNP	seed
JEC059	SqNP	plant
JEC064	SqNP	berry
JEC065	SqNP	seed/berry
JEC066	SqNP	seed
JEC067	SqNP	berry
JEC068	SqNP	seed/root
JEC072	SqNP	bird/seed
JEC073	SqNP	seed
JEC076	SqNP	meat + green
JEC046	SqNP	root
JEC279	NTS	plant
JEC283	NTS	seed
JEC286	NTS	seed
JEC293	NTS	bird/seed
JEC294	NTS	berry/seed + pine
JEC301	NTS	bird or seed*
JEC379	SOV	seed
JEC077	SOV	seed (piñon)
JEC078	SOV	bird
JEC079	SOV	green
JEC080	SOV	seed
JEC084	SOV	seed
JEC085	SOV	berry
JEC086	SOV	berry
JEC098	SOV	seed
JEC099	SOV	seed
JEC100	SOV	meat + seed/berry
JEC102	SOV	meat + seed
JEC117	SOV	berry
JEC118	SOV	meat + seed
JEC125	SOV	bird
JEC128	SOV	seed
JEC209	SOV	seed
JEC156	NOV	seed
JEC157	NOV	meat + root
JEC159	NOV	plant
JEC160	NOV	plant
JEC161	NOV	root
JEC162	NOV	seed/berry
JEC163	NOV	seed
JEC168	NOV	root
JEC174	NOV	seed/berry
JEC176	NOV	berry
JEC178	NOV	plant
JEC151	DSV	seed/berry

Notes: DSV = Deep Springs Valley; DV = Death Valley; Irwin = Fort Irwin; NOV = Northern Owens Valley, NTS = Nevada Test Site; SqNP = Sequoia National Park; SOV = Southern Owens Valley. * - JEC301 contains high levels of odd-chain and branched fatty acids, suggesting it may have been used to cook ruminant animal.

Given the data plotted in Figures 6.5 and 6.6, as well as other fatty acid ratios and the presence of various biomarkers, archaeological sherds were classified into various general food types. Table 6.5 gives the results of this classification (see appendix B for the raw data by sherd). In some cases it was not possible to discriminate between different plant products, particularly seeds/nuts and berries. In these cases the table lists both products separated by a slash, thus, berry/seed indicates that I could not differentiate between the two and the pot could have been used to cook either food. Since seeds and nuts are nearly identical in fatty acid composition (as seen in the test pots described above), this category is indicated simply by the term "seed" in the table below.

As Table 6.5 suggests, plants represent the overwhelming majority of foods cooked within Western Great Basin pots. Of the 70 samples, only 21 (30%) show evidence for having been used to cook animal products (i.e., have cholestane or cholestanol, have high levels of C12:0 and C14:0 relative to long-chain saturated fats, or otherwise match the criteria established above). Moreover, of those 21, 18 appear to have been used to cook plant products as well, that is, they appear to represent stews where meats and roots, greens, seeds, and/or berries were cooked together. Two samples, both from Southern Owens Valley, show evidence for having been used to cook birds alone, while a single sample from Fort Irwin is tentatively identified as having been used to cook terrestrial mammal alone. Fish is not a potential candidate in any samples, suggesting that fish were not prepared in pots in California or the Western Great Basin in prehistoric times. However, when meat products are mixed together with plants, it may be hard to distinguish mammal from fish in the meat component.

For those 17 samples with evidence for meat products other than bird and fish, the relative amount of odd-chain, primarily C15:0 and C17:0, and branched fatty acids was examined. High values for these compounds is a fairly good indicator of the presence of ruminant animal meat. In Malainey's (1997) study, ratios of (C15:0 + C17:0) to (C12:0 + C14:0 + C16:0 + C18:0) greater than 0.04 are characteristic of ruminant animals (e.g., deer, bison), a result also obtained by this author for lamb. Of the 17 samples in this study, 12 have ratios for this value greater than 0.05, strongly suggesting they were used to cook ruminant animals. Levels of branched fatty acids in these samples are generally high as well, supporting this conclusion. Two further samples (JEC028 and JEC157) have ratios of 0.04, though branched fatty acids in these samples are slightly lower, providing less certain but still strong evidence for the presence of ruminant animals. The final three samples (JEC050, JEC102 and JEC241) have ratios less than 0.03 and low levels of branched fatty acids, suggesting other mammals were cooked in these pots. With the exception of JEC301 (see notes to Table 6.5) all samples containing bird had low levels of C15:0 and C17:0 and branched chain fatty acids.

In the Western Great Basin ruminant animals are generally limited to antelope, deer, and mountain sheep. These animals, of course, were important sources of protein and fat for Great Basin peoples. That many of the meat samples appear to be derived from ruminant animals, then, is not too surprising. However, it was expected that other animals would make a stronger showing, particularly birds, rabbits, and rodents. These foods were also important sources of meat (indeed, late period archaeological sites are often dominated by leporid and rodent bones). It appears, then, that the meat from these smaller animals was rarely included in stews prepared in pots.

The strong showing of plant products in this study support the data gleaned from ethnographic reports that suggest pots were often used to prepare plant products (see Chapter 3). However, unlike the ethnographic data, the results here underscore the fact that pottery was predominantly used to cook plant foods, occasionally with meat, but most often by themselves. More specifically, seeds seem to be well represented among the fatty acid profiles, comprising 18 of 33 samples (55%) that could be narrowed to a single food category and appearing as a candidate for food type in 35 of the 70 samples (50%). By comparison, berries account for only 7 of the 33 single category foods (21%) and are a candidate in 13 of the 70 total samples (19%), while roots account for 9% and 20% and greens 6% and 13%, respectively, for the same measures.

Interestingly, a single sample (JEC294) from the Nevada Test Site had high levels of diterpenoids, or resins, of pine, namely pimaric and abietic acids. Indeed, during preparation this sample gave off a strong odor of pine. The resin appears to reside within the fabric of the sherd, and was not visible on the interior or exterior surfaces. As such, the pot may have been used to prepare and concentrate pine pitch (i.e., by boiling off water). Pine resins were often used by Native peoples to waterproof baskets and/or other carrying containers (Kelly and Fowler 1986: 375; Thomas et al. 1986: 266). Alternatively, the resins in this pot may indicate that the pot itself had been waterproofed, though the fact that no resin was visible on the surface argues against this. Moreover, the pot contains other fatty acids, indicating it likely served as a cooking vessel for berries and/or seeds as well as pine resins.

Table 6.5 also points out some interesting regional differences in how pots were used. In Sequoia National Park, Southern Owens Valley, and the Nevada Test Site, seeds and nuts are the dominant food type represented. However, in Northern Owens Valley and Fort Irwin seeds and nuts are equal in importance to other food types, and in Death Valley, where roots, greens, and especially meats are most common, they seem to be of minor importance. Berries also show an interesting distribution, being most common in Southern Owens Valley, Northern Owens Valley, and Sequoia National Park. These areas, of course, are better watered than areas further east and south and may contain higher densities of berries. Their presence in pots from these areas, then, may be a reflection of their relative importance as a food resource. Roots are best represented in Death Valley, Sequoia

National Park, and Northern Owens Valley, and evidence for their presence is surprisingly absent in Southern Owens Valley and the Nevada Test Site.

All five samples containing citric acid (JEC077, JEC156, JEC162, JEC168, and JEC174) are from Owens Valley, one from Southern and four from Northern. Four of the five were assigned to the seed/nut or seed/nut/berry category, with JEC168 identified as root. As indicated in Table 6.1 two food test pots contained also citric acid, piñon and dropseed. JEC077 in particular, from CA-Iny-2 (where piñon grows nearby), bears strong resemblance to the gas chromatogram of piñon and is tentatively assigned to this specific food resource. Given the importance of this food in the prehistoric Great Basin, the fact that more sherd residue profiles do not match piñon is somewhat surprising. However, recall from Chapter 5 that sherds are rarely associated with the piñon-juniper zone.

Table 6.6: Summary of Results of GC-MS Study.

Food Type	**Percentage of Sherds**
Plant, type unknown	13%
Seed only	27%
Seed with other plant	17%
Seed with meat	10%
Non-seed with meat	16%
Roots and Greens only	9%
Berries only	7%

Comparisons to Technological/Attribute from Rim Sherd Data

A quick comparison of the GC-MS data to the technological data described in Chapter 4 is also worthwhile, to see if pot function varies in any systematic way with formal properties. Fifty-four of the 70 sherds discussed above were rim sherds, and 52 could be classified by rim form. The most striking difference is that all 12 rim sherds used to cook seeds and nuts (by themselves) are direct. Similarly, all five pots with meat and seeds mixes have direct rims, and three of four seed and other plant mixes are direct rimmed (one is recurved). On the other hand, pots used to cook products other than seeds are more varied in rim form. Twenty-two of the remaining 30 pots have direct rims, two are incurved, and six are recurved. Pots used to cook meat contribute much to this diversity, including three recurved and one incurved rim. Table 6.7 summarizes these results.

Pots used for cooking only roots and greens are slightly thicker (mean = 6.8 mm) than pots used for seeds (mean = 5.8 mm), berries (mean = 5.7 mm), or those including meat (mean = 5.8 mm). Most of these roots and greens pots are from Northern Owens Valley, where pots tend to be thicker anyway. However, even roots and greens pots from Sequoia, where pots are generally thin, are thick. On the other hand, pots used to cook meat have more narrow mouth openings (mean = 200 mm) as compared to pots used to cook seeds (mean = 245 mm) or other plants (mean = 255 mm). Also interesting is meat pots are twice as likely to be decorated. Four of the 15 pots used for meat are decorated (27%), while only four of the other 39 pots (13%) are similarly decorated.

The percentage of pots with coarse sized temper also varies by product (see Table 6.7). Pots used to cook meats generally have smaller temper than pots used to cook seeds and other plant products such as berries, roots and greens. This suggests that people may have been manipulating temper recipes such that pots used to boil plant products had larger temper. Larger temper, of course, would have increased heating efficiency and may have been an effective technique to increase the temperatures in these pots to efficiently achieve boiling. Meats, on the other hand, would have been simmered and did not require higher temperatures. For this reason, meat pots may have smaller temper. Alternatively, these differences in temper may simply reflect different sources of clay (i.e., sedimentary vs. residual) used to make the pots. Further research, controlling for the type of clay used in a particular pot and/or chemical analysis of temper separate from the clay matrix to determine if temper was purposefully added would go far in clarifying this point.

Table 6.7: Attributes of pots used to cook different products.

	No.	**Avg. Thick**	**Avg. Diam.**	**%Rims Direct**	**%Deco-rated**	**%Crse Temper**	**%Org. ≥ 20%**	**%Smth Exter.**
Roots & Greens (no meat)	7	6.8	229	85%	29%	29%	0%	0%
All plants except seeds (no meat)	20	6.6	255	72%	15%	50%	0%	11%
Seeds & Nuts (no meat)	15	5.8	245	100%	7%	21%	13%	13%
Seeds w/ meat	5	6.3	225	100%	20%	0%	20%	0%
Meat mixes (except seeds)	14	5.7	200	77%	24%	11%	14%	12%

Notes: No. = number of samples in this food class; Avg. = average; %Rims Direct = percentage of rims that are direct in this food class; Crse = Coarse; Org. = Organic; Smth Exter. = Smooth Exterior surface.

Differences in the amount of organic temper is minimal between product types, though pots used to cook meats and seeds appear to have slightly higher densities of this temper type (see Table 6.7). Again, it is unclear if these differences simply represent choices in clay type by potters or amount of organic temper was actively manipulated based on intended use. The rate of exterior smoothing is low and not significantly different for food types.

Although the sample size is small, these findings suggest that pots used to cook seeds and nuts were designed differently than pots used to cook meat stews, and those were different again from those used to cook other plants. Seed-pots in this sample generally have large and unrestricted openings providing ready access to contents. More importantly, this design allows water to freely evaporate from the surface and prevents heat from building up in the neck of the pot, which frequently results in explosive overboiling. As well, these pots have coarser temper than meat pots, perhaps to better transfer heat and withstand thermal shock. Thus, these types of pots are well designed for high temperature boiling. The use of higher temperatures to cook seeds, of course, would facilitate gelatinization of seed products, to break down complex carbohydrates, as discussed in Chapter 4.

Meat-pots appear to be more often incurved and recurved than seed pots (a χ^2 test comparing direct and non-direct pots for meat- vs. seed-pots gives a p_value of 0.06). This construction technique reduces evaporation of water from the pot surface and prevents loss of heat, but can cause violent overboiling if temperatures get too high. Such pots, then, are better suited to simmering and stewing, which takes place at lower temperatures. This cooking technique, of course, is well suited to meat preparation (Reid 1990).

Pots used to cook roots, greens, and berries are also more frequently restricted at their mouths, restricting access to contents and suggesting that contents were less often boiled. As well, these pots are thicker and more coarsely tempered on average than either seed- or meat-pots. Why this is so is unclear. It is possible that these pots were also used in some processing step prior to cooking, and for this reason require additional mechanical stress resistance. This would explain why the pots are thicker, but not why they were more coarsely tempered, which would decrease strength. However, an increase in temper coarseness could have been used to increase heating efficiency which an increase in thickness reduced. Additional study is needed to confirm this hypothesis.

In sum, the forms and shapes of pots seem to be correlated with use. Pots used to cook seeds appear to have been designed with boiling in mind, while pots used for meats and other plants seem to be designed for lower temperature cooking, such as simmering or stewing. This suggests that pots were designed with specific uses in mind, and were not all-purpose or generalized tools. Potters seem to have been keenly aware of how to manipulate pot design to achieve various ends. Moreover, they were cognizant of the relationships between cooking temperature, nutrient extraction, pot form and shape, and heat transfer, and how to modify pots to take advantage of this knowledge.

In this respect, Great Basin pots are not at all the crude and flimsy tools they are often made out to be by anthropologists and archaeologists. Pots appear to have been carefully crafted to take advantage of various physical properties to meet certain needs and requirements. Although they may not be aesthetically pleasing to the Western artistic eye due to a lack of decoration, they are clearly well adapted to the social and physical climate of the prehistoric environments of California and the Great Basin (as discussed in Chapter 8).

Discussion and Conclusions

Based on the density of fatty acids and other lipid compounds in most of the sherds, pots in the Great Basin seem to have served primarily as cooking or storage containers of foods (i.e., rather than water or other non-food containers). This, of course, was expected, given the general shape, structure, and porosity of most Great Basin pots as discussed in Chapter 4. Moreover, pots were overwhelmingly used in the preparation or storage of plant products, especially seeds and nuts, though meats were occasionally boiled along with plants in stews. Evidence for use with roots, greens, and berries was also present in the analyses, while bird and fish were rare and absent (respectively). The individual assignments should be considered tentative, given problems related to decomposition and some overlap in fatty acid ratios between various food types. However, the overall patterns are fairly clear, and are highly consistent with plant usage, particularly seeds and/or nuts.

Knowing how pots were used is a key piece of information in understanding why people began making and using pottery in the prehistoric Great Basin. I know of only two other studies that have attempted to determine the function of Great Basin brownwares. Dean and Heath (1990) visually examined 20 pot sherds from western Utah in the eastern part of the Great Basin for residues adhering to the interior surface of the sherd. Their sample included sherds typed as both Fremont and Shoshonean, though they question this typology. At any rate, they found that 60% of the sherds contained a blackened residue consisting of seeds, both burned and unburned, and other plant parts. Species identified include *Chenopodium* (as well as the more general ChenoAm family), *Poa* (grass), Juniper, Ricegrass, and *Allenrolfea* (pickleweed). Although their technique could not have identified the presence of meat, their results demonstrate that seeds and plants were an important part of pottery use in the Eastern Great Basin.

A second study by Touhy (1990) examined pollen and phytolith accumulations in the blackened residues adhering on the insides of two cooking pots from north-central Nevada in the Central Great Basin (approximately 200 miles north of the Nevada Test Site). Significant levels of festucoid grass phytoliths were recovered from both pots. In addition, one of the pots contained high levels of pine pollen as well as fragments of pine seeds and needles. Although Touhy could not rule out that the pollen and phytoliths were due to natural accumulation (i.e., background "rain"), for various reasons he felt that they accurately reflected pot use. Again, although it was unlikely meat would be detected, the study suggests that these pots were used to prepare plant products, most likely grass seeds and pine nuts in this case.

These two studies, together with the results presented here, suggest that the origins of ceramics in California and the Great Basin had much to do with the use of plant products. While there is some regional variability in the importance of different plant products and meat, the overall results suggest that seeds and nuts were the primary product prepared in pots. Half of the pots examined (with significant levels of fatty acids) displayed evidence consistent with the use of seeds and nuts.

These results are in direct contrast with other analyses of hunter-gatherer pottery in North America. For example, Malainey (1997) and Malainey et al. (1999b) found that 62% (122 of 201) of sherds analyzed from western Canada are attributable to meat alone (large herbivore or beaver). On the other hand, plants (other than corn) are evident in only 28% of the sample, and more than half of those were classified as mixtures of plant with fish or meat products (e.g., plants alone account for only 13% of the total sample, compared to 74% in this study). Similarly, Reid's (1990) summary of ethnographic information on northwest Canadian and Alaskan pottery use suggests that pottery was used exclusively for cooking meat or rendering oils or fat from animal bone or blubber (see also Stimmell and Stromberg 1986).

Future work with organic residues in pottery in California and the Great Basin should seek to examine a wider range of compounds to better define the exact types of foods cooked in pots. Based on the results obtained here, this work should probably focus on plants and especially seeds and nuts, and should include study of a wider range of native foods. Future work could also target examining ratios of various stable isotopes, particularly carbon and nitrogen, and searching for proteins, waxes, and other organic compounds. As well, experimental research should seek to understand how stews composed of different foodstuffs affect overall organic residue signatures. This pilot study shows that there is much that can potentially be learned from studying the organic residues absorbed within the walls of California and Great Basin potsherds.

CHAPTER VII

INAA: CERAMIC PRODUCTION AND MOVEMENT

Introduction

Chemical fingerprinting or provenance analysis (e.g., sourcing) of archaeological materials is becoming increasingly important in our understanding of prehistory in North America, especially in helping us to reconstruct past mobility and exchange systems. Obsidian sourcing has been important in this field, but recent attempts to source andesites and basalts (Bostwick and Burton 1993; Jones et al. 1997; Waechter 2000), cherts (Leudtke 1978; Malyk-Selivanova et al. 1998; Stafford 1998), steatite or soapstone (Allen and Lockhart 1989; Allen et al. 1975; Truncer et al. 1998), metals (Mauk and Hancock 1998), and even trees (Durand et al. 1999), have shown that these lines of inquiry can be quite informative as well.

In the Great Basin, obsidian sourcing has been the most prolific and important sourcing activity among archaeologists. These studies have provided archaeologists with a wealth of information about the economic aspects of obsidian, including quarrying behavior, land and resource ownership, territoriality, artifact production, and exchange networks (e.g., Basgall 1989; Bettinger 1982b; Bouey and Basgall 1984; Gilreath and Hidlebrandt 1997; Jackson 1988). However, despite the success of archaeologists elsewhere in ascribing ceramic artifacts to particular geographic sources (e.g., Bishop et al. 1988; Lizee et al. 1995; Neff 1998; Neff et al. 1994; Neff et al. 1997; Steponaitis et al. 1996; papers in Neff 1992 and Glowacki and Neff n.d.), outside of Fremont ceramics, this technique has been virtually ignored by Great Basin archaeologists (though with notable exceptions such as Hunt 1960; Touhy and Strawn 1986). Yet understanding how the production of pots was organized, that is, whether centralized or distributed, as well as the role pottery played in exchange relations, is important in gaining a better grasp on the motivations people may have had in making pots. And this, of course, is an important end towards understanding the origins of pottery technology. This chapter, then, examines the production and movement of pottery within the Western Great Basin through instrumental neutron activation analysis (INAA) of ceramic artifacts and raw clays from the Western Great Basin.

Ceramic vs. Obsidian Sourcing

Ascribing obsidian to a particular source is a relatively straightforward task (though not without complications; see Shackley 1998a and Glascock et al. 1998). Luckily most obsidian sources are chemically distinct, and once the obsidian sources in an area have been analyzed and characterized, artifacts can then be matched to these sources (see Shackley 1998b and Eerkens and Glascock n.d. for some additional considerations). In many ways the same principal applies to ceramic artifacts, where pot sherds are analyzed chemically and then compared to clays from different clay source zones. Pot sherds displaying similar chemical properties to clays are assumed to be derived from the geographical location in which the clays were collected.

Due to a number of reasons (see Arnold et al. 1991; Bishop et al. 1982; Blackman 1992 for more extensive discussion), such straightforward ascription of pot sherd to clay source zones is rarely possible, making pottery sourcing different in many ways from obsidian sourcing (Neff 1998). First, clay is relatively common and is found virtually everywhere, unlike obsidian which is uncommon and occurs in spatially circumscribed areas. This makes systematic sampling of all source clays a tedious and expensive, if not impossible, process. Second, clay source zones are generally much larger than obsidian source zones, occasionally up to several thousand square kilometers, making ceramic sourcing less accurate in a spatial sense than obsidian sourcing. In such a case one can only know that the sherd came from somewhere within those 1000 square kilometers, whereas obsidian studies can usually track the artifact to a much smaller region (though see Shackley 1998b and Eerkens and Glascock n.d. for exceptions). Third, clay forms under a number of different conditions and is often mixed with other source clays through various natural processes such as river transport, which causes blending of otherwise distinct clays. This can have the effect of creating a continuous distribution of chemically varying clays across an area, unlike obsidians which are generally more spatially and chemically discrete. Finally, raw clay is subject to a number of transformations by people before it actually becomes a pot and ultimately a sherd in the archaeological record. These transformations include such things as souring and leaching of clays, mixing of clays together, addition of chemically different (transforming) or chemically similar (diluting) temper (see Neff et al. 1988, 1989), and potentially, post-depositional change. Firing, particularly at lower temperatures, however, does not appear to alter (i.e., volatize) most elements (Cogswell et al. 1996). Obsidian, on the other hand, remains as it is from acquisition, to the creation of a tool or waste flake, to an archaeological artifact.

As a result of these differences, most archaeologists attempting to source pottery have taken a slightly different approach to provenance analysis (Sayre and Dodson 1957; Neff 1998). Rather than analyzing background clay source zones and then matching pottery to these sources, the approach has often been to simply analyze large numbers of sherds, create “compositional” or “reference” groups among the pot sherds, and only then attempt to assign the compositional groups to geographical locations. In these studies, compositional groups are defined as sub-samples of pot sherds that display a unique chemical signature that differentiates them from the rest of the sherd sample. The assignment of a group to a geographical location, then, is based on compositional *similarities* to clays that have been collected from that area (rather than an exact match, as in obsidian studies), and/or, the region in which the sherds assigned to that group were most commonly found (Bishop et al. 1982).

Two major assumption underlie this approach. First, vessels made of clay from a particular source are chemically more alike than vessels made of clay from a different source. Whether this holds will depend much on how a "clay source" is defined. Clay sources near one another and/or derived from similar parent rocks are more likely to be compositionally similar. In such a case, it may be necessary to lump clay sources into larger clay source zones. The second major assumption is that the most common source of clay for pots in a particular region is local rather than extralocal. Again, the validity of this assumption will depend on how local and extralocal are defined. This assumption is likely to be violated if "local" is defined as within a 10 meter radius of some location but much more likely if defined as within 100 kilometers of that place.

Because of these and other problems, it is important to be cautious in assigning compositional groups to particular regions (see Arnold et al. 1991; Neff 1998; Rice 1987; Steponaitis et al. 1996 for discussions relating to provenance analysis of pottery in general and different case studies). As well, potters may purposefully make use of clays with different chemical signatures from the same area because of their functional or thermal properties. For example, potters may use some clays for their superior thermal shock resistance properties and others for their mechanical shock resistance properties. Thus, clays and sherds from the same region may form chemically distinct compositional groups and at the same time may all be locally produced.

The goal pursued here was, first and foremost, the definition of compositional groups. When source clays were available for collection, they were analyzed to help tie particular compositional groups to geographical locations. However, in many cases either clays could not be collected or the compositional data produced from source clays did not match any of the pot sherds from that or any other region. In such cases, the geographical distribution of sherds from that compositional group was often used to help suggest a geographical origin for the group. Thus, if 90% of the sherds in a compositional group are from one region and/or 50% of the sherds in that region can be ascribed to that compositional group, it is likely (but not certain) that the compositional group is native to that area. As in most compositional studies of ceramics, the assignment of a compositional group to a particular region must be a tentative one that can be modified by future analyses should they suggest otherwise. For example, future studies may show that clays belonging to a compositional group are available over a much wider area than originally thought. Similarly, original compositional groups may prove to be composed of multiple chemically and geographically distinct subgroups in subsequent analyses (i.e., when more samples are added to the analysis).

In many ways, the Great Basin is promising for sourcing ceramics because mixing of source clays is limited. As different basins are hydrologically separated, there is little chance for rivers to transport and mix clays together. Therefore, if the parent geology is different between different basins, it is possible that clays in each basin will have a unique chemical signature. In addition, Great Basin brownwares are often described as being tempered by inclusions that are already present in the parent clay, which may limit the importance of the addition of temper as a transforming, but not a diluting, agent (see Neff et al. 1988, 1989).

Methods and Assumptions

INAA was selected due to its success in past studies and the high precision compositional data it provides on a range of elements related to clay chemistry and formation processes (see Glascock 1992 for a description of the INAA technique). This range includes common alkali elements such as calcium and sodium, transition metals such as titanium and vanadium, and rare earth elements such as dysprosium and ytterbium, among others. Maximization of the number and range of elements was important, because it was not known beforehand what types of elements might be important in distinguishing potential Great Basin source clays. Maximizing elements also increases the chance of finding an element or combination of elements that discriminates between clays from different regions (Harbottle 1991). In addition, Neutron Activation has been employed in a number of other studies, making the results of this study readily comparable to other regional databases. Analyses were undertaken by the author at the Missouri University Research Reactor (MURR) in 1998 and 1999.

For each sample, the density in parts per million (ppm) of following elements was calculated: aluminum (Al), arsenic (As), barium (Ba), calcium (Ca), cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), dysprosium (Dy), europium (Eu), iron (Fe), hafnium (Hf), potassium (K), lanthanum (La), lutetium (Lu), manganese (Mn), sodium (Na), neodymium (Nd), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), samarium (Sm), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), titanium (Ti), uranium (U), vanadium (V), ytterbium (Yb), zinc (Zn), and zirconium (Zr). However, the accuracy of INAA varies somewhat by element, as measured by the Coefficient of Variation (CV). While most elements offer excellent precision (CV < 5%) others are less accurate (CV > 10%; e.g., calcium, nickel and strontium). In fact, nickel is usually present in such low quantities and has a high enough CV that it is rarely worth including in analyses. As such, nickel was dropped from the study.

Sample Preparation

Archaeological sherds, clay samples, and temper samples were all analyzed in this study. Archaeological sherds were prepared by breaking off a 1-2 cm^2 section and grinding off the outer 1mm using a tungsten-carbide drill bit. This removes any potential contamination from sediment that may have adhered to the surface of the sherd. Samples were then gently brushed to remove drilling/burring residue, washed with deionized water, and crushed into a homogenized powder in an agate mortar and pestle. The powdered sherd was then oven dried at 100C for 24 hours to remove any excess water and prepared for irradiation in the reactor. Following irradiation, each sample is measured for the 33 elements listed above. Counting occurs in three distinct phases corresponding to relatively short-, medium-, and long-lived elements (see Glascock 1992 for additional details).

Raw clay samples collected from a variety of locations were treated in a similar manner. Properties of each clay were recorded prior to analysis, including color, consistency, workability, plasticity, and the presence of any natural temper. Small circular tiles, 1 cm thick and 5 cm in diameter, were prepared from each sample and fired in a small kiln to a temperature of 700C. Additional characteristics were then recorded, such as post-firing color, hardness, density, internal structure (e.g., platy, homogenous, vesicular, etc), and overall apparent quality as a potential clay for making pots. Finally a piece of the tile was removed and treated in the same manner as an archaeological sherd.

Statistical Analysis

The ultimate goal of the study is to create discrete compositional reference groups with unique chemical signatures. These reference groups are assumed to represent distinct sources of clay. The ultimate geographic source of these reference groups was determined in one of two ways. Occasionally they could be compared to compositional data gathered from clays actually collected within different areas of interest (when and where clays were available for collection). In cases where clays could not be analyzed, when a clear majority of the pot sherds in a reference group were from a single region (i.e., greater than 80-90%), and/or a large number of sherds from that region were members of the group (i.e., greater than 30-40%), the reference group was assumed to be derived from clays native to that area.

The ppm values for the different elements were analyzed statistically. Ppm values were transformed using the centered log-ratio transformation, as defined and recommended by Aitchison (1983, 1984, 1986; see Tangri and Wright 1993 for a critique and Baxter 1989 for support). This transformation is supposed to help the analyst account for the potential dilution effects of temper. Large amounts of temper, which is primarily made up of silicon (if sand) or calcium (if shell), will cause the ppm values of other elements to be artificially lowered. Since the goal of the analysis is to source the *clay* out of which the pot was made, differing amounts of temper, even if the same clay and temper are used, will cause the compositional data to look quite different in terms of the ppm concentrations of different elements. Log transformations can help somewhat in this regard and are particularly effective at counteracting differing magnitudes of concentrations in elements (i.e., without transformation, elements with higher concentrations will be more heavily weighted in the analysis). However, provided the temper contains low levels of the elements of interest (e.g., rare earth elements and trace elements), the log-ratio transformation can be particularly effective in checking potential dilution effects, as well as differences in magnitude of ppm concentrations. Given that Great Basin pots are often tempered with quartz and feldspar, dilution by silicon was considered to be a likely complication and the centered log-ration transformation a solution.

Following transformation of the ppm concentrations, a principal components analysis (PCA) was undertaken. PCA is a convenient way to capture and view complex multidimensional data, such as compositional data composed of 32 different dimensions (i.e., elements), in four or fewer dimensions (Baxter 1994; Davis 1986). PCA is particularly effective when the original variables are correlated, as is expected with compositional data from discrete chemical sources. In this sense, PCA was used as an aid to help classify sherds into discrete groups rather than a classificatory technique in and of itself (as is true of cluster analysis).

Baxter (1994) discusses some of the theoretical problems in applying PCA to compositional studies where ppm concentrations are used. One of the main problems is that ppm values are not entirely independent. These measures are, in essence, percentages, though expressed on a different scale (i.e., in parts per million instead of parts per hundred). Thus, a higher concentration in one element necessarily lowers concentrations in others, meaning that the values are not independent. However, the larger the number of variables, the less of a problem this is in applying PCA. The use of ratios of different elements can also help in this regard. While other methods exist to help analyze compositional data (e.g., Beier and Mommsen 1994), PCA is readily available in most statistical packages and performs adequately to assist in classification. At the same time, the results of the sherd groupings based on PCA of centered log-ratios were cross-checked for consistency against simple bivariate plots of raw elemental data, PCA of simple log-transformed data, and other archaeological data (as discussed above).

The first five principal components of the PCA accounted for approximately 90% of the variability in the overall data set. Values for these first five principal components and the use of bivariate plots were then used to begin the classification of archaeological sherds into discrete groups. Specimens forming spatially discrete groups within the bivariate plots were initially placed together in a single group. Based on these initial groups, additional specimens were added or subtracted from the group based on the Mahalanobis distance, as expressed by Hotelling's T^2 statistic, from the group centroid for the first 5 principal components (see Sayre 1975 and Glascock 1992 for a definition and description). Specimens falling within a 90% confidence interval ellipse around the group were admitted to the group, while those falling outside the 90% ellipse were excluded. After each addition or removal a new group centroid was calculated. By repeating this process (i.e., adding and subtracting members based on Mahalanobis distance) a final reference compositional group was defined when no further sherds could be added to or subtracted from the group.

Compositional groups based on the PCA results were then re-examined with bivariate plots using logged raw data to examine the consistency and homogeneity of the defined groups. Despite being similar (i.e., close) in principal component space, some specimens were found to display divergent compositional values when the logged raw data were examined in bivariate plots. That is, although the principal component analysis and Mahalanobis distance suggested specimens were part of a compositional group, the raw data suggested otherwise. Such specimens were removed from the compositional group when they displayed more than three or four divergent values for particular elements. Finally, results were screened to determine whether they were consistent with other archaeological data, such as sherd form, shape, color, and geographical location.

Sample

In order to investigate how the production of pottery was organized and how pots were moved across the landscape, it was necessary to take a regional approach. To achieve this goal, it was important to understand how pots were moved into different areas, as well as out of those areas. Moreover, to understand this process on a regional scale, it was important to examine several different areas.

Several contiguous regions in the Western Great Basin were targeted for sampling. The focus began with Owens Valley and spread outwards to surrounding regions. This strategy would facilitate understanding how pots moved into and out of at least one region. For the most part, then, the sampling strategy was extensive rather than intensive. Within regions, the goal was to sample a small number of sherds from a large number of sites. To minimize duplication of pots, sherds within sites were sampled such that no two appeared to be from the same vessel. This was accomplished through spatial distance (sherds separated by more than 40 m were included in the sample as they were less likely to be from the same pot) and through visual characteristics (sherds which did not look alike were sampled). This strategy lends itself quite well to the area, since most sites contain only a handful (20-30) of sherds, allowing for inclusion of one or two of the sherds per site. In a small number of regions where sherds are more plentiful, a secondary goal was to sample a single site more intensively (i.e., with more than seven or eight sherds). This would allow for the comparison of both within- and between-site variability within a region.

Due to the sampling strategy, which spanned several regions, was necessary to make heavy use of existing archaeological collections. The availability of different collections for destructive analysis and the spotty nature of archaeological work in most areas necessitated more of a “take what you can get” strategy than a stratified sample. Many of the desired locations had few or no sherds available for study. Moreover, it was rarely possible to achieve a systematic and/or even geographic distribution of sherds across an area. Thus, in many regions the sherds included in the sample form small clusters around areas where archaeological work has been undertaken, with large areas between clusters. Of course, it is likely that sherds themselves are distributed in such a manner (as discussed in Chapter 5), as pottery was not used in all environmental zones within the Western Great Basin.

Rather than subdivide each area into smaller and smaller portions corresponding to clusters of sherds (e.g., NW Death Valley, SW Death Valley, Central Death Valley, etc.), the analysis below retains the broader regional focus despite these gaps in spatial sampling. For the most part, the spatial distance between regions is greater than the distance between clusters of sherds within a region, making the larger regional groupings valid. However, as discussed below, in some cases the composition of sherds in different sub-areas within a region are distinct, suggesting clays are also distinct. This offered the possibility for more fine-scaled analysis in the movement of pots.

Table 7.1: Background information on INAA sample.

	# Sherds sampled	# Sites repres-ented	Max. # for one site	# Rims, #Bodies, # Bases	Max. distance between 2 sherds (km)	# clay samples analyzed
China Lake	31	15	8	14, 15, 2	40	0
Fort Irwin	32	15	6	7, 25, 0	30	0
Death Valley	40	30	7	40, 0, 0	100	5
Sequoia	33	9	18	30, 3, 0	50	4
Southern Owens	78	28	30	53, 26, 0	30	6
Central Owens	34	10	17	10, 22, 2	20	3
Northern Owens	23	12	5	20, 3, 0	25	3
Deep Springs	15	8	5	6, 9, 0	20	2
Papoose Flat	13	9	4	4, 7, 2	10	0
White Mtns.	3	3	1	0, 3, 0	5	0
Saline Valley	1	1	1	0, 1, 0	-	2
Nevada Test Site	38	16	9	19, 19, 0	50	1

In total, 376 sherds and clays were analyzed, including 341 discrete archaeological pottery artifacts, one ethnographic pot, 30 discrete clay samples, one sample taken from a dried chunk of clay from an archaeological site, two samples of temper hand-picked out of a sherd, and one sample of sand picked out of a clay sample. The archaeological sherds include samples from Naval Air Weapons Station China Lake (all from the northern section in the Coso area), Fort Irwin Army Base, Death Valley, Sequoia National Park, Southern Owens Valley, Central

Owens Valley, Northern Owens Valley (including five on the border between Owens and Long Valleys), the White Mountains (just east of central Owens Valley), Deep Springs Valley, Saline Valley, Papoose Flat, and the Nevada Test Site. Table 7.1 provides summary information on the number and nature of samples analyzed from each region.

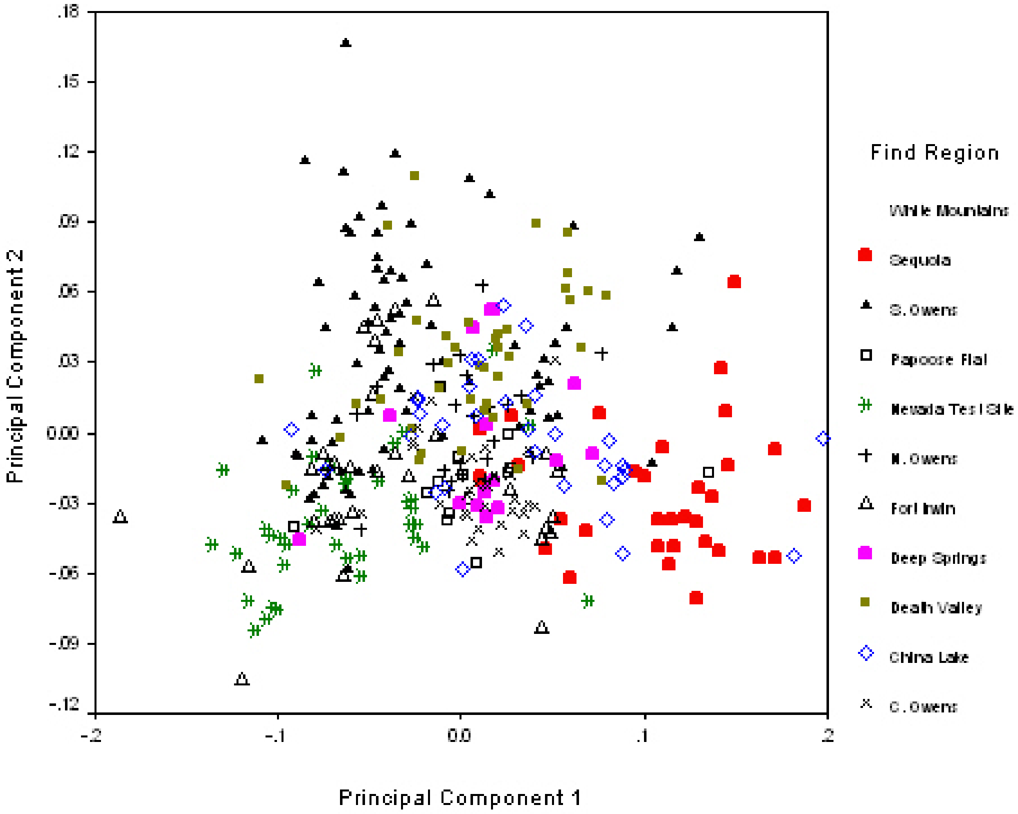
As mentioned 30 clay samples were also analyzed. Clay samples were collected in a somewhat haphazard manner from different regions, that is, where they were conveniently available. Of the 30 samples, 23 represent sedimentary sources of clay and 7 are from residual sources. Sedimentary sources of clay include lake-bed deposits, overbank river deposits, and small pan or pool locations (i.e., small areas where water had accumulated and dried). Residual clays were collected from both decomposing basaltic and granitic outcrops and appear to be more rare and inaccessible (i.e., deeply buried) in the region. In addition to the clay samples listed in Table 7.1, three samples were analyzed from Panamint Valley, one from Fish Lake Valley, and one from the Columbus Salt Marsh.

Many of the clay samples collected were poor for making pots. After firing, several samples proved to be rather soft and friable, such that they could not have held together to form a useful pot. Moreover, many samples did not appear to be very watertight, readily absorbing and leaking water, again suggesting they were not of pottery-making quality. Many of the sedimentary clays fall into this category, and may have contained too much silt or organic material. On the other hand, some of the clays that have the best qualities for making pots were also sedimentary, particularly some of the small pan deposits. Residual clays appear to perform better on average, in terms of their ability to form shock resistant (i.e., hard) and watertight containers, but did not comprise the best clays. This suggests that higher quality clays are rather variable in their spatial distribution and availability and not necessarily of one type (i.e., residual or sedimentary). While high silt and organic content seem to make for poor clay, it is still unclear what accounts for the excellent properties of some of the sedimentary small pan clays. Additional sampling, testing, and compositional analysis of clays from the area would go far towards addressing this question.

Results

Overall, the INAA was quite successful. The majority (78%; 267 of 342) of the pot sherds analyzed were assigned to discrete chemical groups consisting of three sherds or more. Most of the groups, however, contain ten or more specimens, and several contain more than 25 and can be subdivided into smaller discrete subgroups. The significance of the different groups and subgroups are discussed below. Moreover, it was possible to link several of the compositional groups to geographical areas based on chemical similarities to clays and the geographic

Figure 7.1: Principal Components 1 & 2 for all sherds grouped by region found.



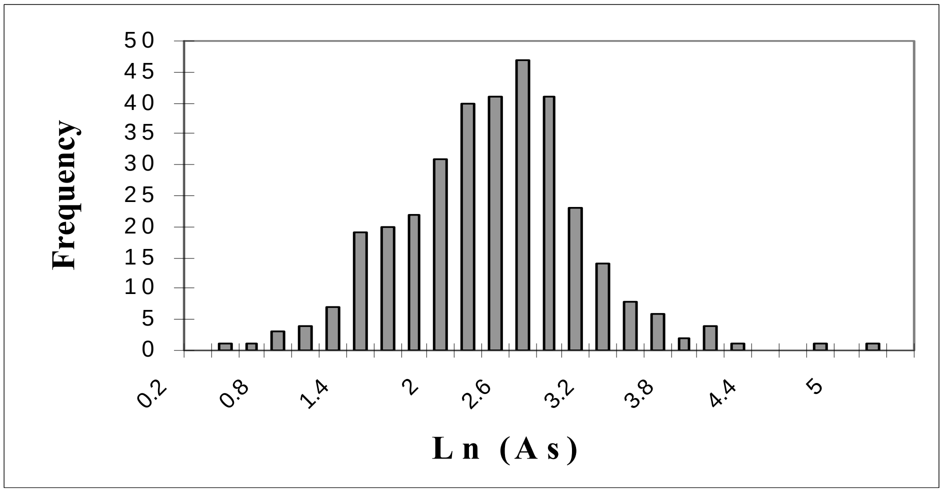
distribution of group members. This allows for the identification of movement of pots between different areas, either through exchange or as part of the seasonal round.

General Observations

Figure 7.1 plots the results of the PCA for the first two principal components, marking pot sherds only by the location in which they were found (i.e., without any type of classification into compositional group). As can be seen, sherds from different areas tend to occupy different regions of the graph (some areas more so than others). However, this graph, which only plots the first two principal components, strongly suggests that sherds in the Western Great Basin differ chemically by region. This initial result indicates that chemical sourcing of sherds has much potential.

The majority of elements analyzed display approximately normal distributions when histograms of the logged values are plotted. For example, Figure 7.2 gives a histogram for arsenic (As) values (natural logs). Occasionally slightly bimodal or trimodal distributions are observed, corresponding to regional differences in clay chemistry. For example in Figure 7.2, the extended peak at 1.6 along the x-axis corresponds primarily to sherds from Sequoia National Park.

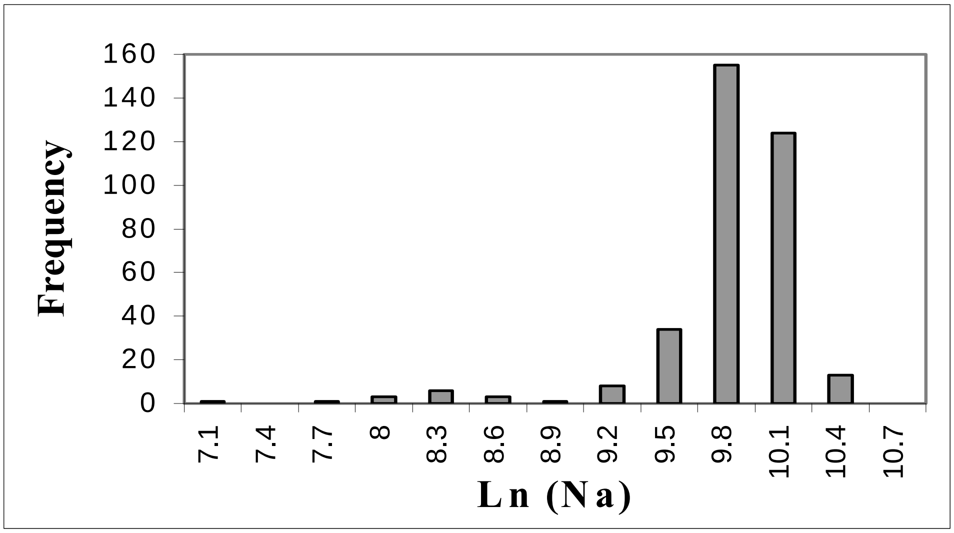
Figure 7.2: Arsenic (natural log) histogram for all sherds.



Two elements, potassium and sodium, however, have unusual distributions. For these elements, a number of samples have low values, falling outside the main group of pot sherds. Importantly, these samples come from a variety of regions and the elements involved are common, suggesting the pattern is not related to regional clay chemistry but some other factor, such as the type of temper added (type of minerals included), type of clay (e.g., acidic or basic), or the degree of weathering or transport the clay minerals have undergone (Pettijohn 1975; Van Olphen 1977; Velde 1992). Moreover, there appears to be little overlap among sherds with low values for these two elements (i.e., sherds with low values for sodium rarely have low values for potassium, but do have lower levels of calcium).

For example, Figure 7.3 gives a histogram for logged values of sodium for all sherds. The histogram clearly shows a gap between the majority of sherds and a small number of sherds with very low values, including sherds from Fort Irwin, Death Valley, China Lake, and the Nevada Test Site, but notably not from Owens Valley, Sequoia National Park, and Deep Springs Valley. These sherds do not appear in an obvious manner to vary outwardly in any other fashion. Thus, no apparent differences in temper and/or paste were noted for these cases. The sherds were also assigned to a variety of chemical groups. Why these samples display low levels of sodium is unknown, but may be related to the types of clays used. Smectite clays are known to have higher levels of sodium, and the degree of weathering is also believed to affect sodium, aluminum, and other elemental values (Kuleff and Djingova 1996; Pettijohn 1975). Additional mineralogical analysis is necessary to determine the reasons for this distribution in sodium.

Figure 7.3: Sodium (natural log) histogram for all sherds



It is also worthwhile to consider the amount of variability among sherds from the ten main regions sampled prior to placing them in discrete groups. Such variability may be indicative of the complexity of the background geology, and hence clays, that are being used in an area. Areas with high geologic diversity are likely to yield a diversity of clays with different chemical signatures, while those with more homogenous geologic/petrographic background should have less diversity in the chemistry of available clays. These figures, of course, will be modified by the degree of trade in ceramics (higher rates of exchange causing greater chemical diversity) as well as the area over which ceramics are collected (smaller regions having less opportunity for geologic diversity). Table 7.2 lists for each region (minus the White Mountains and Saline Valley due to small sample sizes) the number of elements where the Coefficient of Variation (CV) was among the highest two and lowest two values among the ten regions.

Table 7.2 – Variability in pot sherd chemistry by region.

	# elements where CV is among highest 2	# elements where CV is among lowest 2	Maximum distance between 2 sherds (km)
China Lake	9	3	40
Fort Irwin	13	2	30
Death Valley	3	5	100
Sequoia	4	5	50
Southern Owens	9	3	30
Central Owens	0	18	20
Northern Owens	4	6	25
Deep Springs	3	9	20
Papoose Flat	4	7	10
Nevada Test Site	15	6	50

Table 7.2 points out some interesting patterns in chemical variability by region. Areas in the northwest portion of the study area, namely Central and Northern Owens Valley, Papoose Flat and Deep Springs Valley, seem to have relatively little variation, while China Lake, Fort Irwin, and Southern Owens Valley (in the southern portion), and the Nevada Test Site (in the northeast) have much more variability in terms of the variance in the raw data. Although the area over which sherds were sampled is slightly less among the former and slightly larger among the latter (see column 3), this factor does not wholly account for the distribution. Death Valley and Sequoia National Park, which have the two largest distances (in terms of the area over which sherds were sampled), have relatively little variation. Similarly, Papoose Flat has the smallest area but does not have the least variation, and Southern and Northern Owens Valley have nearly equal distances but are quite different in terms of variability among pot sherds. Quite conspicuous in Table 7.2 is the chemical homogeneity of Central Owens Valley,

where 18 of the 32 elements have one of the two lowest CV values. These figures likely speak to the diversity of clay sources available to, and used by, prehistoric potters suggesting that places like central Owens Valley have little diversity and the Nevada Test Site have much.

One final point merits mention. Illite clays are unusual by their high values of K relative to (Na + Ca) (Keller 1970: 800). An examination of this ratio among the INAA samples reveals eleven sherds that stand out with values greater than 2. Most are from the southern part of the study area, including six from Fort Irwin (three classified as group 13 which are especially high, near the values of 4, and three other ungrouped sherds), two from Death Valley, two from the Nevada Test Site (including one with extremely high value over 4), and one from central Owens Valley. High values for this ratio may indicate the use of illite, rather than kaolinite or smectite, as the clay mineral type to make these sherds.

Results by Region

Below the results for each region are discussed, including a breakdown of how sherds were assigned to different groups and which groups appear to be local to each region. Larger compositional groups that were assigned to a geographic region were given names incorporating letters (e.g., WSA indicating group A from the Western Sierra area or SOV1B indicating group 1B from Southern Owens Valley). These represent cases where I felt that geographic provenance was fairly clear. Smaller compositional groups where geographic provenance was less certain or was not assigned were given numbers.

China Lake

Nineteen of the 31 (61%) sherds from China Lake were assigned to chemical groups. Two groups account for 12 of these specimens, six each in groups 14 and 15. Both groups are composed primarily of sherds from China Lake, group 14 entirely so, and group 15 with six of 7 from China Lake (the other from Southern Owens Valley). Based on this information both groups are *tentatively* interpreted as local to the China Lake area. The two groups differ from the broader Western Great Basin sample with slightly lower values of arsenic, barium, and dysprosium. However, the two groups differ from one another than each from the broader data set, suggesting they are not derived from similar or related clay sources. In particular, groups 14 and 15 differ in the values of many transition metals (especially cobalt, chromium, manganese, scandium, and vanadium), where group 15 is much higher, as well as cesium, uranium, thorium, and terbium, where group 14 displays higher values. Rare Earth Elements (REE), however, are quite similar between the two groups.

The spatial distribution of groups 14 and 15 across the China Lake region are slightly different. Four of the six group 15 sherds were found in the Burro Canyon area, in the southern part of the region (some 8 km northeast of China Lake playa). The group 14 sherds, however, are all from the northern part of the study area near the Coso obsidian source, approximately 25 km northwest of the Burro Canyon area.

Like the Fort Irwin sample (discussed below), the sherds from China Lake display a great deal of chemical variation, suggesting the pots they represent are derived from a diversity of geologic backgrounds. Indeed, a large fraction of the sherds were identified as either non-local or outliers within the larger Western Great Basin data set. This finding may speak to the relatively high degree of mobility observed prehistorically among groups in the area (Steward 1938; see also Gilreath and Hildebrandt 1997 and Delacorte 1990 for a discussion and comparison of mobility in this area).

A large fraction (seven of 31 or 23%) of the China Lake sherds were identified as imported to the region. These imported sherds include four with chemical properties placing them in the Western Sierra group (two from group WSA and two from group WSB), two from Death Valley (both from group DV2), and one from Southern Owens Valley (group SOV1A). This distribution suggests interactions with or movement of peoples from a variety of directions into the area, including from the West, East, and North. Interestingly, none of the China Lake sherds displays patterns consistent with the two groups tentatively interpreted as local to Fort Irwin (or vice versa see below), suggesting that pots, and perhaps people, did not frequently move between these two areas. Finally, three sherds (JEC307, JEC312, and JEC333) were assigned to a small chemical group given the temporary name group 16. Given the small number of samples in this group and an absence of clay samples from the region, a geographic provenance could not be assigned to this group. As such, they are treated as ungrouped (i.e., neither local nor traded) until additional information is collected.

Overall, then, few sherds appear to be locally made within the China Lake area. The high overall diversity of elemental values as well as the high percentage of imported and unknown specimens speak to this point. As in the Fort Irwin case (see below), the greater residential mobility of people within the China Lake area may account for this distribution.

Fort Irwin

Of the 34 sherds analyzed from Fort Irwin, 22 (65%) were assigned to seven different chemical groups. Five of the represented groups, termed temporarily compositional groups 10, 11, 12, 13, and 17, are composed only of sherds from the Fort Irwin area, suggesting they may be local to this region. However, the groups are composed of small numbers of samples, 7, 7, 3, 3 and 3 respectively, making their regional affiliation uncertain. Comparisons to the sherds and clays from other areas suggest the clays used to make these pots are unique within the overall Western Great Basin sample. Similarly, a comparison to sherds from the Imperial Valley to the south (data from Hildebrandt et al. n.d.) demonstrates they are not derived from that area either (the prospect was considered unlikely anyway, given the spatial distance). Relative to the broader Great Basin sample, sherds within groups 10-14 and 17 have lower concentrations of cesium, uranium, strontium, and zinc, and higher levels of hafnium. In addition, groups 11 and 12 have distinctly lower values of cobalt, chromium, manganese, titanium, and vanadium (e.g., transition metals), similar to some sherds from the Nevada Test Site, suggesting they may be related to clays derived from locations closer to that area. Group 17 shows some characteristics similar to sherds in the SOV1C group, suggesting that it too may be related to clays from outside the region and closer to Southern Owens Valley. Values of K to (Na + Ca) for group 13 are almost two to four times as high as other samples and as mentioned earlier may indicate the use of illite for the pots from which these samples came.

Given the small sample sizes of the compositional groups, it is not possible to say much about the spatial distribution of these samples. However, there does not appear to be any obvious difference in how they are distributed across the Fort Irwin region. Additional sampling is needed to determine whether these compositional groups are 1) actually local to the region or derived from elsewhere and 2) if the former, are characteristic of distinct subregions within Fort Irwin.

Evidence suggests the Fort Irwin area was used sporadically by groups from the surrounding areas with few or no people living permanently in the area (Eerkens 1999). Some of these chemical groups, then, may represent clays from outside the region, that is, pots carried in and abandoned by people as they moved across the Fort Irwin area rather than locally made. Additional sourcing of clay would be necessary to establish with certainty the geographic origin of these groups. Due to their relatively greater size and the fact that no sherds from other areas match these groups, groups 10 and 11 are tentatively defined as local (see Table 7.3; though as mentioned above group 11 shows some similarity to NTS sherds).

Three samples from Fort Irwin were identified as traded or imported wares. A single specimen from CA-SBR-2865 (in the Drinkwater Basin) appears to be derived from clays native to Death Valley (DV1; see Eerkens et al. n.d.), and is out of context by approximately 50-80 km. A second sherd (JEC265), found as an isolate in the western part of the study are, as well as a sherd from CA-SBR-4449 (JEC256 from the Tiefort Basin) were marginal members of the SOV1B compositional group which appears to be native to Southern Owens Valley. Distances to Southern Owens Valley in both cases exceeds 100 km. All three sherds demonstrate either exchange with or movement of people from areas to the north.

Overall, the sample from Fort Irwin suggests a great variety of sources were used to make the pots whose sherds were deposited in the area. This finding is supported by the CV values summarized in Table 7.2, where Fort Irwin sherds frequently display high variation values for specific elements relative to other areas. Thus, either the region supports great variability in the background geology and chemistry of available clay sources and many different sources were exploited to make pots, or many pots from chemically diverse sources were carried into the region. Based on other evidence (e.g., Eerkens 1999), the latter seems likely.

Death Valley

Of the 40 sherds sampled from Death Valley, a high percentage (34/40 or 85%) were assigned to chemical groups. Of these, 30 (75%) were assigned to a single large group (group 4) with several distinct subdivisions, most of which appear to be local to the Death Valley area. Within the larger Great Basin sample, 39 samples were assigned to group 4, including 30 from Death Valley. Four distinct, but chemically related subgroups were defined within group 4, suggesting they may represent different subsources of a single broad clay source zone. The four subgroups of group 4, given the temporary names DV1, DV2, DV3, and 4D, are composed of 18 (17 Death Valley and one Fort Irwin), seven (five Death Valley and two China Lake), six (five Death Valley and one Central Owens), and eight (three Death Valley, three Deep Springs Valley, one Northern Owens Valley, and one Nevada Test Site) sherds respectively. The DV abbreviation in these groups stands for the fact that they are believed to represent locally available Death Valley (DV) clays (see below). That a large fraction of the Death Valley sherds belong to group 4 may explain the relatively low degree of elemental variability for the region (seen in Table 7.2), despite the large geographic area over which sherds were sampled.

The group 4 samples can be differentiated from the broader Great Basin sample by slightly lower concentrations of lutetium, thorium, uranium and zinc, and higher concentrations of antimony and especially strontium. Groups DV1, DV2, and DV3 can be differentiated from one another based on concentrations of arsenic, barium, and transition metals (especially cobalt, titanium, and vanadium). These differences suggest they are derived from distinct clay sources. Group 4D varies from the former three by significantly lower concentrations in some of the heavy REEs, particularly lutetium, terbium, and ytterbium, suggesting it is more tangentially related to the former three DV subgroups.

The five clay samples analyzed from Death Valley display chemical properties that relate them to the group 4 pottery samples, such as unusually high concentrations of Sr, combined with lower levels of Zn and U. When compared to the group 4 pottery specimens, however, these trends were sometimes greatly exaggerated. For example, while the DV1 pottery group contained average Sr values of 1036 ppm and DV2 averaged 1017 ppm (compared to, for example, 50 SOV1 sherds at 389 ppm), Death Valley clays display average Sr values of 2836 ppm (compared to 483 ppm for 25 other clays collected to the north and west of Death Valley). Higher levels of strontium in the Death Valley clays may be related to the presence of higher concentrations of various calcium carbonates, especially aragonite. Strontium readily substitutes for calcium in the molecular structure of some calcium carbonates. Moreover, Death Valley is a source of strontianite, a member of the aragonite mineral family that is commonly found with calcite and contains high levels of strontium (Friedman 2000). The mobility of strontium in clay and its tendency to bond with carbonates combined with the presence of significant quantities of strontainite in Death Valley may explain the high levels of strontium seen in the Death Valley clays and sherds.

Two Death Valley sedimentary clays, both collected near Mesquite Flat in the north-central part of the valley, fall within the range of DV1. Based on this information and the fact that the majority of samples in DV1 are from Death Valley, group DV1 is assigned to the Death Valley area. Based on similar chemical composition to DV1, and the fact that the majority of specimens in DV2 and DV3 are also from Death Valley, groups DV2 and DV3 are tentatively assigned to Death Valley as well. On the other hand, a clay sample collected from the northeastern end of Deep Springs Valley matched the 4D group. Group 4D, then, is tentatively assigned to both the Deep Springs and Death Valley regions. That this Deep Springs clay source displays such similar chemical properties to clays in Death Valley is interesting as it is located some eighty kilometers to the north-northeast of Death Valley. Group 4D clays, then, may be derived from a single expansive geological stratum that spans the two regions.

There does not appear to be any particular spatial pattern to the distribution of sherds within the DV1 and DV2. That is, each group is composed of sherds found in different parts of the valley. DV3, however, is composed of specimens only from the Mesquite Flat area (as well as one sample from Central Owens Valley). This group *may* be local to the Mesquite Flat area or from areas to the north (given the lack of DV3 specimens in parts of Death Valley to the south of Mesquite Flat). However, the small sample size of this group (n=6) limits the certainty of this conclusion. Based on these observations, then, DV1, DV2, and DV3 are interpreted as representing clays collected somewhere in Death Valley. Given the large size, particularly in the north-south axis, of Death Valley, it is unfortunate a more precise geographic provenance could not be given to the compositional groups. Additional collection and analysis of clays would be necessary to resolve this issue.

Charles Hunt (1960) suggested that all Death Valley pots were made using residual (and non-local) clays. Hunt felt that sedimentary clays contained too many salts and/or calcium carbonate minerals. However, he may not have adequately considered the potential for clays to be leached of these minerals and/or alternative sources of clay, such as mid-elevation locations relatively free of salts. Experimental firing of small tiles made from clays from the valley bottom in Death Valley suggests that some are of pottery quality (i.e., do not explode during firing or flake or fall apart following firing) and may have served prehistoric potters quite well. Furthermore, examination of fresh breaks on sherds under a black light suggests that some do contain calcium carbonate minerals such as calcite, which fluoresce when exposed to ultraviolet light, without any detrimental effects to the stability of the pot. Finally, of the five clays collected and analyzed from Death Valley, the sedimentary clays best match the DV1 compositional group. A single residual sample from decomposing basalt, also collected in the Mesquite Flat area, was much more removed. Together, this information suggests that pots may indeed have been made from sedimentary low-elevation sources. Again, a more extensive and systematic analysis of Death Valley clays should help address this issue.

Four pottery samples from Death Valley were identified as definitely imported from outside the region. Three sherds were attributed to the Nevada Test Site (two to group NTS1A and one to NTS1B) and one to Southern Owens Valley (SOV1C). Interestingly, the latter piece was made with a recurved rim and was decorated with a row of fingernail incisions on the exterior neck, a style that is much more common to Death Valley than Owens Valley. This offers the possibility that it was made by a Death Valley potter during a visit to Southern Owens Valley. Alternatively, the piece could be an exchange item made by a Southern Owens potter, but in the Death Valley style of manufacture. For reasons discussed later, the former seems especially likely. Finally, six Death Valley pot sherds are unassigned statistical outliers within the Western Great Basin INAA data set.

Overall, the Death Valley sample is relatively chemically homogenous and composed of a high proportion of locally-made pots. A single chemical group (group 4) accounts for three-quarters of the entire sample, and a large fraction of these (27/40 or 68%) appear to be made of local clays. This is quite unlike the areas sampled to the south (i.e., Fort Irwin and China Lake). Additional analysis and discussion of the Death Valley pottery sherds may be found in Eerkens et al. (n.d).

Sequoia National Park

Like Death Valley, the sherds sampled from Sequoia National Park are relatively homogenous. As Table 7.2 suggests, the 33 sherds are often among the least variable for a particular element. Part of this may be related to the fact that over half the samples (55%) come from a single site, Hospital Rock (CA-Tul-24). However, there is as much variability among the sherds from this site as there is among the rest of the Sequoia sample, suggesting that this factor alone does not account for the relative homogeneity.

Over four-fifths (85% or 28) of the 33 sherds were placed within a single chemical group, given the name WS (Western Sierra). Although WS is fairly variable internally when compared to other compositional groups, it is quite distinct chemically. Several elements help to distinguish WS, including lower values for arsenic, potassium, rubidium, thorium, and Rare Earth Elements (REEs), especially lanthanum, neodymium, and samarium, and higher values for chromium, iron, and calcium.

Group WS encompasses sherds from several different regions, including Sequoia, Southern Owens Valley, Papoose Flat, and China Lake. Based on the differences in the compositional data, WS was subdivided into three different subgroups, WSA, WSB, and WSC. The subgroups include 23 sherds in WSA (20 from Sequoia, two from China Lake, and one from Papoose Flat), ten in WSB (eight from Sequoia and two from China Lake), and three in WSC (all from Southern Owens Valley). Groups WSA and WSB differ primarily in chromium, rubidium, potassium, and thorium, and uranium, where WSB displays higher concentrations of these elements. However, the similarities in the values of different elements, particularly relative to other chemical groups, suggest that all three WS subgroups are related clay sources. There do not appear to be any spatial differences in the distribution of sherds assigned to these two sources.

Two of four clay samples collected in or near Sequoia National Park fell within the compositional range of WSA. Both of these clays were sampled from residual sources in the Sierra Nevada foothills, and one (JEC205; the sample that best matched WSA) was rated excellent as a potential clay to make ceramics. Based on these data, and the fact that nearly all sherds in WS1 and WS2 are from Sequoia National Park, it seems clear that the WS group is native to the Western Sierra area. WS1, in fact, appears to be local to the west-central region of Sequoia National Park (northeast of Three Rivers). Two other clay samples from the area, collected in and near Lake Kaweah, just west of Sequoia National Park near the California Central Valley bottom, were quite different. This suggests that the clays used to make WS pots are from the Sierra foothills and not the bottom of California's Central Valley.

Only one sherd from Sequoia National Park was identified as clearly imported. This sherd (JEC047) was collected in Cedar Grove, actually located in Fresno County along the South Fork of the Kern River, just north of Sequoia National Park in Kings Canyon National Park at 1500 meters elevation. Chemically JEC047 falls within a group that appears to be local to central or northern Owens Valley (NOV1B). In this respect, the sherd was found closer to central Owens Valley than southern Owens Valley. In outward appearance, the sherd is slightly thicker (at 5.9 mm) than most Sequoia sherds but thinner than most central or northern Owens Valley. It also has a brushed exterior and interior unlike the majority of other Sequoia sherds. Thus, the sherd bears a stronger resemblance to most Owens Valley than other Sequoia sherds, but I note also that it is within the range of Sequoia vessels.

The four remaining sherds were statistical outliers and remain ungrouped. These sherds could be made of chemically unrelated clays that were only rarely used within the Western Sierra area or could have come from imported pots from outside the region. If the latter, they do not appear to be derived from the typically exploited clays from the east or south. That is, these sherds do not match chemical groups attributed to Owens Valley or the Northern Mojave Desert. Furthermore, pottery is relatively rare in areas directly to the west and north (Jackson 1990). The shape, texture, color, and thickness of these four specimens is consistent with locally produced pottery, that is, the sherds look similar to local pottery. In light of these observations the former argument seems more likely, that is, the sherds likely represent local clay sources that were only rarely exploited. However, further clay and sherd sampling is needed to verify this hypothesis, and for the time being the sherds remain unassigned as to geographical origin.

Using INAA, Asaro and Michel (1984) analyzed four sherds from Rockhouse Basin in the Western Sierra Nevada, some 75 km to the south along the South Fork of the Kern River. This is the only other INAA study in the Western Great Basin or California that I am aware of. Although the range of elements obtained in their study differs slightly than those retrieved at MURR, a comparison is possible. The data gathered by Asaro and Michel (1984) for these four sherds compares favorably with the WSA group, supporting the conclusions reached here and suggesting that these four samples are also derived from clays local to the Western Sierra area. As well, it suggests WS clays are available over a fairly wide geographical region. In sum, then, the overwhelming majority of sherds from Sequoia National Park appear to be locally made. Very few sherds (3%) are clearly imported and the number of unknown specimens is similarly low (12%).

Southern Owens Valley

As indicated in Table 7.2 the range of elemental variability among the Southern Owens Valley sherds, like that of Fort Irwin and China Lake, is relatively high. However, unlike those areas, the number of grouped sherds in Southern Owens Valley is much higher. Of the 78 sherds analyzed, 64 (82%) were placed in compositional groups and 61 (79%) were attributed to two groups that appear to be local to the Southern Owens Valley area.

The first of these groups, termed SOV1, is composed of 55 sherds, 50 of which were found in Southern Owens Valley. SOV1 can be further split into four discrete but related subgroups, SOV1A composed of 19 sherd (18 from Southern Owens and one from China Lake), SOV1B composed of 23 sherds (21 from Southern Owens and two from Fort Irwin), SOV1C composed of eight sherds (seven Southern Owens and 1 Death Valley), and SOV1D composed five sherds (four Southern Owens and one Papoose Flat). SOV1 sherds are quite distinct from the broader Western Great Basin sample. These samples are characterized by higher concentrations of arsenic, cobalt, uranium, and thorium, and lower levels of chromium and barium. The main difference between groups SOV1A and SOV1B is in the concentrations of several rare earth elements (REEs), particularly hafnium, lutetium, samarium, terbium and ytterbium, where SOV1A displays significantly higher values. Other heavier metals, such as uranium and zinc, are higher in SOV1B and help to further differentiate between the two groups. Groups SOV1C and SOV1D are somewhat intermediate between these extremes, but tend to be lower in REE elements similar to SOV1B.

The second group, SOV2, is composed of 11 sherds, all from Southern Owens Valley. This group differs in several important aspects from SOV1. Like SOV1 levels of cobalt, thorium, and uranium are higher than most western Great Basin sherds, but arsenic, barium, and chromium are more in line with these other western Great Basin sherds. Instead antimony, terbium, and ytterbium (lower) and vanadium (higher) tend to distinguish SOV2 sherds from other compositional groups.

As mentioned, six clays from Southern Owens Valley were also analyzed. Two of these clays match the SOV1B group quite well. Of these two, the best match was collected from within the Owens Lake playa at Ash Creek, while the second was collected just north of Lone Pine next to a small spring. Both clays are sedimentary in nature, suggesting that the SOV1B group may be derived from sedimentary sources. The closest matches to SOV1A, on the other hand, are a residual clay source where Cottonwood Creek emanates from the Sierra Nevada and a sedimentary source on the Ash Creek alluvial fan. Although the match of these two samples to SOV1A is poor, this hints that SOV1A may be derived from residual sources of clay, and that the difference between SOV1A and SOV1B may relate to the type of clay used (similar clay types but one residual and the other sedimentary).

Geological and clay chemistry studies tend to support such a conclusion. Several sources suggest that metamorphic and residual clays should have higher levels of REEs than transported sedimentary clays. Moreover, residual clays should have lower levels of aluminum and higher levels of calcium and manganese (Kuleff and Djingova 1996; Pettijohn 1975; Velde 1991). A comparison of SOV1A and SOV1B reveals such a pattern. Aluminum is slightly lower in SOV1A while manganese is higher. However calcium is approximately even (in fact, slightly lower in SOV1A). Although not clear-cut, these findings support the hypothesis that SOV1A represents a residual clay source zone and SOV1B represents a sedimentary one. Finally, together with the fact that the vast majority of SOV1 sherds were found in Southern Owens Valley, the results demonstrate that both subgroups, and most likely the SOV1 group altogether, is local to Southern Owens Valley.

A single Southern Owens Valley sedimentary clay sample (JEC192), collected in a cut bank along lower Cottonwood Creek (perhaps an older lakebed sediment), provided a decent match to the SOV2 group. Similarly, a sedimentary clay sample (JEC196) taken from a cut bank of Tinnemaha Creek in Central Owens Valley also provides a decent match. Although different in chemical makeup, the two clay samples are similar in their overall Mahalanobis distance to the SOV2 group centroid. For example, JEC192 is better suited in terms of arsenic values and JEC196 is closer for cerium. However, based on the fact SOV2 is composed exclusively of Southern Owens Valley sherds, and importantly none from Central Owens Valley, this compositional group is also assigned to the Southern Owens Valley region. It is acknowledged, however, that the source of this clay may lie slightly north of Southern Owens Valley, between Southern and Central Owens Valley. Additional analysis of clays will be necessary to resolve this question.

Only four sherds from Southern Owens Valley (5%) were identified as imported from elsewhere. Three appear to be derived from Western Sierra clays (all from WSC), including two from CA-Iny-30 near Owens Lake (JEC116 and

JEC126) and one (JEC098) from CA-Iny-2750 just north of Lone Pine. These sherds represent the only members of this compositional group. The source of this clay, then, may be located near Southern Owens Valley, but on the Western Side of the Sierra Nevada. In appearance, all three WSC sherds are relatively thin, smooth on their exterior, contain ample mica, and contain larger temper particles, consistent with sherds made in Sequoia National Park (see Chapter 4). In addition, one of the sherds (JEC098) is decorated signifying that additional effort was put into making the pot more attractive. These sherds, then, may represent traded vessels, rather than items made by Eastern Sierra people from Western Sierra clays. The fourth displaced sherd (JEC217), from CA-Iny-2 in the Eastern Sierra Foothills, is a member of group 15, which appears to be made from clays native to the China Lake area. In appearance the sherd is much like other Southern Owens Valley or China Lake sherds.

One sample warrants some additional discussion. A single non-brownware sherd (JEC093) from an excavated and well-dated (ca. 1200 BP) site along the shores of Owens Lake appears to predate the inception of traditional Owens Valley Brownware. These sherds represent the oldest examples of native pottery known from Owens Valley. The sherd is low-fired and the coils are incompletely pressed together. Chemically, it falls within the SOV1B group and is therefore interpreted as locally made. However, despite the fact that over 20 m^3 of sediment was excavated, the site produced only two sherds, suggesting that pottery-making at the site was uncommon and that in the region the craft may began on a small-time and experimental basis. In addition, its chemical affiliation suggests that pottery-making may have been largely an indigenous and in-situ development. For additional information on these sherds and the site, see Eerkens et al. (1999).

Finally, a single sherd (JEC233) collected from the shores of Owens Lake outwardly resembles corrugated grayware from the Southwest. The sherd has distinct corrugation marks and is gray in appearance, although it is slightly sandblasted. Such sherds typically date to ca. 1100-800 BP in the Southwest region. The sherd was selected intentionally for INAA analysis due to its unusual appearance, despite the fact that it might predate the inception of Owens Valley Brownware. Chemically, JEC233 is a distinct outlier within the broader Western Great Basin data set, unrelated to any chemical group defined in this study. Furthermore, a comparison with INAA data on sherds from the Mesa Verde region suggests that although it is not an exact match to any compositional group from that area, it is in many respects very similar (Neff, personal communication 1999). This specimen, then, clearly establishes at least sporadic contact with cultures in the Southwest before the inception of local pottery in the area.

These two sherds, JEC093 and JEC233, demonstrate that people in Owens Valley were exposed to and experimented with pottery-making roughly 800-1200 BP. However, people apparently decided not to engage in the craft on a large scale at that time. Instead people waited 300-700 years before picking up the craft on a more permanent and serious basis. Being unrelated to the time period of interest, that is, when pottery making begins in earnest, these two sherds are excluded from further analysis.

In conclusion, despite being rather variable overall in their chemical makeup, all grouped sherds from Southern Owens Valley fall into only three compositional groups (SOV1, SOV2, and WS). Two of these groups account for 79% of the entire Southern Owens Valley sample (minus the two older specimens), and both are interpreted as being local to the region. Thus, a high percentage of Southern Owens Valley sherds are locally made, while only a small percentage (5%) are clearly imported from other regions of California and the Western Great Basin. Interestingly, despite being rather close to Central and Northern Owens Valley geographically, no sherds seem to be imported from (or to, as seen below) these areas. This issue is discussed in greater detail later.

Central Owens Valley

As indicated in Table 7.2, the Central Owens Valley sherds are the least variable of all the regions sampled. Like the Sequoia sample, part of this may be explained by the fact that half the sample comes from a single site, Crater Middens (CA-Iny-1700; see Bettinger 1989 for a description and discussion). However, the sherds from Crater Middens are not any less variable than other sherds from Central Owens Valley. In fact, the majority of ungrouped sherds (four of seven) are from this site, as well as one of the imported sherds. Instead, it appears that Central Owens Valley sherds are simply very similar chemically. This suggests that either the region has a relatively homogenous geological background or that only a small number of clay source zones in the area was exploited to make pots.

A large percentage (76%) of the Central Owens Valley sherds were assigned to Western Great Basin compositional groups. Of these, the majority belong to two major chemical groups, termed COV1 and NOV1. The first of these groups encompasses 11 sherds, including 8 from Central Owens Valley, two from Papoose Flat, and one from Northern Owens Valley. Low levels of antimony, arsenic, cesium, zinc, and zirconium combined with reduced levels of most REEs (especially the lighter elements such as lanthanum, cerium, neodymium, an samarium) tend to characterize this group. Two sedimentary clays collected from Central Owens Valley, one from an oxbow along Owens River near Big Pine and the second from a small pan just south of the Povery Hills (approxiately 12 km south of Big Pine) provide the closest matches among the clay samples to the COV1 compositional group. A third clay sample from Northern Owens Valley also proved to be similar, but was a closer match to NOV1B, and is probably more affiliated with that compositional group. Based on these observations, COV1 is provisionally assigned to the Central Owens Valley region.

The second major group to which Central Owens Valley sherds belong is NOV1. Fifteen Central Owens Valley sherds were assigned to two subgroups of this compositional group, ten to NOV1A and five to NOV1C. Based on similarities to clays collected in Northern Owens Valley, this compositional group appears to be local to that area (as discussed in greater detail below). However, at least one of the subgroups (NOV1C) is composed mainly of Central Owens Valley sherds. Five of the six sherds in NOV1C were found in Central Owens Valley. As well, a significant fraction of the NOV1A sherds are also from Central Owens Valley. Thus, while Northern Owens Valley is the best candidate for the location of NOV1, it is possible that some of the subgroups in this compositional group may be local to Central Owens Valley, particularly NOV1C. Because of this possibility, the NOV1 compositional group is considered to be local to *both* Central and Northern Owens Valley. However, the NOV name is retained based on the current evidence which favors Northern Owens Valley as the source of this clay. Based on this ascription, then, a large percentage (68%) of the Central Owens Valley sherds are interpreted as being locally made.

Only three sherds were identified as imported from outside the region. Two sherds, one each from CA-Iny-1700 and CA-Iny-1782, appear to be manufactured from clays native to the Nevada Test Site (NTS1B). In physical appearance, these samples are not unusual for either Central Owens Valley or Nevada Test Site sherds. A third sherd was placed within the DV3 group of Death Valley. Finally, one sherd (JEC367) from CA-Iny-4581 has some similarity to group 14 from China Lake. Unfortunately, a number of elemental values in JEC367 diverge from group 14 values and preclude including the sherd in that group, leaving the sample a statistical outlier.

Seven additional ungrouped sherds also occur among the Central Owens Valley sample. Several of these ungrouped sherds are broadly similar to one another and other several sherds from Deep Springs and Northern Owens Valley also display some of these similarities. In particular, these sherds have low concentrations of arsenic and REEs. However, many samples have extreme values for one or more elements, and the overall degree of internal variability within these samples is too great to form a single homogenous compositional group. Thus, many of the unknowns from Central Owens Valley may be part of an additional highly variable compositional group local to the Central or Northern Owens Valley area, but it is difficult at this point to define such a group.

Overall, Central Owens Valley sherds are highly homogenous. The majority of sherds fall into two major groups with only a small number of imported pots. One of these groups is clearly local to the Central Owens Valley area and the second may also be local but displays some affinities to Northern Owens Valley clays.

Northern Owens Valley

Although the Northern Owens Valley sample is small (only 23 sherds) a large fraction (78%) were assigned to discrete compositional groups. Overall these sherds are fairly homogenous. As indicated by Table 7.2, elements are more likely to be among the least variable than most variable, despite the fact that sherds are spread over a number of different sites. This information suggests that the range of clays Northern Owens Valley potters made use of was fairly limited.

Compositionally, sherds from Northern Owens Valley fall into a range of groups. The majority (14 or 61%) fall into the NOV1 group. The NOV1 group is composed of 41 sherds, including 14 from Northern Owens Valley, 15 from Central Owens Valley, seven from Papoose Flat, three from Deep Springs Valley, one from the White Mountains, and one from Sequoia National Park. The distribution of these sherds clearly indicates a northwestern emphasis within the study area. The NOV group does not stand out with particularly high or low values for any single element, although hafnium, strontium and calcium are slightly lower. Most values for individual NOV1 samples hover near the overall average for Western Great Basin sherds. However, when these samples are plotted using principal components, the samples stand out, forming a separate cluster of points.

Two clays from Northern Owens Valley show some similarities to the NOV1B group. Both clays were collected near Benton, in what is more properly the Hammil or Chalfant Valley. One represents a sedimentary clay and the other a residual clay. Although raw elemental values for the clays are different than the NOV1 sherd values, the clays show certain elemental patterns that suggest they are related. A third sedimentary clay collected from Fish Slough in Northern Owens Valley was quite different than the NOV1 sherds and other clay samples.

The NOV group can be further divided into three discrete subgroups, given the names NOV1A, NOV1B, and NOV1C here. NOV1A is composed of 23 sherds, including eight from Northern Owens Valley, 10 from Central Owens Valley, three from Deep Springs Valley, and two from Papoose Flat. NOV1B includes 11 sherds, six from Northern Owens Valley, four from Papoose Flat, and one from Sequoia National Park. Finally, NOV1C is comprised of only six sherds, five from Central Owens Valley and one from Papoose Flat. NOV1A and NOV1C are distinguished from NOV1B by elevated concentrations of transition metals and heavy REEs (especially dysprosium, lutetium, and ytterbium) levels. The main distinction between NOV1A and NOV1C is that NOV1C accentuates many of these differences, being even higher than NOV1A for several elements (except scandium, vanadium, and zinc). Antimony, however, is higher in NOV1A.

Based on the distribution of sherds and the similarities to clay samples, NOV1B appears to be local to the Northern Owens Valley area, although it may also be available in Papoose Flat (and without further testing of clays from that area, this assumption is made). Based on chemical similarities, NOV1A and NOV1C may also be local to the Northern Owens Valley area. However, NOV1C does not contain any Northern Owens Valley sherds; in fact, it contains mostly Central Owens Valley sherds, suggesting the clay for this group may actually be located further to the south towards Central Owens Valley. NOV1C, then, is designated local to Northern *and* Central Owens Valley. Similarly, NOV1A contains a diverse array of sherds from the northwestern part of the study area, and is not dominated by Northern Owens Valley or any other regions' sherds. Based on this information, NOV1A is tentatively assigned as "local" to Northern Owens, Central Owens, Deep Springs, and the Papoose Flat area. That is, NOV1A appears to be found over an expansive area.

Four sherds were identified as imported to Northern Owens Valley. Two sherds found on the Volcanic Tablelands appear to come from the Nevada Test Site. One sherd (JEC171) from CA-Mno-2190 was assigned to NTS1A and a second sherd (JEC166) from CA-Mno-6 was assigned to NTS1B. The latter is unusual in physical appearance as it bears a recurved rim, which is a rare trait for pots made in Owens Valley (as discussed in Chapter 4, no whole pots from the region had recurved rims). This suggests it may be a trade item rather than being made by Owens Valley potters while visiting the Nevada Test Site area. Alternatively, it may have been made by a Nevada Test Site potter while visiting Owens Valley. A third sherd (JEC162) collected at CA-Mno-2596 on the Tablelands was assigned to compositional group 4D, which as discussed earlier (and below) appears to be from the Deep Springs Valley area. Finally, a decorated sherd (JEC175) excavated from CA-Mno-1878, on the very northeastern edge of Owens Valley, was included in the COV1 compositional group, suggesting it was traded from Central to Northern Owens Valley. Five sherds remain ungrouped statistical outliers.

Asaro and Michel (1984) also analyzed three sherds from site “5Z13” in Owens Valley by INAA (the site number is part of the Enfield-Weller numbering system). Although the report does not state where in Owens Valley these sherds are from (whether north, central, or south), examination of their INAA data revealed that two were within the chemical range of NOV1A and the third within NOV1B. This suggested that the site 5Z13 was probably located somewhere in Northern Owens Valley. Indeed, a check of the Enfield site records by Linda Reynolds of the US Forest Service confirmed that the site is located just south of Bishop in Northern Owens Valley. These three sherds, then, also appear to be locally made within the Northern Owens Valley region (but are not included in the discussion to follow).

Overall, the Northern Owens Valley assemblage contains a slightly lower percentage (60%) of locally produced sherds than either Central or Southern Owens Valley. Four sherds, or 17%, were identified as definitely imported and 22% are ungrouped.

Deep Springs Valley

Relative to the other regions, only a small sample of sherds were available for study from Deep Springs Valley. Despite this small sample size, which covers a relatively large number of sites, the sherds from Deep Springs Valley are fairly standardized compositionally (as seen in Table 7.2), suggesting that the range of clays exploited by prehistoric potters in the area was small. Despite the small sample size and elemental homogeneity, the range of compositional groups within the sample is relatively large.

Of the 15 sherds analyzed only eight (53%) were assigned to individual compositional groups. Less than half of the 15 (six or 40%) were determined to be local and a high percentage (33%) remain ungrouped statistical outliers. Three sherds were assigned to NOV1A, which as discussed above, appears to be available over a wide area in the White-Inyo range, including Deep Springs Valley. Three additional sherds were assigned to group 4D, which appears to be local to Deep Springs Valley (and Death Valley as discussed above). Of the two clay samples analyzed, only one bore any resemblance to a compositional group. A sedimentary clay collected from Crooked Creek on the northeast end of the valley was quite similar to compositional group 4D, suggesting that 4D is local to Deep Springs Valley. Much like DV1, DV2, and DV3, group 4D has slightly lower thorium, uranium, ytterbium levels along with greatly elevated strontium concentrations. This group can be differentiated from the DV samples by lower concentrations of dysprosium and terbium, higher levels of aluminum and barium, and intermediate levels of cobalt and cesium. However, given the lack of a clear majority of sherds from Deep Springs in this group and the similarities to other Death Valley clays and compositional groups, the 4D group is interpreted as being local to both Deep Springs and Death Valley, that is, it is available in both areas. A second residual clay collected by Antelope Spring in the south-western part of the valley was highly unusual and does not resemble any pot sherd analyzed in the study.

Two sherds (JEC144 and JEC152) were identified as definitely imported from elsewhere, both from the Nevada Test Site. The former is part of the NTS1A group and the latter part of NTS1B. Both sherds are similar in physical appearance to other local sherds from the region. Finally, seven sherds (47%) are ungrouped statistical outliers. Interestingly, three of seven unknowns are decorated and comprise all decorated sherds selected for analysis from Deep Springs Valley. Three of the remaining four unknowns are not rims and may have been decorated near the rim as well (i.e., it was not possible for these body sherds to be decorated since decoration is nearly always close to the rim). This non-random distribution of the decorated rim sherds suggests that these pieces may also be imported to the region (see discussion below). The distribution of recurved rims is also interesting within the sample. Of the nine rim sherds sampled from Deep Springs, three were recurved. Of these, two are ungrouped, and the third is part of the 4D group (with similarities to Death Valley clay, where recurved rims are much more common).

In sum, the majority of samples from Deep Springs do not appear to be locally manufactured within the valley. Only 40% of the sherds could be attributed to local clays (and in the case of NOV1A, local is a generous attribution). To be fair, the small sample size from Deep Springs may have prohibited the formation and identification of additional local groups. That is, with small sample sizes one is less likely to reach the critical mass (i.e., at least four to five sherds) needed to identify a discrete group. Thus, it is possible that some of the outliers in the Deep Springs sample could be part of local compositional groups if a larger sample had been taken and analyzed from Deep Springs. Unfortunately, Deep Springs Valley is small, remote, and little archaeological work has been undertaken (see Delacorte 1990), limiting the sample of sherds available for study. Additional analysis of sherds from the valley would go far towards resolving this issue.

Papoose Flat

Papoose Flat is a small area within the Inyo Mountains lying at around 2500 m in the piñon-juniper zone, just east of and overlooking Owens Valley below. Like Deep Springs, the sample from Papoose Flat is rather small. A total of only 13 sherds was sampled and analyzed. Also like Deep Springs, the range of elemental variability among these 13 samples was fairly restricted (as indicated in Table 7.2), suggesting that the number of clay sources exploited by prehistoric potters was fairly restricted and homogenous. However, unlike Deep Springs Valley, almost every sherd was assigned to a chemical group.

Despite the high degree of chemical homogeneity, a surprisingly large number of compositional groups are represented within the 13 sherd sample. Of the 13 sherds 12 were grouped (92%), representing no less than five of the major Western Great Basin groups, including NOV1 (seven Papoose Flat samples: two from NOV1A, four from NOV1B, and one from NOV1C), COV1 (two sherds), SOV1D (one sherd), WSA (one sherd), and NTS1B (one sherd). The overwhelming majority (9/13 or 69%), then, are derived from clays located just to the west and northwest in Central and Northern Owens Valley. Based on the popularity of NOV1 within the Papoose Flat sample and its proximity to Northern Owens Valley, these clays are tentatively assumed to be locally available in the Papoose Flat area. However, they could just as easily have been carried up into the area from Owens Valley, as suggested in Chapter 5. Unfortunately, no clays were collected and/or analyzed from Papoose Flat. Thus, an analysis of local clays is necessary to verify this hypothesis.

Three other samples are clearly imported from other regions. One sherd each from Southern Owens Valley (JEC135), Western Sierra (JEC138), and the Nevada Test Site (JEC132) were also encountered. A final ungrouped specimen rounds out the 13 samples. This final sherd displays some chemical affinities for NOV1B, but extremely high values for chromium and zirconium (among some other inconsistencies) prohibit inclusion in that group.

In sum, the small sample size prohibits much in-depth analysis and/or rigorous comparison to other areas. The fact that such a high percentage of sherds were grouped suggests that additional sampling of sherds would not disclose the presence of unrecognized local sources of clay (unlike Deep Springs Valley). That is, there were so few ungrouped samples that it seems unlikely that significant discrete and local sources of clay could go unrecognized (though perhaps discrete subgroups could still be formed). Of course, it is possible that local clays simply mirror those in the valley bottom. Of the sherds analyzed, a clear emphasis on Northern and Central Owens Valley as a source of clay for pots is present. The majority of pots appear to be made from clay sources native to those areas. Such a distribution may reflect seasonal movements of peoples from these areas into the upland Papoose Flat area (i.e., from Owens Valley up the western side of the Inyo Mountains). Interestingly, sherds derived from more eastern sources of clay are rare, suggesting that peoples living in those areas did not often make use of Papoose Flat.

Nevada Test Site

Like areas to further to the south in the study area, the sherds from the Nevada Test Site seem to encompass a diverse range of clay types (as indicated by Table 7.2). Variation in element concentration is quite high (relative to other areas) for a number of elements. This variability is reflected in the range of compositional groups represented. A large percentage (74%) of the 38 sherds was assigned to compositional groups, including two groups that appear to be local and a third that is possibly local, and two that are clearly non-local.

The former were given the temporary names NTS1 and NTS2. The two groups are composed of 30 (with 19 from Nevada Test Site, three from Death Valley, two from Deep Springs Valley, two from Northern Owens Valley, two from Central Owens valley, one from Papoose Flat, and one from the White Mountains), and five (all from the Nevada Test Site) specimens respectively. NTS1 can be further subdivided into two discrete subgroups, NTS1A and NTS1B, composed of 14 and 16 samples respectively. That NTS1 includes such a diverse geographical range of sherds, suggests the pots moved far and wide from the Nevada Test Site across the Western Great Basin. A third group, represented only by three sherds from the Nevada Test Site, was given the temporary name Group 9. This group may be local to the NTS area, but without further clay sourcing such attribution is tenuous. As such, the group is not assigned to any region.

NTS1 can be differentiated from other Great Basin compositional groups by lower levels of arsenic, calcium, cobalt, iron, titanium, and vanadium, combined with high concentrations of lanthanum, cerium, rubidium, and zirconium. NTS2, like NTS1, contains low levels of arsenic, calcium (especially low), iron, titanium, and vanadium, and high levels of rubidium, but in addition has particularly low concentrations of most REEs and strontium. NTS1A and NTS1B may be differentiated from each other by barium, thorium, zinc, and uranium (all lower in NTSA except thorium which is higher).

A single clay sample from the Nevada Test Site (a dried clay chunk artifact) bore little resemblance to any of the compositional groups. Although many values, especially the REEs, were in line with NTS2 for this sample, values for transition metals (particularly cobalt, chromium, iron, scandium, and vanadium) were so low as to make the sample a large statistical outlier within the data set.

In contrast to the large number of sherds that appear to be leaving the Nevada Test Site to other regions, few sherds seem to have been imported. Only one sample (JEC302) was grouped within a non-local compositional group, being imported from Deep Springs Valley (group 4D). A second sherd (JEC303), though not part of any western Great Basin compositional group, is also non-local but ungrouped. JEC303 is a black-on-white sherd in a classic Southwestern style. This sample was selected to determine if local potters may have adopted a southwestern style and applied it to a local clay. However, the chemical makeup of this sherd places it far from any western Great Basin sample, suggesting that it, indeed, was imported from far away (likely the Southwest). Finally, nine other ungrouped sherds were encountered within the Nevada Test Site sample.

Overall, then, 63% (24 of 38) samples were determined to be locally made within the Nevada Test Site area, while only 1 sherd was assigned to another Great Basin area and one to the Southwest area. Relative to several other regions, a high percentage of the sherds (26%) were unassigned.

Saline Valley and White Mountains

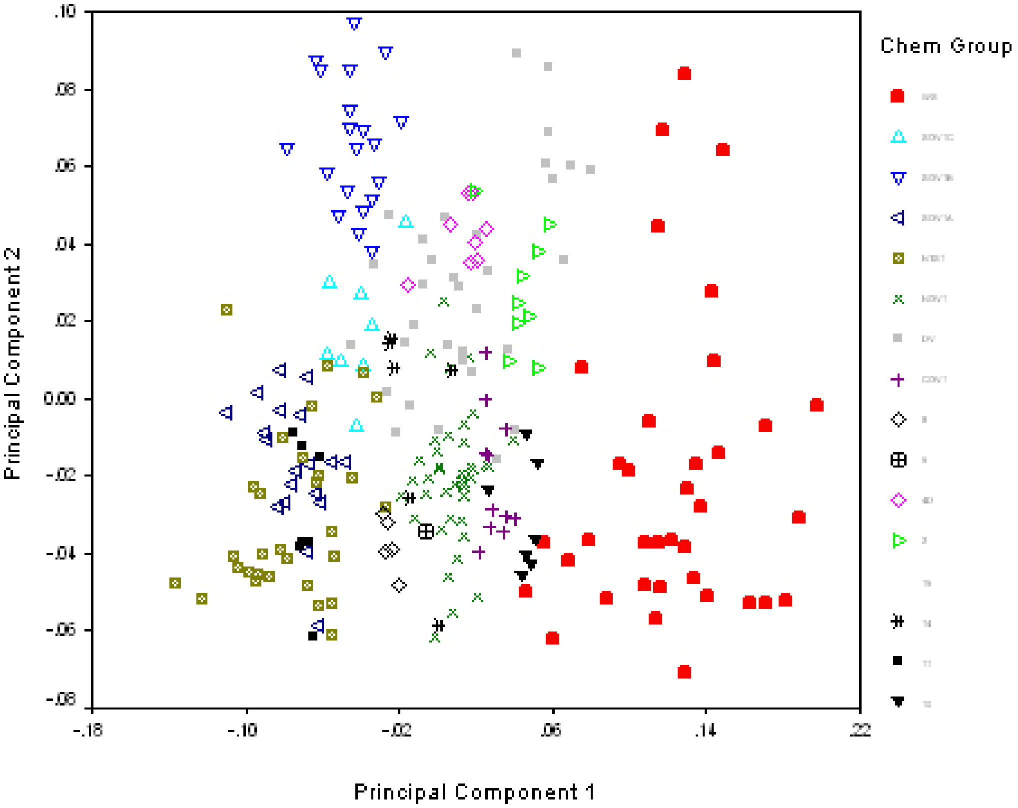
In addition to sherds from the regions discussed above, four additional pot sherds were analyzed, including one from Saline Valley (JEC374) and three from the White Mountains. JEC374 from Saline Valley did not belong to any compositional group, although it does display some similarities to the Nevada Test Site sherds. Two of the White Mountains sherds were assigned to compositional groups, one to the NOV1C group and one to the NTS1B group. The latter is clearly imported, while the former may be local or carried up from Owens Valley. The third sample was ungrouped. Given the small sample size, little more can be said about the White Mountains or Saline Valley pieces.

Summary of Results by Region

Figure 7.4 plots the results of the principal components analysis again (principal components 1 and 2, like in Figure 7.1). However, in Figure 7.4 the sherds are grouped by their compositional affiliation rather than the region in which they were found (as they were in Figure 7.1). Ungrouped sherds are not plotted. The figure shows that different compositional groups are distinct, and that using such an analysis a meaningful division of pot sherds can be achieved.

Table 7.3 sums up the results of the analysis by region. Listed are the percentages of local, ungrouped and traded sherds from each region, as well as the source of traded sherds. The table points out some significant differences in the number of sherds that seem to be leaving versus entering regions. In some areas people seem to produce most of their pots locally, including Sequoia National Park, Death Valley, the Nevada Test Site, and all three subregions of Owens Valley.

Figure 7.4: Principal components 1 and 2 with sherds plotted by chemical group.



Other regions, however, seem to have a much lower percentage of pots that are clearly locally made, including China Lake, Fort Irwin, and Deep Springs. Again, these results do not seem to mirror the degree of reliance on pottery, as determined in Chapter 5. That is, it does not appear that regions where few pots were produced necessarily imported more pots (i.e., as a way to minimize time spent in production; see discussion below).

Table 7.3: Percentages of local, ungrouped and traded sherds.

Region	**% local**	**%ungroup**	**% trade**	**Source of traded sherds**
China Lake	39%	39%[1]	23%	SOV; WS; DV
Fort Irwin	41%	50%[1]	10%	SOV; DV
Death Valley	75%	15%	10%	SOV; NTS
Sequoia	85%	12%	3%	NOV
Southern Owens	79%	17%	5%	WS; (Southwest) [3]
Central Owens	68%	24%	9%	DV; NTS
Northern Owens	60%	22%	17%	NTS; DSV; COV
Deep Springs	40%	47%	13%	NTS
Papoose Flat	54%[2]	8%	38%	SOV; COV; NTS; WS
Nevada Test Site	63%	31%[1]	6%	DSV; Southwest

Notes: [1]- These regions contain small groups composed of only three sherds each. Given this small size, they are treated as ungrouped until further analyses can demonstrate their provenance. [2]- Based mostly on its proximity to Northern Owens, NOV1 was interpreted as local to Papoose Flat. [3]- Two older sherds from Southern Owens Valley, including one from the Southwest, are not included in this table (see text).

A major problem with any chemical analysis such as the one discussed above is the number of ungrouped or outlier sherds typically encountered. Rates of 25% or more are quite normal (Neff personal communication 1998). Not surprisingly, and as seen above, the rate of ungrouped sherds seems to increase with decreasing sample size. Overall, less than 30% of the sherds in this sample are ungrouped. However, a major problem remains in how to interpret such sherds. That is, it is unclear whether they represent local clay sources that are only rarely used, sherds with unusual temper added, or non-local sherds imported from areas not included in the study. Because they often form a significant fraction of the samples analyzed their treatment can have an effect on the overall interpretations of a study.

A brief examination of the ungrouped sherds from the current study, then, is worthwhile. Table 7.4 compares some attributes of the ungrouped sherds against local and traded items, including the percentage of decorated sherds (where this attribute could be determined), the percentage of rims with recurved profiles, the average thickness and diameter of rim sherds, and the average thickness of body sherds. Base sherds are not included in the analysis.

Table 7.4: Comparison of local, traded, and ungrouped sherds.

	Local	**Imported**	**Ungrouped**
% Decorated	10% (17/164)	16% (4/25)	16% (7/44)
Average Rim Thickness	5.80 mm	5.55 mm	5.96 mm
Average Rim Diameter	266 mm	222 mm	220 mm
% Recurved Rims	8% (13/164)	32% (8/25)	16% (7/44)
Average Body Thickness	6.22 mm	5.84 mm	6.08 mm

The table points out some interesting differences between local and traded pots. First, local pots are less often decorated than either imported or ungrouped sherds (although a chi-square test is insignificant at the .05 level). This result was not unexpected given the increased value of a full or empty pot carried over a large distance and suggests that some of these pots may have been the objects of exchange (though see discussion below). Second, local pots are about ½ millimeter thicker on average than imported pots, but about equal in thickness to ungrouped pots. Third, on average, local pots have larger mouth openings than either imported or ungrouped sherds (t-tests are significant for both comparisons at the .05 level). Part of this may be explained by the lower frequency of recurved rims among local pots (table 7.4), since these pots often *tend* to be bowl-shaped with more restricted mouth openings. Finally, among body (i.e, non-rim) sherds, local samples tend to be slightly thicker than ungrouped, and quite a bit thicker (i.e., statistically significant) than imported sherds.

Thus, Table 7.4 points out some marked differences between local and imported pots. Locally made pots are less often decorated and are significantly larger both in diameter and thickness. This result is not too surprising given the weight of clay pots and the distance they were carried, which, according to the INAA data, was occasionally 150 kilometers or more. Smaller and thinner pots would have been lighter and more easily transported. The ungrouped sherds fall between these extremes. Like imported pots, these items were decorated at a similar rate and had narrow mouth openings. However, they were usually as thick as locally made vessels. As well, the percentage of recurved rims is exactly halfway between local and imported pieces. Taken together, these data suggest that ungrouped sherds are likely composed of both imported and locally made pots, not much help in answering the question regarding their origin.

Discussion

This section considers the overall evidence for the production and movement of ceramic vessels. As discussed in the opening chapters, gaining a better understanding of these aspects of ceramics will contribute towards making an argument about why people adopted pottery in the first place.

Production

The results suggest that for most regions the majority of pots were locally made, with only a minor fraction definitely imported from another region. In most regions, between 60 and 85 percent of the sherds were identified as local and between 3 and 18 percent imported. However, the percentage of ungrouped sherds is relatively high and variable, suggesting that the true number of local and imported sherds could fluctuate depending on how these ungrouped sherds are ultimately classified.

Despite the ungrouped problem, there seem to be some clear patterns in the data. A natural division of the regions into three sets is apparent, namely, areas with predominantly local sherds and few imported pieces, areas with medium levels of local and slightly more imported samples, and regions with less than half the sherds identified as local and a high fraction of imported and ungrouped samples. To the former belong Sequoia National Park and Southern Owens Valley, and slightly less so, Death Valley. To the second tier belong Central Owens Valley, Northern Owens Valley, and the Nevada Test Site. And to the last class belong, Fort Irwin, China Lake, Deep Springs Valley, and Papoose Flat. Note, however, that the last set of regions (especially Fort Irwin and China Lake) contain a number of groups composed of only three members that were not given a geographic provenience (and placed in the ungrouped category), and that these groups may yet prove to be locally derived.

A comparison of the data produced in Chapter 5, on the degree of reliance on (or density of) pottery, and the data produced in this chapter is also of interest. If only small numbers of pots are needed, in some cases it may be cheaper to import pots from outside the region than to make a small number locally. Similarly, at times it may be worthwhile to overproduce and sell or exchange surplus to such areas. Thus, a comparison of regions with low and high densities of pottery with the production data could reveal such trends.

However, the data produced here do not support such a supply and demand model. The percentage of locally made sherds does not correlate very well with the degree of reliance on pottery presented in Chapter 5. Thus, many regions that did not rely much on pottery prehistorically, such as Sequoia National Park and Northern and Central Owens Valley, did not necessarily try to lessen their production load by importing pots from other areas. In these areas, the majority of pots still seem to be locally made. Nor does it seem that areas with high densities of pottery, such as Southern Owens Valley, exported large numbers of sherds to nearby areas where fewer pots were produced. In fact, in the latter case, no sherds seem to have been exported to pottery-poor neighboring areas such as Central Owens Valley and Sequoia National Park.

In this respect, it does not look like pottery production and distribution was organized on a cross-regional scale. In most areas, pots seem to have been produced on a small and local scale. As discussed below, when pots are moved the pattern corresponds to an entirely different model than the supply and demand model mentioned above. This local production likely speaks to the role that pottery played in the social lives of people living in the region. Thus, pottery seems to have been an individually organized craft produced for local consumption only. In some places rates of consumption were higher than others, but such demand does not seem to have prompted certain enterprising individuals to overproduce pots for sale. As well, pottery was not a craft that served as a gift to create ties and bonds across ethnic or regional divides.

Movement

Although they are much less common than locally made vessels, the displaced pots also tell an interesting story. First, there are dramatic differences in the rates of importation and exportation between areas. Table 7.5 lists the percentage of imported and exported sherds encountered in the study in or from each region.

Table 7.5: Comparison of imported and exported sherds by region.

	Number exported	**% export**	**% import (table 7.4)**	**Export-Import Ratio**	**System**
China Lake	1	0.32%	23%	.0141	Southern
Fort Irwin	0	0%	10%	.0000	Southern
Death Valley	4	1.34%	10%	.1338	Transitional
Sequoia	8	2.61%	3%	.8715	Southern
Southern Owens	4	1.52%	5%	.3042	Southern
Central Owens	3	0.98%	9%	.1093	Northern
Northern Owens	2	0.63%	17%	.0372	Northern
Deep Springs	2	0.62%	13%	.0475	Northern
Papoose Flat	0	0%	38%	.0000	Transitional
Nevada Test Site	11	3.65%	6%	.6091	Northern

Note: **% export** was determined by dividing **# export** by the total number of sherds not sampled from that region (i.e., the number of potential sherds that could have been exported from that region). Export-Import ratio is (% export ÷ % import). This measure, then, accounts for the different sample sizes in regions.

In Table 7.5, the percentage of exported sherds was calculated by dividing the number of sherds made from clays native to that region but found outside that area (the raw number exported) by the total number of sherds that could potentially have been exported from that region. The latter value is simply the total number of samples in the whole study (i.e., all regions) minus the number of samples from the region. Calculating the percentage of sherds exported in this manner accounts for the effects of different sample sizes in different regions.

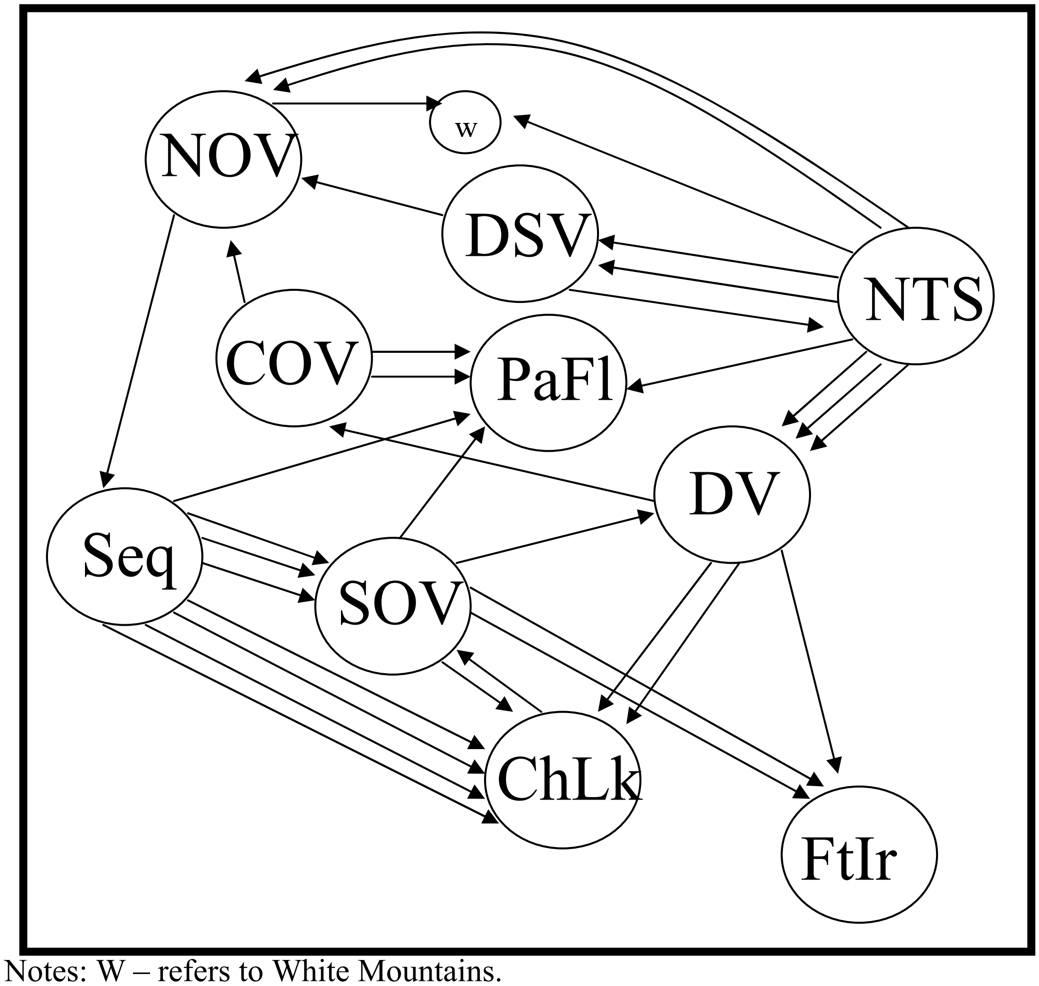
As can be seen from the table, the Nevada Test Site, Sequoia National Park, and to a lesser extent Southern Owens Valley, export a much higher percentage of pots than they import relative than other regions. Central Owens Valley and Death Valley have more modest levels of exported versus imported pots, while China Lake, Fort Irwin, Northern Owens Valley, Papoose Flat and Deep Springs Valley have very few or no exported pots relative to imported ones.

These results can be interpreted one of two ways depending on whether the displaced pots are interpreted as objects of exchange or objects brought along and deposited during seasonal movements. If the former, it suggests that certain areas such as the Nevada Test Site, Sequoia National Park, and Southern Owens Valley had an excess of pots that they must have exchanged for other goods (or sold for shell bead money). Similarly, areas like Northern Owens Valley, China Lake, Fort Irwin, and Deep Springs Valley must have had some resource that the former regions lacked that they could exchange to obtain finished pots. In light of the regions involved, obsidian seems to be a likely candidate. Areas such as Central Owens Valley and Northern Owens Valley have easy access obsidian sources, Fish Springs for the former, and Truman/Queen and Mono Glass Mountain (and Tablelands secondary nodules; see Eerkens and Glascock n.d.) in the case of the latter. A systematic and in-depth study of the distribution of obsidian artifacts in these areas would go far towards addressing this issue. Preliminary analysis of obsidian artifacts in Owens Valley follow this pattern as well, where Southern Owens Valley receives the majority of its obsidian from the Coso source to the south, rather than Fish Springs in Central Owens Valley to the north (Richman and Basgall 1998).

On the other hand, if displaced pots are credited to seasonal movements rather than formalized exchange, it suggests that the people of the Nevada Test Site, Sequoia National Park, and Southern Owens Valley made more frequent use of a larger region than people in other areas. In other words, these groups were more likely to make occasional use of other regions and more often left their pots behind than people in other areas. As discussed below, such movements could be part of reciprocal access to the territories of other groups during particularly difficult times (rather than exclusive ownership of larger territories).

The second interesting trend within the displaced pots is that there are clear patterns in the directions in which they were moved. Figure 7.5 shows the direction that each documented displaced sherd was moved. Each arrow represents the movement of one pot as documented in the INAA study. The figure suggests the presence of two distinct systems, with sherds moving only between certain regions and not others. One of these systems displays a southern emphasis within the study area including China Lake, Fort Irwin, Southern Owens Valley, and Sequoia National Park. The other has a northern emphasis and includes Central Owens Valley, Northern Owens Valley (and the White Mountains), Deep Springs Valley, and the Nevada Test Site. Death Valley and Papoose Flat seem to be transitional areas, with sherds imported and exported from both systems (Papoose Flat with a slight northern bias).

Figure 7.5: Graphical representation of movement of pots between regions.



Notes: W – refers to White Mountains.

Much of this pattern is expected based simply on the proximity of these areas to one another. Thus, because Death Valley and the Nevada Test Site are relatively nearby (within 100 km) some exchange of pottery would be expected. Similarly, the physical distance between the Nevada Test Site and China Lake Naval Weapons Base or between Northern Owens Valley and Fort Irwin, over 220 km in each case, makes it unlikely that many pots would travel between them. Such a result would be expected based simply on the higher frequency of contact expected between people in these areas, similar to a distance-decay model where barriers or resistance to movement between areas are related only to physical distance (Hodder 1980; Renfrew 1977).

However, the distance-decay model can not account for the absence of vessel transportation between some areas that are close together, such as between Southern Owens Valley and Central or Northern Owens Valley (less than 70 and 100 kilometers apart respectively). These data suggest that barriers other than distance affected the movement of pots.

Instead, the data better approximate that expected under a model of vessel movement that minimizes spatial distance but maximizes climatic and environmental dissimilarity. That is, when pots are moving outside the region in which they were made, they seem to be moving to areas that are not necessarily the closest, but areas that are reasonably close yet dramatically different in terms of climate and environment. An examination of precipitation patterns in the Western Great Basin demonstrates this point.

Historic precipitation data for nine western Great Basin weather stations on a month by month basis were compared. Weather stations were chosen to approximate the geographic location of nine of the ten regions examined in this study (a weather station for Papoose Flat was not available). These nine stations are China Lake Armitage for China Lake (coop #45356), Barstow for Fort Irwin (44405), Three Rivers for Sequoia (46908), Haiwee Reservoir for Southern Owens Valley (46006), Furnace Creek for Death Valley (46773), Independence for Central Owens Valley (47668), Bishop Airport for Northern Owens Valley (48380), Deep Springs College for Deep Springs Valley (48460), and Beatty for the Nevada Test Site (47759). These stations best approximate the location of each region while maximizing the length of time each for which each station has data recorded. For example, a weather station exists for Lone Pine which is closer to Southern Owens Valley than the Haiwee station, but the Lone Pine station only has data for the last 15 years whereas Haiwee has data over the last 60. The length of time for each station included exceeds 40 years. Data for these weather stations are available on the internet (at www.wrcc.dri.edu).

Correlation coefficients for monthly precipitation were then calculated between each weather station. Each correlation coefficients represents the degree to which precipitation is correlated on a monthly level between two areas. In other words, the coefficients represent how well large-scale weather systems are likely to deposit rain in two areas.

These coefficients were then regressed against the 3-dimenstional surface distance between each weather station (as calculated by ARC/INFO using 1 km digital elevation data for the region). The corresponding regression is highly significant, that is, areas near one another tend to have highly correlated precipitation records. This result, of course, was expected since two nearby areas are likely to experience similar weather. Next, standardized residuals from the regression were assigned to each surface arc between each weather station. Table 7.6 gives the values for these standardized residuals. The residual value, in a sense, records the similarity in precipitation between two areas corrected by the surface distance. Larger residuals indicate areas that are close but influenced by different climatic systems.

Table 7.6: Calculated residuals for the climate-distance model.

	ChLk	**Irwin**	**Seq.**	**SOV**	**DV**	**COV**	**NOV**	**DSV**
China Lake								
Ft. Irwin	N/A							
Sequoia	1.61	0.92						
S. Owens	0.71	0.82	1.35					
Death Val.	0.16	0.97	1.41	1.05				
C. Owens	0.95	1.08	0.85	0.45	1.87			
N. Owens	0.80	0.69	0.32	0.54	1.73	0.52		
Deep Sprs.	0.53	0.41	1.43	0.35	1.33	1.50	1.62	
Nevada TS	0.10	0.35	0.98	0.39	1.03	1.36	1.34	0.64

A model of expected interaction was then established using these data. The model predicts that people should seek to establish relations not only with nearby regions, but with regions where weather patterns are different. By doing so people may be able to access resources in other territories when resources fall short in their own. Occasionally such access takes place through the movement of staple resources from areas of high density to low (e.g., Braun and Plog 1982; Bettinger 1982b; Speth 1991), but more often it is provided indirectly by moving people to those areas of high density (e.g., Jochim 1981; Smith 1988; Wiessner 1977; Wilmsen 1980; Yengoyan 1972). Such relations are most beneficial between people living in environments that are uncorrelated (i.e., bad years do not occur simultaneously in both areas), since people with their own resource shortfall problems are less likely to share their own insufficient resources. Nor is it worth travelling to a region to harvest resources if the resources in that area are meager to begin with. In such a model, future reciprocal access is implied. In other words, the goal is to find regions that are easily accessible (i.e., nearby) where resources are more likely to be plentiful when your homeland is insufficient. This strategy is particularly well suited to areas with high temporal and spatial variability in the availability of food resources (Halstead and O'Shea 1989), such as the Western Great Basin.

Using this model, the distribution of non-local pots is more interpretable. Table 7.6 suggests that areas such as Northern and Central Owens Valley are quite similar to Southern Owens Valley in terms of precipitation patterns and relative distance. People in these areas, then, were unlikely to seek access to one another's territories, if the goal was to gain access during lean years. On the other hand, according to the data in Table 7.6, people in Southern Owens Valley should have been more intent on establishing relations with people in Sequoia National Park or Death Valley. Similarly, people in Central and Northern Owens Valley should have been more interested in keeping contact with people in Deep Springs Valley, the Nevada Test Site and/or Death Valley. As discussed, this is quite similar to the patterns found among the non-local sherds identified in this study. This suggests that such a model may be better at explaining the movement of prehistoric pots than a simple distance-decay model or an organized distributional system to move goods from high to low density areas. Under such a model we would expect the distribution of exported pots to minimize only the distance between areas and not be affected by differences in climate. Those familiar with the archaeological record of the region will also note that the distribution of artifacts from different obsidian sources follows a similar pattern (i.e., to the distribution of non-local pottery). Though not pursued here, a more detailed examination of the movement of obsidian against that of pottery will certainly reveal interesting patterns. Such an analysis will surely help tease apart artifact movement within the context of seasonal rounds versus that within formalized exchange networks.

All of this suggests, then, that many of the exported pots may have been displaced during the course of occasional movements of people in search of more plentiful food resources. However, it is still unclear whether the non-local pots represent gifts used to formalize relations between people who had reciprocal access to each other's territories (e.g., Gregory 1992; Hirth 1996; Johnson 1994) or whether they represent functional items brought along by people to exploit resources in other territories (and subsequently left behind). Given the small number of decorated pots and their general utilitarian nature the latter seems more likely. One might expect pots involved in a formalized exchange system to have more time invested in them and be different than ordinary everyday-use pots. Decoration is one rather easy and common way to do this (Gregory 1982; Hirth 1996, 1998). The fact that slightly more imported pots are decorated than locally made ones suggests that *some* of these items may indeed have been part of exchange systems. However, that the majority are not and that the difference in the rate of decoration between imported and local pots is small, suggests that many are simply displaced personal belongings rather than gifts.

This conclusion also receives support from an examination of the GC-MS results (see Chapter 6). Of the 74 sherds analyzed in Chapter 6, six are imported, ten are ungrouped, and 58 are locally made. However, there are no apparent differences in the distribution of fatty acid and other lipid compounds among the three classes of sherds. Thus, locally made pots appear to be used for the same purposes as imported pots. This would be expected if people are moving between areas to harvest locally available resources. On the other hand, one might expect pots involved in a formalized exchange system to hold special or unusual contents as part of the gift (rather than normal everyday items). Thus, while some pots may have been the object of gift exchange, the data suggest that the majority of displaced pots are probably the end product of people moving to more plentiful regions during years when they experienced resource shortfall in their home territory.

Conclusions

Chemical compositional analysis of brownware pottery offers the possibility to divide sherds into meaningful and discrete types that are quantifiable and easily repeatable, and not subject to the vagaries of normal typological divisions that have plagued California and Great Basin ceramic studies (as discussed in Chapter 3). Such analysis requires greater financial investment than visual typological studies, but they also offer much more information regarding the production and movement of ceramic pots. Unfortunately, there do not appear to be any visible attributes of the sherds, such as color or temper type, that unambiguously relate to chemical composition group. Thus, nothing about a sherd assigned to the SOV1A group was clearly and visibly different than one assigned to the NOV1A group, even aspects of temper as seen under a 30x microscope. This suggests that visual typological work is unlikely to yield much useful information related to production, movement, or exchange of pots in future ceramic studies, at least on a regional scale.

Overall the majority of pots in the Western Great Basin appear to have been made for local use. Exchange of pottery does not appear to have been a very important activity, at least at the regional scale. On the other hand, when they were carried out of their region of manufacture, pots were occasionally moved long distances. For example, one sherd from Papoose Flat matched the WSA group from Sequoia National Park and one sherd from Death Valley matched the SOV1C group from Southern Owens Valley. Both these pots must have been carried more than 100 kilometers, over and across at least one major mountain range. Such a finding is interesting, given the widespread availability of clays, the heaviness of pots, and the ability of baskets to perform many of the same functions that pots do. This suggests that some groups may have kept ties with other people living over an expansive area.

The results here suggest that such pots were moved primarily within the context of residential movements to regions nearby, but with different precipitation patterns. The use of pots may have been an important part of preparing and/or storing resources (based on the GC-MS data, primarily seeds and nuts) in these foreign areas. Because people may have been unfamiliar with the location and nature of clays in unfamiliar territories and may have been stressed for time, making pots may not have been a desirable option while visiting these regions. Moreover, the number of pots needed may not have been large enough to warrant a new manufacture and firing event (Brown 1989). Instead, it may have been easier to bring along a small number of finished pots from the home territory, leaving them behind before returning home. In this sense, even many of the non-local sherds probably represent vessels made for personal use rather than for any type of formal exchange. Other items, such as obsidian, salt, basketry or other unusual goods, may have served gift purposes instead.

In sum, production of pots seems to have been organized on a very small and local scale for personal use. There is little evidence to support Steward's (1933) claim that some Owens Valley women specialized in pottery production and sold their wares over a large area. Such specialization, if it occurred, could only have been organized on a very local scale with pots being distributed within Southern or Central Owens Valley, but not between or across these regions.

CHAPTER VIII

EVALUATION AND CONCLUSIONS: EXPLAINING THE ADOPTION OF POTTERY

In suggesting reasons why hunter-gatherers of California and the Western Great Basin adopted pottery some 500-700 years ago it is important to ask and answer a number of ancillary questions regarding the process. First, it is important to know how pottery was used and how the craft was organized within the daily lives of people living in the area. Second, we need to know the social context into which pottery was adopted, that is, what were people doing at this time. Third, given that people in the region knew about pottery long before they started making it in earnest, we need to understand why they did not adopt the craft earlier. What was it about this time period that prompted people to adopt pottery-making? These questions are explored below.

Review of Data Presented

This section sums up information presented in the previous chapters to suggest possible reasons for the introduction of ceramics in California and the Western Great Basin. It was argued in Chapter 3 that an important part of understanding why people adopted pottery was reconstructing what pottery was used for and how the production of pots was organized. Chapters 4 through 6 addressed the problem of use, while Chapter 7 focused on production. The following paragraphs sum up the relevant data from each chapter.

Chapter 3 discussed the ethnographic information available on pottery in the study area. This review suggested that much of the data on pottery use may be suspect, as statements given on the behalf of informants often do not match what we find in the archaeological record. The chapter suggested that much of this may be due to a lack of familiarity with pottery by informants in the 1920’s through 1940’s, due to an abandonment of the technology in favor of metal containers much earlier in time (probably by the mid 1800’s). Given these reservations, the ethnographic data do not suggest why pottery was adopted, but do suggest that pots were used to cook a range of different foods, including seeds, nuts, berries, roots, various meat products, and insects. Cooking seems to have been the predominant use of pots according to these accounts, while processing, transport, storage or serving activities are less often mentioned.

Chapter 4 presented a comparison of formal attributes of both whole pots and pot sherds across the study area. The study showed, first, that pottery is rarely decorated in the study area. Only three whole pots and less than 10% of the rim sherds were decorated, though this percentage varied slightly by region. Areas in the eastern and southern part of the study area, such as Death Valley, Deep Springs Valley and the Mojave Desert seem to have slightly higher percentages of decorated rim sherds, up to 20%. Moreover, the decorations that are present usually consist only of small fingernail incisions around lip or rim of the pot. These decorations are clearly not very elaborate or labor intensive (relative to decorations typically encountered in the Southwest or Southeast United States) and are surprisingly homogenous from region to region. Second, a technological study of pot design suggests that resistance to thermal shock and mechanical shock were important attributes. Together with evidence from sooting and carbonization, the evidence suggests the majority of these pots were used in cooking activities, likely boiling. Third, cross-comparison of pots and sherds between different areas suggests that Western Sierra pots are slightly different in surface texture, color, and overall shape than pots and sherds from other areas. These results suggest that pots from this area may have performed in an altogether different capacity (likely serving) than vessels from the Western Great Basin. Fourth, the study demonstrates variability across the study area in terms of wall thickness. Outside of Sequoia National Park, this variability seems to correlate with precipitation patterns, that is, pots in more arid areas seem to have been made thinner. This suggests some degree of concern for fuel efficiency in areas where plant productivity was low and combustible fuel was scarce.

Chapter 5 presented an analysis of the distribution of pottery across the study area. This analysis produced three pertinent results to the discussion. First, pottery is clearly associated with lowland areas, and in most cases with rivers and lakes. This suggests 1) that pottery was probably cached at these fixed points on the landscape (places people knew they would be returning to year after year) and 2) that pottery was used to exploit some type of resource associated with this environmental zone. Such resources may have included marshland plant seeds or roots, insects such as brine fly larvae, freshwater mussels, waterfowl, or nearby dryland seed crops. Second, the degree to which prehistoric inhabitants relied on pottery in different regions of the study area is not related to the degree of residential mobility. There seems to be little correlation between the density of pottery in different areas and prehistoric mobility, suggesting that mobility was not a factor detracting from making pottery. Similarly, aridity did not inhibit pottery production, as many arid areas where firewood is less common have high densities of pottery. Third, omitting three regions (the Northern Owens Valley tablelands, the Coso/China Lake region, and Whirlwind Valley), there is a fairly strong relationship between the number of grinding and milling stones and the number of pot sherds. Thus, pottery was particularly important in the same regions where activities associated with milling and grinding were important.

Chapter 6 presented the results of a Gas Chromatography-Mass Spectrometry (GC-MS) study of 74 sherds from the study area. Results show that, overall, most pots were *not* used to cook meat or meat byproducts (such as bone grease). Instead, storage or cooking of seeds and nuts seem to have been the main function of pots, as over 50% of the sherds display fatty acid signatures consistent with such a use. Seed and nut use is particularly pronounced among pots with direct rims and unrestricted mouth openings. On the other hand, pots with recurved and incurved rims were more often used to cook meats and other plant products, though seeds still seem to be an important product in these pots as well. High levels of fats in many of the sherds is consistent with use in cooking activities. Combined with data from Chapter 4, the results suggest that boiling of seeds was probably the dominant and most important use of pottery in the study area.

Finally, Chapter 7 presented the results of an Instrumental Neutron Activation Analysis (INAA) of nearly 400 sherds and raw clay samples to better address production and movement of pots within the study area. This study demonstrated that in most regions the majority of sherds were locally produced. Overall, fewer than 10% of the sherds could clearly be attributed to a region in the study area outside of that in which it was found. Moreover, patterns in the distribution of non-local sherds is inconsistent with prestige exchange or with production-for-profit or selling of pots. Instead, the distribution suggests that people likely carried pots with them during occasional seasonal movements to exploit resources in other regions, where they may have temporarily been in abundance. Thus, the production, movement, and consumption of pots seems to have been largely on a local scale and was not organized at an interregional or even an intraregional level. The pattern is consistent with small-scale family-oriented production.

Testing Theoretical Models in the Study Area

To refresh the readers memory, Table 8.1 duplicates the information presented in Chapter 2 (Table 2.1). The table reviews different archaeological models that have been proposed to explain the origins of pottery. These are the main models to be considered.

Models that do not work

The review of Chapters 1-7 above demonstrate two obvious points with regard to these theoretical models. First, the small number of pots that are decorated

Table 8.1: Models on the origins of ceramics, and archaeological expectations.

Explanation/Model	**Expectations**
1. *Social*: Competitive Feasting	Pots elaborately decorated & usually for serving. Found in burials & usually broken.
2. *Social*: Symbolic value	Pots decorated. Discrete spatial distributions of styles & high diversity in styles.
3. *Functional*: Storage	Design consistent with storage (e.g., thick walls) & little cooking. Few other storage technologies.
4. *Functional*: Diet breadth increase & Detoxification.	Pot design consistent with cooking, (e.g., sooting on exterior). Diet change. Diverse range of foods cooked.
5. *Social*: Migration/Diffusion	Population replacement, or abandonment and re-occupation. Earliest pottery is well developed.
6. *Functional*: Fuel Intensification	Pots used for cooking & transfer heat efficiently. Fuel demand increases (e.g., cooking). Arid environments.
7. *Economic*: Demand / Population Level	Increase in population size. Diet relatively unchanged. Pots replace other container technology.
8. *Social*: Women's Time and Labor	More vegetable products in diet. Increased sedentism & increased domestic activities (e.g. milling)

and the expedient nature of this decoration when it does exist, suggests that pots did not play a role in prestige or wealth economies in California and Western Great Basin societies. People simply did not imbue pots with elaborate decoration as either a way to express ethnicity or individuality or as a way to increase the value of a pot through added labor. Moreover, decoration within the study area is primarily of a single style and form, that is, one or occasionally two rows of fingernail incisions around the rim, and is remarkably similar across the entire study area. These decorations, then, do not appear to offer producers much in the way of individual- or ethnic-level expression. The competitive feasting and symbolic models, then, can not account for the origins of pottery in the study area. This result finds support in the fact that pots are rarely included in burial assemblages as grave goods. Furthermore, it is unlikely that the material basis of a prestige economy (i.e., pots) would be so easily replaced by an alternative one, such as metal pots and tin cans, as seems to have happened in the historic period. Instead, the data imply that pots were part of a practical or functional technology (using Brian Hayden's terms, see Hayden 1995).

Second, that pots were not adopted earlier, despite the fact that people knew about them, suggests that simple functional models are also incapable of explaining the transition to ceramics. If pots are functionally superior to other container technologies *under all conditions*, they would have been adopted earlier. Clearly, this is not the case. That there was a long delay between exposure to and eventual adoption of pottery technology suggests that factors were at work encouraging people to use alternative technologies. That is, some precondition for pottery was not met until later in time. In this respect, I would argue that models suggesting pots were adopted for storage also do not work in the California and Great Basin case. Archaeological evidence from pre-pottery periods in prehistory in Owens Valley and other parts of the Great Basin (Basgall and McGuire 1988; Bettinger 1999:67; Eerkens n.d.) show that storage was already part of the economy prior to the manufacture of ceramics. Similarly, ethnographic (Steward 1933, 1938; Driver 1937) and archaeological (e.g., Yohe and Valdez 1996; also see discussion by Bettinger 1999:67) data suggest that many other methods of storage were being used during the ceramic period. If pots were invented as a superior method for storage, it seems likely that they would replace other storage systems (unless they were made to store a specific resource previously not exploited). Moreover, the technological data in Chapter 4 do not suggest storage as a major function of pots. Although pots may occasionally have been used to store things (especially short-term), this function does not seem to have been the driving force behind the origins of pottery.

Similarly, models suggesting pots were invented as an efficient means of detoxifying foods or widening the diet breadth do not have much support from the archaeological record. Again, data from Owens Valley and other regions in the study area suggest that diet breadth was already widening quickly before ceramics were adopted (Basgall and McGuire 1988; Bettinger 1975, 1993; Elston 1986). Detoxification of plant resources such as acorn and occasionally buckeye was widely performed in the western part of the study area without the use of pottery. Although pots may occasionally have been used to detoxify foods, this does not seem to be their primary function, and can not explain their origins.

The migration model (number 5 in Table 8.1) is a little more difficult to evaluate. There is much evidence for a recent migration of people in the Western Great Basin. Lamb (1958) long ago proposed a recent migration of Numic speaking groups out of the Southwestern part of the Great Basin, across the entire region. Much subsequent ink has been spilled on this topic (e.g., Ambler and Sutton 1989; Bettinger 1982, 1983; Sutton 1986, 1993; Young and Bettinger 1992; papers in Madsen and Rhode 1994). Are ceramics a marker of this Numic migration, that is, could the migration have happened as late as 500 years ago?

Although some have used ceramics to mark the Numic expansion (e.g., Madsen 1975; Wright 1978), others suggest this is not so (e.g., Lyneis 1982; Touhy 1973). A number of points support the latter. First, there is no evidence for a hiatus in occupation in any region around the time ceramics first make their appearance. This implies that if ceramics are a marker of the Numic spread, a population replacement is implied, rather than a migration of people into an empty landscape. This, indeed, is the argument used by many to model the Numic spread. Second, if pottery is a marker of the Numic spread and it began near Owens Valley, the beginnings of pottery in other parts of the Great Basin cannot be older than approximately 500 BP (and can only be younger). However, some sherds from the

Nevada Test Site have thermoluminescence dates of nearly 1000 BP, suggesting pottery and the Numic spread are independent phenomena. Third, many researchers believe the Numic spread to have occurred much earlier than 500 BP. Original estimates by Lamb (1958) based on glottochronology date the expansion around 1000 BP, though he later felt it could have happened either later or much earlier (Thomas 1994). Others have suggested even earlier dates, over 3000 years ago (e.g., Grayson 1994; Holmer 1994). Fourth, if pottery is a marker of the Numic people, a spread around 500 BP fails to account for the fact that some Northern Paiute speakers used pottery, including Owens Valley and Mono Basin Paiute, and others did not (primarily groups north of there). Finally, if the Numic spread commenced in the Southwestern part of the Great Basin, where pottery-making began some 500 years ago, this does not leave much time for the migration to have happened, only 300-400 years.

Together, these data do not support pottery being brought to the study area as part of a migration late in time. Areas like Owens Valley and the Western Sierra Nevada, where the most data are available to test such a model do not agree with the predictions of a spread, particularly the proposed Numic spread. Finally, even if pottery is a marker of the Numic, the spread it is proposed to have started directly within the study area. This suggests that the original Numic would have adopted pottery for one of the reasons discussed above. Thus, the model used would be applicable in both cases. Although the migration model cannot be disproved conclusively, I believe other models can better account for the origins of pottery.

These arguments eliminate as potential candidates in the adoption of pottery, models 1-5 in Table 8.1 above. I also feel that we can discount model 6, the fuel intensification model. Data in Chapter 4 do suggest that people in the study area were concerned about maximizing heat transfer, and they appear to have modified the design of their pots accordingly. Pots in more arid areas, where presumably firewood was in higher demand, are thinner than in better watered areas. As well, sooting and other characteristics of the pots suggest they were regularly exposed to fire.

However, if a desire to increase fuel efficiency was a primary force behind the adoption of pottery as a technology for cooking, we would expect a greater reliance on pottery and cooking in arid regions. That is, more arid areas should have more pottery. The data from Chapter 5 do not support this position. Some relatively well-watered regions, such as Southern Owens Valley, show a greater reliance on pottery than more arid regions, such as Fort Irwin of the Mojave Desert and Death Valley. Likewise, it is difficult to argue that pottery-making Monache (or Western Mono) groups in Sequoia National Park, where rainfall averages over 50 cm per year and dense forest abounds, needed to conserve firewood, and yet they made use of pottery. Thus, while a concern for fuel efficiency appears to have prompted Native people to modify *how* they made pottery, it does not appear to be a primary factor in *whether* they made it.

Models that do Work

The data above suggests that most of the models developed by archaeologists in other areas to explain the inception of pottery production do not apply in the California and Western Great Basin case. However, two models remain that do seem to apply, population increase and demands on the time and labor of women.

Population increase

Much archaeological evidence from California and the Western Great Basin suggests that population levels increased throughout the course of prehistory. Further, this increase, as evidenced by the density of Desert series projectile points relative to other chronologically sensitive points, is heightened in the Western Great Basin, during the period 700-200 BP (Basgall 2000; Bettinger 1999:68-72; Pippin 1999). This implies that population increase was particularly accelerated during (or just before) the latest period of prehistory. Note that this relationship does not seem to hold as well in the Eastern Great Basin, where pottery is also made, or the Northern Great Basin, where it is generally not made (Bettinger 1999).

The population increase in the Western Great Basin, then, begins just before the inception of pottery making ca. 500 BP. Given the arguments by Brown (1989), I suggest this correlation between population increase and pottery-making in the Western Great Basin is not fortuitous. An increase in population would have created an increased overall demand for water-tight containers (more people = more demand). This demand was met more economically during this period by ceramic vessels and the economy of scale afforded by pottery production, than basketry. Instead of individually making baskets, women within extended families, and perhaps even across families, could have pooled their resources and made batches of pots for less time and energy than it would have taken to make an equivalent number of baskets. These pots did not have to be carried around during the seasonal round. Instead, they were probably cached and used over several seasons at fixed points on the landscape where resources were known to be located year after year.

Certain enterprising women may have taken advantage of this demand as well. For example, Steward (1933) suggests that some women in Owens Valley were specialist potters and produced extra pottery to sell for shell-bead money. Although the data from Chapter 7 did not support Steward’s proposal on a large scale and indicate that such barter did not take place across long distances (i.e., Southern Owens Valley pottery does not make it into Central or Northern Owens, and vice versa), such distribution may have been organized by these women on a smaller sub-regional scale. It is even possible that these women enticed others to adopt pottery to expand their market, and were a driving force in the spread and eventual adoption of pottery on a large scale (see similar types of arguments by

Bender 1981, 1985a, 1985b). Additional research is needed to verify this hypothesis.

Women's time and labor

Thus, it is possible that increasing population changed the economics of pottery production and played a role in the decisions of women to adopt the technology. However, I believe a second and more important demand for water-tight containers was also at play during this time period.

Prior to the inception of pottery, women likely boiled seeds and other foods in baskets using heated stones. This activity required them to constantly be present during meal preparation, including making and attending a fire, heating stones in the fire, moving stones between the fire and a basket, and constantly stirring stones about to avoid burning the basket. As well, pit roasting was probably often used to prepare food. Pit roasting is an efficient method to prepare meats, roots, and tubers (see Wandsnider 1997), which, as discussed below, may have been an important part of the diet. Pit roasting, on the other hand, would not have required constant attention, allowing women to perform other activities while food was being cooked.

I suggest that during the period in question (ca. 700-200 BP), the hunter-gatherers of the study area came to rely more and more on small seed resources. Ethnographic accounts show that small seed resources were the staple food of most Western Great Basin diets. Archaeological evidence suggests that this shift took place around 500-700 BP, precisely when pottery-making began. As women were largely responsible for the collection and preparation of these seeds, their time and labor may have come under serious stress. Seed resources had to be efficiently gathered and processed for consumption on a large scale. One way to accomplish this was through boiling seeds to gelatinize them and extract valuable and nutritious oils. In light of other labor and time demands, I suggest that pottery presented the most economical way to accomplish these tasks.

Time and labor stresses on women may have been exacerbated by a decrease in residential mobility (e.g., Basgall 1989; Bettinger 1999) and a concomitant decrease in birth spacing and increase in family size (that is, the population increase mentioned earlier). With a greater focus on seeds, women, who were responsible for of the most domestic activities as well as childcare, had even greater demands placed on their time and labor. Not only did they have to gather more and prepare more to feed larger families, but they also had to invest more time in breast feeding and caretaking for small children. Pottery may have been an efficient solution to these demands. By allowing seed resources and other foods to cook unattended directly over an open flame, women could have spent less time in meal preparation and more time on other activities such as gathering.

Notable in this regard is the fact that dryland and wetland small seed resources are front-loaded (Bettinger 1999). In other words, these resources are costly to procure and process for storage, but subsequently are easy to prepare for consumption (Bettinger 1999: 73). This property requires women to spend much time in the field gathering seeds away from the base camp. On the other hand piñon nuts and acorn are back-loaded. That is, they are easy to collect and store, but require more preparation time following storage. Importantly, much of the preparation of piñon nuts and acorns (i.e., parching and leaching respectively) can be undertaken in the base camp, where other domestic activities can be attended to as well. In this respect, intensive acorn and piñon use would not have created the same demands on the time and labor of women. This fact may also explain why Sequoia National Park whole pots appear differently than others from the western Great Basin (see Chapter 4). Recall that in Sequoia acorn was a more important staple resource in the aboriginal diet.

Support for these conclusions comes from several sources. First, the GC-MS data in Chapter 6 suggest seeds were an important part of the range of foods for which pots were used. This conclusion is also consistent with their design, as discussed in Chapter 4, which suggests thermal shock resistance was an important consideration. However, this in and of itself does not support the model, for there is nothing to suggest that seeds were not intensively exploited prior to pottery-making (and that women were not as equally stressed before).

Additional supporting evidence for this model comes from Chapter 5 that suggests a positive correlation between increased density of pottery and increased density of groundstone. Milling is traditionally associated with the processing of plants, especially seeds and nuts. Grinding seeds exposes the fatty interior and creates a greater surface area such that organic compounds can more easily be digested. As well, grinding seeds prior to cooking makes gelatinazation through boiling a faster process. That pottery is more common in areas where milling was heaviest suggests the two activities are related, and an increase in milling resulted in an increase in pottery use.

Determining a change in diet, or comparing the intensity of use of different food products, particularly resources that decompose rather easily, such as plants, is a complex problem using archaeological data (e.g., Wohlgemuth 1996). Statistical comparison of flotation samples is notoriously challenging given problems in spatial sampling, sample recovery, and differential decomposition, among others. Moreover, most investigations of subsistence and technological change in the study area, tend to group together the pre-pottery Rose Springs period (650-1350 BP) period with the ceramic-period or Desert Side-Notched period (200 – 650 BP). Thus, studies frequently compare agglomerated Rose Springs/Desert Side-Notched patterns against older patterns, and only rarely examine developments separately within each period. This lumping is partly a result of the nature of archaeological sites, since many were continuously occupied during both periods, and components are difficult to separate. This lumping has tended to obscure difference between the periods.

However, evidence for a shift in diet does come from archaeological work in Owens Valley, the region with the most complete and recent database in the study area and with which I am most familiar. In Table 8.2 I attempt to separate these components and compare changes in plant use in the late prehistoric period in Owens Valley. Components were carefully selected to be single-component only, and an effort was made to standardize preservation and activity area differences by using only well-preserved and house floor contexts. The table compares ceramic-period (i.e., post A.D. 500) and pre-ceramic period (especially pre A.D. 750) contexts. The table focuses on house floors as the unit of comparison (though a milling feature/hearth at Iny-5207, Locus 4 and general midden context at Iny-1428 are also included), and is presented in an attempt to directly compare pre-pottery (Haiwee) and pottery-period (Marana) seed use.

Table 8.2: Comparison of ceramic period and pre-ceramic period flotation studies from house structures and well-dated single component contexts in Owens Valley.

Site	**Context**	**^{14}C Date**	**Liters**	**No. Seeds**	**No. Genus**	**Seeds/ Liter**	**Genera /Seeds**
Iny-5207, Loc. 4	Feature 1	70 ± 50	10.0	587	7	59	.012
Iny-30	Structure 9	180 ± 60	12.8	44	13	3.4	.295
Iny-5207, Loc. 2	Structure 1	270 ± 60	14.5	>1500	16	>100	<.011
Iny-30	Structure 10	390 ± 90	16.7	1046	15	63	.014
Iny-30	Structure 5	410 ± 80	4.0	76	12	19	.158
Iny-1700	Structure 16	425 ± 100	3.0	N/A	3	N/A	N/A
Iny-3769, Loc. 13	Structure 1	430 ± 40	7.0	>20,000	10	>2800	<.001
Iny-30	Structure 1	470 ± 70	10.0	1113	5	111	.004
Iny-30	Structure 7	480 ± 60	6.0	76	5	13	.066
Iny-30 [*]	Structure 13	710 ± 70	6.9	105	12	15	.114
Iny-3769, Loc. 5	Structure 1	780 ± 110	2.0	1	1	0.5	1.0
Iny-3806	Structure 1	1160 ± 60	4.0	41	5	10.3	.122
Iny-3806	Structure 2	1400 ± 80	5.0	70	11	14	.157
Iny-3812	Structure 1	1600 ± 60	1.5	35	4	23	.114

Notes: Ceramic period sites are listed in the top part of the table (above structure 13 at Iny-30), and pre-ceramic Haiwee-aged sites in the bottom part. Table gives total number of carbonized seeds recovered and the number of genera represented. Data are from Basgall and McGuire 1988; Bettinger 1989; Delacorte and McGuire 1993; Eerkens n.d.; Gilreath 1995. [*] - As discussed in Chapter 3, the dating of Structure 13 at Iny-30 is not clear and may contain intrusive materials from a later occupation.

Although there is variability, Table 8.2 does suggest an increasing intensification in seed use across the pre-ceramic to ceramic period in Owens Valley. The number of seeds recovered in many of the ceramic period contexts exceeds 500, and the adjusted frequency of seeds per liter of soil often exceeds 50, while pre-ceramic period contexts generally have far fewer seeds and seeds per liter (with a maximum of 23 per liter). Indeed, some of the late period houses have extremely high concentrations of seeds, occasionally exceeding 2500 carbonized seeds per liter of soil (in this case primarily *Typha* sp. or Cattail). As well, the table shows that the range of plants represented in ceramic period contexts is also generally higher (as indicated by the number of genus level identifications), suggesting a broader diet. However, much of this broadening is explained simply by the larger number of seeds collected. When the number of genera is adjusted by the total number of seeds, as indicated in the last column of Table 8.2, late period sites seem to be less diverse and pre-ceramic contexts more evenly spread across different genera. Thus, in many ceramic period contexts, the majority of seeds are from a small number of plant genera, suggesting a more intensified economy (e.g., see Basgall 1987; Wohlgemuth 1996). Overall, Table 8.2 supports an increasing focus on seeds in ceramic period contexts, as indicated by a higher density of seeds, and an intensive focus on smaller range of seeds, indicated by fewer genera per total number of seeds.

Such an intensification would have increased demand on the time and labor of women, assuming they were responsible for both gathering and preparing these foods. I suggest that ceramics played an integral role in meeting these demands. In pre-ceramic times, a greater reliance on non-seed resources may have allowed women to use pit roasting and other cooking technologies that did not require constant attention. With a shift to a more seed-intensive diet, and the concomitant increased time spent in basket stone boiling activities, the time and labor of women would have been severely taxed. I believe that the adoption of pottery was a direct response to this shift, allowing women to reclaim some of their time and allowing them to process these small seed resources in bulk in pots, thereby reducing labor.

The increased density of pottery in association with lakes also makes sense with this explanation. First, such locations on the landscape would have offered a range of seed resources to prehistoric inhabitants. In particular, wetlands often support dense stands of various plants that produce large amounts of seeds, such as bulrush (*Scirpus* sp.), rush (*Juncus* sp.), cattail (*Typha* sp.), seepweed (*Suaeda depressa*), and pickleweed (*Allenrolfea occidentalis*). Second, the surrounding flatter area often supports rather dense stands of other seed resources, including various grasses and chenopods that could have been harvested in bulk. Finally, marshlands occasionally provide access to an overabundance of resources, available as windrows (Bettinger 1993; Madsen and Schmitt 1998). Windrows occur when wind blows over the surface of a lake and piles up buoyant resources on its shores. Windrows of brine fly (Heizer 1950; Sutton 1988:44-49; Wilke and Lawton 1976:48) and grasshoppers (Jones and Madsen 1989; Madsen and Kirkman 1988; Madsen and Schmitt 1998) have been recorded in the Great Basin. Bettinger (1993:51) suggests that such windrows may also consist of plant seeds. If so, large-scale processing of foods collected in windrows over a relatively short time-frame would have been necessary, as windrows are only available for a limited period of time (before they start decomposing and are consumed by animals). Such punctuated availability and heavy processing would have been taxing on the time and labor of women. It is likely that the use of pottery may have been particularly beneficial during such times, allowing food to be processed and prepared in bulk. Moreover, pots could be placed over the fire to begin cooking and left unattended while additional gathering activities were undertaken.

As mentioned in Chapter 5, three regions do not fit the pattern of increased pottery correlated to increased groundstone: the Tablelands of Northern Owens Valley; the Coso/China Lake area; and Whirlwind Valley. These areas have low densities of pottery relative to groundstone, suggesting that much plant processing was taking place but that pottery was less important in the preparation of these foods. As argued in Chapter 5, in the Whirlwind Valley case this pattern seems to be a product of archaeological sampling, where a large fraction of the groundstone may be associated with pre-pottery occupation. This seems less the case in the Tablelands and Coso/China Lake. Instead, it may be that population densities in these regions simply were not high enough to warrant making pottery. Population densities in the Coso/China Lake area are known to have been low by Great Basin standards (Bettinger 1982a; Steward 1938). Similarly, if populations from Long Valley to the north were regularly making use of the Tablelands of Northern Owens Valley, instead of permanent Owens Valley inhabitants from the south, as indicated by the distribution of obsidian sources (Basgall and Giambastiani 1992; Giambastiani 2000), low population levels here may also explain the diminished concentrations of pottery. Late prehistoric population densities in Long Valley are believed to have been relatively low, as indicated by archaeological data (Bettinger 1977). Seasonal or occasional trips to the seed-rich Tablelands may have prompted these people to engage in large-scale plant processing without the benefit of significant numbers of pots. That is, population levels and demand for ceramic vessels in these regions may not have been high enough to take advantage of the economy of scale of pottery production very often. As a result, pottery levels may have been lower.

Ultimately, then, I suggest that the adoption of pottery was a response to a changing diet in the western Great Basin. The change probably did not involve the incorporation of new species of plants into the diet. Instead, they likely involved harvest of traditionally gathered species, but in levels heretofore not seen, that is, highly intensive harvest of particular species. This shift dramatically changed the nature of prehistoric lifeways, especially mobility and demands on the time and labor of women. I suggest that pottery was a solution to these changes that helped women cope with increasing demands on their time and labor.

Finally, it is worth briefly considering why Native American groups in central and coastal California never took up ceramics in any kind of significant way (i.e., outside of a handful of sherds here and there, for example, see Johnson 1990). If population density was a limiting factor in the adoption on the east side of the Sierra Nevada (in Owens Valley and eastward) early in time, this certainly was not a factor on the west side. Ethnographic data indicate that population densities were much higher, likely by a factor of 10 higher in most areas. As well, intensive plant procurement was also present. Why, then, did these groups never adopt the craft? In this regard, three factors seem relevant.

First, the transition to intensive plant processing economies in this area probably happened earlier in time, prior to the advent of ceramics in other areas. Thus, people may not have been exposed to ceramics and did not consider this technology as a potential solution to the problems associated with intensification. Instead, people may have come up with alternative solutions to these problems and pottery was not needed later in time. For example, longer-lasting stone bowls may have partially fulfilled these needs. Caches of large numbers of stone bowls have been recorded in archaeological contexts (e.g., Rust 1906), and steatite sherds are known from many southern California coastal sites.

Second, western California economies were heavily focused on acorn as a staple resource. As mentioned earlier, acorns are a back-loaded resource and do not require as much time in the field in gathering activities. Instead, much of the time spent processing acorns can be done at the base camp. In this respect, women may not have been as time stressed as in societies where small seeds formed the staple food item. As well, acorns may not need to be boiled in the same way that seeds do to break down various organic constituents into more easily digestible byproducts. In other words, pots may not be as effective and advantageous in processing acorns as they are in processing small seeds.

Finally, pottery may have been perceived as a threat to existing technologies by both the producers and distributors of these alternative crafts. In particular, pottery may have seen as a threat to the basket industry. Basketry was a well-developed technology in California has a long history. Many basket makers were accorded higher status based on the quality of their product. As well, one of the most valuable items at the time of European contact were feather and bead decorated baskets. Such baskets were given away by high status men at various social gatherings to bring prestige and social debt to the feast-giver (see Elsasser 1978; Gayton 1936; Milliken and Bennyhoff 1993). Thus, pottery may have been seen as a threat to these institutions by pulling time away from the production of baskets and redirecting it into pottery. As well, pots may have been seen as a potential replacement altogether of basketry containers. Although it is clear that pottery-making groups east of the Sierra Nevadas still made baskets, the elevated social value of baskets west of the Sierra Nevadas may have made the potential threat more serious. Thus, these California groups may have had very conservative viewpoints on the adoption of new technologies into the range of material culture.

Sassaman (1993) has posed a similar explanation for the resistance to pottery technologies in the Southeast.

Although determining why something did not happen using archaeological data is more difficult than why something did, the question as to why most California groups did not make and use pottery is clearly interesting and worthy of additional research. I have offered a few potentially relevant points above, but other factors could also be at work. Clearly the process of adopting a new technology is going to be a complex one with many factors to consider. The value of existing technologies and perceived threats to such industries will be an important consideration. It seems fairly clear that the processes were quite different on the eastern versus the western Sierra Nevada. On one side the craft was readily adopted, whereas on the other it was not. Differences in environment and diet may have been one important factor but other social causes are likely also to have played a role Future studies seeking to understand why most California groups did not make pottery should seek to better understand the exact cooking techniques used, the importance of different food resources, and the role of different crafts within the context of prehistoric lifeways.

Why Intensification on Seeds?

Finally, although pottery may have been a response to changing diet, population levels, and increased labor demands, the study begs the question why these changes occurred in the first place. That is, why did people switch to a seed-intensive diet and why did population increase?

It should be noted first that these processes are probably not independent phenomena and are related in a number of ways. A large and diverse body of archaeological literature has accumulated concerning the relationships between decreased mobility, population increase, and intensification in hunter-gatherer societies (e.g., Ames 1991; Basgall 1987; Bender 1985a, 1985b; Bouey 1979, 1987; Brown 1985; Cohen 1989; Jochim 1981, 1988; Hayden 1990; Kaufman 1992; Keeley 1988; Kelly 1991, 1992; Lourandos 1985; Madsen 1982, 1993; O'Brien 1987; Price and Brown 1985; Rafferty 1985). Although there is disagreement over what causes what, and which comes first, most of this work acknowledges the interplay between these three factors and others, such as storage, territoriality, political maneuvering, and social complexity. My aim here is not to review this literature but only to point out that sedentism, population levels, and intensification are surely related in some causal fashion in California and the Western Great Basin. These factors, then, probably fed off of one another and are likely part of the same process that ultimately led people to adopt pottery.

In the study area two factors have typically been cited as causing these fundamental changes in intensification, population pressure, due to slow and natural population increase (e.g., Bettinger 1989, 1991; Bouey 1979), and environmental change (e.g., Aikens 1994; Elston 1982). As some have recently criticized (e.g., Basgall 2000; Bettinger 1999) these models are flawed for a number of reasons, including the fact that they fail to give agency to people as complex problem-solvers and they often boil down to a matter of matching archaeological observations with palaeoenvironmental ones without establishing an explicit causal chain of events (Bettinger 1999).

In the population pressure case, as far as can be gathered from the archaeological record and our rough chronological controls, population seems to be increasing throughout almost all of prehistory. Explaining change in terms of population pressure, then, requires that some threshold existed that caused a technology or cultural system to change. In the case of pottery, I would argue that such a threshold *was* met, one in which not only the sheer numbers of people rose, thereby increasing the demand for pots, but the nature of cooking changed as well, leading to a greater demand for water-tight containers per person. Combined, these increased demands may have made it advantageous for people to take advantage of the economy of scale of pottery. However, if we explain seed intensification using this model we are again simply matching two observations (i.e., population increase and pottery use) and linking them within giving a causal mechanism. There is no apparent population level threshold, either theoretical or actual, to explain why such a transition would take place.

Similarly, in the climatic or environmental change model, there does not seem to be clear evidence that climate changed dramatically around the time seed intensification took place, that is, sometime between 700 and 500 BP. Without such a change, the environmental model is clearly not relevant (indeed, even if there were an environmental shift, it would be necessary to show exactly how this would have affected seed use). Part of the problem here may be the scale of our palaeoenvironmental data, which may not allow us to pick up fine-scaled and/or subtle changes which might be important within such a model (see Jones et al. 1999). Until better evidence for a climatic shift around this time is produced and, more importantly, until a theoretical argument is put forward showing *exactly* how such a change would have affected seed use, this factor alone cannot account for the transition to intensive seed-use and/or pottery either.

A more recent explanation is much more satisfying and explicit in this regard. Bettinger (1999) invokes a social model within an evolutionary framework to account for the change to intensive seed procurement. In order to gain control over their time, labor, and resources for individual profit, Bettinger (1999) suggests that people privatized plant resources, rather than sharing them within a larger group. In his own words, a shift took place from “a system in which all resources were treated as public goods, to one in which some resources, notably plant resources, hence resources obtained by women, were regarded as private property” (Bettinger 1999:73). This change in ownership also changed the incentive structure for resource procurement, and fostered greater emphasis on small seed resources, hence intensification.

It is easy to see how individual or local-scale production of pottery (as demonstrated in Chapter 7), again by women, fits into this shift. Within the existing range of cooking techniques, three main options would have been available to women for cooking and preparing plant foods, roasting or parching in pit-hearths, parching with basketry trays, and boiling in baskets. However, all three techniques ultimately would not have facilitated privatization and intensification.

Large-scale cooking features, such as pit hearths, are particularly useful for preparing foods such as roots and tubers, as well as meats. It is possible women could have focused their privatization and intensification efforts on these food resources using pit-hearth cooking. However, pit-hearths are rather labor intensive undertakings. A large pit must be excavated and filled with a substantial amount of fuel and food to make it a worthwhile operation. Because of this, such an undertaking was probably organized at a larger social or group level, and the resources cooked therein shared among all involved in the process. Moreover, such a pit is usually used in the open in view of all others within the village, that is, publically. Indeed, ethnographic examples of pit roasting often show a definite communal aspect to the undertaking (Wandsnider 1997:32-34). Moreover, unless pit-hearth cooking is undertaken far from the residential base camp, it must be done out in the open where the activities and contents may be in full view to other members within the community. In this sense, a shift to a privatized system focused on roots and tubers and pit-hearth roasting or parching may not have been a solution to the problem, owing to the fact that the products cooked therein were subject to sharing and everyone could easily see what was being cooked. Thus, intensification on pit-hearth cooking would not have helped women to privatize resources and take control of their labor. As a result, roots and tubers did not provide an appropriate focus for intensification.

Basketry, on the other hand, was a technology that could be produced and operated by an individual, and it did not require community-level organization and/or sharing. A single person can make and gather the necessary components for a basketry-based cooking system (i.e., baskets, fuel, stones) and can use them to cook foods without additional help (i.e., people can build their own small hearths). As well, baskets can be used inside the house in private and out of the view of others within the community. Flat-shaped baskets in the form of trays could have been used to parch foods, or alternatively, larger vessel-shaped baskets could have been used to boil foods. Parching is particularly suitable to processing nut and larger seed resources (at least those that do not require leaching or other processing), while boiling is especially suited to small seed and leafy-green resources.

However, both cooking technologies using basketry require the cook to be present and actively involved in the process at all times. Parching requires the user to constantly move the food product and tray about so they do not remain in contact with the heat source for too long and burn. Moreover, parching cannot be used to process large amounts of food at once. Small batches of nuts or seeds are parched together, to allow the cook to give equal heating time to each individual nut or seed and to ensure that all sides are evenly heated. Similarly, boiling requires the cook to constantly exchange cooled rocks for hot ones and to move heated stones about so they do not burn a hole through the basket. As discussed earlier, large-scale processing of seeds was not feasible using baskets owing to time and labor demands.

Because of these requirements, neither parching nor boiling using baskets could have met the needs of women in the desire to privatize resources. Unlike pit-roasting, the main drawback here is the time and labor required in these cooking technologies. To process large amounts of food was simply too demanding. Parching is not suitable to large-scale batch processing while boiling would require nearly full-time devotion to the activity.

In sum, the available cooking technologies could not have met the requirements of a shift to privatized goods and large-scale intensive processing. One other option existed for women. It is possible women could have focused attention on foods that did not require cooking, such as berries and some leafy vegetables, that is hand-to-mouth foods. However, intensifying on these resources would have created serious nutritional deficiencies, notably the lack of a storable source of energy provided by fats, oils, and carbohydrates. These compounds are particularly common in roots, tubers, nuts, and seeds. Thus, focusing the diet on foods that did not require cooking, such as berries and leafy vegetables, was not an option. Similarly, eliminating cooking in the consumption of roots, tubers, nuts, and seeds was also not an option, owing to the benefits cooking bestows on breaking down complex organic compounds (e.g., Stahl 1989).

Given the failure of the above technologies to assist in the process of privatization, an alternative cooking technology was needed. I suggest that pottery filled this niche. Pots can be made and used by individuals to cook foods over a small hearth, and importantly, the cook can do this without having to be present. As well, they are particularly effective in boiling or simmering a range of foods, especially small seeds, and in this respect can be responsible for meeting the nutritional needs of people. Moreover, cooking with pots does not require group-level participation, and in this respect resources can be owned and controlled by the individual. These activities can take place within a house in private, that is, out of view of others within the community. Archaeological evidence shows that pottery is a nearly ubiquitous element of late prehistoric house floor assemblages, suggesting indeed, that they were often used inside the house. Finally, as a new technology foods cooked in pots may not have been subject to the same sharing rules that governed other technologies and resources cooked therein. Thus, in using pots individuals may have been able to privately control the resources they prepared therein. As supported by ethnographic accounts, it was women who made pots and filled this technological need. Thus, it is most likely that women eventually decided to adopt pottery in California and the Western Great Basin.

All of this suggests that pots replaced baskets as the container for cooking seeds. As women shifted to intensive seed procurement in response to privatization values, they probably soon realized that the technology was inadequate given the new demands on their time and labor. It is likely that they quickly sought a new cooking system that performed in a similar manner and did not require them to drastically alter a system with which they were already familiar and comfortable. Women had long been familiar with pots due to contact with Southwest groups and occasional experimentation themselves. Not surprisingly, most pots, particularly conical-shaped vessels, have the same general form as cooking baskets. In this respect, pottery was probably a comfortable and easy fit within the existing cooking system. All of this also suggests that pottery was primarily a local or indigenous development to California and the Great Basin, though its advantages predisposed it to a rapid spread across the region. Once the ideas and values about who owned what were altered, such that most things were privately rather than publicly owned, a chain of events transpired that ultimately led people into the adoption of ceramic cooking containers on a large scale.

In sum, if privatization was an important change that took place late in prehistory, as Bettinger (1999) believes, ceramic vessels may have been an integral part in the process of privatization, perhaps even the vehicle that ultimately facilitated the implementation and widespread acceptance of this value system. Using pit roasting, women did not have exclusive rights to the foods they cooked therein. Thus, although the technology could have allowed foods to be processed in bulk unattended, enough to feed growing families, the products of such cooking activities would have been shared. Similarly, although they did have exclusive rights to seed resources parched or boiled in baskets, women could not have processed the amount of seeds necessary to sustain a family group using this technology while still performing the other tasks required of them, such as child care. On the other hand, pots, as well as their contents, could be made, used, and owned by individuals, *and* also allowed women to process seeds at the levels necessary to feed their families. In this way, pots solved both the ownership and the time and labor demand problem created by growing family size and the desires to gain control over labor and resources.

Of course, the next question is why privatization would have taken place at this particular time in prehistory. An in-depth analysis of this question is beyond the scope of this dissertation, however, a few possibilities are offered. For example, it is possible that increasing population size changed the density, availability, and value resources. Thus, territory size and the availability of foods may have decreased to the point where resource shortfall may have been a more frequent occurrence that threatened the livelihoods of families. Privatizing small seed resources and processing them using a new cooking technology, one that was not subject to normal sharing rules, may have been an option pursued by some women to provide more to their immediate families.

Similarly, it may have been the desire of certain aggrandizing individuals to change the system of property and resource ownership such that they could own goods and give them away to create social debt. This value system then may have been applied to other goods as well, such as seed resources, prompting women to adopt pottery. The timing of this shift may not relate to any other particular event (i.e., such as a population increase or environmental shift), but may simply reflect a point in prehistory at which such aggrandizers succeeded in convincing others to stop sharing their goods.

Alternatively, it may have been the introduction of the bow and arrow some 700-1000 years earlier that set the stage for privatization of plant resources. The bow and arrow may have fostered privatization of animal resources (Bettinger 1999). Once this idea and value system became embedded and systematically applied to resources acquired through hunting eventually it may have shifted to plant resources as well. This may have prompted early experimentation with pottery, as seen in the archaeological record (Eerkens et al. 1999). It may have taken some time, however, for these ideas to ingrain themselves within western Great Basin cultures, which would explain the delay between early experimentation and later adoption.

Clearly, the process was complex. Moreover, to study change in a value system in a prehistoric context will be difficult using archaeological data. However, the topic is interesting on both a methodological and theoretical level and is certainly worthy of additional research. Careful and detailed excavation of late prehistoric village sites, including examination of the context of different artifact types, should go far in this respect. For example, the spatial distribution of pottery and small seeds, whether they are found primarily within private house-floor and trash-dump contexts or occur within more communal spaces, would provide interesting data that might be used to test such notions.

Summary and Conclusions

Pottery-making in California and the Western Great Basin began approximately 500 years ago in response to changes in cooking practices (i.e., diet) and population levels. A desire to gain control over the products of labor, especially food, compelled people to shift into an economy based on intensive seed procurement. These societal changes drastically changed demands on the time and labor of women and the overall demand for water-tight containers in the region. What was before a novel technology, occasionally worthy of experimentation (e.g., Eerkens et al. 1999), suddenly became a widespread and more intensive activity. At this point, 500 years ago, women took advantage of the economy of scale afforded by pottery production and engaged in the technology on a level not previously seen in the region. Plain and undecorated pots were produced for functional purposes and for local consumption only, to meet the demands of a new diet and resource ownership system. The craft never acquired the symbolic or prestige value it did in other areas, such as the Southwest, Southeast, or Mississippi River Valley. Instead it remained a utilitarian technology only.

Much of this process in the Western Great Basin seems to have played out in valley bottoms along the shores of lakes and rivers. This result is echoed in a number of different regions worldwide, where the origins of pottery among many hunter-gatherers has a strong environmental basis, often associated with wetland areas (Goodyear 1988:321). Because pots could be cached at these locations, mobile hunter-gatherers could make use of pottery without many of the attendant problems of high mobility, such as having to carry around heavy tools and subjecting them to breakage. Seeds collected in these locations, likely from local marshlands, were processed using pots while they were available (likely late spring to early fall). Pots may have been particularly beneficial in harvesting windrows of such seeds amassed on the shores of lakes. Afterwards, most pots would have been cached for the following year.

However, pots do not appear to be a major part of piñon gathering or processing, judging by the lower densities of potsherds in the piñon-juniper zone. Piñon, then, is likely to have been prepared using other individual technologies, perhaps baskets (Fowler 1986:65), since they do not necessarily require extensive boiling to extract nutrients. In many respects, the unpredictable nature of piñon in a spatial sense (see Thomas 1972b) may not have made pottery use feasible, since pots could not be cached in places where people knew they would be returning. To process piñon using pots, it would have been necessary to carry heavy ceramic vessels to these locations on a yearly basis, a process that was, apparently, more expensive than it was usually worth. Still, the presence of at least some sherds in piñon zone sites indicates it was occasionally done.

The study also shows that people occasionally took their pots with them when they entered other regions and territories to exploit seed resources. Although such sojourns were apparently rare, judging by the small number of displaced sherds, pots were apparently important enough these in food processing activities to warrant carrying a heavy ceramic vessel over what was, at times, a long walking distance (up to 150 km). I suggest, then, that the majority of non-local pot sherds can be explained largely through such movements, rather than any type of formalized exchange.

A concern for fuel efficiency seems to have affected pot design in several areas, but apparently did not affect the overall decision to use, or not use, pottery. Pots in more arid areas are thinner than pots in better watered regions, but the overall density of pots is not especially higher. In this respect, pottery was not a crude technology as it is often described in the archaeological and ethnographic literature. Pots were carefully made to be compatible with a mobile lifestyle and to take advantage of available fuel resources, that is, to maximize heating efficiency in environments where fuel was more scarce.

It should be pointed out that there is variability in both pot use and pot shape. These two variable seem to be correlated, as suggested by the GC-MS and technological (i.e., attribute) data, which shows seed-boiling to be almost exclusively associated with direct-rimmed pots, and meats and other plants to be prepared in vessels with more restricted mouth openings. Indeed, seed processing seems to be the dominant use of most pots, but they were occasionally used to process other foods as well (as is also indicated by their occasional presence in piñon-juniper and alpine environments). The diversity of these uses speaks to the importance of pottery in the daily lives of Western Mono, Paiute, and Shoshone peoples.

In sum, I hope to have made four important points in this dissertation. First, the study and analysis of pottery has much to offer California and Great Basin archaeologists interested in reconstructing prehistoric behavior. Clearly some effort and expenditure is needed to get at this information, but I hope to have laid the groundwork for future studies of ceramics, particularly in the fields of organic residue analysis and chemical provenance analysis (i.e., sourcing). More importantly, I hope to have convinced the reader that such efforts are worthwhile.

Second, the analysis of large and geographically extensive data sets, though often complex and difficult to sort out, offers much for the future of California and Great Basin research. If we are to understand the more general aspects of human behavior with archaeological data (i.e., to address questions of relevance to the field of anthropology), it is imperative to use such large data sets to get beyond issues of small sample size and the problems created by variable individual behavior (e.g., Jochim 1991). In my experience and opinion, Cultural Resource Management and other projects have produced an extremely valuable and extensive database of collections that can be used to begin tackling such broad-scale problems. This database is a lasting and important contribution to the future of archaeology. However, broad-scale research as proposed above is not likely to come from the CRM field, given the constraints of time and money, and must come from the academic side of archaeology (e.g., Gilreath 1999).

Third, under the right circumstances, simple and mobile hunter-gatherer groups can be lured (or forced) into ceramic technologies. Provided various restricting factors are resolved, such as having to regularly carry pots around during the seasonal round, being in one place long enough to complete the production process, and creating a high demand for containers, for example, by changing the incentive structure for foods prepared in boiling vessels (i.e., seeds), such technologies can become an integral part of the material culture. Indeed, the incorporation of such a technology can tell a very interesting story about changes in the values and activities in a society.

Finally, it is clear that the adoption of new technologies such as ceramics is embedded in a social context. To begin understanding such a process it is important for California and Great Basin archaeologists to move away from simplistic environmental and population pressure models commonly used to explain the archaeological record. Clearly these factors influence some aspects of human behavior, such as instigating material culture change, but other internal aspects of human culture also affect material culture and change. It is important to begin examining how these social processes interacted with and affected environment and population levels, and vice versa. New ways to interpret the prehistoric record are being developed in many parts of the globe, yet much of California and Great Basin archaeology still is heavily reliant on culture ecology and optimal foraging. Although we have certainly learned much from these approaches and many aspects are still quite productive and informative, I believe it is important, as some have recently done (e.g., many of the recent studies cited in this dissertation), to begin applying these theories and ideas to the archaeological record of the study area. As well as applying new theoretical models to the archaeological record, it is also important for California and Great Basin archaeologists to incorporate new methodologies. New techniques are being developed in many fields of chemistry, physics, and geology, and have been applied to many archaeological contexts, yet few have found their way into regional studies. I hope this study has followed adequately in the general path of those before me, who have sought to apply these new ideas and techniques, and at the same time I hope to have made a few new footsteps.

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APPENDIX A

SHERD, CLAY, TEMPER ATTRIBUTE AND INAA DATA.

<u>Notes on Attribute Codes:</u>

Sherd#

Gives MURR sample number for samples run using INAA
Gives Catalog number, where available, for extra rim sherds not analyzed by INAA

Region (Where sherd or clay was collected)

CL = China Lake
COV = Central Owens Valley
CSM = Columbus Salt Marsh
DV = Death Valley
DS = Deep Springs Valley
FLV = Fish Lake Valley
FTI = Fort Irwin
NOV = Northern Owens Valley
NTS = Nevada Test Site
PF = Papoose Flat
PV = Panamint Valley
SV = Saline Valley
SOV = Southern Owens Valley
Seq = Sequoia National Park
WM = White Mountains

Site (Where sherd was collected)

Site where archaeological sherd was collected.

Sherd type (Sherd location)

Gives the type of the sherd within the original vessel, that is, where it would have been located, whether rim, body, or base.

Thickness

Given in millimeters (for rims, measurement taken 1cm below lip).

Rim or Mouth Diameter

Estimate of original size of mouth opening, given in millimeters.

Rim Shape

1 = incurved
2 = slightly incurved
3 = direct
4 = slightly recurved
5 = recurved

Exterior and Interior Surface Treatment

R0 = Rough with no brushing strokes
R1 = Roughened with horizontal strokes
R2 = Roughened with vertical strokes
R3 = Roughened with diagonal strokes
R4 = Roughened with random strokes
R5 = Roughened with stroke direction undetermined
S = Smooth
C = Corrugated

Average Temper Size and Density

0 = No temper visible
1 = Low (0-.25 mm in size or 0-25% by volume)
2 = Medium (.25-.50 mm in size or 25-50% by volume)
3 = High (.50-.75 mm in size or over 50% by volume)

Organic and Mica Temper

Subjective scale of 0 (none) through 5 (high amounts). Roughly correlates to percentage by volume (0%, 10%, 20%, 30%, 40%, and 50%).

Core - Describes the color of the core.

0 = Reduced
1 = Oxidized

Decorated – Is the sherd decorated with fingernail incisions.

0 = No
1 = Yes

Coil Type

1 = Exterior
2 = Interior
3 = Not Even (either interior or exterior, but cannot determine).
4 = Even
5 = Mix of different styles

Lip 1 = Flat/Squared
2 = Round-Flat
3 = Round
4 = Round-Pointy
5 = Pointy

Lip Lateralization
1 = Exterior
2 = Interior
No Value or "-" = No Lateralization

Clay Type
Sed. = Sedimentary
Res. = Residual

Clay Qual. (Clay Quality)

Describes the apparent quality of the clay for pottery making purposes. Described as poor, medium, or good.

Notes:

1. Blanks or "-" indicate data missing or no data available.
2. Several attributes in the following table are combined into a single cell. For example, Exterior and Interior Surface Treatment are listed in the table as **Ext / Int Srf** and values are given as "R0 / R1", indicating that the Exterior Surface was coded as R0 (rough), and the Interior Surface was coded as R1 (roughened with horizontal brushing strokes). Similarly, temper attributes are listed in the table as **Temp D/Si** and values given in the form "1 / 2" indicating the temper density was coded 1 (low) and the average size 2 (medium).
3. For **Chemical Group**, Ungrp. refers to ungrouped or outlier sherds.

Table A.1 gives raw data for sherds with both technological and INAA information.
Table A.2 gives INAA data for raw clay and temper samples collected within the study area.
Table A.3 gives technological data for rim sherds not analyzed by INAA.

Appendix A: Table A.1 – Sherds with both INAA and Technological Data

Sherd#	**JEC002**	**JEC003**	**JEC005**	**JEC006**	**JEC007**	**JEC009**	**JEC010**	**JEC011**	**JEC012**
Region	DV	DV	DV	DV	DV	DV	DV	DV	DV
Site	Furnace Creek	Iny-692	Iny-692	Iny-692	Iny-692	Iny-692	Iny-692	Unknwn	Twin Dune
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	7.3	3.7	6.4	4.9	5.1	4.5	8.5	3.7	5.1
Rim Diam.	300	150	150	350	225	125	300	210	150
Rim Shape	4	3	4	3	3	3	3	5	3
Ext/Int Srf	R2 / R1	S / -	- / -	R1 / R1	R1 / -	R1 / R1	R1 / R1	- / R1	- / -
Temp D/Sz	2 / 2	2 / 1	3 / 2	1 / 2	2 / 2	2 / 2	1 / 1	1 / 1	2 / 3
Org / Mica	0 / 0	0 / 1	0 / 2	0 / 5	0 / 0	0 / 2	0 / 2	0 / 1	0 / 1
Decorated	1	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / -	0 / -	1 / 4	1 / -	0 / -	0 / -	0 / -	0 / 1
Lip Sh/Lat	3 / 2	5 / -	3 / -	1 / -	3 / -	5 / 1	3 / 1	3 / -	2 / -
Ch. Group	Ungrp.	DV1	4D	DV3	DV1	NTS1A	DV1	DV1	Ungrp.
AS	12.67	9.84	9.00	11.71	46.56	11.43	8.07	19.13	6.06
LA	48.62	43.39	54.55	48.70	39.69	102.14	80.07	40.33	50.59
LU	0.197	0.401	0.324	0.454	0.274	0.452	0.409	0.251	0.341
ND	37.66	34.21	39.92	37.56	31.69	59.68	57.19	26.67	38.16
SM	6.63	6.55	7.03	7.02	5.92	9.37	9.37	5.74	7.14
U	3.754	4.468	6.224	3.494	3.736	4.123	4.038	2.844	2.884
YB	1.298	2.549	1.816	3.086	1.697	3.005	2.656	1.724	2.672
CE	76.15	83.82	103.36	95.56	78.01	200.10	151.53	73.11	103.09
CO	9.28	17.11	15.01	13.60	17.36	6.79	11.86	19.33	23.69
CR	15.89	12.46	56.17	55.80	37.27	27.32	31.06	34.34	211.34
CS	8.896	2.293	3.838	8.662	3.252	5.942	4.498	3.229	2.926
EU	1.587	1.406	1.445	1.292	1.38	1.567	1.904	1.375	1.606
FE	40456	50809	46751	36796	56439	27457	39833	61108	51178
HF	6.74	5.57	7.15	10.05	7.75	12.31	9.16	5.68	7.18
RB	104.4	84.4	89.9	122.7	91.8	106.3	111.8	76.6	79
SB	7.06	0.789	1.017	1.801	1.127	0.954	0.644	0.978	0.646
SC	8.53	14.04	9.32	11.70	11.90	7.99	11.06	12.15	15.76
SR	947.3	584.9	1652.4	877.3	848.6	1089.2	1260.9	635	626.3
TA	0.677	0.902	1.318	1.415	0.952	1.508	1.580	0.835	1.067
TB	0.538	0.806	0.638	0.891	0.563	1.009	0.955	0.612	0.922
TH	15.88	14.91	25.06	17.33	11.35	21.65	25.51	10.29	14.32
ZN	57.00	71.20	53.20	81.10	61.60	58.60	65.10	62.90	83.00
ZR	203.5	156.5	210.3	263.6	223.0	345.9	275.1	109.0	185.6
AL	92750	89104	84693	85257	96760	93295	89184	89225	84180
BA	1015	883	841	734	678	870	1162	709	733
CA	17582	16864	21696	15186	17502	10937	16529	25060	19756
DY	2.494	3.868	3.107	5.334	3.639	4.65	5.281	3.692	3.383
K	30842	23065	28783	33050	30265	32222	28240	24426	24651
MN	276.4	943.5	798	683.7	714.3	702.9	946	832.2	1145.6
NA	15087	10452	22542	12496	21591	19754	19112	16386	19680
TI	4244	4169	2819	3575	5599	3186	5368	4327	5545
V	121.3	139.1	104.1	87.2	169.6	50.0	112.9	174.7	131.7

Appendix A: Table A.1 Table A.1 Continued

Sherd#	**JEC013**	**JEC014**	**JEC015**	**JEC016**	**JEC017**	**JEC018**	**JEC019**	**JEC020**	**JEC021**
Region Col	DV	DV	DV	DV	DV	DV	DV	DV	DV
Site	GRV-3	GRV-10	Iny-513	Iny-2927	Iny-795	Iny-687	Iny-692	Iny-692	Iny-677
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5	6	4.7	6.7	4.9	4.4	5.2	6	6.2
Rim Diam.	300	350	250	200	200	225	225	225	175
Rim Shape	3	3	3	5	3	2	3	3	2
Ext/Int Srf	- / R1	- / -	- / R1	R1 / R1	S / S	R1 / R1	R1 / -	R1 / R3	R1 / S
Temp D/Sz	1 / 1	1 / 1	2 / 2	2 / 2	2 / 2	2 / 2	1 / 2	3 / 2	1 / 2
Org / Mica	0 / 0	0 / 2	0 / 3	2 / 1	2 / 2	0 / 3	0 / 1	0 / 1	0 / 3
Decorated	0	1	0	1	0	1	0	0	0
Core/Coil	1 / -	0 / 2	0 / 4	1 / 4	0 / 2	0 / 2	0 / 2	0 / -	0 / -
Lip Sh/Lat	3 / 1	3 / 2	4 / -	3 / -	1 / -	1 / -	1 / -	3 / 1	1 / -
Ch. Group	DV1	DV1	DV1	DV3	NTS1B	DV1	DV1	DV1	Ungrp.
AS	15.66	11.11	12.60	8.31	14.99	19.05	20.54	22.29	13.57
LA	88.89	54.57	59.38	45.02	87.12	48.12	56.94	39.51	43.50
LU	0.468	0.404	0.561	0.392	0.518	0.435	0.462	0.224	0.487
ND	67.75	43.38	52.22	31.61	54.94	39.48	44.81	31.69	35.74
SM	10.71	7.11	8.11	6.44	10.51	7.37	8.30	5.48	7.48
U	3.483	4.453	3.138	4.619	5.628	4.542	4.003	2.66	3.111
YB	3.14	2.614	3.787	2.46	3.693	2.808	3.384	1.608	3.217
CE	192.69	97.14	108.46	89.79	191.68	94.68	117.94	76.56	93.97
CO	13.34	15.90	13.17	10.36	7.01	19.30	17.93	17.85	15.51
CR	27.98	24.43	44.27	38.52	28.85	17.66	58.89	28.14	63.21
CS	3.753	6.502	3.593	7.484	8.13	2.886	6.62	3.053	7.204
EU	2.196	1.461	1.42	1.129	1.501	1.525	1.503	1.381	1.425
FE	47105	56254	46200	33563	29624	55619	45958	50908	40213
HF	11.34	7.71	6.67	7.48	14.31	6.17	8.14	5.13	9.70
RB	119	100.1	108.7	152.1	102.3	86.5	124	102.9	113.8
SB	0.976	0.977	0.987	0.987	0.89	0.856	1.904	0.773	1.414
SC	13.26	12.57	15.90	11.30	9.31	15.23	13.42	12.13	12.92
SR	530.8	562	1230.9	397.4	747.5	871.9	1023	1166.7	323.1
TA	1.517	1.255	1.199	1.326	2.845	1.343	1.625	0.750	1.247
TB	1.122	0.903	1.049	0.779	1.216	0.875	1.100	0.452	0.943
TH	26.87	24.69	28.73	19.80	36.50	15.82	18.92	9.09	16.25
ZN	54.00	57.90	79.60	66.40	69.40	64.30	84.30	61.10	57.80
ZR	310.8	213.2	212.5	196.2	371.2	187.0	245.4	136.2	266.1
AL	94130	90043	85947	74229	112818	103892	87659	99662	82787
BA	1424	517	437	515	633	851	656	1218	611
CA	14833	19597	24667	12109	10831	16081	15447	22465	6361
DY	6.141	4.362	6.412	3.832	7.176	4.808	5.961	2.433	5.463
K	34554	23614	20112	30193	21425	25810	25836	32000	25212
MN	726.9	1007.7	789.7	638.9	571.6	910.7	894.3	755.8	666.3
NA	15996	14709	18400	16921	13558	13158	10222	14734	5330
TI	6296	3368	3923	3097	2478	4339	3514	3046	3921
V	122.1	141.4	112.2	82.3	39.3	176.3	95.2	151.4	93.8

Appendix A: Table A.1 Table A.1 Continued

Sherd#	**JEC022**	**JEC023**	**JEC024**	**JEC025**	**JEC026**	**JEC027**	**JEC028**	**JEC029**	**JEC030**
Region Col	DV	DV	DV	DV	DV	DV	DV	DV	DV
Site	Iny-652	193-56	Iny-1249	Iny-1285	Iny-1256	Iny-1237	Iny-1208	Iny-1221	Iny-1207
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5.4	6.2	4.5	4.3	5.9	6.1	5.7	6.1	5.4
Rim Diam.	350	200	300	250	200	200	250	225	225
Rim Shape	2	3	5	3	3	3	5	4	3
Ext/Int Srf	R1 / S	R1 / R1	- / -	- / R1	R1 / R1	R1 / R3	R1 / R1	- / -	R1 / S
Temp D/Sz	2 / 2	2 / 3	2 / 2	3 / 2	1 / 1	3 / 3	2 / 2	3 / 3	2 / 3
Org / Mica	0 / 2	1 / 3	0 / 0	0 / 3	0 / 4	0 / 0	0 / 1	0 / 1	0 / 2
Decorated	0	0	0	0	0	0	1	0	0
Core/Coil	0 / 2	0 / 2	0 / -	0 / 2	0 / -	0 / 1	0 / 2	0 / 2	0 / -
Lip Sh/Lat	1 / -	3 / -	3 / -	2 / -	3 / -	3 / 1	3 / -	3 / -	3 / -
Ch. Group	DV3	Ungrp.	NTS1A	DV2	DV1	Ungrp.	DV2	4D	DV3
AS	13.72	34.88	10.36	13.95	15.26	15.13	7.92	7.39	17.40
LA	61.56	38.05	25.20	58.47	58.20	29.60	56.04	55.48	45.37
LU	0.459	0.412	0.503	0.347	0.427	0.354	0.41	0.296	0.298
ND	38.03	32.39	19.37	43.31	39.58	22.69	43.13	41.60	35.95
SM	7.19	6.61	5.00	7.51	7.52	5.08	7.82	7.32	6.51
U	4.017	4.089	6.596	4.92	4.65	6.393	4.5	4.005	2.451
YB	3.197	2.651	3.091	2.051	2.584	1.83	2.554	1.746	2.163
CE	126.54	60.19	73.26	103.49	102.35	67.69	112.58	107.61	77.88
CO	9.62	12.39	3.74	16.31	17.04	13.58	15.61	13.18	9.66
CR	38.12	51.84	14.29	32.18	26.03	31.46	34.15	19.91	31.52
CS	9.074	5.801	11.815	5.131	6.469	2.395	6.329	4.1	4.838
EU	1.122	1.293	0.326	1.572	1.539	1.007	1.488	1.523	1.361
FE	31276	37119	16109	74927	54177	45545	69296	46548	33169
HF	8.85	6.96	5.30	10.13	9.37	4.96	14.43	7.13	7.05
RB	166.3	98.9	146.6	77.1	88.5	83.6	103.4	94.8	121.1
SB	1.182	7.607	0.851	1.292	1.116	0.587	1.206	1.009	0.878
SC	9.89	11.64	6.67	12.64	13.02	12.14	10.86	9.44	8.70
SR	687.6	1458.2	869.3	706.5	669	306.4	1004	1325.3	730
TA	1.675	1.056	2.616	1.374	1.264	1.289	1.756	1.314	1.235
TB	0.825	0.828	0.819	0.691	0.794	0.510	0.847	0.601	0.759
TH	22.27	14.76	27.56	20.38	24.75	22.89	24.84	19.36	13.69
ZN	83.20	57.10	47.90	81.80	62.80	33.00	65.30	55.50	74.60
ZR	258.6	214.0	126.3	260.6	258.2	161.2	382.2	184.3	189.0
AL	89307	78211	99050	81098	97985	100852	84439	86775	84997
BA	832	611	513	451	551	680	716	987	614
CA	10402	5203	7480	23353	25071	11430	22439	22401	14786
DY	4.659	4.954	4.317	3.732	4.923	2.576	3.886	3.898	3.994
K	34466	19750	30382	20007	30171	28203	25370	28012	25370
MN	951.4	268	376	850.7	1023.3	563.3	862.6	831.4	544.6
NA	14652	2621	26100	21240	19481	16893	18254	21192	18525
TI	3866	3929	1311	5577	4485	2572	4711	4106	3846
V	76.2	88.0	38.1	207.2	148.0	153.7	176.8	121.7	79.1

Appendix A: Table A.1 Table A.1 Continued

Sherd#	**JEC031**	**JEC032**	**JEC033**	**JEC034**	**JEC035**	**JEC036**	**JEC037**	**JEC038**	**JEC039**
Region Col	DV	DV	DV	DV	DV	DV	DV	DV	DV
Site	Iny-1195	Iny-955	Iny-1002	Iny-991	Iny-991	Iny-993	Iny-993	Iny-1049	Iny-1048
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	7.7	5.3	6.1	7	7.2	4.5	5.8	3.9	4.6
Rim Diam.	225	225	250	275	225	250	200	275	150
Rim Shape	5	5	3	4	5	3	3	2	3
Ext/Int Srf	R1 / R4	R1 / S	R1 / R2	- / R1	- / R1	- / -	- / -	R3 / R1	R0 / R1
Temp D/Sz	2 / 3	3 / 2	2 / 2	2 / 2	3 / 3	1 / 1	1 / 2	1 / 2	1 / 1
Org / Mica	2 / 3	0 / 0	0 / 0	0 / 3	0 / 0	0 / 3	0 / 2	0 / 1	0 / 2
Decorated	0	0	0	1	1	0	0	0	0
Core/Coil	0 / 2	1 / -	0 / -	0 / -	0 / -	0 / -	0 / 2	0 / -	0 / 2
Lip Sh/Lat	2 / -	3 / -	2 / 1	1 / -	3 / -	3 / -	1 / -	2 / -	2 / -
Ch. Group	DV3	DV2	DV1	DV2	SOV1C	DV2	DV1	DV1	4D
AS	10.05	13.68	16.41	11.92	20.66	8.56	18.99	35.99	13.65
LA	45.59	38.82	42.47	58.94	66.74	55.61	43.96	86.44	56.92
LU	0.296	0.339	0.247	0.403	0.566	0.495	0.424	0.428	0.386
ND	29.24	29.17	34.60	43.04	47.98	44.94	36.26	66.03	42.69
SM	5.15	5.73	6.07	7.91	9.52	8.58	7.21	9.98	7.81
U	4.763	3.579	2.34	5.651	8.836	4.225	4.127	4.241	3.969
YB	1.688	2.225	1.615	2.445	3.402	3.19	2.993	2.929	2.695
CE	92.46	64.61	81.32	109.68	128.29	106.82	90.64	147.09	102.71
CO	8.32	15.30	18.89	16.44	14.27	16.99	20.48	11.45	15.76
CR	27.06	32.11	30.71	36.35	24.05	34.16	61.85	31.07	24.62
CS	6.165	3.455	3.189	6.131	8.484	5.8	5.103	4.225	5.858
EU	1.02	1.377	1.448	1.55	1.526	1.525	1.376	1.942	1.56
FE	29656	69705	54622	70696	50386	65288	41014	45812	53905
HF	6.43	9.02	5.56	10.82	18.07	10.18	7.09	10.25	9.27
RB	119.7	82.4	90.8	100.7	172.3	94.8	119.9	120.5	103.5
SB	1.083	1.153	0.964	1.212	1.181	0.994	1.466	1.276	1.086
SC	7.32	15.82	12.97	11.85	9.97	13.66	13.76	11.90	12.32
SR	706.3	2213.4	759.8	696.3	512.6	467.6	242.9	600.4	1838.1
TA	1.203	1.222	0.876	1.612	2.910	1.654	1.382	1.577	1.342
TB	0.497	0.644	0.650	0.799	1.056	1.125	0.985	1.024	0.855
TH	19.31	13.05	10.05	20.05	46.56	15.92	15.32	25.59	16.83
ZN	53.20	86.30	63.20	80.40	62.20	86.40	68.80	78.30	76.10
ZR	183.8	232.6	196.5	318.2	480.2	274.1	172.5	276.5	268.0
AL	87705	96189	100814	88838	95987	83141	93468	94602	95418
BA	805	709	934	597	507	559	695	1075	612
CA	14561	25048	19992	25788	20977	27240	36224	12915	26968
DY	2.259	3.827	2.717	4.255	4.977	5.871	5.347	5.191	3.996
K	32225	17706	29650	25422	34024	22133	28609	31981	28072
MN	573	873.1	792.9	1050.1	990.4	1113.1	538.6	696.7	927.1
NA	17894	20259	16447	21415	18741	21050	8326	22371	22917
TI	3197	7186	3930	5408	4515	6114	4804	5521	3952
V	74.6	218.9	169.7	180.1	129.2	173.3	102.2	124.0	129.2

Appendix A: Table A.1 Table A.1 Continued

Sherd#	JEC040	JEC041	JEC042	JEC043	JEC044	JEC045	JEC046	JEC047	JEC048
Region Col	DV	DV	DV	DV	Seq	Seq	Seq	Seq	Seq
Site	Iny-1040	Iny-1051	Iny-1061	Iny-1061	Unknown	Sugar Pine Tr	Bullfrog Lake	Cedar Crove	Crescent Mdw
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	6.1	5.6	4.3	4.2	4	6.1	4.7	5.9	4.9
Rim Diam.	350	200	225	150	400	225	200		200
Rim Shape	3	3	3	3	3	3	3		3
Ext/Int Srf	S / R1	S / R1	R2 / R1	R0 / R0	R1 / R1	S / S	R4 / R5	R1 / R1	R1 / S
Temp D/Sz	3 / 3	2 / 2	2 / 1	1 / 1	1 / 3	1 / 3	2 / 3	1 / 2	2 / 2
Org / Mica	0 / 2	1 / 4	0 / 2	0 / 5	0 / 2	1 / 1	0 / 1	0 / 1	0 / 1
Decorated	1	0	0	1	0	0	0	0	0
Core/Coil	0 / -	0 / 2	0 / 2	0 / 5	0 / -	1 / 4	0 / 4	1 / 2	1 / -
Lip Sh/Lat	1 / -	2 / -	3 / -	4 / 2	5 / 2	3 / -	3 / -	3 / 1	3 / -
Ch. Group	DV1	DV1	DV1	Ungrp.	WSA	WSA	WSA	NOV1B	WSB
AS	16.29	14.16	19.49	16.92	4.89	6.10	2.07	7.79	3.61
LA	55.73	48.71	48.28	46.40	13.30	12.88	22.31	54.12	22.53
LU	0.373	0.436	0.28	0.948	0.253	0.279	0.302	0.473	0.454
ND	40.55	43.09	41.51	55.56	14.22	12.08	20.62	41.96	19.70
SM	7.68	8.57	6.83	13.18	3.07	3.27	4.85	7.72	5.06
U	7.824	3.606	2.987	67.218	0.782	2.319	2.349	4.35	4.884
YB	2.11	3.04	1.71	2.431	1.627	1.821	1.841	3.134	2.929
CE	105.86	97.38	94.25	100.32	23.94	24.61	53.24	104.51	55.46
CO	13.36	22.17	18.27	19.03	14.10	13.24	12.27	13.97	17.27
CR	29.99	26.34	30.82	30.42	59.11	57.56	50.87	36.38	26.18
CS	4.84	5.738	2.986	5.876	2.244	2.705	1.811	4.647	4.201
EU	1.488	1.974	1.557	1.651	0.859	0.908	1.233	1.395	0.982
FE	57235	67218	54874	70807	52518	50009	53346	49316	50543
HF	10.67	6.65	5.79	5.89	3.19	3.34	7.36	10.99	7.01
RB	99.9	114.7	87.8	109.4	16.2	26.7	36	95.6	89.3
SB	0.991	0.855	0.968	1.011	0.501	0.515	0.409	0.99	0.452
SC	8.86	12.34	13.01	12.72	21.04	19.59	20.59	13.21	16.05
SR	745.3	1472.7	1071.4	1155.8	272.6	277.5	443.6	404	315.5
TA	1.445	1.059	0.853	1.083	0.553	0.510	0.949	1.518	0.927
TB	0.605	1.005	0.700	0.842	0.472	0.444	0.586	0.976	0.664
TH	34.19	11.09	12.08	147.39	6.79	6.43	6.91	15.76	23.13
ZN	55.70	89.80	59.30	85.50	83.30	48.30	93.90	78.90	70.90
ZR	361.3	179.8	199.2	607.3	92.2	102.5	169.3	289.7	193.7
AL	83880	111039	103270	101923	96043	98951	97221	90441	92300
BA	711	746	838	470	436	359	746	835	700
CA	25241	30155	26457	21354	26555	32931	38314	20496	19407
DY	3.903	5.434	3.497	3.927	3.141	2.633	4.064	4.926	3.911
K	30146	32292	27991	32681	6035	8156	10357	25544	19544
MN	739	1422.2	748.1	1241.9	862.6	617.2	688.3	965.7	805.7
NA	24181	24169	20579	19746	10963	18693	14416	19375	17371
TI	3781	5316	4307	5764	5420	3921	7092	4135	5510
V	159.4	211.4	162.1	217.8	167.0	154.6	173.2	114.8	114.1

Appendix A: Table A.1 Table A.1 Continued

Sherd#	JEC049	JEC050	JEC051	JEC052	JEC053	JEC054	JEC055	JEC056	JEC057
Region Col	Seq	Seq	Seq	Seq	Seq	Seq	Seq	Seq	Seq
Site	Crescent Meadow	Kern Canyon	Kern Canyon	CA-Fre-266	Tul-2132	Tul-2132	Tul-2132	Tul-2132	Tul-2132
Sherd type	rim	rim	rim	body	rim	rim	rim	rim	body
Thickness	4.3	5.4	5	8.4	4.3	4.6	5.9	3.9	7.1
Rim Diam.	200	250	225		175	400	200		225
Rim Shape	3	3	3		3	3	3		
Ext/Int Srf	S / S	R1 / R2	R1 / R1	R0 / S	R1 / S	S / S	S / S	S / S	R4 / S
Temp D/Sz	2 / 3	1 / 1	2 / 2	2 / 3	1 / 3	2 / 2	2 / 3	2 / 2	1 / 2
Org / Mica	0 / 2	0 / 5	0 / 2	0 / 2	0 / 3	0 / 2	0 / 3	0 / 0	0 / 2
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / -	0 / -	0 / -	1 / -	0 / -	0 / -	1 / -	1 / 3
Lip Sh/Lat	3 / -	3 / -	5 / 1	- / -	5 / 1	1 / -	3 / -	1 / -	- / -
Ch. Group	WSA	WSA	Ungrp.	WSB	WSA	WSB	WSB	WSA	WSA
AS	3.65	8.05	2.83	3.48	2.55	1.24	3.39	1.67	3.50
LA	24.12	21.68	21.01	26.94	27.06	24.80	18.02	23.45	21.90
LU	0.303	0.346	0.248	0.335	0.352	0.344	0.216	0.278	0.555
ND	22.33	22.20	18.23	22.36	24.18	21.08	13.76	23.09	24.88
SM	4.62	5.06	3.46	4.70	5.13	4.63	2.95	4.47	6.94
U	1.817	2.536	2.327	4.326	1.941	3.071	2.473	1.393	1.62
YB	2.237	2.596	1.773	1.977	2.347	2.238	1.269	1.892	3.218
CE	49.79	50.94	40.84	58.21	57.66	45.51	35.82	49.79	51.91
CO	10.79	21.32	8.84	18.42	13.49	9.46	9.68	13.03	23.57
CR	40.22	93.77	11.28	27.90	36.65	24.66	19.27	35.83	25.40
CS	2.311	6.354	10.031	4.073	2.713	3.629	3.796	2.586	2.155
EU	1.552	1.215	0.692	1.256	1.667	0.996	0.758	1.536	1.665
FE	47436	61805	37871	57147	53471	41749	39195	52744	80919
HF	7.41	7.65	4.25	4.73	6.53	6.60	3.28	6.47	6.59
RB	48.6	43.3	94.6	54.5	59.3	76.8	60.9	55.8	26.8
SB	0.232	0.896	0.538	0.335	0.243	0.5	0.507	0.224	0.676
SC	12.02	24.12	12.41	18.26	13.61	14.78	13.49	15.97	27.07
SR	437.7	250.4	150	297.8	617.9	383.2	349	518.1	536.5
TA	0.884	0.671	0.866	0.707	0.753	0.874	0.747	0.779	1.045
TB	0.646	0.701	0.566	1.045	0.992	0.838	0.543	0.912	1.234
TH	6.48	8.97	8.07	8.30	8.20	11.89	10.36	6.36	5.63
ZN	71.00	76.00	46.50	77.30	127.10	67.30	84.50	85.20	122.30
ZR	221.6	127.6	125.2	141.7	166.4	158.1	94.8	171.9	172.6
AL	100229	104638	89121	91964	103367	91572	90595	98075	101442
BA	470	362	264	586	513	906	923	1086	567
CA	28231	30987	6434	34193	29877	21965	23421	29208	35071
DY	3.922	3.961	2.561	3.168	3.795	3.461	2.119	3.87	5.866
K	11034	9699	17989	13731	13094	18640	17859	11711	6721
MN	793.3	995	305.3	882.8	922.7	418	751.7	893.5	1767.9
NA	19309	16159	19471	20142	19022	18658	18034	18242	15436
TI	5740	4565	3597	5213	5347	3908	2616	5759	9208
V	86.1	151.8	101.8	155.4	85.7	81.7	67.9	71.7	202.7

Appendix A: Table A.1 Table A.1 Continued

Sherd#	**JEC058**	**JEC059**	**JEC060**	**JEC061**	**JEC062**	**JEC063**	**JEC064**	**JEC065**	**JEC066**
Region Col	Seq	Seq	Seq	Seq	Seq	Seq	Seq	Seq	Seq
Site	Tul-2132	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24
Sherd type	body	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	7.9	3.4	3.7	5.8	5.5	5.5	3.8	10	5.7
Rim Diam.	400	200		175	350	150	300	275	250
Rim Shape		2	1	3	3	3	3	3	3
Ext/Int Srf	S / S	R1 / S	S / S	S / S	S / S	R1 / S	R1 / R3	R1 / S	R1 / S
Temp D/Sz	2 / 2	2 / 2	2 / 3	2 / 3	2 / 2	1 / 1	2 / 3	1 / 2	1 / 2
Org / Mica	0 / 3	0 / 3	0 / 3	0 / 1	0 / 2	0 / 3	0 / 2	0 / 3	0 / 3
Decorated	0	0	0	0	0	0	0	1	0
Core/Coil	1 / 3	0 / -	0 / -	0 / -	0 / -	0 / -	0 / -	1 / -	0 / 4
Lip Sh/Lat	- / -	3 / -	5 / -	2 / -	2 / 1	3 / -	3 / -	3 / -	3 / -
Ch. Group	Ungrp.	WSA	WSB	Ungrp.	WSA	WSA	WSB	WSA	WSA
AS	13.33	1.94	2.35	10.46	2.41	3.35	3.24	2.35	2.75
LA	33.25	19.42	26.24	38.74	22.50	13.71	17.73	20.38	20.89
LU	0.394	0.277	0.323	0.404	0.254	0.268	0.336	0.433	0.285
ND	45.52	18.42	33.13	32.93	19.87	12.83	14.61	22.61	21.26
SM	5.89	4.00	4.52	6.68	4.24	2.81	4.09	4.92	4.19
U	2.748	1.961	2.663	2.978	1.774	1.068	3.584	2.328	1.799
YB	2.502	1.884	2.083	2.501	1.598	1.335	2.228	2.285	1.983
CE	68.53	41.79	47.74	78.69	44.73	32.10	40.65	43.85	41.20
CO	15.13	10.45	9.16	13.68	10.63	12.84	17.34	23.63	10.31
CR	59.75	20.26	23.91	54.95	23.30	23.64	32.89	32.53	23.13
CS	6.468	2.262	3.739	7.791	2.025	2.497	4.678	2.239	2.637
EU	1.186	1.486	0.976	1.343	1.569	1.27	0.911	1.376	1.559
FE	46235	49701	40011	42307	51075	65510	42143	68967	54350
HF	5.58	6.25	6.25	6.82	6.74	6.27	3.93	2.61	7.25
RB	97.9	39.9	86.4	113.5	39.4	41	88.7	38.4	57.6
SB	1.048	0.261	0.359	1.035	0.214	0.299	0.618	0.292	0.289
SC	18.06	11.85	14.28	13.51	11.47	13.49	15.86	22.64	12.84
SR	279.3	437.3	232.2	220.8	671.3	354.1	255	470.4	593.4
TA	1.189	0.610	0.819	1.237	0.640	0.560	0.666	0.610	0.806
TB	0.731	0.607	0.681	0.503	0.282	0.529	0.799	1.172	0.915
TH	19.79	5.03	11.36	13.48	6.35	5.85	8.87	4.45	5.51
ZN	117.20	111.90	57.80	100.70	79.10	74.30	66.60	97.80	105.40
ZR	148.4	178.3	170.0	167.1	190.4	165.4	84.4	102.7	160.3
AL	107011	102361	96639	90230	98568	109557	95185	112304	104467
BA	1402	464	820	991	420	568	780	380	622
CA	15889	35112	20391	18575	33811	26248	25114	41705	36416
DY	4.227	3.106	2.873	4.767	2.991	1.745	3.024	4.265	2.636
K	19652	7329	23292	27611	6684	8243	18833	12617	11735
MN	662.9	1033.6	400.4	676.7	1081.4	1022.8	1365.3	1075.4	1089.7
NA	8663	22479	19645	11810	21777	17514	14851	16019	22182
TI	4251	4497	4520	3793	4472	5223	4692	6343	5199
V	126.8	96.2	79.8	86.4	71.7	98.4	144.5	162.3	85.5

Appendix A: Table A.1 Table A.1 Continued

Sherd#	**JEC067**	**JEC068**	**JEC069**	**JEC070**	**JEC071**	**JEC072**	**JEC073**	**JEC074**	**JEC075**
Region Col	Seq	Seq	Seq	Seq	Seq	Seq	Seq	Seq	Seq
Site	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24	Tul-24
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5.9	7	4	4.6	5.8	6	5.1	5.9	4.8
Rim Diam.	175	150	200	175	300	150	250	350	225
Rim Shape	3	3	3	3	3	3	3	3	3
Ext/Int Srf	S / S	R1 / R1	R1 / S	R1 / S	R1 / S	R1 / S	R1 / R3	R0 / R0	S / S
Temp D/Sz	2 / 3	1 / 1	1 / 2	2 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 3
Org / Mica	0 / 3	0 / 3	0 / 2	0 / 2	0 / 3	0 / 2	0 / 3	0 / 3	0 / 3
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	1 / 2	1 / -	0 / -	0 / 4	0 / 4	1 / -	0 / -	0 / -
Lip Sh/Lat	2 / -	2 / -	3 / -	5 / -	3 / -	3 / -	2 / -	1 / -	3 / -
Ch. Group	WSA	WSA	WSA	WSA	WSA	Ungrp.	WSB	WSA	WSA
AS	3.77	4.04	3.38	2.07	3.52	10.11	4.02	3.12	3.19
LA	19.25	18.03	22.75	22.90	13.62	31.42	28.50	23.57	25.13
LU	0.342	0.393	0.478	0.276	0.217	0.349	0.428	0.303	0.31
ND	20.45	20.36	27.80	20.92	12.93	51.56	26.06	22.56	28.69
SM	4.59	4.47	6.02	4.47	2.88	5.59	6.27	4.74	4.90
U	1.979	1.84	2.208	1.619	1.455	2.737	5.93	1.959	1.849
YB	2.261	2.063	2.989	1.949	1.247	2.42	2.651	2.104	2.122
CE	45.71	41.84	47.51	46.56	32.02	65.11	54.71	44.05	51.50
CO	18.80	24.34	20.59	12.44	13.14	14.38	16.79	13.11	12.42
CR	39.71	23.97	36.48	36.17	23.61	63.00	48.47	43.57	38.40
CS	3.499	1.647	2.838	2.202	2.788	6.535	6.192	2.036	2.555
EU	1.125	1.331	1.346	1.543	1.274	1.107	1.21	1.484	1.626
FE	59473	69474	61488	46349	66341	45365	51950	45927	52013
HF	4.29	3.43	4.58	5.68	6.38	6.17	8.19	4.91	7.93
RB	48.9	22.3	55.8	45	51.1	98.8	102.9	36.9	54.6
SB	0.511	0.306	0.491	0.346	0.289	0.989	0.695	0.347	0.255
SC	19.41	24.36	25.27	13.19	13.24	13.55	20.27	14.08	12.77
SR	357	377	291.4	425.6	440.3	197.7	263.4	288.2	425.1
TA	0.586	0.623	0.528	0.591	0.568	1.165	0.817	0.672	0.836
TB	0.949	0.857	0.000	0.505	0.000	1.147	1.217	0.946	0.434
TH	7.66	3.71	6.41	5.78	5.69	13.34	18.37	5.87	6.55
ZN	84.40	95.50	98.50	83.40	87.50	84.50	92.00	68.60	84.20
ZR	116.8	70.7	110.8	171.8	150.7	145.5	190.8	108.6	225.2
AL	98236	108975	91170	96171	110390	93975	100845	94676	97755
BA	618	490	378	310	572	1124	617	518	462
CA	32137	41940	35767	35293	29895	19757	28963	33171	34260
DY	4.205	3.168	5.227	2.994	1.335	4.354	4.847	3.608	2.868
K	11945	6788	10703	12781	10004	19557	16748	10724	9515
MN	1009.3	1090.7	1010.5	895.8	965.5	711.2	1024.5	736.8	958.4
NA	17000	16838	16848	21580	17612	8778	18040	19335	22076
TI	6482	7456	5617	6081	5589	4253	5332	5393	5406
V	182.9	166.3	198.2	90.3	94.7	141.4	196.4	86.8	94.3

Appendix A: Table A.1 Continued

Sherd#	**JEC076**	**JEC077**	**JEC078**	**JEC079**	**JEC080**	**JEC081**	**JEC082**	**JEC083**	**JEC084**
Region Col	Seq	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Tul-24	Iny-2	Iny-2	Iny-2	Iny-5207	Iny-5207	Iny-5207	Iny-5207	Iny-5207
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	3.9	5.8	6.7	5.1	6.9	6.2	6.6	5.5	6.5
Rim Diam.	100	200	275	300	150	350	200		300
Rim Shape	3	3	3	3	3	3	3	3	3
Ext/Int Srf	R0 / S	R3 / R1	R1 / R1	R3 / R1	R1 / R3	- / -	- / -	R0 / R1	S / R1
Temp D/Sz	2 / 3	2 / 3	1 / 2	1 / 3	1 / 2	1 / 3	1 / 2	2 / 2	1 / 1
Org / Mica	0 / 4	0 / 3	0 / 2	0 / 1	0 / 1	1 / 1	1 / 0	1 / 1	0 / 1
Decorated	0	0	0	1	0	0	0	0	0
Core/Coil	0 / -	0 / 2	1 / 2	1 / 1	0 / -	1 / -	0 / -	0 / 4	0 / 1
Lip Sh/Lat	3 / -	3 / -	3 / 1	1 / 1	3 / -	3 / 1	3 / -	1 / -	3 / -
Ch. Group	WSB	SOV1A	SOV1B	SOV1C	SOV1C	SOV1B	Ungrp.	SOV1B	SOV1A
AS	5.31	5.65	15.50	9.32	19.08	24.37	30.01	14.58	14.70
LA	22.47	110.93	68.88	70.34	62.43	112.60	58.93	71.25	85.33
LU	0.426	0.565	0.25	0.487	0.557	0.304	0.56	0.27	0.723
ND	20.58	96.52	62.93	63.75	72.64	73.19	88.81	72.57	67.85
SM	4.60	10.72	6.36	7.70	8.91	7.69	7.63	7.43	9.13
U	4.831	15.899	4.8	8.057	9.334	7.961	11.219	4.643	12.032
YB	2.484	2.801	1.486	2.745	3.659	1.479	3.176	1.734	4.103
CE	49.96	165.35	102.90	112.48	117.91	151.94	104.41	102.06	136.65
CO	21.23	12.19	8.65	7.03	11.36	7.87	7.62	9.26	8.34
CR	27.38	31.92	14.18	17.48	23.31	16.68	23.62	17.34	17.23
CS	4.219	7.129	8.528	4.391	6.129	8.601	4.547	8.359	4.906
EU	1.096	1.35	1.278	1.218	1.494	1.392	1.279	1.412	1.365
FE	55783	66665	48068	44087	50099	44345	48847	42506	38093
HF	5.87	24.78	7.63	6.38	11.25	6.09	8.71	5.89	10.53
RB	68.9	141.8	118.8	106.8	101.8	119.4	90.7	123.2	119.3
SB	0.522	0.626	2.224	0.903	1.455	1.98	1.584	1.656	1.238
SC	19.23	13.26	8.66	10.67	11.81	9.50	8.86	9.91	9.22
SR	323.3	258	528.8	186.5	446.5	472.4	456	516.1	315.6
TA	0.717	1.553	1.170	1.409	1.804	1.175	2.132	1.033	1.912
TB	0.800	1.090	0.308	0.515	1.309	0.367	0.687	0.329	0.648
TH	9.52	65.76	35.34	30.16	43.38	43.92	52.54	26.62	33.86
ZN	79.80	79.00	107.40	57.70	76.70	118.00	58.40	153.80	60.90
ZR	176.0	618.8	198.3	189.5	306.2	195.7	224.1	180.4	267.7
AL	93350	98642	95926	94630	84244	90490	90737	102128	94478
BA	569	390	550	668	686	634	371	554	615
CA	35102	19536	18569	15396	24647	23760	21447	16833	14049
DY	3.583	5.545	2.53	4.569	5.441	2.502	4.467	3.02	5.967
K	16007	20621	23426	27012	23857	23657	22616	25778	27848
MN	1135.6	782	688.5	889.8	1099	724.8	642.3	605	809.7
NA	16092	14912	19988	19016	21431	21948	20389	19654	22809
TI	4572	4764	3709	5143	5589	4138	3385	3557	3164
V	136.9	140.9	94.7	115.6	114.2	88.5	103.8	83.0	73.2

Appendix A: Table A.1 Continued

Sherd#	**JEC085**	**JEC086**	**JEC087**	**JEC088**	**JEC089**	**JEC090**	**JEC091**	**JEC092**	**JEC093**
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-5207	Iny-5207	Iny-5207	Iny-5208	AC-S-4	Iny-5208	Iny-5208	CC-3, Loc 1	Iny-3806
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	body
Thickness	4.9	8.5	5.1	7.9	5.1	5.4	5	5.8	5.8
Rim Diam.	400	250	150	175	250	250	350	150	250
Rim Shape	1	3	3	3	3	3	3	3	
Ext/Int Srf	R1 / R1	S / R1	S / R2	S / -	S / S	S / S	R4 / R5	S / S	- / -
Temp D/Sz	2 / 3	1 / 3	1 / 2	2 / 2	3 / 2	2 / 2	1 / 3	2 / 2	1 / 2
Org / Mica	1 / 3	0 / 2	0 / 1	0 / 2	0 / 1	2 / 3	2 / 4	0 / 0	0 / 4
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / -	1 / -	0 / -	0 / -	1 / -	0 / -	0 / -	1 / 2
Lip Sh/Lat	2 / -	1 / -	5 / -	3 / -	3 / -	1 / -	3 / 1	3 / 1	- / -
Ch. Group	SOV2	SOV1D	Ungrp.	SOV1B	Ungrp.	Ungrp.	Ungrp.	SOV1A	SOV1B
AS	14.02	17.74	11.41	11.70	37.81	56.17	8.23	15.56	35.87
LA	43.98	56.35	50.51	61.57	57.43	44.53	45.47	91.31	79.09
LU	0.304	0.479	0.461	0.297	0.321	0.343	0.383	0.805	0.313
ND	32.42	62.46	80.35	69.50	43.34	54.48	30.70	78.78	75.04
SM	6.36	7.26	7.86	7.32	6.54	6.12	6.11	8.88	7.34
U	5.981	7.974	4.751	8.67	2.479	6.409	3.429	14.745	9.989
YB	1.779	3.185	2.975	1.506	2.369	1.787	2.245	4.508	1.58
CE	82.04	97.89	100.89	97.47	104.80	81.31	74.33	140.14	131.63
CO	18.11	10.02	11.88	7.17	15.09	17.39	14.07	6.84	16.19
CR	38.45	26.22	30.13	12.67	35.72	28.51	21.66	16.85	16.98
CS	3.759	7.236	4.094	7.87	2.793	4.725	5.542	4.814	16.644
EU	1.414	1.237	1.384	1.452	1.459	1.207	1.284	1.199	1.339
FE	58018	42665	45873	42247	63543	47797	54505	37859	55248
HF	6.97	6.74	9.50	7.20	8.50	5.70	4.45	9.23	3.18
RB	87.7	124.6	105.5	112.4	42.2	69.5	39.9	123.6	174.8
SB	0.628	1.268	1.026	1.549	3.312	3.378	0.822	1.341	3.124
SC	15.84	10.85	11.15	9.37	18.06	12.52	14.84	8.69	13.51
SR	601.7	403.4	289.1	405.3	600.1	756.9	421.1	220.8	494.9
TA	1.270	1.605	1.394	1.088	0.831	1.309	0.810	2.044	1.073
TB	0.936	0.473	0.582	0.388	0.604	0.780	0.969	0.622	0.377
TH	23.51	31.88	19.13	37.07	9.46	35.95	16.23	43.98	28.55
ZN	76.10	76.20	67.90	128.20	73.60	60.60	56.60	61.30	220.20
ZR	224.9	185.0	236.5	203.8	200.4	158.5	103.6	265.7	114.3
AL	107435	95755	89368	98571	90976	100500	95183	94964	99544
BA	525	417	747	454	503	638	311	388	561
CA	24115	16461	18476	20628	36003	39773	23044	14788	18746
DY	3.243	4.225	5.021	3.139	2.755	3.569	3.928	6.03	3.394
K	19331	27254	27533	25853	17557	16223	9311	30717	34183
MN	964.4	778.6	883.3	555.1	1169.9	875.8	418.4	885.5	1636.2
NA	17251	21008	21102	23444	22261	18470	29121	23868	14872
TI	5943	4345	4657	4114	5546	4809	5199	2714	5639
V	154.4	85.8	103.6	89.3	190.6	128.1	122.1	70.4	121.6

Appendix A: Table A.1 Continued

Sherd#	**JEC094**	**JEC095**	**JEC096**	**JEC097**	**JEC098**	**JEC099**	**JEC100**	**JEC101**	**JEC102**
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-2750 B	Iny-2750 A	Iny-2750 C	Iny-2750 B	Iny-2750 E	Iny-2750 E	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5	6	7	4.7	5	5	6.2	5.2	6.2
Rim Diam.	250	125	350	300	250	225	175	300	275
Rim Shape	3	3	3	3	2	3	3	3	3
Ext/Int Srf	R0 / R0	R3 / R1	R2 / R4	R0 / R1	R0 / R1	R0 / R0	R0 / R1	R0 / R1	R2 / R1
Temp D/Sz	3 / 2	1 / 2	1 / 2	1 / 2	2 / 2	1 / -	1 / 2	1 / 1	1 / 2
Org / Mica	2 / 1	0 / 2	1 / 0	0 / 1	0 / 3	2 / 1	1 / 2	0 / 2	0 / 1
Decorated	0	0	0	0	1	0	1	1	1
Core/Coil	0 / -	0 / 1	0 / 1	1 / -	0 / 1	0 / -	0 / 1	0 / -	1 / 2
Lip Sh/Lat	3 / -	3 / -	3 / -	5 / -	3 / 1	3 / -	1 / -	3 / -	2 / 1
Ch. Group	SOV1A	SOV1A	SOV1B	SOV1A	WSC	SOV1D	SOV1C	SOV1A	SOV1A
AS	15.05	26.09	18.92	16.08	10.05	9.47	20.25	23.32	16.89
LA	55.43	98.14	55.54	97.14	21.02	50.80	61.23	82.74	79.81
LU	0.597	0.96	0.363	1.058	0.158	0.445	0.554	0.928	0.76
ND	60.04	92.92	58.38	122.33	22.99	66.83	81.92	56.19	42.92
SM	7.40	12.61	6.92	13.21	2.96	7.01	8.91	11.56	8.43
U	11.147	14.82	5.13	19.366	2.985	6.36	9.593	14.108	12.718
YB	3.147	6.954	2.279	6.092	0.934	2.87	3.288	5.142	4.159
CE	103.71	160.17	90.82	164.17	35.44	93.10	117.43	152.96	130.13
CO	9.86	10.15	10.22	10.53	27.17	10.54	11.63	11.14	7.80
CR	22.38	20.17	19.97	21.41	55.55	36.09	24.92	0.00	21.65
CS	5.214	6.212	5.926	6.735	3.293	5.439	6.614	5.995	5.56
EU	1.088	1.721	1.365	1.646	0.762	1.178	1.554	1.646	1.342
FE	38588	49686	51292	53731	47841	42437	48359	46293	40532
HF	11.64	13.24	9.15	15.17	3.00	8.89	11.09	12.70	10.10
RB	104.1	86.6	95.7	101.1	55.3	108.3	104.9	91.2	106
SB	1.19	1.219	1.832	1.308	0.421	1.332	1.487	1.173	1.215
SC	9.32	13.15	8.80	14.59	9.16	11.33	12.26	12.33	10.25
SR	225.5	350.2	507.3	380.6	791.1	324.8	442.3	321.7	333.7
TA	2.063	2.706	1.328	3.001	0.540	1.650	1.790	2.258	2.010
TB	0.493	1.997	0.499	1.145	0.173	0.480	0.585	1.472	0.972
TH	32.25	29.94	19.33	57.17	7.27	36.78	33.71	28.19	41.67
ZN	86.40	97.50	133.40	93.40	48.60	78.50	69.70	112.30	106.30
ZR	301.3	346.2	222.4	430.0	95.8	218.9	302.5	388.8	306.4
AL	85891	90525	78492	93096	117574	82355	86689	93047	89900
BA	426	295	706	273	460	445	771	543	370
CA	12729	29426	19627	19499	35943	23569	22075	26691	16959
DY	4.928	8.488	4.082	7.796	1.917	4.471	5.372	7.62	5.942
K	31083	24230	28914	25218	12949	27963	27604	22547	27767
MN	1180.1	1314	895.2	1251.2	646.7	758.3	1021.9	1751.5	873.2
NA	26815	23355	22136	22891	12642	16102	19020	24672	24502
TI	3164	4649	2629	4726	3756	3720	4902	6502	3659
V	66.6	105.4	76.9	95.5	130.6	92.0	113.7	94.1	90.7

Appendix A: Table A.1 Continued

Sherd#	**JEC103**	**JEC104**	**JEC105**	**JEC106**	**JEC107**	**JEC108**	**JEC109**	**JEC110**	**JEC111**
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5.8	5.8	4.4	5.5	8.4	5.4	7.3	4.6	5.3
Rim Diam.	275	250		150	325	300	175	175	250
Rim Shape	2	3	1	3	2	3	3	3	3
Ext/Int Srf	R1 / R1	S / R1	S / R0	- / R3	R2 / R1	R3 / R1	S / R1	R1 / R1	R2 / R1
Temp D/Sz	2 / 2	2 / 1	1 / 1	2 / 2	1 / 1	1 / 1	1 / 1	2 / 3	1 / 2
Org / Mica	4 / 1	0 / 2	1 / 0	0 / 1	1 / 1	0 / 5	1 / 1	0 / 1	2 / 1
Decorated	1	1	1	1	0	0	0	0	0
Core/Coil	0 / -	0 / -	1 / 1	0 / -	0 / 2	0 / -	0 / 2	0 / 1	0 / -
Lip Sh/Lat	1 / -	1 / -	1 / 1	1 / -	3 / -	1 / -	3 / -	5 / -	3 / -
Ch. Group	SOV1A	SOV1B	SOV1B	SOV1D	SOV1A	SOV2	SOV1B	Ungrp.	SOV1B
AS	16.77	12.85	22.48	8.41	13.97	10.10	51.97	151.13	15.47
LA	80.23	56.94	43.88	41.05	88.90	45.46	51.20	67.10	69.68
LU	0.845	0.341	0.314	0.373	0.834	0.34	0.374	0.163	0.24
ND	37.57	31.64	29.91	23.73	46.36	33.19	34.21	35.05	37.22
SM	8.58	6.28	5.31	5.23	9.35	6.39	6.30	5.50	6.15
U	15.725	5.183	4.664	6.641	12.488	5.582	7.067	7.734	4.024
YB	4.423	2.036	1.836	2.077	4.778	2.145	2.01	1.355	1.399
CE	133.85	94.17	69.79	68.39	126.58	88.95	84.60	94.24	104.51
CO	8.49	9.61	9.66	8.18	8.27	19.53	12.84	7.92	9.38
CR	21.10	21.07	0.00	0.00	21.58	32.86	24.67	19.13	0.00
CS	4.425	8.677	7.505	6.363	3.735	3.429	9.739	10.142	7.804
EU	1.222	1.165	1.072	0.892	1.463	1.375	1.259	1.063	1.206
FE	40844	51862	47638	38431	49206	53562	57927	73175	37576
HF	12.00	8.54	6.82	5.21	11.93	7.01	7.45	4.88	4.77
RB	95.8	127	114.8	136.4	86.2	70.1	145.3	136.5	128.5
SB	1.321	1.851	1.478	1.023	1.303	0.488	2.098	3.071	1.396
SC	10.13	8.70	10.20	9.01	9.64	14.29	10.76	9.53	9.25
SR	289.6	377.9	474.9	281.9	344.5	542.6	395.7	461.9	336.5
TA	2.275	1.228	1.143	1.522	2.377	1.317	1.271	0.983	0.913
TB	0.988	0.651	0.544	0.527	1.093	0.618	0.642	0.463	0.506
TH	68.68	29.28	22.58	30.32	51.54	22.78	27.72	25.83	23.66
ZN	87.30	107.00	123.00	76.20	62.00	82.30	343.20	119.80	126.50
ZR	338.3	238.2	209.0	161.7	303.7	190.7	234.9	170.0	117.5
AL	97885	81685	86259	89943	86997	97895	88390	87026	105296
BA	323	477	452	442	466	556	791	428	583
CA	14660	17591	22546	14005	16689	27757	17703	13421	14786
DY	5.683	3.284	3.413	3.066	5.962	3.965	3.839	2.303	2.452
K	26391	28260	28240	33973	24960	18699	31163	26165	28828
MN	783.9	613.3	670.1	608	663.3	908.3	1186.8	438.5	645
NA	24006	19175	17514	18888	23136	17494	14571	17207	19503
TI	3709	3742	3114	2539	3274	5129	4163	3476	3287
V	90.9	82.0	109.6	91.7	96.0	158.5	128.9	124.3	99.3

Appendix A: Table A.1 Continued

Sherd#	**JEC112**	**JEC113**	**JEC114**	**JEC115**	**JEC116**	**JEC117**	**JEC118**	**JEC119**	**JEC120**
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	pipe
Thickness	5.8	6.3	4.9	7.1	4.2	5.3	7.4	6.9	4.7
Rim Diam.	275	325	250	250	200	350	250	175	100
Rim Shape	3	3	3	3	3	2	2	3	
Ext/Int Srf	R4 / R1	R4 / R1	R1 / R0	R1 / R1	R0 / R1	R1 / R1	R4 / R1	R0 / R1	- / -
Temp D/Sz	1 / 2	2 / 2	1 / 2	1 / 3	2 / 3	1 / 3	2 / 1	2 / 1	1 / 2
Org / Mica	0 / 3	0 / 2	0 / 3	2 / 1	0 / 3	1 / 4	2 / 2	1 / 1	0 / 4
Decorated	0	0	0	0	0	0	0	0	1
Core/Coil	1 / 4	1 / 4	0 / -	1 / -	0 / -	0 / 1	0 / 1	0 / 2	0 / 3
Lip Sh/Lat	2 / -	1 / -	3 / -	3 / 1	2 / -	2 / -	3 / 1	3 / -	- / -
Ch. Group	Ungrp.	Ungrp.	SOV1B	SOV1A	WSC	SOV1B	SOV1C	SOV1A	SOV1D
AS	5.32	10.03	12.77	25.89	10.64	16.36	22.50	13.39	13.87
LA	42.52	41.71	63.17	87.33	20.63	89.75	82.22	83.88	57.58
LU	0.409	0.461	0.307	0.945	0.179	0.304	0.489	0.764	0.4
ND	33.86	31.36	37.68	60.09	18.44	48.81	50.26	42.48	45.83
SM	6.86	7.30	6.66	12.54	3.24	8.18	8.75	8.45	6.94
U	4.351	7.372	6.02	14.026	2.945	5.029	7.024	11.264	5.434
YB	2.635	2.982	1.574	5.796	1.276	1.734	2.733	4.469	2.216
CE	80.15	84.35	103.75	155.10	37.83	120.92	129.14	117.31	91.69
CO	20.38	20.37	8.43	10.43	27.87	9.97	9.28	7.04	14.52
CR	41.30	40.73	17.62	20.48	50.94	19.50	19.95	18.84	0.00
CS	4.118	3.954	8.627	6.385	3.396	9.502	6.175	3.622	8.075
EU	1.36	1.38	1.376	1.706	0.823	1.635	1.585	1.32	1.332
FE	51207	53653	38135	47429	47010	45196	67716	40633	54474
HF	7.12	7.12	7.47	14.72	2.79	4.54	12.15	9.26	7.14
RB	96.7	96.3	136.9	90.2	61.5	135.9	100.8	99.5	150.9
SB	1.234	1.103	1.696	1.219	0.521	1.646	1.704	1.207	1.072
SC	17.53	18.01	9.51	12.65	9.86	11.27	8.27	9.26	15.25
SR	286.3	374.8	375.1	355.8	584.4	416.4	315.9	244.2	444.5
TA	1.009	1.162	1.125	2.463	0.592	1.038	1.425	2.136	1.256
TB	0.895	0.830	0.632	1.494	0.336	0.745	0.821	1.091	0.724
TH	13.95	37.20	28.06	23.39	9.27	42.13	42.44	44.72	25.74
ZN	87.80	84.20	115.90	124.90	53.80	176.80	111.50	67.00	111.50
ZR	136.3	180.6	206.7	404.7	108.0	202.1	268.9	258.5	185.5
AL	96450	100334	89251	80871	116135	103358	93378	96123	91962
BA	629	586	614	451	561	524	337	362	444
CA	26347	25729	26036	24577	34291	15240	14584	13300	15720
DY	4.439	5.345	3.191	8.523	1.519	4.26	5.495	5.67	4.697
K	26509	25990	33433	23240	16307	29528	28599	21539	33187
MN	1125.9	1180.1	788.3	1360.9	711.5	717.1	811.8	661.1	753
NA	19217	19538	19954	25236	12551	15539	18527	24416	15658
TI	5023	5581	3783	3576	3783	3243	3718	3958	5008
V	154.2	155.6	85.9	113.3	136.9	88.8	171.2	93.8	158.3

Appendix A: Table A.1 Continued

Sherd#	**JEC121**	**JEC122**	**JEC123**	**JEC124**	**JEC125**	**JEC126**	**JEC127**	**JEC128**	**JEC129**
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	7	4.2	9.4	7.1	6.2	5.3	5.2	6.7	8.9
Rim Diam.	200	300	450	250	225	175	200	300	300
Rim Shape	2	3	3	3	2	3	3	3	3
Ext/Int Srf	S / S	R1 / R1	R0 / R0	S / R1	S / S	R0 / R1	R0 / R1	S / R1	S / R0
Temp D/Sz	1 / 2	2 / 3	1 / 1	1 / 2	1 / 2	2 / 2	1 / 2	1 / 1	2 / 2
Org / Mica	3 / 2	1 / 2	1 / 3	2 / 3	4 / 1	0 / 3	0 / 5	1 / 1	0 / 2
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / 4	0 / 4	0 / -	0 / -	1 / -	0 / -	0 / -	0 / 1	0 / -
Lip Sh/Lat	3 / -	2 / -	1 / 1	1 / -	3 / -	2 / -	3 / -	3 / -	1 / 1
Ch. Group	SOV1B	SOV1A	SOV2	SOV2	SOV1B	WSC	SOV1B	SOV1B	SOV2
AS	27.60	14.56	12.86	15.57	28.18	8.28	26.75	15.36	9.19
LA	73.84	96.59	40.29	48.00	63.96	25.58	54.89	53.84	45.88
LU	0.386	0.898	0.296	0.384	0.375	0.199	0.374	0.298	0.346
ND	52.63	67.39	33.57	37.63	42.66	20.51	38.83	31.83	40.33
SM	8.03	11.18	5.89	7.00	7.48	3.96	6.66	6.02	6.52
U	8.247	13.12	4.69	6.045	7.941	2.659	8.783	4.21	4.961
YB	2.16	5.642	1.792	2.231	2.092	1.226	1.964	1.921	2.054
CE	121.82	156.04	77.79	84.60	105.34	46.64	81.84	89.59	86.64
CO	10.34	11.80	13.37	17.52	10.29	23.99	8.53	10.78	13.84
CR	21.57	18.09	29.93	37.51	21.21	49.09	10.96	21.74	31.18
CS	8.595	4.762	2.935	3.704	8.514	3.666	11.124	9.218	2.82
EU	1.478	1.638	1.291	1.504	1.36	1.053	1.394	1.128	1.42
FE	75253	46019	45862	58006	76709	50643	47199	53483	46614
HF	12.75	13.36	5.58	9.14	10.70	3.63	5.95	6.39	6.85
RB	99.4	83.6	88.7	80.2	110.2	71	138.3	128.7	87.8
SB	1.886	1.218	0.451	0.685	1.856	0.484	2.099	1.396	0.467
SC	9.10	11.80	11.65	16.33	8.30	12.69	14.95	9.43	11.95
SR	376.6	266.3	536.9	529.7	419	609.9	370.1	403.6	745.9
TA	1.560	2.314	1.298	1.357	1.358	0.713	0.865	1.279	1.466
TB	0.762	1.405	0.526	0.711	0.707	0.383	0.667	0.629	0.676
TH	41.23	34.52	16.15	23.16	33.16	11.84	21.59	26.99	21.52
ZN	111.30	97.40	65.70	82.60	101.30	58.90	119.50	92.10	64.10
ZR	311.9	399.6	150.4	201.7	279.7	126.7	194.5	131.7	171.9
AL	88454	84152	95925	105255	86240	104776	106512	81542	97886
BA	417	336	733	728	406	685	670	493	757
CA	24250	15652	24348	28448	16920	32437	15539	14072	22123
DY	4.012	8.429	3.721	4.266	3.176	2.565	3.829	3.39	3.271
K	22420	23498	24725	24220	27894	16621	26630	34356	24482
MN	754.9	1374.2	749.6	975.1	817.2	743.4	697.8	624.6	824
NA	19146	23782	21674	17931	17791	13540	18169	18902	22783
TI	3721	4448	4753	5166	4363	7145	3761	3741	4729
V	152.8	75.8	123.2	174.2	151.2	159.5	129.0	79.1	130.1

Appendix A: Table A.1 Continued

Sherd#	**JEC130**	**JEC131**	**JEC132**	**JEC133**	**JEC134**	**JEC135**	**JEC136**	**JEC137**	**JEC138**
Region Col	PF	PF	PF	PF	PF	PF	PF	PF	PF
Site	Iny-3595	Iny-3603	Iny-3605	4-c-10b	5-u-21	Iny-4760	Iny-3607	6-q-4	Iny-3605
Sherd type	rim	rim	rim	rim	body	body	body	body	body
Thickness	4.2	9.1	5.5	7.9	6.2	6.7	5.4	4.4	4.4
Rim Diam.	300	350	150	250	350		300	250	200
Rim Shape	3	2	5	5					
Ext/Int Srf	R1 / R1	R1 / R1	S / R1	S / S	- / -	- / -	- / -	R1 / S	S / R2
Temp D/Sz	2 / 3	2 / 3	2 / 2	1 / 1	2 / 3	1 / 2	2 / 3	2 / 3	2 / 3
Org / Mica	0 / 1	0 / 1	0 / 0	2 / 1	0 / 3	2 / 1	0 / 1	0 / 0	0 / 2
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	1 / -	0 / 4	0 / -	0 / -	1 / -	0 / -	0 / -	0 / -	0 / -
Lip Sh/Lat	2 / 1	3 / -	3 / -	2 / -	- / -	- / -	- / -	- / -	- / -
Ch. Group	NOV1A	NOV1A	NTS1B	Ungrp.	NOV1C	SOV1D	NOV1B	COV1	WSA
AS	9.79	11.54	3.76	4.84	7.11	8.72	9.18	4.41	0.00
LA	48.31	45.23	31.93	59.44	57.97	53.37	48.64	30.59	17.63
LU	0.639	0.571	0.28	0.344	0.718	0.374	0.411	0.299	0.206
ND	36.33	39.51	30.73	42.51	51.38	33.10	40.98	22.98	16.86
SM	8.34	8.24	4.46	7.27	10.24	7.02	7.38	4.69	3.44
U	8.759	8.053	3.544	3.507	9.503	9.156	4.377	6.206	1.619
YB	4.029	3.628	1.687	2.233	5.011	2.021	2.884	1.642	1.379
CE	79.32	72.10	56.08	90.43	88.48	86.63	96.24	63.75	33.08
CO	13.65	16.21	4.14	9.98	15.29	13.95	10.94	14.01	7.25
CR	36.06	51.89	21.61	46.48	23.27	24.54	29.03	25.10	16.40
CS	2.956	3.095	3.296	3.658	2.607	6.817	4.193	2.143	1.627
EU	1.252	1.348	0.68	1.335	1.596	1.28	1.363	0.968	1.5
FE	47150	53801	16682	29989	47446	46566	42066	43273	41841
HF	8.19	7.08	5.24	6.65	4.63	5.30	8.90	5.13	5.80
RB	83.7	71.5	112.9	104.5	75.5	113.4	89.6	84.7	28.9
SB	0.805	0.987	0.821	0.734	0.638	0.863	0.88	0.412	0.127
SC	12.76	16.12	8.71	10.29	16.67	11.24	11.49	11.92	10.31
SR	284.6	363.3	69.6	278.1	363.1	444.5	342.5	259.1	602.9
TA	1.454	1.547	2.957	1.862	3.238	1.406	1.342	1.021	0.541
TB	1.050	0.977	0.382	0.763	1.380	0.671	0.817	0.416	0.440
TH	20.33	17.33	23.27	19.89	18.99	34.14	14.51	20.06	3.91
ZN	84.80	71.10	61.90	77.60	80.70	95.60	85.60	45.40	104.40
ZR	250.0	247.7	100.2	136.6	149.4	190.3	234.9	154.3	173.8
AL	107231	101091	90346	87250	99809	96140	94169	99547	104881
BA	709	811	406	811	880	573	657	873	254
CA	13731	19204	4854	15479	19282	19358	16725	9804	37653
DY	6.575	5.4	2.438	4.616	7.644	3.02	4.475	2.905	2.488
K	22490	16820	17668	24525	26885	20861	28334	31243	8792
MN	724.5	604.6	210.8	546.9	930	803	657.4	514.6	888.4
NA	13523	14484	8011	12149	12293	16506	21406	12606	26302
TI	3333	3975	1559	4288	3952	5667	4232	4065	4608
V	136.0	156.8	39.7	75.3	148.1	102.3	89.7	114.9	52.3

Appendix A: Table A.1 Continued

Sherd#	JEC139	JEC140	JEC141	JEC142	JEC143	JEC144	JEC145	JEC146	JEC147
Region Col	PF	PF	DSV	DSV	DSV	DSV	DSV	DSV	DSV
Site	Iny-3605	Iny-3605	A16/1	Iny-3726	Iny-3721	A13/1	A48/1	B243/1	A56/1
Sherd type	body	body	rim	rim	rim	rim	rim	rim	rim
Thickness	6.6	4.4	4.8	4.6	5.5	6.5	6	5.5	5.6
Rim Diam.	250	275	250	275	350	200	200	225	175
Rim Shape			3	1	3	3	3	5	4
Ext/Int Srf	R3 / R0	- / -	R4 / R1	S / R1	R2 / R1	R0 / -	R3 / R1	S / R1	- / S
Temp D/Sz	1 / 2	3 / 3	1 / 2	1 / 1	1 / 1	2 / 3	2 / 3	1 / 2	3 / 3
Org / Mica	2 / 1	0 / 1	0 / 3	0 / 3	0 / 1	0 / 0	0 / 4	0 / 3	0 / 0
Decorated	0	0	0	0	0	0	0	0	1
Core/Coil	1 / 4	0 / 4	0 / 2	0 / 2	0 / 4	0 / -	0 / 2	1 / -	0 / -
Lip Sh/Lat	- / -	- / -	3 / -	3 / -	3 / -	3 / -	3 / -	3 / -	3 / -
Ch. Group	NOV1B	COV1	NOV1A	NOV1A	4D	NTS1A	NOV1A	4D	Ungrp.
AS	9.27	6.28	10.20	14.02	14.42	8.40	10.17	20.27	4.94
LA	57.62	35.50	57.50	64.65	52.61	63.69	61.57	68.79	33.34
LU	0.479	0.372	0.601	0.758	0.251	0.31	0.723	0.314	0.303
ND	43.29	28.94	43.81	59.86	38.97	39.25	47.20	52.92	30.91
SM	8.24	5.58	9.05	10.65	6.62	7.35	10.65	8.49	6.21
U	5.557	7.295	7.121	10.789	3.962	3.457	9.487	3.319	4.312
YB	3.254	1.88	3.851	4.688	1.606	2.02	5.132	2.109	2.085
CE	107.75	64.53	92.48	94.86	101.23	121.29	85.61	116.55	65.96
CO	12.68	13.89	16.22	19.73	12.88	8.68	16.51	12.56	17.80
CR	37.86	26.27	36.48	43.35	40.86	37.47	42.51	42.70	27.17
CS	4.652	2.698	3.346	3.9	5.118	4.786	2.97	5.265	2.534
EU	1.453	1.098	1.425	1.584	1.426	1.053	1.611	1.713	1.219
FE	45838	48185	50091	58849	48066	26173	55106	55051	47419
HF	8.72	4.01	4.95	8.60	8.26	7.64	6.51	8.88	6.10
RB	99	82	66.7	69.2	92.1	147.4	61.4	90.1	86.3
SB	1.099	0.556	0.944	1.04	1.187	1.119	0.973	1.299	0.567
SC	12.43	12.57	14.52	15.99	10.21	8.56	14.87	11.59	12.12
SR	289.1	286.5	251	482.6	816	386.3	385.1	930.9	392.2
TA	1.515	0.913	1.354	1.335	1.101	1.491	1.368	1.237	0.808
TB	0.970	0.546	1.119	1.389	0.575	0.716	1.321	0.794	0.674
TH	16.65	27.89	22.63	30.98	15.29	29.73	26.12	22.92	16.69
ZN	108.40	64.60	69.20	100.90	86.80	77.00	77.40	101.60	59.00
ZR	272.8	120.4	168.0	267.2	239.0	210.9	210.3	242.5	169.3
AL	89422	102005	108519	108459	97087	88564	101793	96145	96574
BA	655	715	613	681	1000	585	596	756	678
CA	19442	15725	23765	26183	18969	24632	20909	24743	24349
DY	4.595	3.007	5.875	8.019	2.719	3.164	8.117	4.562	3.708
K	25083	26620	22122	18235	24159	27152	23872	23219	24865
MN	848	695	671.6	951.2	453.5	466.6	878.9	493.1	767.7
NA	20001	12998	17302	17454	16956	18495	14859	15981	13485
TI	5842	3266	4220	5157	4859	3596	4784	4415	3081
V	105.0	127.9	143.5	188.7	127.2	53.9	152.4	126.9	127.5

Appendix A: Table A.1 Continued

Sherd#	**JEC148**	**JEC149**	**JEC150**	**JEC151**	**JEC152**	**JEC153**	**JEC154**	**JEC155**	**JEC156**
Region Col	DSV	DSV	DSV	DSV	DSV	DSV	DSV	DSV	NOV
Site	A56/1	A56/1	A56/1	A56/1	B243/1	B243/1	A38/1	A38/1	Iny-400
Sherd type	rim	rim	body	body	body	body	body	body	rim
Thickness	5.9	6.4	6.3	3.8	5.6	6	6.2	4.5	5.5
Rim Diam.	150	100	150	175			175		
Rim Shape	5	3							3
Ext/Int Srf	R0 / R1	R0 / S	S / S	S / S	S / S	S / S	R0 / R4	R0 / S	R3 / R3
Temp D/Sz	1 / 2	1 / 2	1 / 3	2 / 3	1 / 2	2 / 2	2 / 2	1 / 2	1 / 1
Org / Mica	0 / 0	0 / 1	0 / 2	0 / 0	0 / 1	0 / 4	0 / 2	2 / 1	0 / 2
Decorated	0	1	1	0	0	0	0	0	0
Core/Coil	1 / -	0 / -	0 / -	0 / 4	0 / -	0 / -	0 / 3	0 / -	0 / 2
Lip Sh/Lat	1 / -	1 / -	- / -	- / -	- / -	- / -	- / -	- / -	2 / 1
Ch. Group	Ungrp.	Ungrp.	Ungrp.	4D	NTS1B	Ungrp.	Ungrp.	Ungrp.	Ungrp.
AS	2.96	3.60	4.03	13.06	5.24	5.63	7.03	9.94	6.38
LA	58.36	32.34	59.70	60.06	70.64	70.06	50.57	46.34	66.48
LU	0.286	0.329	0.298	0.216	0.517	0.195	0.465	0.379	0.262
ND	42.87	28.94	45.47	42.69	48.01	64.34	35.87	37.17	42.91
SM	6.80	5.24	7.04	7.01	8.59	9.00	6.91	6.60	5.57
U	3.468	4.33	3.019	2.277	3.907	2.834	5.841	2.767	3.308
YB	1.993	2.002	1.95	1.63	3.575	1.27	2.79	2.514	1.696
CE	85.40	60.86	86.66	91.86	136.55	143.41	88.87	76.29	121.87
CO	11.23	14.10	10.50	11.16	6.24	18.79	15.97	13.77	6.90
CR	49.87	25.74	47.80	33.09	23.75	19.73	56.05	53.90	11.60
CS	3.51	2.412	3.647	3.376	9.683	3.164	4.287	5.073	16.292
EU	1.311	1.144	1.323	1.524	1.018	2.129	1.272	1.273	1.199
FE	30358	50754	30358	40336	25320	50496	56576	41490	31245
HF	7.44	5.15	7.36	6.02	9.83	4.68	8.95	7.52	7.25
RB	104.5	75.8	108.4	96.6	149	87.5	102.5	87	95.6
SB	0.798	0.504	0.856	1.232	0.899	0.421	0.632	1.166	0.653
SC	10.09	13.91	10.16	9.03	7.47	11.86	15.49	12.21	6.62
SR	413.2	461	297.2	896.6	303.4	1591.2	225.2	358.3	607.5
TA	1.456	0.827	1.543	1.011	2.106	1.101	1.400	1.472	1.332
TB	0.637	0.497	0.691	0.660	1.046	0.674	0.758	0.708	0.526
TH	17.11	13.47	16.07	15.86	31.55	10.52	33.04	16.43	21.66
ZN	77.70	48.90	87.50	80.10	80.40	96.50	82.20	93.30	66.60
ZR	208.6	102.4	204.7	137.5	250.5	155.7	236.4	172.0	188.4
AL	89342	99656	88313	87894	101354	90263	91945	91215	105233
BA	854	825	741	1098	560	1947	616	546	1574
CA	16855	32043	17224	20792	16082	25960	20478	18289	21204
DY	3.593	3.036	3.912	3.222	5.35	3.013	4.425	4.431	2.958
K	30503	22899	28883	33104	35093	30831	24971	26212	21665
MN	757.5	744.5	587.5	413.6	723.9	875.7	929.6	636	396.6
NA	16160	13639	14603	18444	14897	20046	16816	12660	20114
TI	3265	3767	4050	4350	1734	4296	5394	4743	2835
V	74.1	116.2	73.0	98.0	43.6	100.3	147.8	96.6	50.3

Appendix A: Table A.1 Continued

Sherd#	**JEC157**	**JEC158**	**JEC159**	**JEC160**	**JEC161**	**JEC162**	**JEC163**	**JEC164**	**JEC165**
Region Col	NOV	NOV	NOV	NOV	NOV	NOV	NOV	NOV	NOV
Site	Mno-1991	Mno-2581	Mno-2596	Iny-3387	Mno-2596	Mno-2596	Mno-2648	Iny-1994	Mno-6
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	6.7	6.7	7.8	5.3	8.9	7.2	6.2	6.7	5.5
Rim Diam.	150	225	150	400	150	300	225	175	350
Rim Shape	3	3	5	3	3	3	3	3	3
Ext/Int Srf	R1 / R1	R1 / R2	S / R0	R1 / R1	R3 / R1	R4 / R3	R1 / R2	R1 / R0	R1 / R1
Temp D/Sz	3 / 3	1 / 2	2 / 1	2 / 2	1 / 2	2 / 2	2 / 3	2 / 2	1 / 2
Org / Mica	1 / 4	0 / 3	0 / 4	0 / 1	0 / 2	1 / 2	0 / 4	0 / 3	0 / 4
Decorated	0	1	0	0	0	0	0	0	0
Core/Coil	0 / 2	0 / 2	0 / -	0 / 2	0 / -	1 / 4	1 / 2	0 / -	0 / 4
Lip Sh/Lat	4 / -	2 / 1	3 / -	3 / -	3 / -	3 / -	3 / -	5 / 1	2 / 1
Ch. Group	Ungrp.	NOV1A	Ungrp.	NOV1A	Ungrp.	4D	NOV1A	NOV1A	NOV1A
AS	10.06	15.06	6.13	12.17	7.04	10.65	11.55	12.78	10.76
LA	43.82	57.54	73.81	49.28	76.79	58.06	54.61	49.53	56.76
LU	0.349	0.753	0.16	0.603	0.261	0.207	0.611	0.643	0.659
ND	30.63	49.69	67.70	39.48	65.03	38.33	50.89	39.11	51.73
SM	5.90	9.87	9.19	7.93	9.48	6.19	8.96	8.51	9.35
U	4.782	10.506	1.85	6.071	2.934	2.276	7.158	9.494	7.913
YB	1.933	4.546	1.421	3.904	1.546	1.637	4.001	3.943	4.164
CE	69.86	94.80	140.61	93.30	144.50	91.41	81.73	82.96	94.65
CO	11.63	18.86	18.62	15.55	12.19	8.51	15.68	15.63	16.65
CR	22.03	40.89	18.48	39.35	28.84	19.17	32.79	36.68	35.93
CS	8.817	4.339	3.465	3.633	3.294	4.203	3.829	3.244	4.282
EU	1.296	1.536	2.087	1.276	2.199	1.242	1.405	1.372	1.496
FE	53096	56638	50671	51011	59883	34334	49312	50572	51922
HF	6.21	8.71	4.58	7.50	9.27	6.19	5.73	6.64	6.32
RB	137.4	84.5	92.7	93.7	94.4	114.3	79.3	76.1	82.7
SB	1.05	1.258	0.434	1.14	0.736	0.811	0.927	1.012	1.019
SC	13.10	15.88	11.36	14.08	8.54	7.69	14.13	14.34	15.22
SR	659.3	333.4	1824.5	281.2	1251.4	500.9	466.6	339.7	416.7
TA	1.599	1.775	0.771	1.480	1.228	1.126	1.241	1.305	1.365
TB	0.596	1.362	0.612	1.010	0.732	0.604	1.132	1.106	1.160
TH	14.77	21.24	9.69	27.70	13.26	14.15	25.49	32.19	21.36
ZN	82.30	67.40	121.40	71.20	92.10	77.60	87.20	60.50	102.80
ZR	171.5	261.9	138.5	160.5	298.3	162.5	161.1	226.7	185.5
AL	98789	99928	97563	104397	90322	91362	104875	112647	111826
BA	684	721	1467	746	947	840	877	614	736
CA	19824	17555	31568	16211	26052	13928	22180	17653	21993
DY	4.189	7.765	2.847	5.149	4.037	3.479	6.573	6.932	6.595
K	21552	18750	27185	23603	26243	27358	23715	18773	20172
MN	397.9	951.4	747.3	852.2	524	372.2	697.1	701	857
NA	15953	16064	21695	16408	21703	15898	15955	15431	16083
TI	3920	4344	5191	3855	5107	3231	4388	3716	4681
V	84.6	161.0	122.9	134.8	144.4	75.5	151.4	152.9	124.9

Appendix A: Table A.1 Continued

Sherd#	**JEC166**	**JEC167**	**JEC168**	**JEC169**	**JEC170**	**JEC171**	**JEC172**	**JEC173**	**JEC174**
Region Col	NOV	NOV	NOV	NOV	NOV	NOV	NOV	NOV	NOV
Site	Mno-6	Mno-1753	Mno-2189	Mno-2189	Mno-2189	Mno-2190	Mno-2190	Mno-2190	Mno-1878
Sherd type	body	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	9.5	5.8	8.9	6.4	6.8	6.6	5.7	6	6.3
Rim Diam.	250	350	175	400	350	100	400	300	225
Rim Shape		3	4	3	3	5	3	3	3
Ext/Int Srf	R1 / R2	R1 / R0	R1 / S	R1 / S	R1 / R1	R1 / S	R1 / S	R0 / R1	R1 / R1
Temp D/Sz	2 / 2	2 / 3	2 / 2	2 / 2	2 / 2	1 / 2	1 / 2	2 / 3	2 / 3
Org / Mica	0 / 0	0 / 2	2 / 4	0 / 1	0 / 2	1 / 0	0 / 3	0 / 2	2 / 2
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / 4	0 / -	0 / 1	0 / -	1 / 2	0 / -	0 / 4	0 / -	1 / -
Lip Sh/Lat	- / -	3 / -	3 / 1	3 / 1	3 / -	3 / -	3 / -	3 / -	3 / 1
Ch. Group	NTS1B	NOV1A	NOV1A	Ungrp.	NOV1B	NTS1A	NOV1A	NOV1B	NOV1B
AS	3.60	12.07	11.45	19.19	9.96	7.25	16.39	6.72	8.67
LA	64.76	45.80	47.62	27.39	41.89	40.77	63.63	32.40	43.37
LU	0.456	0.573	0.573	0.332	0.413	0.374	0.861	0.265	0.473
ND	44.34	37.50	38.36	22.79	36.23	32.23	55.62	24.48	37.82
SM	8.01	7.49	7.79	4.92	6.77	5.72	11.47	4.64	8.62
U	7.902	6.424	5.347	3.7	6.119	3.902	11.638	5.395	5.756
YB	2.657	3.6	4.058	2.152	2.551	2.411	5.351	1.471	3.203
CE	117.02	80.02	75.46	51.56	80.10	73.62	107.80	50.89	80.53
CO	7.44	14.68	16.45	9.86	12.49	5.70	21.68	8.89	9.61
CR	20.42	40.02	27.29	26.59	20.13	27.66	55.37	16.66	19.34
CS	4.212	3.465	2.741	8.563	5.655	9.53	4.558	4.36	4.737
EU	1.155	1.256	1.488	1.101	1.126	0.943	1.697	0.776	1.507
FE	41054	50217	48628	38336	43422	26116	66275	37506	42812
HF	18.85	5.38	5.64	4.87	4.20	6.47	8.83	3.87	4.61
RB	154.8	92.1	67.2	142.8	134.8	169.6	70.7	112.9	103.5
SB	1.039	1.101	0.822	1.242	0.837	1.494	1.303	0.679	0.637
SC	9.27	13.84	14.65	9.85	11.22	8.72	19.23	9.96	10.68
SR	369.9	378.8	479.1	534.8	416.7	371.7	333.8	316.2	314.3
TA	1.675	1.230	1.030	1.417	1.359	1.384	1.580	1.105	2.067
TB	0.820	0.926	1.091	0.626	0.729	0.700	1.602	0.456	1.178
TH	48.12	19.05	15.32	10.96	18.25	19.73	37.59	15.05	18.23
ZN	49.80	62.40	69.50	112.20	129.00	91.00	78.80	125.00	120.20
ZR	461.1	165.2	187.4	141.8	134.0	172.7	265.1	124.3	142.9
AL	86201	101595	103583	93221	98810	91443	113825	88198	93119
BA	605	693	889	835	607	747	577	446	730
CA	19789	19605	22587	17557	17534	11424	18697	16977	19928
DY	5.297	6.353	5.483	2.633	4.841	3.959	9.061	2.964	5.015
K	34415	23334	19484	28253	24372	29310	13465	31881	22229
MN	456.7	729.8	725.5	796.7	830.2	466.7	1121.5	614	741.6
NA	17836	15280	16376	18658	15549	13575	15586	15456	15018
TI	4377	4567	4194	3997	3502	2802	4493	3223	3794
V	121.6	146.6	153.3	105.3	86.4	54.0	209.1	72.4	98.9

Appendix A: Table A.1 Continued

Sherd#	**JEC175**	**JEC176**	**JEC177**	**JEC178**	**JEC179**	**JEC180**	**JEC209**	**JEC211**	**JEC212**
Region Col	NOV	NOV	NOV	NOV	SOV	SOV	SOV	SOV	SOV
Site	Mno-1878	Mno-1878	Mno-1878	Mno-1878	N9/1	Iny-3769	Iny-5207	Iny-5207 L1	Iny-5207 L1
Sherd type	rim	rim	body	body	body	body	body	body	body
Thickness	5.1	5.6	6	6.1	5.1	5.3	5.8	6.7	6.8
Rim Diam.	250	400			250	350			
Rim Shape	4	2			3	3			
Ext/Int Srf	R1 / R0	R1 / R0	S / R0	S / R0	R2 / R1	R1 / R3	- / -	- / -	- / -
Temp D/Sz	2 / 3	2 / 2	1 / 3	2 / 3	3 / 1	2 / 3	- / -	1 / 1	1 / 1
Org / Mica	0 / 0	0 / 0	0 / 1	2 / 0	0 / 3	2 / 0	0 / 1	0 / 2	0 / 4
Decorated	1	0	0	0	0	0	0	0	0
Core/Coil	0 / -	1 / -	1 / -	0 / -	0 / -	0 / -	0 / -	0 / -	1 / -
Lip Sh/Lat	2 / -	3 / -	- / -	- / -	3 / -	2 / -	- / -	- / -	- / -
Ch. Group	COV1	NOV1B	NOV1B	NOV1B	Ungrp.	SOV1C	SOV1B	Ungrp.	SOV2
AS	7.07	9.17	8.37	8.02	15.24	11.45	31.16	11.50	10.59
LA	33.17	42.30	42.93	46.85	47.85	78.84	60.90	55.66	48.37
LU	0.346	0.342	0.365	0.424	0.392	0.457	0.277	0.243	0.309
ND	26.84	30.55	29.19	40.87	33.19	50.85	53.42	28.88	37.25
SM	5.12	5.41	5.86	7.77	6.47	7.63	6.27	5.81	6.17
U	6.082	5.544	5.6	5.898	8.095	6.576	5.122	8.097	4.648
YB	1.908	2.098	2.272	2.915	2.108	2.885	1.564	1.105	1.821
CE	65.62	69.65	70.88	84.37	90.31	131.34	99.07	89.89	86.97
CO	14.75	9.82	12.26	9.55	14.48	9.17	7.81	5.80	17.54
CR	27.97	19.04	19.94	18.69	28.16	32.47	19.79	10.28	34.42
CS	4.647	5.09	5.122	5.298	3.373	6.7	8.556	6.06	3.389
EU	1.128	0.991	1.028	1.273	1.309	1.236	1.22	1.169	1.327
FE	49950	43467	46762	43581	48202	44223	56709	31650	52476
HF	4.14	5.29	5.16	4.88	7.82	8.98	8.93	5.34	6.36
RB	105.8	105.3	100	112.7	90.9	113.2	102	121.6	88.2
SB	0.625	0.702	0.747	0.689	0.643	1.304	2.028	1.446	0.533
SC	13.06	10.48	11.23	10.65	12.96	11.85	8.47	6.49	14.15
SR	327.3	279.3	374.5	344.3	473.5	406.2	483.9	557.5	615.7
TA	0.828	1.205	1.051	1.975	1.759	1.841	1.257	0.885	1.158
TB	0.551	0.722	0.735	1.039	0.667	0.777	0.365	0.210	0.278
TH	27.67	16.89	17.04	18.32	34.63	31.85	29.65	42.36	20.80
ZN	70.60	125.90	126.60	118.50	75.70	95.30	101.10	75.40	77.80
ZR	107.7	148.3	125.6	123.2	207.3	234.2	207.3	140.8	168.7
AL	103814	101492	98827	89942	95371	84289	94239	88218	101111
BA	1093	693	839	857	701	549	578	696	647
CA	14224	20331	19650	20962	22818	17072	21015	19686	24969
DY	2.811	3.711	3.405	4.881	3.512	4.245	2.567	1.933	3.018
K	25532	22529	22712	22088	19665	25883	24684	24749	22258
MN	685	917.9	819.6	656.1	801	653.7	531.9	440	891.5
NA	10740	15597	15747	15366	17827	18126	21635	23773	20248
TI	3420	3352	3618	3466	4455	3651	3099	2706	4474
V	134.9	107.8	96.3	100.1	145.6	112.0	123.6	73.1	159.0

Appendix A: Table A.1 Continued

Sherd#	**JEC213**	**JEC214**	**JEC215**	**JEC216**	**JEC217**	**JEC218**	**JEC219**	**JEC220**	**JEC221**
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-5207 L1	Iny-5207 L4	Iny-5076	Iny-5075	Iny-2	Iny-2	Iny-2	Iny-2	Iny-3769
Sherd type	body	body	body	body	body	body	body	body	body
Thickness	5.8	7.1	5.5	5.1	4.3	3.7	5.7	6.5	5.6
Rim Diam.							225	150	200
Rim Shape									
Ext/Int Srf	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -
Temp D/Sz	1 / 1	2 / 3	2 / 3	2 / 2	2 / 2	1 / 2	1 / 1	2 / 2	1 / 2
Org / Mica	0 / 2	0 / 0	0 / 1	0 / 3	2 / 1	0 / 0	0 / 1	0 / 1	0 / 1
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	1 / -	0 / -	0 / -	0 / -	0 / -	0 / -	1 / -	0 / 4	0 / 4
Lip Sh/Lat	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -
Ch. Group	SOV2	SOV1B	SOV1A	SOV2	15	SOV1B	SOV1A	SOV1A	SOV1B
AS	14.58	27.85	13.52	17.88	6.85	23.93	16.11	14.85	18.22
LA	38.90	61.08	68.02	42.56	37.92	73.41	102.95	76.40	59.73
LU	0.314	0.444	0.685	0.332	0.367	0.372	1.096	0.969	0.6
ND	33.60	70.13	86.04	31.61	31.77	49.66	66.93	53.95	74.21
SM	5.97	7.40	7.28	5.73	5.60	7.81	13.61	10.59	9.02
U	5.328	5.903	9.708	6.684	2.986	5.717	16.755	25.879	9.055
YB	1.849	2.694	3.878	1.81	2.246	2.159	6.51	4.946	3.715
CE	74.12	107.61	117.51	78.87	70.53	107.36	181.72	139.32	120.85
CO	18.41	6.83	8.05	14.16	21.12	8.88	11.29	7.80	12.50
CR	36.96	21.40	15.52	24.03	68.30	16.09	22.93	14.10	24.82
CS	3.678	7.718	3.552	3.144	2.125	6.661	6.34	4.209	8.355
EU	1.346	1.293	1.03	1.171	1.31	1.452	1.877	1.312	1.572
FE	57975	43232	36303	44842	59916	44452	54705	52861	44513
HF	8.51	6.76	10.45	6.63	8.09	7.31	17.51	13.70	10.92
RB	87.3	123.4	130.3	98.8	65.3	102.2	115.1	88.3	124.1
SB	0.609	3.084	1.121	0.676	0.483	1.808	1.096	0.713	1.531
SC	15.73	10.64	7.54	12.04	18.63	9.24	13.81	10.89	10.50
SR	553.3	821.1	240.3	396	656	489	453.9	298.4	813.9
TA	1.263	1.673	2.081	1.531	0.987	1.260	2.940	2.562	1.828
TB	0.282	0.407	0.778	0.267	0.834	0.354	0.807	0.592	0.503
TH	13.72	31.50	43.96	17.74	13.79	29.10	52.45	34.73	24.83
ZN	80.70	66.40	47.60	63.90	74.50	88.50	108.80	70.60	79.30
ZR	211.6	171.8	256.1	168.0	168.9	172.4	411.0	406.9	280.8
AL	107890	83101	86383	93345	89424	102973	89249	86122	83530
BA	616	537	280	547	719	667	601	426	701
CA	25120	19654	11745	20731	30648	15643	20155	15972	24685
DY	2.871	4.338	5.339	2.51	3.971	4.072	10.327	6.764	6.154
K	21935	28081	27966	21445	19278	20987	22033	20346	27698
MN	925.5	593.7	922.2	740.8	1066.9	681.7	1650.3	1065.8	963
NA	17642	20315	24753	18765	17817	20623	23862	24324	23121
TI	5008	4401	3329	4071	5809	3689	5382	4153	4534
V	153.8	79.7	79.5	145.5	173.7	94.5	125.2	52.2	100.6

Appendix A: Table A.1 Continued

Sherd#	**JEC222**	**JEC223**	**JEC224**	**JEC225**	**JEC226**	**JEC227**	**JEC228**	**JEC229**	**JEC233**
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	CaC-4	CaC-3	CaC-2	CC-4	CC-3; Loc.2	CC-3, Loc1	AC-S-4	CaC-1, Loc 2	CaC-1, Loc 2
Sherd type	body	body	body	body	body	body	body	body	body
Thickness	7.1	7	9	7.5	7.1	6.8	9		
Rim Diam.	275	175	250	150			350		
Rim Shape									
Ext/Int Srf	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -	C / -
Temp D/Sz	2 / 3	3 / 2	2 / 3	2 / 3	1 / 1	2 / 3	1 / 1	1 / 1	1 / 3
Org / Mica	2 / 1	2 / 0	0 / 1	0 / 1	4 / 2	0 / 0	0 / 2	0 / 3	0 / 0
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / -	0 / -	0 / -	0 / -	1 / -	0 / -	0 / 2	- / -
Lip Sh/Lat	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -
Ch. Group	Ungrp.	Ungrp.	SOV1A	SOV1C	Ungrp.	SOV1C	Ungrp.	SOV2	Ungrp.
AS	100.04	45.54	9.75	12.31	11.26	7.97	29.09	12.27	6.03
LA	61.25	51.11	64.75	60.93	42.65	40.37	42.01	43.15	36.60
LU	0.547	0.463	0.661	0.38	0.348	0.395	0.397	0.356	0.685
ND	65.49	52.30	36.08	51.60	62.55	32.40	33.09	31.31	41.41
SM	8.11	6.31	7.28	6.30	6.49	5.48	6.69	6.42	7.55
U	8.478	10.915	17.087	8.06	6.401	4.991	6.252	7.574	3.782
YB	3.184	2.451	3.248	2.109	1.984	2.244	2.105	1.972	4.899
CE	109.48	85.74	110.58	85.02	83.36	73.70	86.97	84.47	71.87
CO	11.89	6.39	7.72	9.67	18.89	6.21	17.43	17.19	9.44
CR	26.52	21.39	16.43	18.65	34.78	10.93	37.24	37.38	57.77
CS	12.7	9.573	6.065	4.731	3.647	2.597	6.533	3.311	3.867
EU	1.479	0.995	1.058	1.195	1.351	1.073	1.431	1.44	1.639
FE	48807	40080	32397	45729	53951	35422	56728	59095	68517
HF	10.32	7.53	8.02	5.72	7.27	5.78	8.70	8.58	20.16
RB	121.5	105.2	145.8	101.5	72	91.6	99.6	81.6	115.1
SB	7.66	5.748	0.901	0.949	0.799	0.859	3.97	0.575	0.716
SC	12.25	10.18	9.21	11.47	13.32	8.63	14.35	15.43	16.96
SR	573.9	507.2	433.6	449.7	589.4	340.7	726.6	600.1	253.9
TA	1.731	1.575	2.042	1.115	1.380	1.408	1.452	1.305	2.051
TB	0.947	0.303	0.499	0.296	0.311	0.324	0.315	0.317	0.518
TH	23.77	37.24	58.41	23.87	28.97	16.51	28.32	33.13	13.05
ZN	80.40	62.80	69.10	68.00	67.60	53.70	87.00	80.00	45.10
ZR	237.8	200.2	241.6	149.9	164.8	172.0	211.7	212.9	441.6
AL	91555	83112	88042	98195	97916	100078	96184	103558	65559
BA	862	338	461	530	683	723	536	608	1497
CA	24139	21163	16128	18560	25563	10924	38911	29160	17519
DY	5.125	3.942	3.979	3.346	3.946	3.783	3.693	3.808	6.992
K	31033	26287	27292	25539	18299	30336	16718	20748	28681
MN	986.1	482.1	812.1	696.7	828	539.9	872.2	917.2	121
NA	21896	21860	26114	17265	17391	19739	22234	19000	3601
TI	4978	3641	2276	3809	5420	3015	5625	5538	16915
V	95.7	80.4	66.6	105.4	140.6	82.7	139.9	158.2	230.8

Appendix A: Table A.1 Continued

Sherd#	**JEC235**	**JEC236**	**JEC237**	**JEC238**	**JEC239**	**JEC240**	**JEC241**	**JEC242**	**JEC243**
Region Col	FTI	FTI	FTI	FTI	FTI	FTI	FTI	FTI	FTI
Site	Sbr-4170	Sbr-4170	Sbr-4170	Armor Car	Sbr-6218	Sbr-4170	Sbr-4170	Sbr-4170	Sbr-4213
Sherd type	body	rim	body	body	body	body	body	body	body
Thickness	6.7	6.5	3.5	7.0	5.7	7.2	6.2	7.6	6.3
Rim Diam.	250	175	150	250	300	175	200	225	100
Rim Shape		4			5				
Ext/Int Srf	R0 / R0	R0 / R1	S / S	R0 / R0	R0 / S	R1 / R1	R0 / R1	S / S	R0 / R0
Temp D/Sz	2 / -	3 / -	3 / -	3 / -	3 / -	1 / -	1 / -	2 / -	2 / -
Org / Mica	0 / 1	2 / 1	0 / 1	0 / 0	0 / 0	0 / 1	1 / 1	2 / 2	0 / 0
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / -	1 / -	0 / -	0 / -	0 / -	0 / -	1 / -	0 / -
Lip Sh/Lat	- / -	5 / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -
Ch. Group	11	11	Ungrp.	12	Ungrp.	11	11	Ungrp.	12
AS	10.35	7.06	9.24	16.49	3.74	9.70	10.53	25.02	13.09
LA	63.79	70.09	64.23	62.30	28.70	68.37	66.02	103.49	56.63
LU	0.481	0.517	0.412	0.464	0.532	0.480	0.492	0.692	0.473
ND	48.04	50.96	51.81	44.59	22.59	64.94	52.18	97.93	40.62
SM	8.62	9.32	8.61	7.86	6.46	9.32	9.14	17.76	7.87
U	5.059	5.101	4.767	4.536	3.184	5.785	5.066	3.147	4.004
YB	3.464	3.601	2.362	3.198	4.035	3.579	3.67	5.366	3.259
CE	125.56	135.28	130.49	115.03	58.05	132.93	133.08	195.17	113.81
CO	7.52	7.37	8.52	7.82	10.43	6.89	7.31	3.34	7.21
CR	27.28	29.66	45.99	30.47	54.25	27.02	29.88	23.08	29.05
CS	4.08	3.983	6.8	4.539	4.506	3.953	4.283	15.735	4.304
EU	1.197	1.192	1.273	1.243	1.394	1.193	1.271	1.858	1.071
FE	30989	32263	27099	30227	43548	31322	33067	25977	31931
HF	10.54	9.65	5.98	10.00	9.94	9.05	8.51	7.84	9.88
RB	91.2	86.8	145.7	120.9	107.8	86.5	93.7	238.8	118.4
SB	0.937	0.755	0.760	0.834	0.554	0.920	0.897	2.753	0.938
SC	9.46	9.66	9.37	9.02	14.35	9.67	9.91	10.73	9.01
SR	195	142.3	246.9	196.4	157.7	215.2	175.7	80.1	206.8
TA	1.838	1.915	1.084	1.654	1.230	1.858	2.117	1.537	1.701
TB	1.015	1.068	0.799	0.889	0.927	0.994	1.035	1.957	0.923
TH	26.86	28.29	27.56	20.30	8.97	28.19	28.46	37.99	25.74
ZN	60.00	63.30	65.60	71.10	31.60	63.00	62.20	37.80	78.40
ZR	259.3	238.5	159.4	289.2	288.3	221.5	201.4	217.0	276.8
AL	84891	85473	82315	84764	66767	90715	86162	85306	79826
BA	517.4	480.5	776.7	688.4	4174.9	561.4	430.2	676.0	480.8
CA	9617	10430	35691	7817	59061	11444	11886	6108	8554
DY	5.34	5.368	3.802	4.386	5.638	5.613	5.075	9.717	3.895
K	23373	20961	31003	27336	26431	22355	22209	36853	30411
MN	461.6	477.5	523	607.5	182.4	483.4	441.4	141.3	554.3
NA	20475	19584	13454	19595	1768	20562	20001	11502	20937
TI	3234	3294	2028	3055	7868	3406	2449	2473	2610
V	61.5	69.9	80.3	67.0	121.6	66.6	60.4	53.5	52.5

Appendix A: Table A.1 Continued

Sherd#	JEC244	JEC245	JEC246	JEC247	JEC248	JEC249	JEC250	JEC251	JEC252
Region Col	FTI	FTI	FTI	FTI	FTI	FTI	FTI	FTI	FTI
Site	Sbr-4213	Sbr-6235	Sbr-6215	Sbr-111	Sbr-111	Sbr-6215	Sbr-6226	Sbr-5251	Sbr-5251
Sherd type	body	rim	body	body	body	body	body	body	rim
Thickness	6.2	7.3	6.8	5.2	4.7	6.8	6.9	4.5	5.3
Rim Diam.		225				325	175	275	250
Rim Shape		5							4
Ext/Int Srf	R0 / R0	R0 / S	S / S	R0 / S	R0 / S	R1 / -	R0 / R1	R5 / R0	- / R2
Temp D/Sz	2 / -	2 / -	2 / -	2 / -	3 / -	3 / -	2 / -	1 / -	2 / -
Org / Mica	0 / 1	0 / 1	0 / 1	1 / 1	0 / 3	2 / 1	0 / 2	0 / 0	0 / 1
Decorated	0	1	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / -	0 / -	0 / -	0 / -	0 / 2	0 / -	1 / -	1 / -
Lip Sh/Lat	- / -	5 / -	- / -	- / -	- / -	- / -	- / -	- / -	1 / 1
Ch. Group	11	17	17	12	11	17	11	10	10
AS	12.24	18.85	16.13	8.59	12.37	13.12	11.37	7.12	4.83
LA	52.74	53.83	65.50	48.07	45.20	60.58	52.25	52.77	45.71
LU	0.442	0.414	0.533	0.466	0.390	0.488	0.372	0.444	0.384
ND	38.95	39.38	50.71	40.17	33.42	46.98	42.40	43.73	44.18
SM	7.64	7.23	10.02	7.54	6.26	9.20	7.17	8.32	7.80
U	4.211	6.311	4.292	3.948	3.702	4.185	4.05	2.79	2.58
YB	3.208	2.851	4.083	3.372	2.68	3.674	2.61	2.932	2.786
CE	114.69	113.29	129.26	82.36	77.14	116.00	88.50	95.97	84.10
CO	7.25	10.52	10.01	5.03	4.88	10.29	5.10	12.73	12.04
CR	25.89	35.27	40.45	29.92	28.64	38.62	23.90	43.82	43.11
CS	4.208	5.361	5.69	4.176	3.731	5.288	4.217	3.358	3.01
EU	1.003	0.968	1.369	1.091	0.915	1.231	1.064	1.788	1.581
FE	34588	37015	43293	29018	29080	42889	27057	45610	44012
HF	10.29	9.93	10.11	8.61	10.04	9.23	7.54	8.73	8.84
RB	117.2	116.3	113.5	114.3	124.4	106	108	101.3	86.8
SB	0.965	1.513	1.133	0.798	0.651	1.125	0.768	0.615	0.510
SC	8.73	10.34	12.32	9.00	8.52	11.51	7.57	14.92	14.09
SR	233	272.1	300.9	167.2	224.1	272.1	265.3	1465.6	404
TA	1.603	1.945	1.817	1.294	1.522	1.621	1.670	1.099	1.039
TB	0.749	0.821	1.230	0.870	0.814	1.089	0.781	0.993	1.020
TH	21.97	26.17	28.63	18.26	19.74	25.80	22.82	15.01	13.97
ZN	86.10	90.60	89.00	56.70	56.20	91.70	53.40	67.20	67.50
ZR	252.8	231.1	231.2	210.5	267.5	269.5	200.8	247.1	235.5
AL	79193	94464	84478	81510	86694	85093	83649	96640	86761
BA	353.0	589.7	399.2	545.0	460.3	624.8	546.4	558.6	710.1
CA	7471	14026	17030	6960	12843	24044	8897	24432	22927
DY	4.405	3.755	5.625	4.821	3.503	5.917	3.726	4.991	4.764
K	28887	29068	24602	28470	34071	23284	30745	21197	18894
MN	573.8	852.4	678.9	252.7	405.5	756.4	407.2	690.2	653.2
NA	21511	13271	14799	10981	17125	14254	20708	20812	20435
TI	2245	3868	2636	2834	2549	3434	2278	3628	3901
V	56.4	73.6	86.7	59.5	47.1	81.9	45.8	121.6	118.6

Appendix A: Table A.1 Continued

Sherd#	**JEC253**	**JEC254**	**JEC255**	**JEC256**	**JEC257**	**JEC258**	**JEC259**	**JEC260**	**JEC261**
Region Col	FTI	FTI	FTI	FTI	FTI	FTI	FTI	FTI	FTI
Site	Sbr-5251	Sbr-5250	Sbr-4449	Sbr-4449	Sbr-2865	Sbr-2865	Sbr-2865	Sbr-2865	CL-56
Sherd type	body	body	body	body	body	body	body	body	rim
Thickness	5.9	5.0	5.4	4.2	7.0	5.3	7.9	7.6	5.1
Rim Diam.	300				225				200
Rim Shape									2
Ext/Int Srf	R0 / R0	R0 / R0	R5 / R0	R0 / S	S / S	R0 / R0	S / R0	R0 / S	R0 / R1
Temp D/Sz	3 / -	3 / -	3 / -	3 / -	2 / -	2 / -	2 / -	2 / -	3 / -
Org / Mica	0 / 3	0 / 4	0 / 4	0 / 0	0 / 0	1 / 2	1 / 0	0 / 0	0 / 2
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / -	0 / -	1 / -	0 / -	0 / -	0 / -	0 / -	0 / -
Lip Sh/Lat	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -	3 / -
Ch. Group	Ungrp.	Ungrp.	Ungrp.	Ungrp.	13	DV1	13	13	10
AS	5.68	9.17	4.67	16.47	11.96	15.90	12.29	10.87	4.49
LA	28.56	62.41	84.72	29.14	51.56	86.21	50.41	49.46	49.67
LU	0.344	0.829	0.597	0.309	0.228	0.396	0.225	0.236	0.506
ND	22.32	58.89	75.33	24.19	31.21	70.63	31.34	31.96	37.34
SM	4.70	12.62	14.98	4.83	4.80	12.29	4.70	4.68	8.43
U	4.177	4.131	3.907	6.463	3.193	3.658	2.964	3.189	3.782
YB	2.618	6.426	4.444	1.931	1.671	2.869	1.438	1.468	3.8
CE	55.08	135.48	136.20	52.99	93.32	157.24	89.35	89.94	99.85
CO	4.49	4.39	4.50	5.61	9.66	15.73	8.66	9.27	17.44
CR	40.65	32.00	24.39	43.09	28.15	85.73	27.53	26.51	35.24
CS	10.609	11.189	15.488	35.599	3.534	6.885	3.121	3.451	3.425
EU	0.669	1.133	1.512	0.780	0.762	2.137	0.732	0.739	1.594
FE	24686	33911	32391	21031	51401	51952	53124	51542	53088
HF	3.32	4.83	7.91	3.88	4.65	8.86	4.39	4.38	6.72
RB	286.4	304.5	274.8	152.1	107.5	128.4	111.9	104.2	96.7
SB	0.393	0.501	0.336	0.706	1.907	1.832	1.765	1.906	0.720
SC	13.85	12.10	14.99	7.42	8.35	16.06	8.34	8.11	17.45
SR	180.4	623.8	149.2	280.7	221.1	321.4	175	230.6	532.2
TA	1.942	1.529	2.809	0.968	1.035	0.991	1.004	1.041	1.201
TB	0.652	1.808	1.584	0.492	0.379	1.199	0.389	0.455	1.065
TH	13.01	35.86	38.59	11.84	15.03	26.85	14.47	14.45	21.34
ZN	47.50	48.60	66.90	58.30	57.40	106.40	56.70	61.30	74.60
ZR	78.5	132.1	186.5	96.3	119.3	229.1	97.2	114.2	160.6
AL	93271	106249	96530	60323	75777	93094	77942	78030	93509
BA	465.2	596.6	675.0	578.5	1401.3	734.9	1441.8	1471.4	613.4
CA	12366	7036	6566	46813	9489	18504	7991	9421	28305
DY	3.395	9.82	8.911	2.704	1.864	5.888	2.56	2.238	6.076
K	40867	50049	33238	28885	42742	26470	43496	47826	22045
MN	208.4	102.5	355.5	385.4	445.4	743.7	442.8	450.9	1016.1
NA	3712	5555	11999	10553	3641	10720	2693	3514	16650
TI	1650	2042	3244	1716	1383	4919	1741	1687	4467
V	39.2	57.4	55.3	60.8	48.0	105.8	47.6	45.6	123.9

Appendix A: Table A.1 Continued

Sherd#	**JEC262**	**JEC263**	**JEC264**	**JEC265**	**JEC266**	**JEC267**	**JEC268**	**JEC269**	**JEC270**
Region Col	FTI	FTI	FTI	FTI	FTI	NTS	NTS	NTS	NTS
Site	CL-56	CL-56	CL-56	CL-isol	CL-53	Ny-10133	Ny-10133	Ny-10133	Ny-10133
Sherd type	rim	body	body	rim	rim	rim	rim	rim	rim
Thickness	4.8	5.2	4.8	4.4	4.7	5.4	5.2	5.1	5.4
Rim Diam.	175			250	225	450	340	400	450
Rim Shape	3			4	3	2	3	1	3
Ext/Int Srf	R0 / R0	R0 / R0	R0 / R1	R1 / R1	R2 / R0	R0 / R3	R0 / R3	R0 / R0	R0 / R0
Temp D/Sz	2 / -	2 / -	2 / -	3 / -	2 / -	1 / -	2 / -	2 / -	2 / -
Org / Mica	0 / 2	0 / 2	0 / 2	0 / 0	0 / 2	0 / 2	0 / 0	0 / 0	0 / 3
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	1 / 2	0 / -	0 / -	1 / -	0 / 2	0 / 4	0 / -	0 / -	0 / -
Lip Sh/Lat	3 / -	- / -	- / -	1 / 1	3 / -	2 / 1	1 / -	2 / -	3 / -
Ch. Group	10	10	10	Ungrp.	10	NTS1B	NTS1B	NTS1B	NTS1A
AS	4.31	5.07	11.30	17.07	7.50	6.51	10.56	5.08	8.64
LA	52.02	51.08	83.02	26.85	47.83	88.99	80.06	92.91	83.27
LU	0.442	0.481	0.447	0.256	0.443	0.508	0.425	0.461	0.429
ND	43.76	45.97	63.98	24.78	38.92	57.41	49.68	57.53	49.47
SM	8.33	8.25	9.59	4.67	7.73	8.78	8.36	9.08	8.37
U	2.877	2.503	2.636	2.786	2.815	5.829	3.878	5.025	3.291
YB	3.227	3.297	3.439	1.538	3.115	3.38	2.863	3.081	3.072
CE	102.81	109.54	148.69	55.11	94.07	163.93	142.88	163.84	144.20
CO	16.84	17.65	16.92	9.75	17.46	4.38	5.51	5.77	5.39
CR	34.78	34.67	31.34	22.98	35.01	13.61	25.81	25.66	25.88
CS	3.578	3.5	3.499	5.273	3.567	11.987	7.436	7.463	7.386
EU	1.576	1.605	1.681	0.820	1.575	0.873	1.172	1.205	1.165
FE	51460	52398	49865	26101	51801	21857	30602	30726	30370
HF	6.70	6.64	7.16	3.98	6.35	9.27	10.49	10.01	9.53
RB	89.5	93.6	92.8	122.6	89.7	156.3	121.7	131.4	121.2
SB	0.674	0.679	0.547	0.664	0.798	0.780	0.984	0.994	0.884
SC	16.92	17.56	17.40	8.12	17.16	5.70	8.66	8.90	8.71
SR	412.1	459.2	475.9	463.7	480.7	200.9	352.8	294.7	460.7
TA	0.980	1.178	1.325	1.377	1.132	2.373	1.703	1.763	1.660
TB	0.980	0.950	1.074	0.523	0.919	0.972	0.827	0.832	0.809
TH	17.52	17.79	22.42	14.78	15.36	33.51	31.32	33.68	31.04
ZN	69.90	93.70	71.70	80.30	90.10	71.10	76.40	81.40	79.00
ZR	164.5	171.7	225.2	105.3	160.5	235.0	307.9	264.8	247.6
AL	91258	95620	92393	80967	94460	85699	104748	114646	107491
BA	532.5	766.3	739.2	723.3	693.6	516.7	705.8	708.0	744.9
CA	27604	30422	34373	13184	28555	11966	14089	12888	14214
DY	6.025	5.576	6.79	2.321	5.774	5.923	4.367	4.245	4.475
K	20900	23612	26592	33623	19332	27430	30365	34402	33292
MN	1061.5	1164.7	975.7	479.9	986.3	427.7	583.4	602.8	562.7
NA	16120	17096	18147	19388	16070	15163	14880	16384	15348
TI	4595	4197	4672	1522	3884	2401	2972	3238	3184
V	112.9	108.1	126.1	59.2	129.0	29.5	59.4	49.1	49.8

Appendix A: Table A.1 Continued

Sherd#	**JEC271**	**JEC272**	**JEC273**	**JEC274**	**JEC275**	**JEC276**	**JEC277**	**JEC278**	**JEC279**
Region Col	NTS	NTS	NTS	NTS	NTS	NTS	NTS	NTS	NTS
Site	Ny-10133	Ny-10133	Ny-10133	Ny-10133	Ny-10133	Ny-3621	Ny-3621	Ny-3621	Ny-3621
Sherd type	rim	body	body	body	rim	rim	rim	rim	rim
Thickness	4.6	5.2	7.9	9.5	5.9	4.7	5.7	5.4	6.0
Rim Diam.	250		100		400	100	400	350	450
Rim Shape	1		5		3		3	3	1
Ext/Int Srf	R2 / R1	- / -	R2 / R0	S / R0	R2 / R2	R1 / R0	S / R1	R0 / R0	S / R1
Temp D/Sz	1 / -	- / -	2 / -	1 / -	1 / -	1 / -	2 / -	1 / -	2 / -
Org / Mica	0 / 0	- / -	0 / 0	0 / 1	0 / 1	0 / 1	0 / 3	0 / 2	0 / 1
Decorated	0	0	0	0	0	1	0	0	0
Core/Coil	0 / -	1 / -	0 / -	0 / -	1 / 1	0 / -	1 / 2	0 / -	0 / -
Lip Sh/Lat	1 / -	- / -	- / -	- / -	5 / -	5 / 2	4 / -	2 / -	2 / -
Ch. Group	Ungrp.	Ungrp.	Ungrp.	NTS1B	NTS1B	Ungrp.	NTS1A	Ungrp.	NTS1B
AS	11.34	0.00	11.88	3.53	4.70	6.68	3.55	4.08	10.72
LA	48.14	53.34	31.10	79.81	62.85	60.70	58.53	162.54	74.01
LU	0.358	0.670	0.430	0.420	0.485	0.369	0.366	0.437	0.448
ND	32.19	43.71	27.08	49.40	47.43	41.91	40.64	106.45	47.23
SM	5.28	9.27	6.29	7.57	8.35	6.78	6.47	14.16	9.08
U	6.039	15.985	2.172	3.059	5.334	5.327	4.645	2.987	6.221
YB	1.848	3.051	3.042	3.1	3.38	2.8	2.368	3.185	3.294
CE	76.33	102.80	62.18	133.22	126.78	112.39	108.95	283.78	155.24
CO	5.91	4.42	9.48	3.82	4.37	7.40	7.05	2.13	4.98
CR	26.53	71.75	61.05	14.54	12.39	33.52	30.83	10.92	29.09
CS	6.071	12.572	4.898	11.33	11.572	5.299	5.556	11.837	7.633
EU	0.892	1.326	1.259	0.963	0.836	1.178	1.180	3.287	1.169
FE	24253	23237	39938	25067	21826	35273	32145	24007	27252
HF	5.87	5.53	8.57	8.74	8.55	12.17	9.77	16.66	13.06
RB	191.3	128	91.1	111.1	157.8	119.7	115	57.2	100.3
SB	1.260	0.538	0.811	0.725	0.748	1.134	0.988	0.653	0.867
SC	8.19	16.64	13.00	6.44	5.68	9.08	8.88	10.23	7.91
SR	207	136.7	110.8	346.2	223.8	553.9	410.5	363.2	169.7
TA	1.703	1.516	1.140	1.757	2.417	1.476	1.341	1.329	2.463
TB	0.468	0.923	0.872	0.807	0.994	0.744	0.730	1.133	0.998
TH	31.81	27.22	13.56	32.65	31.99	18.42	18.06	24.21	29.00
ZN	82.90	89.00	50.50	67.50	72.90	107.10	82.60	90.60	70.90
ZR	114.3	185.5	243.2	201.9	195.4	327.5	275.4	579.3	292.9
AL	94421	108773	75689	94420	83148	83873	88032	106118	104815
BA	665.1	370.0	549.6	924.8	509.8	1096.6	1096.5	2390.2	494.4
CA	9273	4013	6537	15434	11919	16650	14585	15877	10075
DY	2.999	5.575	5.228	5.19	5.362	4.135	3.782	5.63	5.503
K	32757	19581	22372	33384	27469	31252	31255	28582	31502
MN	441.6	77.4	184.6	511.7	441.5	628.5	701.4	916.6	413.4
NA	16367	861	2356	13438	15418	19066	18200	18883	22590
TI	2026	4446	4530	2289	2598	3818	3407	3203	3350
V	69.2	122.6	92.9	33.5	26.9	75.8	69.2	38.9	41.7

Appendix A: Table A.1 Continued

Sherd#	**JEC280**	**JEC282**	**JEC283**	**JEC284**	**JEC285**	**JEC286**	**JEC287**	**JEC288**	**JEC289**
Region Col	NTS	NTS	NTS	NTS	NTS	NTS	NTS	NTS	NTS
Site	Ny-3621	Ny-3620	Ny-3620	Ny-3393	Ny-3620	Ny-3393	Ny-3620	Ny-3620	Ny-3393
Sherd type	rim	rim	body	body	body	body	rim	body	rim
Thickness	6.6	5.4	6.5	5.6	5.8	5.4	4.4	6.1	5.3
Rim Diam.	225	175	200	350		150	275	250	250
Rim Shape	5	4		3		3	1	3	3
Ext/Int Srf	R0 / R1	R3 / R1	S / S	R0 / -	R0 / R0	R0 / R0	R2 / R1	R0 / R0	R3 / R1
Temp D/Sz	3 / -	2 / -	2 / -	2 / -	1 / -	2 / -	2 / -	2 / -	2 / -
Org / Mica	0 / 2	0 / 0	0 / 3	1 / 0	0 / 1	0 / 0	0 / 3	0 / 1	0 / 3
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	1 / -	0 / -	0 / -	0 / -	0 / -	0 / -	0 / -	0 / 2
Lip Sh/Lat	3 / -	2 / -	- / -	- / -	- / -	- / -	1 / 2	- / -	2 / -
Ch. Group	Ungrp.	NTS1A	NTS1B	NTS1B	Ungrp.	NTS1A	9	NTS1A	NTS1A
AS	13.90	6.04	8.23	10.74	10.00	7.84	7.16	8.19	7.71
LA	94.66	92.23	102.61	54.38	100.70	78.66	94.87	107.29	47.44
LU	0.469	0.494	0.553	0.508	0.461	0.403	0.546	0.505	0.382
ND	68.80	72.85	65.32	40.84	57.55	39.53	54.91	61.94	31.38
SM	10.10	11.96	10.74	7.96	11.09	7.59	11.48	11.39	6.22
U	5.404	3.094	5.781	4.706	4.209	3.214	4.328	3.805	3.57
YB	3.599	3.706	3.781	3.239	3.254	2.787	3.757	3.996	2.894
CE	168.01	194.35	180.64	111.90	206.44	154.81	179.79	213.82	94.87
CO	5.20	6.73	4.63	5.62	7.43	6.07	6.01	8.12	7.66
CR	11.82	29.81	18.52	24.41	27.62	25.83	28.28	26.96	28.34
CS	7.764	6.41	9.369	7.914	6.203	7.466	8.474	5.895	9.001
EU	1.408	1.359	1.330	0.832	1.463	1.221	1.659	1.659	1.118
FE	23450	34905	28019	25460	28564	31291	30328	28466	31821
HF	12.25	10.62	11.08	8.42	13.28	10.82	13.80	12.99	7.18
RB	141.4	125.8	89.4	159.6	106.8	116.4	114.3	116.4	116.9
SB	1.212	0.824	0.800	0.953	1.020	0.924	0.855	0.813	1.076
SC	5.88	10.00	8.15	7.24	8.64	8.51	9.07	8.49	10.03
SR	286.9	483.2	353.2	211.1	288.3	347.3	151.7	285	375.9
TA	1.597	2.253	2.203	1.831	1.731	1.814	2.664	1.637	1.292
TB	1.105	1.403	1.129	0.904	1.194	0.756	1.163	1.000	0.648
TH	17.60	24.65	40.72	25.58	23.64	33.70	32.78	22.59	19.02
ZN	64.70	104.70	81.30	76.10	116.50	112.50	79.50	103.20	94.20
ZR	336.1	267.4	247.9	235.5	395.3	303.0	393.4	406.2	188.8
AL	85930	107229	118855	85498	89176	113940	107424	92213	92355
BA	1229.0	1416.8	776.4	588.8	951.2	987.7	913.5	972.2	658.6
CA	6863	15640	12556	11849	11939	13356	9866	11969	16967
DY	6.125	6.339	5.679	5.704	5.013	4.411	7.9	5.645	4.131
K	42842	31814	25350	30362	34416	27835	23616	33432	30621
MN	291.9	591.6	599.7	615	903.9	584.7	639.3	843.3	880.2
NA	15851	15446	14114	14199	17427	14870	12998	19184	12985
TI	2262	3306	2619	2729	4544	3485	3308	3654	2400
V	53.9	72.4	48.0	39.0	66.3	70.2	46.2	58.2	58.4

Appendix A: Table A.1 Continued

Sherd#	**JEC290**	**JEC291**	**JEC292**	**JEC293**	**JEC294**	**JEC295**	**JEC296**	**JEC297**	**JEC298**
Region Col	NTS	NTS	NTS	NTS	NTS	NTS	NTS	NTS	NTS
Site	Ny-941	Ny-941	Ny-1920	Ny-1920	Ny-938	Ny-938	Ny 937	Ny 004	Ny 3393
Sherd type	body	rim	body	rim	body	body	body	body	rim
Thickness	9.1	5.1	5.2	6.2	5.8	4.9	5.5	7.7	5.4
Rim Diam.	150	450	250	250	250	350			400
Rim Shape		1							3
Ext/Int Srf	R0 / R0	R1 / R1	R2 / R2	R0 / R1	R0 / R1	R2 / R2	R0 / R0	R0 / R0	R1 / R1
Temp D/Sz	2 / -	1 / -	2 / -	1 / -	2 / -	2 / -	2 / -	1 / -	2 / -
Org / Mica	1 / 2	1 / 1	1 / 1	0 / 4	0 / 0	0 / 1	0 / 1	0 / 0	1 / 3
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / 2	0 / -	1 / -	0 / -	0 / -	0 / -	1 / -	0 / -
Lip Sh/Lat	- / -	1 / -	- / -	3 / -	- / -	- / -	- / -	- / -	4 / -
Ch. Group	NTS1A	9	NTS1A	8	NTS1B	9	8	Ungrp.	8
AS	6.49	6.84	7.48	5.38	5.10	7.81	5.25	6.86	6.69
LA	90.97	95.43	70.29	47.32	83.78	70.38	38.39	50.32	49.06
LU	0.490	0.580	0.401	0.431	0.421	0.475	0.355	0.369	0.428
ND	63.36	59.80	40.21	33.90	48.19	45.28	25.16	42.02	32.19
SM	12.84	12.50	7.24	6.74	8.74	9.34	5.22	7.60	6.53
U	3.407	6.88	3.608	4.163	4.374	6.582	4.514	3.382	4.322
YB	3.467	4.123	2.717	2.541	2.663	3.413	1.994	2.356	2.57
CE	196.82	216.42	146.60	95.11	169.56	196.43	85.62	102.04	97.15
CO	6.05	6.37	7.91	15.02	5.70	6.01	12.93	12.30	14.31
CR	25.31	30.32	33.54	53.50	24.05	32.90	43.67	40.46	48.03
CS	6.258	8.819	7.296	6.099	7.632	8.557	5.273	5.212	5.464
EU	1.404	1.692	1.096	1.233	0.848	1.180	0.968	1.582	1.183
FE	35292	30802	32063	43356	26732	30511	39619	56559	39500
HF	10.75	14.78	10.86	8.74	9.02	14.84	7.86	7.01	9.21
RB	136.4	106.3	148.5	157.2	158.5	97.7	161	82.7	148.1
SB	0.709	1.007	1.086	0.616	0.820	1.008	0.502	0.859	0.574
SC	8.97	10.53	8.86	10.32	6.86	10.09	8.56	16.71	9.34
SR	468.2	153.1	296.5	140.9	194.9	157.5	188.3	838.6	141.9
TA	2.304	3.410	1.757	1.506	1.889	3.618	1.417	0.902	1.487
TB	1.334	1.300	0.801	0.757	0.778	1.499	0.865	0.761	0.669
TH	23.51	41.36	26.48	20.90	25.87	45.81	28.61	14.01	20.82
ZN	165.00	79.30	154.30	141.20	118.80	82.90	89.90	98.60	126.00
ZR	290.3	377.1	276.5	260.7	239.2	375.5	187.7	159.5	217.2
AL	104359	123591	88022	96792	82654	125654	96652	86509	99852
BA	1171.1	668.3	712.9	451.5	428.3	332.3	300.0	975.0	385.9
CA	14326	9169	11475	10673	10342	8559	7442	20996	10320
DY	7.317	8.728	5.336	4.246	4.919	5.921	4.397	4.155	4.233
K	28826	19940	37248	30452	28076	21421	31233	23998	33644
MN	677.2	620.7	640.3	690.7	609.4	624.5	698.5	532.7	746.5
NA	15709	9866	16165	13275	15378	10031	13852	10799	14058
TI	2504	3101	3052	2868	1649	3240	2505	4056	2901
V	71.0	48.0	59.1	77.2	44.0	32.5	78.7	117.4	80.2

Appendix A: Table A.1 Continued

Sherd#	JEC299	JEC300	JEC301	JEC302	JEC303	JEC304	JEC305	JEC306	JEC307
Region Col	NTS	NTS	NTS	NTS	NTS	NTS	NTS	CL	CL
Site	Ny 945	Ny 009	Ny 960	Ny 1408	Ny 1408	Ny 1958	Ny 5606	Iny-1928	iso G9/10
Sherd type	body	rim	body	rim	body	body	body	rim	base
Thickness	5.3	5.0	7.2	6.2	3.9	6.7	4.9	5.8	7.5
Rim Diam.	250	300	225	400		150		225	
Rim Shape		1		3			3	2	
Ext/Int Srf	R0 / R0	S / R0	R0 / R0	R1 / R0	R5 / R0	R0 / S	R0 / R0	R1 / R1	R0 / R5
Temp D/Sz	1 / -	1 / -	2 / -	1 / -	3 / -	2 / -	1 / -	2 / -	2 / -
Org / Mica	0 / 3	0 / 1	0 / 0	0 / 2	0 / 0	1 / 2	0 / 1	0 / 4	0 / 2
Decorated	0	0	0	0	0	0	0	1	0
Core/Coil	1 / -	0 / -	0 / -	0 / -	0 / -	0 / -	0 / -	0 / 2	0 / -
Lip Sh/Lat	- / -	1 / 2	- / -	2 / 1	- / -	- / -	2 / -	3 / -	- / -
Ch. Group	Ungrp.	8	NTS1A	4D	Ungrp.	NTS1A	8	WSB	16
AS	5.01	6.78	4.47	7.45	6.73	5.84	7.12	3.85	18.30
LA	141.13	45.20	63.80	39.97	33.55	108.20	42.13	39.44	52.72
LU	0.411	0.447	0.380	0.292	0.462	0.502	0.417	0.396	0.481
ND	82.43	32.15	37.61	28.53	25.91	76.31	29.06	34.32	40.88
SM	13.74	6.43	6.45	5.04	6.62	14.06	5.79	6.75	7.80
U	2.372	6.463	4.242	2.958	2.803	3.122	5.95	4.28273	5.2086
YB	2.738	2.52	2.489	1.689	3.459	3.639	2.35	2.70305	3.21499
CE	270.04	97.34	122.18	86.52	92.47	224.40	87.58	80.13	90.19
CO	2.98	15.55	7.05	10.67	35.99	7.04	16.38	24.58	9.30
CR	12.46	49.42	27.00	28.53	195.59	29.10	40.00	30.95	19.83
CS	15.453	5.978	7.129	7.432	3.729	6.562	5.545	3.47484	2.81104
EU	3.179	1.192	1.236	1.133	1.569	1.402	1.030	1.414	1.343
FE	22879	42378	33516	37919	71061	36049	38336	64188	42496
HF	14.47	10.16	5.96	6.89	6.11	11.54	8.24	8.76	6.08
RB	72.9	158.2	143.3	117.3	41.1	138.5	155	101.9	67.695
SB	0.667	0.682	0.736	1.254	0.836	0.775	0.631	0.414	0.922
SC	9.22	9.86	11.39	11.25	28.37	9.14	8.34	19.92	11.63
SR	374.2	181.8	423.4	815.4	180	441.9	144.6	443.82	272.43
TA	1.297	1.541	1.253	1.038	1.291	2.223	1.432	0.738	1.284
TB	0.967	0.719	0.920	0.772	1.269	1.630	0.785	0.819	0.859
TH	23.31	21.67	23.59	14.78	12.60	23.22	20.80	20.54	15.35
ZN	91.00	139.90	75.40	90.50	101.60	173.30	89.80	100.93	69.98
ZR	523.7	275.4	144.5	193.0	122.3	326.1	197.3	231.7	144.1
AL	99383	101012	93992	101559	126449	101333	96709	92799	84126
BA	2061.7	459.2	847.0	954.6	646.1	999.5	520.9	658.6	705.3
CA	16553	9952	20456	21155	14591	16554	8649	29942	16345
DY	4.496	3.413	3.567	2.295	4.563	7.012	3.349	4.01879	5.59712
K	30064	28276	33831	25617	15712	29797	29687	18885	23283
MN	1016.8	738.3	461.1	764.1	1072.5	741.0	879.4	1161.5	791.9
NA	18646	13722	16137	15525	3168	16609	14680	16145	17499
TI	2255	3083	1764	3376	8233	3159	2532	4348	3501
V	30.1	72.0	54.5	87.5	142.4	84.4	70.9	177.3	99.0

Appendix A: Table A.1 Continued

Sherd#	**JEC308**	**JEC309**	**JEC310**	**JEC311**	**JEC312**	**JEC313**	**JEC314**	**JEC315**	**JEC316**
Region Col	CL	CL	CL	CL	CL	CL	CL	CL	CL
Site	Iny-1928	Iny-1935	Iny-2079	Iny-2079	Iny-3033	Iny-3433	Iny-4307	Iny-4307	Iny-4307
Sherd type	body	body	body	body	body	body	rim	rim	body
Thickness	4.6	7.2	6.1	4.2	5.2	5.1	5.9	5.1	6.9
Rim Diam.	125	250	225	175	250	125	200	175	225
Rim Shape							5	3	
Ext/Int Srf	R2 / R2	R1 / R1	R2 / R1	R0 / R0	R2 / R1	R1 / R1	S / R1	R1 / R1	R4 / R1
Temp D/Sz	2 / -	1 / -	1 / -	2 / -	1 / -	2 / -	1 / -	2 / -	2 / -
Org / Mica	0 / 2	2 / 4	0 / 4	0 / 3	0 / 2	1 / 1	0 / 2	0 / 2	2 / 2
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / 3	0 / -	0 / -	0 / -	0 / 4	1 / -	1 / -	- / -	0 / -
Lip Sh/Lat	- / -	- / -	- / -	- / -	- / -	- / -	3 / -	3 / -	- / -
Ch. Group	Ungrp.	DV2	WSA	Ungrp.	16	WSA	14	DV2	Ungrp.
AS	34.11	7.09	0.00	5.16	11.03	6.61	4.13	21.00	8.27
LA	38.90	42.83	27.22	46.82	46.50	20.82	49.87	47.20	60.26
LU	0.463	0.481	0.463	0.268	0.318	0.285	0.626	0.384	0.478
ND	27.74	36.79	32.16	47.02	37.84	16.93	40.27	32.36	40.11
SM	5.88	7.64	7.17	7.95	6.78	3.83	8.17	6.03	7.27
U	3.608	4.607	1.672	5.122	6.893	4.050	10.166	2.975	9.351
YB	2.764	3.154	3.020	1.724	1.944	1.484	3.515	2.364	2.534
CE	73.12	83.50	60.66	95.25	87.21	38.36	93.49	88.08	93.21
CO	15.69	19.91	28.29	12.52	12.58	44.88	12.96	15.23	9.79
CR	43.42	32.71	29.62	14.02	32.67	207.83	20.40	21.36	17.86
CS	4.959	4.639	2.792	2.604	4.701	2.269	3.779	4.133	4.375
EU	1.137	1.403	1.801	1.618	1.353	0.904	1.446	1.274	1.291
FE	66964	60919	85454	53194	59070	102289	48153	38205	43451
HF	7.64	8.50	7.80	4.89	9.52	4.45	11.49	5.89	6.12
RB	95.84	98.66	39.69	80.94	81.18	34.48	105.63	100.27	92.39
SB	0.879	1.112	0.165	0.266	1.174	0.000	0.445	0.912	0.892
SC	13.20	16.22	28.48	10.76	12.10	22.37	15.76	12.54	11.23
SR	371.38	601.65	516.24	457.62	625.28	390.59	334.44	436.74	316.61
TA	0.996	2.278	0.407	1.032	1.602	0.367	1.438	0.848	1.465
TB	0.738	0.932	0.933	0.774	0.583	0.411	0.892	0.771	0.723
TH	17.75	19.32	4.70	11.01	28.62	7.73	32.40	18.12	26.49
ZN	87.36	88.41	100.67	92.68	76.01	63.72	77.65	111.88	89.85
ZR	173.8	211.1	185.1	158.4	239.9	127.3	296.9	162.0	179.6
AL	77290	97699	110857	97775	95489	94644	89598	87074	97470
BA	489.6	542.7	603.3	606.4	616.4	367.4	746.2	730.0	665.6
CA	24260	28036	42362	25191	20760	36465	22859	19189	16051
DY	4.222	4.804	6.003	3.872	3.705	2.586	5.246	6.375	3.889
K	22690	16211	5782	18921	22614	9623	28957	23984	31405
MN	666.1	1094.9	1505.5	764.4	511.5	1067.9	913.0	1212.0	695.6
NA	15400	17701	13388	13827	16527	8703	15610	19556	22813
TI	3694	4260	5871	6557	4587	3797	3308	1999	3788
V	251.6	159.4	288.1	147.8	146.8	332.3	135.5	89.6	89.7

Appendix A: Table A.1 Continued

Sherd#	JEC317	JEC318	JEC319	JEC320	JEC321	JEC322	JEC323	JEC324	JEC325
Region Col	CL	CL	CL	CL	CL	CL	CL	CL	CL
Site	Iny-4307	Iny-4307	Iny-4307	Iny-4307	Iny-4307	Iny-4329	Iny-4329	Iny-4329	Iny-4329
Sherd type	rim	base	rim	body	rim	rim	body	rim	body
Thickness	6.8	8.5	4.7	5.2	6.1	7.8	6.2	6.2	5.9
Rim Diam.	275		250	200	125	150	250	350	350
Rim Shape	4		3		3	3		3	
Ext/Int Srf	R0 / R1	- / -	R1 / R1	R2 / R2	R0 / R0	R0 / R0	R3 / R0	R1 / R1	R2 / R0
Temp D/Sz	2 / -	2 / -	1 / -	1 / -	1 / -	1 / -	2 / -	2 / -	1 / -
Org / Mica	2 / 1	1 / 4	0 / 3	0 / 1	2 / 2	3 / 1	2 / 3	0 / 2	1 / 1
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / 4	- / -	0 / 2	0 / 2	0 / -	0 / -	0 / 3	- / 2	1 / 3
Lip Sh/Lat	5 / -	- / -	3 / -	- / -	4 / -	3 / -	- / -	1 / 1	- / -
Ch. Group	SOV1A	14	15	Ungrp.	Ungrp.	14	14	14	14
AS	22.08	4.72	6.57	41.81	13.78	18.58	11.62	11.85	9.18
LA	75.90	31.37	42.93	54.10	44.20	62.46	60.79	58.57	62.18
LU	0.781	0.540	0.387	0.406	0.352	0.393	0.324	0.305	0.318
ND	40.62	26.19	32.69	37.77	34.46	48.01	39.37	38.37	40.08
SM	8.54	7.41	6.67	6.73	6.67	8.73	7.46	7.00	7.47
U	15.566	14.304	3.394	3.158	6.142	11.042	10.198	9.866	10.708
YB	4.194	2.951	2.496	2.922	2.067	2.136	1.480	1.471	1.384
CE	117.87	69.65	84.20	88.12	88.36	115.60	89.56	88.79	93.59
CO	6.46	17.92	25.04	13.75	18.85	14.88	7.25	7.36	7.04
CR	21.18	25.27	33.73	37.46	36.10	26.19	12.64	13.33	13.75
CS	5.228	18.726	3.881	5.272	5.262	5.982	7.784	8.200	8.052
EU	1.166	1.169	1.463	1.369	1.420	1.704	1.390	1.376	1.424
FE	39968	55636	68652	53484	54789	51768	40108	40207	39616
HF	8.80	6.60	8.76	4.81	7.01	8.76	6.12	6.31	5.92
RB	106.83	141.03	120.39	100.77	94.99	73.88	93.13	96.95	100.86
SB	1.139	0.518	0.479	-	-	-	-	-	-
SC	10.24	15.28	20.21	16.15	15.73	13.31	10.42	10.83	11.05
SR	261.55	378.08	421.14	313.50	547.13	605.72	559.33	544.39	527.95
TA	1.919	1.902	0.698	1.116	1.412	1.237	1.158	1.183	1.191
TB	0.866	0.916	0.811	0.854	0.640	0.674	0.553	0.603	0.560
TH	68.27	80.06	14.42	19.16	22.35	42.72	47.31	38.97	44.19
ZN	0.00	73.54	103.51	0.00	75.57	88.63	106.48	100.52	131.40
ZR	266.8	198.1	235.4	133.2	177.5	261.9	178.7	173.3	183.8
AL	93639	96202	97283	99088	102749	103930	112719	110052	112133
BA	457.8	645.3	626.7	605.1	744.0	657.2	525.2	339.9	430.3
CA	13446	23353	25815	18907	26428	23399	19096	17956	19234
DY	5.071	4.723	3.125	4.192	3.907	3.394	2.797	2.692	2.801
K	23579	32567	22592	27111	19045	20508	20320	19737	24524
MN	535.1	957.1	1214.6	854.0	1025.7	761.6	551.4	619.9	558.9
NA	21833	15975	14993	15722	17947	23977	22402	22964	23208
TI	3861	3619	4219	3493	4864	4615	3492	3402	4754
V	86.9	138.9	189.5	134.7	142.3	131.4	104.5	84.9	94.9

Appendix A: Table A.1 Continued

Sherd#	**JEC326**	**JEC327**	**JEC328**	**JEC329**	**JEC330**	**JEC331**	**JEC332**	**JEC333**	**JEC334**
Region Col	CL	CL	CL	CL	CL	CL	CL	CL	CL
Site	Iny-4329	Iny-5086	Iny-5091	Iny-5091	Iny-5091	Iny-5093	Iny-5093	P-20-91	P-168-159
Sherd type	body	body	rim	body	rim	rim	rim	rim	rim
Thickness	6.6	5.0	7.3	6.1	7.1	7.6	4.7	4.7	5.3
Rim Diam.	150	200	250	150	175	250	150	200	275
Rim Shape			1		3	3	3	1	1
Ext/Int Srf	R0 / -	R2 / R0	R3 / R1	R0 / R1	R3 / R1	R4 / R1	R0 / R0	R2 / R1	R1 / R1
Temp D/Sz	3 / -	1 / -	2 / -	2 / -	2 / -	2 / -	3 / -	1 / -	2 / -
Org / Mica	2 / 2	0 / 2	0 / 2	0 / 3	0 / 3	0 / 2	0 / 3	0 / 1	0 / 3
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	- / -	0 / -	- / 2	- / -	- / 2	0 / 2	- / -	0 / 2	- / 2
Lip Sh/Lat	- / -	- / -	5 / -	- / -	5 / -	5 / -	1 / -	3 / -	1 / 2
Ch. Group	15	Ungrp.	15	15	15	15	Ungrp.	16	WSB
AS	5.76	6.76	8.29	8.69	10.07	11.75	4.46	17.96	4.51
LA	45.24	56.95	48.53	45.45	47.19	47.13	35.43	48.71	37.05
LU	0.388	0.468	0.375	0.387	0.425	0.397	0.163	0.475	0.481
ND	31.91	26.89	39.43	36.16	37.15	33.68	24.53	38.06	33.87
SM	5.81	5.71	7.17	7.00	7.22	7.14	3.80	7.19	7.39
U	1.637	5.890	3.109	3.248	2.628	3.719	2.218	6.147	3.969
YB	2.409	3.149	3.045	2.484	3.044	2.389	1.073	3.052	3.054
CE	87.61	85.92	84.31	81.28	84.52	83.95	61.10	89.04	73.80
CO	20.24	9.82	23.23	23.31	23.83	23.06	8.57	14.58	23.87
CR	30.36	64.37	39.19	40.04	39.13	39.76	19.04	35.66	28.66
CS	2.070	7.006	2.976	2.936	2.990	2.896	2.457	5.440	3.134
EU	1.363	0.853	1.557	1.543	1.582	1.517	0.966	1.343	1.535
FE	54235	35769	67946	68710	70288	68907	29198	61924	65147
HF	6.25	4.67	7.96	6.96	7.80	6.93	4.42	12.72	8.90
RB	73.25	104.15	81.09	83.31	86.17	83.05	84.08	101.10	72.40
SB	0.722	2.602	0.506	0.550	0.579	0.583	0.305	1.562	0.391
SC	18.76	10.90	20.98	21.26	21.68	21.00	6.41	15.52	23.29
SR	597.2	143.66	508.34	500.08	548.62	519.06	463.41	396.48	475.35
TA	1.087	2.409	0.762	0.724	0.666	0.751	0.865	1.806	0.992
TB	1.387	0.701	0.867	1.546	1.547	1.261	0.407	0.843	1.440
TH	11.87	55.01	13.09	12.21	12.82	15.74	9.48	26.41	14.36
ZN	77.68	44.38	98.57	99.24	99.90	94.66	84.65	96.91	91.47
ZR	149.8	128.9	192.9	167.6	184.6	166.8	110.3	316.5	220.1
AL	97163	73045	101304	99148	100569	101998	87747	94056	94952
BA	648.2	243.9	648.8	608.7	681.9	647.1	1557.7	431.7	446.0
CA	29501	8774	29025	28429	29829	28575	14561	23784	32628
DY	3.707	4.818	4.349	4.927	4.757	4.725	1.842	4.379	4.602
K	18774	20346	19030	20078	19207	20728	28589	17281	16945
MN	970.3	365.9	1047.0	991.2	1047.7	997.8	492.7	771.7	1013.0
NA	15416	6311	15625	15386	15844	15662	23841	16510	16698
TI	4245	2500	5143	4407	4852	5289	2762	6068	4384
V	126.9	94.3	197.8	202.8	196.1	194.8	75.0	176.1	188.1

Appendix A: Table A.1 Continued

Sherd#	JEC335	JEC336	JEC337	JEC338	JEC339	JEC340	JEC341	JEC342	JEC343
Region Col	CL	CL	COV	COV	COV	COV	COV	COV	COV
Site	T-6-1	P-79-56	Iny-1782	Iny-1782	Iny-1782	Iny-1782	Iny-1782	Iny-1704	Iny-1704
Sherd type	body	body	body	rim	rim	body	body	rim	body
Thickness	6.1	5.8	7.5	7.6	9.3	7.7	5.6	6.7	5.5
Rim Diam.	250	200	225	200	320	225		280	150
Rim Shape				3	3			3	
Ext/Int Srf	R2 / R1	S / R0	R2 / R1	R2 / R1	R0 / R1	R2 / R1	R0 / R1	R2 / R1	R2 / R3
Temp D/Sz	1 / -	2 / -	1 / 2	1 / 3	1 / 2	2 / 1	2 / 3	1 / 2	1 / 2
Org / Mica	0 / 1	0 / 0	0 / 0	0 / 0	0 / 2	1 / 1	0 / 2	0 / 3	0 / 2
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	- / 3	- / -	0 / 2	0 / -	1 / -	1 / 4	0 / -	0 / 2	- / -
Lip Sh/Lat	- / -	- / -	- / -	3 / -	1 / -	- / -	- / -	3 / -	- / -
Ch. Group	Ungrp.	Ungrp.	NTS1B	NOV1A	Ungrp.	Ungrp.	NOV1A	NOV1A	NOV1A
AS	51.95	18.21	0.00	14.05	8.79	8.36	8.96	13.40	9.49
LA	37.54	69.36	76.94	47.10	78.85	34.95	46.05	47.83	48.48
LU	0.419	0.517	0.423	0.544	0.533	0.356	0.501	0.546	0.545
ND	31.90	54.13	45.35	37.25	48.46	27.19	35.77	39.79	32.81
SM	5.72	8.37	8.99	7.79	8.88	4.72	7.71	8.11	8.42
U	5.805	3.897	5.914	7.833	5.602	6.025	7.367	7.493	7.505
YB	2.556	3.654	2.550	3.220	3.333	2.177	3.247	3.322	3.411
CE	70.95	127.81	142.65	88.86	139.80	64.43	89.90	88.20	87.08
CO	18.94	8.19	10.32	16.41	14.98	6.10	15.88	15.50	16.24
CR	125.10	22.57	15.56	37.53	40.91	13.07	37.34	32.86	34.08
CS	5.488	2.621	6.095	3.579	4.914	2.812	3.692	2.723	2.799
EU	1.159	2.327	1.495	1.238	1.568	0.958	1.257	1.328	1.328
FE	36971	44950	35578	48858	51593	37872	48712	46846	47695
HF	7.25	11.91	13.77	7.93	11.90	5.51	5.33	5.83	4.73
RB	93.86	51.57	230.07	85.74	95.71	89.02	86.10	60.15	62.20
SB	1.285	0.838	0.898	0.951	1.234	0.744	0.918	0.994	0.913
SC	15.61	15.18	10.28	16.21	14.65	9.15	16.09	15.30	15.54
SR	473.08	215.31	199.71	303.02	358.03	162.21	236.59	325.22	384.40
TA	1.662	1.117	1.370	1.373	1.499	1.389	1.256	1.523	1.434
TB	1.001	1.005	1.605	0.973	1.478	0.555	1.568	1.602	1.082
TH	15.69	13.29	42.59	20.99	20.82	16.24	19.00	19.52	32.60
ZN	86.23	76.72	71.61	68.36	105.90	66.09	74.29	66.01	62.73
ZR	167.9	360.8	332.4	210.2	263.0	146.9	168.4	185.5	144.1
AL	91751	102470	98212	100774	97821	108420	105326	108358	103563
BA	557.8	1801.9	1030.2	749.5	727.1	713.5	864.5	641.2	733.3
CA	37366	13341	7195	15018	23490	10763	14732	18484	18187
DY	3.814	5.167	5.307	5.663	5.011	3.211	5.108	6.551	6.014
K	23763	28931	44658	24713	25726	27364	24529	18390	19786
MN	475.0	1140.8	737.9	773.1	1060.6	548.0	745.5	797.6	759.4
NA	16447	24971	11336	14568	18995	15678	14103	16308	16780
TI	5158	4067	4830	4352	4634	3335	4147	3901	3950
V	82.4	88.9	100.7	142.8	139.3	83.4	144.7	126.7	143.8

Appendix A: Table A.1 Continued

Sherd#	JEC344	JEC345	JEC346	JEC347	JEC348	JEC349	JEC350	JEC351	JEC352
Region Col	COV	COV	COV	COV	COV	COV	COV	COV	COV
Site	Iny-1704	Iny-1704	Iny-1704	Iny-1742	Iny-1701	Iny-1700	Iny-1700	Iny-1700	Iny-1700
Sherd type	body	body	body	rim	body	rim	rim	rim	body
Thickness	6.6	8.0	7.2	4.7	6.5	6.7	6.0	7.2	7.6
Rim Diam.	275	500	350	275	300	250	400	200	
Rim Shape				1		3	3	5	
Ext/Int Srf	S / R1	R2 / R1	R1 / R0	R2 / R0	S / R1	R1 / R3	S / S	- / R0	S / R1
Temp D/Sz	2 / 1	1 / 2	1 / 1	2 / 1	2 / 2	2 / 3	2 / 2	3 / 2	2 / 2
Org / Mica	1 / 2	0 / 1	0 / 0	0 / 0	0 / 3	0 / 1	1 / 3	1 / 3	0 / 1
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / 4	0 / -	0 / 4	0 / 2	0 / -	0 / -	0 / 4	0 / -	1 / 3
Lip Sh/Lat	- / -	- / -	- / -	3 / -	- / -	3 / -	3 / -	3 / -	- / -
Ch. Group	NOV1C	NOV1A	NOV1C	DV3	NOV1A	Ungrp.	NOV1C	COV1	COV1
AS	6.75	12.99	8.97	14.05	11.98	6.44	8.38	3.67	4.81
LA	55.56	48.34	54.27	52.25	52.35	37.21	56.53	41.60	47.38
LU	0.617	0.583	0.672	0.303	0.556	0.315	0.687	0.378	0.348
ND	40.12	38.86	42.63	39.92	41.51	27.69	43.49	32.22	35.03
SM	8.54	8.26	8.78	6.43	8.81	4.97	9.33	5.97	5.84
U	8.465	7.988	8.738	3.146	7.085	3.965	7.335	5.567	3.896
YB	4.104	3.600	4.211	1.863	3.354	1.937	4.540	2.419	2.317
CE	102.88	91.64	103.06	94.84	87.78	75.26	91.93	81.18	84.39
CO	17.52	17.40	18.11	8.97	16.92	8.77	16.49	12.27	12.22
CR	37.79	40.88	39.58	35.07	40.98	37.62	32.01	27.10	35.49
CS	4.209	3.819	4.269	5.340	3.404	4.710	3.084	2.350	3.191
EU	1.348	1.286	1.409	1.291	1.419	1.043	1.560	1.272	1.277
FE	49992	52724	52213	34398	48376	25548	49043	44862	48553
HF	7.34	9.39	9.30	8.06	5.92	7.40	5.98	4.84	5.93
RB	85.22	79.89	92.37	121.66	64.91	159.61	72.10	96.39	87.33
SB	0.773	1.066	0.929	0.969	1.006	0.985	0.809	0.514	0.644
SC	13.75	16.01	14.31	9.17	16.43	8.62	15.41	11.66	14.34
SR	372.11	252.36	346.47	376.68	285.93	350.80	321.03	418.94	449.64
TA	1.837	1.439	1.804	1.404	1.255	1.993	1.304	1.240	1.282
TB	1.143	1.108	1.943	1.133	1.077	0.591	1.973	0.926	1.187
TH	25.01	20.30	25.70	17.74	19.56	15.65	20.36	18.48	21.24
ZN	70.56	69.24	76.70	132.17	61.48	102.10	68.04	52.08	63.28
ZR	182.9	242.6	240.0	175.3	182.3	178.6	186.2	126.4	135.5
AL	106354	106215	103183	85935	104055	83053	105925	85319	87627
BA	886.9	878.6	729.3	629.3	717.6	737.4	910.9	971.3	674.4
CA	18070	14896	16864	21036	18166	13198	19179	20093	22114
DY	6.147	5.722	6.246	3.450	5.929	3.073	7.037	4.262	4.462
K	19262	19087	16435	26265	17125	31709	19046	29830	25167
MN	868.9	788.7	958.5	560.0	721.2	433.5	872.2	692.3	585.4
NA	15724	12601	16028	16394	14814	17579	15072	16784	16108
TI	4103	4729	5007	3536	4343	3469	5146	4364	3350
V	139.1	164.0	145.1	73.8	141.9	61.0	138.9	121.3	114.3

Appendix A: Table A.1 Continued

Sherd#	JEC353	JEC354	JEC355	JEC356	JEC357	JEC358	JEC359	JEC360	JEC361
Region Col	COV	COV	COV	COV	COV	COV	COV	COV	COV
Site	Iny-1700	Iny-1700	Iny-1700	Iny-1700	Iny-1700	Iny-1700	Iny-1700	Iny-1700	Iny-1700
Sherd type	body	body	body	body	base	body	body	body	body
Thickness	4.7	4.1	6.4	5.2	12.7	6.3	4.6	7.1	5.0
Rim Diam.	275	150	175			225		105	
Rim Shape									
Ext/Int Srf	S / S	R0 / R0	R0 / R1	S / S	- / -	R0 / R0	R0 / S	R2 / R1	S / S
Temp D/Sz	1 / 3	1 / 1	2 / 2	2 / 1	3 / 2	1 / 3	1 / 1	3 / 2	1 / 1
Org / Mica	1 / 1	0 / 1	2 / 0	0 / 3	1 / 1	1 / 1	0 / 1	1 / 1	0 / 1
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / 4	0 / -	0 / -	0 / -	- / -	0 / -	0 / -	0 / -	0 / -
Lip Sh/Lat	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -
Ch. Group	NOV1C	COV1	Ungrp.	Ungrp.	COV1	Ungrp.	COV1	COV1	NTS1B
AS	13.40	3.13	4.49	21.97	5.41	8.23	5.65	5.22	4.21
LA	65.67	35.60	39.57	38.56	51.79	36.51	31.97	39.10	41.21
LU	0.671	0.393	0.295	0.373	0.431	0.314	0.342	0.373	0.324
ND	51.39	27.22	29.28	27.19	37.49	25.18	23.92	32.83	32.40
SM	10.47	5.31	5.15	5.87	6.74	4.82	4.63	6.36	5.18
U	10.803	8.550	3.667	4.082	4.488	4.223	6.831	5.556	4.469
YB	4.345	2.338	1.896	2.283	2.735	1.844	1.974	2.202	1.989
CE	106.70	69.28	77.61	65.93	94.89	74.22	65.21	73.46	64.49
CO	15.18	9.44	8.47	16.34	14.97	8.45	9.24	16.19	5.33
CR	35.47	22.92	36.25	46.67	43.43	33.91	21.89	22.87	30.31
CS	3.475	5.334	4.532	3.338	4.346	4.598	4.723	2.723	3.618
EU	1.390	1.018	0.982	1.106	1.227	0.947	0.891	1.362	0.916
FE	47143	62887	24619	61689	53221	24925	58266	47583	22217
HF	6.39	4.98	7.16	7.75	7.09	7.11	4.62	4.08	6.86
RB	73.14	108.66	159.96	75.48	112.30	145.65	100.59	87.35	105.89
SB	0.941	0.483	0.982	0.894	0.680	0.981	0.446	0.451	0.685
SC	14.30	14.75	8.42	17.35	15.50	8.27	13.54	15.60	9.61
SR	377.38	260.98	362.65	416.21	310.91	324.99	336.00	334.06	231.15
TA	1.630	1.020	1.607	1.324	1.420	1.618	0.770	1.086	2.858
TB	1.868	0.687	0.595	0.691	1.270	0.550	0.927	1.248	0.551
TH	30.54	14.55	18.01	16.78	21.10	16.74	13.70	16.95	24.22
ZN	66.75	56.52	100.22	75.82	77.72	67.56	52.14	57.37	68.65
ZR	193.3	140.7	160.9	179.6	193.4	180.6	118.9	118.9	125.7
AL	102315	80382	85391	99179	89435	82519	80677	105606	84711
BA	836.8	1050.6	805.3	892.4	768.8	659.5	1096.5	1038.0	628.4
CA	17708	19350	12822	23014	21141	15245	19850	19777	10737
DY	6.380	3.752	2.945	3.919	4.349	2.614	2.920	3.415	3.409
K	18860	19872	31335	17768	22235	26692	22244	29164	17801
MN	756.1	474.4	409.8	852.1	759.8	415.9	597.9	700.8	245.0
NA	13629	15752	16918	14999	14840	17116	15218	10086	9509
TI	3670	3114	2553	4452	3031	2371	2917	2985	1712
V	138.2	171.3	61.6	175.1	140.0	72.3	158.3	136.0	54.7

Appendix A: Table A.1 Continued

Sherd#	**JEC362**	**JEC363**	**JEC364**	**JEC365**	**JEC366**	**JEC367**	**JEC368**	**JEC369**	**JEC370**
Region Col	COV	COV	COV	COV	COV	COV	COV	COV	COV
Site	Iny-1700	Iny-1700	Iny-1700	Iny-1700	Iny-4580	Iny-4581	Iny-4582	Iny-4583	Iny-1756
Sherd type	base	rim	body	body	rim	body	body	body	rim
Thickness	10.0	7.9	6.8	7.3	6.2	4.7	8.8	8.3	7.2
Rim Diam.		450		275	260	275	230	100	220
Rim Shape		3			3				3
Ext/Int Srf	- / -	R2 / R1	R0 / -	R2 / R1	R1 / R1	S / R1	S / S	R0 / R0	R0 / R1
Temp D/Sz	1 / 2	1 / 1	3 / 2	1 / 1	3 / 1	1 / 1	1 / 1	2 / 2	1 / 1
Org / Mica	0 / 1	0 / 3	0 / 0	0 / 1	0 / 1	0 / 2	0 / 1	0 / 2	1 / 4
Decorated	0	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / -	0 / -	0 / -	0 / 4	0 / 4	1 / -	1 / 3	0 / 4
Lip Sh/Lat	- / -	3 / -	- / -	- / -	2 / -	- / -	- / -	- / -	3 / -
Ch. Group	NOV1A	NOV1A	COV1	NOV1A	COV1	Ungrp.	Ungrp.	NOV1A	NOV1C
AS	11.53	11.69	5.94	9.16	0.00	3.93	7.78	10.16	13.04
LA	46.68	51.81	41.88	47.52	43.44	41.40	54.92	50.60	56.31
LU	0.548	0.615	0.412	0.503	0.375	0.343	0.517	0.501	0.687
ND	34.27	41.77	36.42	37.84	28.45	65.29	40.13	41.79	44.58
SM	7.55	8.22	6.93	7.61	5.88	6.03	7.73	8.38	9.15
U	7.028	6.774	5.562	6.908	6.027	8.542	5.666	5.878	8.415
YB	3.430	4.077	2.588	3.171	2.220	1.913	3.022	3.164	4.521
CE	89.87	97.06	81.81	88.69	77.70	74.48	96.04	87.08	98.65
CO	14.66	16.68	15.45	14.97	14.42	17.87	15.85	15.61	17.87
CR	35.77	36.69	33.27	39.29	26.98	22.80	55.11	38.69	40.42
CS	3.093	3.795	2.868	3.216	2.733	3.672	3.638	3.112	4.207
EU	1.206	1.351	1.379	1.250	1.279	1.231	1.339	1.384	1.423
FE	49236	51943	54063	47518	46158	50956	64376	48778	53364
HF	5.15	6.34	5.96	5.54	4.21	4.97	10.26	6.22	8.62
RB	75.95	82.70	80.57	78.50	92.14	63.57	58.60	61.45	87.05
SB	1.129	0.935	0.650	0.947	0.559	0.546	0.771	0.901	1.053
SC	15.25	15.07	13.46	15.04	12.81	14.22	18.29	16.17	14.34
SR	319.47	289.55	331.59	323.23	349.48	273.42	295.77	403.18	297.69
TA	1.398	1.420	1.497	1.291	1.037	1.015	1.658	1.289	1.682
TB	0.998	1.158	1.240	1.366	0.669	1.069	1.387	1.110	1.871
TH	20.04	25.37	15.48	23.10	26.98	93.00	25.22	19.50	24.12
ZN	63.16	68.41	55.05	62.55	52.21	49.96	72.96	69.74	69.36
ZR	141.8	168.9	138.1	155.9	117.4	145.7	248.1	162.1	212.6
AL	100213	104045	98185	99072	91827	99063	100297	104649	104222
BA	668.0	616.0	763.4	692.2	699.2	807.2	600.4	701.6	559.9
CA	17055	17398	18834	16185	18139	14822	20952	21015	16961
DY	4.973	6.087	3.832	4.819	3.174	3.680	4.432	5.863	6.683
K	22609	17679	23171	18766	24279	18902	16086	17245	17952
MN	723.5	742.4	785.8	718.0	654.2	810.4	919.5	716.5	937.6
NA	14852	13650	13593	14171	12460	12856	13168	16411	15726
TI	4048	3794	3404	3757	3150	3912	5100	4064	4767
V	146.9	135.8	165.7	145.8	121.7	123.7	187.8	118.4	165.8

Appendix A: Table A.1 Continued

Sherd#	JEC371	JEC372	JEC373	JEC374	JEC375	JEC376	JEC379	JEC380
Region Col	WM	WM	WM	SV	PF	PF	SOV	SOV
Site	Iny-2191	Iny-2194	Iny-2196	N/A	6-q-4	isolate	G-1	G-1
Sherd type	body	body	body	body	base	base	body	body
Thickness	3.8	5.6	5.5	5.5	15.5	13.7	6.1	5.2
Rim Diam.								
Rim Shape								
Ext/Int Srf	R0 / S	R4 / R1	R0 / S	R0 / R0	R0 / R0	R0 / R0	R0 / R0	R0 / R0
Temp D/Sz	1 / 1	1 / 2	1 / 1	2 / 2	3 / 3	2 / 2	2 / 2	2 / 2
Org / Mica	0 / 2	0 / 0	0 / 0	- / -	- / -	- / -	0 / 2	0 / 3
Decorated	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / 3	0 / -	- / -	- / -	- / -	- / -	- / -
Lip Sh/Lat	- / -	- / -	- / -	- / -	- / -	- / -	- / -	- / -
Ch. Group	Ungrp.	NOV1C	NTS1B	Ungrp.	NOV1B	NOV1B	SOV1B	SOV1A
AS	9.85	8.28	6.81	5.89	8.75	7.72	21.67	16.63
LA	62.99	52.70	69.74	77.57	56.94	46.01	62.59	83.60
LU	0.302	0.696	0.515	0.408	0.429	0.476	0.419	0.840
ND	46.81	41.75	42.96	56.14	39.52	35.31	37.98	55.88
SM	7.19	8.87	8.14	9.49	7.49	8.02	7.39	11.00
U	4.150	8.374	5.752	3.404	5.090	7.609	6.881	15.576
YB	1.719	4.370	3.461	2.707	2.527	2.775	2.589	4.828
CE	96.04	88.81	124.65	149.74	109.48	92.38	96.53	144.12
CO	10.03	13.35	4.96	11.16	11.75	11.34	7.03	9.29
CR	37.58	35.01	24.44	30.88	32.10	32.71	12.93	15.82
CS	4.733	3.122	10.380	4.806	4.446	4.101	6.166	4.699
EU	1.504	1.364	1.055	1.991	1.372	1.313	1.213	1.606
FE	45541	45952	31456	41548	40957	39909	49434	46619
HF	6.09	8.52	11.73	8.82	8.95	9.90	7.74	12.63
RB	91.34	87.51	138.31	116.53	104.05	95.58	106.33	91.09
SB	1.066	0.634	1.015	0.756	1.063	0.921	3.054	1.696
SC	10.67	14.48	8.80	11.79	11.22	10.50	7.01	11.60
SR	709.55	230.86	234.75	631.76	314.51	220.59	382.16	311.26
TA	1.239	1.527	2.236	1.527	1.506	1.315	1.878	2.420
TB	0.651	1.576	1.102	1.032	1.365	0.906	0.567	1.400
TH	25.49	22.43	34.70	23.38	20.62	35.68	43.87	40.83
ZN	87.66	63.22	130.40	88.99	78.80	78.05	83.16	87.01
ZR	157.8	229.9	292.4	245.6	231.0	235.8	211.7	395.6
AL	93740	111267	102361	88170	92303	94391	94137	91513
BA	877.0	808.6	632.2	1032.4	794.9	832.0	407.7	409.5
CA	19567	16923	11988	16967	16444	16741	12675	20677
DY	3.193	7.026	5.951	5.501	5.437	4.288	3.591	7.871
K	30175	22487	30291	35161	28958	26678	26151	22606
MN	340.4	812.4	529.3	871.8	731.0	835.1	581.8	1312.2
NA	15352	14971	12126	21185	20918	20540	26576	28898
TI	4048	3644	3479	5702	4421	4515	3626	4312
V	109.3	124.3	52.3	111.5	102.2	98.4	105.5	113.3

Table A.2: INAA data for raw clay samples collected.

Clay Smp#	**JEC181**	**JEC182**	**JEC183**	**JEC184**	**JEC185**	**JEC186**	**JEC187**	**JEC188**	**JEC189**
Region	DV	DV	DV	DV	DV	PV	PV	PV	SOV
Site	Salt Pan at Cow Creek	Playa @ Devil’s Cornfield	Strata N. of Furnace Creek	Salt Creek	Basalt east of Stovepipe W.	Strata W. of Townes Pass	Playa in valley bottom on 190	Strata on W. side of valley	Owens Lake @ Ash Creek
Temp D/Sz	1 / 1	2 / 1	1 / 3	1 / 1	2 / 2	1 / 1	1 / 2	1 / 3	1 / 1
Mica	1	2	0	0	0	0	2	1	5
Clay Type	Sed.	Sed.	Sed.	Sed.	Res.	Sed.	Sed.	Res.	Sed.
Clay Qual.	poor	medium	poor	poor	poor	poor	good	medium	poor
AS	23.21	21.56	66.66	19.24	19.14	33.44	31.94	2.76	27.16
LA	24.58	36.908	28.581	31.498	16.513	33.017	41.737	28.726	47.934
LU	0.196	0.345	0.286	0.247	0.156	0.31	0.358	0.291	0.389
ND	20.34	33.6	24.28	28.31	16.03	31.33	33.01	24.11	35.81
SM	3.768	5.476	4.478	4.639	3.228	5.669	5.713	4.796	6.207
U	2.264	5.976	4.312	3.194	7.15	2.99	4.015	2.892	10.241
YB	1.552	2.132	1.996	1.784	0.831	2.187	2.418	1.87	1.988
CE	49.72	72.57	56.78	61.71	33.28	67.27	80.68	65.46	82.57
CO	8.921	12.401	7.922	9.178	17.384	18.452	20.72	19.375	17.024
CR	31.95	55.17	39.22	39.15	128.73	73.63	63.77	58.33	16.30
CS	7.345	5.003	27.305	5.547	0.631	7.214	6.242	6.107	15.592
EU	0.684	1.082	0.806	0.905	0.632	1.13	1.156	1.075	1.211
FE	21068	31690	24669	23462	26203	37801	48543	40083	44698
HF	3.629	5.409	3.968	3.9	2.328	3.814	4.02	6.971	5.045
RB	114.2	142.5	195.8	114	36.3	154.6	129.6	97.3	196.9
SB	1.439	1.713	2.043	2.155	1.007	2.501	4.617	1.009	3.084
SC	6.512	10.63	7.539	7.858	7.755	14.477	14.515	13.719	11.841
SR	2912.4	2988.3	5650.6	704.2	1922.6	210.3	287.1	423.1	459.2
TA	0.702	1.004	0.774	0.811	0.602	0.813	0.952	1.042	1.096
TB	0.455	0.645	0.496	0.599	0.288	0.714	0.791	0.615	0.607
TH	8.94	14.59	11.01	9.66	3.98	10.27	15.73	12.68	20.83
ZN	63.8	82	85.7	77.1	43.5	111.5	370.5	94.5	132.2
ZR	97.4	131.8	134.5	132.4	108.4	103.7	136.9	207.4	151.7
AL	45084	76772	54640	65074	48893	85042	86846	86003	90002
BA	542.7	567.8	553.4	588.6	185.6	527.9	440.8	404.2	760.4
CA	43673	71003	141930	96191.7	81806.7	91026.9	54562.6	19064.4	40641
DY	2.021	3.527	2.95	3.128	0.814	4.084	3.8	3.167	2.75
K	20111	27316	24164	25963	20620	39531	23503	21759	34963
MN	608.5	719.3	453.8	590.8	522.8	620.2	1312.4	851.9	1437.5
NA	105350	30814	52711	29105	68175	3760	11454	17201	23434
TI	3909.9	3213.8	1289.7	3050.7	2878.9	3638.8	3867.7	4514.5	4971.1
V	66.7	79.5	62.6	93.4	105.8	107.1	136.9	104.2	110.8

Table A.2 Continued.

Clay Smp#	JEC190	JEC191	JEC192	JEC193	JEC194	JEC195	JEC196	JEC197	JEC198
Region	SOV	SOV	SOV	SOV	SOV	COV	COV	COV	NOV
Site	Strata @ Alabam. Hills @ Spring	Granite at mouth Cotton-wood Cr	Old lake strata @ Cotton-wood Cr	Pan @ Ash Creek fan	Alabam. Hills @ Spring	River oxbow @ Big Pine	Strata @ Owens River @ Tinnem.	Pan South of Poverty Hills	Fish Slough, SW side
Temp D/Sz	1 / 3	2 / 3	1 / 3	1 / 2	1 / 2	1 / 1	1 / 2	1 / 2	- / -
Mica	0	1	5	5	2	4	2	1	-
Clay Type	Sed.	Res.	Sed.	Sed.	Res.	Sed.	Sed.	Sed.	Sed.
Clay Qual.	poor	poor	poor	poor	poor	poor	poor	good	poor
AS	905.40	14.24	15.01	21.65	7.67	10.10	7.79	50.24	6.01
LA	26.431	44.391	59.716	63.31	30.763	34.708	43.287	36.602	18.785
LU	0.306	0.236	0.512	0.414	0.345	0.35	0.503	0.346	0.261
ND	19.27	23.16	39.09	44.83	24.98	27.21	40.24	27.66	15.13
SM	4.154	3.726	7.851	7.849	4.98	5.045	7.822	5.357	3.23
U	8.818	2.504	20.808	7.845	5.747	5.562	15.031	3.71	6.092
YB	1.424	1.69	2.015	2.761	2.241	2.165	2.518	2.072	1.495
CE	49.64	71.25	119.29	132.03	60.68	63.68	84.99	74.31	38.20
CO	34.742	4.033	24.506	26.595	8.447	6.648	29.129	15.835	1.961
CR	18.00	6.55	29.05	34.77	21.34	30.53	64.37	39.74	8.85
CS	5.821	2.189	9.359	16.34	10.077	24.676	5.41	7.661	3.418
EU	0.682	0.691	1.335	1.52	0.774	0.839	1.42	1.018	0.324
FE	146574	17281	57836	61206	27837	24117	70817	38477	9441
HF	2.888	5.389	4.244	6.432	4.98	6.566	4.786	4.979	3.777
RB	96.2	123.9	210.8	227.2	146.1	123.2	129.6	147.6	108.6
SB	1.321	0.276	1.239	2.972	1.205	3.08	0.658	1.682	0.746
SC	7.607	3.582	15.337	18.816	6.903	7.468	16.037	11.965	2.871
SR	1527.6	260.5	443.8	210.7	575.4	369.4	409.5	334.8	976.8
TA	0.63	1.145	1.637	1.63	1.303	1.321	0.983	1.217	1.029
TB	0.353	0.425	0.663	0.753	0.626	0.59	0.83	0.558	0.426
TH	9.76	21.29	36.96	50.77	16.24	13.52	16.44	17.00	9.97
ZN	63.9	33.1	150.7	185.8	81.5	80.7	132.9	134.9	48.9
ZR	114.8	132.1	183.2	193.9	128.5	185.9	193.3	133	118.9
AL	40355	74532	100484	104577	73887	67598	85269	79217	44902
BA	779.3	821.8	611.3	615.7	616.7	864.6	599.2	664	319.3
CA	77302.2	8510.7	21324.9	18139.5	26617.6	26313.9	33727	22362.3	80542.8
DY	4.398	2.126	2.917	5.134	2.89	3.606	4.058	3.002	2.021
K		32295	31572	31907	30643	23798	23321	33629	22259
MN	11590.6	341.7	1958.4	2001	718.7	750.4	981.3	1284	398.3
NA	12103	20387	19193	14242	24177	20113	15773	23572	15942
TI	4466.3	1907.8	9316.8	5977.7	2172.6	2199.8	6341.5	3788.4	804.6
V		25.6	162	144.1	89	72.6	278.1	99.4	24.1

Table A.2 Continued.

Clay Smp#	**JEC199**	**JEC200**	**JEC201**	**JEC202**	**JEC203**	**JEC204**	**JEC205**	**JEC206**	**JEC207**
Region	NOV	NOV	DSV	DSV	FLV	CSM	Seq	Seq	Seq
Site	Strata N. of Benton	Creek bed, N. of Benton	Antelope Spring	Crooked Creek, north end	Playa @ N. end of Valley	South side of Playa	Granite S. of Park	Granite on 198 @ 3800 ft.	Slough E. of Lake Kaweah
Temp D/Sz	1 / 2	0 / 0	1 / 3	- / -	1 / 1	1 / 2	2 / 2	1 / 1	1 / 1
Mica	1	2	2	-	1	1	2	1	5
Clay Type	Res.	Sed.	Res.	Sed.	Sed.	Sed.	Res.	Res.	Sed.
Clay Qual.	poor	medium	poor	poor	poor	good	good	medium	poor
AS	36.19	18.55	2.68	5.98	9.94	56.26	2.74	12.76	4.16
LA	37.483	41.231	48.419	56.592	37.433	38.916	13.644	36.918	40.513
LU	0.304	0.359	0.561	0.296	0.32	0.332	0.439	0.576	0.492
ND	32.96	36.59	34.9	38.91	27.58	26.9	15.5	32.84	31.18
SM	5.835	6.541	7.541	6.788	5.179	5.431	4.099	9.174	7.172
U	4.625	4.336	4.183	3.345	4.73	5.172	0.974	3.773	8.033
YB	2.028	2.222	3.95	2.077	2.126	2.056	2.292	3.169	3.408
CE	73.18	84.07	99.40	110.09	74.75	76.18	28.53	128.06	81.59
CO	13.711	15.261	7.551	13.752	8.819	8.327	34.505	29.898	19.367
CR	41.42	53.95	42.84	40.08	26.97	44.81	71.14	82.67	62.93
CS	12.472	14.375	2.716	4.813	10.098	27.582	5.155	9.58	6.71
EU	1.15	1.297	1.5	1.385	0.842	0.902	1.483	2.773	1.492
FE	36779	38351	27238	36856	25917	24404	90821	158179	56651
HF	4.929	5.716	18.67	6.811	5.981	5.288	2.311	8.548	4.201
RB	147.8	161.1	89.5	127.1	143.1	167.5	15.1	34.6	129
SB	2.759	5.492	0.421	1.986	2.089	6.38	0.251	2.121	0.879
SC	11.388	11.828	10.157	9.816	7.733	8.818	29.031	47.673	16.977
SR	436.6	360.5	188.4	862	333.3	504.2	312.9	0	176.4
TA	1.09	1.278	1.496	1.126	1.36	1.149	0.595	3.13	1.093
TB	0.682	0.765	1.302	0.365	0.738	0.723	0.893	1.407	0.534
TH	12.85	14.35	11.97	13.06	16.39	15.53	2.57	8.21	16.59
ZN	81.4	121.5	48.1	119.8	78.8	79.1	126.8	134.4	140.3
ZR	165.7	165.7	387.8	153.8	120.8	164	81.8	204.2	117.6
AL	84111	87618	63813	84001	71339	85464	112022	145353	106447
BA	782.8	1021	519.2	790.5	468.4	733.3	136.9	246.4	940.2
CA	43654	22499.1	12542.2	38126.4	68250	17187	30606.4	1825.9	25261.8
DY	3.431	3.678	5.486	3.837	3.751	3.341	3.222	6.597	5.636
K	24740	30658	22970	30632	32706	34505	2515	1733	20321
MN	372.6	1008.4	465.7	914.3	694.6	620.1	1600.6	1141.8	892.4
NA	11071	14822	16331	21527	17092	21793	14356	1950	15186
TI	3498.1	4159.6	7599.6	3337.8	2384.1	3047.5	8861.6	24040.9	6223.4
V	104.9	110.5	71.6	86.6	60.4	80.8	229.8	511.5	153.1

Table A.2 Continued.

Clay Smp#	**JEC208**	**JEC281**	**JEC377**	**JEC378**		**JEC230**	**JEC231**	**JEC232**
Region	Seq	NTS	SV	SV		SOV	SOV	SOV
Site	Lake Kaweah	Ny-3621 Clay Chunk	Pan in N. end of Valley	Strata from N. end.		Temper from JEC158	Temper from JEC222	Temper from JEC191
Temp D/Sz	1 / 2	1 / 1	1 / 1	1 / 1		1 / 2	2 / 3	2 / 3
Mica	4	0	2	0		-	-	-
Clay Type	Sed.	Unknwn.	Sed.	Res.		Temper	Temper	Temper
Clay Qual.	poor	good	medium	medium				
AS	10.61	3.99	112.78	9.13		3.13	1.31	7.23
LA	45.016	53.968	38.9133	79.8912		9.903	9.888	15.229
LU	0.527	0.5935	0.42527	0.31435		0.095	0.088	0.057
ND	35.03	37.72	33.0358	39.3281		12.34	6.16	6.53
SM	7.434	7.544	7.05929	6.56536		1.489	1.267	0.908
U	9.988	7.799	2.65314	8.5871		1.681	1.592	0.955
YB	2.957	4.089	2.87506	1.51611		0.708	0.534	0.341
CE	89.82	87.70	80.23	130.29		15.19	17.65	22.05
CO	18.091	0.996	11.8194	19.1552		1.84	1.858	0.432
CR	68.78	2.14	51.43	38.64		2.97	3.79	0.56
CS	6.311	4.741	8.00743	10.0021		1.724	1.244	1.72
EU	1.417	0.6347	1.35217	1.17046		0.488	0.355	0.239
FE	45744	7799	27793	47430		5072	12452	2712
HF	5.441	6.103	6.21922	2.79467		0.615	1.755	1.224
RB	120	199.1	116.121	158.511		156.9	116.5	156.2
SB	1.473	0.4871	2.92388	1.30797		0.311	0.2	0.107
SC	14.299	1.952	10.2326	16.2548		1.871	2.186	0.335
SR	345.6	92.2	377.384	467.328		203.6	355.2	309.9
TA	1.324	2.1898	1.11339	0.86988		0.586	0.25	0.236
TB	1.216	0.9667	0.85058	0.5759		0.131	0.098	0.06
TH	19.56	31.98	11.55	21.67		3.46	5.40	6.82
ZN		55.2	83.5124	157.447		8.7	11.4	4.4
ZR	169.1	143	146.598	124.566		35.5	54.7	29.7
AL	92460	67241	79280	103779		60227	74996	70938
BA	746.1	315.7	629.836	579.193		998.8	1342.3	908
CA	25069.9	9291.6	50237.3	23043		3831	8720	12543
DY	4.817	5.128	4.94354	2.51387		1.118	0.601	0.731
K	17820	45295	25323	24943		41152	52225	43630
MN	943.2	621.4	486.548	1146.86		202.4	225.4	100.8
NA	17052	22323	9119	10530		15568	21436	16915
TI	6176.8	772.6	3622.78	2349.56		707.8	901.6	0
V	120.2		80.4034	106.304		13.6	25.8	8.7

Table A.3: Technological Attributes of rim sherds not analyzed by INAA.

Sherd#								
Region Col	DV	DV	DV	DV	DV	DV	DV	DV
Site	Mesquite Flat	DV4	DV30	DV30	DV30	DV30	DV127	DV115
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5.5	5.3	4.9	5.5	5.3	5.3	6.6	6.4
Rim Diam.	320	380	240	200	320	300	320	260
Rim Shape	3	4	3	3	3	4	4	3
Ext/Int Srf	R1 / R1	- / -	- / -	R1 / R1	R1 / R1	R2 / R1	- / -	- / -
Temp D/Sz	2 / 2	3 / 2	3 / 2	3 / 1	2 / 2	3 / 3	2 / 2	2 / 3
Org / Mica	0 / 2	0 / 1	0 / 0	0 / 1	0 / 3	0 / 1	0 / 0	0 / 0
Decorated	0	0	0	0	0	0	0	0
Core/Coil	- / -	- / -	- / 2	- / 2	- / 4	- / -	- / 2	- / 2
Lip Sh/Lat	1 / -	3 / -	3 / -	1 / -	2 / -	3 / -	3 / -	1 / 2

Sherd#								
Region Col	DV	DV	DV	DV	DV	DV	DV	DV
Site	DV112	48-55	OCF-1	DV147	DV131	DV199	DV193	DV193
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	6	7	6.5	3.9	7.4	5.1	5.3	5.6
Rim Diam.	160	260	300	160	320	220	300	260
Rim Shape	3	5	4	5	4	2	3	2
Ext/Int Srf	R0 / R1	S / R1	R1 / R1	- / -	- / R1	R0 / R1	R2 / R1	- / -
Temp D/Sz	1 / 2	1 / 3	2 / 3	2 / 3	3 / 2	1 / 1	2 / 2	1 / 1
Org / Mica	0 / 0	0 / 0	0 / 0	0 / 1	0 / 0	2 / 4	0 / 2	0 / 1
Decorated	0	1	0	1	1	0	0	0
Core/Coil	- / 2	- / 4	- / 2	- / -	- / -	- / -	- / -	- / -
Lip Sh/Lat	3 / -	3 / -	2 / -	5 / -	3 / -	3 / 2	3 / -	3 / -

Sherd#								
Region Col	DV	DV	DV	DV	DV	DV	DV	DV
Site	DV195	DV195	DV209	DV209	DV209	DV206	DV210	DV219
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	6	6.3	4.6	6.3	5.7	6	4.5	5
Rim Diam.	300	180	160	340	280	300	220	240
Rim Shape	2	5	3	3	1	4	3	3
Ext/Int Srf	R2 / R1	S / S	R2 / R1	- / R1	- / R1	R2 / R1	R1 / R2	R1 / R1
Temp D/Sz	1 / 1	2 / 3	2 / 2	2 / 2	2 / 2	2 / 3	1 / 2	2 / 2
Org / Mica	0 / 3	0 / 0	0 / 1	0 / 3	1 / 0	0 / 0	1 / 3	0 / 0
Decorated	0	0	0	1	0	0	0	0
Core/Coil	- / -	- / -	- / -	- / 1	- / -	- / 2	- / 4	- / 2
Lip Sh/Lat	2 / -	3 / -	3 / -	2 / -	3 / -	3 / -	4 / -	3 / -

Table A.3: Continued.

Sherd#								354-550
Region Col	DV	DV	DV	DV	DV	DV	DV	DSV
Site	DV219	DV223	DV221	DV226	DV227	DV230	DV229	Iny-3726
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5.4	5.6	4.2	5.2	7.1	6.8	6.2	4.6
Rim Diam.	300	280	220	350	280	360	360	450
Rim Shape	3	3	3	4	3	3	3	1
Ext/Int Srf	R1 / R3	S / R0	R0 / R1	R1 / R1	- / R1	R1 / R1	R4 / R1	S / S
Temp D/Sz	2 / 3	1 / 2	1 / 2	2 / 2	2 / 2	2 / 2	2 / 3	- / -
Org / Mica	0 / 0	0 / 2	0 / 0	0 / 1	0 / 0	0 / 0	0 / 2	- / -
Decorated	0	0	0	0	1	1	0	0
Core/Coil	- / 4	- / 2	- / 2	- / -	- / 2	- / -	- / -	- / -
Lip Sh/Lat	2 / -	3 / -	3 / -	3 / -	3 / -	1 / -	4 / -	3 / -

Sherd#			8-4093-S	1805-A	4601-B	7374-BB	14-1192	462-B
Region Col	DSV	DSV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Soldier Pass	White Mtn City	Iny-2750 B	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5.7	5.6	4.9	4.8	4.2	5.8	4.6	4.7
Rim Diam.	260	240	150	150	150	175	175	75
Rim Shape	1	3	3	3	1	3	3	3
Ext/Int Srf	R1 / R1	R2 / R1	R0 / R0	R2 / R1	- / -	S / R2	- / R4	R0 / R3
Temp D/Sz	1 / 2	3 / 3	2 / 3	2 / 2	1 / 1	1 / 2	1 / 1	2 / 2
Org / Mica	0 / 2	0 / 2	- / -	0 / 0	0 / 3	0 / 1	2 / 0	0 / 0
Decorated	0	0	0	0	0	0	0	0
Core/Coil	0 / -	0 / 4	- / -	0 / 4	- / -	- / -	0 / 2	0 / -
Lip Sh/Lat	1 / 1	3 / -	2 / 1	3 / -	2 / -	5 / -	5 / -	2 / -

Sherd#	6821-RR	2679-F	3747-B	462-A	2679-B	2662-A	3542-B	5894-F
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	5.4	5	7	6	5.5	5.8	5.4	8.2
Rim Diam.	225	200	275	225	150	125	250	300
Rim Shape	2	3	3	3	3	3	3	5
Ext/Int Srf	R0 / R0	R0 / R3	R2 / R1	R3 / R1	R0 / S	R0 / R1	- / R2	- / -
Temp D/Sz	2 / 1	2 / 3	1 / 1	2 / 1	1 / 1	2 / 2	1 / 1	2 / 3
Org / Mica	1 / 1	0 / 2	0 / 0	1 / 1	0 / 1	0 / 3	0 / 0	0 / 0
Decorated	0	0	0	0	0	0	0	0
Core/Coil	1 / 4	- / -	- / 4	0 / 2	1 / 2	0 / -	- / -	0 / -
Lip Sh/Lat	2 / 1	4 / -	1 / 1	3 / 1	3 / -	3 / -	3 / -	3 / -

Table A.3: Continued.

Sherd#	31-424	3542-A	44-2708	1306-B	2679-G	4829-A	3323-B	7374-DD
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	3.6	4.6	5.1	3.8	6.1	5.9	7.2	5.7
Rim Diam.	275	400	125	125	250	250	275	150
Rim Shape	3	3	3	1	3	3	3	3
Ext/Int Srf	S / S	R2 / R2	R0 / -	R0 / R0	S / S	R1 / R2	R1 / R1	R0 / R2
Temp D/Sz	2 / 2	3 / 2	3 / 2	1 / 1	1 / 2	2 / 1	1 / 2	1 / 1
Org / Mica	0 / 0	0 / 3	0 / 3	0 / 2	0 / 0	0 / 2	0 / 0	0 / 0
Decorated	0	0	0	0	0	0	0	0
Core/Coil	- / -	- / -	0 / -	1 / 2	1 / 1	- / 1	- / 1	- / 4
Lip Sh/Lat	1 / -	2 / -	3 / -	3 / -	3 / -	1 / 2	3 / 1	2 / 1

Sherd#	32-578-B	21-1665	7411-K	4585-A	78-7473	3450-A	6712-E	6712-D
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	6.1	7	6.6	3.6	4.3	6.3	4.7	6
Rim Diam.	350	300	225	200	225	275	300	250
Rim Shape	5	3	3	2	1	2	3	3
Ext/Int Srf	- / -	R4 / R1	R1 / -	R0 / R2	R2 / R0	R1 / R1	R0 / R0	R1 / S
Temp D/Sz	2 / 3	1 / 1	2 / 1	1 / 2	2 / 2	1 / 2	2 / 2	1 / 1
Org / Mica	0 / 0	0 / 1	0 / 1	0 / 3	3 / 3	3 / 0	0 / 0	1 / 2
Decorated	0	0	0	0	0	0	0	0
Core/Coil	- / -	- / 1	- / -	- / -	- / 2	- / 1	0 / 1	- / 1
Lip Sh/Lat	3 / -	2 / -	4 / 1	3 / -	3 / 1	5 / -	5 / -	2 / 1

Sherd#	522-A	4638-A	33-266-A	33-266-C	6821-D	7437-E/I	5227-D	2800-A
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	6.3	6	6.7	6.3	9.9	6.2	6.7	5.9
Rim Diam.	300	350	225	250	350	200	250	225
Rim Shape	3	3	3	3	3	3	3	3
Ext/Int Srf	R1 / R2	R3 / R1	R1 / R1	R0 / S	R2 / R0	R3 / R1	R2 / R2	R4 / S
Temp D/Sz	2 / 1	2 / 2	2 / 3	2 / 2	1 / 1	1 / 3	1 / 2	1 / 2
Org / Mica	3 / 2	1 / 2	0 / 3	0 / 2	2 / 4	0 / 4	0 / 2	2 / 3
Decorated	0	0	0	0	0	0	0	0
Core/Coil	- / -	0 / 1	- / 4	- / 4	0 / 2	- / 4	- / 1	- / -
Lip Sh/Lat	3 / -	3 / -	2 / -	1 / -	1 / -	3 / -	5 / -	3 / -

Table A.3: Continued.

Sherd#	6821-A	6985-B	18-1378	23-1942	23-5070	4601-A	6821-YYYY	6821-kkk
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	7.2	5.6	8.5	3.8	6.7	6	5.7	8
Rim Diam.	350	200	400	100	350	250	175	250
Rim Shape	1	3	2	3	3	3	3	3
Ext/Int Srf	R1 / R1	R0 / S	R1 / R1	R3 / R2	R2 / R1	R2 / R1	R0 / R1	R1 / R1
Temp D/Sz	1 / 1	1 / 1	1 / 1	2 / 2	1 / 1	1 / 1	3 / 2	2 / 2
Org / Mica	2 / 3	1 / 4	0 / 2	0 / 3	1 / 1	1 / 2	4 / 0	3 / 2
Decorated	0	0	0	0	0	0	0	0
Core/Coil	0 / 2	0 / -	- / -	- / -	0 / 2	0 / 1	0 / 4	0 / -
Lip Sh/Lat	3 / 2	3 / -	3 / 1	2 / 1	3 / 1	1 / 1	4 / -	1 / -

Sherd#								
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-3769, locus 13	Iny-3769, locus 13	Iny-3769, locus 13	Iny-1452	Iny-1447	Iny-1447	Iny-1430	Iny-1430
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	6.4	4.8	6.2	7.5	4.7	4.4	5.4	4.6
Rim Diam.	250	90	180	125	150	175	175	175
Rim Shape	3	1	3		3	3	3	1
Ext/Int Srf	R2 / R1	R3 / R1	R3 / R1	R2 / R0	R1 / R1	R0 / R1	R1 / R1	R2 / R1
Temp D/Sz	3 / 2	2 / 1	2 / 2	1 / 1	1 / 1	1 / 1	2 / 2	1 / 1
Org / Mica	0 / 2	1 / 0	0 / 0	0 / 4	2 / 1	2 / 2	0 / 1	0 / 0
Decorated	1	0	0	0	0	0	0	0
Core/Coil	- / 4	- / 1	- / 1	0 / 3	1 / -	0 / -	0 / 1	0 / 2
Lip Sh/Lat	3 / 2	4 / 1	3 / 1	- / -	3 / -	2 / -	3 / -	1 / -

Sherd#								14-1447
Region Col	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
Site	Iny-1430	Iny-1447	Iny-1447	Iny-1447	Iny-1430	Iny-1434	Iny-1430	Iny-30
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	4	5.2	8.6	5.8	7.2	8.6	5.4	7.8
Rim Diam.	175	200	225	250	300	400	400	
Rim Shape	1	3		3	3	3	3	
Ext/Int Srf	R1 / R1	R1 / R1	R0 / R0	R1 / R1	S / R1	- / S	R0 / R1	- / -
Temp D/Sz	2 / 1	2 / 2	2 / 1	3 / 2	2 / 3	2 / 2	2 / 2	2 / 2
Org / Mica	0 / 1	2 / 3	2 / 1	1 / 4	0 / 3	2 / 1	3 / 0	0 / 2
Decorated	0	0	0	0	0	1	0	0
Core/Coil	1 / -	1 / 1	0 / -	0 / -	0 / 1	0 / 2	1 / 4	0 / -
Lip Sh/Lat	1 / 1	3 / -	3 / -	4 / -	5 / 1	1 / -	2 / 1	2 / -

Table A.3: Continued.

Sherd#	56-5342		87.59.29	87.53.32	87.53.32	87.53. 10.4	87.53. 10.23	87.53. 10.22
Region Col	SOV	SOV	SV	SV	SV	Seq	Seq	Seq
Site	Iny-30	Iny-1447	Waucoba Springs	Grape-vine Cyn.	Grape-vine Cyn.	S. Fork Kern Riv.	S. Fork Kern Riv.	S. Fork Kern Riv.
Sherd type	rim	rim	rim	rim	rim	rim	rim	rim
Thickness	6.6		6.8	6.6	5.8	4.7	6.4	5.6
Rim Diam.	-	-	300	260	250	180	-	-
Rim Shape	3		3	4	3	3	3	1
Ext/Int Srf	S / R2	- / -	R0 / R1	R0 / R0	R3 / R1	R2 / R1	- / R1	R0 / S
Temp D/Sz	1 / 2	- / -	1 / 2	2 / 1	3 / 1	1 / 1	1 / 1	3 / 3
Org / Mica	0 / 2	- / -	0 / 4	0 / 0	2 / 2	0 / 2	3 / 2	0 / 2
Decorated	0	1	1	0	0	0	0	0
Core/Coil	- / 1	- / -	- / -	- / -	- / -	1 / 1	0 / 1	0 / 1
Lip Sh/Lat	3 / 1	- / -	3 / -	3 / -	3 / -	2 / -	3 / -	3 / -

Sherd#	87.53. 10.3							
Region Col	Seq							
Site	S. Fork Kern Riv.							
Sherd type	rim							
Thickness	6							
Rim Diam.	-							
Rim Shape	1							
Ext/Int Srf	- / -							
Temp D/Sz	1 / 3							
Org / Mica	0 / 2							
Decorated	0							
Core/Coil	0 / -							
Lip Sh/Lat	3 / -							

APPENDIX B

GC-MS DATA.

Notes:

1. Table B.1 gives the percentage of each fatty acid (all compounds above the heavy black line) relative to the total fatty acid content. Total fatty acid content is defined as the total density of all compounds above the black heavy line in the table. Compounds below the heavy black line are also given as a percentage of the total fatty acid content, but unlike the former, do not contribute to the total fatty acid content.

2. "-br" refers to branched fatty acids. All branched fatty acids were combined. Thus, C15:0-br includes the total percentage of C15:0-iso, C15:0-anteiso, and other C15:0 branched fatty acids.

3. The Cholestane isomer was identified by NIST as 5α, 8α, 9β, 14β-cholestane.

4. Short-even, Short-odd, Long-even, and Long-odd Alkanes refer to different types of straight-chain hydrocarbons. Short is considered less than 20 carbon atoms, long is considered as 20 or more.

5. "Dicarb. FA" refers to the total aliphatic dicarboxylic acid content. The most common of these compounds in the archaeological sherds include Hexanedioic acid, dimethyl ester (or adipic acid); Octanedioic acid, dimethyl ester (pimelic acid); and Nonedioic acid, dimethyl ester (or azelaic acid). Many of these compounds may be the byproducts of oxidation of longer-chained and unsaturated fatty acids.

6. "Hydroxy FA" refers to hydroxyalkanoic fatty acid compounds with a free hydroxyl group. The two main hydroxy fatty acids observed in the archaeological sherds are Octanoic acid, 3-hydroxy-, methyl ester and Octanoic acid, 8-hydroxy-, methyl ester. These compounds are not uncommon in plant lipid profiles.

7. "Epoxy FA" refers to other oxygenated fatty acids or compounds containing an oxo group. Compounds observed among the sherds include Methyl 4-oxoundecanoate; Methyl 10-oxohexadecanoate; Methyl 8-oxononanoate; Octanoic acid, 7-oxo-, methyl ester; Nonanoic acid, 4-oxo-, methyl ester (most common); and Nonanoic acid, 9-oxo-, methyl ester (second most common).

8. Diterpenoids refer to pine resins, including abeitic and, especially, pimaric acids.

Table B.1: GC-MS data for archaeological sherds.

INAA Sample	**JEC151**	**JEC003**	**JEC011**	**JEC015**	**JEC016**	**JEC020**	**JEC021**	**JEC026**
GC-MS #	0320I	0318J	0319A	0317Q	0407I	0320D	0320A	0319B
Region	DSV	DV	DV	DV	DV	DV	DV	DV
c9:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c10:0	0.00%	0.00%	0.53%	0.00%	0.00%	0.00%	1.52%	0.11%
c11:0	0.00%	0.00%	1.72%	0.00%	0.00%	2.30%	1.14%	0.54%
c12:0	0.29%	1.09%	14.05%	10.00%	10.17%	24.18%	28.09%	19.87%
c13:0	0.10%	1.75%	3.98%	0.31%	0.69%	4.61%	1.14%	2.15%
c14:0	3.66%	4.81%	13.45%	15.75%	14.60%	19.88%	20.09%	22.06%
c14:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c15:0	1.43%	3.87%	4.90%	5.00%	5.31%	3.45%	3.80%	4.30%
c15:0-br	0.86%	0.51%	1.72%	4.69%	0.00%	0.46%	1.90%	1.34%
c16:0	43.96%	40.34%	41.68%	52.31%	44.12%	39.62%	35.47%	35.58%
c16:1	2.09%	2.92%	0.00%	0.00%	1.96%	0.00%	0.00%	3.22%
c17:0	1.71%	2.41%	0.80%	1.25%	1.50%	0.00%	0.76%	0.54%
c17:0-br	0.48%	0.00%	0.66%	0.94%	1.04%	0.00%	0.76%	0.54%
c18:0	25.37%	23.35%	5.42%	9.75%	12.59%	5.50%	5.19%	6.37%
c18:1	17.79%	13.68%	10.56%	20.32%	7.51%	0.00%	0.00%	3.38%
c18:2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c19:0	0.10%	0.36%	0.27%	0.00%	0.12%	0.00%	0.00%	0.00%
c20:0	1.90%	3.43%	0.13%	0.00%	0.23%	0.00%	0.00%	0.00%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:0	0.19%	1.09%	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
c22:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c24:0	0.10%	0.29%	0.13%	0.00%	0.12%	0.00%	0.15%	0.00%
Cholestane	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	trace	0.00%
Citric acid	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Short-even Alk	5.42%	0.00%	0.13%	0.00%	0.00%	13.82%	2.66%	0.81%
Short-odd Alk	1.81%	0.00%	0.00%	0.00%	0.00%	13.82%	18.60%	2.69%
Long-even Alk	2.09%	2.63%	28.10%	4.06%	5.66%	643.66%	109.31%	25.51%
Long-odd Alk	0.10%	2.04%	22.80%	6.56%	5.54%	280.96%	3.95%	8.06%
Dicarb. FA	1.84%	68.83%	0.64%	0.31%	0.58%	0.00%	0.00%	0.11%
Hydroxy FA	0.00%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%
Epoxy FA	3.52%	10.07%	2.44%	0.00%	0.23%	1.15%	0.15%	1.07%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table B.1: Continued.

INAA Sample	**JEC028**	**JEC031**	**JEC035**	**JEC037**	**JEC038**	**JEC039**	**JEC041**	**JEC237**
GC-MS #	0407G	0320C	0318F	0318L	0320E	0319H	0320B	0809C
Region	DV	DV	DV	DV	DV	DV	DV	Irwin
c9:0	0.00%	0.00%	0.00%	11.17%	0.00%	0.00%	0.00%	0.00%
c10:0	0.00%	0.00%	0.00%	7.45%	0.00%	0.00%	0.00%	0.00%
c11:0	0.06%	0.00%	0.00%	1.24%	0.10%	0.07%	0.00%	0.00%
c12:0	10.46%	0.49%	0.00%	31.28%	15.19%	7.78%	8.58%	1.15%
c13:0	0.48%	0.33%	0.00%	0.62%	0.89%	0.71%	1.58%	0.54%
c14:0	14.16%	4.21%	2.80%	12.60%	18.42%	14.86%	17.04%	9.57%
c14:1	0.95%	0.00%	0.00%	0.00%	0.30%	0.71%	0.00%	1.23%
c15:0	2.54%	1.63%	3.99%	1.99%	3.95%	2.83%	2.71%	6.37%
c15:0-br	1.74%	0.49%	0.66%	0.50%	0.00%	0.35%	3.61%	0.00%
c16:0	40.41%	41.16%	54.73%	24.69%	39.43%	37.31%	43.29%	41.08%
c16:1	8.08%	0.00%	0.00%	2.11%	4.04%	8.14%	1.58%	12.59%
c17:0	0.48%	3.09%	2.44%	0.37%	1.09%	0.88%	0.90%	1.00%
c17:0-br	0.00%	0.49%	0.22%	0.00%	0.69%	0.71%	0.68%	0.00%
c18:0	9.31%	44.86%	31.52%	3.61%	9.24%	13.44%	14.23%	11.51%
c18:1	11.18%	0.00%	2.98%	2.24%	6.39%	12.20%	5.80%	14.97%
c18:2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c19:0	0.00%	0.49%	0.22%	0.00%	0.00%	0.00%	0.00%	0.00%
c20:0	0.16%	2.12%	0.44%	0.00%	0.20%	0.00%	0.00%	0.00%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:0	0.00%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c24:0	0.00%	0.16%	0.00%	0.12%	0.10%	0.00%	0.00%	0.00%
Cholestane	0.00%	0.00%	0.00%	0.00%	0.00%	trace	trace	0.00%
Citric acid	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Short-even Alk	0.00%	0.00%	0.00%	0.25%	0.00%	0.00%	0.00%	0.00%
Short-odd Alk	0.00%	0.00%	0.00%	0.12%	0.00%	0.00%	0.00%	0.08%
Long-even Alk	12.20%	3.91%	41.66%	12.41%	11.24%	41.57%	57.34%	0.00%
Long-odd Alk	5.71%	1.47%	31.02%	11.67%	0.59%	21.40%	2.03%	0.00%
Dicarb. FA	0.22%	1.37%	0.00%	14.90%	0.04%	0.25%	0.00%	0.00%
Hydroxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Epoxy FA	0.00%	0.00%	0.00%	2.48%	0.08%	0.00%	0.00%	0.00%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table B.1: Continued.

INAA Sample	JEC238	JEC239	JEC240	JEC241	JEC242	JEC156	JEC157	JEC159
GC-MS #	0809D	0809H	0809I	0809J	0809K	0320L	0320M	0318G
Region	Irwin	Irwin	Irwin	Irwin	Irwin	NOV	NOV	NOV
c9:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.00%
c10:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.57%	0.25%
c11:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.67%	0.75%
c12:0	0.00%	1.36%	0.89%	1.12%	1.00%	0.00%	6.95%	5.28%
c13:0	0.00%	0.15%	0.15%	0.51%	0.00%	0.13%	1.24%	2.01%
c14:0	4.81%	8.07%	11.18%	17.74%	12.67%	5.46%	15.30%	11.74%
c14:1	0.00%	0.45%	1.04%	0.44%	0.38%	0.00%	0.00%	0.00%
c15:0	2.15%	3.62%	3.56%	1.90%	3.51%	2.21%	2.29%	3.27%
c15:0-br	0.00%	0.00%	0.00%	0.00%	0.00%	0.95%	0.67%	1.01%
c16:0	27.61%	30.40%	38.67%	39.22%	39.82%	21.06%	53.75%	39.06%
c16:1	10.22%	16.61%	9.35%	4.01%	11.28%	7.25%	3.43%	8.54%
c17:0	0.72%	1.21%	1.74%	0.29%	1.88%	0.00%	1.33%	0.00%
c17:0-br	0.00%	0.00%	0.00%	0.00%	0.00%	0.63%	0.29%	0.25%
c18:0	27.91%	11.87%	19.11%	14.53%	18.34%	4.57%	8.14%	9.12%
c18:1	26.03%	24.35%	12.30%	9.37%	8.12%	37.28%	4.16%	18.71%
c18:2	0.54%	1.91%	0.00%	0.00%	0.00%	4.41%	5.02%	0.00%
c19:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c20:0	0.00%	0.00%	0.00%	0.00%	0.00%	14.81%	0.69%	0.00%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.63%	0.00%	0.00%
c22:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c24:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.63%	0.00%	0.00%
Cholestane	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Citric acid	0.00%	0.00%	0.00%	0.00%	0.00%	5.04%	0.00%	0.00%
Short-even Alk	1.43%	6.64%	1.04%	0.73%	0.38%	3.78%	0.57%	1.51%
Short-odd Alk	1.61%	2.11%	0.89%	0.73%	0.50%	0.95%	0.00%	2.01%
Long-even Alk	0.00%	0.30%	0.00%	0.00%	0.00%	31.19%	1.52%	2.52%
Long-odd Alk	0.18%	0.30%	0.06%	0.88%	0.25%	18.90%	3.90%	0.75%
Dicarb. FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.13%	0.00%
Hydroxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Epoxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table B.1: Continued.

INAA Sample	**JEC160**	**JEC161**	**JEC162**	**JEC163**	**JEC168**	**JEC174**	**JEC176**	**JEC178**
GC-MS #	0407F	0320Q	0320N	0318M	0319C	0318E	0320O	0809B
Region	NOV	NOV	NOV	NOV	NOV	NOV	NOV	NOV
c9:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c10:0	0.00%	0.00%	0.00%	0.32%	0.00%	0.00%	0.00%	0.00%
c11:0	0.00%	0.00%	0.00%	0.32%	0.36%	0.00%	0.00%	0.00%
c12:0	5.65%	0.00%	1.19%	4.87%	7.16%	1.46%	0.64%	0.00%
c13:0	0.74%	0.00%	0.00%	0.65%	1.79%	0.88%	0.00%	0.00%
c14:0	10.89%	10.11%	9.76%	10.19%	14.64%	3.04%	4.47%	7.36%
c14:1	0.00%	0.00%	0.00%	0.00%	0.89%	0.00%	0.00%	0.00%
c15:0	2.23%	2.53%	2.97%	2.60%	0.00%	2.34%	0.42%	1.94%
c15:0-br	1.04%	1.27%	1.19%	1.95%	2.15%	1.46%	0.00%	0.00%
c16:0	48.95%	50.80%	36.19%	31.29%	44.04%	25.71%	16.54%	45.55%
c16:1	6.39%	6.01%	5.16%	8.11%	7.44%	2.05%	1.91%	2.92%
c17:0	1.49%	1.27%	0.00%	0.00%	0.18%	0.58%	0.00%	0.78%
c17:0-br	0.89%	0.32%	0.00%	1.30%	1.61%	0.00%	0.00%	0.00%
c18:0	12.34%	11.39%	8.56%	8.73%	7.05%	12.90%	4.47%	39.84%
c18:1	8.24%	16.31%	35.97%	29.67%	12.33%	47.12%	71.57%	1.22%
c18:2	0.00%	0.00%	0.00%	0.00%	0.00%	2.46%	0.00%	0.00%
c19:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c20:0	1.15%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:1	0.00%	0.00%	0.00%	0.00%	0.36%	0.00%	0.00%	0.00%
c24:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cholestane	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Citric acid	0.00%	0.00%	0.59%	0.00%	89.63%	0.12%	0.00%	0.00%
Short-even Alk	9.66%	0.00%	6.54%	32.45%	1.97%	2.05%	4.14%	8.12%
Short-odd Alk	2.82%	0.00%	2.97%	42.84%	2.68%	0.88%	1.91%	5.80%
Long-even Alk	11.00%	0.00%	10.11%	12.01%	5.72%	4.68%	6.05%	2.32%
Long-odd Alk	1.63%	0.32%	8.33%	4.54%	0.25%	0.00%	0.00%	0.58%
Dicarb. FA	0.00%	0.00%	0.00%	0.32%	0.07%	0.00%	0.96%	0.00%
Hydroxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Epoxy FA	0.00%	0.00%	0.00%	0.13%	0.18%	0.00%	0.00%	0.00%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table B.1: Continued.

INAA Sample	**JEC279**	**JEC283**	**JEC286**	**JEC293**	**JEC294**	**JEC301**	**JEC047**	**JEC050**
GC-MS #	0407M	0407L	0407N	0318H	0320H	0407J	0318B	0407H
Region	NTS	NTS	NTS	NTS	NTS	NTS	Sequoia	Sequoia
c9:0	0.00%	0.00%	0.00%	0.00%	3.32%	0.00%	0.00%	0.00%
c10:0	0.00%	0.00%	0.00%	0.00%	0.89%	0.00%	0.00%	0.00%
c11:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.23%
c12:0	1.25%	1.66%	3.66%	1.78%	0.22%	1.10%	2.51%	21.80%
c13:0	0.00%	0.95%	2.25%	0.00%	0.00%	0.20%	0.54%	1.72%
c14:0	7.74%	8.99%	9.69%	4.39%	0.61%	6.08%	6.73%	32.65%
c14:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.80%	0.00%
c15:0	0.00%	3.79%	5.07%	1.00%	0.22%	3.91%	3.14%	2.29%
c15:0-br	4.38%	2.84%	1.41%	0.00%	0.00%	4.52%	1.71%	2.87%
c16:0	26.36%	31.59%	37.10%	35.48%	31.27%	38.33%	25.55%	28.90%
c16:1	7.88%	10.42%	5.22%	9.77%	0.00%	5.02%	15.90%	5.16%
c17:0	0.63%	0.47%	0.56%	0.00%	0.22%	0.50%	0.45%	0.00%
c17:0-br	0.63%	1.18%	0.00%	0.00%	0.00%	1.00%	0.36%	0.00%
c18:0	13.87%	7.52%	9.74%	11.17%	12.83%	7.77%	5.50%	4.38%
c18:1	37.27%	30.60%	23.88%	37.42%	48.64%	29.04%	34.61%	0.00%
c18:2	0.00%	0.00%	1.41%	0.00%	0.00%	0.00%	0.72%	0.00%
c19:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c20:0	0.00%	0.00%	0.00%	0.00%	1.33%	0.00%	0.27%	0.00%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:0	0.00%	0.00%	0.00%	0.00%	0.22%	0.00%	0.09%	0.00%
c22:1	0.00%	0.00%	0.00%	0.00%	0.00%	2.51%	0.00%	0.00%
c24:0	0.00%	0.00%	0.00%	0.00%	0.22%	0.00%	0.09%	0.00%
Cholestane	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	trace
Citric acid	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Short-even Alk	6.88%	3.32%	6.76%	8.88%	0.00%	0.00%	0.00%	4.01%
Short-odd Alk	1.88%	2.13%	4.79%	12.43%	0.00%	0.00%	0.00%	3.44%
Long-even Alk	0.00%	2.60%	5.63%	0.00%	0.00%	3.01%	3.05%	54.49%
Long-odd Alk	0.00%	3.08%	2.82%	0.00%	0.00%	5.52%	4.76%	25.47%
Dicarb. FA	0.00%	0.00%	0.00%	0.00%	18.39%	0.00%	0.09%	0.00%
Hydroxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Epoxy FA	0.00%	0.00%	0.00%	0.00%	1.77%	0.00%	0.00%	0.00%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	114.23%	0.00%	0.00%	0.00%

Table B.1: Continued.

INAA Sample	**JEC054**	**JEC057**	**JEC058**	**JEC059**	**JEC064**	**JEC065**	**JEC066**	**JEC067**
GC-MS #	0407K	0318K	0317A	0318D	0317C	0320F	0317B	0320P
Region	Sequoia	Sequoia	Sequoia	Sequoia	Sequoia	Sequoia	Sequoia	Sequoia
c9:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c10:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c11:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.59%
c12:0	0.00%	0.00%	0.00%	3.36%	0.47%	3.86%	0.00%	4.73%
c13:0	0.00%	0.00%	0.00%	0.63%	0.37%	0.12%	0.00%	0.59%
c14:0	8.45%	1.97%	4.07%	8.08%	3.52%	7.34%	5.31%	4.59%
c14:1	1.50%	0.00%	1.04%	0.00%	0.00%	0.00%	0.00%	0.00%
c15:0	3.19%	0.00%	2.90%	4.20%	1.59%	0.00%	2.74%	3.55%
c15:0-br	1.12%	0.00%	1.04%	1.05%	0.65%	0.89%	0.00%	0.00%
c16:0	26.03%	41.40%	21.86%	45.13%	33.44%	49.84%	53.46%	34.58%
c16:1	17.81%	34.14%	32.33%	5.20%	0.00%	3.27%	0.00%	2.36%
c17:0	0.37%	0.00%	0.83%	1.26%	3.93%	0.59%	1.37%	0.59%
c17:0-br	0.00%	0.00%	0.00%	0.42%	0.47%	0.59%	0.91%	0.00%
c18:0	9.14%	4.58%	4.03%	19.00%	47.93%	15.36%	33.92%	13.59%
c18:1	32.19%	17.90%	31.91%	10.82%	5.85%	17.84%	0.00%	34.58%
c18:2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c19:0	0.00%	0.00%	0.00%	0.00%	0.47%	0.00%	0.00%	0.00%
c20:0	0.00%	0.00%	0.00%	0.41%	1.03%	0.00%	1.83%	0.00%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.00%	0.00%	0.00%	0.09%	0.00%	0.00%	0.00%
c22:0	0.00%	0.00%	0.00%	0.00%	0.09%	0.30%	0.46%	0.00%
c22:1	0.19%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c24:0	0.00%	0.00%	0.00%	0.42%	0.09%	0.00%	0.00%	0.24%
Cholestane	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Citric acid	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Short-even Alk	0.56%	0.00%	1.45%	0.00%	3.18%	3.56%	3.20%	31.32%
Short-odd Alk	0.00%	0.00%	0.00%	1.68%	5.52%	12.76%	5.03%	43.73%
Long-even Alk	0.00%	5.87%	0.00%	29.21%	6.64%	123.79%	35.19%	121.13%
Long-odd Alk	0.00%	2.67%	0.00%	14.29%	2.81%	56.70%	29.71%	42.54%
Dicarb. FA	0.00%	3.95%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Hydroxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Epoxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table B.1: Continued.

INAA Sample	**JEC068**	**JEC072**	**JEC073**	**JEC076**	**JEC046**	**JEC379**	**JEC077**	**JEC078**
GC-MS #	0318I	0318O	0320G	0318C	0311D	0317M	0319L	0317E
Region	Sequoia	Sequoia	Sequoia	Sequoia	Sequoia	SOV	SOV	SOV
c9:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c10:0	0.00%	0.00%	0.00%	0.98%	0.00%	0.00%	0.00%	0.00%
c11:0	0.00%	0.00%	0.00%	0.98%	0.00%	0.00%	0.00%	0.00%
c12:0	5.96%	6.84%	0.00%	14.35%	2.09%	0.00%	0.84%	3.57%
c13:0	0.20%	0.40%	0.00%	1.63%	0.30%	0.00%	0.21%	0.71%
c14:0	5.57%	6.82%	5.80%	20.98%	11.30%	4.66%	3.79%	5.55%
c14:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.31%	0.00%
c15:0	0.00%	2.01%	0.00%	3.59%	0.60%	0.00%	0.00%	1.43%
c15:0-br	0.00%	0.40%	0.00%	1.30%	0.00%	4.51%	1.99%	0.00%
c16:0	28.76%	34.52%	44.86%	31.93%	50.06%	52.38%	44.76%	28.66%
c16:1	55.65%	6.84%	6.43%	9.13%	6.87%	5.80%	5.72%	4.99%
c17:0	0.00%	0.00%	0.00%	0.98%	0.90%	0.64%	3.04%	0.00%
c17:0-br	0.00%	0.40%	0.00%	0.33%	0.00%	0.64%	0.21%	0.00%
c18:0	3.26%	5.46%	12.81%	4.33%	13.18%	13.46%	10.95%	17.43%
c18:1	0.61%	36.28%	30.09%	9.72%	14.70%	17.91%	24.39%	35.22%
c18:2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.97%	2.43%
c19:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c20:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.26%	0.00%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.00%
c22:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	0.00%
c22:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c24:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.00%
Cholestane	0.00%	0.00%	0.00%	trace	0.00%	0.00%	0.00%	0.00%
Citric acid	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.10%	0.00%
Short-even Alk	5.96%	47.10%	0.00%	1.30%	0.00%	0.00%	0.00%	5.71%
Short-odd Alk	4.47%	25.36%	0.00%	0.00%	0.00%	0.00%	0.00%	0.29%
Long-even Alk	47.69%	48.31%	0.00%	49.56%	5.08%	0.00%	0.10%	1.43%
Long-odd Alk	6.46%	4.19%	3.39%	1.43%	5.38%	0.00%	0.21%	0.71%
Dicarb. FA	0.00%	0.00%	0.00%	0.00%	0.30%	0.00%	8.17%	0.71%
Hydroxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.21%	0.00%
Epoxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.04%	0.00%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table B.1: Continued.

INAA Sample	**JEC079**	**JEC080**	**JEC084**	**JEC085**	**JEC086**	**JEC098**	**JEC099**	**JEC100**
GC-MS #	0317D	0319I	0317O	0224G	0317K	0317L	0317I	0317G
Region	SOV	SOV	SOV	SOV	SOV	SOV	SOV	SOV
c9:0	0.00%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.63%
c10:0	1.59%	0.33%	0.00%	0.00%	0.00%	0.11%	0.00%	0.84%
c11:0	0.79%	0.08%	0.10%	0.00%	0.00%	0.22%	0.00%	0.84%
c12:0	7.55%	0.91%	2.35%	0.38%	0.00%	1.57%	2.59%	2.93%
c13:0	0.79%	0.50%	0.26%	0.00%	0.00%	0.78%	0.43%	1.67%
c14:0	5.62%	3.22%	5.71%	2.75%	1.26%	4.68%	7.48%	7.15%
c14:1	0.00%	0.00%	3.91%	0.00%	0.00%	0.56%	2.16%	0.00%
c15:0	4.18%	2.32%	2.09%	0.00%	0.51%	3.36%	3.02%	3.34%
c15:0-br	0.40%	0.41%	0.52%	0.00%	0.77%	1.01%	2.37%	0.63%
c16:0	27.77%	43.90%	23.71%	27.56%	38.90%	45.69%	25.76%	41.81%
c16:1	33.78%	2.49%	12.53%	2.31%	0.61%	6.49%	15.97%	1.88%
c17:0	0.00%	1.74%	1.04%	0.77%	1.53%	2.01%	0.43%	1.46%
c17:0-br	0.00%	2.82%	0.00%	0.00%	0.77%	0.45%	0.00%	0.84%
c18:0	7.47%	12.70%	12.26%	10.33%	27.49%	12.53%	7.75%	16.71%
c18:1	10.05%	26.89%	35.51%	55.14%	27.92%	19.53%	32.04%	17.86%
c18:2	0.00%	0.00%	0.00%	0.77%	0.00%	0.00%	0.00%	0.00%
c19:0	0.00%	0.17%	0.00%	0.00%	0.00%	0.22%	0.00%	0.08%
c20:0	0.00%	1.41%	0.00%	0.00%	0.26%	0.67%	0.00%	1.05%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%	0.00%	0.21%
c22:1	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c24:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%
Cholestane	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	trace
Citric acid	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Short-even Alk	13.90%	0.41%	0.78%	0.00%	1.53%	0.00%	1.29%	0.00%
Short-odd Alk	5.56%	0.50%	1.83%	0.00%	0.77%	0.00%	0.43%	0.00%
Long-even Alk	3.18%	0.25%	0.00%	0.00%	0.00%	0.00%	2.16%	0.00%
Long-odd Alk	0.16%	0.00%	0.26%	0.00%	0.00%	0.00%	0.00%	0.21%
Dicarb. FA	0.79%	0.41%	0.00%	11.91%	0.00%	1.23%	0.00%	0.84%
Hydroxy FA	0.00%	0.00%	0.00%	5.38%	0.00%	0.00%	0.00%	0.00%
Epoxy FA	0.00%	0.00%	0.00%	2.46%	0.00%	0.90%	0.00%	0.00%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table B.1: Continued.

INAA Sample	**JEC102**	**JEC117**	**JEC118**	**JEC125**	**JEC128**	**JEC209**
GC-MS #	0317F	0809F	0317J	0809G	0317H	0317P
Region	SOV	SOV	SOV	SOV	SOV	SOV
c9:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c10:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c11:0	0.37%	0.00%	0.00%	0.00%	0.00%	0.00%
c12:0	4.80%	0.00%	2.82%	0.00%	4.98%	0.57%
c13:0	1.11%	0.00%	0.56%	0.00%	1.00%	0.23%
c14:0	11.59%	0.21%	6.19%	0.00%	8.60%	7.03%
c14:1	1.48%	0.00%	0.00%	0.00%	0.00%	1.26%
c15:0	0.55%	0.00%	2.54%	0.00%	0.00%	2.98%
c15:0-br	1.85%	0.00%	1.41%	0.00%	0.00%	0.80%
c16:0	26.87%	27.02%	29.02%	36.13%	39.17%	23.43%
c16:1	12.63%	0.89%	7.61%	3.13%	7.97%	16.48%
c17:0	0.55%	0.36%	0.28%	0.42%	0.00%	0.46%
c17:0-br	0.37%	0.00%	0.56%	0.00%	0.00%	0.11%
c18:0	7.65%	41.70%	10.62%	37.76%	20.33%	6.87%
c18:1	29.99%	26.48%	37.82%	21.10%	17.96%	39.21%
c18:2	0.00%	3.20%	0.00%	1.46%	0.00%	0.46%
c19:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c20:0	0.18%	0.36%	0.56%	0.00%	0.00%	0.00%
c20:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c21:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c22:1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
c24:0	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%
Cholestane	trace	0.00%	trace	0.00%	0.00%	0.00%
Citric acid	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Short-even Alk	0.00%	0.07%	1.13%	0.00%	6.97%	0.00%
Short-odd Alk	0.00%	0.36%	1.97%	0.42%	7.97%	0.00%
Long-even Alk	1.48%	0.18%	17.76%	1.88%	49.78%	0.23%
Long-odd Alk	2.59%	0.18%	14.09%	1.46%	35.84%	0.23%
Dicarb. FA	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%
Hydroxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Epoxy FA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Diterpenoids	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%