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Riveted Handles: A Superior Ceramic Vessel Construction Technique on Chupadero Black-on-white Jars

Alexander Kurota and Micah I. Smith

This paper introduces a new ceramic vessel forming technique discovered during the course of the research associated with the Office of Contract Archeology University of New Mexico (OCA/UNM) site evaluation project on White Sands Missile Range (WSMR). Unusually bumpy surface finish was noted on several interiors of Chupadero Black-on-white jars. This surface finish was noted directly on the opposite side of the jar exterior where a handle was attached. Evident lumps of clay on the interior side of the jars were often so obvious that a possible association of the exterior handle and the inner clay lumps was raised. It appeared that the prehistoric potters might have invented an extra strong handle attachment to withstand the stress pressure of carrying a heavy weight of liquid-filled Chupadero Black-on-white jars. With their globular body and narrow mouth opening, these vessels have widely been considered as excellent containers for liquid transport (Figure 1). Yet, without solid visual evidence demonstrating this association between the exterior handle location and the interior clay bumps, our observations merely remained in a hypothetical realm.

Figure 1. Examples of Chupadero Black-on-white jars from White Sands Missile Range.

It was not until indisputable evidence was found on a Chupadero Black-on-white jar rim sherd recently discovered by archaeologist Matt Cuba that positively linked the exterior handle with the interior bumpy finish. The rim sherd revealed a clay coil protruding through the interior jar wall exactly from the area where the handle was attached on the exterior wall (Figure 2a). We found a similar such handle fragment during a field visit to the Shaman Village, LA 117502 (Figure 2b). In fact, the clay coil functioned as a handle which was made by running the clay coil through the wall of the jar prior to the entire vessel was fired. Because the jar on which the handle was attached had a very narrow mouth opening, it was not possible for the potter to smooth out the clay coil protruding on the interior wall. By contrast, the smoothing of the coils was much easier achieved on the interior neck which did not require pushing the potter's hand through the restricted opening of the jar (Figure 2c). Our subsequent observations of such handle attachment on numerous Chupadero Black-on-white jars from two residential sites Adams Corona and Hiner Ruin aided into a realization of the existence of *riveted handles* – a superior ceramic vessel construction technique. This technique is fundamentally different from that found on most of the Southwestern vessels where the handles were attached to the walls of fully shaped vessels as appendages, rather than being a part of the wall and its contours (Rice 1987:214).

We argue that the *riveted handles* dramatically improved the durability of the handle which, in turn, increased the vessel's overall load carrying capacity. Such a superior bonding technique likely was necessary for the Chupadero Black-on-white jars to have been used for liquid transport. In this article we provide a description of how the *riveted handles* were created and discuss their advantages.

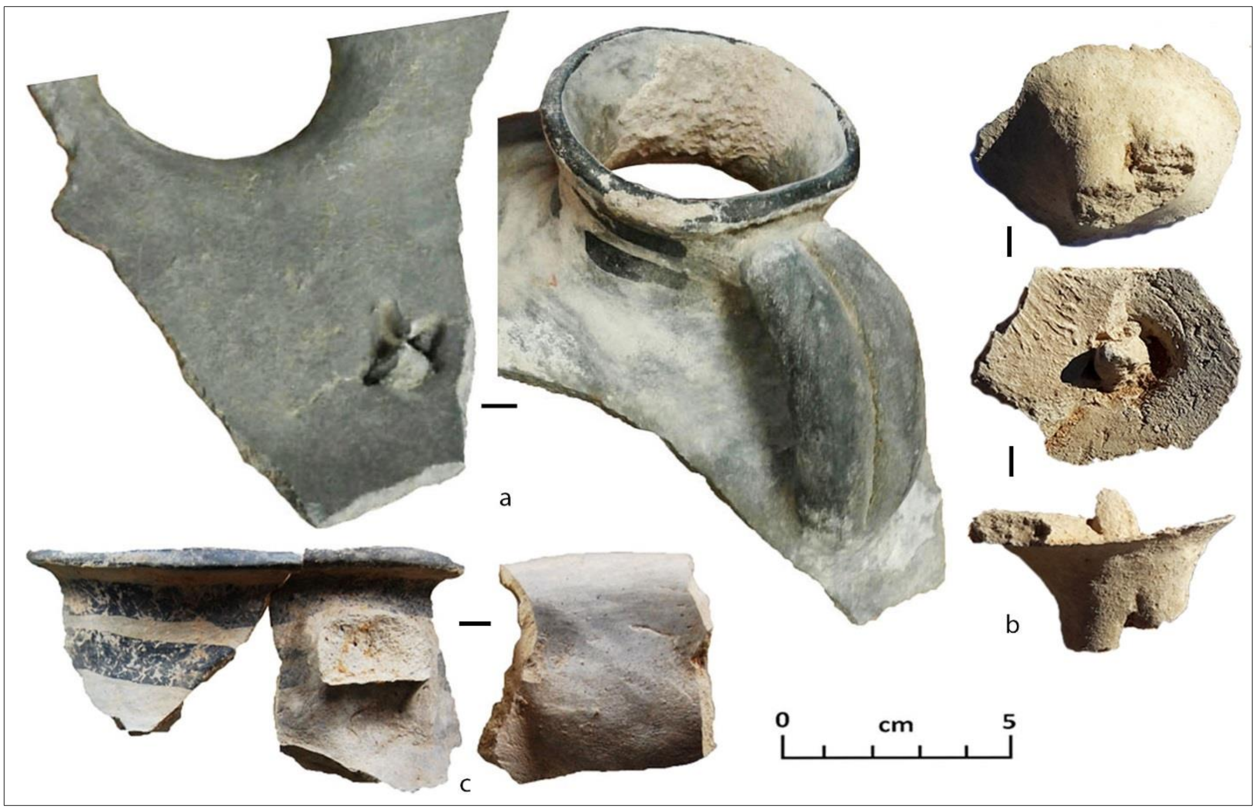

Figure 2. Examples of riveted handle attachment on Chupadero Black-on-white ceramics from White Sands Missile Range (a, b) handles with unobliterated coils (rivets); and (c) handle with lump of clay on the interior showing obliterated rivet.

Evidence for Chupadero Black-on-white Riveted Handles from WSMR

Chupadero Black-on-white jars were built with restricted necks; some showing direct, others everted (sharply recurved) rims. Typical handles on these jars are vertically-aligned with one end being positioned on the upper jar neck area and the other on the upper body slightly below the neck. Chupadero Black-on-white handles vary in number of coils from one to four or even more and it appears that even the handles with more than one coil were affixed onto the jars with the *riveted handles*.

A detailed inspection of the rim sherd found by Matt Cuba revealed traces of impressions around the unobliterated interior portion of the jar which provided some clues on how the holes for the handle attachment were made. While still in plastic state, an awl-like tool was used to puncture the vessel at the handle attachment points, then the potter moved the awl horizontally and vertically in an effort to enlarge each hole without damaging the soft unfired walls. This would have resulted in a cross-like impression on the interior jar wall that is visible in Figure 2a. The same technique was probably used for the creation of both the upper and lower attachment points (Figure 3a).

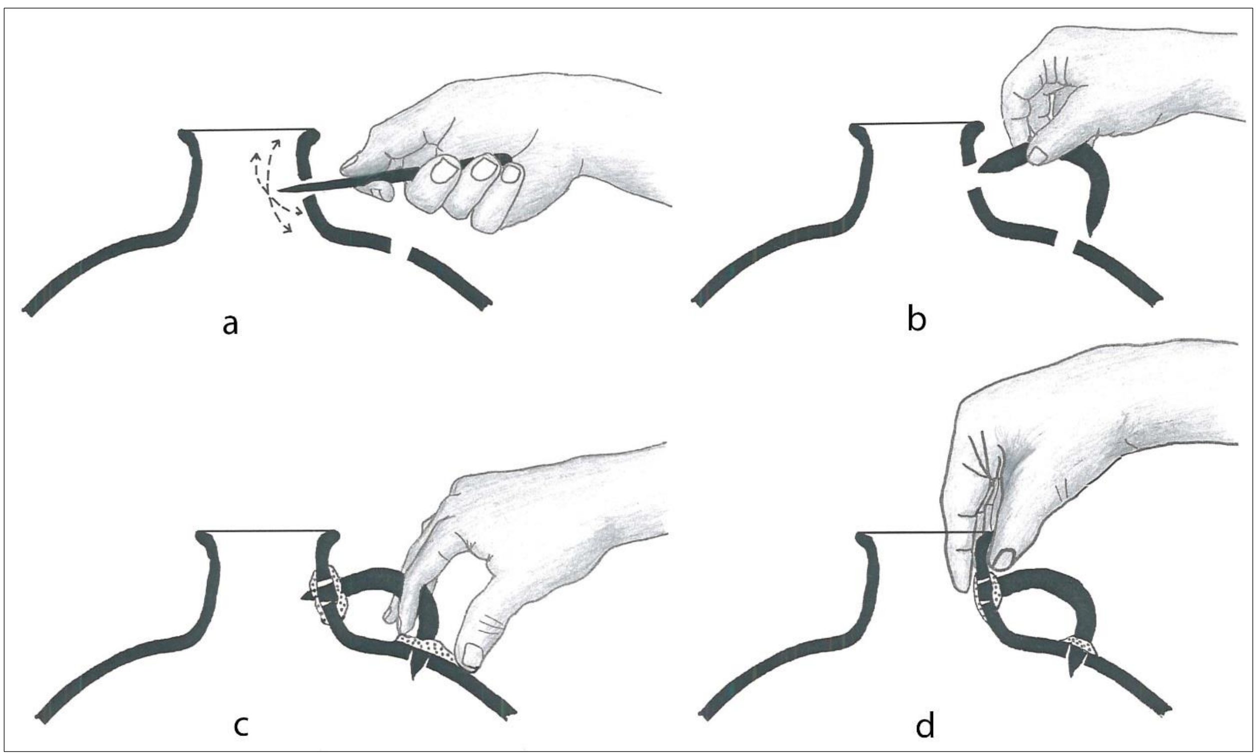

Figure 3. Reconstructed sequence of *riveted handle* attachment on Chupadero Black-on-white jars: (a) an awl-type tool is used to perforate the jar walls in a cruciform shape motion; (b) a bent clay coil (handle) is placed inside the pre-made holes; (c) lumps of clay are added to the three areas in an effort to make a tight connection (except the lower bottom where the potter could not reach with hand); and (d) final stage of smoothing the clay lumps which often leaves bumps on the interior necks of jars.

Prior to attachment, both ends of the handle coils were tapered into pointed ends, giving them a spike-shaped appearance. The spiked ends were then pushed through the cross-shaped puncture area (Figure 3b) and sealed on the exterior surface with additional clay (Figure 3c). In some cases, the clay coils is smeared on the interior side of the jar to make it a true rivet with a widened end of the spike that can no longer come out of the hole. The upper end of the handle (located on the jar neck) was then obliterated and smoothed over on the interior surface (Figure 3d). Due to the restricted necks and small rim diameter on typical Chupadero Black-on-white jars, such obliteration was largely impossible for the lower end of the handle on the vessel shoulder, where the clay coil protrusion was left intact (Figure 3d).

Evidence from Adams Corona Ruin and Hiner Ruin

To verify whether this technique of handle attachment was used on Chupadero jars from other regions, we conducted an inspection of the massive ceramics assemblage from the Adams Corona Ruin, LA 176561, housed at the Maxwell Museum.

On March 24th and 27th 2017, Alex Kurota obtained permission from Maxwell Museum's Archaeology Collections Manager Karen Price to review over 10,000 ceramics from Adams Corona Ruin, LA 176561, and Hiner Ruin, LA 176565. These two sites used to be major prehistoric residential villages and are located about seven miles east of the modern town of Corona in central New Mexico.

Kurota reviewed several hundred clear plastic bags containing thousands of Chupadero Black-on-white body and rim sherds. When handle fragments were encountered, the interior and exterior surfaces of the original vessel wall were inspected for possible traces of *riveted handles*.

The results of this exercise were stunning: over 40 pieces of ceramics with evidence for *riveted handles* were encountered. Interestingly, the inspection of these two ceramic assemblages revealed that Chupadero Black-on-white jars made at these residential village sites were often times significantly larger than those found on White Sands Missile Range. Indeed, some of the Chupadero Black-on-white partially reconstructed jars from Adams Corona Ruin indicated to have been about 50 cm to 60 cm or larger in maximum diameter while those found in southern Tularosa Basin typically range from 35 cm or 45 cm. As a result, many Adams Corona and Hiner Ruin jar handles were much bigger and more robust than those from WSMR (as larger jars would have required a more robust handles).

Furthermore, rim diameter estimated obtained from large Chupadero Black-on-white rim sherds from WSMR tend to be also smaller typically averaging from 5 to 6 cm with the largest estimated to be around 11 cm. By contrast, rim diameters measured on partially preserved jars from Adams Corona and Hiner Ruin tend to average from 6 to 8 cm with numerous examples measuring 12 or 13 cm. These observations further support the inference that Chupadero B/W jars at Adams Corona and Hiner Ruin were made into significantly bigger vessels than those found on WSMR. It can be speculated that, due to their size, such large jars would have been more suited for long term storage than for transport of commodities.

Nevertheless, the inspection of the primarily Adams Corona Ruin assemblage revealed that there is a large body of handles with the protruding coil on the interior side of the vessel. It was also noted that such handles were associated with jars that had very narrow rim diameters and thus would not have allowed for the potter to fit his or her hand through the neck and smooth the interior. The interior walls of jars with such handles often revealed large lumps of clay which have been slightly smoothed over or left unobliterated (Figure 4).

Figure 4. Examples of riveted jar handles with unobliterated clay lumps (c, e) or protruding handles (a, b, d, f-g) from Adams Corona Ruin; "h" is from an unknown site and is also housed at the Maxwell Museum under archive record no. 65,24.271. Image courtesy of Maxwell Museum of Anthropology, University of New Mexico. Note arrow in the lower right corner pointing to a clay coil (rivet) protruding through the interior wall.

Several handles with partially obliterated interior clay lumps have also been noted in the assemblage. These fragments most likely came from jars with rim diameters large enough for smoothing the interior wall. However, careful observation of these specimens revealed that at least some layer of clay from the original handle remains on the interior walls of jars. Some of those patches were only 2 to 3 cm in dimeter (Figure 5 c, d, e, g, i, and j), others reached up to 4 or 5 cm (Figure 5 a, b, f, and h). In one case, a clay patch was smoothed from the interior clay coil and reached almost to the interior rim level of the jar.

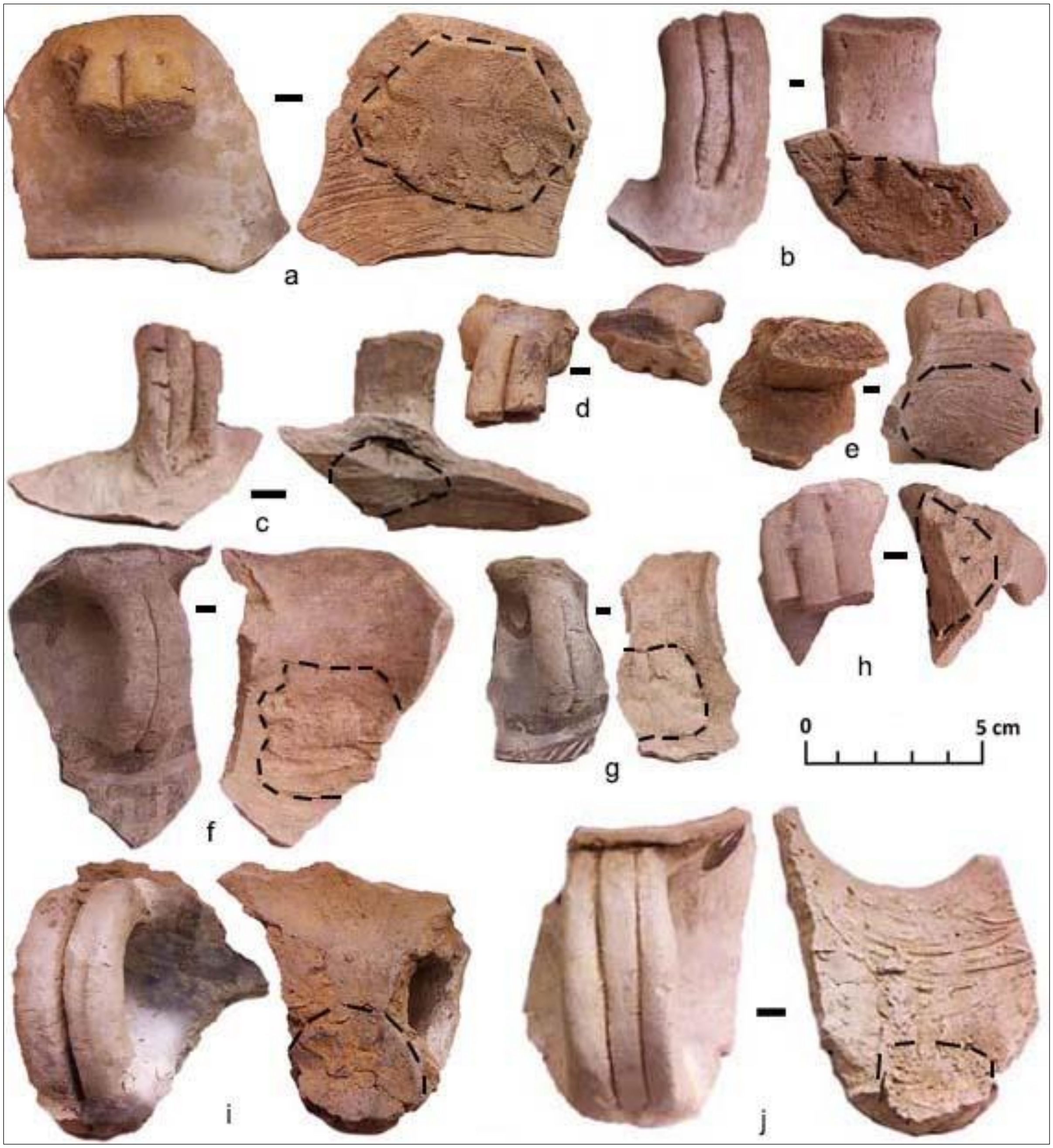

Figure 5. Examples of handles showing partially obliterated clay lumps on the vessel interior from Adams Corona Ruin. Dashed lines indicate the spatial extent of the smeared clay patch. Image courtesy of Maxwell Museum of Anthropology, University of New Mexico.

Discussion

It appears the riveted handles may have been invented as a result of real-life experience by the prehistoric people while using the Chupadero Black-on-white jars. With their globular body and restricted rims, these jars likely would have served as excellent liquid transport containers (Chamberlin 2002:278:Table 5). Most liquids, including water, are heavy, which would have put stress on the jar handles that were attached using the common applique technique which implies merely surficial attachment on the exterior wall. As a consequence, such handles likely would have detached from the jars full of water (or other liquids) which ultimately would have resulted in breaking the jar. Perhaps even a bigger loss could have been considered the loss of precious water when multiple lives of the members of a prehistoric group depended on it under harsh dry summer conditions of the prehistoric central and southern New Mexico region. Rice (1987:242) also argues that not all prehistoric handles were indented for lifting, particularly those on large vessels (as those would have been too heavy to lift without detaching the applique-style handles).

Therefore, it was likely a result of one or perhaps multiple prehistoric potters who invented the riveting technique on Chupadero Black-on-white jars. Alternatively, the technique may have been adopted from the neighboring regions although we are not aware of an analogous construction in the Southwest. Unlike the applique style handle attachment (where the clay mass spread around the handle on the interior carries the main load of weight), the weight of the water jar is diverted onto the jar wall in the riveting technique thus taking the stress away from the handle. Rivets can resist tension to a certain degree although their main function is to transmit loads along the piece of the material (Sofaer 2006:136). This invention resulted in superior carrying capacity qualities for Chupadero B/W jars that would have made them dependable ceramic containers to be used for the transport of heavy commodities. Chamberlin (2002:281) elaborates that mechanical stress resistance, containment, and transportability are important qualities of vessels used for transport of commodities.

The use of riveted handles goes back into at least into the Bronze Age in Europe when such technique was used on vessels made of metal (Hill 1947). Riveting (hammering, thus flattening] metal pegs into container walls, therefore producing rivets) has also been known in the early Chinese metallurgy that goes back several millennia until about 300 B.C. (Barnard 1980:12).

One of the few known examples of the riveted handle technique is reported from the Late Bronze Age on the island of Cyprus. Some of the local ceramic vases used to carry and pour liquids had their handles attached through walls (Pilides 1991:146). With the globular body, narrow necks and handles attached from rim to upper body, the vases of the Handmade Burnished Wares, also called Barbarian Wares (Pilides 1991:174) resemble the shapes of Chupadero Black-on-white jars although the Cypriot vases have much taller necks.

Sofaer (2006) documented the Early to Middle Bronze Age ceramic pots from a site in Hungary. The author (Sofaer 2006:135) calls the riveted handles “pegs” when the handles are pushed through the walls of jars and mugs in a similar way the Chupadero Black-on-white jar handles were made. Unlike the Chupadero jars, the Bronze Age vases from Hungary had wider necks so the smoothing of the "pegs" would have been achieved easier. Yet, the pegs were left often unsmoothed. Sofaer (2006:1325) attributes this fact to the choice the potters made pegs on finely made pottery were smoothed while those on utility wares were unsmoothed.

In the United States, riveted handles are reported from the Keernan Site, a probable La Salle's Fort St; Luis in Texas dating to the late 17th century. The ceramic ware with riveted handles is called Goliad Plain and it was made by Aracana Indians (Gilmore 1973:44).

Alternative Handle Attachment for Liquid Transport

Adams Corona Ruin ceramic assemblage also revealed a small number of sherds with handles placed horizontally along the upper body of the jars. Unfortunately, no complete or a large enough jar was found that would show the overall vessel shape and size. Nevertheless, close inspection of these jar fragments revealed that two such handles would have been build one on either side of the neck making it a unique Chupadero Black-on-white vessel form. Interestingly, these jars also have very narrow rim diameters typically not exceeding 5 cm. With the narrow mouth and the small globular body, these two-handled jars somewhat resemble the ceramic canteens of the historic period.

It is possible that this was a fairly new invention by the Chupadero Black-on-white potters that further increased vessels' load carrying capacity. Indeed, dividing the weight of a jar filled with water between two handles would have decreased the stress on each handle by 50 %. In fact, the two-handled jars not only would have been able to easier carry the weight but also would have been able to carry more weight. It is hypothesized a piece of cordage ran through the two handles which would have made it an easily carried liquid transporting container (Figure 6). Little evidence for riveting was noted on these sherds hence it is not clear whether these handles are merely applique or whether evidence for the riveting was obliterated before the neck of the canteen was built.

Only perhaps four to five such canteen-style handles were noted in the Adams Corona Ruin assemblage and one possibly from West Dry Lake Pueblo, LA 104864. This could suggest a perhaps a new trend developing for liquid carrying containers for the Jornada Mogollon. Whitney's (2017) research of prehistoric flat-backed canteens offers some insights onto the development of the canteen vessel forms in the southwest. Clearly, more research is needed to evaluate when the canteen-style Chupadero jars were introduced.

Figure 6. Stylized reconstruction of a canteen-shaped Chupadero Black-on-white jar from Adams Corona Ruin.

Summary

The study of the *riveted handles* on Chupadero Black-on-white jars offers insights into possible early engineering-type of challenges prehistoric potters faced to improve the carrying load capacity for liquid transport vessels. Our inspection of jar sherds from sites on WSMR as well as the residential villages Adams Corona and Hiner Ruin indicates that the technique can be observed on jars both in southern and central New Mexico. We are not aware of similar techniques used in other parts of the Southwest but water jugs belonging to other ceramic traditions also may have been built in this fashion. More research of the riveting technique is needed to better understand its approximate period of introduction, the area of origin of the idea and possible parallels in the Southwest and beyond. Weight stress experiments in comparing the common applique handles and the *riveted handles* could provide concrete datasets on how much improvement this ceramic vessel forming technique actually provided.

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We are grateful to WSMR Stewardships Archaeologist Stan Berryman (now retired), James Bowman and William Godby for their support of our research. This research was performed as part of the environmental/cultural resource management compliance program of White Sands Missile Range. We also appreciate research information on the riveted handles provided to us by David Snow. Archaeologist Matt Cuba provided photographs of a Chupadero jar with riveted handle from WSMR. Our big thank you goes to Maxwell Museum's Archaeology Collections Manager Karen Price for allowing us to review ceramics from Adams Corona Ruin and Hiner Ruin. At the same time we also thank Maxwell Museum Staff for allowing us to publish images of ceramics showing evidence for riveted handles. Finally, we thank the entire Office of Contract Archeology for the logistical support of this research project.

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Plain Brown Ware Production and Distribution in the Northeastern Hohokam Periphery and Arizona Transition Zone: Temper Provenance Data and Economic Implications

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During the last 30 years, temper-based provenance studies of Phoenix and Tucson Basin Hohokam plain ware pottery have documented extensive exchange of utilitarian containers made using a small number of spatially restricted materials. Abbott (2009; also Van Keuren et al. 1997) has identified specialized production of Hohokam plain ware in the Phoenix Basin based on the abundance of pottery tempered with either South Mountain Granodiorite sand or crushed middle Gila River micaceous schist (Motsinger 1998:92). On average, 79 percent of the plain ware pottery recovered from A.D. 450-1000 deposits at nine Phoenix Basin sites contained temper from those two sources (Abbott 2009:Table 3). Recent excavations at La Villa, AZ T:12:148 (ASM), provide a site-specific example of that pattern over the same span of time (Heidke and Aragon 2016:Table 5.10; Heidke and Ownby 2015:Table 5.9; Ownby 2016:Table 4.6). In the Tucson Basin, specialized plain ware pottery production began sometime after A.D. 700 and before A.D. 950 (Heidke 2003:Table 5.16; Heidke et al. 2002:Figure 12.6), with provenance data from Honey Bee Village, AZ BB:9:88 (ASM), suggesting that specialized plain ware pottery production began by A.D. 850 (Heidke 2012:Table 7.12). Critically, there are sites in both the Phoenix and Tucson Basins that provide evidence of community specialization in pottery manufacture. Those sites have yielded direct evidence of production and high percentages of plain ware made from a locally available temper resource (Heidke 2011:Table 4.11).

Temper-based provenance studies have also been ongoing in the Lower Verde River (Heidke et al. 1996; Miksa et al. 2003), Upper and Lower Tonto Creek (Heidke et al. 2017; Heidke and Miksa 2000; Miksa 1992; Miksa and Heidke 1995; Ownby et al. 2016; Stark and Heidke 1992), Flagstaff (Heidke et al. 2007; Miksa et al. 2007), and Snowflake (Heidke et al. 2016) areas, although they have not received as much attention as those conducted using pottery from the Phoenix and Tucson Basins. This short article seeks to rectify that situation. Different approaches to plain ware production and distribution before and after A.D. 1000 have been documented in both Phoenix and Tucson Basin collections. There is an overwhelming consensus among archaeologists that the Hohokam regional system (Wilcox 1979) achieved its greatest influence and maximum areal extent from A.D. 750 to 1000 (Crown 1991a, 1991b; Doyel 1991; Gumerman 1991; Wilcox 1991a). Therefore, the current study focuses on plain brown ware made before A.D. 1000.

Provenance data collected from Hohokam sites located east-northeast of the Phoenix Basin are compared with similar data from Arizona Transition Zone sites. The Hohokam sites are located in an area Wood and McAllister (1980:180) term the Northeastern Hohokam

Periphery, although Wilcox and Shenk (1977:183) would place two of the sites—CTC, AZ U:2:95 (ASM), and Middendrum, AZ U:2:107 (ASM)—in the Hohokam "core area," rather than the periphery, because they are located along the Lower Verde River below Bartlett Dam. Arizona Transition Zone sites are located in the Upper Tonto Basin, an area whose material culture is distinctly different from that documented in the Hohokam-influenced lower basin (Clark and Gilman 2012; Elson et al. 1995:449; Whittlesey 1998a, 1998b), north of Flagstaff, east of Snowflake, and the sub-Mogollon Rim area east of Payson. It should be noted that Wilcox (1991b:271) places the Flagstaff area in the Hohokam "far periphery," whereas I have followed Herr (2012b) and included sites located there in the Arizona Transition Zone group.

The natural environments of the two study areas are very different. As with all Hohokam settlements, the sites included here are located on the floors and slopes (*bajadas*) of basins, generally at elevations below 3,500 ft (1,065 m), and coincide with those areas most favorable for floodwater and irrigation farming, as well as for gathering mesquite and cactus products (Fish and Nabhan 1991:30; Masse 1991:216; Turner and Brown 1994). Critically, the Mogollon Rim and other uplands abruptly limit the distribution of those important resource plants (Fish and Nabhan 1991:42). In contrast, the Arizona Transition Zone represents the mountainous band across the central portion of the state that separates the Colorado Plateau from the Southern Basin and Range province (Menges and Pearthree 1989:Figure 1). It is the wettest portion of Arizona, composed of microenvironments that vary with elevation, aspect, and underlying bedrock geology (Herr 2012b:78). Here, arable land is discontinuous; accordingly, farming households were dispersed across the region (Herr 2012a). However, a variety of arboreal resources and game was widely available throughout the region (Brown 1994; Pase and Brown 1994).

Prehistoric potters working in all of the areas included in the study tempered their clays with sand. Sand temper provenance was determined petrographically following methods discussed in Miksa and Heidke (1995, 2001). Actualistic petrofacies models of the fluvial sand compositions available in each area were created using the Gazzi-Dickinson point-counting technique (Dickinson 1970; Gazzi 1966) and multivariate statistical analysis of the resulting petrographic data (Figure 1). Once modeled, individual petrofacies compositions were identified in sand-tempered pottery using a low power binocular microscope, verified petrographically, and provide indirect evidence of production (Costin 1991). Interpretation of the provenance data is contingent upon knowing how far prehistoric potters are likely to have traveled to collect temper and what sand temper resources were locally available to the inhabitants of a particular site. Agreement between the composition of a sherd's sand temper and that of the sands found in the washes located closest to the recovery site may be the best measure of "local" ceramic production, although ethnographic data summarized in Heidke (2011:Table 4.10; Heidke et al. 2002:Table 12.2) suggest prehistoric potters may have traveled up to 3 km to collect a sand temper resource. Temper compositions that are not available within 3 km of a site are considered "nonlocal" resources, and pots tempered with them nonlocal items.

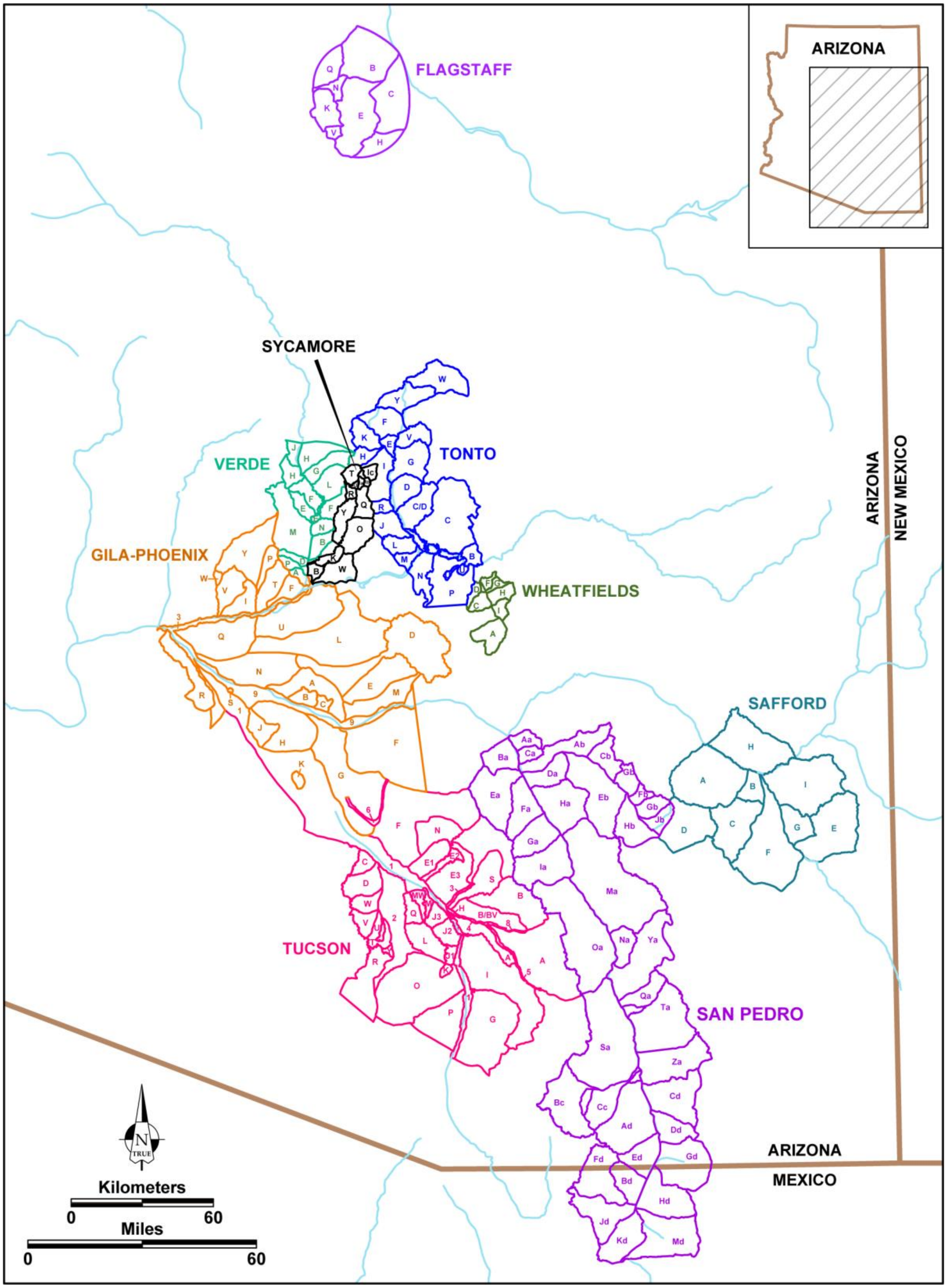

Figure 1. Location of Arizona and northern Sonora petrofacies models. Individual petrofacies within each model are indicated by their letter designation.

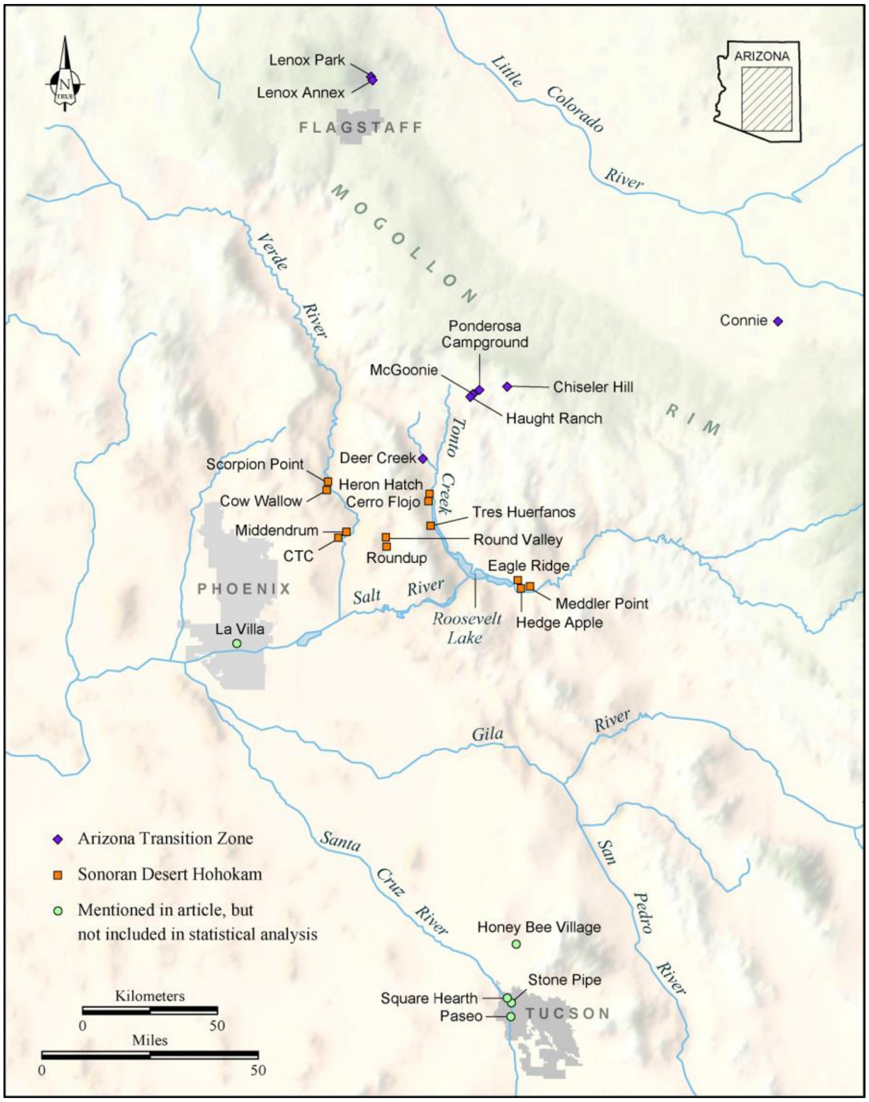

Figure 2. Location of Sonoran Desert Hohokam and Arizona Transition Zone archaeological sites discussed in this study.

The location of sites included in the plain brown ware provenance study are shown in Figure 2, while Table 1 reports their names, as well as listing the deposits from those sites that plain brown ware samples were drawn from and their dating. The dating used here reflects the author's assessment of the published ceramic type data. Temper sources are reported in Table 2. Local temper sources are reported in two columns. Sources shown in the geologically compatible column are those found in the washes located closest to a site, whereas those shown in the behaviorally local column are available in washes located within 3 km of the site. Compositions that are not available within 3 km of a site are reported as nonlocal. Binocular microscopic and petrographic sampling procedures varied by project, although each strove to provide a representative collection for analysis (Heidke and Miksa 2000:112; Miksa and Heidke 1995:176, 179; Miksa et al. 2007:119; Ownby et al. 2016:16; Stark and Heidke 1992:140-141, 156; Whittlesey and Montgomery 2009:230-232; Whittlesey et al. 1998:6-7).

Table 1. Sites included in the plain brown ware provenance analysis.

Area	Subarea	Site Number	Site Name	Site Type	Features	Deposit Date Range (A.D.)
Hohokam	Lower Verde	AZ U:2:61 (ASM)	Cow Wallow	Farmstead	6	850-950
Hohokam	Lower Verde	AZ U:2:80 (ASM)	Scorpion Point	Ballcourt village	2, 3, 9, 10, 16, 19, 26, 60, 61, 82, 98, 162, 228	750-950
Hohokam	Lower Verde	AZ U:2:95 (ASM)	CTC	Farmstead	2, 3	940-960
Hohokam	Lower Verde	AZ U:2:107 (ASM)	Middendrum	Hamlet	1, 2	750-950
Hohokam	Lower Tonto Basin	AZ U:3:224 (ASM)	Heron Hatch	Farmstead	1, 5	750-950
Hohokam	Lower Tonto Basin	AZ U:3:294 (ASM)	Cerro Flojo	Farmstead	1, 15, 17, 21, 55, 56, 60	850-950
Hohokam	Lower Tonto Basin	AZ U:3:298 (ASM)	Tres Huerfanos	Farmstead	102, 104, 201	850-950
Hohokam	Lower Verde	AZ U:3:337 (ASM)	Roundup	Farmstead/Hamlet	4, 12	940-960
Hohokam	Lower Verde	AZ U:3:341 A (ASM)	Round Valley	Farmstead/Hamlet	3, 9, 12	750-850
Hohokam	Lower Tonto Basin	AZ V:5:4 (ASM)	Meddler Point	Village	6, 211	850-950
Hohokam	Lower Tonto Basin	AZ V:5:104 (ASM)	Eagle Ridge	Hamlet	Locus B (all)	100-600
Hohokam	Lower Tonto Basin	AZ V:5:189 (ASM)	Hedge Apple	Farmstead/Hamlet	2, 3, 4, 6, 7, 11, 15, 18, 19, 20, 45	750-850
Transition Zone	Little Green Valley	AZ O:12:19 (ASM)	Ponderosa Campground	Pithouse habitation	31, 41, 48, 113, 131	600-1000
Transition Zone	Little Green Valley	AZ O:12:25 (ASM)	McGoonie	Pithouse habitation	1, 2, 8, 10, 11, 15, 17, 18, 21, 22, 27	850-1000
Transition Zone	Little Green Valley	AZ O:12:38 (ASM)	Haught Ranch	Pithouse habitation	2, 7, 10, 11, 23, 24, 28, 30, 46	600-900
Transition Zone	Upper Tonto Basin	AZ O:15:52 (ASM)	Deer Creek	Hamlet	2, 6, 11, 12, 13, 14, 18, 21, 22, 25, 31, 32, 46, 48, 50, 51, 59, 66, 70, 71, 85, 88, 117	750-850
Transition Zone	Sharp Creek	AZ P:9:39 (ASM)	Chiseler Hill	Pithouse habitation	1, 2	700-950
Transition Zone	Hay Hollow Valley	AZ Q:5:2 (ASM)	Connie	Large habitation	4, 5, 8, 13, 14, 15, 17, 20, 22, 24, 31, 32, 33, 41, 48, 56, 57, 67, 68	300-600
Transition Zone	Flagstaff	NA 20,700	Lenox Park	Large habitation	Locus A (all)	400-1025
Transition Zone	Flagstaff	NA 20,700	Lenox Park	Large habitation	Locus B (all)	400-700
Transition Zone	Flagstaff	NA 25,779	Lenox Annex	Small habitation	5	800-1000

Table 2. Local and nonlocal temper sources.

Area	Site Name	Deposit Date Range (A.D.)	Local Plain Brown Ware Temper Sources: Geologically Compatible	Local Plain Brown Ware Temper Sources: Behaviorally Local	Nonlocal Temper Sources	Citation
Hohokam	Cow Wallow	850-950	Verde H	Verde F and G	Phyllite	Heidke et al. 1996; Montgomery and Heckman 1998a
Hohokam	Scorpion Point	750-950	Verde H	Verde G and J	Other sands, phyllite, schist	Heidke et al. 1996; Montgomery and Heckman 1998b
Hohokam	CTC	940-960	Verde E	Verde F and N	Other sands, phyllite, schist	Heidke et al. 1996; Montgomery and Heckman 1998a
Hohokam	Middendrum	750-950	Verde E	Verde F and N	Other sands, phyllite, schist	Heidke et al. 1996; Montgomery and Heckman 1998a
Hohokam	Heron Hatch	750-950	Slate (Tonto I)	Hackberry (Tonto D) and Cocomunga (Tonto G)	Other sands, schist	Heidke and Miksa 2000
Hohokam	Cerro Flojo	850-950	Slate (Tonto I)	Hackberry (Tonto D)	Other sands, schist	Heidke and Miksa 2000
Hohokam	Tres Huerfanos	850-950	Slate (Tonto I)	Hackberry (Tonto D)	Other sands, schist	Heidke and Miksa 2000
Hohokam	Roundup	940-960	Pine (Sycamore O)	Maverick (Sycamore Y)	Other sands, phyllite, schist	Miksa et al. 2003
Hohokam	Round Valley	750-850	Maverick (Sycamore Y)	Pine (Sycamore O), Crabtree (Sycamore Q)	Other sands, phyllite, schist	Miksa et al. 2003
Hohokam	Meddler Point	850-950	Meddler (Tonto B)	Pinto (Tonto P), Wildcat-Poison Terraces (Tonto U)	Other sands, schist	Miksa and Heidke 1995
Hohokam	Eagle Ridge	100-600	Meddler (Tonto B)	Armer (Tonto C), Pinto (Tonto P), Wildcat-Poison Terraces (Tonto U)	Other sands, schist	Miksa and Heidke 1995
Hohokam	Hedge Apple	750-850	Meddler (Tonto B)	Pinto (Tonto P), Wildcat-Poison Terraces (Tonto U)	Other sands, schist	Miksa and Heidke 1995
Transition Zone	Ponderosa Campground	600-1000	Lion Springs (Tonto Y), Doubtful Canyon (Tonto W)	N/A	Other sands	Ownby et al. 2016
Transition Zone	McGoonie	850-1000	Lion Springs (Tonto Y)	N/A	Other sands	Ownby et al. 2016
Transition Zone	Haught Ranch	600-900	Lion Springs (Tonto Y)	N/A	Other sands	Ownby et al. 2016
Transition Zone	Deer Creek	750-850	Deer (Tonto H)	Gisela (Tonto E), Slate (Tonto I), Clover (Tonto K)	Other sands	Heidke and Miksa 2000; Stark and Heidke 1992
Transition Zone	Chiseler Hill	700-950	Doubtful Canyon (Tonto W)	N/A	Other sands	Ownby et al. 2016
Transition Zone	Connie	300-600	Unnamed project, specific source	N/A	Other sands	Heidke et al. 2016
Transition Zone	Lenox Park, Locus A	400-1025	Sugarloaf (Flagstaff K)	Lenox (Flagstaff E)	San Francisco Mountain, Tusayan, Prescott Gray Ware	Miksa et al. 2007
Transition Zone	Lenox Park, Locus B	400-700	Sugarloaf (Flagstaff K)	Lenox (Flagstaff E)	San Francisco Mountain, Tusayan, Prescott Gray Ware	Miksa et al. 2007
Transition Zone	Lenox Annex	800-1000	Sugarloaf (Flagstaff K)	Lenox (Flagstaff E)	San Francisco Mountain, Tusayan, Prescott Gray Ware	Miksa et al. 2007

Group membership of sites located in the two geographic areas was evaluated using discriminant analysis. Discriminant analysis is a statistical technique designed to study differences between and among two or more groups of objects with respect to one or more variable(s) (Klecka 1980). In the current study, individual sites, or site loci, are the objects, and the quotient resulting from dividing the count of sherds tempered with locally available material by the total sherd count is the variable. Probabilities of group membership resulting from the discriminant analysis are summarized in Table 3. The group membership of 80.9 percent of the site samples (17 of 21) was predicted accurately using the temper provenance-based discriminating variable.

Klecka (1980:50) notes that while the percentage of cases predicted accurately is the most intuitive measure of discrimination, the magnitude of that percentage should be judged in relation to the expected percentage of correct classifications made by random assignment. A proportional reduction in error statistic, *tau*, can be calculated, which provides a standard measure of improvement over random assignment regardless of the number of groups (Klecka 1980:50-51). The maximum value for *tau* is 1.0, a value that represents no errors in prediction, while a value of 0.0 indicates no improvement over random assignment. Classification based on the discriminant model resulted in *tau* 0.619, indicating that 61.9 percent fewer errors were made than would be expected by random assignment (i.e., four actual errors versus 10.5 expected by chance). The 80.9 percent accuracy and 0.619 value of *tau* argue for the effectiveness of the discriminant model. Like contemporaneous Hohokam sites in the Phoenix and Tucson Basins, the Northeastern Hohokam Periphery sites yielded relatively high percentages of nonlocal plain ware, whereas Arizona Transition Zone sites have relatively high percentages of locally made plain ware.

Reviewing characteristics of the four misclassified sites is informative. Two of the misclassifed sites—Eagle Ridge, Locus B, AZ V:5:104 (ASM), and Connie, AZ Q:5:2 (ASM)—represent places where occupation ended by A.D. 600. This suggests that regional patterns in ceramic production and distribution before A.D. 600 may differ markedly from those documented later in time, a point returned to below. The other two misclassified sites—Cow Wallow, AZ U:2:61 (ASM), and Chiseler Hill, AZ P:9:39 (ASM)—are among the three sites included in the discriminant analysis in which variable values were based on fewer than 20 sherds. That finding suggests small sample sizes may not be as representative of regional patterns as those based on larger samples.

The indirect manufacturing evidence summarized in Table 3 documents the occurrence of plain brown ware pottery made with locally available tempers in 18 of the 21 collections. Only those from Tres Huerfanos, AZ U:3:298 (ASM); Chiseler Hill; and Connie lack pottery made at or near the site. Accordingly, one might expect to find some direct evidence of production—such as stored raw materials (clay or pigment), forming or finishing tools (turntables, anvils, scrapers, polishers), facilities associated with production (clay storage and mixing basins, kilns, wind screens), or manufacturing debris ("wasters") (Mills and Crown 1995; Stark 1985; Sullivan 1988)—at many of the sites included in this study. Unfortunately, direct evidence of production collected from most sites is equivocal at best.

Table 3. Provenance data and discriminant analysis results. Misclassified sites are indicated by shaded predicted group membership probabilities.

Area	Site Name (Discriminant Analysis Object)	Deposit Date Range (A.D.)	Temper Provenance		Local ÷ Total (Discriminant Analysis Variable)	Discriminant Analysis Predicted Group Membership		Citation
			Local	Nonlocal		Hohokam	Arizona Transition Zone	
Hohokam	Cow Wallow	850-950	8	2	0.800	0.314	0.686	Heidke et al. 1996; Montgomery and Heckman 1998a
Hohokam	Scorpion Point	750-950	15	69	0.179	0.790	0.210	Heidke et al. 1996; Montgomery and Heckman 1998b
Hohokam	CTC	940-960	11	12	0.478	0.577	0.423	Heidke et al. 1996; Montgomery and Heckman 1998a
Hohokam	Middendrum	750-950	13	12	0.520	0.542	0.458	Heidke et al. 1996; Montgomery and Heckman 1998a
Hohokam	Heron Hatch	750-950	4	25	0.138	0.812	0.188	Heidke and Miksa 2000
Hohokam	Cerro Flojo	850-950	1	36	0.027	0.863	0.137	Heidke and Miksa 2000
Hohokam	Tres Huerfanos	850-950	0	11	0.000	0.874	0.126	Heidke and Miksa 2000
Hohokam	Roundup	940-960	14	180	0.072	0.844	0.156	Klucas and Woodson 1999; Miksa et al. 2003
Hohokam	Round Valley	750-850	68	118	0.366	0.667	0.333	Klucas 1999; Miksa et al. 2003
Hohokam	Meddler Point	850-950	4	32	0.111	0.826	0.174	Heidke and Miksa 2000
Hohokam	Eagle Ridge, Locus B	100-600	40	13	0.755	0.348	0.652	Heidke and Miksa 2000
Hohokam	Hedge Apple	750-850	7	105	0.063	0.848	0.152	Heidke and Miksa 2000
Transition Zone	Ponderosa Campground	600-1000	314	14	0.957	0.211	0.789	Heidke et al. 2017
Transition Zone	McGoonie	850-1000	308	24	0.928	0.229	0.771	Heidke et al. 2017
Transition Zone	Haught Ranch	600-900	373	19	0.952	0.215	0.785	Heidke et al. 2017
Transition Zone	Deer Creek	750-850	96	39	0.711	0.382	0.618	Heidke and Miksa 2000
Transition Zone	Chiseler Hill	700-950	0	14	0.000	0.874	0.126	Heidke et al. 2017
Transition Zone	Connie	300-600	0	1,255	0.000	0.874	0.126	Heidke et al. 2016
Transition Zone	Lenox Park, Locus A	400-1025	4,980	219[a]	0.958	0.211	0.789	Miksa et al. 2007; Van Keuren and Herr 2007
Transition Zone	Lenox Park, Locus B	400-700	432	39[a]	0.917	0.235	0.765	Miksa et al. 2007; Van Keuren and Herr 2007
Transition Zone	Lenox Annex	800-1000	160	74[a]	0.684	0.404	0.596	Miksa et al. 2007; Van Keuren and Herr 2007

[a]Flagstaff subarea nonlocal counts include unpainted San Francisco Mountain, Tusayan, and Prescott Gray Ware types.

No ground stone pottery anvils were recovered from any of the sites, but at least 135 polishers were recovered from 17 of them (Adams 1995b, 2002; Craig and Eppley 1992; Heidke et al. 2007; Knoblock et al. 2003; Towner et al. 1998). The four sites, or loci, lacking polishers are Middendrum; Roundup, AZ U:3:337 (ASM); Chiseler Hill; and Lenox Park, Locus B. Unfortunately, tribological studies of polisher surfaces have found that, in many cases, they were used to make wood or bone items or to apply wall/floor plaster (Adams 1995a:86). In two recent, tribological studies of ground stone artifacts recovered from sites located in the Lower Tonto Basin, Adams (1995a:Table 2.3, 2002:Table 10.13) reports that only 104 of 203 polishers (51.2 percent) were used in pottery manufacture. Her finding calls into question the usefulness of a generic “polisher” artifact category when attempting to assess direct manufacturing evidence.

DISCUSSION

Results of the provenance data discriminant analysis indicate the exchange of plain, brown ware pottery was common in the Northeastern Hohokam Periphery, whereas little exchange took place within the Arizona Transition Zone. The discriminant analysis results also suggest that approaches to plain ware production and distribution differed before and after A.D. 600. Early Ceramic Period sites located in both geographic areas exhibited unusual local: nonlocal provenance data. More than 75 percent of the plain ware recovered from the Early Ceramic Period site located in the Northeastern Hohokam Periphery—Eagle Ridge, Locus B—was tempered with locally available sands, whereas all the plain ware recovered from the Early Ceramic Period site located in the Arizona Transition Zone—Connie—was tempered with diabasic sands that were not available locally (Heidke et al. 2016). The nearest mapped geologic units with a diabasic composition are located far to the southwest of the site along the Mogollon Rim, principally in Gila County, Arizona (Wrucke 1989:Figure 1).

Early Ceramic Period collections may be especially sensitive to site-specific, rather than broadly regional, developments. Plain ware temper provenance data collected from three Early Ceramic sites located in the Tucson Basin suggest the range of local:nonlocal signatures one might expect to encounter. At the Paseo site, AZ BB:13:111 (ASM), nearly 70 percent of the plain ware was found to be tempered with sands available within 3 km of the settlement (Heidke and Ownby 2016:Table 5.8), a provenance signature not unlike that exhibited by the Eagle Ridge pottery. The collection from Square Hearth, AZ AA:16:745 (ASM), provides a very different signature. There, more than 88 percent of the plain ware was tempered with a nonlocal, but regionally available, sand composition (Heidke et al. 1998:Table 13.9). The collection from Stone Pipe, AZ BB:13:425 (ASM), falls somewhere between those two extremes. Plain ware produced in four different locations within the Tucson Basin was identified, with the locally available source comprising approximately 21 percent of the collection (Heidke et al. 1998:543). Finally, the collection from the Snowflake-area Connie site provides yet another signature. As mentioned above, there the plain ware temper is regionally unavailable (Heidke et al. 2016:Table 10.7). Therefore, the Early Ceramic Period temper provenance data imply that some people moved over large areas at this time, that potters went great distances to acquire specific resources, and/or that a large amount of exchange in utilitarian goods took place among early farming communities. Those three hypotheses need not be mutually exclusive.

By A.D. 700, the two regionally variable ceramic production and distribution patterns identified in this study were established, at least in the collections included in the discriminant analysis. The difference between the patterns draws a contrast between plain ware production and distribution in a land-rich labor-poor portion of the Southwest—the Arizona Transition Zone—and a peripheral Hohokam area, where a premium was placed on labor (Doyel 1991:259; Herr 2012b:92). The small population size of Arizona Transition Zone communities left little opportunity for economic specialization, with plain brown ware manufacture apparently a result of unspecialized household production using locally available temper resources (Hagstrum 1995:287; Herr 1999:16). Making one’s own personal possessions was likely a basic part of life, and the notion of ownership may have been closely associated with that of craftsmanship (Erikson 2009:173, 175).

Canal irrigation systems in the Hohokam core area required the labor of many people to build, maintain, and rebuild (Hegmon et al. 2016:173). Inter-community dependencies arose after individual households came to rely upon the surplus production of complementary goods made in other communities. Exchange may have initially involved only food-stuffs (Gasser and Miksicek 1985:494; Hodder and Orton 1976:77), with craft specialities developing somewhat later in time, after known and reliable market places were established. Although many archaeologists believe that the Hohokam ballcourt system was instrumental in facilitating exchange within the regional system (Abbott et al. 2001:21; Abbott et al. 2007; Craig et al. 2012:52; Doyel 1991:252; Heidke et al. 2002:171; Wilcox 1979:111), the Lower Tonto Basin plain ware provenance data indicate that need not have been the case, because no ballcourts have been documented there (Elson et al. 1995:448). However, a relatively small Hohokam population in the lower basin may have precluded the need for an integrative structure, such as a ballcourt, or, if one was present, it may now be covered by Roosevelt Lake, taken out by Tonto Creek or the Salt River, or remain unrecognized or undiscovered (Clark and Vint 2004:277; Gregory 1995:148; Stark et al. 1995:354).

Whittlesey (1998b:619) marshals evidence that shows each peripheral area adopted and incorporated elements of Hohokam culture—red-on-buff pottery, house-in-pit domestic architecture, courtyard group and plaza-based site structure, cremation mortuary complex and ritual paraphernalia, and ballcourt ceremonialism—in distinctive ways. Specialized craft production, however, appears to be an element present in both core and peripheral areas. Testing that assertion further would require additional petrofacies modeling and the collection of ceramic provenance data from other Hohokam peripheries, such as Gila Bend, Agua Fria, Upper Verde River, Safford, San Pedro, or Upper Santa Cruz. Similarly, testing the assertion that unspecialized plain brown ware production was common among Arizona Transition Zone households would require similar work using pottery from other sites located in areas where the geology makes it feasible to determine temper provenance accurately and precisely (Ownby and Miksa 2012:Figure 1; Reynolds 1988).

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More than 600 sand samples were collected during the course of those eight projects. Petrographers James P. Lombard, Elizabeth J. Miksa, Diana Kamilli, Michael K. Wiley, Danielle Montague-Judd, Carlos Lavayen, and Mary F. Ownby collected, processed, point-counted, statistically analyzed, and described those sands, developed the quantitative and qualitative petrofacies models used to characterize temper sand provenance in the archaeological ceramic collections, and verified/refined the binocular microscopic temper characterizations. Ceramicists Tiffany C. Clark and Meaghan A. Trowbridge recorded the temper provenance data from State Route 260—Payson to Heber Project area site collections, while Susan D. Hall assisted the

author in recording temper provenance data during the State Route 77—Snowflake Passing Lanes Project.

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Response to Andy Ward (Pottery Southwest 33(1)--

Confusion at the frog races!

Clint Swink

In "Slip Experimenting" (PSW Vol. 32, No. 4) I state in the beginning sentence under "Procedure," that "The primary goal of this slip experiment was to locate a bright red-firing montmorillonite clay that enables an organic paint to fire black, a characteristic of some White Mountain Redwares (WMRW) especially St. Johns Polychrome (Carlson 1970; Wilson 2012)."

That was my goal and I did not find that clay in this round of experiments. One doesn't usually get all the gifts at once.

I sincerely apologize for Mr. Ward's and other reader's confusion when I cooked those frogs in firing #405 which was designed to show the limited oxidation *potential* of organic paints on 20 slip clays applied on the bowl face, and oxidation color of the same clays to the bowl exterior. The firing was not designed to produce St. John's Polychrome as readers may have thought, only the individual clay's *potential* toward that goal, and none did. Andy also noted that the "sketchy part of my report was that involving the firing." And he went on to say: "It would have been nice to see a photo or two or even a sketch to help show the firing process."

In that paper I wrote: "Firing #405 had to be a combination of atmospheres. I drew on my 4-step limited oxidation model (Swink 1993, 2004) for the bowl face which would bring out the best organic paint results, and I wanted full oxidation on the exterior to illustrate the range of slip colors which could be expected. Additionally the paint tests would reflect their qualities in each atmosphere. Simply put, this was to be an above ground smother with later oxidation, which was designed to create and preserve organic blacks at high temperatures and allow the reds to oxidize at lower temperatures."

Figures 1 through 6 provide a short version of that firing discussion with sketches. For more verbal detail please see the original article.

The Primary Fire

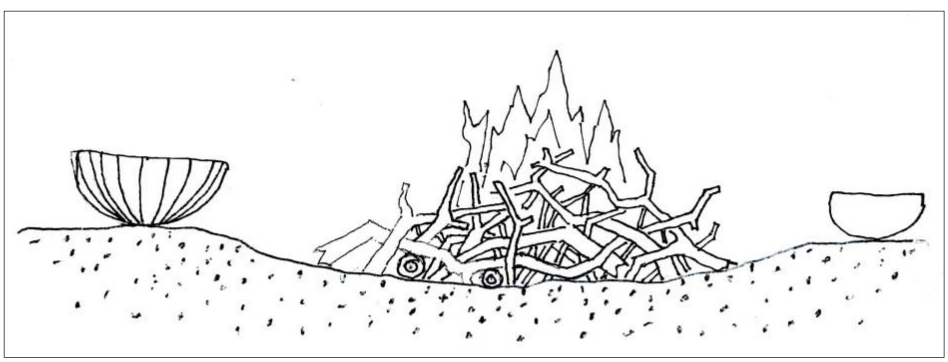

Figure 1: In a shallow basin, a primary fire was burned to dry the pots and create a bed of hot coals.

The Setting

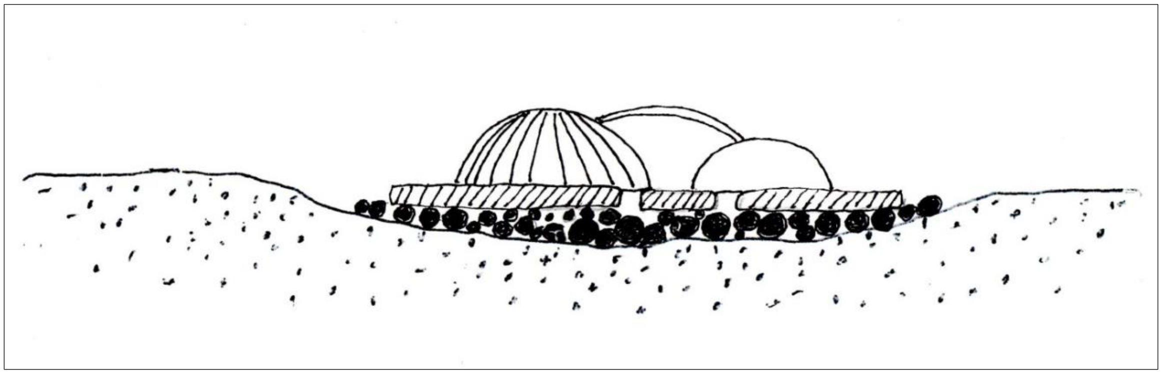

Figure 2: Tabular sandstone was placed on the hot coal bed to accomadate the inverted pottery. A firing sherd was placed over the void between the pots.

The Secondary Fire

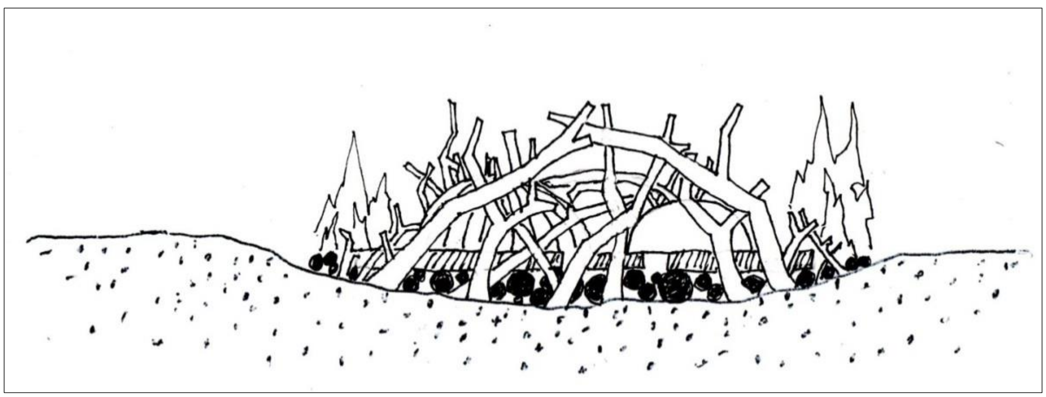

Figure 3: A fuel support tripod was built over the setting; wood fuel was added and allowed to ignite on the margins of the setting.

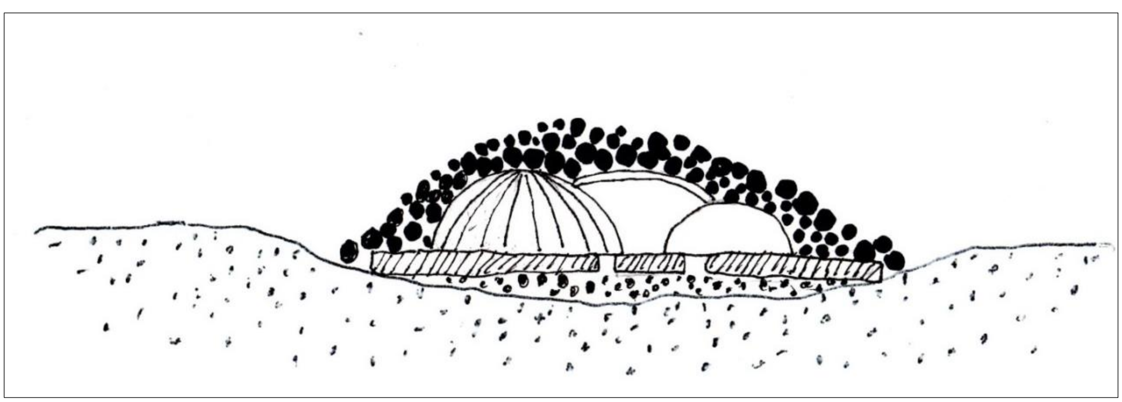

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Figure 4: The Secondary Fire burned for 70 minutes until a layer of coals covered the setting.

The Smothering

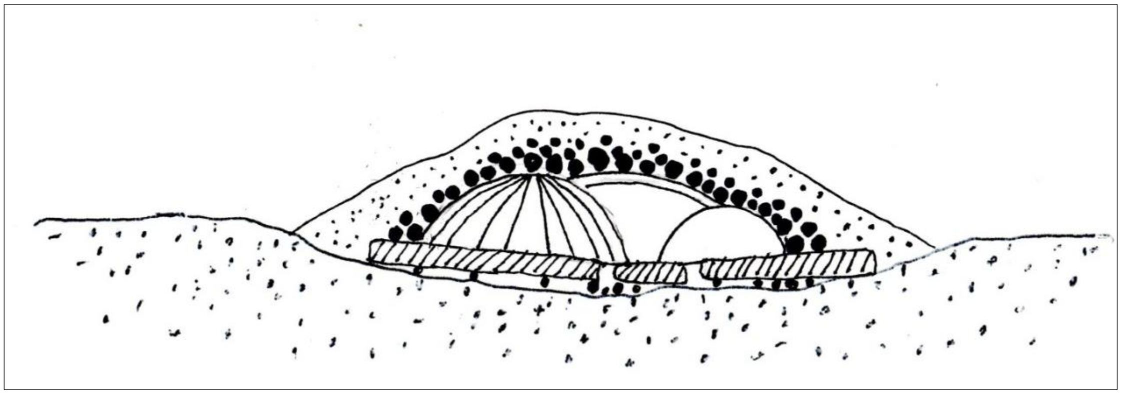

Figure 5: At the end of the secondary firing after all flaming fuel was removed, the firing was smothered with dirt.

The Oxidation

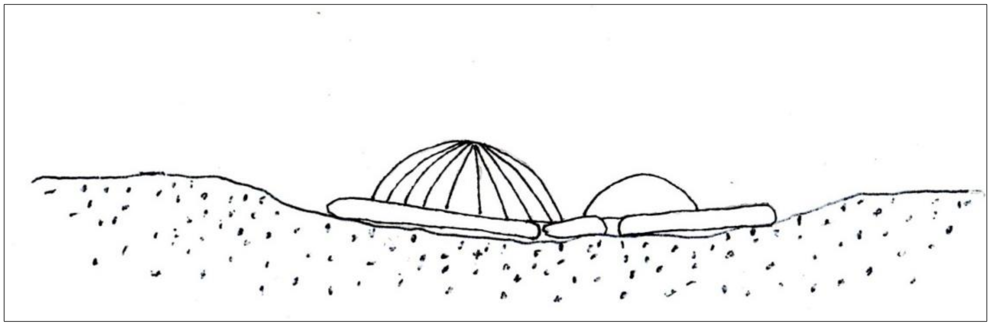

Figure 6: After 20 minutes the firing was uncovered and allowed to completely oxidize.

Yes, this was an experimental firing. I can't remember any of my firings that didn't have an experimental component. What I learned in this firing will be put to use, with some tweaking and experimenting on the forthcoming St. John's polychrome firing. Following firing #405, another slip test bowl was fired which produced a dandy red-firing montmorillonite that won the red frog jumping race hands down.

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Announcements

Southwest Kiln Conference
August 4-6, 2017
Tijeras Ranger Station, Tijeras, NM

The Southwest Kiln Conference (SWKC) focuses on the art, science and technology of recreating prehistoric southwestern pottery. This event has been held nearly every year since 2003 at various sites in the American Southwest. The SWKC provides opportunities for people with a range of interests and skill levels, presentations and demonstrations of prehistoric pottery technology, pottery firings and a field trip to dig clay.

Pecos Conference 2017
August 10-13, 2017
Rowe Mesa, New Mexico

The 2017 Pecos Conference will take place at picturesque Rowe Mesa in Santa Fe National Forest, August 10-13, 2017. The conference this year is just five miles off I-25 from the Rowe exit east of Santa Fe. The roads to the site are accessible for cars, trucks, RVs and trailers. Registration for attendees, presenters and vendors for the 2017 conference is now open via the Registration Page on the Pecos Conference web site at www.pecosconference.org. For additional information contact:Gary Newgent at organizer@pecosconference.org

20th Biennial Jornada Mogollon Conference
El Paso Museum of Archaeology
October 13 & 14, 2017

The El Paso Museum of Archaeology will host the 20th Biennial Jornada Mogollon Archaeology Conference in October 2017 in El Paso, Texas. Proposals for individual papers or sessions are now being accepted. Abstracts are due August 19, 2017; for more information see: https://archaeology.elpasotexas.gov/events/2017/10/13/call-for-papers.

Society for American Archaeology 83rd Annual Meeting
April 11-18, 2018
Washington, D.C.

Submissions for presentations are now open for the 2018 SAA Annual Meeting in Washington, D.C. The deadline is September 7, 2017. For additional information visit the SAA website at http://saa.org/AbouttheSociety/AnnualMeeting/tabid/138/Default.aspx.

Old Pueblo Archaeology Bulletin

The latest issue of the ***Old Pueblo Archaeology*** bulletin – issue no. 78 – has just been published electronically! This new issue's feature article by archaeologists Barbara J. Roth and Darrell G. Creel is titled "Mimbres Pueblo Life and Livelihood." In it Dr. Roth and Dr. Creel summarize the Mimbres culture of the ancient American Southwest, touching on its environmental setting, history of archaeological research, pueblo construction, ceramics, daily life, and regional depopulation, and including information on their recent excavations at Elk Ridge, a Classic Mimbres pueblo site. Previous issues of the bulletin can be viewed at Old Pueblo Archaeology Center's website at http://www.oldpueblo.org/about-us/publications/

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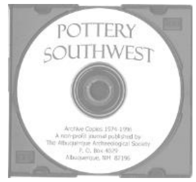

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