Journal of California and Great Basin Anthropology | Vol. 32, No. 1 (2012) | pp. 65–75

GC-MS and Attribute Analysis of Intermountain Brownware from the Southern Great Basin of North America

BRITT J. BETENSON
Kaibab National Forest, Fredonia, Arizona

KAREN G. HARRY
Department of Anthropology, University of Nevada, Las Vegas

SPENCER M. STEINBERG
Department of Chemistry, University of Nevada, Las Vegas

Intermountain Brownware pottery refers to a utilitarian ware made by late prehistoric to early historic period hunter-gatherers of southern Nevada, western Utah, and northern Arizona. The pottery, which is confined to jar forms, is typically described as thick and poorly made, but a systematic characterization of Intermountain Brownware sherds has been lacking. This paper seeks to remedy that situation. Residue and attribute analyses were undertaken on a sample of sherds to investigate the production technology, performance characteristics, and function of the vessels. We conclude that the vessels were used for boiling seeds, and that while their performance attributes may not have been ideal for this purpose, they were a necessary outcome of the production constraints imposed by the mobile lifestyle of their makers.

Across the world and throughout time, the use of ceramics has been strongly correlated with sedentary and agriculturally-based societies (Arnold 1985:109, 120). Despite this strong correlation, archaeological and ethnographic data indicate that the producers of Intermountain Brownware pottery were neither sedentary nor full-time agriculturalists (Firor 1994:6, 60; Walling et al. 1986:25; Westfall et al. 1987:9). These wares instead appear to have been produced and utilized by non-agricultural, seasonally-mobile populations adapted to the diverse landscape and sparse resources of the Great Basin and Colorado Plateau.

Intermountain Brownware pottery is typically described as a crudely made ceramic characterized by thick walls and coarse temper (Baldwin 1942; Pippin 1986:9; Tuohy 1986:3). It occurs most frequently in the form of conical jars, though globular pots with rounded bases are also known (Janetski 1990:57). Despite these generalizations, a systematic characterization of these ceramics has been lacking. This paper seeks to correct this oversight. Specifically, we present the results of both attribute and residue analyses of Intermountain Brownware sherds in order to define their physical characteristics and to evaluate what those characteristics tell us about the manufacturing technology, performance characteristics, and function of these wares. We conclude with a discussion of why the producers of Intermountain Brownware ceramics might have elected to manufacture them in the manner that they did.

BACKGROUND

Intermountain Brownware ceramics are found in southern Utah, northern Arizona, and southern Nevada in archaeological contexts dating from the late prehistoric (i.e., mid- to late-1200s) to the early historic (late 1800s) period. The region where they are found is essentially equivalent to the aboriginal territory of the Southern Paiute (Fig. 1), and indeed another term for these ceramics is Southern Paiute Utility Ware. However, because we cannot be certain that all producers of Intermountain Brownware were Paiute, we

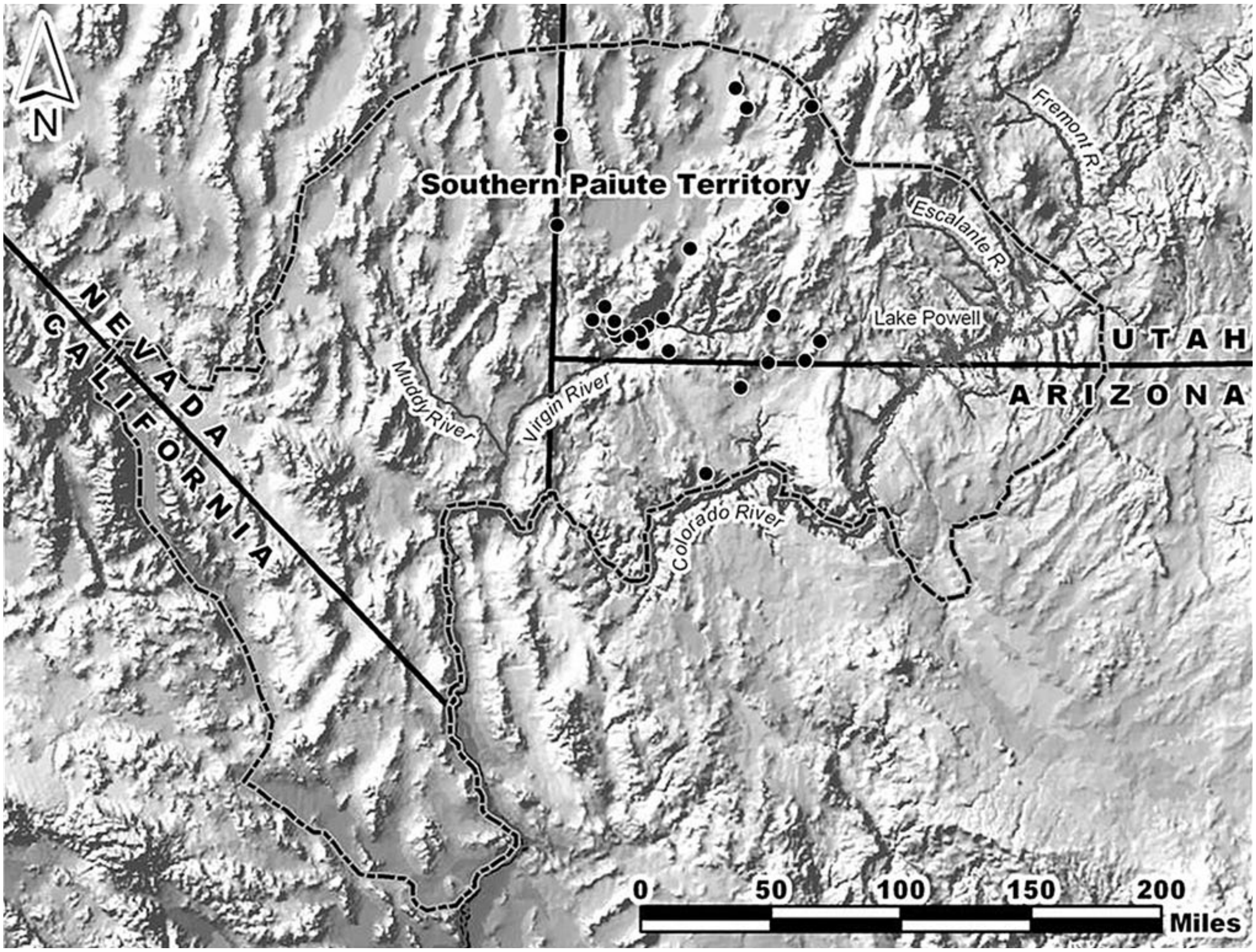

Figure 1. Map of Southern Paiute ancestral territory (after Kelly 1976).

have elected to use the term Intermountain Brownware in this paper.

Intermountain Brownware is one of three basic brownwares produced by Great Basin tribes; the other two are Shoshoni Brownware and Owens Valley Brownware (Tuohy 1990). All three wares were produced by groups of people with settlement patterns that ranged from highly residentially-mobile hunting and gathering to nearly sedentary horticulture. In addition to the brown wares mentioned above, some gray ware ceramics, associated with the Fremont Culture, were produced in the northeastern portion of the Great Basin.

ENVIRONMENTAL CONTEXT

The area where Intermountain Brownware is found contains diverse landscapes. Encompassing portions of both the Great Basin and the Colorado Plateau, the region has not only desert landscapes but also high mountains and wide valleys, broad plateaus, and river-cut canyons. Within this large area are a variety of ecozones containing a diversity of plant and animal species that could have been exploited for food by the indigenous people. In the lowland areas, grass seeds could have been collected in the summer, and in the fall and winter pine nuts and large game could have been procured in upland areas. Other resources, such as agave and rabbits, would have been available year-round.

DESCRIPTIONS OF INTERMOUNTAIN BROWNWARE

Our knowledge of Intermountain Brownware ceramics comes from two sources: historic documents and the

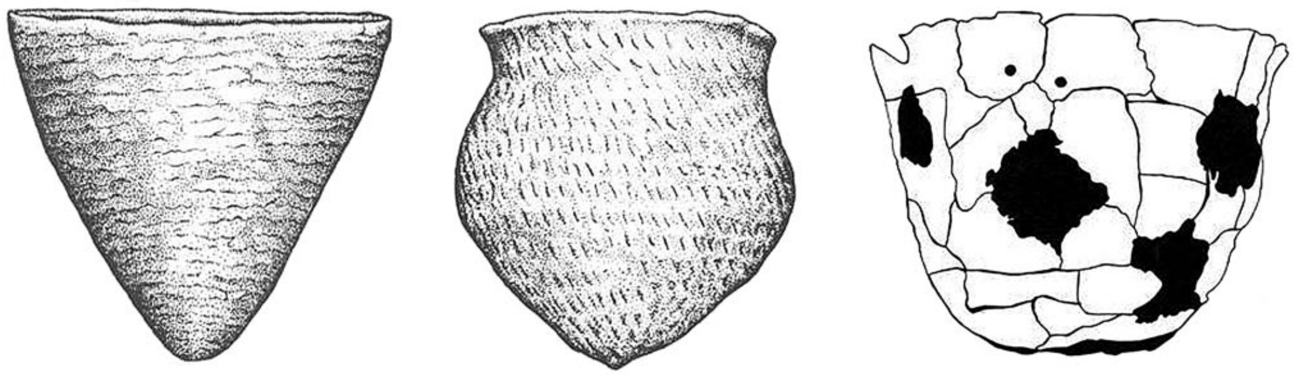

Figure 2. Intermountain Brownware vessel forms.

archaeological record. During the early historic period, the Southern Paiute produced pottery identical to that identified at archaeological sites as Intermountain Brownware. Ethnographic accounts (Kelly 1976:77; Kelly and Fowler 1986:375–377; Lowie 1924:225; Sapir 1992:801) describe this Southern Paiute pottery as a brown, thick-walled, and sand-tempered ceramic, with the most commonly mentioned form being the conical vessel. According to Lowie's (1924:22) consultants, this shape enabled the users to place the vessels directly in the ground and build fires up around them. A few consultants referred to the use of flat-bottomed vessels as well (Kelly 1964:77; see Figure 2 for an illustration of ethnographic brownwares from the Great Basin). In all of the historic accounts the pottery is described as being used for cooking purposes. Observers reported seeing the pots sitting directly in the fire (Fremont 1845:263; Hafen and Hafen 1954:188; Brooks 1972:44, 54) and being used for the "boiling and stewing of horse beef" (Fremont 1845:263) or "pottage" (presumably referring to a mush or a gruel; Brooks 1972:44). Kaibab Paiute consultants interviewed by Isabel Kelly in 1932 recalled that the ceramic vessels were used to cook a mush containing such ingredients as sunflower seeds, pine nuts, and pumpkins (Kelly 1976:42). It is likely that pottery production had waned significantly by the early 1900s due to the migration of American settlers to the western U.S. and the introduction of the technologies they brought with them. Pots and other tools were quickly replaced by metal implements such as Dutch ovens (Fowler and Fowler 1971:105).

Intermountain Brownware ceramics were first recognized as a distinct type by Baldwin (1942), who labeled them Southern Paiute Utility Ware. Baldwin described the ceramics as having a very coarse texture and a crumbly fracture, and occurring as deep bowls, tall narrow jars, and large jars with very wide mouths (Fig. 2). Both the bowls and the jars were said to have pointed or semi-pointed bases and to be "more or less conical in form." The thickness of the vessel walls was described as averaging 5 mm. for the bowls and 6 mm. for the jars (Baldwin 1950). More recent observations (Moffit et al. 1978:4; Pippin 1986; Tuohy 1986, 1990:57–59) have mirrored those made by Baldwin.

DATA ANALYSIS

Sampling Methods

In order to investigate the production technology, performance characteristics, and functions of Intermountain Brownware ceramics, 154 sherds were selected for study. These sherds, which were obtained from collections housed at the Southern Utah University Archaeological Archives and the Grand Canyon Staircase-Escalante National Monument, were derived from thirty-three sites and two non-site locations (see Fig. 1). They were recovered from settings ranging from 2,835 to 6,900 feet above sea level, in locations that can be broadly assigned to two ecological zones. At lower elevations, brushy vegetation such as creosote, sage brush, and rabbit brush predominate, whereas the higher elevations are characterized by pinyon-juniper woodland settings. Approximately 80% of the 130 sherds for which environmental information was available came from lowland settings, while 20% came from upland zones. All of the sherds were recovered from surface contexts. (For additional information on the proveniences of the sherds, see Betenson 2005.)

The 154 sherds included 100 body sherds, 52 rim sherds, and 2 refitted conical bases. A standardized suite of attributes was recorded on all 154 sherds, while residue analysis was conducted on 32 sherds.

Attribute Analysis

The attributes recorded and discussed in this paper included (a) thickness, (b) hardness, (c) the presence of sooting, (d) rim shape and diameter, and (e) the maximum size and degree of sorting of the temper particles. All of the attribute analyses were conducted by the senior author.

Thickness measurements, taken with digital calipers to the nearest millimeter, were recorded for all sherds. Three points were taken on body sherds, and the resulting measurements were averaged to obtain one average thickness measurement per sherd. For rim sherds, a single measurement was taken just below the rim.

Hardness was calculated using the Mohs hardness test. This test measures the resistance of the sherd to being scratched by one of ten standard minerals, each of which is ranked on a scale of one (being the softest) through ten (being the hardest). Each sherd was scratched on both its interior and exterior surface and its hardness score recorded as a range, with the lower number representing the hardest mineral that did not scratch the surface and the upper number representing the softest mineral that could scratch the surface. For example, a sherd having a hardness score of 5–6 means that the sherd surface was not scratched by apatite (ranked 5), but was scratched by feldspar (ranked 6).

The presence or absence of sooting was recorded for each sherd. Sooting was recognizable as a lustrous, finely cracked, blackened coating on the sherd (Hally 1983:8).

Rim shape was recorded as straight, inverted, or everted. Rim diameter, measured to the nearest centimeter, was obtained by fitting the curve of the rim to a diameter measurement template. The measurement of rim diameter was restricted to those sherds for which at least five percent of the arc was present.

To categorize the temper inclusions, the paste of each sherd was examined under a binocular microscope. The size of the maximum temper particle was recorded to the nearest 0.1 cm., and the degree of sorting was recorded using Orton et al.'s (1993:239) ranked system of very poor, poor, fair, good, and very good. The ranking was based on the subjective assessment of how evenly the aplastic inclusions were distributed within the paste.

Residue Analysis

Residue analysis was performed by the chemopyrolysis of ground pottery samples. Chemolysis can be defined as the thermally-induced decomposition and derivitization of complex organic materials. The chemolysis process involves simultaneous pyrolysis processes and chemical reactions. Chemopyrolysis is performed by ballistically heating ground sherd samples that have been mixed with excess tetramethylammonium hydroxide to pyrolysis temperatures (400 to 600°C). The tetramethylammonium hydroxide serves two purposes. First, it causes the saponification and decomposition of biomolecules such as lipids, lignin, carbohydrates, and protein into lower molecular weight fatty acids, phenols, sugars, furans, and other products. The polar functional groups on these molecules are then methylated by the tetramethyl ammonium cation, producing volatile and semi-volatile compounds (methyl ethers and esters) that are suitable for gas chromatographic separation and analysis. For this project, the chemopyrolysis products were analyzed using Gas Chromatography-Mass Spectrometry (GC-MS). The majority of the identified products were lipids, or fats contained in plant and animal residues, that were extracted from pores in the pottery fabric. Lipids present in foods fill pore spaces of unslipped ceramics during cooking, processing, transporting, or storage (Eerkens 2001:92). Pyrolysis or chemopyrolysis is performed in an inert helium atmosphere. During chemopyrolysis, volatile products are delivered by helium flow to the gas chromatograph. These compounds are then fractionated by gas chromatography as a result of their differential retention on a coated capillary column and differences in volatility. The fractionated effluent from the gas chromatograph is delivered to the mass spectrometer through a heated transfer oven, where the chemopyrolysis products are detected by electron impact mass spectrometry (Leute 1987:136; Varmuza et al. 2005). The electron impact of organic analytes creates positively-charged parent ions that subsequently fragment in a characteristic fashion, producing daughter ions of different mass that can be separated and detected by the mass spectrometer (Leute 1987:135; McLafferty 1973). These mass spectra can be used to identify the various decomposition products through a comparison with the spectra in a National Institute of Standards and Technology (NIST) mass spectrum library that is accessed by the mass spectrometer software.

Thirty-three residue samples were analyzed. These included 32 samples taken from the sherd fabric, and one sample taken from residue found adhering to one of the sherd surfaces. To obtain the samples from the sherd interiors, a 1 x 1 cm. sample was removed from each sherd using a Dremmel tool. The surface of each sample was then removed to a depth of approximately 1 cm. using a Dremmel sander attachment. The sanded sherd was handled with sterile tweezers while a small amount of methanol was poured over all surfaces. The saturated sherd was then put under a fume hood to speed evaporation of the methanol. The methanol was used to rinse away contaminants present in the lab or that resulted from handling.

After the methanol evaporated and the sherd appeared dry, it was placed inside a sterile porcelain mortar. The mortar and pestle were washed with hot water and alkaline soap between each experiment to eliminate any residues that might have accumulated during the preparation of each sherd for analysis. The sherd was then pulverized into a fine powder with the pestle. Each powder sample was placed inside a plastic specimen container that was labeled for subsequent identification.

The residue analysis was performed with a Varian 3400 gas chromatograph with a splitless injector, coupled to a Varian Saturn 3 ion-trap mass spectrometer via a heated transfer oven. A fused high temperature silica column (Supelco EC-5) was used for all analyses. Helium was used as the carrier gas. The column head pressure was adjusted to 10 psi at 40 ºC with ultra high-purity helium. The GC column temperature program was as follows: The initial column temperature was held at 40 ºC for 4 minutes after sample introduction. The column temperature was then raised at 10 ºC min-1 to 250ºC, and then 20ºC min–1 to 280ºC. The column was held at 280ºC for 15 minutes before cooling to 40ºC. A CDS Pyroprobe 2000 with a CDS Model 1500 interface was used in conjunction with the mass spectrometer to perform chemolysis on the samples. A portion of the sample (approximately 10–20 mg.) was packed into a 2 mm. diameter quartz tube and held in place with quartz wool. A 10 µL portion of tetramethylammonium hydroxide (25% in methanol) was added using a syringe and placed into the pyrolysis probe. The sample was heated for 30 seconds at 80ºC to remove the methanol. The probe was inserted into the CDS Model 1500 interface and then ballistically heated to 500 ºC for 20 seconds to effect chemolysis. The chemolysis products were then swept from the quartz tube into the GC using helium as the carrier gas (Nemr 2004:29, 35; Steinberg et al. 2009:342–343). The remainder of the sample was stored in the specimen container so that it could be used in further trials if necessary.

RESULTS

Attribute Analysis

Manufacturing Technology. The results of the attribute analysis are summarized in Table 1. The physical characteristics observed in the ceramic collection suggest that the vessels were expediently produced yet carefully fired. Expedient production is indicated by the paste characteristics. The fact that most sherds contained very poorly- to poorly-sorted inclusions indicates that they were not well mixed prior to the formation of the vessel, and the size of the inclusions suggests that little effort was

Table 1

SUMMARY OF THE RESULTS OF THE ATTRIBUTE ANALYSIS

Attribute	Sample	Results
Thickness		
Body sherds	All sherds (n=154)	$\bar{x}$=7.30; s=1.17
Rim sherds	All rim sherds (n=53)	$\bar{x}$=5.63; s=1.15
Hardness		
Interior surface	All sherds (n=154)	Median=4–5; Range=2–3 to 7–8
Exterior surface	All sherds (n=154)	Median=4–5; Range=2–3 to 7–8
Sooting	All sherds (n=154)	Present on 10.4% of sherds
Rim Form and Size		
Shape	All rim sherds (n=53)	86% are straight; 14% are slightly everted
Diameter	All rims with >5% of arc present (n=16)	$\bar{x}$=26.0; s=3.8
Aplastic Inclusions		
Degree of sorting	All sherds (n=154)	Very poor=44.3%; Poor=39.6%; Fair=14.3%; Good=1.9%
Maximum size	All sherds (n=154)	$\bar{x}$=1.20; s=.5

made to remove large grains. Expedient production is also reflected in the vessel shapes. The high frequency of straight rims suggests that most of the sherds come from conical vessels having straight sides and unrestricted openings, such as those shown in Figure 2 (left and center). The everted rims are believed to have come from the smaller, globular vessels (Fig. 2, right). Compared to the rounded cooking pots commonly associated with fully sedentary, agriculturally-based societies, these shapes could have been formed relatively quickly since they do not require intermediate drying stages in the building up of the wall.

Despite the lack of time invested in preparing the pastes and shaping the vessels, care seems to have been taken in their firing. The median score of the sherds on the Mohs hardness test was a 4–5, with two-thirds of the sherds falling between either 4–5 or 5–6 (Table 2). These scores are higher than expected, since non-kiln fired ceramics typically score in the 3 to 5 range on the Mohs hardness scale (Rice 1987:356). To aid in the interpretation of these scores, hardness measurements were also obtained for several pieces of Puebloan pottery (Hansen 2002). The ceramics used for the comparison were recovered from two sites in southern Nevada; both sites yielded both Puebloan and Intermountain Brownware ceramics, and sherds of each type were analyzed. To minimize variability between observers, the senior author conducted all of the hardness measurements. The results of these analyses are presented in Table 2. The data show that the Intermountain Brownware sherds used in this study (from southwestern Utah and northwestern Arizona) are fairly hard relative to both the Intermountain Brownware sherds and the Puebloan sherds from southern Nevada. Because hardness is related to firing temperature, these data suggest that the brownwares examined in this study were fired at temperatures comparable to or perhaps even higher than those used to fire the Puebloan wares.

Table 2

RESULTS OF MOHS HARDNESS TESTS, COMPARING INTERMOUNTAIN BROWNWARE AND PUEBLOAN CERAMICS[a]

	Ceramics Used in Present Study	Ceramics from Southern Nevada Sites	
Results of Mohs Hardness Test	Intermountain Brownware (n = 54)	Intermountain Brownware (n = 30)	Puebloan (n = 30)
2–3	–	60.0%	23.3%
3–4	13.0%	33.3%	36.7%
4–5	42.2%	3.3%	30.0%
5–6	24.7%	–	3.3%
6–7	9.2%	3.3%	23.3%
7–8	11.0%	–	–

[a] Measurements refer to those taken on the exterior of the sherds

Performance Attributes. The physical characteristics of the sherds allow us to make inferences about the performance attributes of the whole vessels. The thick walls would have slowed the transmission of heat and the open orifices would have facilitated heat loss through escaping steam. Therefore, the heating efficiency of the Intermountain Brownware vessels would have been poor. Furthermore, the thick walls would have made the vessels susceptible to developing cracks due to thermal stress, which can result when a cooking pot is subjected to repeated heating cycles. Despite these drawbacks, the vessel attributes also offered several performance advantages. The large openings would have minimized boiling-over during cooking and facilitated easy access to the vessel contents, and the conical bases would have made it easy to prop up the vessels in cooking fires. Finally, the thick walls and relatively hard pastes would have resulted in strong vessels having relatively high impact resistance.

Function. Only one recorded attribute, sooting, directly attests to how the vessels were used. Sooting was present on 10.4% of the sherds, indicating that at least some of the vessels were used over an open fire. Experiments by Hally (1983) have shown that two types of soot deposits result from this type of use. Near the base of the pot, where the vessel is in direct contact with the fire, deposits of solid carbon accumulate. These deposits can easily be removed by rubbing. In contrast, higher up on the vessel where the pot is exposed to less heat, soot deposits permanently adhere and cannot be rubbed away once the pot has cooled. The presence of soot deposits on some, though not all, of the sherds suggests that the Intermountain Brownware vessels represented in this study were used over open fires, with soot permanently adhering to only some areas of the pots. Since all of the sherds were recovered from the surface, any impermanent carbon deposits that may have accumulated were probably removed by rain and other weathering processes.

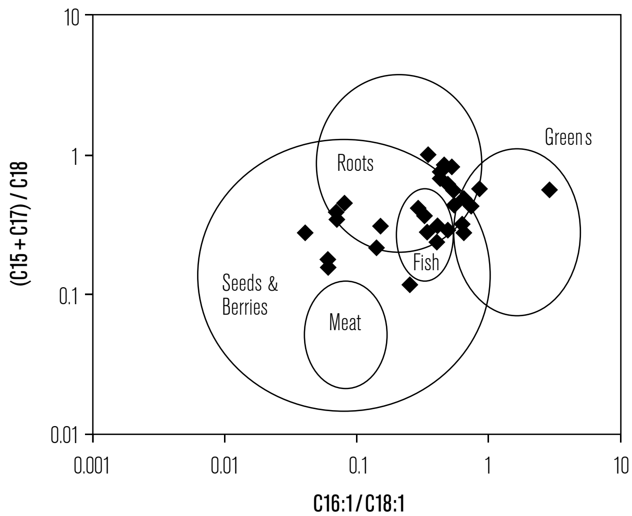

Figure 3. GC-MS results of ratios (C15 +C17)/C18 and C16:1/C18.1.

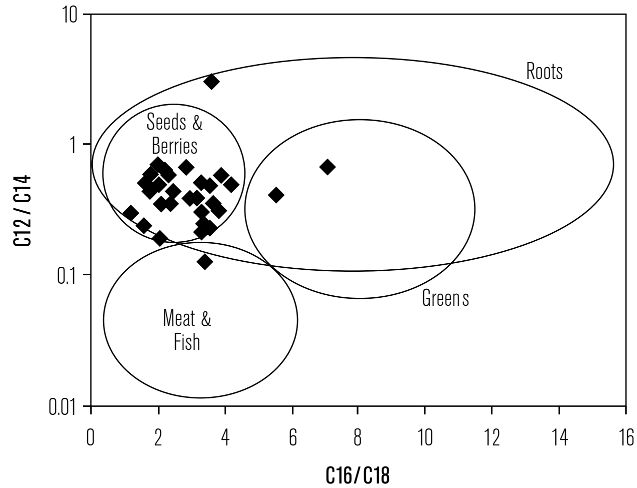

Figure 4. GC-MS results of ratios C12:0/C14:0 and C16:0/C18:0.

Residue Analysis

High concentrations of fatty acids were found in every analyzed residue sample, suggesting that foods had either been cooked or stored in all of the ceramics. The most common fatty acids observed were the medium-chained ones (those ranging from C12–C18:1), though lower concentrations of both short-chained and long-chained fatty acids were also present (see Betenson 2005 for the data). No cholesterol was present in any of the samples.

The interpretation of the residues follows the procedure outlined by Eerkens (2005). That procedure relies on a comparison of ratios of various fatty acids to distinguish meat, fish, roots, greens, seeds and nuts, and berries. The gas chromotograms indicate that our samples contained elevated levels of C16:0, C18:0, and C18:1. High C16 and C18 levels with low levels of C12 and C14, in conjunction with the absence of cholesterol, is evidence that this collection of ceramics had not been used to process, cook, or store meat (Eerkens 2001:102). Biplots of the fatty acid ratios obtained in our study graphically illustrate the similarity of our ratios with those obtained from the experimental analysis of seeds and berries (Figs. 3 and 4).

DISCUSSION

The results of the attribute and residue analyses support the interpretation that the vessels represented in our sample functioned as cooking containers. The large, open orifices would have made them unsuitable for storage (Smith 1983), and the conical bases would have made them difficult to use as serving containers. These physical characteristics, combined with the identification of residues in all of the sherds subjected to GC-MS analysis, suggest that the vessels were used for cooking.

Clues as to the cooking techniques used are provided by the vessel forms and sooting patterns. The conical bases imply that the vessels were embedded in the heat source, and the low proportion (10.4%) of sooted sherds points to the use of hot flames rather than coals. Consistent with the findings reported by Hally (1983) and discussed above, experiments conducted by Skibo (1992:157–162) indicate that soot will not accumulate when a vessel's walls are exposed to temperatures greater than 400°C. Such temperatures are not achieved with coals, but can be achieved with open fires. Therefore, we interpret the sooting patterns found in our sample as indicating use over an open fire, so that soot accumulation was limited to the upper areas of the vessels where the heat was less intense. This type of cooking would be suitable for a short-term boiling of foods but not for long-term simmering, since it would be difficult to control the temperature of the contents and loss of water through evaporation would be high.

However, the attributes of the vessels were not ideal even for short-term boiling. As discussed above, the thick walls would have inhibited the transmission of heat, and—most importantly—have increased the pot's susceptibility to thermal shock. That susceptibility would have been worsened by the presence of the large sand inclusions left in the pastes. Finally, the loss of heat through the large orifices would have further increased the heating inefficiency of the vessels, and required more attention from the cook (since the contents could boil dry), than if the vessel had a restricted opening.

If the attributes of the ceramics cannot be explained by the functional needs associated with the finished vessel, what does explain them? We argue that the thick walls and the conical, open shape of the vessels were a by-product of the mobile lifestyle practiced by the makers of the Intermountain Brownware ceramics. This lifestyle would have presented at least two obstacles to pottery production. First, time constraints would have made it difficult to complete all of the steps that may be required to make a high-quality vessel. The manufacture of a well-made pot can take up to several weeks (Arnold 1985), and as Eerkens (2008:309) has noted, the hunting and gathering lifestyle of the Great Basin populations may have required them to move before all of the desired stages could be completed. Additionally, time conflicts caused by the need to gather food may have limited the amount of time that women could spend on making pottery (Eerkens 2008:310).

A second challenge facing the Great Basin potters may have been a lack of knowledge and skill. Although Intermountain Brownware ceramics were part of the material culture of the study region, they clearly represented a fairly minor part. Unlike the more sedentary farming groups found in adjacent areas, the makers of the Intermountain Brownware pottery appear to have used ceramics only for cooking, and only in limited amounts. This limited use would have meant that each potter made only a few vessels per year. The manufacturing of a high quality vessel is not easy, and the thin-walled, restricted-orifice, rounded vessel is one of the hardest shapes to master. Additionally, it requires the use of highly plastic clays, which may not always be immediately available. For sedentary peoples who make and use pots on a regular basis, information about appropriate clay sources is passed down through the generations, and the necessary skills are acquired through the substantial time that is spent potting. For the hunters and gatherers of the Great Basin, however, limited pottery production may have precluded the development of the specialized skills and knowledge needed to make these types of vessels.

The thick-walled, conical-shaped vessels represented by Intermountain Brownware may be interpreted as a compromise between the need for ceramic cooking vessels and the need to find a vessel shape that could be quickly and easily manufactured. Compared to more typical thin-walled, rounded cooking vessels, the thick-walled, open ones require little skill to manufacture, can be quickly formed, and can be produced using less-than-ideal pastes. Therefore, we argue that the thick walls found in these ceramics occur not because they were particularly desired, but because they were the predictable result of using clays that had not been thoroughly prepared (i.e., through the removal of large sand particles and/or through the grinding and aging of the clays). A comparison of the average thickness of the sherds with the degree of sorting observed (Table 3) provides some support for this interpretation. These data show that the thickness of the sherds tends to be inversely correlated with the degree of sorting, suggesting that thicker walls are manufactured when less time is spent preparing the clays.

Despite the expedient nature of the paste preparation and the shaping of the vessels, the hardness test results indicate that they were fired at temperatures similar to those used for other low-fired terra-cotta pottery. This is not particularly surprising, since time constraints are less relevant during the firing stage of pottery production. Even very brief fires can result in well fired pots, as indicated by the short (less than 20 minutes) firings used by some Puebloan potters (Shepard 1956:87, Table 3). Thus, firing would have imposed few costs on the Intermountain Brownware producers, but it would

Table 3

AVERAGE SHERD THICKNESS[a] BY DEGREE OF SORTING

Degree of Sorting	Number (mm.)	Mean (mm.)	Standard Deviation (mm.)
Very Poor	68	7.4	1.1
Poor	61	7.1	0.7
Fair	20	7.2	1.1
Good	3	6.4	0.4

[a] Rim and base sherds are excluded from this table

have imparted substantial advantages in the increased heating efficiency and durability of the finished product.

CONCLUSIONS

Our results suggest that the Intermountain Brownware vessels included in this study were used to cook foods; specifically, they were used for short-term boiling over an intense heat. These findings are consistent with observations described in the ethnographic literature. They differ from the ethnographic data, however, in that no evidence was found to indicate that meat was ever cooked in the vessels. Instead, the GC-MS data suggest that they were used to cook seeds, reinforcing the results reported by Eerkens (2001, 2005) in the Great Basin and by Tuohy (1990) in central and western Nevada.

It is unclear why our results differ from the cooking patterns described ethnographically. One possibility is that meat *had* been cooked in the vessels, but that the resulting cholesterol residues either were not preserved or were not detected by the GC-MS analysis. A second possibility is that the encroachment of settlers into Southern Paiute territory during the historic period altered indigenous subsistence practices. The archaeological record suggests that in the western Great Basin the use of pottery was largely confined to lowland settings, where vessels were presumably cached and re-used on a seasonal basis (Eerkens 2008). A similar strategy may have been used in the study region discussed here, since 80% of our analyzed samples were recovered from lowland settings. The hunters and gatherers of the Great Basin are believed to have used these areas in the spring and summer to harvest grass seeds and other lowland resources. Because the subsistence practices during this season would have been focused on seed collecting rather than hunting, the lack of meat residues in the pottery may simply reflect this seasonal focus. During the historic period, the Paiutes lost access to many of these lowland areas, which may have resulted in a shift in their seasonal subsistence activities and cooking practices.

Nevertheless, the attributes of the Intermountain Brownware vessels would have made them adequate for cooking seeds. The evidence suggests that the pots were placed in a hot fire during cooking, which would have caused the contents to come to a rapid boil. As others have argued (Eerkens 2005:96; Reid 1990), this type of rapid boiling works well for processing carbohydrate-rich foods such as seeds. Although the open orifices would have contributed to a loss of heat and water during cooking, they would have also allowed the cooks to easily monitor and stir the contents, an important consideration to keeping the liquid from boiling dry.

Although Intermountain Brownware vessels were not the most efficient pots, their shortcomings were likely less problematic to the people who used them than they would have been to the agricultural people of adjacent areas. The pots would have had poor resistance to thermal shock, but given the limited amount of time that they were placed over a fire, this may not have been an important consideration. In comparison to the historic Puebloan peoples, whose preparation of corn and beans required that vessels be used for several hours every day (Kobayashi 1996:307), the time spent boiling seeds was quite short. Under these circumstances, the increased durability imparted by the thicker pot walls may even have offset the drawbacks of the decreased thermal stress resistance.

This paper adds to a growing body of recent literature on the use of ceramics by mobile or semi-sedentary hunters and gatherers (Bright and Ugan 1999; Dean and Heath 1990; Eerkens 2002a, 2002b, 2003, 2005, 2008; Frink and Harry 2008; Harry and Frink 2009; Harry, Frink, Charest, et al. 2009; Harry, Frink, Swink, et al. 2009; Reid 1989, 1990; Simms and Bright 1997). Our results suggest that—as is the case with the pottery of other hunter-gatherers—the key to understanding the technology of Intermountain Brownware may lie less in its intended use than in the production challenges faced by the people who produced it.

ACKNOWLEDGEMENTS

We are sincerely grateful to Ekhlas "Lisa" Nemr for conducting the GC-MS at the U.N.L.V. Chemistry Lab; to Dr. Jelmer Eerkens of U.C. Davis for interpreting our GC-MS plots; and to Barbara Frank, curator of the Southern Utah University Archaeological Archive, and Matthew Zweifel, Archaeologist of the Grand Staircase-Escalante National Monument, for allowing access to the artifacts used in this study. We also would like to thank two anonymous reviewers for providing comments which have greatly strengthened the manuscript.

REFERENCES

Arnold, Dean E.
1985 *Ceramic Theory and Cultural Process*. Cambridge: Cambridge University Press.

Baldwin, Gordon C.
1942 Archaeology in Southern Nevada. *The Kiva* 7(4): 13–16.
1950 The Pottery of the Southern Paiute. *American Antiquity* 16:50–56.

Betenson, Britt J.
2005 *Pottery and Mobility: A Functional Analysis of Intermountain Brownware*. Master's thesis, University of Nevada, Las Vegas.

Bright, Jason R., and Andrew Ugan
1999 Ceramics and Mobility: Assessing the Role of Foraging Behavior and Its Implications for Culture-History. *Utah Archaeology* 12:17–29.

Brooks, Juanita (ed.)
1972 *Journal of the Southern Indian Mission: Diary of Thomas D. Brown*. Logan, Utah: Utah State University Press.

Dean, Patricia, and Kathleen Heath
1990 Form and Function: Understanding Gray Pottery in Northeastern Great Basin. In *Hunter-Gatherer Pottery from the Far West*, Joanne M. Mack, ed., pp. 19–28. *Nevada State Museum Anthropological Papers* 23. Carson City, Nevada.

Eerkens, Jelmer W.
2001 *The Origins of Pottery among Late Prehistoric Hunter-Gatherers in California and the Western Great Basin*. Ph.D. dissertation, University of California, Santa Barbara.
2002a Ceramic Production among Small-Scale and Mobile Hunters and Gatherers: A Case Study from the Southwestern Great Basin. *Journal of Anthropological Archaeology* 21: 200–229.
2002b Preservation and Identification of Piñon Resins by GC-MS in Pottery from the Western Great Basin. *Archaeometry* 44(1):117–127.
2003 Residential Mobility and Pottery Use in the Western Great Basin. *Current Anthropology* 44(5):728–738.
2005 GC-MS Analysis and Fatty Acid Ratios of Archaeological Potsherds from the Western Great Basin of North America. *Archaeometry* 47(1):83–102.
2008 Nomadic Potters: Relationships between Ceramic Technologies and Mobility Strategies. In *The Archaeology of Mobility: Old World and New World Nomadism*, H. Barnard and W. Wendrich, eds., pp. 307–326. Los Angeles: Cotsen Institute of Archaeology.

Firor, James
1994 *Excavation of Two Prehistoric Southern Paiute Sites Near Kanab, Utah*. Report prepared by Alpine Archaeological Consultants, Inc. for ERA Utah Properties, Inc, Kanab, Utah.

Fowler, Catherine S., and Don D. Fowler
1971 Notes on the History of the Southern Paiutes and Western Shoshonis. *Utah Historical Quarterly* 39(2).

Fremont, John C.
1845 *Report of the Exploring Expedition to the Rocky Mountains in the year 1842 and to Oregon and Northern California in the years 1843–1844*. Washington, D.C.: Gales and Seaton Printers.

Frink, L., and K. Harry
2008 The Beauty of the "Ugly" Eskimo Cooking Pots. *American Antiquity* 73(1):103–120.

Hafen, LeRoy R., and Ann W. Hafen
1954 *Journals of Forty-Niners: Salt Lake to Los Angeles*. Glendale, California: The Aurthur H. Clark Company.

Hally, David J.
1983 Use Alteration of Pottery Vessel Surfaces: An Important Source of Evidence for the Identification of Vessel Function. *North American Archaeologist* 4:1–25.

Hansen, Britt J.
2002 *A Physical Attribute Comparison between Brownwares and Graywares at Two Southern Nevada Sites*. MS on file at University of Nevada, Las Vegas.

Harry, Karen, and Liam Frink
2009 The Arctic Cooking Pot: Why was it Adopted? *American Anthropologist* 111(3):330–343.

Harry, Karen G., L. Frink, Andreas Charest, and Brendan O'Toole
2009 How to Make an Unfired Clay Cooking Pot: Understanding the Technological Choices Made by Arctic Potters. *Journal of Archaeological Method and Theory* 16(1):33–50.

Harry, Karen G., Liam Frink, Clint Swink, and Corry Dangerfield
2009 An Experimental Approach to Understanding Thule Pottery Technology. *North American Archaeologist* 30(3):291–311.

Janetski, Joel C.
1990 Ethnicity and Post Formative Ceramics in the Eastern Great Basin. In *Hunter-Gatherer Pottery from the Far West*, Joanne M. Mack, ed., pp. 53–66. Carson City, Nevada: Nevada State Museum.

Kelly, Isabel
1964 Southern Paiute Ethnography. *University of Utah Anthropological Papers* 69. Salt Lake City.
1976 *Paiute Indians II: Southern Paiute Ethnography*. New York and London: Garland Publishing, Inc.

Kelly, Isabel T., and Catherine S. Fowler
1986 Southern Paiute. In *Handbook of North American Indians, Volume 11, Great Basin*, Warren D'Azevedo, ed., pp. 368–397. Washington, D.C.: Smithsonian Institution.

Kobayashi, Masashi
1996 *An Ethnoarchaeological Study of the Relationship between Vessel Form and Function*. Ph.D. dissertation, University of Arizona. UMI Microfilms.

Leute, Ulrich
1987 *Archaeometry: An Introduction to Physical Methods in Archaeology and the History of Art*. Printed in the Federal Republic of Germany. New Delhi, India: Allied Publishers Private Ltd..

Lowie, Robert H.
1924 Notes on Shoshonean Ethnography. *American Museum of Natural History Anthropological Papers 20*(3):185–314. New York.

McLafferty, F. W.
1973 *Interpretation of Mass Spectra*. Second Edition. Reading Massachusetts: The Benjamin/Cummings Publishing Company.

Moffitt, Kathleen, Sandra Rayl, and Michael Metcalf
1978 Archaeological Investigations along the Navajo-McCullough Transmission Line, Southern Utah and Northern Arizona. *Museum of Northern Arizona Research Papers* 10. Flagstaff.

Nemr, Ekhlas Lisa
2004 *Measurement of Lignin and Organic Carbon in Lake Mead Sediment*. Master's thesis, University of Nevada, Las Vegas. Ann Arbor: University Microfilms.

Orton, Clive, Paul Tyers, and Alan Vince
1993 *Pottery in Archaeology*. [*Cambridge Manuals in Archaeology*.] Cambridge: Cambridge University Press.

Pippin, L. C.
1986 Intermountain Brown Wares: An Assessment. In *Pottery of the Great Basin and Adjacent Areas*, Suzanne Griset, ed., pp. 9–11. *University of Utah Anthropological Papers* 111. Salt Lake City.

Reid, Kenneth C.
1989 A Materials Science Perspective on Hunter-Gatherer Pottery. In *Pottery Technology: Ideas and Approaches*, G. Bronitsky, ed., pp. 167–180. Boulder, Colorado: Westview Press.

1990 Simmering Down: A Second Look at Ralph Linton's North American Cooking Pots. In *Hunter-Gatherer Pottery from the Far West*, Joanne M. Mack, ed., pp. 7–18. *Nevada State Museum Anthropological Papers* 23. Carson City, Nevada.

Rice, Prudence M.
1987 *Pottery Analysis: A Sourcebook*. Chicago and London: University of Chicago Press.

Sapir, Edward
1992 *The Collected Works of Edward Sapir X: Southern Paiute and Ute Linguistics and Ethnography*, William Bright, ed. Berlin and New York: Mouton de Gruyter.

Shepard, Anna O.
1956 *Ceramics for the Archaeologist*. Washington, D.C.: Carnegie Institution.

Simms, S.R., and Jason Bright
1997 Plain-ware Ceramics and Residential Mobility: A Case Study from the Great Basin. *Journal of Archaeological Science* 24:779–792.

Skibo, James M.
1992 *Pottery Function: A Use-Alteration Perspective*. New York and London: Plenum Press.

Smith, M.F., Jr.
1983 *The Study of Ceramic Function from Artifact Form and Shape*. Ph.D. dissertation, University of Oregon.

Steinberg, Spencer M., Elklas L. Nemr, and Mark Rudin
2009 Characterization of the Lignin Signature in Lake Mead, NV, Sediment: Comparison of On-Line Flash Chemopyrolysis (600°) and Off-Line Chemolysis (250°). *Environmental Geochemistry and Health* 31:339–352.

Tuohy, Donald R.
1986 Ethnographic Specimens of Basin Brown Ware. In *Pottery of the Great Basin and Adjacent Areas*, Suzanne Griset, ed., pp. 27–36. *University of Utah Anthropological Papers* 111. Salt Lake City.

1990 Second Thoughts on Shoshoni Pots from Nevada and Elsewhere. In *Hunter-Gatherer Pottery from the Far West*, Joanne M. Mack, ed., pp. 84–105. *Nevada State Museum Anthropological Papers* 23. Carson City, Nevada.

Varmuza, Kurt, Athanasios Makristathis, Josef Schwarzmeier, Horst Seidler, and Robert M. Mader
2005 Exploration of Anthropological Specimens by GC-MS and Chemometrics. *Mass Spectrometry Reviews* 24:427– 452.

Walling, Barbara A., Richard A. Thompson, Gardiner F. Dalley, and Dennis G. Weder
1986 *Excavations at Quail Creek*. [*Bureau of Land Management Cultural Resource Series* 20.] Salt Lake City, Utah: Bureau of Land Management, Utah State Office.

Westfall, Deborah A., William F. Davis, and Eric Blinman
1987 *Green Spring: An Anasazi and Southern Paiute Encampment in the St. George Basin of Utah*. [*Bureau of Land Management Cultural Resource Series* 21.] Salt Lake City, Utah: Bureau of Land Management, Utah State Office.