Journal of Anthropological Archaeology **21,** 200–229 (2002)
doi:10.1006/jaar.2001.0393

Ceramic Production among Small-Scale and Mobile Hunters and Gatherers: A Case Study from the Southwestern Great Basin

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Received March 16, 2001; revision received July 2, 2001; accepted November 8, 2001

Archaeologists often stress the importance of sedentism, large population sizes, and the economy of scale in the development of ceramic technologies worldwide. Yet pottery making is known among many mobile and small-scale societies that make only small numbers of pots. Unfortunately, we know very little about how this technology was organized in such societies. Using Instrumental Neutron Activation Analysis we explore how pottery production, distribution, and consumption were organized within one such group, the Numa (i.e., Paiute and Shoshone) of the southwestern Great Basin. Results suggest that pots were produced and used locally, that exchange of pots was minimal, and that production was organized at an individual or family level. The creation of regional distribution networks by specialized potters, as proposed by Julian Steward (1933), is not supported. As a result we also question the importance of an economy of scale of pottery production in this particular case.

INTRODUCTION

A review of the ethnographic and archaeological literature suggests that pottery making is uncommon among small-scale (i.e., low-population-density) and residentially mobile hunting-and-gathering groups (e.g., Arnold 1985). Although part of this may result from the "crudeness" and expedient nature of pottery production in most mobile hunter-gatherer settings, leading to a lack of interest among anthropologists and a focus on other technologies such as basketry and lithics, it is almost certainly a real phenomenon. For many reasons discussed below, pottery use and production do not integrate well with small population size and residential mobility.

However, it is also clear from anthropological and archaeological research that several such groups do (or did) engage in the production of fired earthenware vessels. This article explores how pottery production was organized within one such group, the Numic speakers, or Numa, of the southwestern Great Basin in North America (i.e., Paiute and Shoshone). Our goal is to evaluate a model proposed by Julian Steward (1933:266) about the scale and organization of ceramic production in one region of the southwestern Great Basin, Owens Valley (see also Bettinger 1989:324; and Bettinger and King 1971, who elaborate on this model). Steward suggested that several Owens Valley Paiute women were specialist potters, owned specific clay sources, and sold or traded their goods across and outside the valley. Using Instrumental Neutron Activation Analysis (INAA), we analyzed nearly 400 pottery and clay samples from several distinct valley systems and geographic regions to test this model and explore patterns in the production and movement of ceramic vessels. In the end, we evaluate Steward's ideas about ceramic production and economies of scale among

0278-4165/02 $35.00

the Numa and offer some ideas about how this process might be organized among small-scale mobile groups in general.

POTTERY MAKING, MOBILITY, AND THE ECONOMY OF SCALE

A review by Arnold (1985) suggests that fewer than 30% of mobile societies make and use pottery on a regular basis. Although neither mobility nor the hunting and gathering mode of subsistence necessarily preclude ceramic technologies, there are many factors common to such groups that do not promote the craft. First, pottery is heavy and breakable and less amenable to transport during times of high residential mobility. Carrying heavy pots around to process foods and other resources located in different areas may be less desirable than the use of more lightweight and flexible containers such as baskets.

Second, the production of pots requires the manufacturer to be in one place for a significant amount of time (at least 3–4 days and often up to several weeks) to carry out the raw material gathering, vessel forming, drying, and firing steps. Several of these steps, particularly drying, require the potter to be present to monitor progress and make adjustments based on changing local conditions, such as wind direction or exposure to sunlight. Many mobile groups may not be in one place long enough to see the production cycle through.

Third, the need to produce pots during the dry season (Arnold 1985) often conflicts with the harvesting of certain food resources, particularly dryland seeds and tubers. Not only are groups likely to be more residentially mobile while focusing on dryland seeds and tubers due to their patchy and heterogeneous availability, limiting ceramic production opportunities as above, but both men and women are also likely to spend much time away from the base camp gathering food and may not have the time to produce pots. In some areas, particularly the southwestern Great Basin, such dry-season resources form the staple of the diet. More importantly, most dryland seeds are available only during a narrow window of time and maximizing the number of women in the field gathering may have been important. Thus, it may have been difficult to sacrifice available gatherers to the production of pots if women are responsible for both activities, as often seems to be the case.

Fourth, mobile groups may not be able to establish consistent access to sources of clay. Developing a working knowledge of specific clays and how they respond to different forming styles, firing, and other steps in the production process is important in the development of a successful ceramic technology (Skibo and Blinman 1999:172). Without reliable access it may be difficult for potters to create the knowledge base to make ceramics work for them.

Finally, population levels in such societies may be too low to take advantage of the economy of scale afforded by pottery production. For example, Brown (1989) suggests that pottery production is only worthwhile when demand for pots is high and large numbers can be produced in a single firing event. This is so because one of the most time-consuming and energy-demanding steps, firing, can be performed almost as easily for one pot as it can for many. Thus, the per-unit cost decreases with increasing output, a result that is not true of other container technologies such as basketry, stone bowls, or wooden bowls, where items are made one at a time at the same per-unit cost regardless of total output. As a result, pots, which may be weaker and shorter lived than these alternative containers, are preferred because large numbers can be produced at once. One way to create high demand for pots is through the presence of a large population base. Of course, other factors can contribute to a higher demand as well, such as an increase in the social or prestige value of pots (see Hayden 1995) or an increase in boiling or cooking activities requiring pots. However, small populations are at a disadvantage to start with because, all other things being equal, they need fewer containers than larger ones.

For these reasons, then, small population size and high residential mobility impose certain restrictions and constraints that do not favor the production of pottery (Brown 1989:200; Close 1995; Rice 1999; Skibo and Blinman 1999; Welsby 1997). We know from ethnographic and archaeological work that mobile hunting and gathering societies in the southwestern Great Basin did engage in the production of ceramic vessels (e.g., Drucker 1937; Steward 1938, 1941; Stewart 1942). Numic groups are often referenced in the anthropological literature for their high mobility, low population densities, and extreme "simplicity" on the social complexity yardstick (Thomas 1981), making this case of pottery production an unusual one. Among the Numa pottery production is never a large-scale activity and pot sherds are usually found in low numbers (often less than 100 per site). Yet pottery is ubiquitous enough in late-period sites to suggest it was an important part of the late prehistoric material culture in this desert environment. In this case, then, it appears that the conflicts and incompatibilities of low population density and high mobility were resolved and that the demand for earthenware containers outweighed the costs and benefits of alternatives such as baskets, gourds, or stone or wooden bowls.

In this regard, we are particularly interested in comments made by Julian Steward (1933) for potters in Owens Valley, the region with the most extensive and detailed ethnographic record. He suggested that certain potters in the region, all women, owned specific clay sources and sold their goods over a large range, with shell beads serving as the unit of currency. These comments are especially interesting given the disparity in the distribution of ceramics in the region, where some areas, such as southern Owens Valley, contain high densities of ceramics and others, such as central or northern Owens Valley, have very few (e.g., Eerkens 2000; Elsasser 1960; Gilreath 1995:243; Weaver 1986). Such a distribution suggests that women used large numbers of pots in some areas and very few in others.

If Steward's observations apply to prehistoric contexts, it is possible that women in Owens Valley were still able to take advantage of the economy of scale of pottery production, despite low population densities, by pooling demand at a larger spatial scale and organizing a regional redistribution of pottery. In other words, certain enterprising women could have overproduced pots, selling or exchanging them for money or other goods. In this manner, large numbers of pots could be fired at once, allowing women to take advantage of the economy of scale without having to consume them all locally. Although they incur high transportation costs and may have difficulty pinpointing the location of residentially mobile consumers, it is possible that these factors allowed Owens Valley and other Numa women to use pottery, despite small population sizes.

Thus, in order to make pottery production worthwhile, it is possible that some small-scale societies organize regional redistribution systems. In such a system, large numbers of pots would be produced in just a few areas, but would be widely distributed across a sparse population base. Although the demand for pots at any particular location might not be high enough to warrant production, given the costs of firing just a few pots at a time, such a system allows women to fire far more pots than they would need locally, decreasing the per-unit cost of each pot and allowing them to take advantage of the economy of scale. Pooling costs and demands at a larger spatial scale, then, might make pottery production worthwhile despite a small population size.

INAA and provenance analysis of pottery and clay samples from the southwestern Great Basin was undertaken to investigate this hypothesis.

GREAT BASIN ARTIFACT SOURCING AND POTTERY

Sourcing or chemical fingerprinting of archaeological materials is becoming increasingly important in our understanding of prehistory, especially in helping to reconstruct past mobility and exchange systems. In the desert west, obsidian sourcing has been a mainstay in the chemical sourcing field, but recent attempts to source andesites and basalts (Bostwick and Burton 1993; Jones et al. 1997; Waechter 2000), steatite or soapstone (Allen et al. 1975; Allen and Lockhart 1989), and even trees (Durand et al. 1999) have shown that these lines of inquiry can be quite informative. Despite success in many areas worldwide with sourcing pottery (e.g., Bishop et al. 1988; Neff 1998; Neff et al. 1994; 1997; Steponaitis et al. 1996; papers in Neff 1992), this avenue of research has been virtually ignored by Great Basin archaeologists (though see Eerkens et al. 2002; Hunt 1960; and Touhy and Strawn 1986).

As a whole, ceramic studies in the Great Basin lag far behind the analysis of other artifact categories. Despite the fact that pot sherds are a common constituent of late prehistoric sites, we still know very little about the production, function, curation, exchange, and chronology of the largely plain and undecorated brownware common to the region. Just as obsidian sourcing has dramatically changed our understanding of lithic procurement, mobility, and exchange patterns (e.g., Basgall 1989; Bettinger 1982; Bouey and Basgall 1984; Ericson 1981; Gilreath and Hidlebrandt 1997; Jackson 1988), ceramic sourcing has the potential to reshape our understanding of this technology and how it was incorporated into a residentially mobile lifestyle.

A major hindrance to the advancement of pottery studies in the Great Basin is the lack of any objective and meaningful typologies. Recent critical reviews of Great Basin ceramic studies suggest that the traditional typological systems have failed (Bettinger 1986; Dean 1992; Pippin 1986). The divisions between commonly recognized types (i.e., Shoshoni Ware, Southern Paiute Utility Ware, Tulare Plain Ware, Owens Valley Brownware, etc.) are difficult to recognize and reproduce and cause researchers to lump ceramics rather than focus on meaningful variation within assemblages. The failure to create a working typology has probably led to a situation where many researchers feel that the analysis of ceramics lends little to furthering our understanding of prehistory. We aim to address this problem by creating a typology based on chemical properties of prehistoric southwestern Great Basin brownware using INAA. Although this is just one way of classifying sherds, it does represent an objective and repeatable typology that has implications for the provenance of particular sherds. In this respect, the typology is relatively unrelated to chronology, ethnicity, or other factors that might form the basis of an equally valid typology.

Ceramic typologies play a fundamental role in our understanding of past societies in many parts of the world, especially in the nearby American Southwest, where ceramic analysis has a long history and many innovative techniques have been developed (Cordell 1997). Archaeologists there have defined types based on various outwardly visible attributes, particularly painted design elements, though others such as temper types and construction technique have also been employed. Using these different categories archaeologists have studied many aspects of prehistoric lifeways, including exchange, worldview, information flow, migration, the organization of women's labor, the evolution of ceramic technology, and chronology. Although chemical sourcing has added to this database, the use of these types as the basic unit of analysis continues, even in chemical-based studies, where traditional types are frequently compared to compositional types.

Unfortunately, this strategy of typing sherds using outwardly visible attributes has failed in the Great Basin. In large part, this is due to the lack of decorative designs on ceramics and the short time-depth of pottery in the area. Although directly dated assemblages with pot sherds are few, it appears that pottery making began sometime after 1300 A.D. and possibly as late as 1500 A.D. (Basgall and McGuire 1988; Delacorte 1999; Pippin 1986; Rhode 1994). A small percentage of pots (ca. 5–10%) are decorated with fingernail incisions or punctate holes around the neck or on the lip of the vessel. However, this design motif is relatively constant across the entire Great Basin and does not appear to carry geographic or temporal information about the pot. Figure 1 provides a schematic of two very typical coil-and-scrape brownware sherds, one of which is decorated on the lip. In addition, studies based on lip and neck form (Griset 1988) and mode of exterior and interior finish (Bettinger 1986) have either failed to turn up significant and consistent types that are related to geography and/or chronology or have not been followed up by others studying ceramics. In most respects, Great Basin pots appear to be too variable within individual sites and regions to make classification of sherds into unique temporal or geographic types based on visible attri-

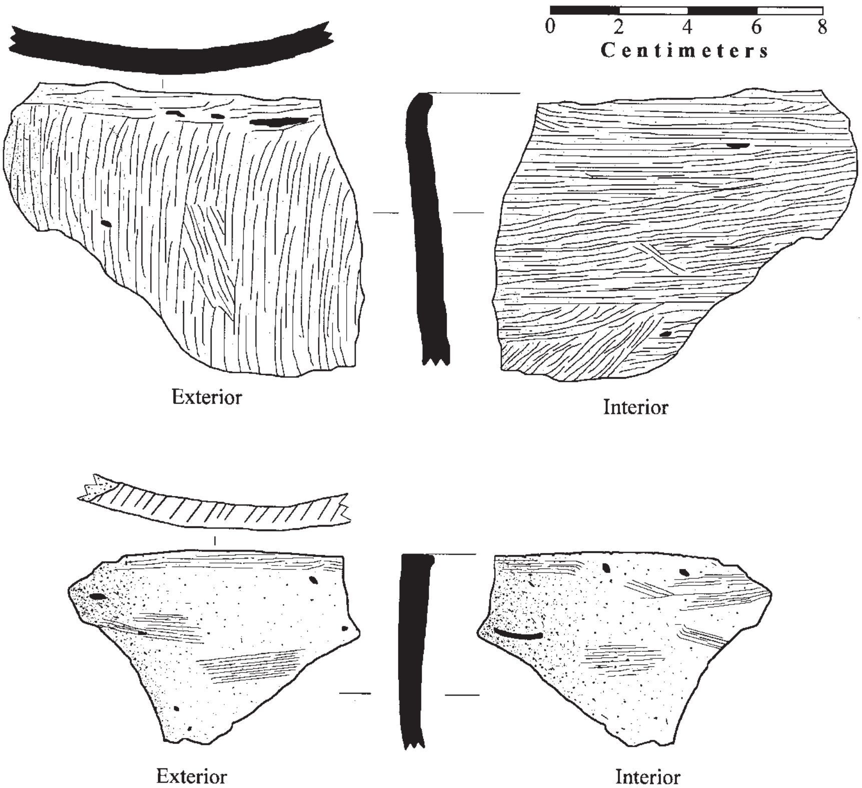

FIG. 1. Schematic of an undecorated and decorated sherd from southern Owens Valley.

butes a useful exercise. Clearly an alternative method is needed.

CERAMIC SOURCING AND INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

We chose to characterize pot sherds using INAA in an attempt to create a geographic or source-specific typology of Great Basin ceramics. INAA has been successful in other areas and provides high-precision data on the concentration, in parts per million (ppm), for a range of elements. At the Missouri University Research Reactor (MURR) 33 elements are routinely measured, including different metals (Al), semimetals (As and Sb), alkali earths (Ca, Sr, and Ba), alkali metals (Na, K, Rb, and Cs), transition metals (Sc, Ti, V, Cr, Mn, Fe, Co, Zn, Ni, Zr, Hf, Ta), rare earth elements (La, Ce, Nd, Sm, Eu, Tb, Dy, Yb, and Lu), and actinide elements (Th and U). Maximization of the number and range of elements was important because it was not known beforehand what types of elements or combination of elements, if any, might be important in distinguishing regional clay and pottery assemblages. Because most southwestern Great Basin sherds contain Ni in concentrations below detection limits, this element was dropped, leaving 32 elements within the analysis.

Samples were prepared according the standard MURR procedure (see Glascock 1992; Neff 2000). In short, this involves weighing 200 mg of crushed powder from each sample into a polyethylene vial and irradiating the sample for 5 s at a flux of 8×10^{13} $n/cm^2/s$. Following irradiation, the sample is placed at a fixed distance from a high-resolution germanium detector to collect a spectrum of emitted gamma rays. This first irradiation allows determination of nine short-lived elements. A second irradiation involves placing 200 mg of each sample into a high-purity quartz vial and irradiating at the same flux for a period of 24 h. This second irradiation allows determination of the remaining 24 elements. Standards of SRM-1633a Flyash and SRM-688 Basalt Rock were used for quantification of the elemental concentrations in the unknowns, and samples of Ohio Red Clay were run as quality controls with each batch of samples.

The goal of this study is similar to that of lithic sourcing, that is, to divide artifacts on the basis of where they are from. In lithic sourcing this goal is relatively straighforward [Neff 2000; though not without assumptions and complications (see Shackley 1998 and Glascock et al. 1998)]. Chemical profiles of stone tools are matched to the chemistry of known lithic source materials, such as obsidian flows or chert outcrops. The subsequent distribution of artifacts by source (i.e., type) across the landscape is then used to reconstruct prehistoric patterns in exchange, mobility, and the organization of technology, among other topics.

While many of the same principles apply to ceramic sourcing, there are a number of special considerations (Neff 2000). First, clay is relatively common and is found virtually everywhere, which makes sampling source clays a tedious and expensive process. Second, clay source zones are generally larger than obsidian source zones (usually as large as the geologic strata that define them), occasionally up to several hundred square miles. This makes ceramic sourcing less accurate than obsidian sourcing in a spatial sense. Third, clays form under a number of conditions and are often mixed with other source clays though natural processes, such as river transport, which cause 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 more heterogeneous and 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, including such things as souring and leaching of clays, mixing of clays, the addition of chemically different temper, and postdepositional change (e.g., see Arnold et al. 1991; Bishop et al. 1982; Blackman 1992; Cogswell et al. 1996; Neff 1998, 2000 for more extensive discussions). Obsidian, on the other hand, remains as it is from acquisition to the creation of a tool or waste flake to an archaeological artifact.

In some ways, the Great Basin seems promising for ceramic sourcing because different basins are hydrologically separated, and there is little chance for rivers to transport and mix clays from different regions. Therefore, if there are differences in parent geology, it is possible that clay in each basin will have a unique chemical signature. In addition, Great Basin brownware is often described as being tempered by inclusions that are naturally present in the parent clay (Steward 1938), which may limit the role of temper in altering chemical results.

SAMPLING STRATEGY

Because this study was concerned with regional patterns in ceramics and the creation of a large-scale typological system, it was necessary to use existing archaeological collections of pot sherds. In this respect, the limited distribution of ceramics in time (post 700 B.P.), the small numbers of ceramics recovered at most sites (usually less than 100 sherds in late prehistoric sites), and the spotty nature of archaeological work in most regions placed many restrictions on the range of sherds that could be sampled. Moreover, because the process is partially destructive, requiring about 1–2 cm^2 of the sherd to be crushed, we were also limited by what different museums and agencies were willing to have analyzed, though most were very generous in promoting the study.

Given these limitations, our sampling strategy had three goals. First, we sought to examine pottery from a number of nearby, yet discrete, regions or valley systems. Second, we attempted to sample pottery from a range of sites within each region. And third, where possible, we tried to sample a number of sherds from a single site. This strategy would allow estimation of both between-region, between-site, and within-site variability, respectively. Another requirement of the sampling strategy was to have each sherd represent a unique pot. Thus, if a site had multiple sherds that appeared to be from the same vessel, only one was analyzed. As a control across the entire sample, and to be able to relate chemistry to variation in other attributes such as vessel shape, lip shape, mouth diameter, and thickness, an attempt was made to sample mostly rim sherds. Rim sherds provide the most information related to these attributes, and also bring some degree of standardization to the study. However, it was not always possible to analyze a rim sherd from each site, and in such situations body sherds were included. Finally, to ultimately relate sherd chemistry to source provenance, a number of clay samples were also analyzed.

In total, 380 samples were analyzed, including 342 discrete archaeological pot sherds, 4 samples repeating sherds (to check for consistency in the technique), 30 discrete clay samples, 1 sample taken from a dried chunk of clay from an archaeological site, 2 samples of temper picked out of a sherd, and 1 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 5 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. Figure 2 gives the location of these different regions. Table 1 provides summary information on the number

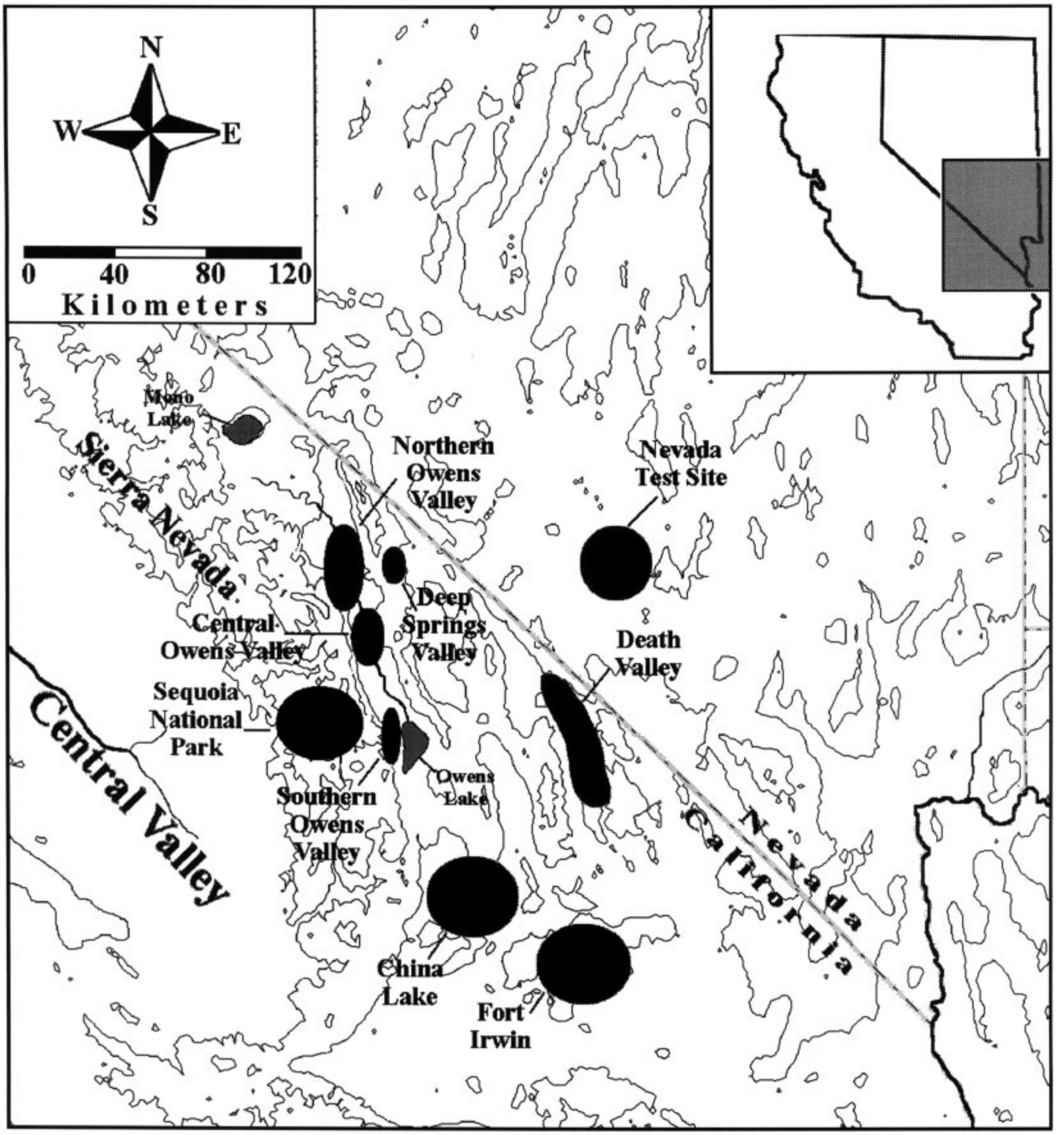

FIG. 2. Map of study area showing regions sampled.

and nature of samples analyzed from each region.

STATISTICAL ANALYSIS

A main goal of the study was to identify discrete clay chemical signatures, or reference groups, that would characterize different clay source zones. The geographic source of reference groups was determined in one of two ways. First, they were compared to compositional data gathered from natural and accessible clays collected within different areas of interest. Clays rarely had a direct match to reference groups. This is probably a result of us not

TABLE 1
Background Information on Samples

	No. Sherds Sampled	No. Sites represented	Max. no. for one site	Nos. Rims, bodies, bases	Max. distance between 2 sherds (km)	No. of 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

sampling the exact clays used by prehistoric potters and/or because we added no temper. Instead of direct matches, similarities in the chemical properties of clays to reference groups were used to determine geographic affinity of reference groups. Thus, if sherds in a particular reference group had high concentrations of K and the clays from a particular region also had high K relative to other clays, this was used as evidence for ascribing provenance to the reference group. The second method was more applicable in regions where clays were not available for analysis. In these areas, when a clear majority of the pot sherds in a reference group were from a single region (i.e., greater than 75%) and a large number of sherds from that region belonged to the group, the reference group was assumed to be derived from clays native to that area. In practice, the two techniques were often used in combination.

To assist in the creation of reference groups a principal components analysis (PCA) was performed on the INAA data. 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 a much smaller number of dimensions (Baxter 1994; Davis 1986, Neff 2002). PCA is particularly effective when the original variables are correlated, as is expected with compositional data from discrete chemical sources.

Concentration values for different elements 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 (Leese et al. 1989). Large amounts of temper, which is made up primarily of silicon and oxygen (if sand) or calcium, carbon, and oxygen (if shell), will cause the parts-per-million values of other elements to be artificially lowered. Since the goal of the analysis is to source the *clay* from which the pot was made, differing amounts of temper, even if the same clay is used, will cause the compositional data to look quite different in terms of the parts-per-million concentrations of different elements (Neff et al. 1988). Simple log transformations can help somewhat in this regard and are particularly effective at counteracting differing magnitudes of concentration in elements (i.e., without transformation, elements with higher concentrations will be more heavily weighted in a PCA), but they cannot account for dilution effects. Instead, as long as the temper contains low levels of the elements of interest (e.g., minor and trace elements), the log-ratio transformation is effective in counteracting temper dilution effects as well as differences in magnitude of parts-per-million concentrations.

Values for the first five principal components were graphed in bivariate plots to begin the classification of sherds into compositional reference groups. Specimens forming spatially discrete clusters within the bivariate plots were initially placed together in compositional reference groups. A cluster analysis using average between-groups linkage and squared euclidean distance on these first five principal components was also used to corroborate the bivariate plot analysis and assist in the initial formation of groups. Based on these initial groups, additional specimens were added or subtracted based on the Mahalanobis distance, as expressed by Hotelling's T^2 statistic, from the group centroid for the first five principal components (see Bishop and Neff 1989; Sayre 1975; and Glascock 1992; Neff 2002 discusses the use of PCA for dimensionality reduction in Mahalanobis distance). Specimens falling within a 90% confidence interval ellipse around the group were admitted, 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 reference groups based on the PCA results were then reexamined 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. 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 3 or 4 divergent values for particular elements. Finally, results were screened to make sure they were consistent with other archaeological data, such as sherd form, shape, color, and geographical location.

RESULTS

The first five principal components of the PCA account for approximately 90% of the variability in the overall data set, suggesting that we have captured much of the total variability in these five new dimensions. Figure 3 plots the first two principal components for all sherds (minus three outliers; two from Fort Irwin and one corrugated Southwestern sherd collected in southern Owens), labeling each sherd based on where it was collected rather than its compositional reference group. From Fig. 3 it is already clear that sherds from the same region tend to cluster together. For example, almost every sherd from Sequoia National Park falls on the right-hand side of the graph, sherds from southern Owens Valley primarily on the left, sherds from central Owens in the lower center, northern Owens sherds in the center, sherds from the Nevada Test Site in the lower left, and Death Valley sherds in the upper center. This initial finding bodes well for our ultimate goal of creating meaningful reference groups related to regional clay chemical signatures. In opposition to the previous regions, the Deep Springs Valley, China Lake, and Fort Irwin samples are more spread out across the two principal components, suggesting higher variability in sherd composition.

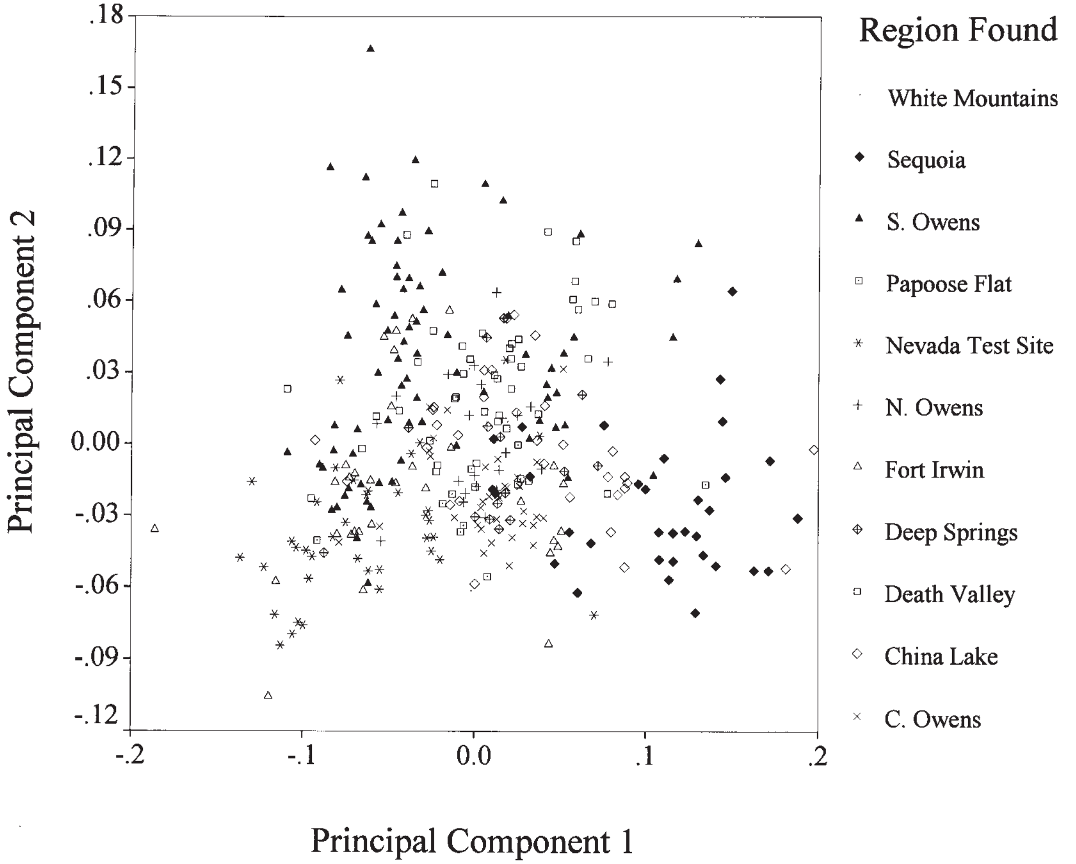

FIG. 3. Principal Components 1 and 2, with sherds labeled by region where found.

The creation of reference groups according to the procedures defined supports these initial conclusions. Most reference groups consist of sherds primarily from a single region, with occasional members from other nearby regions and, rarely, members from faraway places. Based on these results we were able to assign 78% (267 of 342) of the pot sherds to discrete compositional reference groups. In total, 17 reference groups were defined. Most of these groups consist of 10 or more specimens and several have more than 25, although some contain as few as 3. In many cases, it was possible to link groups to geographical areas based on chemical similarities to clays and the geographic distribution of group members. Where this was possible, an acronym was used to define the group (i.e., SOV1 for southern Owens Valley group 1). When the geographic provenance of a group was less clear or indeterminate, a temporary number was assigned (i.e., group 10 or group 11). Most of the larger groups can be subdivided into smaller discrete subgroups which were given alphabetic subheadings, such as SOV1A or SOV1B. The remaining 22% of the data set (75 of 342) are statistical outliers or "ungrouped" specimens and could not be assigned to chemical groups. The significance of these ungrouped sherds is discussed below. The sections below describe major reference groups encountered and their apparent geographical affinities.

Western Sierra and Death Valley Groups

The clearest division of the sherds is between those from west of the Sierra Nevada and those from the Basin and Range and Mojave Desert regions. Of the 33 sherds examined from Sequoia National Park in the Western Sierra Nevada, 28 (85%) belong to a major reference group distinct on a number of principal components and elements. This reference group, given the name Western Sierra (WS), bears similarity to several clays collected from Sequoia National Park. Like WS, these clays are all distinctly low in their concentrations of semimetals (As and SB), alkali metals (Cs, K, and Rb; but not Na), actinides (Th and U), and rare earth elements (REEs), particularly the lighter REEs La, Nd, and Sm, as well as higher concentrations of most transition metals, particularly Cr, Fe, and Ca. Three subgroups within WS were defined, WSA, WSB, and WSC. Figure 4 provides a biplot of K and Sr for all sherds and shows the distinctly low concentrations of K for WSA, always less than 15,000 ppm and often under 10,000 ppm. WSB sherds are slightly higher in K than their WSA counterparts, as seen in Fig. 4, but are similar to WSA by their low concentrations of semimetals (As and Sb) and REEs and higher levels of Fe, Cr, and Ca.

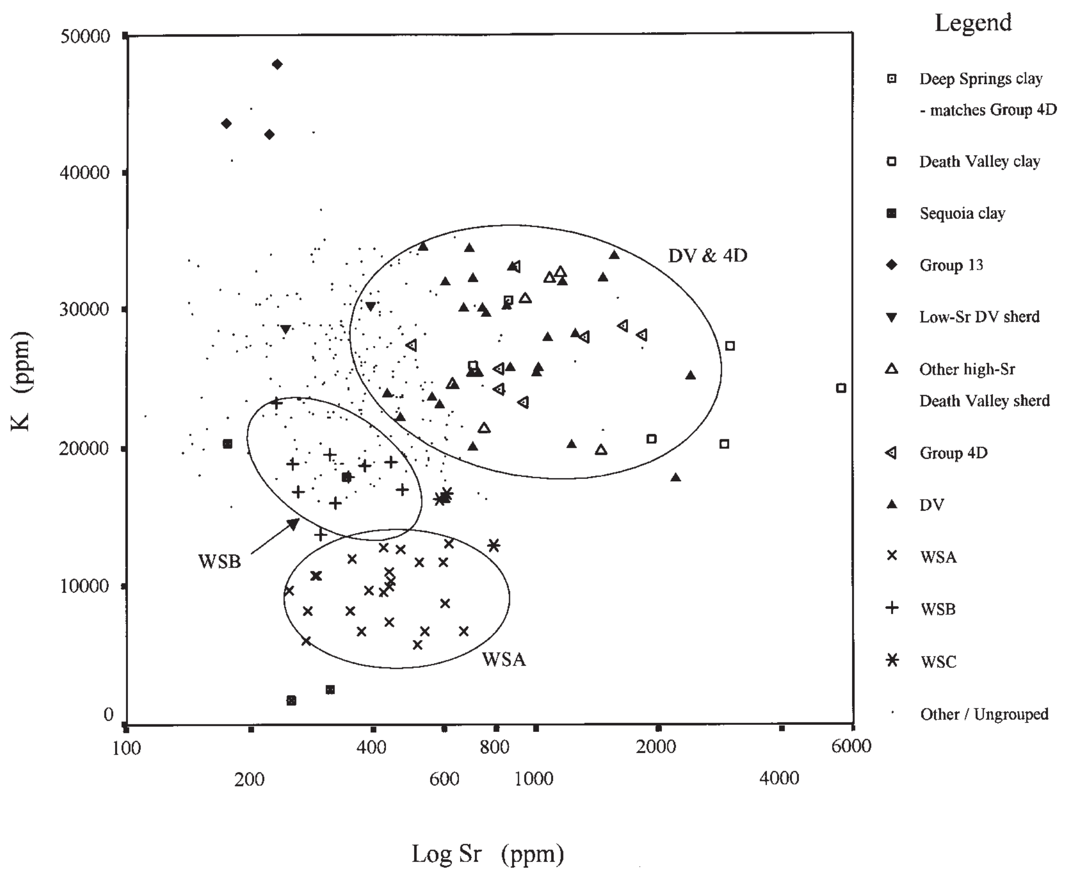

FIG. 4. Biplot of Sr and K showing separation of DV and WS sherds.

WSC, which is composed only of three sherds collected in southern Owens Valley (not the Western Sierra) is similar to WSB, but differs in several elements, including Sr, plotted in Fig. 4.

Eight sherds collected outside the Sequoia region were placed within the WS reference group, including four from China Lake, one from Papoose Flat, and the three from southern Owens Valley in WSC. The distribution of sherds in WS, being composed primarily of sherds collected in Sequoia National Park, suggests the compositional group represents clays collected west of the Sierra Nevada. Additional support for a western Sierran origin for these samples comes from analysis of clays collected within and near Sequoia National Park. Two of the four clays have extremely low levels of K, an order of magnitude lower than all other clays, and all display low levels of As, Rb, and REEs similar to the WS compositional group. Clays are also plotted in Fig. 4. These results also match those reported by geologists working with compositional data in rocks and minerals from the region. For example, Dodge et al. (1982; see also Ague and Brimhall 1988; Bateman 1992; Bateman and Dodge 1970) demonstrate that K, Rb, U, and most REEs vary across the Sierra Nevada, with western regions depleted and eastern ones enriched in these elements. Finally, INAA results on four sherds collected some 75 km south of Sequoia National Park in the Rockhouse Basin (Asaro and Michael 1984) mirror those obtained here, and their sherds fall squarely within the WS group. Unfortunately, Asaro and Michael (1984) did not measure Sr, and the sherds could not be plotted in Fig. 4. Together, the results suggest it is fairly easy to differentiate brownwares derived from clay sources on the western side of the Sierra Nevadas from those derived from the eastern side.

A second major division of the sherds is also depicted in Fig. 4 by Sr. The graph shows that while most sherds have less than 500 ppm Sr, a small fraction have higher values, often by 2–3 times this amount. The majority of these sherds were collected in Death Valley (27 of the 42 Death Valley sherds have Sr $>$ 700 ppm). Many of these high-Sr sherds also display lower concentrations of U, Th, and Lu and higher levels of Sb. These distinctive characteristics tended to separate these sherds from others and warranted the definition of a compositional group. Based on similarities to clays collected in Death Valley and the predominance of Death Valley sherds within the group it was given the name DV and is interpreted as being local to the Death Valley area. For example, the five clays collected in Death Valley (see Fig. 4) average 2836 ppm Sr, while 25 other clays collected to the north and west of Death Valley average only 483 ppm (Eerkens et al. 2002).

There is also support for this geographic ascription based on geological evidence. Chemical studies on rocks and minerals document a west-to-east increase in Sr, with some areas, such as the Sierra Nevada and White-Inyo Mountains, being much lower than ranges further east near Death Valley such as the Funeral and Black Mountains (Kistler and Peterman 1973; Leeman 1970; Sylveser et al. 1978). Although they have low concentrations of Sr, two additional sherds from Death Valley also seem to belong to the DV group based on other chemical properties. These are depicted in Fig. 4 by filled-in inverted triangles. In total, the DV group is composed of 31 samples, 29 from Death Valley and 2 from the China Lake region.

Six additional high-Sr sherds collected in Death Valley are also plotted in Fig. 4 as open triangles. However, based on other chemical properties, such as U, Sb, Th, and Lu, they could not be assigned to the DV group. Two seem to be part of the Nevada Test Site (NTS) compositional group discussed below, while the other four are unassigned outliers. The latter four may be from other high-Sr Death Valley clay sources, but additional research with local clays and sherds is necessary to verify this hypothesis.

A second high-Sr compositional group that is clearly related to DV based on its chemical properties is plotted separately in Fig. 4. Group 4D is composed of eight sherds, three from Death Valley, three from Deep Springs Valley, one from northern Owens Valley, and one from the Nevada Test Site, and appears to be a subgroup of DV. However, it is distinct from other DV samples by lower concentrations of the heavy REEs, particularly Lu, Tb, and Yb. A clay sample collected from the northeastern end of Deep Springs Valley matches the sherds in this group, casting doubt on a Death Valley origin for this compositional group. Based on the small number of sherds from a diversity of locations currently in this compositional group we were unable to assign it to a geographic locality.

Group 13, composed of three sherds from the Fort Irwin area is also distinct on K and Sr relative to other southwestern Great Basin samples, being particularly high in K and low in Sr. Unfortunately, the small size of this group and the absence of clay samples from Fort Irwin prohibits the ascription of this group to any geographic area. Additionally, the high mobility of groups using this region and the likelihood that peoples from the surrounding areas regularly made use of the area (see Eerkens 1999) makes tracking the source of these sherds difficult.

Nevada Test Site and Owens Valley Groups

Figure 5 plots Co and the ratio of Cr and Sb for all sherds except those from WS, DV, 4D, and 13 (which were shown to be discrete in Fig. 4). Three major and several minor groups occupy separate locations on the graph. On the lower left hand side is the NTS1 group, composed of 33 sherds. This reference group has low concentrations of semimetals (As and Sb) and transition metals (especially Co, Fe, Ti, and V) combined with higher concentrations of several lighter REEs (La, Ce, Nd, and Sm) and Ca. A large faction (67%) of the sherds in this group were collected within the Nevada Test Site, suggesting that the reference group is native to that region. A single clay sample collected from the Nevada Test Site shows some similarities to this group, though it is compositionally distinct. This further supports a Nevada Test Site provenance for NTS1.

The upper-center part of Fig. 5 shows NTS2, a small reference group composed of only five sherds. This reference group is similar to NTS1 in several respects, having low concentrations of semimetals and most transition metals, but has extremely low concentrations of REEs and Sr. Given the spatial distribution of sherds in this group, all from the Nevada Test Site, it is also assumed to be local to the Nevada Test Site.

Co and the ratio of Cr and Sb also serve to differentiate the majority of sherds collected in southern Owens Valley from those collected in the central and northern parts of the valley. In the lower center part of the graph is the SOV1 group, composed of 55 samples, 52 of which are from southern Owens Valley (of 78 total sherds sampled from this region). The other 3 SOV1 members are comprised of one sherd each from Papoose Flat, China Lake, and Death Valley. SOV1 is quite distinct compositionally from other western Great Basin sherds, including higher concentrations of the actinides (U and Th) and semimetals (As and Sb) and lower levels of Ba and some transition metals, especially Cr and Sc. Figure 5 shows that the ratio of Cr to Sb in this group is particularly low and distinctive. Although none matched the reference group exactly, several clays collected and analyzed from southern Owens Valley show strong similarities (note, however, the high Co values of 3 of the 6 southern Owens Valley clays). Combined with the fact that 95% of the sherds in this reference group were found in southern Owens Valley, these pieces of information provide strong support for a

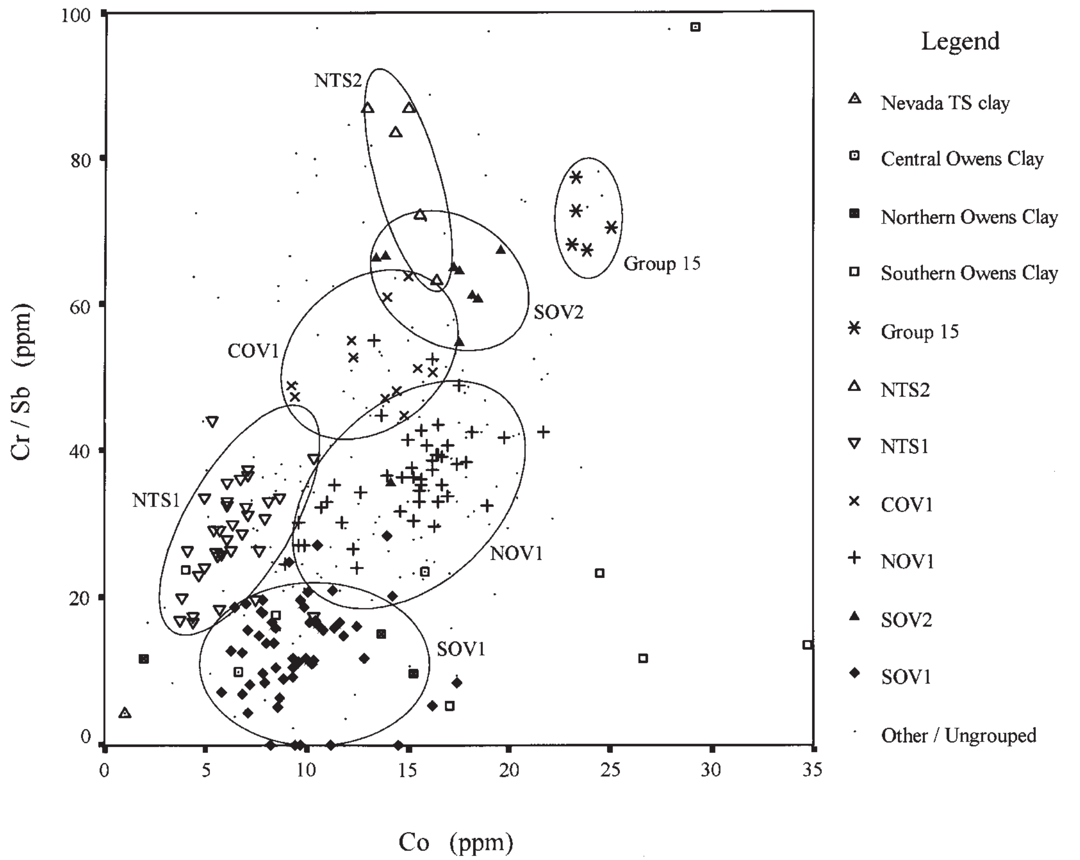

FIG. 5. Biplot of Co and Cr/Sb ratio showing separation of NTS1, SOV1, SOV2, COV1, and NOV1.

southern Owens Valley source for this reference group.

The majority of sherds from northern and central Owens Valley are also differentiated in the center part of Fig. 5, labeled NOV1. Of the 41 sherds in this reference group, 71% (29 of 41) come from the former two regions. The remaining 29% come from Papoose Flat (17%; 7 of 41), Deep Springs Valley (7%; 3 of 41), the White Mountains (2%; 1 of 41), and Sequoia National Park (2%; 1 of 41). Of the sherds sampled from northern Owens Valley, 61% belong to this group, and of those from central Owens Valley, 44% do. Two clays collected in northern Owens Valley show similarities to the NOV1 reference group, suggesting a northern Owens Valley source. However, the predominance of central Owens Valley sherds in the group and a decent match with one central Owens Valley clay suggests it is also locally available in that area. In fact, NOV1C, a subgroup of NOV1, is composed primarily of sherds from central Owens Valley. As a result the NOV1 group is interpreted as being available to potters in both central and northern Owens Valley. NOV1 does not stand out with particularly high or low values for any single element, and most values hover near the overall average for western Great Basin sherds. However, in multivariate space these sherds stand out as unique from others.

Two smaller reference groups from southern and central Owens Valley are also relatively distinct in Fig. 5. SOV2 is composed of 9 sherds all collected in southern Owens Valley, suggesting a southern Owens Valley source for this reference group. Higher values for some of the lighter transition metals, particularly Sc and V, and lower levels of some of the heavy REEs, particularly Tb and Yb, tend to differentiate these sherds from SOV1. Similarly, COV1 is composed of 11 sherds, 8 collected in central Owens Valley, 2 from Papoose Flat, and 1 from northern Owens Valley. Although not evident from Fig. 5, two clay samples collected in central Owens Valley are similar to the COV1 sherds, suggesting a central Owens Valley source for this reference group. COV1 sherds are depleted in the semimetals (As and Sb) and heavier transition metals (Zn and Zr) and have lower concentrations of ligher REEs (Ce, La, Nd, and Sm).

Mojave Desert Groups

Relative to Sequoia National Park, Owens Valley, Death Valley, and the Nevada Test Site, sherds from the Mojave Desert, including China Lake and Fort Irwin, are much more variable in composition. In the former cases, most sherds within a region belong to one or two major reference groups. In the Mojave Desert, sherds are spread out across a large number of minor reference groups composed of seven samples or less. As well, a higher percentage of sherds are ungrouped outliers. These facts speak to the extreme chemical diversity of pottery from the region.

At least eight minor reference groups composed of 3 sherds or more are present among the Mojave sherds. Importantly, these compositional reference groups are dissimilar and are not subgroups of a single larger chemical group. For example, Fig. 6 plots V and Th for all sherds sampled from the Mojave Desert. Although it is not possible to discriminate all 8 compositional groups on a single biplot, this figure does serve to completely separate groups 14 and 15 from all others and to show that 10 and 16 are unlike 11, 12, 13, and 17. Other biplots and principal components can be used to separate 10 from 16 and then 11, 12, 13, and 17 from one another. For example, Fig. 4 showed the distinctiveness of group 13 for K and Sr.

Unfortunately, no clay samples were analyzed from the Mojave Desert, and as a result, the geographic provenance of these samples cannot be firmly established. They are not from regions to the west or north, as they do not match the chemical signatures of clays and sherds collected in those areas. Similarly, they are chemically unlike clays and sherds collected further to the south in the Imperial Valley (Hildebrand et al. 2002). The Mojave Desert reference groups, then, would appear to be either local in origin or derived from areas to the east or south.

The large number of reference groups present suggests that either the Mojave Desert contains more chemically discrete clay sources used by potters (i.e., the variability in the parent geological formations and resultant clays that were used for pottery production is higher) or that a larger fraction of pots were brought into the area from a range of sources outside the area. Given the high mobility of groups using the Mojave Desert and the apparent lack of full-time year-round residents in the Fort Irwin area (see Eerkens 1999) the latter is a definite possibility. However, a more complete chemical analysis of clays and a comparison of the geology of the Mojave Desert to other regions is necessary to establish this.

None of the Mojave groups contain sherds from both China Lake and Fort Irwin. As well, the spatial distribution of sherds in most of these reference groups suggests a more localized production area. For example, sherds from group 10 are from sites in and around Tiefort Basin while those in group 11 are all from the Drinkwa-

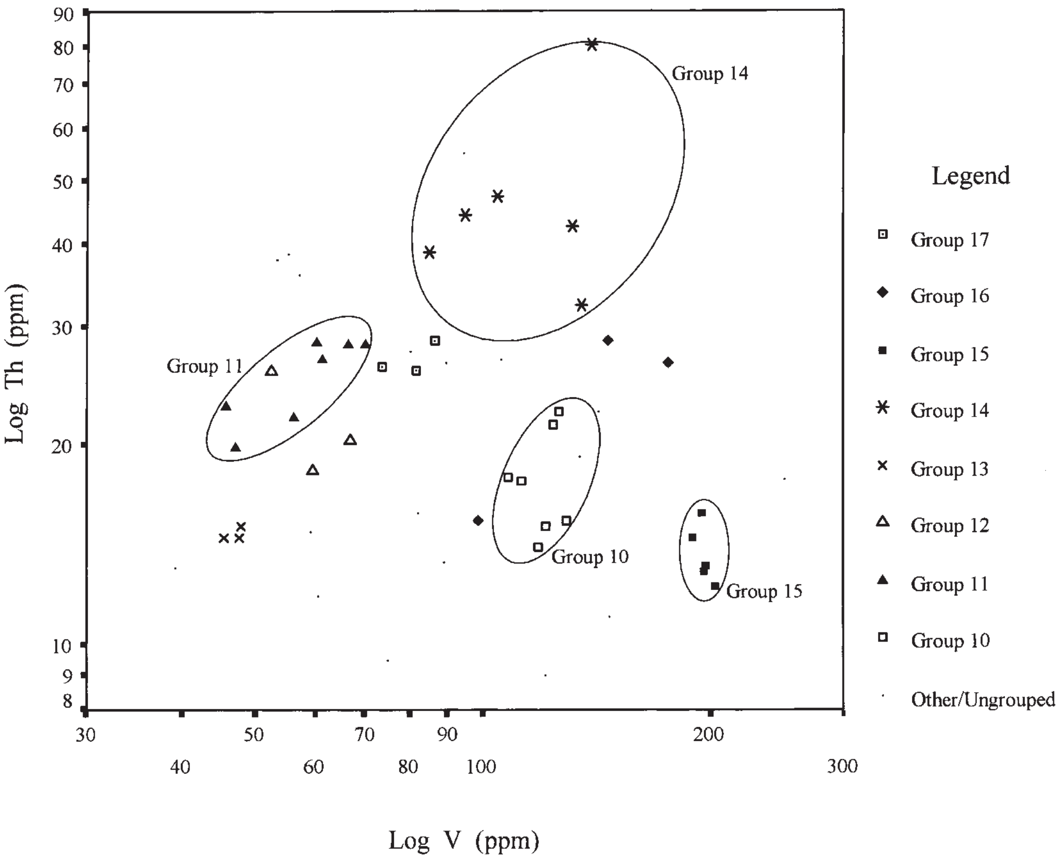

FIG. 6. Biplot of V and Th for all sherds collected in the Mojave Desert.

ter Basin, both in the Fort Irwin area. Based on this fact, the larger of the Mojave groups are provisionally assigned a local origin. Thus, groups 10 and 11 are provisionally assigned to the Fort Irwin area, and groups 14 and 15 to China Lake. Because they are composed of only three samples each and provenance is less certain, groups 12, 13, 16, and 17 are treated as if they are ungrouped.

Subgroups of Major Reference Groups

Finally, most of the larger reference groups can be broken down into discrete subgroups. For example, SOV1 and NOV1 can be divided into four and three subgroups respectively. In both cases, a REE-rich and a REE-poor subgroup exist. Similarly, DV has three subgroups, NTS has three, and WS three. In these cases other elements such as transition metals help to define the different subgroups.

By way of example, Fig. 7 plots Sb and Lu for all SOV1 and SOV2 sherds. SOV1A, the REE-rich subgroup, falls on the right-hand side of the graph, SOV1B on the upper left, and SOV1C and SOV1D overlap near the center of the graph. Also evident is that the four subgroups have different relationships between Sb and Lu. While Sb and Lu are positively correlated in SOV1B, SOV1C, and SOV1D (though with different slopes), the same is not true of SOV1A, where Sb remains relatively constant with increasing Lu.

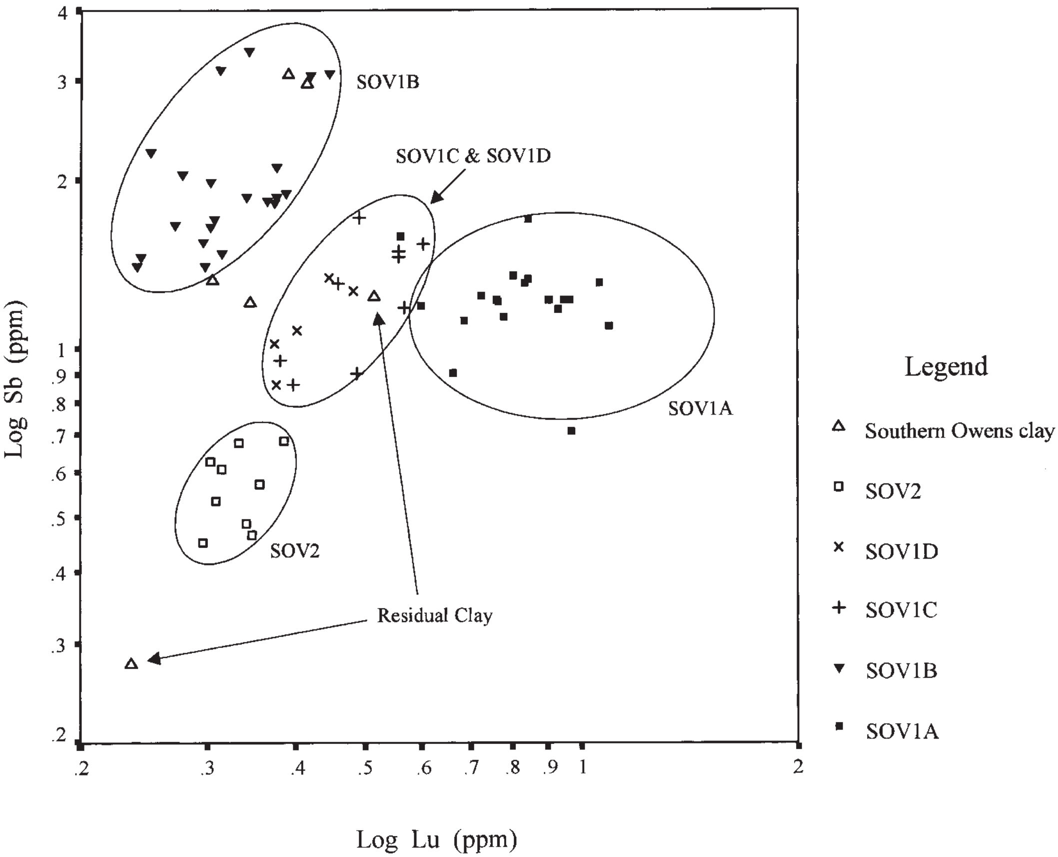

FIG. 7. Biplot of Sb and Lu for all SOV1 and SOV2 sherds showing separation of SOV1 subgroups.

The significance of such subgroups within major reference groups is discussed below.

Summary

A summary of the 17 reference groups defined and how sherds from different regions are distributed across these groups is given in Table 2. As can be seen, some regions such as Papoose Flat, China Lake, and Fort Irwin have their sherds spread out over a large number of reference groups, while others such as Sequoia National Park, southern Owens Valley, and central Owens Valley are distributed across a small set of groups. These results are summarized by region in Table 3, where the percentages of local, imported (exotic), and ungrouped or outlier specimens are shown. Included in the ungrouped category are all groups composed of 3 samples or less where geographic source was not known. Also summarized in Table 3 is the source of imported sherds to each region. Two sherds were demonstrated to be of Southwestern-like clays, and macroscopic inspection of these items suggested they were not local due to their gray pastes. Indeed one had been painted in the classic Southwest black-on-white style and the other appeared corrugated.

An analysis of the attributes of local, imported, and unassigned sherds demonstrates that there are significant differences in the shape and size of local vs nonlocal

TABLE 2
Comparison of Compositional Reference Groups and Sherd Composition by Region.

Reference Group	Sequoia NP	Death Valley	Nevada TS	South Owens	Central Owens	North. Owens	Pap. Flat	Deep Springs	China Lake	Fort Irwin
WS	28			3			1		4	
DV		27							2	
Group 4D		3	1			1		3		
NTS1		3	22		2	2	1	2		
NTS2			5							
SOV1		1		50			1		1	
SOV2				9						
COV1					8	1	2			
NOV1	1				15	14	7	3		
Group 10										7
Group 11										7
Group 12										3
Group 13										3
Group 14									6	
Group 15									5	
Group 16									3	
Group 17										3
Outlier	4	6	10	16	9	5	1	7	10	9
Total	33	40	38	78	34	23	13	15	31	32

Note. Not included in Table 2 are an outlier from Saline Valley, and an outlier, a NOV1, and a NTS1 from the White Mountains.

pots. Table 4 shows that imported pots are thinner, have narrower mouth openings, are more often restricted at their mouths (i.e., are more often recurved in the neck / rim), and are slightly more often decorated (though this difference is not significant). In other words, transported pots are smaller and lighter in weight and often have their goods protected by a restricted mouth opening. This result is not too sur-

TABLE 3
Summary of the INAA Study.

	% local	% import	% ungrouped	Source of traded sherds
Sequoia	85	3	12	NOV
Death Valley	75	10	15	SOV, NTS
Nevada Test Site	71	5	31	Group 4D, Southwest
Southern Owens	76	5	19	WS, Southwest
Central Owens	68	6	24	NTS
Northern Owens	60	17	22	NTS, Group 4D, COV
Papoose Flat	69[b]	23	8	SOV, NTS, WS
Deep Springs	20	33	47	NTS, NOV
China Lake	35	23	43[a]	SOV, WS, DV
Fort Irwin	44	0	56[a]	

[a] These regions contain small groups composed of only 3 sherds each that are suspected to be local. However, given the small sample size, they are treated as ungrouped until further analyses can establish their provenance.
[b] Based mostly on its proximity to northern and central Owens, NOV1 and COV1 were interpreted as local to Papoose Flat.

TABLE 4
Attributes of Local, Imported, and Ungrouped Rim and Body Sherds

	Local	Imported	Ungrouped
% of rims decorated	10% (17/164)	16% (4/25)	16% (7/44)
Avg. thickness for rims	5.80 mm	5.55 mm	5.96 mm
Avg. diameter for rims	266 mm	222 mm	220 mm
% of rims recurved	8% (13/164)	32% (8/25)	16% (7/44)
Avg. thickness for body sherds	6.22 mm	5.84 mm	6.08 mm

prising, given the weight of pots and the distance over which they were sometimes carried, occasionally up to 100 km from their original region of manufacture.

At this point it is still unclear whether ungrouped sherds represent local but more rarely used clay sources or if they represent pots imported from areas outside the current study area. A comparison of attributes in Table 4 suggests that they are intermediate between local and imported sherds. For example, ungrouped sherds tend to be decorated as often as, and have narrow mouth openings like, imported ones, but are thicker and are rarely recurved, like locally produced pots. These results suggest that the ungrouped category is composed of a mix of local and nonlocal pots.

Unfortunately, the reference groups correlate with no visible attributes on the pot sherds. For example, there seem to be no attributes, such as sherd thickness or sherd color, that distinguish SOV2 from SOV1 sherds. A more detailed analysis is currently underway by the senior author using electron microprobe and petrographic analyses of thin sections to see if temper constituents systematically vary between compositional groups. However, visual inspection under a 30X microscope revealed no dramatic differences in temper between compositional groups.

DISCUSSION

The results of the study demonstrate several important points of relevance to southwestern Great Basin archaeology and more general hunter-gatherer and ceramic-use studies. First, in the southwestern Great Basin, it is clear that ceramic sourcing works and is a worthwhile undertaking. On a regional scale it is possible to define locally made vs imported ceramics. This result has the possibility to advance Great Basin ceramic studies by allowing archaeologists to create more objective and meaningful categories into which sherds can be placed. These types, related to geographic provenance, will allow us to more accurately model the movement of people and their ceramic pots across the landscape and interactions between different regions (Eerkens et al. 2002).

Second, potters in most regions seem to have made use of several different sources of clay, as demonstrated by the presence of more than one local chemical reference group in many regions. Multiple major reference groups likely indicate the availability of discrete parent sources of clay or temper within a region. These sources could include different strata with unique geological histories or discrete geological structures, such as different granitic plutons or basalt flows.

Many of the major compositional reference groups are also composed of multiple discrete subgroups, which could represent one of a number of possibilities. First, these subgroups could represent the same parent clay source, but with different added temper recipes, such as quartz, shell, sherd, or volcanic ash. In the southwestern

Great Basin sherds seem to be tempered mainly by crushed granite or sand dominated by quartz. Second, different subgroups could represent discrete, but geologically related, parent sources, such as clays from different volcanic extrusive or intrusive events separated in time. These volcanic bodies may have similar but slightly different chemical compositions as the magma chamber evolved over time. Finally, these subgroups could represent the same parent source of clay at different stages of transport. For example, as a residual clay is transported by fluvial processes from its original point of formation to a location downslope (i.e., as a sedimentary source of clay), certain elements, such as Ca, Mn, and Na, tend to be leached from the clay. As a result, these elements will decrease and others, such as Al and some REEs, will increase in concentration in transported sedimentary clays (Kuleff and Djingova 1996; Pettijohn 1975; Velde 1991).

A closer examination of some of the subgroups of the SOV1 and NOV1 reference groups tends to support the latter. Aluminum is slightly lower in 1A subgroups while Mn and Ca are generally higher than in the 1B subgroups, suggesting the former may be primary or residual sources and the latter transported. Further support comes from the fact that several sedimentary clay samples in southern Owens Valley tend to fall within the range of SOV1B, as seen in Fig. 7, while one of residual clays is closer to SOV1A. These findings support the conclusion that the different subgroups represent the same parent clay source collected at different points of transport in their depositional history. However, petrographic analysis of pot sherd thin sections will be required to substantiate this hypothesis.

On a more general level the results also have implications for how pottery production was organized in small-scale and mobile Great Basin societies. First, the study demonstrates that in most regions the majority of pots are locally made and used. In most regions, over 60% of the pots appear to be locally made and less than 20% are clearly imported from other regions. The main exceptions to this pattern are in China Lake, Fort Irwin, and Deep Springs Valley, where people were more residentially mobile. Moreover, in most of the more sedentary regions, such as Sequoia National Park and central and southern Owens Valley less than 6% of the pots are imported and nearly 70% or more are locally made.

Thus, in most areas pots appear to have been produced from a small number of clay source zones primarily for local consumption. However, in the Mojave Desert and Deep Springs Valley, where people were probably more residentially mobile (see Steward 1938), a larger number of source zones were utilized and, most likely, a higher percentage of pots were brought in from outside the area. Yet, how the small percentage of pots that were transported got to their final resting place, whether through formalized exchange or within the context of seasonal rounds, is still unclear.

An examination of the distribution of imported pots brings to light an interesting observation that sheds light on this issue. Nonlocal pots are not haphazardly or evenly distributed across the landscape. Instead when people are moving pots they seem to be doing so primarily between regions that are relatively close but have divergent precipitation patterns. For example, despite rather large sample sizes and short distances, there is not a single example of a pot being carried between southern and either central or northern Owens Valley. When they are transported, pots produced in southern Owens Valley are primarily moving to the southeast into the Mojave Desert or east into Death Valley. Similarly, most pots moving into southern Owens Valley are coming from the western Sierra Nevada. Both these areas (the Mojave Desert and the western Sierra) are in close spatial proximity to southern Owens Valley, but have quite different weather patterns based on historic climatic data (Eerkens 2001).

By contrast, most pots being carried into or out of central and northern Owens Valley come and go from regions in the northeast part of the study area, including Deep Springs Valley and the Nevada Test Site. Again, these are areas that are relatively close but have dissimilar patterns in rainfall. A more detailed comparison of precipitation patterns, as measured by historic weather station data, and the direction of pottery exchange is given in Eerkens (2001). All of this implies that pottery is moving primarily between areas where there is less chance of both simultaneously experiencing "bad" or drought conditions.

This suggests two things. First, the overproduction model of pottery production to take advantage of the economy of scale is not supported. If pots were overproduced in some areas and redistributed to others nearby, we would expect to see a more even distribution of transported pots. That is, to minimize effort and energy expenditure we would expect the distribution of pots in all directions with nearby areas receiving the majority of pots regardless of climate. Such a pattern would result in a more classic fall-off curve where the frequency of pots from a source decreases evenly in all directions with walking distance from the source (see Renfrew 1977). Clearly this pattern does not obtain and, thus, we see no evidence to support Julian Steward's suggestion that specialist potters in Owens Valley overproduced and distributed pots across the southwestern Great Basin. Even in areas where pots are uncommon and presumably few were made, such as central and northern Owens Valley, the majority were still locally made and very few imported, and in particular none came from nearby pottery-rich areas like southern Owens Valley.

Second, it also suggests that people in the southwestern Great Basin were occasionally visiting, and likely making use of, other territories for the purposes of buffering resource shortfall in their own home range. Such a system has been well documented among the Australian Aborigines of the Western Desert (e.g., Yengoyan 1972), but to our knowledge has not been discussed or documented among American Great Basin groups. Such access could have involved a formal system of requesting and granting access to foreign territories marked by the formalized exchange of gifts, including ceramic pots or goods carried within pots (see Earle 1994; Gregory 1982; Halstead and O'Shea 1989; Hodder 1980; Johnson 1994; Winterhalder 1997). A reciprocal access system involving gifts might account for the presence of nonlocal pots in the pattern observed in the southwestern Great Basin. Alternatively, such access may have been undertaken with no kind of formal permission at all or may have involved other nonceramic gifts. In such a context, nonlocal pots may simply be a byproduct of resource extraction in a foreign territory; that is, pots may be curated tools that were part of a seasonal round that occasionally extended beyond the normal range of movements.

Several observations support the latter. Great Basin pots are rarely decorated or elaborated to increase their social value, as is common with objects that are part of a formal gift exchange system. Although pots are easily elaborated through painting, stamping, burnishing, or other techniques, in most southwestern Great Basin regions only between 5 and 10% of the pots are decorated in any manner (Eerkens 2001). Moreover, even when they are decorated it is very minimal. Decoration motifs are quite standardized across the Great Basin and are comprised mostly of a single row of fingernail incisions around the rim or on the lip of the pot. As well, although imported pots are slightly more often decorated than locally made ones (16% vs 10%), the difference is not statistically significant. Nor are imported pots different in any visible manner from local ones. Thus, imported pots do not bear the social elaboration we expect of gifts and are no different than locally made ones.

Of course, it is still possible that imported pots are simply the containers used to carry some type of gift. Yet, gas chromatography–mass spectrometry analysis of imported vs local pots shows them to have been used to cook the same range of foods (Eerkens 2001), suggesting they served the same purposes. One might expect that pots circulating in a formalized gift exchange system would play a different social and functional role and might have been used to carry unusual goods, but the data do not support this position. It is possible, though, that such containers were later incorporated within the normal range of economic activities of pots, thereby obscuring any unusual residue patterns. However, as the data currently stand, there is no indication that imported pots were made, used, or decorated any differently than locally made pots. Finally, if pots are the vehicle to move some type of gift, they are inefficient at this task given their weight and vulnerability to breakage. Baskets, gourds, or hide containers would seem to be more suitable for long-distance transport of a prestigious gift.

In sum, the data all point to the conclusion that the majority of imported pots were simply carried in by people during the course of seasonal movements. During lean years, small groups of people may have taken a few pots with them during residential moves to other regions in search of more plentiful food resources. Carrying finished pots may have been preferred to the production of new vessels in an area where potters were unfamiliar with local clay resources, particularly if they were under time duress to be collecting food. Some of these pots seem to have been subsequently left behind, accounting for the pattern we see in the archaeological record. There may have been a formalized system of exchange involving gifts as part of the procedure for gaining access to a foreign territory, but pots do not seem to have been part of such a system. Thus even the imported pots documented by INAA above were probably not traded but were made by women for their own use.

The number of discrete reference groups present and the diversity in sherd chemistry by region, then, may indicate the degree to which a region was used in such a fashion. Thus, this suggests that areas such as Deep Springs Valley, Fort Irwin, and China Lake were often used by nonlocal groups to buffer resource shortfall, while Sequoia National Park and southern and central Owens Valley were more rarely so used. This accords well with the observations of Eerkens (1999) that Fort Irwin was not permanently occupied by any single ethnic group, but was sporadically used by a number of groups from the surrounding area. Such a pattern would result in a situation where pots were brought into the region from a number of surrounding areas, creating a diverse chemical makeup of sherds and a large number of small reference groups. Additional testing of source clays and pot sherds from these regions and areas to the east will help to clarify this hypothesis.

CONCLUSIONS

Together, the data from the southwestern Great Basin do not support the overproduction of pots for exchange. Despite lower population densities, people did not organize themselves at a regional level to increase demand for pots such that they could take advantage of the economy of scale of pottery production. Similarly, it does not appear that certain enterprising individuals were able to organize such distribution networks to move their goods. If some women were specialist potters and sold their vessels for profit, as suggested by Steward (1933:265–268) in Owens Valley, they seem to have done so on a very local scale only. However, it should also be noted that Paiute and Shoshone had abandoned pottery making for some time by the time Steward began his fieldwork and it is possible that his informants were incorrect in their assessments of pottery production. Moreover, ethnographic information about pottery and pottery production collected by Driver (1937) for the same area is at odds with archaeological data. For example, Driver reports that pots were usually painted with black, white, and red colors, a trait that is clearly absent among prehistoric sherds. All of this suggests that much of the ethnographic data collected in the 20th century about pottery making is unreliable when applied to the prehistoric record (Eerkens 2001). Indeed, Steward felt that data he collected on pottery production in other areas of the Great Basin were of "doubtful worth" given the length of time since the abandonment of this technology and the lack of first-hand knowledge by informants (Steward 1943:274). His comments on specialization in Owens Valley also seem to be incorrect.

The INAA data suggest that the production of pottery in the southwestern Great Basin was organized on a small scale, likely at the family or individual level. The majority of pots in most regions were made and consumed locally and formal interregional (or even intraregional) gift exchange of these vessels was negligible. Thus, pots were produced for utilitarian functions and were not a source of prestige or status. If gift exchange was an important activity prehistorically between different areas, as the ethnographic record suggests, pots do not seem to be an important component of this activity.

Several factors may have contributed to the utilitarian, rather than prestige, status of pottery among southwestern Great Basin people. First, a semisedentary to mobile lifestyle encouraged caching of pots in certain locations, especially lakeside and riverside settings (Eerkens 2001). Cached items, of course, are not visible to others during the period in which they are stored away, making it difficult to bestow prestige or elevated status upon the owner during these times. Other less heavy items that could be carried around during the entire year, such as jewelry, beadwork, or baskets, likely played this role instead.

Second, low population densities in the region assured that trading partners would be living at some distance. Elevating the social value of pots through long-distance exchange, then, would have been difficult given the heaviness of pots and the effort required in transporting them over long distances. Smaller items that are lighter in weight would have been more efficient in this respect. Moreover, high residential mobility may have made predicting the location of potential trading partners difficult, and potential partners would, at times, be at great distances from the producers of pots. Establishing a predictable and permanent market for pots, then, would have been a difficult undertaking.

Finally, pots may have been seen as a threat that could undermine the value of traditionally recognized prestige goods or gifts. The producers and owners of such socially valued items, then, may have intentionally reduced pots to the position of utilitarian nonprestige item (see Sassaman 1993 for a similar explanation in the southeastern United States). This is particularly relevant since pottery was a relatively new technology to the region, being introduced only 500–700 years ago. Thus, potters may not have had enough time to develop the craft into a more socially valued one.

Taken together, the data suggest that pottery production in the southwestern Great Basin was a small-time individual- or family-level activity and was not organized at any higher regional level. Skibo and Blinman (1999) come to a similar conclusion for the earliest pottery on the nearby Colorado Plateau. The number of pot sherds at most late prehistoric southwestern Great Basin sites is small, usually less than 100. For example, the minimum number of vessels associated with most house floor assemblages in southern Owens Valley, an area that actually has much higher concentrations of pottery relative to other regions, is only between 2 and 3 distinct pots per house (Eerkens n.d.). It is unknown how long a particular house was occupied, but this suggests that any particular family unit was not using a large number of pots at any one time. Moreover, if pots were being cached at certain points on the landscape, as seem to be the case (Eerkens 2001), they were probably only being used at certain times of the year and were not a ubiquitous tool in the Numic toolkit. Only a few pots were needed per family during a limited time of the year. In short, this does not sound like high use or high demand.

Given the small numbers of pots present at southwestern Great Basin sites, it is hard to envision a family unit firing large numbers of vessels all at once in order to take advantage of the economy of scale. What would a semimobile group do with a large number of pots? The evidence does not suggest they traded or sold these items. Nor would they be likely to carry along more than the minimum number needed on the seasonal round. Instead, a system focused on the production of a small number or even a single pot (one to four) as they were needed seems more likely, despite the higher per-unit cost of doing so.

Bringing this back to a more general level, the organization and beginnings of pottery production in small-scale and mobile societies may have less to do with an economy of scale (i.e., the ability to produce large numbers of vessels at a lower average cost) than with other advantages of the technology. As others have argued, these advantages include that pots allow women to boil or simmer foods unattended over an open fire (see Arnold 1985:128; Crown and Wills 1995; Van Kamp 1979:74), that they are efficient subterranean storage containers (Moore 1995; Peterson 1980), that they are efficient at detoxifying foods to broaden the diet (Braun 1983; Ikawa-Smith 1976), and that they make more efficient use of fuel during cooking (Bettinger et al. 1994:95). A population that is small in size is likely to have limited overall demand for containers. Moreover, such societies are unlikely to be able to organize production at higher a regional level, for example, by creating specialists who redistribute their goods over a large area. As well, a semi- to highly mobile lifestyle may limit the usefulness and compatibility of earthenware containers to certain seasons. Thus, the demand and market are unlikely to be present to make pottery technology worthwhile from an economy-of-scale perspective in such societies.

Although the economy of scale is clearly an advantage of ceramic technologies when large numbers of vessels are needed (Brown 1989), this does not seem to be the case for small-scale mobile societies. That many such groups still make and use pots suggests that they pick up and make use of the technology for other reasons. Family- or individual-level production of small numbers with predominantly local consumption may be the norm. As well, high mobility is likely to preclude the establishment of pots as items of prestige, particularly if they are cached for much of the year and only see intensive use during a small window of time.

Of course, each society is unique and has different social and functional needs. People go through different histories leading to the adoption pottery and may do so for different reasons. Testing the ideas proposed here within other small-scale and mobile societies that made pots will have to be an empirical process and will go far in expanding our very limited knowledge of the organization and incorporation pottery technology in such societies. We are encouraged that others have come to similar (albeit slightly different) conclusions in nearby regions (e.g., Skibo and Blinman 1999) and hope these ideas will be applied and tested in other contexts.

ACKNOWLEDGMENTS

This research was supported by a predoctoral grant from the Wenner–Gren Foundation for Anthropological Research (No. 6259) and a National Science Foundation Dissertation Improvement Grant (No. 9902836) to the senior author and a National Science Foundation grant (No. SBR-9802366) to Missouri University Research Reactor. We also kindly thank two anonymous reviewers for providing valuable comments.

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