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Permalink

https://escholarship.org/uc/item/40b9221s

Journal

North American Archaeologist, 24(1)

ISSN

0197-6931

Author

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Publication Date

2003

NORTH AMERICAN ARCHAEOLOGIST, Vol. 24(1) 1-27, 2003

TOWARDS A CHRONOLOGY OF BROWNWARE POTTERY IN THE WESTERN GREAT BASIN: A CASE STUDY FROM OWENS VALLEY*

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ABSTRACT

Great Basin brownware is often perceived as highly variable and lacking distinct subdivisions. Combined with the lack of painted decoration, the result has been to lump all brownware into a single all-encompassing temporal category. This article examines this perception in the Owens Valley of California where pot sherds are often found associated with late prehistoric house floors. An analysis of these sherd assemblages reveals important changes in how pots were made through time and suggests changes in prehistoric human behavior.

INTRODUCTION

Ceramic typologies and chronologies have been an important part of archaeological research in areas where people made and used earthenware pots. However, this is distinctly not the case for the late prehistoric period in the western Great Basin. Despite the fact that large numbers of pot sherds have now been recovered in various surveys and excavations, there are no published accounts of attempts to segregate pottery into distinct temporal periods or to systematicalaly compare pottery from different regions.

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*Much of this research was supported by a National Science Foundation dissertation improvement grant (#9902836) and a predoctoral grant from the Wenner-Gren Foundations for Anthropological Research grant (#6529).

In general, western Great Basin brownware is interpreted as being too variable to create meaningful types or subcategories (see Bettinger, 1986; Pippin, 1986). Variability within any particular period of time or within regions is seen as being greater than the variability between them. This great variation is often attributed to the unsystematic way in which pots were made. That is, Great Basin brownware is assumed to represent a single but highly variable artifact category, not because it is an agglomerated category composed of pots made in distinct times by distinct cultural entities with different traditions, but because it was equally variable throughout time and space. Below, I refer to this as the "single-type" hypothesis.

Earlier work (see Eerkens, 2001; Eerkens et al., 2002a, 2002b) attempted to test of the single-type hypothesis with regards to space with some success. Pots are not made in the same way across space, and there are distinct differences in how they were manufactured in different regions in the western Great Basin. These differences were related to the varying functions that pots served. This article attempts to test the temporal part of the single-type assumption.

OWENS VALLEY BROWNWARE

It is generally accepted that the late prehistoric inhabitants of Owens Valley, the ancestors of the Owens Valley Paiute, did not begin making and using brownware pottery until the Marana period (ca. 700 BP to historic times; Bettinger and Taylor, 1974). There is evidence for earlier experimentation with pots around 1200 BP (Eerkens et al., 1999) and local pottery production is clearly in full swing by 500 BP, however, the exact timing for the introduction of pottery is not known. Recent study in southern Owens Valley suggests that pottery-making does not begin until well into the Marana period, at approximately 500 BP (Delacorte, 1999). Unfortunately, there are few sites and radiocarbon dates associated with the period between 700 and 500 BP, thus, it is possible pots were made earlier but we lack evidence for their production. All that can be said is that prior to 700 BP very few pots were made and that by 500 BP Paiute were engaged in a modest level of pot production in Owens Valley. Pots quickly and completely drop out of the suite of material artifacts upon contact with European settlers around AD 1850, being replaced by metal containers.

The brownware of the Owens Valley region was made using the coil-and-scrape method, whereby long rolls of clay were neatly stacked upon one another, pressed together, and scraped with the fingers or a small object such as a bundle of twigs or a pebble to meld the coils together. Pots were apparently fired in uncontrolled atmospheres, likely a small pit covered with brush, leading to variable colors on the exterior and interior surfaces and the core. Most pots range from brown-red to brown-black in color and less than 10 percent of the pots were decorated. It has been suggested by some (Steward, 1933) that temper was not intentionally added to clays prior to firing, but that mineral and organic temper components were naturally present within the clays Paiute collected for their pots. However, this hypothesis needs to be tested and is currently under investigation by the author through electron microprobe and petrographic analysis of thin sections.

In Owens Valley, large conical pots with direct rims were the most common shape, though a small number of pots are bowl-shaped and a very small percentage (ca. 3 percent) have recurved rims. Most whole pots range between 20 and 35 cm in height and 20 and 40 cm in diameter at their mouths, yet a small number of miniature pots have been collected. Other ceramic objects include pipes (Griset, 1988), suggesting that the baked-clay technology extended beyond merely the production of vessels.

Recent studies suggest that western Great Basin pots are primarily cooking vessels used to boil seeds and nuts, though roots, berries, and greens were occasionally cooked as well. Meats seem to have been only rarely processed in pots, likely as part of stews containing seeds and other plant products (Eerkens, 2001). There seems to be a fairly strong correlation between the introduction of intensive seed procurement, increased milling activity, and pottery use. Indeed, the increased role of seeds in the diet likely precipitated the adoption of pottery in the region. Very few pots seem to have been traded within the region and the craft appears to represent an individual or family-level operation. Pots are clearly utilitarian objects and did not enter into the realm of socially- or ritually-valued (i.e., prestige) objects as indicated by their lack of trade, their association with domestic contexts, and their lack of decoration or other embellishments (Eerkens, 2001).

DEVELOPING A CHRONOLOGY IN SOUTHERN OWENS VALLEY

Several problems have hindered the development of a temporally sensitive ceramic typology in the western Great Basin. First, there is a lack of well-dated single-component sites containing pottery (Pippin, 1986). In addition, most ceramic-period sites contain only modest numbers of sherds, usually less than 200, thereby minimizing the sample size in association with any dates and creating problems when attempting to seriate sherds from sites (i.e., only a small number of pots are generally represented per site). Second, no sites with multiple and stratigraphically separated ceramic-bearing layers have been excavated. This has prevented systematic comparison of pottery over time within a single site. A third obstacle to studying temporal change may relate to expectations that pottery decoration is the most sensitive attribute of temporal change, as we have learned from ceramic studies in the American Southwest and other regions. Except for the small fraction that display fingernail impressions around the rim or lip, western Great Basin pottery is undecorated (Eerkens, 2001). However, even this decoration motif appears to be extremely consistent through time and space and presents little opportunity to segregate pots into meaningful spacio-temporal categories.

Excavations in southern Owens Valley over the last 15 years have greatly expanded the number of well-dated and single-component pottery-bearing assemblages. In particular, excavation of many late prehistoric houses and other features containing pottery that have been independently dated by radiometric methods allows us to begin examining change through time in the ceramic technology of the Paiute inhabitants of this region. As well, sites in this region generally contain larger numbers of sherds representing more pots than in other regions (Eerkens, 2001), allowing for more rigorous statistical comparison of pottery assemblages. This unique database allows us to begin comparing ceramic assemblages through time and provides the potential for developing a chronology of sherds.

Thirteen such late prehistoric feature-components are included in this analysis. Six of these represent house floor assemblages excavated at CA-INY-30, on Lubkin Creek to the northeast of Owens Lake (see Figure 1 for location and see Basgall and McGuire, 1988, for a detailed description of the site). Pottery assemblages from structures 1, 5, 7, 8, 9, and 10 were included in the analysis. Two additional house floor assemblages come from CA-INY-5207, locus 2 at Bartlett Point near Carroll Creek on the west side of Owens Lake (Eerkens, 1997) and CA-INY-3769, locus 13 some 10 km north of Owens Lake near the Alabama Hills (Delacorte, 1999). For the latter, sherds associated with Feature 1, a large external hearth or midden dump just outside, but clearly associated with the house structure, were also included in the analysis. Feature 1 at CA-INY-1447 was also included and represents a central hearth within a prehistoric wickiup or house structure (Gilreath, 1995). All the aforementioned house structures represent saucer-shaped (in cross section) and circular (in plan view) concentrations of charcoal and compacted earth ranging between 4 and 8 meters in diameter. Thus, these nine assemblages all come from domestic structures and contexts.

A note should be made here regarding structure 7 at CA-INY-30. Two radiocarbon dates were retrieved from the structure, one modern in age and a second from 480 ± 60 BP. Basgall and McGuire (1988) rejected the former as modern contamination of the house floor and accepted the latter as more reliably dating the structure and associated artifact assemblage. However, it is noted here that a protohistoric *Olivella* bead and seven glass trade beads were found within the structure fill, including some on the floor. The significance of these protohistoric items is discussed below.

The final four components represent pottery assemblages associated with other types of features. Feature 7 at CA-INY-1430, locus 4, is composed of a dark brown ashy zone containing high quantities of burned bone which produced a modern radiocarbon date (Gilreath, 1995). Although no historic artifacts were recovered, the bones of tule elk, a species introduced in recent times, were identified among the faunal remains. The second such feature, at CA-INY-5207, locus 4, is

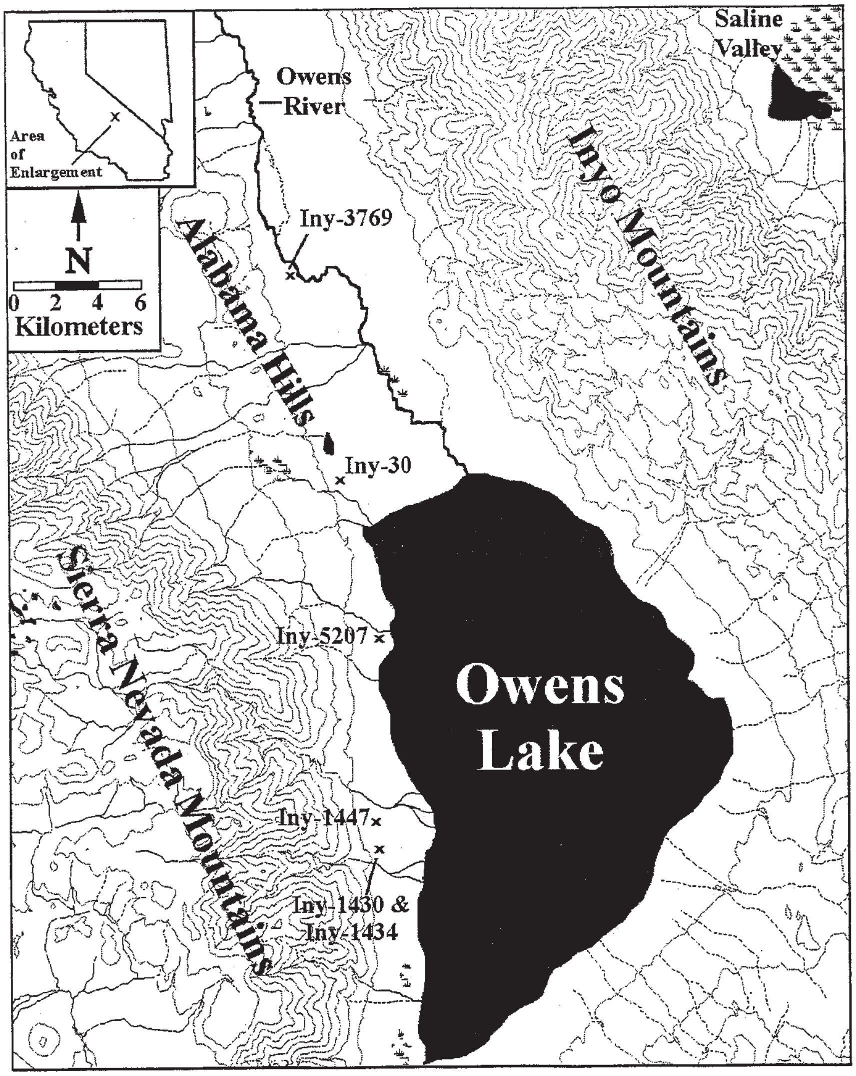

Figure 1. Map of southern Owens Valley showing approximate locations of sites.

composed of a large boulder near the shores of Owens Lake with several mortars and milling slicks (Eerkens, 1997). Excavations around the milling station revealed several burns, one of which was radiocarbon dated to recent times and had a single pot sherd in association, though no historic artifacts were recovered. The final two components represent two burn features from CA-INY-1434, which is near U.S. Highway 395 along Ash Creek and the western shore of Owens Lake (Gilreath, 1995). Feature 1 from locus 1 is a concentration of fire-affected rock and charcoal about 75 cm in diameter with a basin or dish shape. Although some modern roadside debris contaminates the uppermost part of the deposit, Gilreath (1995:144) felt that the feature was relatively intact and undisturbed. Feature 2 from locus 2 represents a charcoal smear approximately 80 × 45 cm across, with much fire-affected rock and 16 associated pot sherds. Figure 1 plots the approximate location of these sites relative to one another and important geographic features in Southern Owens Valley.

Readers familiar with pottery from the region will notice that I omitted the earliest dated house floor containing brownware sherds from the region, namely structure 13 from CA-INY-30 which has been radiocarbon dated at 710 ± 70 BP. This feature was not included for two main reasons. First, during excavation several intrusive pits from higher stratigraphic layers were noted penetrating the floor zone (Basgall and McGuire, 1988). Pot sherds were clearly within the fill of these pits. Although the excavators tried to delineate and separate sediments associated with these pits from those associated with the original floor, examination of the sherds believed to be associated with the latter (i.e., not intrusive) shows that many are from the same pot as sherds clearly associated with the pits. In other words, the fact that sherds within the pits have the same temper, thickness, color, and construction style as those believed to be native to the floor must cast doubt on the integrity of the house floor assemblage. Second, a thermoluminescence date on one of the sherds from the floor returned a date of 310 BP ± 50 (Rhode, 1994; UWTL-100) casting further doubt on the association of the pottery with the much earlier radiocarbon date. As well, pot sherds from this structure do not fit the chronological patterns discussed below and appear more like middle-Marana sherds, as the thermoluminescence date suggests, than early Marana ones. For these reasons, it was felt that the radiocarbon assay does not date the associated pottery and the structure was not included in the study.

Table 1 lists the assemblages incorporated in the study, including a brief description of the feature, the radiocarbon date, and the number of body and rim sherds in association. Table 1 also lists references so that readers wishing more detailed information on the assemblages and associated features can consult the original site reports. The reader will notice that several assemblages have more than one radiocarbon date (including some that do not overlap at the 2-sigma level). For the purposes of this study, multiple dates on a single feature were averaged to obtain a single determination per assemblage.

Table 1. Background Information on Assemblages Included in the Study.
Assemblages Arranged in Chronological Order from Youngest (on Top) to Oldest (on Bottom)

Site (reference)	Context	Description	^{14}C Dates (Beta Lab #)	Body	Rim	MNV
Iny-1430, loc. 4[a]	Feature 7	Ashy zone	10 ± 60 (66965)	11	1	1
Iny-5207, loc. 4[b]	Burn 1	Burn near BRM	70 ± 50 (113512)	1	0	1
Iny-30[c]	Structure 9	House floor	180 ± 60 (20521)	27	5	4
Iny-5207, loc. 2[b]	Feature 1	House floor	140 ± 90 (135415) 270 ± 60 (113511)	14	4	2
Iny-3769, loc. 13[d]	Structure 1 & Feature 1	House floor & associated burn	180 ± 60 (55690) 430 ± 40 (112086) 270 ± 60 (112085)	N/A	3	3
Iny-30[c]	Structure 10	House floor	330 ± 60 (12668) 390 ± 90 (12667)	62	12	7
Iny-1447[a]	Feature 1	Hearth & house floor	390 ± 70 (66966)	27	9	4
Iny-30[c]	Structure 1	House floor	310 ± 70 (12662) 470 ± 70 (12661)	18	1	2
Iny-30[c]	Structure 5	House floor	410 ± 80 (20699)	7	1	2
Iny-1434, loc. 2[a]	Feature 2	Charcoal smear	450 ± 70 (67638)	16	0	3
Iny-1434, loc. 1[a]	Feature 1	Hearth	470 ± 80 (66959)	3	0	1
Iny-30[c]	Structure 8	House floor	470 ± 50 (20524)*	30	5	4
Iny-30[c]	Structure 7	House floor	480 ± 60 (12665)	14	1	1

Notes: MNV = minimum number of vessels; loc. = locus; *date from Structure 8 represents the deeper and older floor zone, which Basgall and McGuire (1988) feel is associated with the pottery studied. [a]Gilreath, 1995; [b]Eerkens, 1997; [c]Basgall and McGuire, 1988; [d]Delacorte, 1999.

In total for this study, 230 body sherds and 42 rim sherds were analyzed from the 13 assemblages. Unfortunately, due to an error on my part, only three unique rims (i.e., representing three different pots) and none of the body sherds from Iny-3769, locus 13 were analyzed. However, data from Delacorte (1999) on the pottery assemblage were used to fill in this omission, where possible. This gives an average of 18 body sherds and two rim sherds per assemblage though there is much variability. The 272 total sherds represent a minimum of 35 unique vessels.

METHODS

Only those sherds in association with the features or structures discussed above were included in the analysis. For example, for house floor assemblages, only those sherds lying directly on to 20 cm above the actual floor were included. Limiting the sherds to only those in clear association with the feature or structure, of course, greatly limits the number included in the study. In all cases, additional pot sherds were present at the site in adjacent excavation units or overlying the feature or structure in question, but were not included. This tends to limit the sample size and maximizes the influence each sherd has on the analysis (i.e., increases the chance of error due to sampling), but ensures greater confidence in chronological sensitivity.

For each assemblage, a minimum number of vessels (MNV) was determined, taking into account the range of variability typically seen within whole brownware ceramic pots. In particular, the attributes of estimated diameter, temper characteristics, the presence of decoration, and occasionally thickness, were used to determine if two sherds represented a single or two different pots. Given that brownware is quite variable even within a single pot, I tended to err on the side of caution, assuming that similar but slightly different sherds came from the same pot. Thus, the MNV should be considered a conservative estimate of the total number of vessels present within an assemblage.

I use the term "temper" to refer to any non-clay minerals or other components of the sherds. Temper does not denote the intentional addition of these items to the clay and can be either naturally occurring within the clay or artificially added. In most cases, temper is composed of granitic minerals such as quartz, feldspar, and iron oxides. However temper can also include organic items, such as grass blades, piñon nut hulls, or crushed bone, or other inorganic items, such as salt, crushed pottery sherds, or crushed rock.

Rim and body sherds were studied separately within each assemblage. For body sherds the following measurements were taken: average thickness (in mm); the color of the core representing either an oxidized (orange) or reduced (dark) firing atmosphere; the style of coiling (see below); the method of surface finish on the exterior and interior surfaces (smoothed, brushed, or roughened); the amount of mica, mainly biotite, present (none, low, medium, high); and the amount of organic temper present (none, low, medium, high). As well, the average size of mineral temper constituents (none, less than 0.25mm, between 0.25 and 0.5mm, more than 0.5mm) and the average density of mineral temper (none, less than 25 percent by volume, between 25 percent and 50 perent by volume, greater than 50 percent by volume) were visually estimated. For all temper constituents, scores were assigned based on the value above ranging from 0 for none to 3 for the highest or largest amount.

For rim sherds, in addition to the attributes above, the following attributes were measured: estimated mouth diameter (in mm); shape of the neck (incurved, direct, or recurved); shape of lip (flat, rounded, or pointed); lateralization of the lip (leaning towards the interior, exterior, or even); and the presence or absence of decoration. In several cases rim sherds conjoined and had been glued together. These conjoined segments were treated as a single sherd, rather than individually, in the analyses below. Figure 2 presents a schematic for most of these attributes on a hypothetical pot.

Figure 3 presents drawings of two very typical brownware rim sherds from CA-INY-30 (catalog numbers are given; the upper sherd is from the floor of structure 10 and the bottom is from general salvage work—note that the latter was not included in the analysis because it is not associated with any feature). Both have direct rims. The upper sherd has vertical brushing on the exterior and

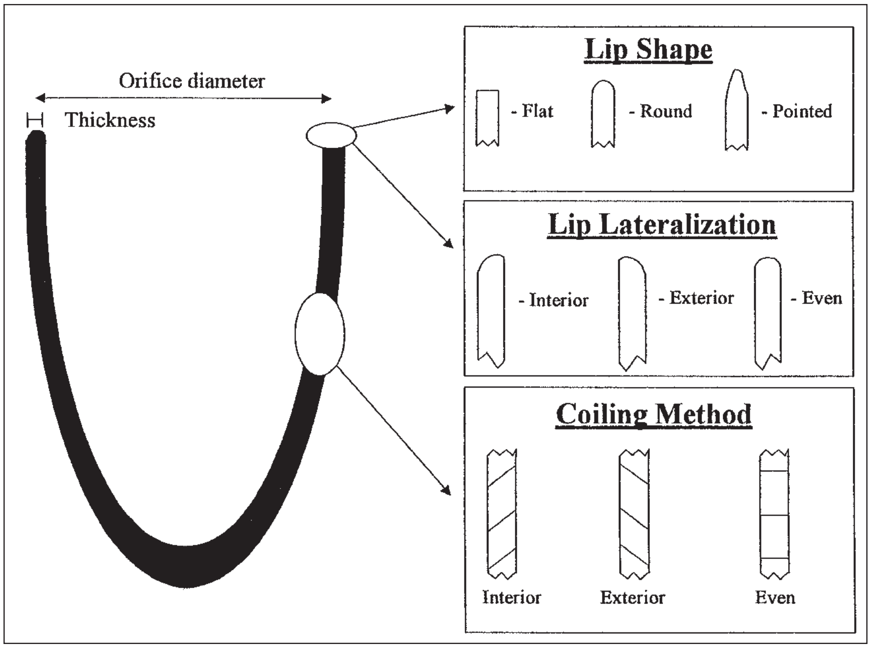

Figure 2. Attributes measured during analysis.

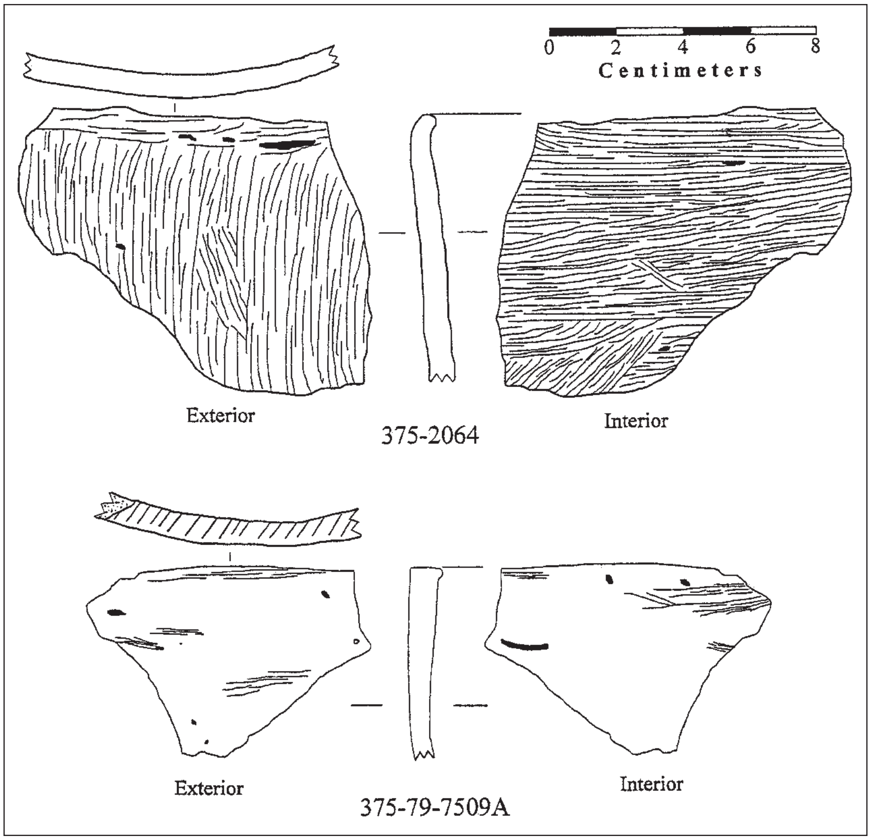

Figure 3. Schematic of two brownware sherds from southern Owens Valley.

horizontal brushing on the interior brushing while the lower sherd is decorated *on* the lip and has more faint horizontal brushing on both the interior and exterior surfaces. The thicker black circular and linear features represent voids left by organic fiber temper that was burned out during firing.

Most of the attributes listed above are standard in ceramic analyses (see Shepard, 1968) and do not need further explanation, with the exception of coiling style. Coiling style essentially records how coils were melded or attached to one another. It was observed during the analysis that some pots had coils that seemed to 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, others seemed to have coils that extended down over the exterior of the lower coil, and still others had coils that were evenly stacked on one another. This could be seen in the cross section of some sherds where the coils were still visible. Since it was not possible to orient body sherds to determine which direction was up (i.e., towards the rim), the interior and exterior categories were collapsed into an uneven category. That is, on body sherds it was only possible to determine if the coils were evenly or unevenly stacked on top of one another.

Finally, it is important to consider the effects of using radiocarbon dates to estimate changes that take place in a real-world calendar. Given the peaks and valleys in the calibration curve used to translate radiocarbon dates into calendrical ones, it is fair to ask how a radiocarbon chronology will convert to a calendrical one and whether a radiocarbon date of, say, 180 ± 60 BP represents a different time period than one of 240 ± 60 BP. As well, given that radiocarbon dates have associated errors that are often quite large in the context of the period under examination (i.e., ± 60 years over a total interval of 500 years) it is important to consider the temporal discreteness of any periods defined within such a chronology. I delay discussion of these issues until the "discussion" section of the article and carry on for the moment as if radiocarbon dates represent real-world calendrical dates.

RESULTS

The analysis below is divided into two parts. The first is based on a study of all rim and body sherds associated with each feature. This part of the study includes the largest number of sherds (271) but is based on a small number of attributes, since many could not be measured on body sherds. It is also clear in this part of the analysis that many pots are represented by multiple sherds. The second part is based only on the analysis of rim sherds representing unique pots, as determined by size, shape, color, decoration, and temper characteristics. Only one rim sherd from each unique vessel was included in the analysis. Although these rim sherds contain many more attributes to study change through time, there were only 26 that could be included in the study.

Analysis of All Sherds

Tables 2 and 3 list the average values for different assemblages for the attributes measured on all sherds. Note that for temper size, temper density, the amount of mica, and the amount of organic temper, a simple average of the scores (ranging between 0 and 3) was reported. Because they were measured on integral rather than continuous scales, these values cannot be compared to one another in a rigorous statistical manner. However, they do provide a single overall value describing the average state of this attribute within an assemblage. As well, less emphasis was given within the study to assemblages with small sample sizes, indicated by asterisks in the first columns of Tables 2 and 3.

Many of the attributes measured for body sherds do not show any clear patterns through time. For example, there is no apparent change in the percentage of sherds

Table 2. Average Values for Assemblages Related to Thickness, Cores, Coiling Style, and Temper

Context	Date	Thickness	%Oxid. core	%Even coil	Temper size	Temper density	Mica temper	Organic temper
Iny-1430, Feat. 7	10	4.7	0.00	0.00	1.00	1.00	0.00	0.00
Iny-5207, Burn 1*	70	5.3	0.00	N/A	1.00	2.00	1.00	0.00
Iny-30, Struct. 9	180	5.2	0.48	0.24	2.25	2.09	0.59	0.44
Iny-5207, Feat. 1	205	5.4	0.12	0.22	2.50	1.38	1.53	0.18
Iny-3769, Struct. 1	293	5.8	—	—	—	—	—	—
Iny-30, Struct. 10	360	5.7	0.11	0.42	1.77	1.62	1.57	0.67
Iny-1447, Feat. 1	390	6.0	0.44	N/A	1.14	1.42	1.31	1.67
Iny-30, Struct. 1	390	6.6	0.53	0.56	1.68	1.84	1.21	0.37
Iny-30, Struct. 5*	410	7.0	0.13	0.40	1.25	1.50	2.25	0.88
Iny-1434, Feat. 2	450	6.8	0.00	N/A	1.88	2.88	2.19	2.06
Iny-1434, Feat. 1*	470	6.3	1.00	N/A	2.00	2.00	2.00	2.00
Iny-30, Struct. 8	470	6.3	0.88	0.97	1.91	1.76	2.68	0.06
Iny-30, Struct. 7	480	4.9	0.60	0.44	2.00	1.93	0.80	0.13

Notes: %Oxid. core = percent of sherds with oxidized core; %Even coil = percent of sherds with evenly stacked coils; * = indicates assemblage with sample size less than 10 sherds; N/A = indicates no sherds in assemblage displayed evidence to measure this attribute; — = indicates body sherds from this assemblage not measured. Attributes for temper constituents indicate only average score.

Table 3. Assemblage Attributes for Exterior and Interior Surface Treatment

		Exterior surface			Interior surface		
Context	Date	Smooth	Brushed	Rough	Smooth	Brushed	Rough
Iny-1430, Feat. 7	10	0.00	1.00	0.00	0.00	1.00	0.00
Iny-5207, Burn 1*	70	0.00	1.00	0.00	0.00	1.00	0.00
Iny-30, Struct. 9	180	0.03	0.71	0.26	0.06	0.68	0.26
Iny-5207, Feat. 1	205	0.12	0.71	0.18	0.06	0.88	0.06
Iny-3769, Struct. 1	293	—	—	—	—	—	—
Iny-30, Struct. 10	360	0.38	0.46	0.15	0.34	0.53	0.13
Iny-1447, Feat. 1	390	0.31	0.36	0.33	0.08	0.78	0.14
Iny-30, Struct. 1	390	0.32	0.37	0.32	0.24	0.65	0.12
Iny-30, Struct. 5*	410	0.71	0.14	0.14	0.86	0.14	0.00
Iny-1434, Feat. 2	450	0.88	0.00	0.13	0.63	0.13	0.25
Iny-1434, Feat. 1*	470	0.00	0.00	1.00	0.00	0.00	1.00
Iny-30, Struct. 8	470	0.74	0.18	0.09	0.00	1.00	0.00
Iny-30, Struct. 7	480	0.07	0.47	0.47	0.00	1.00	0.00

Notes: * = indicates assemblage with sample size less than 10 sherds; — = indicates body sherds from this assemblage not measured.

with oxidized cores. This suggests that firing practices did not change significantly during the 400 years of pottery production, at least not in a way that affected the availability of oxygen within the firing environment. Similarly, there are no appreciable differences in the size and density of mineral temper. This indicates that mineral temper recipes, whether naturally within the clay or intentionally added, did not change noticeably through time in either size or density. The amount of organic temper is also not clearly patterned through time, though earlier assemblages tend to have slightly higher levels of voids where plant particles present within the clay were burned out during firing.

Other attributes, however, show a greater degree of patterning through time. Perhaps the clearest example of this is the thickness of sherds. With the exception of Structure 7, at CA-INY-30, there seems to be a clear trend towards decreasing thickness in sherds through time. Even if we include Structure 7 at 480 BP, a regression on the 13 assemblages between thickness and date gives a Pearson's R value of 0.65, suggesting some degree of correlation between the two variables. Table 2 also provides the first hint that the sherds from Structure 7 are somehow out of place temporally given the earlier radiocarbon date of 480 ± 60. If, instead, we take the "modern" date (along with the historic beads) as a more reliable date for the pottery, and assign a value of 0 BP to this assemblage, a much stronger correlation between thickness and age obtains, yielding a Pearson's *R* of 0.89. It appears that sherds decrease by about 1 mm in thickness around 400 BP.

The amount of mica present within sherds also seems to change through time, with earlier assemblages containing higher amounts. Recent electron microprobe and thin section work shows that the mica is primarily biotite, though some mica has been altered into chlorite. Again, there seems to be a marked change around 400 BP. As well, Structure 7 from CA-INY-30 displays patterns consistent with a later rather than earlier assemblage. This suggests, again, that the 480 ± 60 radiocarbon assay does not date the pottery from this structure.

The meaning of the reduction in mica is not entirely clear. Mica does not seem to have any clear and direct implications for the function of a pot. Instead, it may represent a change in the source of clays used by prehistoric potters from one containing ample mica to one containing little. Sedimentary clays in the region, such as at Owens Lake, are often quite high in mica, while residual clays of decomposing granite near the valley bottom are often lacking in this mineral. In this respect, the change in mica levels may indicate a move towards the use of residual over more sedimentary clays for pots.

The percentage of sherds within a collection with evenly stacked coils also seems to decrease through time. Although the decrease is less clear since several collections did not have enough sherds with this attribute visible, thereby reducing the sample size, there seems to be a decrease from early assemblages where 40 percent or greater of the sherds have evenly stacked coils to later assemblages where less than 25 percent are coiled in this fashion. This suggests that an uneven style of coiling developed and became more popular through time. Note, however, that in this fashion structure 7 from CA-INY-30, with 50 percent of the sherds having evenly stacked coils, looks more like an earlier assemblage than a later one (unlike for thickness and mica content).

Table 3 gives summary information for exterior and interior surface finish for the 13 assemblages. Clear from the table is that the percentage of sherds with smoothed exterior surfaces decreases through time, from a range of 71 to 88 percent in assemblages older than 400 radiocarbon years BP, to less than 20 percent for the youngest assemblages. One clear outlier in this respect is feature 1 from CA-INY-1434. However, this structure only had three associated sherds, and this anomaly could easily be due to errors associated with sampling a small number of sherds. As did average thickness and levels of mica, exterior surface preparation suggests that the sherds from structure 7 at CA-INY-30 are much younger than the age suggested by the 480 BP radiocarbon date since very few are smooth on their exterior surface. Thus, exterior surfaces within the total sherd assemblage suggests a change occurred in how potters were finishing their pots. Whether this is due to stylistic or functional changes is not immediately clear, but is considered in greater detail below.

There is less patterning evident among those sherds that are brushed versus those that are roughened on their exterior surfaces. Roughened surfaces appear to be slightly more common during the middle part of the ceramic period (relative to brushed sherds), but several early and later assemblages also have significant numbers of rough exterior surfaces.

Similarly, patterning among interior surfaces is not clear-cut. Smoothing seems to be slightly more common in the earlier assemblages, and roughening in the middle part of the ceramic period. However, the pattern is weak as several assemblages do not conform.

In sum, the analysis suggests division of the assemblages into three temporal groups. The earliest assemblages (ceramic 1), those dating older than 400 BP, are composed of rather thick sherds with much mica, are more often coiled with evenly stacked coils, and are often smoothed on their exterior surfaces. Organic temper is also somewhat higher in these assemblages. The second set of assemblages (ceramic 2) date between 290 and 400 BP. Pots from this period are still rather thick, though somewhat thinner than the previous period, contain less mica, coils are still often evenly stacked, and only about 1/3 of the pots are smoothed on their exterior surfaces. Structure 1 at CA-INY-3769, locus 13 seems to be part of this group, but additional analysis of the body sherds will be necessary to determine this. The final group of assemblages (ceramic 3) dates to the latest prehistoric and protohistoric period, certainly after 210 BP, but perhaps slightly earlier. Pots from this period are clearly the thinnest, have little mica present, are rarely made with evenly stacked coils, and are rarely smooth on their exterior or interior surfaces. Structure 7 from CA-INY-30 clearly belongs within this final group of assemblages, indicating that the modern rather than the 480 BP radiocarbon assay more accurately dates the pottery from this domestic context. The presence of glass trade and other protohistoric shell beads supports this position. Exactly when the shift occurs between the middle and late ceramic periods is unclear, and could have happened anytime between 210 and 290 BP. Note that I use the temporary terms ceramic 1, 2, and 3 to avoid confusion with other tripartite divisions of prehistory, such as early, middle, and late.

Analysis of Rim Sherds

This section considers changes in pottery attributes that are not visible or measurable on body sherds. In particular, analysis of rim sherds allows determination of attributes relating to pot size, the presence of decoration, and the shape of the lip. Unfortunately the sample size of rim sherds is extremely small, and only 26 rim sherds that represent unique pots are included in the analysis below. Because of this small sample size, rim sherds were combined into three temporal groups according to the outline defined in the previous section, namely, early (dating older than 400 BP), middle (dating between 290 and 400 BP), and late (dating after 210 BP).

First, it is worth reexamining average thickness. Analysis of whole pots shows that thickness usually varies across a vessel, often from a minimum near the rim to a maximum at the base (Eerkens, 2001). By only considering body sherds, as above, we are taking samples from all across a pot, without controlling for location. However, using only rim sherds we can achieve some degree of standardization by controlling the location where we sample thickness. As indicated in Table 4, decreasing thickness through time holds within the rim sherd assemblage as well. Although a *T*-test comparing means is not significant between any of the three temporal groups at the .05 level, this result is very consistent with the analysis of body sherds. Also listed in Table 4 is the Coefficient of Variation (standard deviation divided by mean; CV). The thickness CV values indicate that early and late assemblages are quite variable, while middle assemblages are more standardized. However, a comparison of these CV values using the D'AD statistic (see Eerkens and Bettinger, 2001; Feltz and Miller, 1996) is not significant at the .05 level for thickness.

Comparison of the average diameters of rim sherds from the three ceramic periods indicates little difference through time. The youngest (ceramic 3) pots seem to be slightly larger at their mouths (and presumably overall) than later pots, however, a *T*-test shows the difference is not significant at the .05 level. Variation within the youngest pots also seems to be greater than earlier assemblages. Statistical comparison of the late and middle period CV's is again not significant at the .05 level (though close with a *p* value of .08).

In fact, greater diversity seems to be one of the characteristics among ceramic 3 rim sherds. For example, greater diversity in rim form is indicated in Table 4 by the percentage of direct rims. Incurved rims were the only other form encountered (i.e., no recurved rims were within the rim sherd assemblage). While 25 percent of the ceramic 3 rims were incurved, only 8 percent of ceramic 2, and none of ceramic 1 rims were similarly shaped. As well, there is greater

Table 4. Attributes of Rim Sherds, Divided into Early, Middle, and Late Marana Period

Ceramic period	No.	Thickness Avg.	Thickness CV	Diameter Avg	Diameter CV	Direct rims	Lip shape Flat	Lip shape Round	Lip shape Point	Lip later.	Decorated
3	8	4.9	0.29	266	0.37	75%	38%	38%	25%	0%	0%
2	14	5.8	0.23	248	0.26	92%	15%	85%	0%	29%	14%
1	4	6.6	0.31	244	0.21	100%	0%	75%	25%	50%	25%

Notes: No. = Total number of rim sherds per period; Avg. = Average; CV = Coefficient of Variation; Lip later. = percentage of sherds with a lateralized lip (to either interior or exterior).

diversity in lip forms, where ceramic 3 lips seem to be evenly divided among flat, rounded, and pointed forms, while ceramic 2 and ceramic 3 rims are predominantly rounded.

On the other hand, there is less diversity among ceramic 3 assemblages in terms of lip lateralization and decoration. None of these rims are lateralized (i.e., all are symmetrical with respect to the walls of the pot). Ceramic 1 and 2 pots are more often lateralized to the exterior (with only one ceramic 2 lip showing exterior lateralization). Similarly, although only three of the rims are decorated, all are found in either ceramic 2 or 1 period assemblages. Unfortunately, a chi-square test comparing time period and decoration is far from significant at the .05 level (*p* value = .56) due to the small sample size. Thus, it is not possible to state with confidence that the rate of decoration decreases through time.

A comparison of exterior and interior surface treatment by ceramic period is presented in Table 5 for the rim sherd assemblage. Because rim sherds could be oriented with respect to the vertical and horizontal dimensions (unlike body sherds), it was possible to identify the specific direction and orientation of brushing strokes. Four different brushing styles were recognized including vertical, horizontal, diagonal, and random (or mixed) brush marks. It is clear overall, that external styles of finishing are more diverse than interior ones. While six different patterns were recognized for the former, only three were seen on internal surfaces. However, no clear temporal patterns are evident for either external or internal surfaces as brushing and finishing styles are similarly diverse in all three ceramic periods.

In sum, the rim sherd analysis does not show any additional directional changes through time. Pots are clearly thinner and slightly larger later in time, but these differences are not significant given the small sample size currently available. More clear are changes in the diversity of rim and lip styles and size. Ceramic 3 vessels seem to be more varied and diverse than those from earlier periods.

Table 5. Surface Treatment Attributes for Rim Sherds Divided into Early, Middle, and Late Marana

Ceramic period	External surface						Internal surface		
	Rough	Vertical	Horiz.	Diag.	Random	Smooth	Rough	Vertical	Horiz.
3	0%	38%	38%	13%	0%	13%	0%	13%	88%
2	23%	23%	15%	23%	15%	0%	7%	0%	93%
1	25%	25%	25%	0%	0%	25%	0%	25%	75%

Note: Horiz. = horizontal brush strokes; diag. = diagonal brush strokes.

DISCUSSION

The results above suggest that the single-type hypothesis for Owens Valley brownware is incorrect. There appear to be noticeable and measurable differences in pottery assemblages through time in southern Owens Valley. This section reviews the provisional ceramic chronology based on the evidence presented above, examines the viability and discreteness of the apparent chronology using the most recent radiocarbon calibration curve, and finally considers the behavioral implications of the chronology.

Summarizing the Chronology

Based on the results of the analysis, there appear to be at least three separate and distinct periods of pottery production in Southern Owens Valley. Manufacturing techniques and styles are surely changing throughout the entire period of ceramic production, including random drift and intentional modifications to improve functionality or appearance. However, based on current evidence from radiocarbon dated sites, sherd assemblages within these three temporal periods seem to be more like one another than sherds in subsequent or ensuing periods.

The evidence suggests an early (perhaps initial) period composed of rather thick pots, often over 6.5 mm, containing high levels of mica. These pots are often intentionally smoothed on their exterior surfaces, often have their coils neatly stacked on top of one another, and not infrequently include organic temper. Overall, vessels seem to be fairly standardized in terms of size and shape. This suggests the production of only a limited range of vessel forms and by deduction, a more narrow range of uses for pots. Direct rims with rounded lips seem to be the predominant shape, though the sample size of unique rim sherds is very small ($n = 4$). I refer to this period with the temporary term “ceramic 1.”

The ensuing period saw a reduction in thickness of pots by about 0.5 mm, a reduction in levels of mica, and a reduction in rates of exterior smoothing. The method of stacking coils appears to be the same as in the previous period, with coils stacked neatly on top of one another. As well, vessel size and shape are rather standardized suggesting a narrow range of use for vessels within this period. This has been termed “ceramic 2.”

The final period of manufacture again saw a reduction in the thickness of pots by another 0.5–1.0 mm. Pots in this period have only small amounts of mica and are only rarely smooth on their exterior surfaces. Brushing seems to have been the preferred method of exterior surface finish. A slight increase in vessel size is implied by larger mouth opening diameters within this period. As well, a change in manufacturing style is suggested by the frequent presence of sherds with unevenly stacked coils. Based on evidence among rim sherds, many of these pots were constructed by overlapping coils on the exterior side of the pot. That is, clay from the higher coil was pushed down on the exterior side of the pot to conjoin with the lower coil and clay from the lower coil was brought up on the interior surface to meet the higher coil. At the same time, judging by CV values and rim and lip forms, pots in this period seem to be more diverse in size and shape, implying a greater range of uses for pots. This period is temporarily designated "ceramic 3."

Calibrating the Chronology

The chronology developed above is based entirely on radiocarbon dates. However, it is important to examine how these radiocarbon dates translate into real-world calendrical ones. Figure 4 plots the radiocarbon calibration curve from the OX-Cal computer program version 3.5, showing how radiocarbon dates translate into calendrical ones (based on tree-rings) for the period between cal AD 1200 and 1950 (see Ramsey, 1995). The figure also shows how the three ceramic periods defined above calibrate. Unfortunately there are a number of bumps in the curve, particularly after cal AD 1700, meaning that there is not a one-to-one correlation between radiocarbon and calendrical dates. This creates problems because it is statistically possible for a radiocarbon date to fall within the calendrical range for two, or even all three, ceramic periods if the associated ± error is large enough. This section considers the statistical viability of the chronology given the calibration issue. Where multiple radiocarbon dates exist for a feature (except structure 7 at CA-INY-30 where the modern assay was used), they were averaged according to the procedure given by Long and Rippeteau (1974).

Ceramic 1 assemblages date between 410 and 500 radiocarbon years BP, which calibrates into a fairly narrow region on the curve, roughly between cal AD 1425 and 1475. Taking into account the two-sigma error range of the oldest (feature 1 at CA-INY-1434 at 470 ± 80) and youngest (structure 5 at CA-INY-30 at 410 ± 80) dates within this group of assemblages, the calibrated range spans cal AD 1300 to cal AD 1650.

Ceramic 2 assemblages date between 293 and 390 BP, which calibrates into a range of roughly cal AD 1475 to 1640. Taking into account the two-sigma error range of the oldest assemblage (structure 1 at CA-INY-30 with the two dates averaging to 390 ± 50) and youngest assemblage (structure 1 at CA-INY-3769 with the three dates averaging to 293 ± 30), this covers a period of cal AD 1430 to cal AD 1660. This clearly overlaps with almost the entire range of the ceramic 1 assemblages.

Ceramic 3 assemblages date between 0 BP and 205 BP. We know that earthenware pots were abandoned shortly after contact with European settlers around AD 1850. The youngest assemblage from this period is from structure 1 at CA-INY-5207, where the two radiocarbon dates average to 205 ± 50 BP. The two-sigma range of these dates is from cal AD 1520 to AD 1850. However, only 1.9 percent of this covers the period between cal AD 1520 and cal AD 1550, due to a small dip in the curve between these dates. If we reject the small chance that this part of the curve dates the assemblage, a range of cal AD 1630 to AD 1850

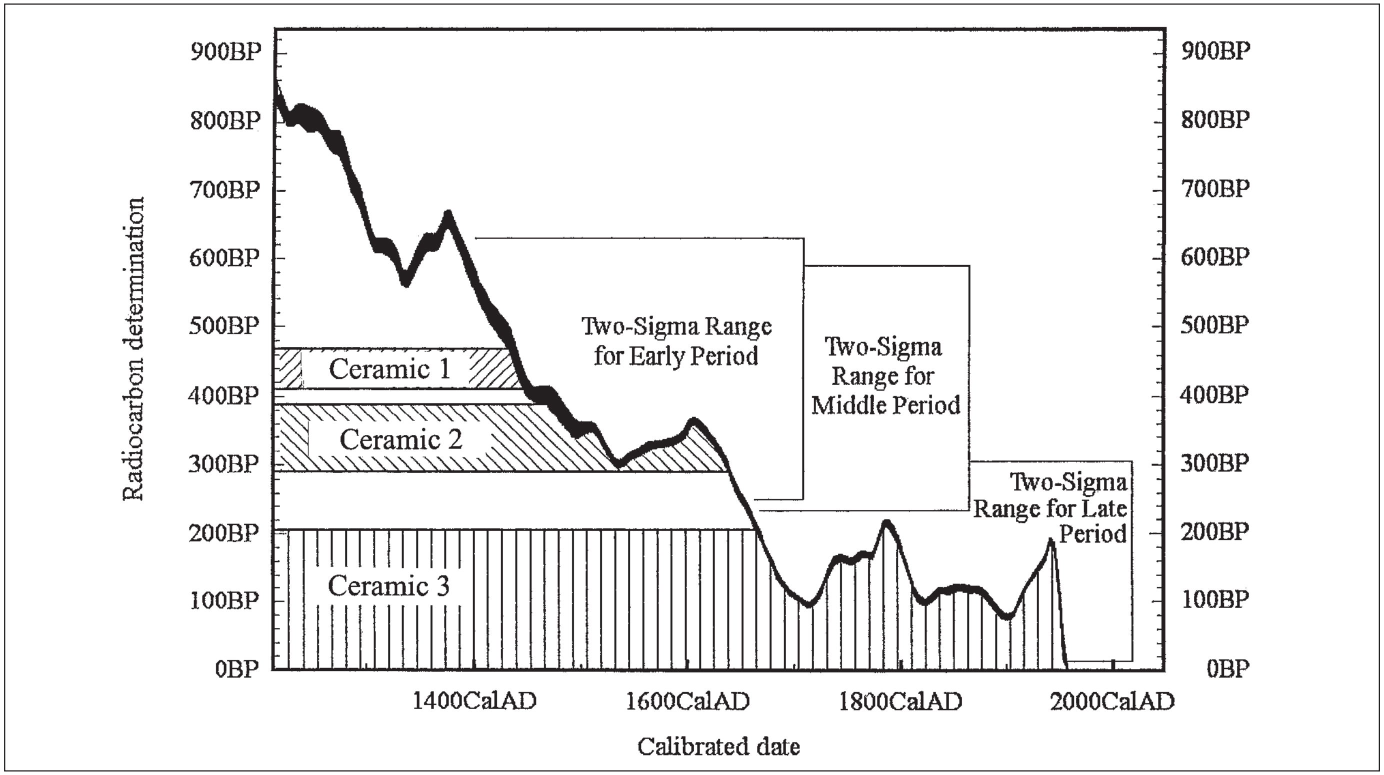

Figure 4. Radiocarbon curve for last 800 years showing calibration of early, middle, and late ceramic assemblages from southern Owens Valley.

obtains for the latest ceramic assemblages. The latter range is almost discrete from either ceramic 1 or 2 assemblages and overlaps only for a very small region between cal AD 1630 and cal AD 1660.

Based on this information, it is difficult to statistically support the division between the earliest and middle ceramic periods. Although there may be real differences among the ceramics produced between approximately cal AD 1425-1475 and cal AD 1475-1640 (corresponding to the calibrated ceramic 1 and 2 periods respectively), it is hard to argue for this convincingly based on the radiocarbon evidence alone. Given the associated errors with the dates and the bumps and dips in the calibration curve, it is possible that all these assemblages date to the same calendrical period. Unfortunately, it will not be possible to prove or disprove the viability of this part of the chronology through additional excavation of features with ceramics that are radiocarbon dated. Such dates are likely to fall within the range of both ceramic 1 and 2 periods. Ceramic assemblages that are dated by alternative means, such as dendrochronology or sites with multiple and separate pottery-bearing strata, will be necessary to prove the distinctiveness of ceramics across the AD 1400 to 1600 boundary. For the moment the chronological discreteness of the earliest and middle period must remain an hypothesis.

There does appear to be a clear and statistically recognizable temporal difference between ceramics from the early/middle and the late Marana period. The dates associated with ceramics from assemblages dating to these periods respectively only overlap for a very small range of time. Thus, it should be possible to test this part of the chronology through the analysis and radiocarbon dating of additional pottery-bearing features in southern Owens Valley.

Implications of the Chronology for Prehistoric Behavior

Changes in the shape, size, and composition of pots also imply changes for the role of pots within prehistoric lifeways in southern Owens Valley. I explore these changes here.

First, there is a clear trend towards decreasing thickness from early/middle Marana ceramics to late ones. If this reduction is a result of a change in the function of pots, two explanations seem likely. Thinner pots could represent a desire to lighten the weight of pots by decreasing mass. However, if a reduction in heaviness were the goal we might expect to see more use of organic temper through time as well, since organically tempered pots can be up to 40 percent lighter in weight (Skibo et al., 1989).

A more likely explanation that is consistent with the other changes seen (and discussed below) is a desire to increase the heating efficiency of pots. Thinner pots transfer heat from an external source to the contents of the pot quicker, reducing the amount of fuel required to cook foods (Braun, 1983). Of course, thinner pots also have decreased tensile strength and resistance to impact stress. It is possible that the decrease in mica observed through time represents an effort to increase strength by changing the source of clay from a sedimentary one, such as Owens Lake or Owens River that has high mica content, to one closer to a parent source or perhaps a residual in-situ source of decomposing bedrock. Experimental work with local clays suggests that when fired to 700ºC most residual sources of clay are stronger than sedimentary sources, though some sedimentary sources are also quite strong (Eerkens, 2001:129). Thus, a reduction in mica may represent the use of alternative sources of clay, the byproduct of a desire to increase strength. Research with thin sections is currently under way to examine the mineralogy of southern Owens Valley pottery. Comparison of the angularity and composition of mineral temper should help to determine the source of clays and tempers used to construct pots in the different time periods.

A desire to increase heating efficiency would also explain why we see a decrease in the rate of surface smoothing between early-middle and late Marana period assemblages. Increasing the surface area that is exposed to an external heat source will increase absorption of heat (Juhl, 1995; Lischka, 1978:227). Smooth pots have the lowest surface area possible. However, creating grooves by brushing or intentionally roughening the exterior of a pot is one way to increase the surface area, and hence, the heating efficiency of a pot. An increase in the percentage of brushed or roughened pots, then, is consistent with an increase in heating efficiency (as is thinner pots). It is possible that a change in the style of coiling was also a response to a need for increasing the strength of thinner pots. How coils are attached and melded would certainly affect how resistant a pot is to impact stress, and it is possible that stacking coils in an uneven fashion would increase the resistance to certain types and directions of forces. However, experimental work testing the strength of different coiling styles in fired pots will be necessary to test this hypothesis. Currently, the reasons why coiling style seems to have changed is unclear.

It is fairly clear that a change in the size or density of temper was not a solution used to increase heating efficiency and/or increase the strength of pots in this region. Despite the fact that these attributes do affect the heating properties and tensile strength of a pot (see Bronitsky and Hamer, 1986; Skibo et al., 1989), the size and density of mineral temper within southern Owens Valley pots does not seem to change appreciably through time. Similarly, it does not appear that Paiute changed their firing techniques, or if so, these changes are not visible in the cores of sherds. For example they did not increase the amount of oxygen present during firing to achieve higher temperatures, which would increase the strength of the pot, since there are no apparent changes in the state of sherd cores, whether oxidized or reduced, through time.

Exactly why there was a desire to increase heating efficiency is unclear. However, a likely influence would have been a reduction in the availability of nearby firewood due to increasing sedentism. The archaeological record of the region suggests that populations in Owens Valley were continually reducing their mobility through time (Basgall, 1989; Bettinger, 1989, 1999). An increase in sedentism would likely have resulted in decreased availability of sources of fuel as they were used in the vicinity of more permanent settlements. A response to this may have been to increase the heating efficiency of ceramic pots such that they consumed less fuel to cook the same amount of food. Thinning and roughening pots would have been one option, though these responses would have decreased the strength of pots to impact stress. Changes in other attributes such as clay source and construction technique, then, may represent an attempt to compensate for decreased strength.

As pots became thinner through time, they also seem to be increasing in size. This suggests that late prehistoric and protohistoric Paiute were increasing the amount of food cooked per meal, perhaps in response to increasing family size or a desire to increase the economy of scale of food production. Increasing the size of pots while decreasing the thickness would have heightened the need to increase resistance to impact stress. This factor may have precipitated some of the changes discussed above such as a change in the source of clays and coiling style.

An increase in the diversity and variability of pots over time is also interesting. This could mean that the range of uses for pots was increasing, requiring more diversity in the shapes and sizes of pots. Alternatively, a greater number of potters could be responsible for the ceramic 3 assemblages, with each potter contributing some of her (assuming women were responsible) unique skills, learning environment, and personality to the suite of pots made. Either of these possibilities, or both, could explain this situation. It is hoped that future work with organic residues, use wear, and mineralogy will address this question.

CONCLUSIONS

Several points are worth mentioning in conclusion. First, given the small sample of sherds available for study in southern Owens Valley, the results presented here should be considered tentative. Additional well-dated assemblages are needed to verify and support or refute the chronology developed. Unfortunately, because the number of sherds recovered in most sites in association with stratigraphically discrete features is small it is unlikely the sample available for study will increase significantly in the near future. However, it is hoped that others will attempt to test the chronology presented here through the analysis of pottery-bearing features that are dated.

Second, it is clearly not possible to pick up a single sherd and assign it a chronological date based on the data presented above. Examination of the data shows that some sherds associated with early features are thin, have little mica, are brushed on their exterior, or have unevenly stacked coils. Similarly, some late sherds are thick, have ample mica, are smooth, or have evenly stacked coils. Although it is possible these sherds are intrusive from later or earlier time periods, the variability within Owens Valley brownware, even within a single pot, implies that some individual sherds will not conform to the chronology. This may be particularly relevant for ceramic 3 assemblages which seem to be quite diverse in terms of the shapes and sizes of pots present. A small subsample of sherds from this time period may appear more like earlier periods due to random chance (i.e., sampling error). Instead, whole assemblages of sherds should be analyzed together where possible and, if the chronology is valid, the average values should conform to the guidelines presented for different ceramic periods.

Third, the usefulness of any typology relates to the ability of others to repeat it. Some of the attributes I use, such as thickness and diameter, are relatively easy to quantify and measure (though even here there is room for variation depending on where thickness is taken on a particular sherd or who is measuring curvature, in the case of diameter). However, others are less quantifiable and more subjective. For example, the amount of mica or organic temper present within a sherd, which I recorded on a scale from 0 to 3, is impossible to quantify in the abstract without a reference collection. As well, it may be difficult to quantify what constitutes a rough versus a smooth surface, after all what appears smooth to the naked eye is often quite rough under a high-powered microscope. That is, smooth and rough are relative notions and can be interpreted differently by different archaeologists.

Work that is currently under way with thin sections from the region should help to resolve some of these shortcomings and refine the chronology presented here. In particular, this work should help to quantify some of these attributes, particularly the amount of mica present, and the size and density of mineral temper. As well, this work will help to identify and quantify the percentage of particular mineral types, such as quartz, feldspar, magnetite, and so on.

Moreover, it is unclear how applicable this chronology is to other areas of the western Great Basin. Thus, it is possible that pottery in northern Owens Valley does not follow the same developmental trajectory. Verifying the validity of the chronology presented above in other regions will simply require empirical data from well-dated contexts.

Fourth, and most importantly, pottery from the region does not fit the single-type hypothesis for Owens Valley brownware. Earlier research (Eerkens, 2001; Eerkens et al., 2002a, 2002b) questioned the validity of this hypothesis with regards to space. Pots appear to be made and used differently in different regions. The analysis presented above questions this hypothesis with regards to time. Pots appear to have been made differently through time in this one region, and should not be lumped into a single all-inclusive category. Doing so glosses over important variability related to changes in how pots were used through time.

Finally, what of the pottery from structure 13 at CA-INY-30, the assemblage that was supposed to contain the oldest dated sherds from southern Owens Valley? With an average thickness of 5.7 mm on 50 sherds (including six rims and an MNV of 4), an average mica score of 2.1, 38 percent having smoothed exteriors, and 67 percent having evenly stacked coils, the assemblage fits squarely within the range of other ceramic 1 and 2 ceramics and is distinctly different than ceramic 3 assemblages. In fact, the assemblage fits very well within other ceramic 2 assemblages, a finding supported by the 310 BP ± 50 thermoluminescence date on one of these sherds reported by Rhode (1994). This supports the position suggested above that the 710 BP radiocarbon date does not date the pottery assemblage.

ACKNOWLEDGMENTS

I would like to thank Lisa Deitz and Robert Bettinger for granting access to collections housed at UC Davis and Matt Hall for granting access to collections at UC Riverside. Finally, thanks to Jeffrey Rosenthal and Jay King for reading and commenting on an earlier draft, and Roger Moeller for expediting the publication process.

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