POTTERY SOUTHWEST

Volume 37, No. 3-4 MARCH 2022
FALL-WINTER ISSN 0738-8020

MISSION STATEMENT

Pottery Southwest, a scholarly journal devoted to the prehistoric and historic pottery of the Greater Southwest (*https://potterysouthwest.unm.edu*), provides a venue for student, professional, and avocational archaeologists in which to publish scholarly articles, as well as providing an opportunity to share questions and answers. Published by the Albuquerque Archaeological Society since 1974, *Pottery Southwest* is available free of charge on its website which is hosted by the Maxwell Museum of the University of New Mexico.

CONTENTS

Pottery Southwest is a non-profit journal of the Albuquerque Archaeological Society

POTTERY KILNS, UNFIRED SHERDS, AND LANDSCAPE ARCHAEOLOGY: EARLY PUEBLO I CERAMIC PRODUCTION AND EXCHANGE IN THE WHITE MESA PRODUCTION ZONE, SOUTHEASTERN UTAH

William A. Lucius, Ph.D., Independent Scholar and Ceramic Analyst

"One of the strongest arguments in favor of technological analysis is that it necessarily forces one to consider the human element. We can describe a potsherd by reference to its color, hardness, pattern, and so on, without giving a thought to the way it was made, but once we attempt to describe how it was made we must visualize the potter's environment and her particular limitations. In the attempt to obtain the same results by methods open to her, we gain a truer evaluation of her achievement and at the same time shape fresh questions never before apparent to us" (Shepard 1939:286-287).

Abstract

An almost total lack of data concerning the structure of ceramic production in the prehistoric Southwest and a similar lack of interest by ethnographers in documentation of those behaviors has resulted in a range of unwarranted assumptions about the organization of ceramic production in egalitarian farming cultures across the American Southwest. Without prior knowledge of exactly where on the landscape each piece of pottery was made (its production provenience), declarations about the exchange systems that served to distribute pottery to where it was found (its recovery provenience) are at best dubious. Excavation of the Early Pueblo I Jensen Site (42SA22747) in southeastern Utah revealed the association of pottery kilns with unfired sherds. Technological and typological ceramic analysis, in parallel with clay voucher sampling of clay sources in the 5 km resource catchment of the site, allowed for documentation of which portion of the ceramic assemblage represents local production in the White Mesa Production Zone, defined as a community of potters living in residential association with the clay resources used for pottery production in the general area of the modern town of Blanding on the northern end of White Mesa. Although the Jensen Site is where pottery was fired, the focus of the analysis is the larger production community on White Mesa. The analysis also serves to document sherds in the ceramic assemblage derived from other production zones in the larger Blanding Manufacturing Tract, resulting in an unambiguous record of ceramic production and exchange in the Early Pueblo I period (A.D. 750-800).

Introduction

In 2006, I was contacted by Winston Hurst to review excavation photos of several round-to-oval, rock-lined thermal features exposed during his excavation of the Jensen Site (42SA22747), an Early Pueblo I hamlet located within the town limits of Blanding in Southeastern Utah. Specifically, he wondered if they might be pottery firing kilns and asked for an opinion because of my expertise in ceramic technology and experience in the replication and firing of prehistoric Ancestral Pueblo pottery. I had doubts that they were kilns, given that they were unlike later Pueblo II and Pueblo III rectangular sandstone slab-lined kilns which are consistently located away from habitations and in direct association with the clay and fuel sources used for pottery firing (Brisbin and Ives 1999; Fuller 1984:54; Helm 1973). Subsequently, Winston provided a guided tour of the site, which consisted of two excavated Pueblo I pithouses and three soot-blackened, rock-lined basins within a partially backfilled house pit located directly to the west

(Figures 1 and 2). The features were kilns and the amount of charcoal visible throughout the depression was consistent with their repeated use and cleaning prior to reuse. During the tour Winston also noted that the excavation recovered unfired sherds, which is consistent with vessel breakage prior to firing. In the spirit of the volunteer nature of the Jensen Site excavation project, I offered to perform the ceramic analysis on a *pro bono* basis using an updated version of the Resource Approach to Ceramic Analysis (Lucius 2020:42), accompanied by clay voucher sampling of the 5 km resource catchment of the site (Roper 1979:120).

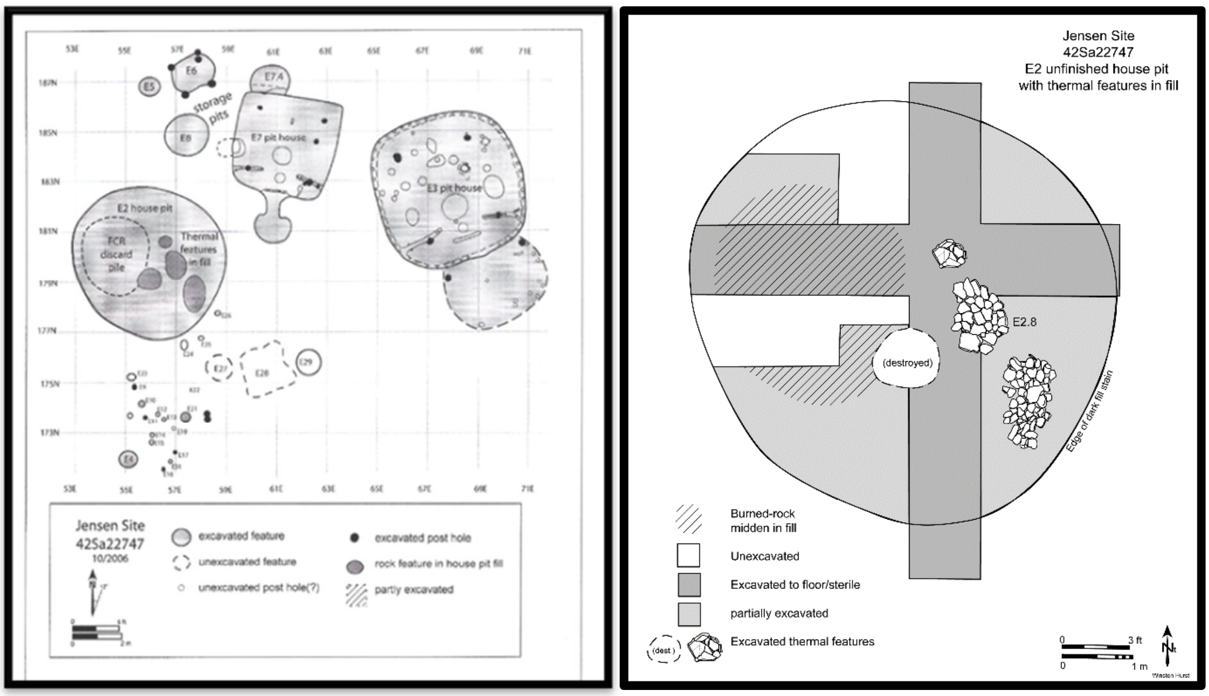


Figure 1. Jensen Site and kiln location plan maps, by Winston Hurst. Used with permission of Winston Hurst.

Upon completion of the analysis I returned the sherds and samples for curation and submitted my analysis report for inclusion in the final site report. Although I have occasionally referenced the analysis and its resulting data, the site report was never completed and therefore my contribution was never published. The following paper provides the analysis data in a stand-alone format focused on the topic of ceramic production and exchange from the perspective of compositional signatures of pottery production in the White Mesa Production Zone (hereafter the WMPZ), as documented by the ceramic assemblage recovered from excavation of the Jensen Site.

A Concern with Ceramic Production

Although traditional ceramic analysis links pottery types with large-order regional subdivisions of the Ancestral Pueblo occupation of the Northern Southwest (Breternitz, Rohn, and Morris 1974), the locational data that accompany ceramic assemblages record only their recovery proveniences. There is nothing about where pottery was recovered that is informative about where on the landscape potters made and fired those pots; their production proveniences are unknown.

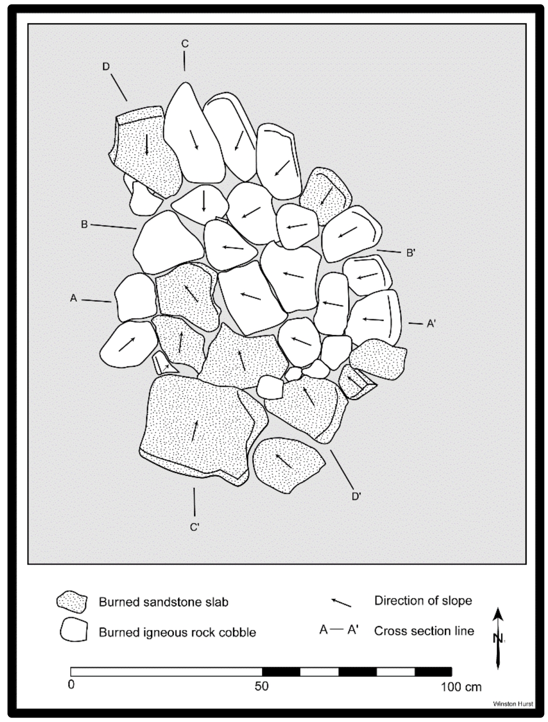


Figure 2. Jensen Site kiln photograph and plan map, by Winston Hurst. Used with permission of Winston Hurst.

The Resource Approach to Ceramic Analysis allows for typological assignments while being profoundly technological in scope (Shepard 1936:389-391). Technological analysis enlists sourcing analysis for the unambiguous assignment of ceramic artifacts to discrete production locales on the cultural landscape. This approach references ceramic ecology (Arnold 1975; Arnold 1976; Matson 1965) to state that potters reduce transport costs by living in residential association with the bulky raw materials of production, including clay, tempering materials, and fuel, and transport the finished products (pots). Every sherd therefore records its production provenience in terms of the temper and clay constituents of the ceramic paste. Technological analysis serves to document those resource combinations, but linking sherds to a production landscape is impossible without prior knowledge of where pottery production occurred (Scarlett, Speakman, and Glasscock 2007). The Criterion of Abundance (Bishop, Rands, and Holley 1982:310) cannot be enlisted to sort out local versus non-local ceramic production.

To my knowledge, the Jensen Site is the only excavated site within the Mesa Verde Region with unambiguous evidence of pottery production. The Jensen Site is located within the Blanding Manufacturing Tract, a geographic subdivision of the Mesa Verde Region where potters consistently crushed diorite river cobbles for temper (Lucius 2020:43). Attention to temper type allows for the association of sherds with the Blanding Tract. Documentation of production in the WMPZ, which represents a community of potters who used local resources for ceramic production (Rands and Bishop 1980:20) requires attention to clay type. The working assumption is that the clay sources used for production were obtained locally. A program of landscape archaeology was designed to locate and sample all clays within the 5 km resource catchment of the production community. Sourcing analysis requires knowledge of which of the available clays were selected for production. Simple comparison of ceramic pastes and clay sources is impossible because kiln firing destroys the original raw clay color of the ceramic paste. The unfired sherds recovered by excavation necessarily document local production, and thus they are the Rosetta Stone that records the raw clay colors of the pots fired at the site (Shepard 1936:399-400). Refiring analysis is a technological procedure that brings all sherds (or sherd nips), clay voucher samples, and unfired sherds to a comparable refired state that allows for identification of local production by refired clay colors, which are reported in Munsell notation (Lucius 2020:42-43). The following paper presents the analysis procedures used to generate the desired data of ceramic production in the WMPZ.

The Organization and Procedures of the Ceramic Analysis

Several classes of artifacts in the site assemblage are not ceramics. A small number of jacal fragments were noted. Basket-liners (Morris 1927) are readily recognizable as thick, sandy, and usually sooted clay fragments with smoothed interior surface and coiled basket impressions from being pressed while plastic onto open baskets. None contained temper nor were they intentionally fired. Similarly, none of the various raw clays contain temper. A single small, unfired, but sooted pinch pot lacking added temper was noted and recorded as raw clay.

Determination of local production necessarily requires identification and removal of exotic sherds from the discussion. Extra-regional sherds are readily identified by their distinctive temper types. Temper type is determined by inspection of a freshly fractured cross-section of every sherd using a binocular microscope at 30-power magnification (Shepard 1936:406) after they have passed through refiring analysis (Lucius 2020:42-43). Figure 3 documents the various temper types recorded in the ceramic assemblage in terms of percentages. Table 1 presents those exotic sherds (0.7% of the overall ceramic assemblage) assignable to the Mogollon Culture, the Kayenta Region, and an unknown production area in terms of Culture Category, ware, color variety, and type assignments. The ceramic data are summarized in terms of weight (in grams) rather than sherd counts (Millet 1979; Orton 1982; Solheim 1960).

Sherds exhibiting crushed conglomerate, iron sandstone, and crushed andesite tempers comprise a small fraction (6.3%) of the assemblage and represent exotic sherds from other manufacturing tracts within the Mesa Verde Region (Table 2; Figure 4). Crushed andesite temper is diagnostic of manufacture in the Dolores Tract of southwestern Colorado. Crushed conglomerate temper is diagnostic of manufacture in the Cedar Point Tract, which is adjacent to the Blanding Tract and extends into Colorado (Figure 5). The physical location of the Red Sandstone Tract on the landscape is unknown. No production zones have been defined for any of those tracts.

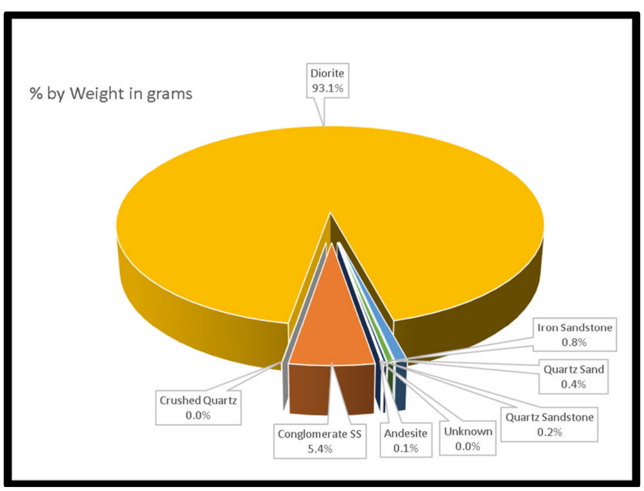


Figure 3. Jensen Site Ceramic Sherds by Temper Type (Total Wt. = 62,603.4 grams).

Table 1. Exotic Pottery Types Removed from the Analysis.
Italicized and underlined percentages separately equal 100%

Culture Category And Typology	Sherd Weight (g) Sum	Sherd Weight (g) % Type by Color Variety	% of Culture Category	% of Region	% of Color Variety
Ancestral Pueblo	326.2	-	77.9		
Kayenta Region	227.2	-		69.7	
Red Color Variety	29.9	-			13.1
Tallahogan Red	29.9	100.0			
Quartz Sand					
White Color Variety	164.2	-			72.3
Early Pueblo White	0.7	37.0			
Quartz Sand	*56.4*	*92.9*			
Quartz Sandstone	*4.3*	*7.1*			
Lino Black-on-white	103.5	63.0			
Quartz Sandstone					
Gray Color Variety	33.1	-			14.6
Early Pueblo Gray	33.1	100.0			
Quartz Sand					100.0
Unknown Region	99.0	-		30.3	
Orange Color Variety	29.1	-			29.4
Early Pueblo Orange	29.1	100.0			
Quartz Sandstone	*15.1*	*51.9*			
Unknown	*14.0*	*48.1*			
White Color Variety	9.1	-			9.2
Early Pueblo White	9.1	100.0			
Quartz Sand					
Gray Color Variety	60.8	-			61.4
Early Pueblo Gray	60.8	100.0			
Crushed Quartz	*11.6*	*19.0*			
Quartz Sand	*39.8*	*65.5*			100.0
Unknown	*9.4*	*15.5*		100.0	
Mogollon	92.4	-	22.1		
Unknown Region				100.0	
Brown Color Variety	92.4	-			100.0
Unknown Brown	92.4	100.0			
Quartz Sand	*89.7*	*97.1*			
Unknown	*2.7*	*2.9*			
Grand Total	418.6		100.0		

Table 2. Non-Blanding Tract Sherds Removed from the Analysis.
Underlined percentages equal 100%

Culture Category and Typology	Sherd Weight (g) Sum	% of Type by Variety	% of Tract
Ancestral Pueblo	3,929.7	-	
Mesa Verde Region	3,929.7	-	
Cedar Point Tract	3,398.8	-	86.5
White Color Variety	830.8	-	
Early Pueblo White	830.8	100.0	
Gray Color Variety	2,568.0	-	
Chapin Gray	467.7	<u>18.2</u>	
Early Pueblo Gray	2,100.5	<u>81.8</u>	
Dolores Tract	37.1	-	0.9
White Color Variety	37.1	-	
Early Pueblo White	37.1	100.0	
Iron Sandstone Tract	75.1	-	12.6
White Color Variety	75.1	-	
Early Pueblo White	75.1	100.0	
Gray Color Variety	417.7	-	
Chapin Gray	19.8	<u>4.7</u>	
Early Pueblo Gray	385.1	<u>92.0</u>	
Moccasin Gray	13.8	<u>3.3</u>	
Grand Total	3,929.7		100.0

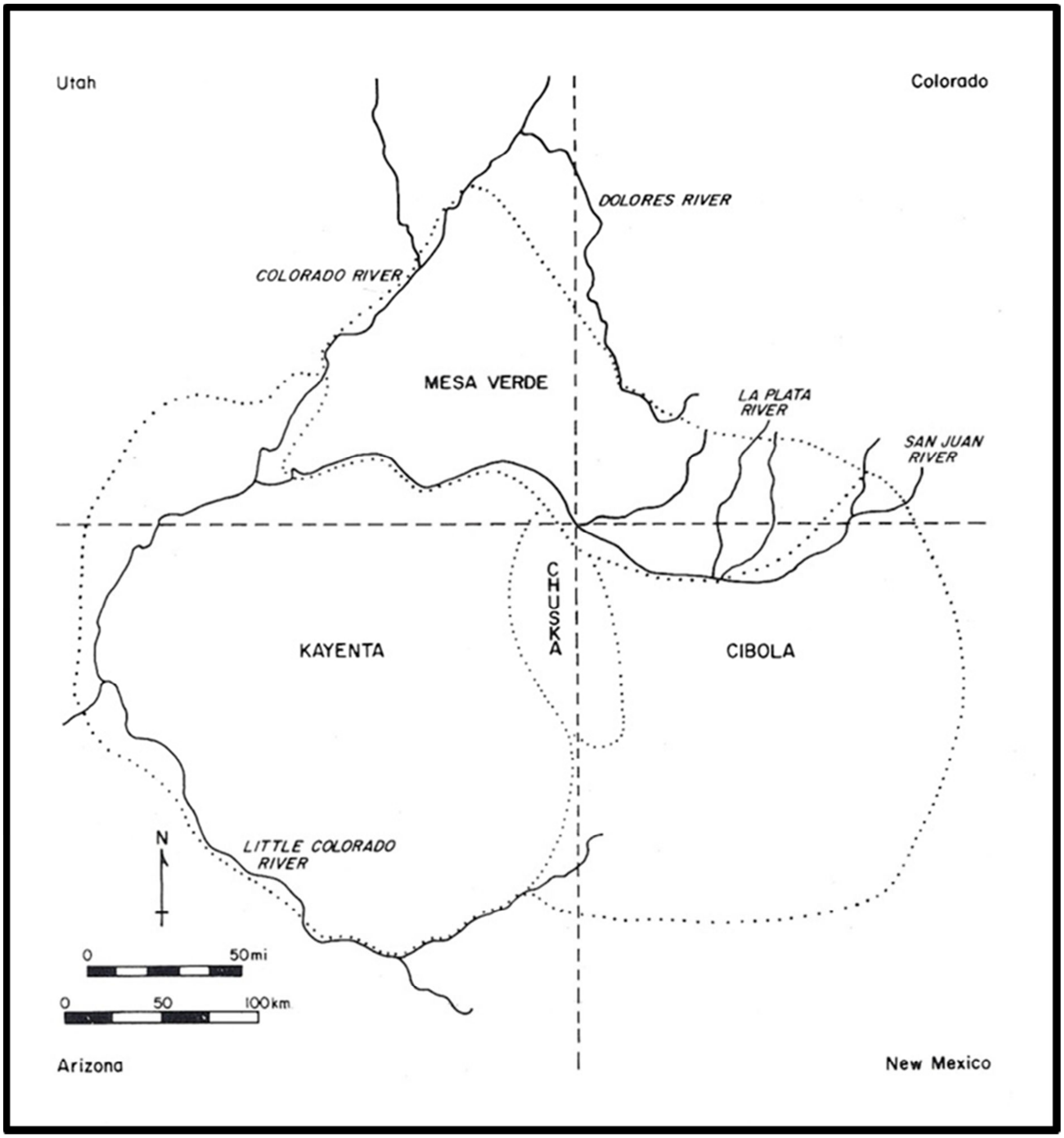


Figure 4. Regional Subdivisions of the Northern Ancestral Pueblo. From Lucius and Breternitz 1992:Figure 1.

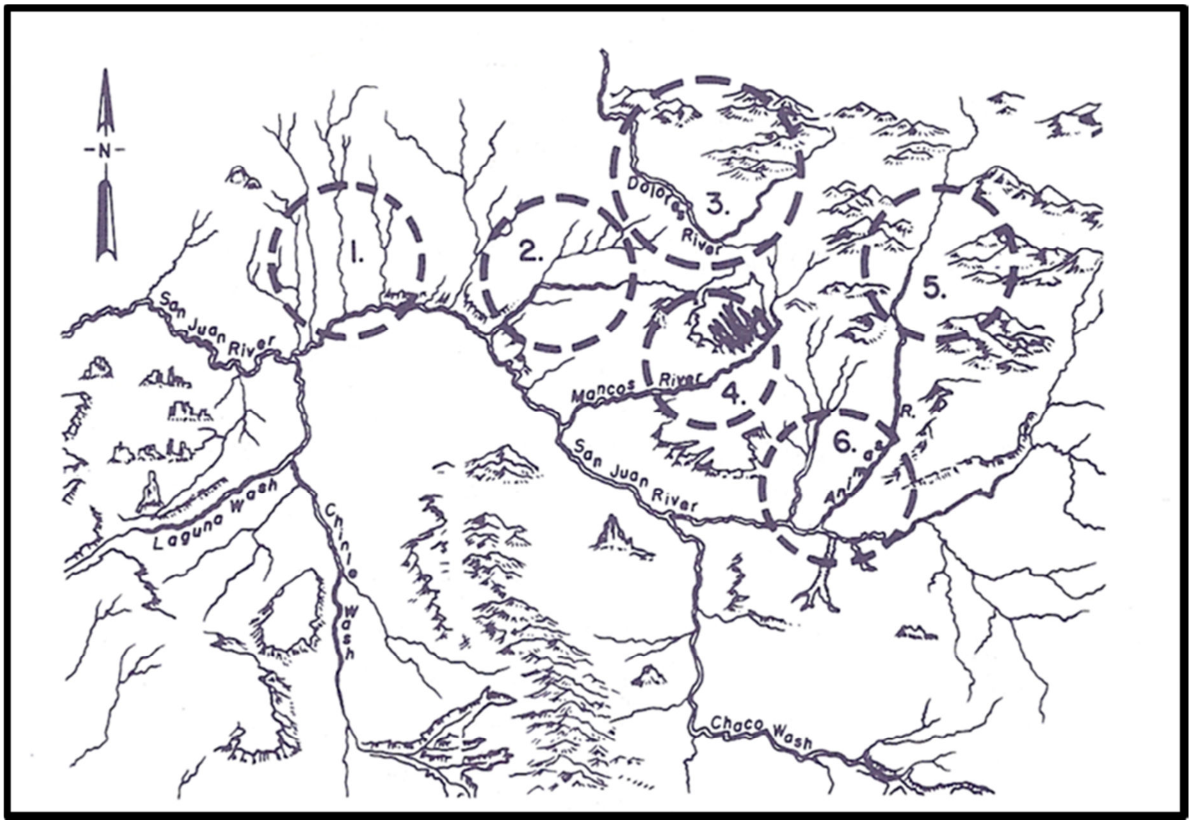


Figure 5. Mesa Verde Region Ceramic Manufacturing Tracts. 1. Blanding; 2. Cedar Point; 3. Dolores; 4. Mancos River; 5. Animas; 6. San Juan. From Lucius 1984:Figure 135.

Figure 6 presents a typological diagram of the revised systematics of ceramic wares, color varieties, and named types associated with the Mesa Verde Region of the Northern Southwest (Lucius 2020). Note that the white color variety type Chapin Black-on-white, which exhibits iron paint, occurs only as an import from the Dolores Tract (Table 2). Technological analysis of compositional variability revealed two new types opaque to traditional typological analysis that have only been named so they can be included in this discussion. The new compositional type Blanding Black-on-white exhibits carbon paint, design motifs, and layouts that can only be separated from the Kayenta type Lino Black-on-white (Colton 1955:Ware 8A, Type 4) by temper type. Diorite temper indicates manufacture in the Blanding Tract while quartz sandstone temper documents production in the Kayenta Region. Paying attention to temper type allows for proper recognition of imported Lino Black-on-white sherds that also occur in the Jensen Site ceramic assemblage, as noted in Table 1. Recognition of the Blanding Black-on-white compositional type is also important because it records the in-migration of Kayenta potters (in the form of clan segments) versed in the production technology of organic paint black-on-white pottery as well as the motifs and design fields of Lino Black-on-white into an abandoned cultural landscape that occurred after a severe climate episode that marked the end of the Basketmaker III agricultural adaptation in the Northern Southwest (Sinensky et. al. 2022:13). The new compositional type Blanding Smudged is a white color variety type that exhibits carbon smudging of bowls, resulting in a white exterior

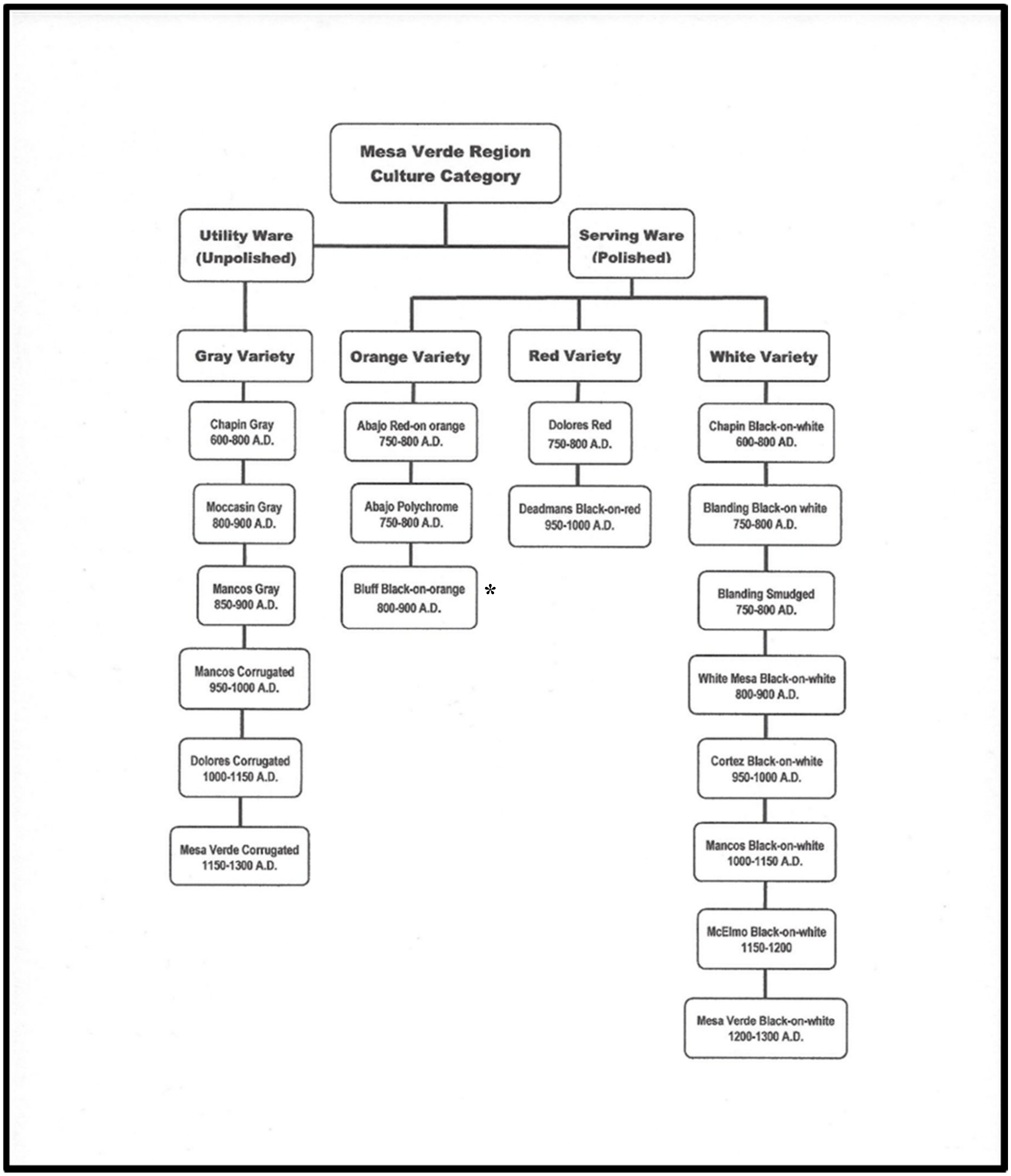


Figure 6. Mesa Verde Region Ceramic Typology Systematics.

* Traditional Southwestern ceramic typology recognizes the orange pottery as either Abajo Red-on-orange or the subsequent type Bluff Black-on-red. Attribute analysis, however, demonstrates that the term "black-on-red" is incorrect, given that the type does not exhibit a red slip. Indeed, refiring analysis and replication studies reveal that the potters who made both types intentionally manipulated the firing atmosphere to create an orange body clay color. For the purposes of this paper this type will be referred to as Bluff Black-on-orange.

and a black, glossy interior. Smudging results from the intentional carbon blackening of the interior of bowls during the firing process (Haury 1940:84; Wilson 1988:426), probably by firing bowls face down to ensure carbon transfer to the bowl interior. Refiring analysis serves to burn away the impregnated carbon and reveals the lack of painted designs under the smudging, which supports the proposition that smudging was an intentional decorative treatment. Daifuku (1961:50-51) suggests that white color variety smudged bowls are characteristic of production during the Basketmaker III-Pueblo I period north of the Mogollon Rim.

Removal of exotic sherds leaves only the diorite-tempered sherds diagnostic of manufacture in the Blanding Tract. Table 3 presents the typological assignments of those sherds prior to focusing on technological ceramic analysis. Small percentages of Late Pueblo I (A.D. 800-900) sherds of Moccasin Gray and Bluff Black-on-orange are incongruous in an otherwise Early Pueblo I (A.D. 750-800) assemblage (Lucius 1984:Figure 113). Their presence can be understood as remnants of a later occupation that was obliterated by heavy equipment scraping of the site in anticipation of house construction. Those sherds have been removed from the following data presentations.

Table 3. Blanding Tract Sherd Typology.
Underlined percentages equal 100%

Blanding Tract Typology	**Sherd Weight (g)** Sum	% of Type by Color Variety	**% of Ware**
Serving Ware	21,981.3	-	37.7
Orange Color Variety	3,864.3	-	
Abajo Polychrome	1.7	<0.0	
Abajo Red-on-orange	1,837.5	47.6	
Bluff Black-on-orange	17.0	0.4	
Early Pueblo Orange	2,008.1	52.0	
Red Color Variety	72.8	-	
Dolores Red	72.8	100.0	
White Color Variety	18,044.2	-	
Blanding Black-on-white	1,145.7	6.3	
Blanding Smudged	608.6	3.4	
Early Pueblo White	16,289.9	90.3	
Utility Ware	36,273.8	-	62.3
Gray Color Variety	36,273.8	-	
Chapin Gray	5,105.6	14.1	
Moccasin Gray	728.9	2.0	
Early Pueblo Gray	30,439.3	83.9	
Grand Total	58,255.1		100.0

A total of 83.7 percent of the diorite-tempered sherds cannot be assigned to named types because they lack rims or painted designs required for type distinction. Because the current research focus is to include all sherds regardless of type status, an Early Pueblo grouped type category (Lucius and Breternitz 1992) has been included to account for sherds in each color variety. There is no grouped type designation for red color variety sherds; the presence of a red slip is sufficient for type distinction (Lucius and Wilson 1981:2.7).

Documentation of the sherds that represent local production requires linking fired sherds to the unfired sherds, and by extension to the clay sources in the resource landscape in terms of refired clay colors. The locations and descriptions of the clay voucher samples used for data comparison are presented in Table 4. Note that the clay source that refires to the Munsell color 5YR6/6 was not located in the 5-kilometer resource catchment of the Jensen Site. It may have been removed by road alignments and gravel operations or is buried underneath residences or streets in the town of Blanding. Although further fieldwork might identify the raw clay source, its absence is trivial given that its raw and refired clay colors are known from untempered clays and unfired sherds. The refired clay colors of unfired sherds with the Munsell colors of 10R5/8, 2.5YR5/8, 5YR7/4, and 7.5YR8/3 have exact counterparts in ceramic clay outcrops within the resource catchment of the Jensen Site (Arnold 1975a:189; Shepard 1976:148), as highlighted in Table 5. The refired clay colors of raw clays in the assemblage have also been added to the table. Of the five refired clay colors shown in Table 5, those with Munsell colors 10R5/8 and 2.5YR5/8 derive from the Upper Brushy Basin Member of the Morrison Formation. The other three are securely associated with the overlying undivided Burro Canyon/Dakota Formation (Skipp and Aubry 1992:6).

Table 4. Clay and Temper Voucher Samples Data Summary.

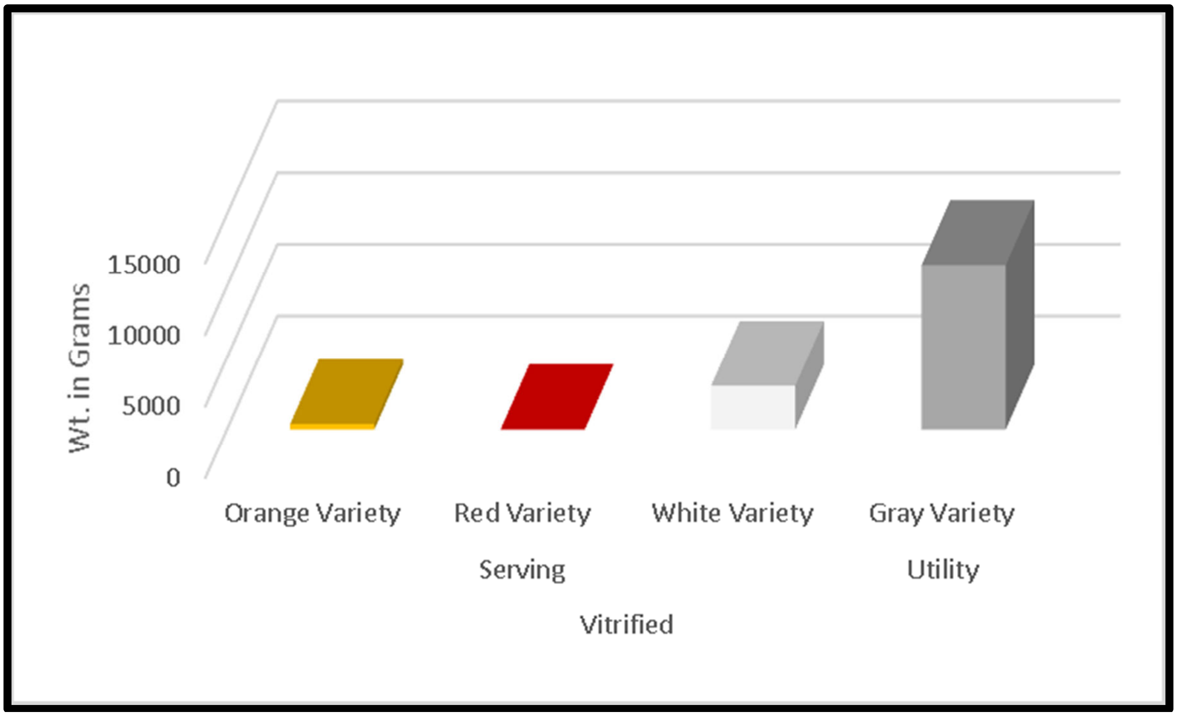
Sample #	Facies	Locale	UTM Zone	Easting	Northing	Clay	Comments
00CVS01	Upper Morrison	Big Canyon	12S	630701	4169054	2.5YR5/8	Excellent
00CVS09	Upper Morrison	Recapture	12S	637518	4169017	10R5/8	Excellent
01CVS04	Upper Morrison	Recapture	12S	637233	4169694	2.5YR5/8	Good
01CVS05	Middle Morrison	Recapture	12S	637233	4169696	7.5YR7/6	Good
03CVS01	Upper Morrison	Recapture	12S	637239	4169688	2.5YR6/8	Duplicate
03CVS05	Upper Morrison	Recapture	12S	637299	4169484	2.5YR6/8	Duplicate
03CVS06	Upper Morrison	Recapture	12S	637298	4169489	2.5YR6/8	Duplicate
03CVS07	Undif BC/Dakota	Recapture	12S	637232	4169239	White	Unusable
03CVS08	Undif BC/Dakota	Recapture	12S	637272	4169050	10YR8/2	Unusable
03CVS22	Undif BC/Dakota	Recapture	12S	637272	4169232	7.5YR8/2	Excellent
07CVS02	Undif BC/Dakota	Blanding	12S	633763	4167464	7.5YR8/3	Unusable
07CVS03	Undif BC/Dakota	Blanding	12S	633718	4167898	5YR7/4	Unusable
07CVS04	Undif BC/Dakota	Blanding	12S	632176	4169638	7.5YR8/3	Good
07CVS05	Undif BC/Dakota	Blanding	12S	636262	4167434	2.5YR7/4	Good
07CVS06	Undif BC/Dakota	Blanding	12S	636259	4167429	WHITE	Unusable
07CVS07	Undif BC/Dakota	Blanding	12S	637504	4167076	5YR7/6	Good
08CVS01	Undif BC/Dakota	Blanding	12S	637107	4168718	5YR8/4	Good
08CVS02	Undif BC/Dakota	Blanding	12S	637203	4168748	N/A	Unusable
08CVS03	Undif BC/Dakota	Blanding	12S	637206	4168739	10YR8/2	Good
08CVS04	Undif BC/Dakota	Blanding	12S	636243	4168631	7.5YRS/2	Unusable

Table 5. Voucher Samples, Raw Clays, and Unfired Sherds Correlation.

Refired Clay Color	Clay Vouchers (# of samples)	Raw Clays Wt/%	Unfired Sherds Wt/%
10R5/8	1	16.9/3.7	11.1/3.7
2.5YR5/8	2	0/0	64.9/21.7
2.5YR6/6	0	8.7/1.9	0/0
2.5YR6/8	3	2.2/0.5	0/0
2.5YR7/4	1	0/0	0/0
5YR6/6	0	21.7/4.7	23.6/7.9
5YR6/8	0	69.3/15.1	0/0
5YR7/4	1	4.6/1.0	46.6/15.6
5YR7/6	1	0/0	0/0
5YR8/4	1	0/0	0/0
7.5YR7/3	0	2.0/0.4	0/0
7.5YR7/4	0	4.3/0.9	0/0
7.5YR7/6	1	0/0	0/0
7.5YR8/2	2	0/0	0/0
7.5YR8/3	2	283.9/62.0	152.8/51.1
7.5YR8/4	0	7.0/1.5	0/0
10YR8/2	2	32.8/7.2	0/0
WHITE	2	4.9/1.1	0/0
Total	19	458.3/100	299/100

Documentation of local production (WMPZ) versus production within the larger Blanding Tract is complicated by the occurrence of vitrified sherds. Vitrification is an irreversible condition (Smith 1971:355) that precludes determination of refired clay color and therefore prevents association of those sherds with any specific production zone within the Blanding Tract. Vitrification results from the complex interaction of clay content, firing temperature, and firing atmosphere. Traits associated with overfiring include dark pastes, reduced porosity, glass formation, and vessel wall blistering and bloating.

The amount of vitrification in diorite-tempered sherds by ware and color variety is summarized in Figure 7. Vitrification occurs primarily in utility ware sherds, with fewer occurrences in the various color varieties of serving ware sherds. The use of iron-rich Upper Brushy Basin red clays for utility ware production may account for some portion of the observed vitrification. Replication experiments reveal that iron oxide becomes a fluxing agent that encourages melting at earthenware firing temperatures. Other vitrified sherds suggest that some clay bodies were simply overfired. In general, the low-iron clays used for white color variety pots are refractive and therefore less likely to exhibit vitrification. Orange color variety pottery documents an oxidation firing regime, which in general avoids the problem of vitrification. Red variety color sherds exhibit a red slip over a low-iron body clay that is unlikely to vitrify. Removal of all vitrified sherds (25.9%) from consideration allows for construction of graphs and supporting data tables used to identify those sherds representing production in the WMPZ and by extension those representative of manufacture elsewhere in the larger Blanding Tract.



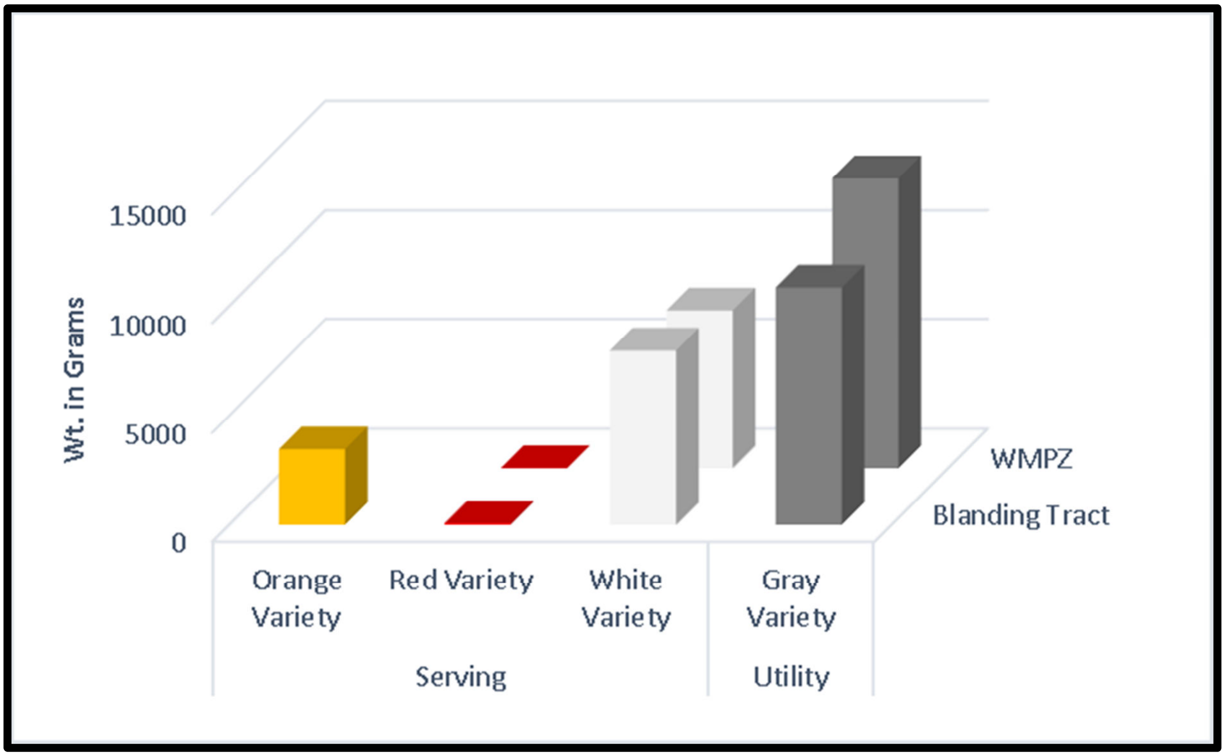
Blanding Tract Typology	**Sherd Weight (g)**	**Sum % of Color Variety**	**% of Ware**
Vitrified	14,894.1	-	
Serving Ware	3,433.0	-	23.0
Orange Color Variety	385.2	11.2	
Red Color Variety	13.0	0.4	
White Color Variety	3,034.8	88.4	
Utility Ware	11,461.1	-	77.0
Gray Color Variety	11,461.1	100.0	
Grand Total	14,894.1		100.0

Underlined percentages equal 100%

Figure 7. Graph and Companion Data Table: Vitrified Sherd Occurrence by Ware and Color.

Data Presentation

The following data presentations are organized in terms of production locale, ware, and color variety sherds and are summarized in terms of raw count and percentages. The overall summaries presented in Figure 8 are subsequently divided into color varieties and presented individually. The data table reveals that, despite the fact that ceramic production took place at the site, the majority (53.6%) of the Jensen Site assemblage represents manufacture somewhere else in the larger Blanding Tract.

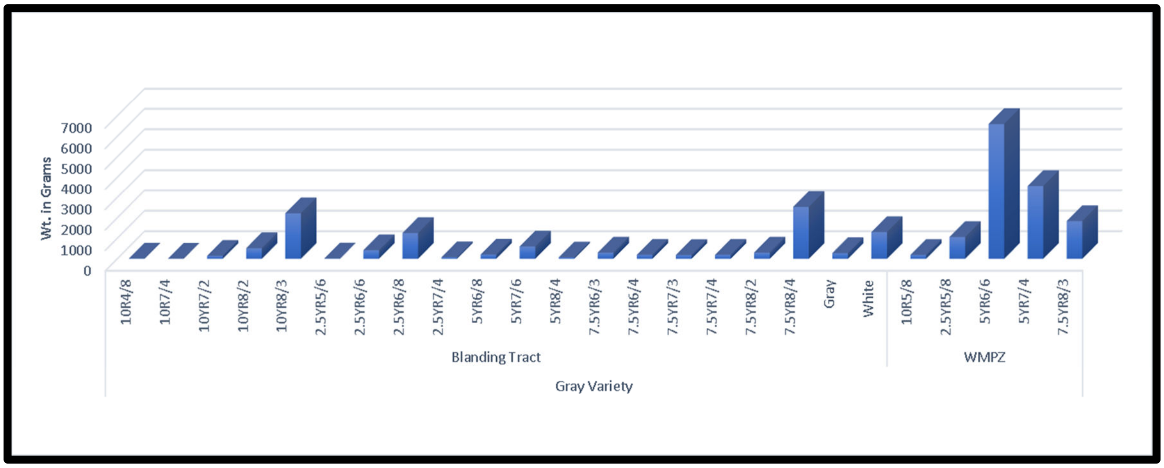


Typology	Blanding Tract Sum	Blanding Tract % by Ware	WMPZ Sum	WMPZ % by Ware	Grand Total by Ware
Serving Ware	11,495.5	-	7,217.3	-	43.7
Orange Color Variety	3,462.1	30.1			
Red Color Variety	61.9	0.5	7.9	0.1	
White Color Variety	7,971.5	69.4	7,209.4	99.9	
Utility Ware	10,851.0	-	13,273.0	-	56.3
Gray Color Variety	10,851.0	100.0	13,273.0	100.0	
Grand Total By Ware	22,346.5		20,490.3		100.0

Underlined percentages equal 100%

Figure 8. Graph and Companion Data Table: Production Locales and Wares by Color Variety.

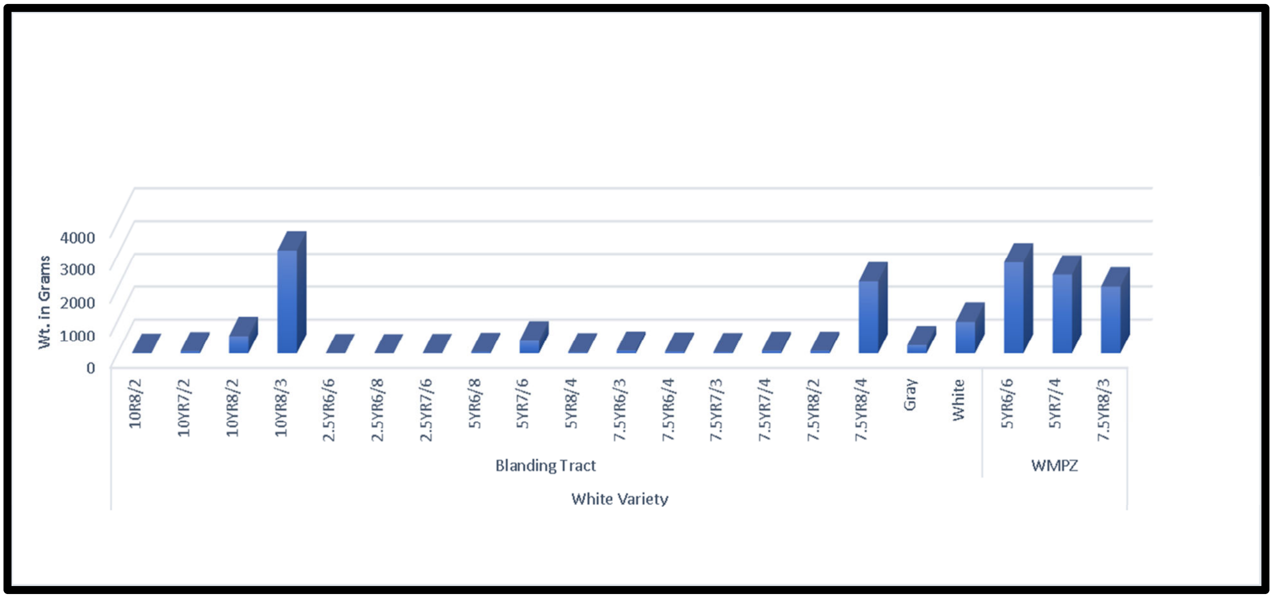
Utility ware sherds are never slipped or polished and generally exhibit a gray surface color, given they were fired in a reducing atmosphere that inhibits full expression of the iron content of the clay body. Refiring analysis reveals that a wide range of clay types was selected for production (Figure 9) of jars used for storage and cooking.



Refired Clay Color Munsell Notation	Sum	% of Production	% of Color Variety
Gray Color Variety			
Blanding Tract	10,851.0	100.0	45.0
10R4/8	12.6	0.1	
10R7/4	5.4	<0.0	
10YR7/2	145.1	1.3	
10YR8/2	518.1	4.8	
10YR8/3	2,220.6	20.5	
2.5YR5/6	14.6	0.1	
2.5YR6/6	421.9	3.9	
2.5YR6/8	1,261.3	11.5	
2.5YR7/4	75.0	0.7	
5YR6/8	206.6	1.9	
5YR7/6	600.2	5.5	
5YR8/4	67.2	0.6	
7.5YR6/3	303.4	2.8	
7.5YR6/4	197.5	1.8	
7.5YR7/3	187.7	1.7	
7.5YR7/4	194.5	1.8	
7.5YR8/2	303.0	2.8	
7.5YR8/4	2,534.3	23.4	
Gray	278.6	2.6	
White	1,303.4	12.0	
WMPZ	13,272.0	100.0	55.0
10R5/8	190.7	1.4	
2.5YR5/8	1,066.5	8.0	
5YR6/6	6,622.7	49.7	
5YR7/4	3576.7	26.9	
7.5YR8/3	1,838.3	13.8	
Grand Total	24,124.0		100.0

Figure 9. Graph and Companion Data Table: Production Locales, Utility Ware Gray Color Variety by Refired Clay Color.

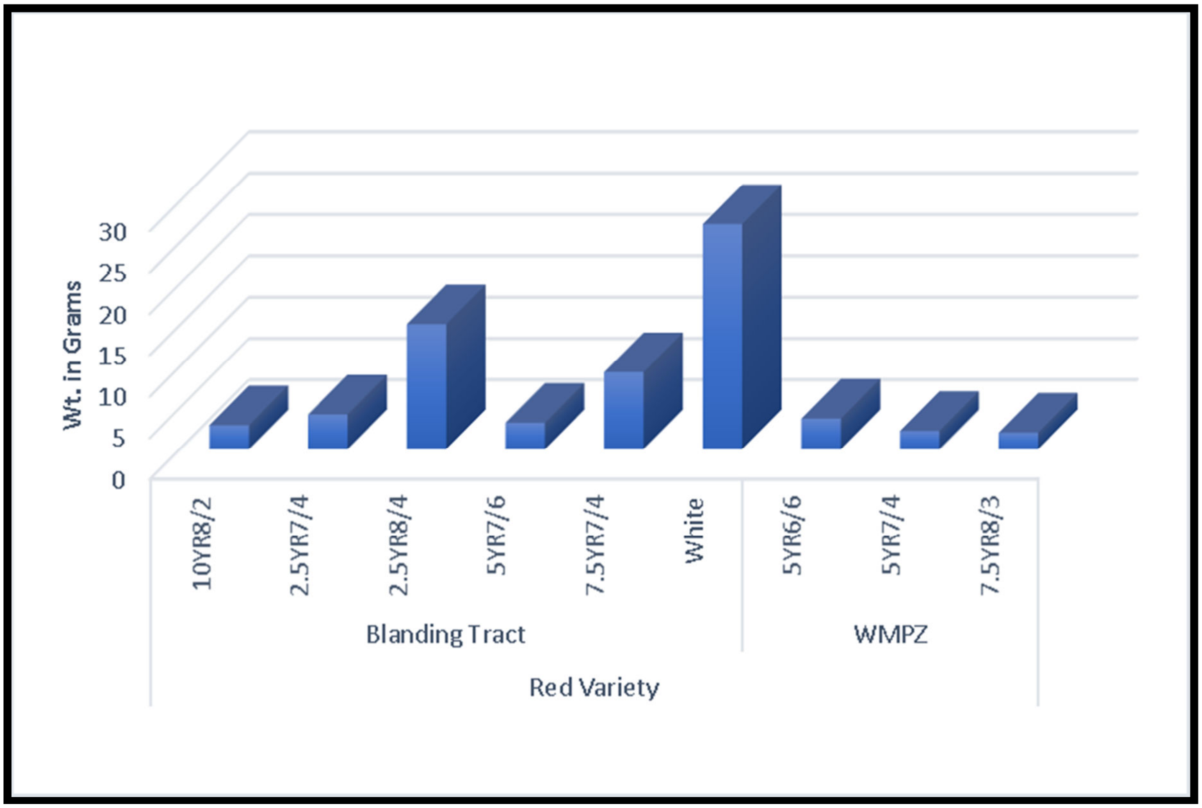
White color variety sherds in the assemblage always exhibit stone polish, but are never slipped. When present, the painted lines and dots document the use of organic paint probably derived from beeweed (*Cleome serrulata*), as verified by replication studies. Refiring analysis reveals that the range of clay types selected for production (Figure 10) favors low-iron clays. Production emphasized bowl and jar containers for water storage, serving, and ceremonial use.



Refired Clay Color Munsell Notation	Sum	% of Production	% of Color Variety
White Color Variety			
Blanding Tract	7,971.5	100.0	52.5
10R8/2	14.5	0.2	
10YR7/2	65.5	0.8	
10YR8/2	592.6	6.6	
10YR8/3	3,143.0	39.4	
2.5YR6/6	4.8	0.1	
2.5YR6/8	3.2	< 0.0	
2.5YR7/6	7.9	0.1	
5YR6/8	42.4	0.5	
5YR7/6	393.9	4.9	
5YR8/4	33.2	0.4	
7.5YR6/3	83.9	1.1	
7.5YR6/4	54.6	0.7	
7.5YR7/3	36.1	0.5	
7.5YR7/4	76.3	1.0	
7.5YR8/2	76.0	1.0	
7.5YR8/4	2,190.9	27.5	
Gray	250.0	3.1	
White	965.7	12.1	
WMPZ	7,209.4	100.0	47.5
5YR6/6	2,776.1	38.5	
5YR7/4	2,400.0	33.3	
7.5YR8/3	2,033.3	28.2	
Grand Total	15,180.9		100.0

Figure 10. Graph and Companion Data Table: Production Locales, Serving Ware White Color Variety by Refired Clay Color.

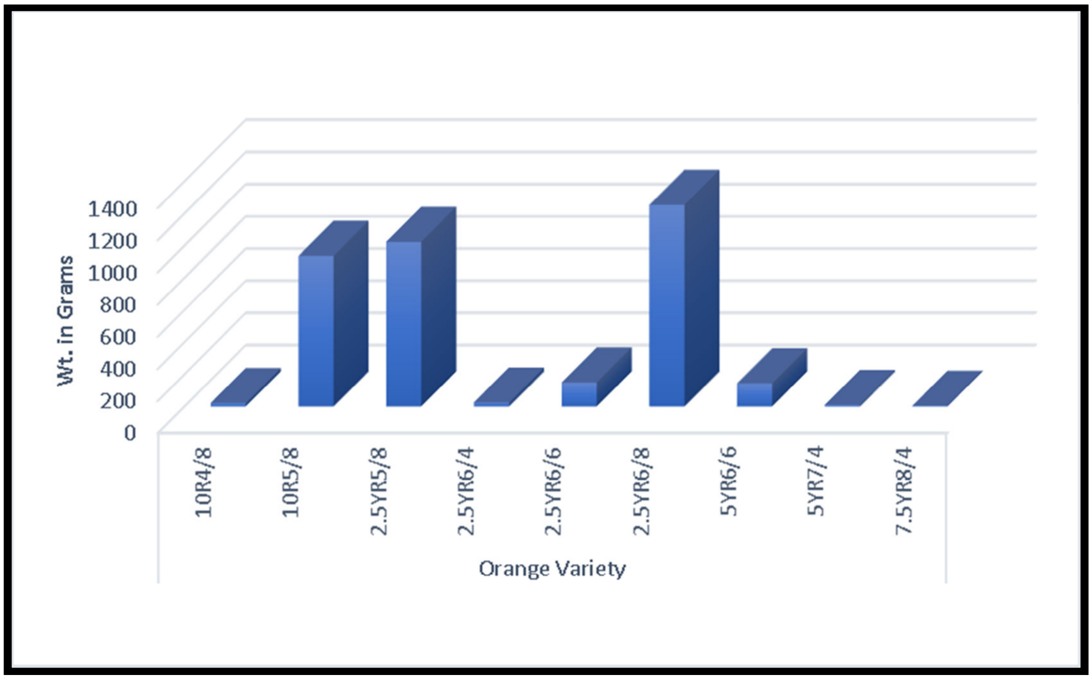
Field experience demonstrates that occasional red color variety sherds occur in Pueblo I sites across the Blanding Tract and in the Dolores Tract, which is where the color variety was first described (Lucius and Wilson 1981). Those sherds always exhibit a polished deep-red slip over a white or at least a low-iron clay. No painted motifs or designs occur. Although bowl forms predominate, some jar sherds occur in the Jensen Site assemblage. Red color variety vessels may indicate a special use but are reported as a serving ware (Figure 11).



Refired Clay Color Munsell Notation	Sum	% of Production	% of Color Variety
Red Color Variety			
Blanding Tract	61.9	100.0	88.7
10YR8/2	2.9	4.7	
2.5YR7/4	4.2	6.8	
2.5YR8/4	15.1	24.4	
5YR7/6	3.2	5.2	
7.5YR7/4	9.3	15.0	
White	27.2	43.9	
WMPZ	7.9	100.0	11.3
5YR6/6	3.7	46.8	
5YR7/4	2.2	27.8	
7.5YR8/3	2.0	25.4	
Grand Total	69.8		100.0

Figure 11. Graph and Companion Data Table: Production Locales, Serving Ware Red Color Variety by Refired Clay Color.

Orange color variety sherds are always polished but never slipped and were fired in an oxidizing atmosphere that allows for full expression of the iron content of clays associated with Upper Brushy Basin clay sources (Figure 12). Red iron oxide painted motifs and designs occur on bowl and jar forms that were produced for serving and ceremonial uses. Fieldwork and research associated with the Blanding Red Ware Project (Lucius 2020:40) revealed that the refired clay colors of orange color variety sherds cannot be used to distinguish individual production zones within the Blanding Tract. The south-trending drainages of the Abajo Mountains expose a continuous, occasionally thick layer of red clay that drapes over the landscape below a cap rock of erosion-resistant conglomerate sandstone that marks the boundary between the Upper Brushy Basin Member of the Morrison Formation below and the Burro Canyon Formation above (Skipp and Aubrey 1992:2). Although unfired sherds with the refired clay colors 10R5/8 and 2.5YR5/8 occur in the Jensen Site, clays with identical refired clay colors occur wherever erosion has exposed red clay beds across and beyond the Blanding Tract. Association of individual sherds with production zones will require elemental chemical characterization of sherds and clay sources (DiNaso et al. 2019). There is no evidence that Pueblo I orange pottery production occurred anywhere else in the Mesa Verde Region.



Refired Clay Color Munsell Notation	Sum	% of Color Variety
Orange Color Variety		
Blanding Tract	3,568.9	100.0
10R4/8	21.4	0.6
10R5/8	936.6	26.2
2.5YR5/8	1,023.7	28.7
2.5YR6/4	25.0	0.7
2.5YR6/6	1,49.7	4.2
2.5YR6/8	1,253.6	35.1
5YR6/6	144.4	4.0
5YR7/4	9.7	0.3
7.5YR8/4	4.8	0.1
Grand Total	3,568.9	

Figure 12. Graph and Companion Data Table: Production Locales, Serving Ware Orange Color Variety by Refired Clay Color.

Discussion and Conclusions

Stephen J. Gould (2007:157) raises the pertinent question of how we can directly observe processes that occurred in the past. Although he phrased the inquiry in the context of biological evolution, it equally applies to how we can directly observe cultural behaviors from the archaeological record. The three topics of interest to the research were reconstruction of ceramic production, exchange, and cultural interaction in prehistory.

The primary goal of the research was to demonstrate that sourcing pottery sherds to a discrete production locale is possible, given that excavation has demonstrated that pottery production occurred at the Jensen Site. A technological attribute-based ceramic analysis served to create a database that documents the unambiguous association of unique resource combinations with the specific community responsible for their production (Shepard 1936:389). The presence of unfired sherds at the Jensen site with associated kilns tells us which clay sources in the resource landscape were used for production, and reflexively which sherds in the ceramic assemblage match the refired clay colors of the clay sources and unfired sherds. Determination of where pottery made by WMPZ potters ended up is currently unknown, given that traditional typological analysis is mute concerning the temper and clay combinations of individual sherds in ceramic assemblages. Technological analysis of extant and future ceramic collections from sites within and exterior to the Blanding Tract should allow for their identification. However, determination of the location of other production zones across the Blanding Tract is a problem of circularity. Specific resource combinations cannot be associated with production zones without prior knowledge of where production occurred. Without directed research focused on excavation of suspected production communities it is improbable that the needed data will become available.

The ability to document the compositional signatures of sherds produced in the WMPZ enables consideration of topic of exchange, and by extension, the nature of cultural interaction. The goal is to document ceramic exchange between production communities, specifically within the Blanding Tract and with other communities within and exterior to the Mesa Verde Region. Contrary to the common assumption that the pottery found at a site was made at the site, the occurrence of pottery from other production communities signals the participation of many communities in an exchange system organized to ensure cultural interaction (Lucius 2021). The working assumption of the research is that pottery production was for exchange (Hegmon, Hurst, and Allison 1995:38-40; Sahlins 1972:83) and that exchange is the material consequence of cultural interactions of a gift economy (Sahlins 1972:186). Exchange serves to establish and maintain interaction between dispersed communities (Chang 1975:222-223) across the cultural landscape, allowing for a successful agricultural adaptation in the Northern Southwest (Ford 1972:3).

An unexpected topic of interest resulting from the research is migration, given that the Jensen Site ceramic database unambiguously documents the arrival of potters and pottery technology from the Kayenta Region. The ability to identify the material consequences of in-migration by potters from a different region suggests that reliance by archaeologists on traditional stylistic typology has precluded identification of similar events throughout the span of Ancestral Pueblo occupation of the Northern Southwest. Such a ceramic analysis should be performed in all cases of suspected migrations to test that assumption.

The characterizations and propositions of the analysis should not be interpreted as manifest truths. Temper characterizations require verification by independent petrographic analysis. Similarly, the clay voucher sample and sherd matches require verification through appropriate elemental chemical analysis techniques (Shepard 1976:Foreward). In addition, the various axioms and predictions of the analysis will require repeated evaluation. Because "a good theory also must make definite predictions about the results of future observations" (Hawking and Mlodinow 2005:13), without further testing, their predictive value remains unknown (Hill 1970:24).

Finally, the preceding analysis and interpretations have been presented so that future archaeologists will routinely ask which, if any, of the pottery recovered from their site represents local manufacture, with the expectation that the resulting data will lead to an even wider range of questions concerning the nature of ceramic production, exchange, and interaction in prehistory.

Acknowledgments. Winston Hurst offered access to and ensured that the boxes of sherds representing the ceramic assemblage of the Jensen Site were delivered to my door. He also drafted and updated the plan maps of the report and provided editorial comments on a near final draft. My wife, Irene Lopez Wessell, also provided editorial comments. Although their assistance has improved the final document, I am responsible for any deficiencies of the report, the approach for ceramic analysis, and interpretations of the resulting database.

References Cited

Arnold, Dean E.

1975 Ceramic Ecology of the Ayacucho Basin, Peru: Implications for Prehistory. *Current Anthropology* 16:183-205.

1976 Ecological Variables and Ceramic Production: Towards a General Model. In *Primitive Art and Technology*, edited by J. S. Raymond, B. Loveseth, C. Arnold, and G. Reardon, pp. 92-108. Archaeological Association, Department of Archaeology, University of Calgary, Calgary.

Bishop, Ronald L., Robert L. Rands, and George R. Holley

1982 Ceramic Compositional Analysis in Archaeological Perspective. *Advances in Archaeological Method and Theory* 5:275-330.

Breternitz, David A., Arthur H. Rohn, Jr., and Elizabeth A. Morris, compilers

1974 *Prehistoric Ceramics of the Mesa Verde Region*. Museum of Northern Arizona Ceramic Series No. 5, Flagstaff.

Brisbin, Joel M., and Gay A. Ives

1999 Mesa Verde Segment Trench Kiln Firing Kilns. In *Mesa Verde Waterline Replacement Project Phase III: Archeological and Historical Studies,* pp. 281-310. Manuscript on file, Division of Research and Resource Management, Mesa Verde National Park, Colorado.

Chang, Kwang-Chih

1975 Ancient Trade as Economics or as Ecology. In *Ancient Civilization and Trade*, edited by Jeremy A. Sabloff and C. C. Lamberg-Karlovsky, pp. 221-224. School of American Research and University of New Mexico Press, Santa Fe and Albuquerque.

Colton, Harold S., editor
1955 *Pottery Types of the Southwest*: *Wares 8A, 8B, 9A, 9B, Tusayan Gray and White Ware, Little Colorado Gray and White Ware*. Museum of Northern Arizona Ceramic Series 3A, Northern Arizona Society of Science and Art, Flagstaff.

Daifuku, Hiroshi
1961 *Jeddito 264: A Report on the Excavation of a Basketmaker III-Pueblo I Site in Northeastern Arizona with a Review of Some Current Theories in Southwestern Archaeology*. Reports of the Awatovi Expedition, No. 7 and Papers of the Peabody Museum of Archaeology and Ethnology Vol. 33, No. 1, Harvard University, Cambridge.

Di Naso, Steven M., David M. Dove, Winston Hurst, and William A. Lucius
2019 *Identifying San Juan Redware Production Locales and Trading Partners: Research Update 2019*. Paper and Poster presented at the 92nd Annual Pecos Conference, Cloudcroft, New Mexico.

Ford, Richard I.
1972 An Ecological Perspective on the Eastern Pueblos. In *New Perspectives on the Pueblos*, edited by Alfonso Ortiz, pp. 1-17. A School of American Research Book, University of New Mexico Press, Albuquerque.

Fuller, Steven L.
1984 *Late Anasazi Kilns in the Yellowjacket District, Southwestern Colorado*. CASA Papers No. 4. Complete Archaeological Service Associates, Cortez, Colorado.

Gould, Stephen J.
2007 Worm for a Century, and All Seasons. In *The Richness of Life: The Essential Stephen Jay Gould*, edited by Steven Rose, pp. 155-165. W. W. Norton and Company, New York.

Haury, Emil W.
1940 *Excavations in the Forestdale Valley, East-Central Arizona*. University of Arizona Bulletin 11(4), Social Science Bulletin 12. University of Arizona, Tucson.

Hawking, Stephen with Leonard Mlodinow
2005 *A Briefer History of Time*. Bantam Dell, New York.

Hegmon, Michelle, Winston Hurst, and James R. Allison
1995 Production for Local Consumption and Exchange: Comparisons of Early Red and White Ware Ceramics in the San Juan Region. In *Ceramic Production in the American Southwest*, edited by Barbara J. Mills and Patricia L. Crown, pp. 30-62. The University of Arizona Press, Tucson.

Helm, Claudia
1973 The Kiln Site. In *Highway U-95 Archaeology: Comb Wash to Grand Flat*, edited by Gardiner F. Dalley, pp. 209-221. Department of Anthropology, University of Utah, Salt Lake City.

Hill, James N.
1970 Prehistoric Social Organization in the American Southwest: Theory and Method. In *Reconstructing Prehistoric Pueblo Societies,* edited by William A. Longacre, pp. 11-58. School of American Research and University of New Mexico Press, Santa Fe and Albuquerque.

Lucius, William A.
1984 The Ceramic Data Base. Appendix C in *Dolores Archaeological Program: Synthetic Report 1978-1981*. United States Department of the Interior Bureau of Reclamation, Engineering and Research Center, Denver.
2020 Poking the Dragon: Changing the Typology of San Juan Redware and its Types for Data Reporting. *Pottery Southwest* 36(3-4):38-57.
2021 Data in Search of a Model: Mesa Verde Region Orange and Red Pottery Production, Exchange, and Cultural Interaction. *Pottery Southwest* 37(2):29-42.

Lucius, William A., and David A. Breternitz
1992 *Northern Anasazi Ceramic Styles: A Field Guide for Identification*. Center for Indigenous Studies in the Americas Publications in Anthropology No. 1, Phoenix.

Lucius, William A., and Dean Wilson
1981 Formal Descriptions of Mesa Verde Region Ceramic Types: Three New, One Old. *Pottery Southwest* 8(3):4-7; 8(4):2-5.

Matson, Frederick R.
1965 Ceramic Ecology: An Approach to the Study of the Early Cultures of the Near East. In *Ceramics and Man*, edited by Frederick R. Matson, pp. 202-217. Viking Fund Publications in Anthropology No. 41. Wenner-Gren Foundation for Anthropological Research, New York.

Millet, Martin
1979 How Much Pottery? In *Pottery and the Archaeologist*, edited by Martin Millet, pp. 77-80. London Institute of Archaeology Publications Vol. 18, Occasional Publication No. 4. University College, London.

Morris, Earl H.
1927 *The Beginnings of Pottery Making in the San Juan Area: Unfired Prototypes and the Wares of the Earliest Ceramic Period*. Anthropological Papers of the American Museum of Natural History Vol. 28, Part 2.

Orton, Clive
1982 Computer Simulation Experiments to Assess the Performance of Measures of Quantity of Pottery. *World Archaeology* 14(1):1-20.

Rands, Robert L., and Ronald L. Bishop
1980 Resource Procurement Zones and Patterns of Ceramic Exchange in the Palenque Region, Mexico. In *Models and Methods in Regional Exchange*, edited by Robert E. Fry, pp. 19-46. SAA Papers No. 1. Society for American Archaeology, Washington, D.C.

Roper, Donna C.
1979 The Method and Theory of Site Catchment Analysis: A Review. In *Advances in Archaeological Method and Theory* 2:119-140.

Sahlins, Marshall
1972 *Stone Age Economics*. Aldine-Atherton, Chicago.

Scarlett, Timothy James, Robert J. Speakman, and Michael D. Glascock
2007 Pottery in the Mormon Economy: An Historical, Archaeological, and Archaeometric Study. *Historical Archaeology* 41(4):72-97.

Shepard, Anna O.
1936 The Technology of Pecos Pottery. Part Two of *The Pottery of Pecos*, Volume II, by A. V. Kidder and Anna O. Shepard, pp. 389-636. Papers of the Southwestern Expedition No. 7, Department of Archaeology, Phillips Academy, Andover, Massachusetts. Yale University Press, New Haven.
1939 Technology of La Plata Pottery. Appendix A in *Archaeological Studies in the La Plata District, Southwestern Colorado and Northwestern New Mexico*, by Earl H. Morris, pp. 249-287. Carnegie Institution of Washington Publication No. 519, Washington, D.C.
1976 *Ceramics for the Archaeologist*. Seventh Printing. Carnegie Institution of Washington Publication 609. Washington, D.C.

Sinensky, R. J., Gregson Schachner, Richard H. Wilshusen, and Brian N. Damiata
2022 Volcanic Climate Forcing, Extreme Cold and the Neolithic Transition in the Northern US Southwest. *Antiquity* 96(385):123-141.

Skipp, Gary, and W. M. Aubry
1992 *X-Ray Diffraction Studies of the <2-µm Fraction from the Upper Part of the Brushy Basin Member of the Upper Jurassic Morrison Formation and the Lower Cretaceous Burro Canyon Formation in the Four Corners Area, Colorado*. U.S. Geological Survey Bulletin 1808-K.

Smith, Watson
1971 *Painted Ceramics of the Western Mound at Awatovi*. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 28. Harvard University, Cambridge.

Solheim, Wilhelm G., II
1960 The Use of Sherd Weights and Counts in the Handling of Archaeological Data. *Current Anthropology* 1(4):325-329.

Wilson, C. Dean
1988 An Evaluation of Individual Migration as an Explanation for the Presence of Smudged Ceramics in Dolores Project Area. In *Dolores Archaeological Program: Supporting Studies: Additive and Reductive Technologies*, compiled by Eric Blinman, Carl J. Phagan, and Richard H. Wilshusen, pp. 425-435. United States Department of the Interior Bureau of Reclamation, Engineering and Research Center, Denver.

CERAMIC PRODUCTION AT KUAUA PUEBLO: MATERIALS AND RESOURCES

Hayward H. Franklin
Research Associate, Maxwell Museum of Anthropology, University of New Mexico

Introduction

The Site of Kuaua and Archaeological Background

Kuaua (LA 167) is a large Ancestral Pueblo ruin preserved within Coronado State Historic Site, in the Middle Rio Grande Valley near Bernalillo, New Mexico. It was one of several very large residential communities occupied during the Classic period, lasting from A.D. 1325 to the Pueblo Revolt of 1680. Overviews of the Middle Rio Grande Culture Area are available in Cordell (1979, 2006), Cordell and Habicht-Mauche (2012), and Morales (1997). Because this large community, occupying 900-1200 rooms, was constructed of adobe, not masonry, the walls have not withstood the test of time. However, excavations have revealed the outlines of the first story rooms in a portion of the pueblo (Figure 1). See Franklin 2019 for a summary of the archaeology and history of Kuaua.

Figure 1. Kuaua (Coronado State Historic Site) today. Mapquest 2017.

Kuaua was the scene of extensive excavations during the 1930s, when it became a part of the New Mexico State Park System. The plan was to open as much of the site as possible for public view, and especially to impress visitors with the vast extent of the large prehistoric pueblo during the celebrations of the 400th anniversary of Coronado's party arriving in the Southwest in 1540. After the hurried excavations of the 1930s, attention turned to the kiva murals, still partially intact on some wall surfaces. These were photographed and removed as carefully as possible and placed in museum storage. Portions of the murals may be viewed in the site's museum. Details of the murals, representations, and interpretations were published by Bertha Dutton in *Sun Father's Way* (1963). Reports on work in the kivas and elsewhere at Kuaua were prepared by Tichy (1939). Artifact analysis was not carried out on a large scale in the 1930s, however, and the huge quantities of ceramics and other items lay in museum storage in Santa Fe and Albuquerque for decades.

In recent years, stabilization activities and facilities construction have required limited excavations followed by examination of the recovered ceramics (for example, Wilson 2005; Carrillo 1987). Combined with a few chronometric dates, the pottery counts from these limited samples have provided an overall view of the general pottery types and time span of the occupation.

2017 Archaeological Testing and Analyses

In 2017, a limited testing project around the site periphery was undertaken under the direction of the Coronado State Historic Site staff in order to determine the extent of cultural debris in and around the main room blocks and plazas of the site. The research design focused on determining the extent of artifact deposition at the margins of the site walls, and on substantiating the chronological sequence of occupation of rooms of the three major plazas. The ceramics, consisting of over 2,000 potsherds, were cleaned, bagged, provenienced, and cataloged by a volunteer crew from the Friends of Coronado Historic Site. At that point, a trained pottery analysis crew, directed by the author, analyzed the complete collection. Frequencies of pottery ware and type, vessel form, and vessel part were recorded on paper forms. These data were then entered into a spreadsheet, from which information was derived about the chronology of the pottery, as well as its distribution across and around the extensive site area. Results of this project were published in *Pottery Southwest* (Franklin 2019). The present study uses the same data sample, and now examines the paste clays and tempering materials.

Identifying Local Ceramic Production

While progress is being made with identifying the ceramic types and varieties, and thus refining the chronology of Kuaua, we are also concerned with identifying the nature of local pottery manufacture. This includes both the production of painted ceramics as well as unpainted utility (culinary) ceramics. It is now clear that the painted pottery at Kuaua is almost exclusively Rio Grande Glazeware, with a few other wares arriving as imports from elsewhere (Franklin 2019), including very small amounts of biscuitware (both Biscuit A and B) and Jemez Black-on-white (B/w). Two typical Rio Grande glazeware vessels found at the site are shown in Figures 2 and 3.

Figure 2. Glaze D bowl. Coronado State Historic Site Museum. Photo by Hayward Franklin.

Figure 3. Glaze D-E jar. Coronado State Historic Site Museum. Photo by Hayward Franklin.

This paper investigates the natural resources collection strategies used by prehistoric Pueblo potters to manufacture vast quantities of Rio Grande Glazes and local corrugated and plain surfaced utility wares at Kuaua. Knowing the types (and quantities) of ceramics that were made locally by resident potters is a necessary precursor to evaluating the corresponding amounts of ceramics obtained at Kuaua from other contemporary Classic Pueblo towns in the regional exchange network. This would be a first step in a more comprehensive evaluation of the complete complex panorama of the regional complex of manufacturing localities, as well as the trade and exchange networks that functioned during the Classic Pueblo period.

Potentially, even finer variability at an intra-village level might be identified. Residential groups, including interacting groups of potters, and potentially even families or individual potters might be discerned—the local "communities of practice" that formed the social groups in which ceramics were made (Cordell and Habicht-Mauche 2012).

Unfortunately for identification of local versus non-local glazewares, the Rio Grande glazeware in the Kuaua vicinity tends to be rather uniform in outward decorative appearance, with basic design styles held in common by potters at numerous production centers and sites across a wide region. Although these designs changed slowly with time, and are essential for chronological placement, they tend to be quite homogeneous over a wide area of the Middle Rio Grande at any given time. As such, basic decorations on contemporaneous glazeware vessels are not site-specific in an obvious way. Hence, within the group of towns along the Rio Grande, close attention to construction materials, especially clays and rock tempers, is necessary to differentiate localized production customs and patterns.

Of course, gaining compatible data from a large number of archaeological sites, obtained with the same field methods and laboratory analytical processes, is nearly impossible. A major obstacle is that many of the Classic period pueblo villages have been destroyed by erosion or modern expansion of the city of Albuquerque. Thus, an uneven record of the archaeological past across the Middle Rio Grande region hampers the ability to make precise regional comparisons of production and trade. Of the remaining villages, some prominent Classic period site locations (for instance, Pottery Mound, Tonque, and Tijeras Pueblo) have been the scene of many archaeological excavations, carried out by various scholars with differing research questions. Although these and other contemporaneous Classic period sites have received detailed archaeological attention in recent years, Kuaua has not been one of them.

There is also limited comparable evidence from Classic sites of the basic identification of ceramic fabrics, that is, paste clays and tempering materials, which provide evidence for local patterns of manufacture. To expand this body of knowledge, this project was designed to a) identify the basic pottery clay and tempering materials in the Kuaua glazed and utility pottery, b) locate potential sources of these clays and rock tempers in the surrounding environment, and c) estimate the percentage of glaze-painted and utility ceramics manufactured in the Kuaua community. Conversely the project was expected to identify the approximate amounts of ceramics that were manufactured elsewhere; and if possible, specify the area, district, or even sites where the non-local specimens were made, based on prior archaeological knowledge.

Theory and Method of Materials Analysis

Basic Ceramic Materials

To supply the pottery needs of a town of this size, potters needed abundant supplies of two basic materials, paste clay for pottery wall construction, and suitable tempering materials to be added to the clay. Ancient and modern Pueblo potters always add non-plastic materials ("grog" or "temper") to the paste clay in order to reduce drying shrinkage and strengthen the vessel walls. Body clays and rock tempers obtained by potters from their surrounding environment can yield clues about the wares that were manufactured by the local potters of the community.

Accordingly, the paste clays and rock tempers chosen by the potters of Kuaua should be identified and then matched against known natural resources available in the immediate vicinity. In this pursuit, an appreciation of the geographic and geologic resources of a site's environment is critical to understanding what choices were available and which were utilized by local potters. Then, having determined the identity of "local" production via the materials used as basic building blocks of manufacture, comparison to pottery from other population centers can be undertaken. Ideally, the amount of locally made pottery can be measured against that which was traded in from other sources. Finally, those external sources may be identifiable, depending on the extent of archaeological knowledge of comparable pottery practices at other sites in the region. Detailed discussions of the theoretical foundation of ceramic identification and sourcing have been provided by Shepard (1942, 1965), Rice (1987), and Arnold (1985). Studies by Lucius (2021) are current examples of the application of source-area analysis to identify production areas for Mesa Verde area orange and redware pottery based on matching ceramics to natural resources.

In a large community like Kuaua, the many potters and potting families required massive amounts of paste clays and tempers. These basic building blocks offer the best evidence of local production. There are abundant body clays and tempering materials available widely in the Kuaua environment; it is even possible that the proximity of basic ceramic resources in the environment played a role in the selection of village location.

Success in sourcing of pottery initially relies on the need to determine pottery manufacturing locations. A basic dichotomy exists between what was made at the town or village being studied, and that which was brought in by trade and exchange with other towns. Just identifying with accuracy the types and quantities of pottery known to have been made at the focal site may difficult. The first goal at Kuaua was to identify the pastes and tempers of a large sample of the pottery, and then attempt to match these to clay and natural rock sources available in the wider vicinity of these potters. Because potters selected basic materials from a local "catchment area" or "source area" within a convenient distance from home, identifying what resources were (and were not) available to local potters can help reveal what materials local potters worked with. A uniform resource that has wide geographic/geologic occurrence in the site's vicinity may hamper the ability to pinpoint a collection area. However, the most parsimonious assumption is that the closest materials (body clays or rock tempers) that match those of the ceramics are the most likely to have been exploited.

Potters also required slip clays and paint pigments. While paste clays and tempers are basic building blocks of pottery, the slips and paints that form the decorative surface are needed in much smaller amounts. They also tend to be of a specific requirement, and are not always easily obtainable in the immediate vicinity. Longer distance collecting trips or exchange with other communities may be necessary to acquire slip clays and paint materials (especially mineral-based ones). In fact, paint pigments such as the well-known black glaze paints of this time period are known to have been very widely traded for use in ceramics at many Classic period villages (Cordell and Habicht-Mauche 2012). Locating the geographic origins of slips and paints is inherently more difficult, since they were often obtained at greater distances than body paste clay materials.

Previous Identifications of Ceramic Materials at Kuaua and Vicinity

Anna Shepard's Temper Analysis

Beginning with her collaboration with Kidder at excavations at Pecos Pueblo, Anna Shepard demonstrated both the theory and the methods used in a detailed scientific study of ceramic materials (Kidder and Shepard 1936). Later, in her groundbreaking volume *Rio Grande Glaze Paint Ware* (Shepard 1942), she discussed the value of site-to-site comparisons across the glazeware production zone. This included a brief analysis of samples of pottery from Kuaua (1942:191-195). A sample of sherds was examined, mostly by binocular microscope, but evidently with small samples checked using petrographic thin sections. The sherds were taken from collections excavated from the North Plaza, and although not specifically documented in the text, they were undoubtedly excavated in 1938 under the direction of Dorothy Luhrs (Luhrs 1938; Ellis 2020). Shepard (1942:191) identified four major rock tempering materials. Their overall averages, as listed, are: andesite, 46.3 percent; vitreous andesite 24.0 percent; devitrified tuff 17.4 percent; and crystalline basalt, 6.2 percent. The remaining 6 percent was comprised of very small amounts of other materials.

Shepard also examined a sample of culinary ware from the same plaza tests through a binocular microscope. These "had a strong preponderance of vitreous andesite (84%), and other materials present in smaller percentages include: crystalline basalt, mica schist, andesite, vitric tuff, volcanic sand, and several pastes of uncertain classification" (Shepard 1942:193). Based on the high percentage of "vitreous andesite" in the culinary ware (which she assumed to be largely of local manufacture), Shepard concluded that this was the major temper utilized by Kuaua potters.

The exact locations from which of all the intrusive glazeware was obtained could not be determined for certain by Shepard. Based on available knowledge, she suggested that "we know that andesite was the characteristic temper of Galisteo to the east, devitrified tuff of the Northern Pajarito to the north, and crystalline basalt of Zia to the west, while vitreous andesite is found most frequently in the pottery of Bernalillo [Kuaua] itself" (Shepard 1942:192). These data were obviously a bit unexpected, and pointed, at least, to very extensive trade in glazeware, based on non-local tempers: "These facts suggest that Bernalillo may have been importing considerable pottery" (Shepard 1942:191).

Supportive data came from comparison of colors of paste clays. It is not clear whether Shepard made these observations directly on the sherds, or whether kiln firing to a standardized oxidizing temperature was employed. In any case, there emerged an association of non-local "andesite" temper with "buff, tan, whiteish" pastes (98%). By contrast, probable local tempers including "devitrified tuff" and "vitreous andesite" were found to be in association with red colored clays (70-81 percent) (Shepard 1942:194). Thus, a general association between certain tempers and clay paste colors was evident.

In the end, Shepard concluded that several tempers were used in glazeware found at Kuaua, and that at least some were of non-local origin. Indeed, Shepard already had some basic information available on Tonque and the Galisteo region. Of the imported glazewares at Kuaua, she assigned a portion to Tonque Pueblo, or farther to the east into the Galisteo Basin. The light buff to white paste specifically was thought to point to importation from those pueblos east of the Rio Grande. The "crystalline basalt" tempered ceramics were assigned to Zia, a pueblo Shepard was familiar with based on her studies of glazeware pottery imported upstream into the Jemez towns such as Unshagi (Reiter 1938; Shepard 1938).

It is difficult today to evaluate Shepard's results in light of newer analyses, including this project. Analyses by Carrillo (1987) and Wilson (2005) in more recent projects do not identify andesite as a local temper, nor does the present analysis. Newer geological maps show the local igneous rocks mainly as basalts, the term also used by Helene Warren at Casa Quemada, adjacent to Kuaua (Snow and Warren 2017:38-39). It seems that there may be two points of confusion, including: 1) the terminology assigned to the igneous rock tempers themselves, and 2) the lack of actual geological environmental referencing as a verification of the temper identifications and locations.

The confusion of geological terms is unfortunate, although it is realized that even in this "hard science," mineral compositions of such rocks may vary considerably and continuously within a single rock "type" (for example within the broad generic term "granite"). It also appears that Shepard used terminology that may not correspond to current definitions. Her extensive use of the term "andesite" may in fact include several intermediate igneous rocks of local and non-local occurrence. At Kuaua her "vitreous andesite" almost certainly refers to the local basalt flows and breccias identified in this analysis.

In addition, Shepard did not investigate the surrounding environment of Kuaua, either in terms of rock tempers or clays. Personal inspections were not undertaken, and she makes no mention of geological maps (primitive as these would have been in those days). Thus, there were no ground-truth comparisons to local materials which might have revealed matching rock tempers or clays within the conveniently accessible vicinity of Kuaua.

In spite of these obstacles of correspondence between her 1942 work and the advantages that more recent knowledge of both pottery and geology can offer, Shepard's main conclusions have been verified. Solid, substantiated conclusions include:

1) Kuaua potters utilized igneous rock tempers in both culinary wares and glazewares.
2) Basalt and basalt mixtures from local resources were utilized.
3) Substantial amounts of glazewares recovered at Kuaua were derived from other centers in the region, especially Zia, Tonque, and Galisteo Basin towns.

Most significantly, she was able to identify imported glazeware from several districts and pueblos which had some data available by 1942. An ambitious undertaking, her survey of the geographical points of manufacture, and thus a preliminary assessment of trade and exchange, was groundbreaking. Indeed, we still need to "fill in the blanks" in the ceramic record begun by *Rio Grande Glaze Paint Ware* (Shepard 1942). In regard to the method and theory of ceramic sourcing, Shepard paved the way for all subsequent studies.

Observations by Helene Warren

Helene Warren's extensive researches into tempering materials at different sites led her to many locations. Her identification of "hornblende latite" as the dominant rock temper at Tonque (1969) as well as her work on the Cochiti Reservoir project remain as prime examples of sourcing tempers to environmental resources. Although she mentioned Kuaua in several projects, Warren did not indicate that she ever conducted any extensive examination of main-site Kuaua ceramics or comparisons to nearby rock resources, nor did she indicate that she ever conducted thin-section petrography.

As part of studies supporting land exchanges proposed by the U.S. Forest Service, Helene and Dan Warren described pottery tempers in the vicinity of the Ball Ranch, northeast of San Felipe Pueblo (Warren and Warren 1995:304). In a brief review of the tempers utilized in this general area, she described the basalts of the San Felipe flow at Canjilon Pueblo (LA 2049), north of the confluence of the Jemez River and the Rio Grande. She also mentioned the use of basalts at the Zia villages to the west. Warren then referred to "andesite vitrophyres" from Jemez volcanics that were "described by Shepard (1942) at Kuaua Pueblo" (Warren and Warren 1995:304). She then stated that this material "occurs as cobbles in the stream or pediment gravel near the site." Her description of this rock would appear to match that of the mixed contact-zone breccia identified by the current project near Canjilon Hill, which is not an andesite. Furthermore, Kuaua potters evidently did not rely on scattered and variable small cobbles mixed with the stream sand on the river margins next to the village due to their variable composition and mixture with worn cobbles.

Finally, Helene Warren described the tempers of pottery recovered at Casa Quemada, site of an early seventeenth century historic hacienda adjacent to Kuaua Pueblo to the south (see below). Identification of ceramic types at the site was carried out by David Snow, while Warren examined the tempers of 175 glazeware sherds (Snow and Warren 2017:38-39). The sample size was small, and consisted mainly of post-1600 late glazes (Glaze F). Warren found that some (14%) had "fine-grained basalt." It was similar to Zia basalt, but "is most common in the San Felipe-Bernalillo area. The place of manufacture is not known. It was also identified at Canjilon Pueblo (LA 2049), an historic site just north of Jemez Dam on the basalt mesa" (Snow and Warren 2017:38-39).

This description fits the dark basalt and tuff-breccia mixture identified in most of the Kuaua ceramics on this project, the main rock temper in most of the glazeware and utility ware over a long period of the Classic at Kuaua. Warren also noted that sandstone was sometimes also used as temper, and that "a nearby source is likely" (Snow and Warren 2017:38-39). This has also been borne out independently with the analysis for the current project. In the same work at Casa

Quemada, Warren also noted the presence of Tonque "hornblende latite," as well as matte-painted imports from other historic pueblos at San Felipe, San Lazaro, and Cochiti. In all, Warren's limited observations from two locations peripheral to the main Kuaua Pueblo appear to accord generally with the igneous and sandstone rock tempers identified independently on the larger samples of this project.

1970 Salvage Excavations at the Kuaua Campground, Wiseman 2017

Salvage excavations in anticipation of construction of a campground for Coronado State Monument were carried out in 1970 by a team of archaeologists at the site of Casa Quemada, the early seventeenth century historic hacienda mentioned above. Now destroyed, the remains of several Spanish colonial structures were excavated. Evidence of earlier pithouses was also found. Excavation notes and analysis records from several researchers have now been compiled into a single report by Regge Wiseman (2017), forming an important part of the Kuaua archaeological and historical record. Identification of ceramic types at the site was carried out by David Snow. Helene Warren examined tempers of 175 glaze sherds, almost all from 1600s vessels (Snow and Warren 2017:38-39). Her results are described above.

Salvage Excavations at Kuaua Southeast Corner, Vierra 1986

The second project at Kuaua to include ceramic analysis in more recent years was conducted by Vierra (1987), when new restrooms were installed at the southeast corner of the site near the parking lot. Carrillo (1987) conducted the ceramic analysis. The 173 recovered glazeware sherds included a complete series of glazeware sherds from Glaze A to F, which accords with recent findings on a larger sample from the testing of 2017 (Franklin 2019). Historic sherds included two Puname Polychrome, as well as majolica sherds, probably from the historic Spanish site, Casa Quemada, located just south of Kuaua. No paste or temper analysis was conducted.

Wall Trenching, Akins and Hannaford 2005

Wall trenching reported by Akins and Hannaford (2005) included pottery analysis by Dean Wilson. His examination observed "silty high-iron clays" and rock tempers which included "sand, fine tuff, gray crystalline basalt, and local tuff latite" (Wilson 2005:23). He also noted that the glazeware had a greater variety of temper than the grayware utility, and concluded that the "great majority of the pottery was locally produced" (Wilson 2005:25). Wilson's analysis of a small sample accords well with the findings of the current project, and the general conclusions are basically the same, including the red clay description, which seemingly describes the riverine clay collected and tested in this project. The identification of the specific tempers is also similar, except that "local tuff latite" does not agree entirely with the temper identification of this project. Local tuff is certainly included in the rocks identified at Canjilon Hill, although no latite, an intermediate igneous rock, was identified in this project, either as temper or available in the local environment. However, hornblende latite, a known temper used at Tonque Pueblo, is seen in some of the imported glazeware at Kuaua.

Work in the Area of Zia Pueblo

Zia Pueblo, some 16 miles upstream from Kuaua on the Jemez River, has been occupied for many centuries. During the Classic period, it was a thriving village comparable to Kuaua (Shepard 1942). Ellis's (1966:807) excavations in the Zia ash mound revealed Coalition black-and-white ceramics and early- to mid-Classic glazewares. Additional evidence from nearby smaller sites near Zia Pueblo has appeared in data recovery and survey projects in recent years. These include projects by Nancy Hammack and others (1983), and McKenna (2000, 2015). The ceramic history at Zia seems to be quite similar to that of Kuaua, and trade relations must have existed during the Classic period, as the glazeware ceramics are comparable.

Hammack and others (1983) excavated three sites near Zia pueblo. Sites were mainly Coalition period, but one also had an early Classic period component. One site, LA 25852, contained no above ground architecture, having two pitstructures that were used into the early Classic era. The early Classic use of the site was estimated at 1350-1450, with a single archaeomagnetic date of 1420 (Hammack et al. 1983:110-116). Ceramics included Rio Grande Glazewares (180 sherds in all), in rim styles of A, B, C, and D, with the majority being typical of Glaze A. Of 177 glazed decorated sherds, all but 12 were Glaze A.

Temper of the glazeware was consistently igneous rocks. Local Zia diabase basalt was the most common (43%), with crystalline basalt (38%) next. Tonque "augite latite" appeared only in late Cieneguilla Glaze-on-yellow Polychrome and San Lazaro Glaze Polychrome, indicating trade with San Lazaro during Glaze C and D times. Utility wares predominantly contained Zia diabase (67%), while 33% contained "fine sand." Locally made glazeware included Agua Fria Glaze-on-red and the utility wares, but yellow wares were manufactured elsewhere. As is typical of Zia area ceramic production, orange paste clays were predominant in this site.

A survey of earlier sites around Zia indicated a shift to basalt temper began in the thirteenth century (McKenna 2000). McKenna (2015) also reported a survey along Arroyo Chamisa, a tributary of the Jemez river, near the Pueblo of Zia. Sites were small, probable encampments or field houses, many without verfiable residential architecture. Presumably these were related to the main Zia Pueblo nearby. McKenna (2015:12-16) describes the ceramic assemblage, and it is reminiscent of the site described above by Hammack and others in 1983. Dominated by Glaze A red-slipped glazeware (89%), it was typical assemblage dating to between 1300 and 1450, with no Glaze B. Glaze A (Agua Fria Glaze-on-red) dominates (89%), with a few Glaze C and D sherds, and a smaller peak in Glaze E (Puaray Glaze Polychrome). A very few black-on-white sherds date to the earlier Developmental period. Plain Gray was the most common utility ware, as was usual in this period. A couple of sherds of micaceous utility, clearly of manufacture elsewhere, were present. Micaceous ware is known from the Tewa district north of Santa Fe, but very little Tewa painted ware (Biscuit ware) was brought to Zia (or Kuaua), and none was seen during McKenna's survey. Equally rare, one Jemez Black-on-white bowl sherd was identified. While tradeware from Jemez was rare coming into Zia, Zia glazewares were commonly traded upstream to the Jemez (Franklin and Barbour 2016).

These more recent projects reaffirm that Zia was a strong center of production during the Classic period. Zia ceramic materials, typified by orange pastes and local basalt temper, in many respects resemble the red pastes and local temper used at Kuaua.

Samples and Procedures

Analytical Procedures

Ongoing ceramic research at Kuaua has included identification of large numbers of sherds from the 2017 excavations to basic known wares and pottery types. This basic identification was followed by analysis of representative samples (Franklin 2019). The study reported here used the same data sample to examine paste clays and lithic tempering materials. These data were then compared to local deposits that would have been conveniently obtainable by prehistoric potters. Comparative environmental data have been gathered through personal field observations in the site area, as well as from published geological and environmental descriptions. Additional data came from three detailed geological maps which, fortunately for this project, have been generated and published in recent years.

Sample Selection

A sample of 1,000 sherds was examined by binocular microscope. It was drawn from randomly chosen bags of ceramics obtained during the 2017 test excavations described above (Franklin 2019). Two major pottery wares were examined, Rio Grande Glazeware and Rio Grande Grayware. Any sherd that was of a recognizable ware known to have originated outside of this Middle Rio Grande Classic tradition was not analyzed for temper (for instance White Mountain redwares, Hopi yellow wares, and biscuitwares), although these imports are rare in the collection.

From each randomly chosen bag of ceramics, every Rio Grande tradition sherd larger than 2 cm across was selected, until the 1,000 sherd limit was reached. Then, glazeware and utility ware were separated, and the two groups examined and tallied for temper separately. Individual Rio Grande Glazeware pottery types were not identified in this re-analysis, because these cannot reliably be identified without a bowl rim present. Using only glazeware bowl rims would have made this temper analysis sample quite small. The tests in this study were designed to determine the tempers and pastes of the local glazeware and utility ware at Kuaua in general terms, not by specific pottery type, in order to identify the geographical/geological localities of rock tempers and clay deposits that were probably utilized by Kuaua potters.

Microscopic Analysis

Initial temper identifications were done by the author on 1,000 sherds, using binocular microscope observations at 10 to 30x magnification. Each sample sherd was clipped and examined on both internal exposed surfaces. Some specimens were photographed with a digital microscope. Rock temper materials were identified, and the clip placed into a container by temper category. The main sherd was then returned to its original bag. Clips were saved separately. Ten temper/ware types were distinguished by this initial examination procedure. At the end, the sorted clips were tallied by temper type, distinguishing utility ware from glazeware specimens. Thin section petrography of a smaller subset is planned for the future.

Identification of Tempering Materials

Temper types and frequencies in the study sample are given in Table 1. The ten categories of temper and their frequencies are listed. Also shown are the percentages of temper types by ware. Due to the large sample size, these tallies should be representative of the Kuaua collection as a whole. Rock types seen as tempering agents were identified as specifically as possible. Along with the rock identification, a known or probable geographic origin is also given, below, based on general regional geological knowledge and personal field observations. Figures 4 to 8 show cross sections of sherds with some of these rock tempers clearly visible.

Table 1. Tempering Materials at Kuaua, Sample from the 2017 Testing.

Code	Temper Type	Utility Ware	%	Glaze-ware	%	Total	%
1*	Potsherd	0	0	7	1.3	7	0.7
2*	Basalt, dense black (Santa Ana flow)	264	57.9	92	16.9	356	35.6
3	Basalt, shiny, vitreous, black (Zia basalt)	12	2.6	58	10.7	70	7.0
4*	Breccia, basalt and sandstone	78	17.1	27	5.0	105	10.5
5*	Sandstone, rounded quartz, no mafics	72	15.8	188	34.6	260	26.0
6	Basalt, vesicular, red (mid-Rio Grande)	0	0	5	0.9	5	0.5
7	Hornblende latite (Tonque Pueblo)	0	0	56	10.3	56	5.6
8	Andesite-diorite (San Marcos-Galisteo)	0	0	65	11.9	65	6.5
9	Inter. Igneous rock (Sandia granite?)	7	1.5	46	8.5	53	5.3
10	Micaceous (Tijeras Canyon?)	23	5.0	0	0	23	2.3
	Total	456	100.0	544	100	1,000	100.0
	Local tempers		90.8		57.8		72.8
	Non-local tempers		9.2		42.2		27.2

* Indicates tempers available in the Kuaua vicinity.

Each of these ten observed tempers is now discussed, in order of analysis code number.

1. Potsherd: Ground potsherds used as tempering material.

2. Basalt, dense black (Santa Ana flow): This the most common temper in the sample, consisting of black to gray fragments of dense fine-grained basalt. Small-grained aphanitic texture throughout is typical; individual mineral grains are not visible with the naked eye. Large vesicles or air bubbles are very rare. Color is dull black, and not glassy (Figures 4 and 5). This rock would not be identified as "andesite" mineralogically. Massive flows of basalt to the north of Kuaua on the west side of the river are named the Santa Ana and San Felipe basalt flows. These undoubtedly served as convenient sources for rock tempering materials.

3. Zia basalt: Shiny, vitreous, black, very fine-grained basalt. Occasional inclusions of white feldspars, and possibly sanidine appear. This temper conforms to descriptions by Shepard (1938) and Ellis (1966). Zia potters have historically utilized the same temper, and modern Zia potters continue to utilize the local glassy basalts for temper (Batkin 1987; Frank and Harlow 1990; Harlow and Lanmon 2003).

4. Breccia: Mixture of basalt and sandstone, sometimes with tuff. Small-to-medium round fragments of the same basalt as in 2, above. However, a mixture of quartz sandstone as a matrix may also be present. Some specimens also have white tuff along with sandstone and black basalt. The resulting mixture may also be termed a "volcanic breccia" geologically (Figures 6 and 7). This geologically odd and complex mixture occurs uniquely at Canjilon Hill, the volcanic plug (or diatreme) that is located about two miles north of Kuaua, next to the Rio Grande, and described below.

5. Sandstone: This category is typified by cemented rounded quartz grains comprising a high percentage of the minerals present (Figure 8). The sedimentary rock is white to dull tan, sometimes reddish, and may have derived from several subsets of Tertiary sandstones in the general area. Basically, no consistent mafic minerals or micas occur; that is, no hornblende, augite, muscovite, or biotite are embedded with the quartz. The coarse quartz sandstones may have inclusions of intermediate rocks such as feldspars embedded in the matrix. These fragments are gray or purple in color, as clasts within the quartz sandstone. Despite some internal variability, none of these quartz-dominant sandstone ingredients appear to be typical of any granite, diorite, monzonite, latite, or andesite, igneous rock types identified as pottery tempers elsewhere.

6. Vesicular basalt: This includes the red or purple scoria basalt typical of the Albuquerque West Mesa basalt flows and volcanic vents. It was commonly employed as tempering material at Classic pueblos in the Albuquerque area (Franklin 2017).

7. Hornblende latite: This intermediate igneous rock considered diagnostic of production at Tonque Pueblo, the large Classic pueblo on the east side of the Rio Grande along the San Pedro drainage near modern San Felipe Pueblo. A fairly well-studied rock temper, it consists of an intermediate volcanic rock with a white to gray groundmass interspersed with black laths of hornblende. This distinctive temper was initially described by Helene Warren (1969), and has also been studied since that time.

8. Andesite-diorite-monzonite: An intermediate igneous rock, moderately fine-grained, with a light gray matrix, and inclusions of augite or hornblende, but not biotite or muscovite. This is a more generic category, but may refer to tempers at San Marcos pueblo (Schleher 2010c, 2017; Schleher, Huntley, and Herhahn 2012), and eastward into the Galisteo Basin (Shepard 1942).

9. Sandia granite: Intermediate plutonic igneous rock with abundant amounts of quartz, and either pink orthoclase or white plagioclase feldspars. Also typified by mafic inclusions of hornblende, and biotite and muscovite micas (Franklin 2017; Kelley 1977, 1982).

10. Micaceous: Temper consisting predominantly of mica flakes or plates, either dark (biotite), or shiny white and translucent (muscovite). Where these are closely compacted, they occur as veins of greenish micaceous schist. Possibly from Tijeras Canyon (Franklin 2012b; Habicht-Mauche and Burgess 2016), but other localized outcrops are known in the Sandia and Manzano ranges (Franklin 2021).

Figure 4. Basalt temper in glazeware. Photo by Hayward Franklin.

Figure 5. Basalt temper in utility ware. Photo by Hayward Franklin.

Figure 6. Breccia temper in glazeware. Photo by Hayward Franklin.

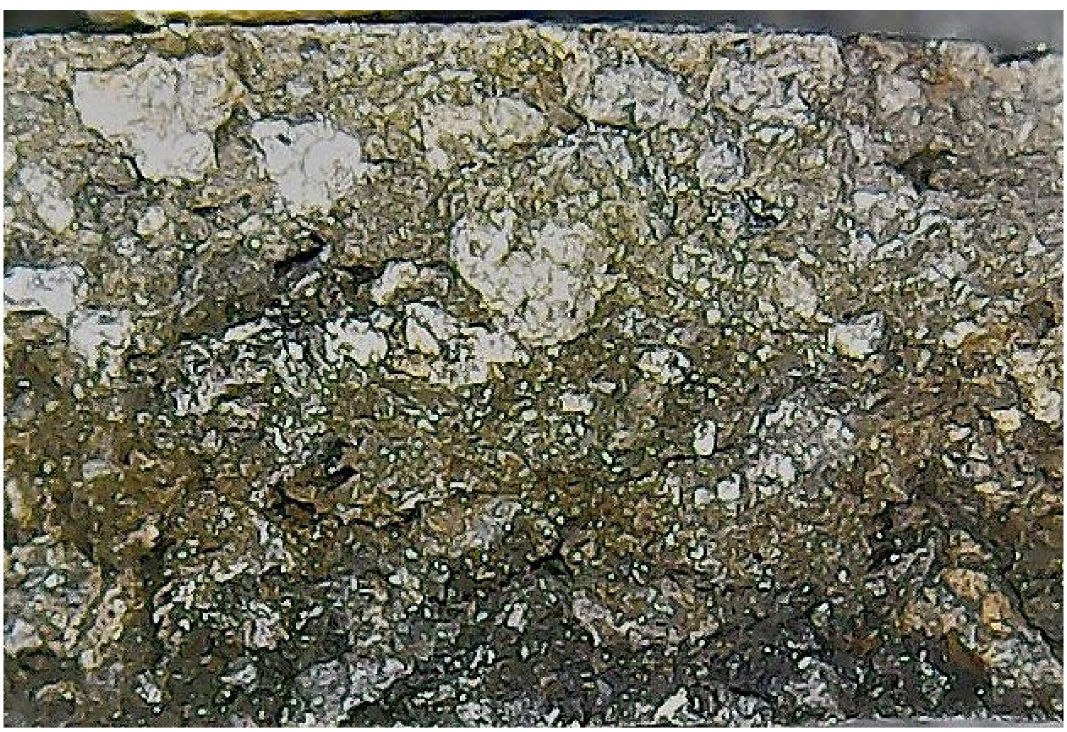


Figure 7. Tuff temper in utility ware. Photo by Hayward Franklin.

Figure 8. Sandstone temper in glazeware. Photo by Hayward Franklin.

Rock Fragments from the Kuaua Collection

An additional interesting and unexpected bit of evidence emerged from 40 rock fragments included in nine different bags of potsherds by the 2017 field crew. These small broken rocks, a total of 40, had all been fragmented, and all derived from archaeological contexts in the site (that is, they are artifacts). All but one were undoubtedly carried into the village from lithic sources in the general Kuaua vicinity. At least one possible use may have been preparation of rock tempers for Kuaua glazeware and utility ware pottery. In fact, many of these match the identified rock tempers, and they may represent rocks utilized for temper.

Table 2 gives the identifications and counts for these small rock specimens. The types of rock present in the bags tend to match closely the rock tempers already identified in the sherd sample, described above. Examination of the rock types showed the presence of Santa Ana basalt (6), four types of sandstone (22), and volcanic breccia (9). Miscellaneous pieces include quartzite (2), and micaceous schist (1). The piece of micaceous schist is intriguing, since no natural sources of this material exist in the vicinity of Kuaua. The micaceous utility pottery found at Kuaua is thought to have been imported from elsewhere, and this rock specimen may have also been imported.

Table 2. Rocks from Potsherd Bags.

Rock Type	Description	Count
Basalt	Dull gray-black, fine grained, no vesicles	5
Basalt	Clear laths of white. Maybe translucent sanidine?	1
Sandstone	Pure quartz, mostly clear grains	8
Sandstone	Fine grained white-gray quartz, some feldspar?	3
Sandstone	Pink, fine grained, occasional black particles	10
Sandstone	Pink, with various rock fragments, mostly feldspars	1
Breccia	Heated and welded sandstone with basalt interspersed	9
Quartzite	Welded by heat	2
Micaceous Schist	Unknown non-local source	1
Total		**40**

Environmental Sources of Tempering Materials

Locating Potential Resources

A promising lead towards understanding the types of temper and paste materials used by prehistoric potters is tracing constituent materials to their environmental sources. In the case of paste clays and rock tempers, large quantities were needed by the many potters at Kuaua, and fortunately, abundant resources for basic ceramic "building blocks" were available within a catchment area that was easily accessible on foot. Although not precisely defined, a general range of about 5 to 7 km, perhaps a little more, from "home" might be considered to fall within a catchment area for collecting pastes and tempers.

In this project, comparison of the rock tempers identified during microscopic examination of the sherds to potential environmental resources in the vicinity yielded definite clues as to the geologic origins of the rocks selected by Kuaua potters. Determination of environmental availability of the lithic tempers and paste clays was attempted in two ways: a) by examining high quality geological studies and maps, and b) by following up with inspection on foot some of the more promising locations.

Geology Reports, Maps, and Ground Observations

Geological studies by Vincent Kelley (1977, 1982) are good sources of information. But more applicable to this study are two recent detailed geological maps, Connell (2006) and Williams and Cole (2007). The New Mexico Geological Society/New Mexico Bureau of Geology and Mineral Resources *Highway Geologic Map* (Wilks 2005) is also useful. While the keyed labels are not always the same, these three maps yield excellent spatial information. Field visits to some of these localities allowed inspection of several of the most promising deposits for lithic pottery tempers. A portion of the Connell map (Figure 9) illustrates a likely catchment area for collection of paste clays and tempering rocks.

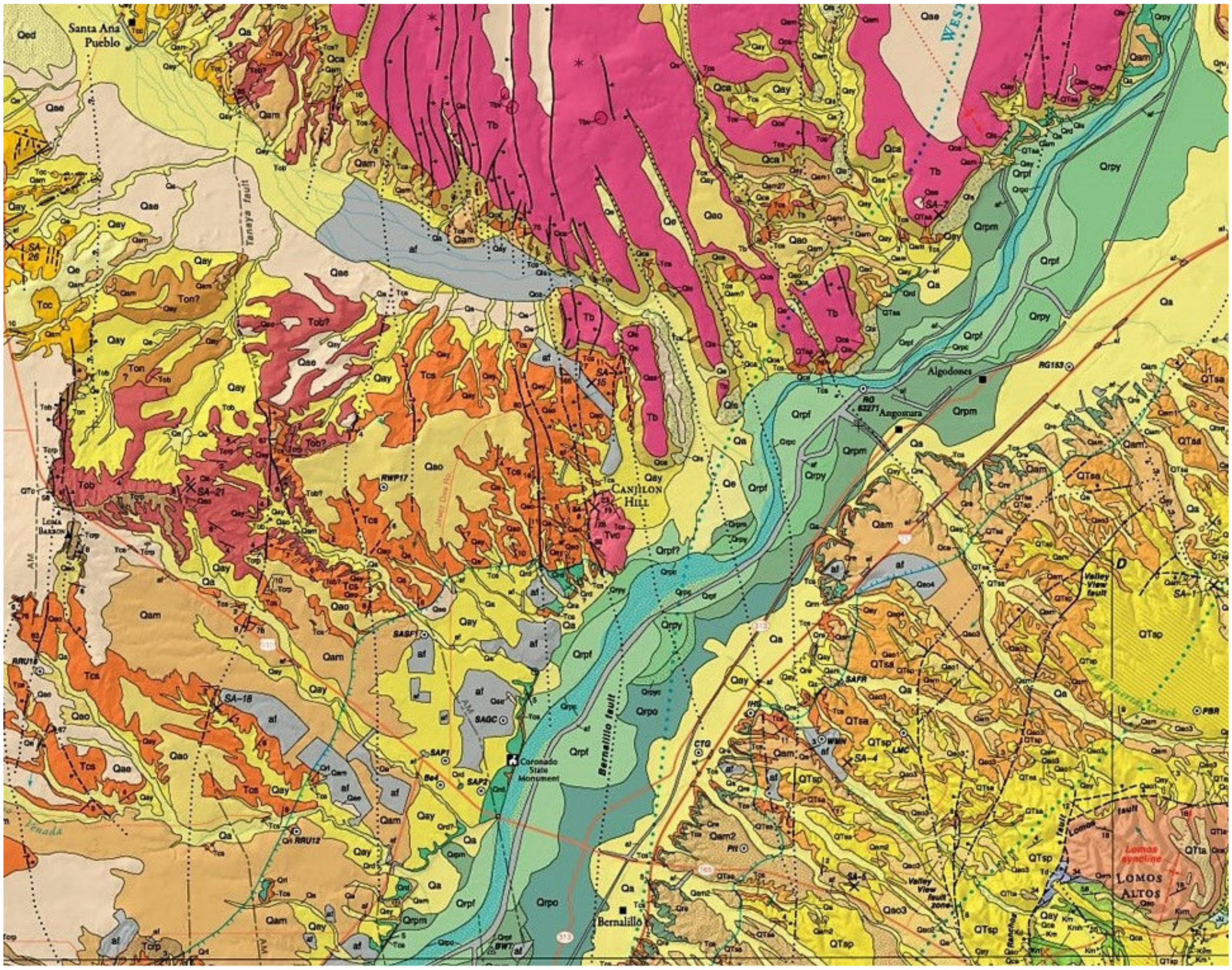


Figure 9. Bernalillo/Kuaua area portion of geologic map (Connell 2006). Kuaua location is labeled Coronado State Monument. Codes for hard rock outcrops of potential temper that are widespread and available within about 5 miles (8 km) of Kuaua**:** **Tcs** – Tertiary Pliocene Ceja Member of the Santa Fe Formation, also known locally as the Santa Ana Member of the Santa Fe Formation. Includes "clasts of red granite, basalt, and chert, and quartzite" in the sandstone matrix. **Tob** – Tertiary sandstone. Pink to red sandstone. **Tvc** – Canjilon Hill basalt, including dense black basalt flows, as well as tuff, lava, and breccia, often as a complex mix. **Tb** – Massive San Felipe Mesa volcanic field. **Qay** – Quaternary alluvium. Mixed sands and gravels near rivers and streams.

Modern Alluvium. Examining the Connell map (Figure 9), we see three major rock exposures in the Kuaua catchment. The closest is Quaternary alluvium (Qay) next to the river, on which the site is located. This deposit is a loose mixture of sands and rounded gravels carried in from elsewhere. By field inspection, it does not contain sufficient quantities of any specific rock type to have been used as a consistent source of specific rock tempers by potters. In fact, we know that early (and modern) Pueblo potters sought locations where abundant and consistent hard-rock materials could be obtained, even at a greater distance. Also, close examination of temper sometimes reveals quartz grains cemented together as sedimentary sandstone rock fragments, not loose sand. Shepard (1942:193) also discounted use of local sands as temper, based on the expectation that sands would (and actually do) consist of an unreliable variety of minerals and rock fragments derived from different sources. Kuaua pottery temper does not show such random mixtures; in fact, her petrographic thin-section examination showed that Kuaua pottery "proved to contain only a single kind of rock" (Shepard 1942:193).

Sandstones. To the north, up the long slope where U. S. 550 runs today, there are extensive, if intermittent, exposures of sandstone. These are Tertiary Pliocene deposits of the widespread Santa Fe Formation, of which the local exposure is the Ceja Member. The Connell key lists these sandstones as Tcs and Tob (Figure 9). Although they all are of the same major time period and overall formation, the various members differ in detail. In addition to typical quartz grains, some of these local deposits also include pink to red sandstone as well as white-yellow. These sandstones also have various inclusions mixed into the sand matrix, giving considerable variety to the composition. These include clasts of red granite, basalt, chert, and quartzite (Figure 9) (Connell 2006). Similarly, the Williams and Cole map lists "fine to medium grained porphyritic granitic rock fragments in the quartz grained sandstone."

The distances from Kuaua to the sandstone outcrops are not great. This wide expanse of sandstone is situated from approximately 2.5 to 8 km in distance. Redder and coarser sandstones lie farther uphill to the northwest. In all, a number of sandstone formations were accessible to Kuauans within an area of accessible terrain and distance. The sandstone variability noted within the sandstone temper sorting category is certainly due to collection from different spots across the sandstone-dominated countryside northwest of Kuaua.

The quantities of sandstone temper in the sample are quite high (Tables 1 and 2). The diversity within the group certainly reflects the differential mineralogical composition of these Santa Fe Formation outcrops. Although this analysis was able to quantify the numbers of sandstone-tempered sherds, the finer variants of sandstone tempers evident in the environment are not immediately separable with the binocular microscope. Perhaps thin section petrography will succeed in narrowing the sandstone identities to specific local exposures in the environment.

Basalts and Breccia. Preference for basaltic rocks was common in the Middle Rio Grande region during the Classic period, and has been noted in the Albuquerque District at several major pueblos (Franklin 2010b, 2012a, 2017; Schleher 2010a), and also at Zia Pueblo to the west of Kuaua on the Jemez River (Ellis 1966; Shepard 1938). In prehistoric times, Kuaua potters were definitely aware of the advantages of basaltic temper and employed it in both utility and painted pottery, as these analyses illustrate. Volcanic basalt was especially favored in production of utility ware, as it may have resisted the thermal shock imparted to cooking vessels used over a fire (Bronitsky and Hamer 1986).

The three geologic maps clearly identify the locations and extents of the basaltic lava fields. The extensive massive lava field to the north, extending down close to the Rio Grande, is cut by the lower end of the Jemez River as it empties into the river. Together, the Santa Ana and San Felipe portions of this extensive flow afforded potters access to basaltic rocks. Labeled as Tb (Tertiary basalt) and shown in pink, these basalts cover a large area on the west side of the Rio Grande (Figure 9).

From Kuaua, the major part of the volcanic flows lies 5-6 km to the north, and begins just south of the confluence of the Jemez River with the Rio Grande. But the lava fields south of the confluence are even closer. At the southern end of the lava fields is a unique feature, referred to locally as "Canjilon Hill," clearly shown as Tvc and labeled "Canjilon Hill" (Figure 9). It is a tall vertical column of black lava protruding through the sandstone, forming a prominent peak on the landscape (Figure 10). This volcanic plug or diatreme resulted when magma intruded into preexisting sandstone formations near the river. Associated horizontal basaltic sills extend laterally from the plug, and are prominently seen, with pockets embedded into the pre-existing sandstone along the margin of the river for some distance. This is a complex local geological feature undoubtedly visited by Kuaua potters, as it is an easy walk of 4 km (2.5 miles) from home. Debris from the main promontory mesa is scattered even closer to Kuaua (ca. 2 miles or 3.2 km.). Photos of the general hill and mesa are shown in Figures 10, 11, and 12.

Figure 10. Canjilon Hill and nearby volcanic mesa. Photo from nmnaturalhistory.org.

Figure 11. Basalt at Canjilon Hill and nearby volcanic mesa. Photo by Hayward Franklin.

Figure 12. Basalt caps and sills in sandstone at Canjilon Hill. Photo by Hayward Franklin.

Dense black basalt (aphanitic, and rarely vesicular) is the predominant rock type intruded into the sandstone in this complex geologic environment. The basalt composition and texture might also qualify as a diabase (dolerite), which often occurs in shallow intrusions such as dikes and sills. A volcanic breccia (basalt fragments, and sometimes tuff, embedded in a sandstone matrix) is also found in localized contact zones. In some cases, the contact zone shows sandstone melted and altered due to heat. Other exposures show white tuff, apparently deposited prior to the flows of black basaltic lava. No rocks were identified as andesite. Figure13 shows *in situ* examples of the pure basalts and the breccias. These are commonly exposed by modern erosion and are quite visible today. Figure 14 shows hand specimens of these rocks, including pure basalt, and breccias composed of basalt, sandstone, and tuff.

Figure 13. Breccia and welded sandstone at Canjilon Hill. Photo by Hayward Franklin.

Figure 14. Top row: Basalt; Bottom row: Breccia, all from Canjilon Hill. Photo by Hayward Franklin.

The Canjilon Hill complex has the potential to have been the source area where Kuaua potters obtained the rock tempers identified microscopically. Small pieces of all these rocks described above, basalt and basalt with sandstone, were identified in the Kuaua pottery, and in fact they make up the great majority of the utility ware temper, and also a substantial portion of the glazeware temper. They were classified during analysis as black basalt, and breccia. Given the fact that Canjilon Hill is the closest large outcrop of native igneous rock to Kuaua, it is not surprising that potters evidently depended on its exposed rocks to be used as temper in their wares.

Matching Tempers to Natural and Cultural Origins

Frequency of Occurrence

The identified totals and percentages of each of the temper types are given in Table 1. One obvious pattern is that temper types differ markedly between painted glazeware and utility ware, suggesting that potters selected tempers based on the type of vessel they planned to build. Many of the identified tempers are available near Kuaua. However, a number of the identified tempers are not available in the Kuaua catchment area, suggesting that the pot was probably made elsewhere.

Specific details of Rio Grande Grayware tempers remain incompletely studied in the region. Table 1 shows that utility vessels were commonly made of locally available dark basalt (57.9% of utility sherds), with fewer sherds containing basalt-sandstone breccia (17.1%), or pure sandstone (15.8%). Thus, known locally tempered utility comprise 90.8 percent of all utility ware in the Kuaua sample. Utility or Grayware possibly not made locally, based on non-local temper includes: Zia basalt (2.6%), intermediate igneous rock (probably Sandia Granite,1.5%), and micaceous rock (schist or phyllite) (possibly Tijeras Pueblo or San Antonio Pueblo, 5.0%). No utility pottery was identified as having temper of vesicular basalt, hornblende latite, or andesite-diorite-monzonite, all tempers known to be non-local.

Rio Grande Glazeware temper frequencies are quite different (Table 1). Predictably, the painted pottery is much more varied in its tempers. Potsherd (7 sherds, 1.3%; probably dating very early in Kuaua's Classic period occupation), local sandstones (34.6%), local Santa Ana basalt (16.9%), and local Canjilon breccia (5.0%) account for 57.8% of temper, indicating local production, while 90.8 percent of utility is tempered with these same local materials.

The glazeware also reveals substantial tempers from more distant production locales (Table 1). Together, some 42.2% of glazeware derives from non-local sources. These include glazewares having Zia basalt (10.7%); hornblende latite, a signature rock temper employed at Tonque Pueblo (10.3%); vesicular basalt (0.9%) and Sandia granite intermediate igneous rock (8.5%) from the Albuquerque area; and andesite-diorites from San Marcos Pueblo and possibly the Galisteo Basin (11.9%). No glazeware contained the micaceous temper observed in some of the utility ware. Identification of these tempers as generally "non-local" is more certain than their estimates of specific geographical/cultural site origins.

Finally, during the Classic period, the relative frequency of painted pottery increased relative to earlier phases. In many Classic assemblages, the ratio is about 1:1, and this was also the case in the tallies of the 2017 collection (Franklin 2019). In this random sample study of 1,000 sherds, 456 are utility while 544 are glaze painted sherds. Thus, these sums tend to confirm the large amount of painted pottery compared to utility ware during this time.

Local Manufacture

Given the major rock tempers identified in the large potsherd samples examined microscopically, as well as the geological evidence of the exposed rocks available to potters in the nearby vicinity of their village, certain general conclusions may be drawn. First, Kuaua potters conformed to the long-standing tradition of Classic Period potters in the Middle Rio Grande region in relying almost exclusively on lithic tempers derived from rock outcrops in their vicinity. Kuauans collected suitable lithic tempers from hard rock exposures within a distance of 2 to 5 miles from the pueblo while avoiding closer deposits of mixed riverine sands. Matching pottery temper to natural resources has strongly suggested that potters at Kuaua used sandstones and volcanic intrusions (including basalt, mixed breccias and tuff) predominantly in their wares. Together, these two general rock types account for a minimum of 57.8 percent of the glazeware and a minimum of 90.8 percent of the utility ware tempers studied (Table 1). These two major types of rock are also the main ones identified in the nine small pieces of rock recovered from archaeological contexts (Table 2). Therefore, much of the Kuaua pottery can be ascribed to local production.

Non-local Manufacture

The minor amounts of glazeware with potsherd temper are early Glaze A in time, probably Los Padillas or Arenal Glaze Polychrome. Sherd-tempered vessels may or may not have been manufactured at Kuaua. Kuaua potters adopted the crushed igneous rock tempers common throughout the Middle Rio Grande Classic early in the glazeware production sequence.

Glazeware and utility ware identified as having tempers other than the local basalts and sandstones discussed above would logically be assigned to manufacturing locations elsewhere in the region. That is, they would be "imported" from contemporaneous towns and villages with whom Kuauans maintained trade relations. As identified on this project, those tempers would include Zia glassy basalt, vesicular red basalt, hornblende latite, andesite-diorite, and micaceous tempers, and possibly potsherd temper.

The tempering agents thought to be non-local can in some instances be tentatively assigned to known production centers at Classic period pueblos elsewhere. In other cases, only generic "probable" districts or geological zones can be proposed for their areas of production. At present, information is too inadequate for many sites and their matching geological sources to be able to pinpoint the origins of these intrusive pottery pieces. With better sourcing studies throughout the region, more definite points of origin for traded pottery at Kuaua will become clearer.

Comparable temper/paste evidence is available from a few well studied Classic period sites in the Kuaua vicinity. These include both site studies and regional syntheses, including those at Tijeras Pueblo (Habicht-Mauche 1995; Habicht-Mauche et al. 2000); Pottery Mound (Eckert 2008; Franklin 2010a; Schleher 2010b); along the Rio Grande at Montaño Bridge Pueblo (Schleher 2010a); Tonque Pueblo (Eckert et al. 2018; Snow and Warren 1971; Warren 1969). Related studies are at San Marcos (Schleher 2010c, 2017), and on the Pajarito Plateau and Caja del Rio (Schleher and Boyd 2005). Tempers and clays have been identified by Franklin at several riverine pueblos in the Middle Rio Grande: Valencia Pueblo (1997), Montaño Bridge Pueblo (2010b), Piedras Marcadas (2017), and the Chamisal Site (2012a). Salvage projects in Alameda have also revealed essentially the same sequence of local glazewares (Kurota 2008, 2013). Glazeware materials were also studied at Isleta Mission by Marshall (2015). No verified examples of glazeware from the Salinas pueblos have been identified at Kuaua, although tempers of that district have been fairly well studied, including detailed newer analyses by Herhahn and Huntley (2017). Together, these studies of local ceramic materials usage in the Middle Rio Grande production area provide some measure of potential assignment of the non-local Kuaua pottery to its origins.

The non-local tempers in this sample of glazeware at Kuaua seem to indicate importation mainly from Zia, Tonque Pueblo, and the San Marcos/Galisteo Basin District, with smaller amounts from the Middle Rio Grande (Albuquerque Basin) area. To a much lesser extent, non-local origins are also suggested for small amounts of Zia Utility. Additionally, 5 percent of utility ware is micaceous-tempered plain gray, likely originating in the Sandia Mountains.

Despite good data from certain other site locations, it is obvious that having a systematic and area-wide comparative analysis of reliable samples from more sites would help in assessing and sourcing production locations. Shepard, in *Rio Grande Glazeware* (1942), envisioned integrating site data into a regional database for the future. Only then can we securely pinpoint origins for all the non-local ceramics at Kuaua.

Clay Body Materials

Locating Paste Clays

In order to substantiate the results of the temper analysis, a subset of the 1,000 sherd sample was evaluated for their constituent body clays, using kiln oxidation analysis (Rice 1987:343-345). The temper categories selected for this test were those already determined to be likely locally produced, based on the temper and environmental data presented above. That is, would local clay data tend to corroborate the temper data? A conjunction of local tempers with local clays would strengthen the conclusions about the amounts and kinds of pottery actually constructed by local potters at Kuaua.

The premise was that suitable potters' clay would be available in quantity in the local Kuaua environment, given the massive demand by resident potters. The most obvious source would be the riverine clay of the Rio Grande. Available in shallow pools and side channels, clay is not continuously deposited by the river, but inspection soon yielded good quality clays. For this project, clay was collected from a shallow inlet about 0.4 km (0.25 mi) upstream from the main site. This riverine clay appears to be suitable for pottery body clay. The only other clay source available close to Kuaua in large amounts would be from the Jemez River, as it empties into the Rio Grande about 4.8 km (3 mi) upstream. This deposit is similar to the red clay which is used upstream at Zia. The reddish outflow from the Jemez River affects the color of Rio Grande clay at least as far downstream as Kuaua. This gives the riverine clay at Kuaua a reddish-brown hue that disappears into the darker browner clays and silts farther downstream.

Having obtained the most obvious good raw clay near Kuaua, kiln refiring and coloration comparison was used for evaluation. This method was described by Shepard (1965:219) and Rice (1987), and has been used widely. This test asked the questions: First, do the clays of these pottery pastes, thought to be local, show uniformity of Munsell color, and do they match the riverine clay? And secondly, if so, is there a consistent correlation between certain tempers and the riverine clay that would be a marker of what would be considered local production at Kuaua?

Firing Testing of Body Clays

Sample Preparation. The collected river clay was soaked for about a week, and evaluated for plasticity. It flattened and rolled into a cylindrical shape quite easily. It also seemed to resist cracking, even without added temper, if dried slowly. Two circular briquettes were formed, and the initial, unfired color recorded by Munsell Soil Color Chart (1973). Results are given in Table 3 and Figure 15. Also included in the test was a piece of unfired but worked clay collected during the test pit excavations of 2017.

Table 3. Kiln Oxidation Firing of Raw Clay and Ceramic Sherds.

Material	**Raw, Dried Color**	**Kiln Fired Color**
Rio Grande Riverine Clay (2 briquettes)	5YR 6/3 to 5YR 6/4	5YR 5/8 to 5YR 6/8
Raw Worked Clay from Kuaua (1 piece)	5YR 6/4	5YR 6/8

Ware	**red-brown 2.5YR 5/8**	**5YR 5/6**	**5YR 6/6**	**reddish-tan 5YR 5/8**	**5YR 6/8**	**light tan 7.5YR 5/8**	**5YR 6/8**	**Total**
Utility Ware Basalt Temper				4	5	1		10
Glazeware Basalt Temper	1	2		2	5			10
Utility Ware Breccia Temper			2	1	6		1	10
Glazeware Breccia Temper	1			1	7		1	10
Utility Ware Sandstone Temper	2			2	8			10
Glazeware Sandstone Temper				1	6		1	10
Zia Glazeware? Zia Basalt Temper	3				7			10
Total	7 10.0%	2 2.9%	2 2.9%	11 15.7%	44 62.9%	1 1.4%	3 4.3%	70 100%

Figure 15. Representative results of the kiln firing test. Top left and center: Rio Grande riverine clay briquettes. Top right: Unfired but worked clay from 2017 excavations at Kuaua, now fired. Bottom: Refired glazeware sherds.

Next, a subset of the 1,000 temper sample sherds was selected for the kiln test. Sherds thought to be local, based on the temper analyses presented above, were selected: sherds with pure basalt temper, basalt-breccia temper, and sandstone temper. However, non-local Zia glazeware, with glassy basalt temper, was also included in the test. Accordingly, ten clips of each local temper and ware category (plus glassy basalt) were randomly selected from the sorted clips of the temper sample. Thus, there were 70 clips, 10 each of each of the seven temper/ware categories (Table 3). This was to determine if Zia production could be distinguished from Kuaua ceramics, based on either temper or paste color or both, since the ceramics of these two centers have basalt tempers and reddish body clays that are similar enough that it might be difficult to always correctly distinguish them.

Kiln Firing. The riverine clay briquettes, the worked clay from the site, and all 70 sherds were fired in an electric kiln in one firing. The standard firing routine is heat to 900°C, hold for 10 minutes, and slowly cool to room temperature. The process raises sherds to a standardized oxidized temperature that is a little higher than that of the original pottery firing. As a result, the paste clays reach full coloration, and sherds can be compared to each other and to environmental clays using a Munsell Color Chart. Obviously, this method is not testing clay minerals or chemical composition directly, but it reflects those attributes in terms of specific hues, values, and chroma. Also, the test can be carried out on large samples of pottery fragments and raw clays inexpensively.

Interpretation of Fired Pottery Samples

Table 3 shows the resulting oxidized colors for the 70 sherd samples. Fired samples were identified according to a Munsell Soil Color Chart, in indirect sunlight. Table 3 arranges the seven Munsell colors of this sample according to Hue, going from darker and redder, on the left, to lighter and yellower, on the right. This range of adjacent coloration on the Munsell chart might be called "light reddish brown" grading into a "light tan" in commonly used terms.

Also tested were two briquettes formed from river clay, and one piece of raw worked clay from the site. Figure 15 shows the two fired clay briquettes, the previously unfired but worked clay from the 2017 excavations, and several refired glazeware sherds. These likewise fired to a medium reddish-tan, in the range of 5YR 5/8 to 5YR 6/8 on the Munsell Chart (Table 3). These two are adjacent color chips on the Munsell chart, differing by just slightly different Values (lightness of a color), while being identical for Hue and Chroma.

The most obvious trend in the oxidized results of Table 3 is the strong agreement in oxidized color between the raw clays and the great majority of glazeware and utility sherd clips containing tempers thought to represent local Kuaua manufacture. Riverine clays and the unfired clay sample from the site all agreed with each other at the two adjacent Munsell chips of 5YR 5/8 and 5YR 6/8 (reddish tan). This is also the coloration of the majority of the sherd clips; almost 79 percent of the whole sample falls on the same two chips. Therefore, I conclude that the river clay, the worked clay piece, and most of the 70 sherds show that they could have been derived from the same basic source of clay. This tends to confirm, at least generally, that riverine clay was probably the source of body clay chosen by potters when making wares at Kuaua. Interestingly, this color dominance and uniformity applies to utility ware as much as glazeware, and both could have been formed from the same clay source. Further, the same clay color applies to the local tempers (basalt, breccia, and sandstone). So, although several temper sources appear to have been utilized by Kuaua potters, it appears that a single Rio Grande body clay was commonly utilized. Why prehistoric potters apparently mixed at least three sources of rock temper with the same body clay in the overall Kuaua pottery production is not clear.

Despite the overall Munsell color unity of the vast majority of the local wares, there is also evidence in Table 3 of some variability around the central mode of medium reddish-tan. Such variation on the overall color theme occurs almost entirely in the glazeware (groups 2, 4, 6, and 7), while utility ware remains uniformly centered on 5YR 5/8 and 5YR 6/8, reddish-tan. Small counts of darker and redder colors, as well as lighter and more tan-colors than the central norm, are seen in glazeware that contains tempers that are local, as defined above. These samples are small, but this may imply that other clay sources were sometimes used in local glazeware. Or such variation could simply result from differing collection localities along riverine margins in the Kuaua vicinity.

Finally, the inclusion of ten glazeware pieces, thought to be from Zia Pueblo based on temper, showed an interesting pattern (Table 3). While 7 of the 10 pieces fired to the color of 5YR 6/8, associated with Kuaua manufacture, three fired to a darker red-brown 2.5YR 5/8 color. Overall, the refired "Zia" sherds yielded coloration similar to that of the Kuaua tempered pottery. As such, Zia glazeware is close to that of Kuaua in both paste color and basaltic tempers. Of course, this similarity certainly derives from obtaining basic building materials from very similar geological sources along the same Jemez River drainage and adjacent Rio Grande margins. Employment of orange-red clays and basalt tempering are common to both. Both villages, only 15 miles (24 km) apart, utilized the abundant brightly colored clays, as well as basalts derived from the same large-scale volcanic lava fields situated just north of their villages. Analytically, this makes a definitive separation of the wares of the two pueblos uncertain. At a gross level of analysis, a more orange body clay and glassy basalt temper would suggest Zia origins, while a redder body clay and basalt or breccia temper would suggest manufacture at Kuaua. However, successful analysis in conclusively distinguishing the prehistoric production of Zia and Kuaua will need to rely on thin-section petrographic comparisons in the future.

Slip Clays

Good red, white, and yellow slip clays were a rare commodity, and not as conveniently obtainable as body clays and tempers. In many cases, treks to distant sources of high quality colored clays may have been required, or slips or clays obtained by trade/exchange with distant towns that specialized in such items. Actual sources of slip clays have not been adequately researched, compared to glazed paint resources. Possible sources for colored slip clays in the area of Kuaua may include these localities:

La Cueva picnic ground, Sandia Mountains (red, tan)
La Bajada Hill (yellow and red)
Placitas, Las Huertas (red)
Tonque (yellow and red)
Galisteo Basin (white and gray)
Rio Puerco (white and yellow)

Of these potential locations, La Bajada Hill, 12 miles (19.3 km) north, might be one of the most available. To the south, suitable red and yellow slip clays outcrop in the northern Sandia Mountains and farther south in the vicinity of Tijeras Pueblo (Franklin 2012b). The distance to Tijeras Pueblo is about 27 miles (43 km) following watercourses. Trade with Tonque Pueblo (11-14 miles/18-23 km away, depending on the route), already verified with finished pottery imports, might have supplied slip clays. Tonque was the site of a historic brick factory which manufactured red and yellow bricks. The obvious clay resources at Tonque (Eckert, Schleher, and Snow 2018) may have been distributed widely prehistorically as raw materials for slipping painted wares.

Glaze Paints

The black glaze paints used by Classic period glazeware potters have been the subject of intense interest by archaeologists for many years. Indeed, much has been learned about the mining, pigment preparation, distribution and utilization of glaze paints. Compendiums of this research are available in The *Social Life of Pots* (Habicht-Mauche et. al. 2006) and *Potters and Communities of Practice* (Cordell and Habicht-Mauche 2012). Newer research in the Salinas District adds information on resource utilization (Spielmann 2017).

The general conclusion from a large body of research on the topic is that glaze paints were derived from raw galena (lead ore), primarily from the Cerrillos Hills, but also from the Hansonburg and Magdalena districts to the south. Preparation of pigments for painting might have occurred at only a few villages, such as San Marcos Pueblo (Schleher, Huntley, and Herhahn 2012), for distribution outward to other Classic period towns through a network of trade and exchange. There is no evidence that potters at Kuaua, who certainly used glaze pigments abundantly, were able to obtain the raw materials within their local resource area. Instead, a likely route of import would have been from the mines at Cerrillos Hills, 28 miles (45 km) away, possibly via preparation centers at San Marcos or Tonque Pueblo. It would be desirable for future testing to include glaze pigments from Kuaua, a site mostly neglected in this regard, to substantiate this assumption.

Summary and Interpretation

This project was an experiment to determine whether the parameters of local production at Kuaua Pueblo could be identified. Characteristics of tempers were studied on a large sherd sample (n=1,000), including identification of lithic tempers and location of possible sources of the various local tempers. In addition, for a smaller subset of the original sample (n=70), refiring experiments were made, a potential source of plastic body clays was located, and the potential clay resources were compared to samples of Kuaua ceramics clay. As a result, we now know new details of the characteristics of Kuaua pottery production, both of glazeware and utility ware.

Selection of Basic Temper and Clay Resources

Sources of matching lithic tempers and body clays exist within a radius of 5 miles (8 km) from the pueblo, well within the range that Arnold (1985) specifies as a typical foot travel limit for modern potters to obtain these materials.

During the Classic period, crushed potsherds were used as temper during the Glaze A phase, but soon gave over to use of crushed igneous rocks, mostly volcanic in origin, a practice that persisted for the next 300 years. Middle Rio Grande Pueblo potters soon settled on a regime of rock tempers derived from the varied geological formations in the Valley and surrounding uplands. They almost never employed alluvial deposits along the margins of the rivers, even though these were readily available "out the back door," likely because there is no consistency of grain size or rock type in the alluvial deposits.

By the Classic period, potters apparently consciously utilized very specific igneous rocks. Generally, igneous rocks are angular, bind well to the clay, and do not alter during pottery firing. As a widespread custom, volcanic rock tempers were employed by potters resident along the river from Santa Fe to Socorro, especially varieties of basalt available as outcrops. These flows, which differ somewhat in basaltic texture and porosity, are available in most places along the west side of the Rio, within a mile or two from the numerous towns situated along the river's edge.

At Kuaua, this practice involved use of available basalts and mixed breccias, as well as sandstones. These were obtainable from surface exposures in the local environment within a distance of five miles from the pueblo. Grayware utility jars in the 1,000 sherd sample are 90.8 percent tempered with these materials, while the more heterogeneous glazeware is 57.8 percent tempered with the local rocks.

Required in large quantities, vessel body clays were also available naturally in the Kuaua environment. Alluvial clays of good plasticity for vessel building were available in pockets in many places along the Rio Grande margins or up along tributaries. A large proportion of Kuaua ceramics were formed from these rather uniform body clays.

Aside from the body clays, smaller or more distant outcrops of high quality clay materials were necessary for use as thin slips on glazeware. A concerted search for the sources of these rarer commodities has not been undertaken. It is possible that localities for high quality colored slip clays were visited by Kuaua potters. Potential sources of slip clay include primary clay exposures in the Jemez River Valley, at La Bajada Hill, the Sandia Foothills, and Tijeras Canyon. Alternatively, these slips or slips from more distant sources may have been obtained by trade.

Trade and Exchange

By logical elimination, those specimens that do not exhibit the diagnostic clay and temper traits believed to typify local production likely represent manufacture at other contemporaneous Classic period towns. Non-local tempers were seen in about 9 percent of utility ware and 42 percent of glazeware sherds. Exactly which contemporary towns supplied these finished ceramics, and how they were obtained, is more difficult question. Based on incomplete evidence, towns with glazeware trade connections to Kuaua probably include Zia Pueblo, upstream on the Jemez River (glassy black basalt temper), Classic pueblos of the Albuquerque Basin (vesicular basalt and granite), Tijeras Pueblo (early glazeware with sherd temper, utility ware tempered with mica and schist), Tonque Pueblo (hornblende latite), San Marcos Pueblo (augite monzonite), and Galisteo Basin (various intermediate igneous rocks). These centers vary from 12 miles (19 km) to 34 miles (45 km) from Kuaua. Glazeware imports from these distant contemporaneous Classic pueblos represent overlapping zones of production and trade connections about which we possess incomplete information.

Zia has been credited in the past with being the sole place of manufacture of the glazewares found traded upstream into the Jemez Province (for example Franklin and Barbour 2016). However, based on their similar pastes/tempers, some of the glazed and culinary pottery found at the Jemez pueblos might have been made at Kuaua. Thin-section analysis of pottery from the Jemez pueblos would be needed to definitively determine whether some of the “Zia” pottery was actually made at Kuaua.

Culinary ware is usually thought to remain for use where it was manufactured. Thus, its pastes and tempers should reflect more uniform characteristics than painted wares (Arnold 1985; Rice 1987). If true, paste and temper studies on utility ware should give us a good idea of the characteristics of locally available materials. As such, utility ware ought to be the first major ware examined by the archaeologist, not the last. And yet it is sometimes ignored completely!

Uniformity in culinary ware materials would presumably result from consistent use of an easily accessible source. While these common dictums about utility wares may hold true generally, they require testing and verification. In fact, assessment of trade/exchange networks should always include utility wares. Here at Kuaua, some imports of utility pottery (about 9%) appear to have derived from contemporaneous towns from which the more obvious painted trade wares were obtained.

At Pottery Mound, 35 miles (56 km) to the south on the Rio Puerco, consistent minor amounts of utility ware were certainly derived from the same distant sources as the better-documented and more visually obvious painted wares from the Acoma-Zuni District and the Hopi Mesas (Franklin 2014). Indeed, the “lowly and unimpressive” utility wares were also functional as containers for liquids (including water for long journeys), as well as other items destined for a distant place.

There are cases in the general Middle Rio Grande of substantial trade in utility pottery, based on materials composition or visible style known to have been produced elsewhere. Warren (1981) noted the consistent occurrence of micaceous utility ware at Classic period glazeware villages along the Middle Rio Grande and its tributaries, although mica rock does not occur naturally along the river valley. This has been verified at various other sites since 1981. An obvious example at Kuaua is the group of 23 pieces of utility ware tempered with mica schist or phyllite schist, which does not naturally occur near here. One possible interpretation at Kuaua would be trade of finished mica-tempered pottery from production towns. Tijeras Pueblo, 27 miles (43 km) from Kuaua, is known to have employed micaeous schist in its utility ware (Franklin 2012b; Franklin and Schleher 2012; Habicht-Mauche and Burgess 2016). Alternatively, it is possible that potters along the river may have made treks to the mountains to obtain raw materials such as mica and schist in Tijeras Canyon or from closer outcrops at the north end of the Sandia Mountains.

Continuity of Traditions and Practices into Historic Period

During the early Spanish Colonial period (1600 to the Revolt of 1680), Pueblo glazeware production (Glaze F) continued in the Middle Rio Grande pueblos, which saw the native wares influenced by European forms. Pueblo potters produced flared rim soup plates, candelabra, and other non-traditional ceramic forms, while continuing to make traditional bowls and ollas. This trend seems to have been in vogue from the estancia at Casa Quemada next to Kuaua (Snow and Warren 2017), south to Isleta (Marshall 2021). However, Kuaua itself seems to have been in decline, and less pottery was made in Glaze F than in any of the preceding glazeware phases (Franklin 2019). The main site was abandoned about the time of the Revolt, and never reoccupied as a major town.

Zia was a major producer of basalt-tempered glazewares, which were widely traded into the Classic period towns of the Jemez Province for almost the entire span of glazeware production (Franklin and Barbour 2016; Shepard 1938). It is probable that some of the similar Kuaua basalt-tempered glazeware was also exported to other contemporary pueblo towns in the region, but these have not been recognized in a trade context elsewhere.

In sum, prehistoric inhabitants of Kuaua possessed an intimate knowledge of their environment and the resources that it contained. During three hundred years, Classic period ceramics exhibited variability in painted style trends, from Glazes A through F, yet maintained continuity in essential production methods and materials. This project studied local production materials and their availability within a convenient collection range exploited by prehistoric potters at Kuaua Pueblo. Of course, the unwritten complexity of knowledge possessed by these expert potters about their environment can never be fully understood by us. Especially in the Middle Rio Grande Valley, our spatial view is inhibited by modern construction and land disturbance that has modified the prehistoric landscape. Indeed, many prehistoric pueblos, some the size of Kuaua, have been eradicated completely. However, it is still possible 500 years later, to glimpse a view of how potters were able to successfully manufacture the quantities of varied and beautiful wares that we still admire today.

Acknowledgments. I want to express my gratitude to the volunteers who have identified and recorded a large amount of ceramics from two Kuaua collections, as well as the support of the staff at Coronado Historic Site, including Matt Barbour, Ethan Ortega, and Annie Campagna. Their expertise and friendship have been most valuable.

References Cited

Akins, Nancy J., and Charles A. Hannaford
2005 *Archaeological Testing at Kuaua Pueblo, Coronado State Monument, New Mexico*. Archaeology Notes No. 310. Office of Archaeological Studies, Museum of New Mexico, Santa Fe.

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

Batkin, Jonathan
1987 *Pottery of the Pueblos of New Mexico, 1700-1940*. Taylor Museum of the Colorado Springs Fine Art Center, Colorado Springs.

Bronitsky, Gordon, and Robert Hamer
1986 Experiments in Ceramic Technology: The Effects of Various Tempering Materials on Impact and Thermal Shock Resistance. *American Antiquity* 51(1):89-101.

Carrillo, Charles M.
1987 Ceramic Assemblage. In *Test Excavations at Kuaua Pueblo (LA 187),* by Bradley J. Vierra, pp. 19-21. Laboratory of Anthropology Notes No. 396. Museum of New Mexico, Santa Fe.

Condie, Carol J., editor
2007 *Los Ranchos Plaza (LA 46638). Test Excavations at a Spanish Colonial Settlement in Bernalillo County, New Mexico, 1996-1997*, with contributions by Kathryn E. Sargeant, Carol J. Condie, Mary P. Davis, Hayward H. Franklin, Dan Scurlock, and Dan W. Stiteler. Maxwell Museum Technical Series No. 4, University of New Mexico, Albuquerque.

Connell, Sean D.
2006 Preliminary Geologic Map of the Albuquerque-Rio Rancho Metropolitan Area & Vicinity, Bernalillo and Sandoval Counties, New Mexico. *New Mexico Bureau of Geology and Mineral Resources Open-File Report 496*, Socorro, New Mexico.

Cordell, Linda S.
1979 *A Cultural Resources Overview of the Middle Rio Grande Valley, New Mexico*. USDA Forest Service, Southwestern Region, Albuquerque and Bureau of Land Management, New Mexico State Office, Santa Fe.
2006 Rio Grande Glaze Paint Ware in Southwestern Archaeology. In *The Social Life of Pots: Glaze Wares and Cultural Dynamics in the Southwest AD 1250-1680*, edited by Judith A. Habicht-Mauche, Suzanne L. Eckert, and Deborah L. Huntley, pp. 253-271. The University of Arizona Press, Tucson.

Cordell, Linda S., and Judith A. Habicht-Mauche, editors
2012 *Potters and Communities of Practice: Glaze Paint and Polychrome Pottery in the American Southwest, AD. 1250-1700*. The University of Arizona Press, Tucson.

Dutton, Bertha P.
1963 *Sun Father's Way: The Kiva Murals of Kuaua*. University of New Mexico Press, Albuquerque.

Dyer, Jennifer Boyd
2008 *Middle Rio Grande Ceramic Reference Manual, Volume 1: Cochiti Pueblo to Socorro, New Mexico* (compact disk). USDI, Bureau of Reclamation, Albuquerque Area Office, Albuquerque.

Eckert, Suzanne L.
2008 *Pottery and Practice: The Expression of Identity at Pottery Mound and Hummingbird Pueblo.* University of New Mexico Press, Albuquerque.

Eckert, Suzanne L., Kari L. Schleher, and David H. Snow
2018 Following the Yellow Brick Road: Yellow Slip Clays and the Production of Rio Grande Glaze Ware in North Central New Mexico. *Journal of Archaeological Science Reports* 21:565-574.

Ellis, Deborah
2020 Dorothy Louise Luhrs. *Pottery Southwest* 36(1-2):3-9.

Ellis, Florence Hawley
1966 The Immediate History of Zia Pueblo as Derived from Excavation in Refuse Deposits. *American Antiquity* 31(6):806-811.

Frank, Larry, and Francis H. Harlow
1990 *Historic Pottery of the Pueblo Indians, 1600-1880,* second edition. Schiffer Publishing, West Chester, Pennsylvania.

Franklin, Hayward H.
1997 Valencia Pueblo Ceramics, with Petrographic Analysis by Betty Garrett. In *Excavations at Valencia Pueblo (LA 953) and a Nearby Hispanic Settlement (LA 67321), Valencia County, New Mexico*, edited by Kenneth L. Brown and Bradley J. Vierra, pp. 125-257. Report No. 185-400F. Office of Contract Archeology, University of New Mexico, Albuquerque.
2010a *The Pottery of Pottery Mound: A Study of the 1979 UNM Field School Collections, Part 2: Ceramic Materials and Regional Exchange*. Maxwell Museum Technical Series No. 12. Maxwell Museum of Anthropology, University of New Mexico, Albuquerque.
2010b Montano Site Complex (LA 33223) Ceramic Analysis. In *Report on 1988 Data Recovery at the Montano Site Complex, LA 33223, City of Albuquerque, New Mexico, and Subsequent Analysis of Collections*, edited by Gerry Raymond, pp. 5-1 to 5-48. Report to Wilson and Co. and City of Albuquerque. Criterion Environmental, Albuquerque.
2012a Chamisal Pottery: Temper and Paste Materials, Production, and Trade, manuscript dated 3/17/2012, prepared for publication in comprehensive report on the Chamisal Site, LA 22765.
2012b Potters' Resources in the Vicinity of Tijeras Pueblo, New Mexico. In *Glen Canyon, Legislative Struggles, & Contract Archaeology: Papers in Honor of Carol J. Condie*, edited by Emily J. Brown, Carol J. Condie, and Helen K. Crotty, pp. 71-80. Papers of the Archaeological Society of New Mexico No. 38. Archaeological Society of New Mexico, Albuquerque.
2014 *The Pottery of Pottery Mound: Ceramic Surface Sampling, External Trade, and Internal Diversity.* Maxwell Museum Technical Series No. 22. Maxwell Museum of Anthropology, University of New Mexico, Albuquerque.
2017 *Piedras Marcadas (LA 290) Ceramics: The Pottery of a Classic Period Rio Grande Pueblo.* Maxwell Museum, University of New Mexico, Technical Series No. 30. Maxwell Museum of Anthropology, University of New Mexico, Albuquerque.
2019 Ceramic Analysis at Kuaua (LA 187): 2017 Site Testing and Chronology. *Pottery Southwest* 35(1-2):7-28.
2021 *Ancient Pueblitos of the Sandia Foothills*. Maxwell Museum, University of New Mexico, Technical Series, No. 36. Maxwell Museum of Anthropology, University of New Mexico, Albuquerque.

Franklin, Hayward H., and Matthew J. Barbour
2016 Ceramics from the Jemez Pueblo of Kwastiyukwa (LA 482). In *History and Archaeology—Connecting the Dots: Papers in Honor of David H. Snow*, edited by Emily J. Brown, Carol J. Condie, and Helen K. Crotty, pp. 69-86. Papers of the Archaeological Society of New Mexico No. 42. Archaeological Society of New Mexico, Albuquerque.

Franklin, Hayward H., and Kari L. Schleher
2012 On-Ramps to the Glazeware Interstate: Ceramic Trade at Pottery Mound Pueblo and Montano Bridge Pueblo, New Mexico. In *Potters and Communities of Practice: Glaze Paint and Polychrome Pottery in the American Southwest, A.D. 1250-1700,* edited by Linda S. Cordell and Judith A. Habicht-Mauche, pp. 65-74. The University of Arizona Press, Tucson.

Habicht-Mauche, Judith A.
1995 Changing Patterns of Pottery Manufacture and Trade in the Northern Rio Grande Region. In *Ceramic Production in the American Southwest*, edited by Barbara J. Mills and Patricia L. Crown, pp. 167-199. The University of Arizona Press, Tucson.

Habicht-Mauche, Judith A., Stephen T. Glenn, Homer Milford, and A. Russell Flegal
2000 Isotopic Tracing of Prehistoric Rio Grande Glaze-Paint Production and Trade. *Journal of Archaeological Science* 27(8):709-713.

Habicht-Mauche, Judith A., Suzanne L. Eckert, and Deborah L. Huntley, editors
2006 *The Social Life of Pots: Glaze Wares and Cultural Dynamics in the Southwest, AD 1250-1680*. The University of Arizona Press, Tucson.

Habicht-Mauche, Judith A., and Hunter D. Jones Burgess
2016 The Life and Times of Tijeras Utility Ware. In *History and Archaeology—Connecting the Dots: Papers in Honor of David H. Snow*, edited by Emily J. Brown, Carol J. Condie, and Helen K. Crotty, pp. 129-145. Papers of the Archaeological Society of New Mexico No. 42. Archaeological Society of New Mexico, Albuquerque.

Hammack, Nancy S., Alan Ferg, and Bruce Bradley
1983 Excavations at Three Developmental Period Sites near Zia and Santa Ana Pueblos, New Mexico. *CASA Papers* No. 2, Complete Archaeological Service Associates, Cortez, Colorado.

Harlow, Francis H., and Dwight P. Lanmon
2003 *The Pottery of Zia Pueblo*. School of American Research Press, Santa Fe.

Harlow, Francis H., Duane Anderson, and Dwight P. Lanmon
2005 *The Pottery of Santa Ana Pueblo.* Museum of New Mexico Press, Santa Fe.

Herhahn, Cynthia, and Deborah Huntley
2017 Dynamic Knowledgescapes: Rio Grande and Salinas Glaze Ware Production and Exchange. In *Landscapes of Social Transformation in the Salinas Province and the Eastern Pueblo World*, edited by Katherine A. Spielmann, pp. 203-238. The University of Arizona Press, Tucson.

Kelley, Vincent C.
1977 *Geology of the Albuquerque Basin, New Mexico*. New Mexico Bureau of Mines and Mineral Resources Memoir 33. New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico.
1982 *Albuquerque: Its Mountains, Valley, Water, and Volcanoes*, third edition. New Mexico Bureau of Mines and Mineral Resources Scenic Trips to the Geologic Past, No. 9. New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico.

Kelley, V. C., and A. M. Kudo
1978 *Volcanoes and Related Basalts of Albuquerque Basin, New Mexico*. New Mexico Bureau of Mines and Mineral Resources Circular 156. New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico.

Kidder, Alfred V., and Anna O. Shepard
1936 *The Pottery of Pecos, Vol*. 2: *Glaze Paint, Culinary, and Other Wares*. Papers of the Phillips Academy No. 7, New Haven.

Kurota, Alexander
2008 Ceramic Analysis. In *Archaeological Investigations at the Alameda Elementary School Kindergarten (LA 421)*, edited by Robert Estes, pp. 97-119. OCA/UNM Report No. 185-825. Office of Contract Archeology, University of New Mexico, Albuquerque.
2013 Pueblo Ceramics of the Alameda School Site, LA 421. In *Final Report on Excavations of the Alameda School Site (LA 421): A Classic Period Pueblo of the Tiguex Province*, edited by Robin M. Cordero, pp. 91-174. OCA/UNM Report No. 185-969. Office of Contract Archeology, University of New Mexico, Albuquerque.

Lucius, William A.
2021 Data in Search of a Model: Mesa Verde Region Orange and Red Pottery Production, Exchange, and Cultural Interaction. *Pottery Southwest* 37(2):29-42.

Luhrs, Dorothy L.
1938 *Stratigraphy Tests in the North Plaza at Kuaua (LA 187)*. Report on file (NMCRIS #130093), Laboratory of Anthropology, Santa Fe and Coronado State Historic Site, Bernalillo, New Mexico.

Marshall, Michael M.
2015 *Archaeological Investigations at the Isleta Pueblo Mission Complex: The Ceramic Analysis.* Prepared for the Pueblo of Isleta Historic Preservation Office under a Grant from the National Park Service. Cibola Research Consultants Report No. 557. Cibola Research Consultants, Corrales, New Mexico.
2021 Seventeenth Century Colono Form Ceramics from the Isleta Pueblo Mission, New Mexico. *Pottery Southwest* 37(1):2-35.

McKenna, Peter J.
2000 Cultural Resource Survey: Proposed Borrow Pits in the Zia Hills and Dales, Zia Pueblo Lands, New Mexico. BIA Southwest Region Report ZI91-26. Report on file, Bureau of Indian Affairs, Southwest Region, Albuquerque.
2015 Cultural Resource Survey: Separating Archaeological Wheat from Chaff on the Zia Dumps Project along Borrego Road (NP-78), Pueblo of Zia, New Mexico. BIA Southwest Region Report ZI14-253. Report on file, Bureau of Indian Affairs, Southwest Region, Albuquerque.

Mera, Harry P.
1933 *A Proposed Revision of the Rio Grande Paint Sequence*. Laboratory of Anthropology Technical Series Bulletin No. 5. Laboratory of Anthropology, Santa Fe.
1939 *Style Trends of Pueblo Pottery in the Rio Grande and Little Colorado Cultural Areas from the Sixteenth to the Nineteenth Century*. Laboratory of Anthropology Memoirs Vol. 3. Laboratory of Anthropology, Santa Fe.

Morales, Thomas M.
1997 Glazeware Pottery Production and Distribution in the Upper-Middle Rio Grande Valley. Ph.D. dissertation, Department of Anthropology, University of New Mexico, Albuquerque.

Munsell Soil Color Charts
1973 Munsell Soil Color Charts. Munsell Products, MacBeth Color and Photometry, Division of Kollmorgen Corp., Baltimore.

Mutschler, Felix E.
1956 Geology of the Canjilon Cauldron Sink near Bernalillo, Sandoval County, New Mexico. Master's thesis, Department of Geology, University of New Mexico, Albuquerque.

Reiter, Paul
1938 *The Jemez Pueblo of Unshagi, New Mexico, with Notes on the Earlier Excavations at Amoxiumqua and Giusewa,* Parts I and II. Monographs of the School of American Research Nos. 5 and 6, Santa Fe and University of New Mexico Monograph Series Vol. 1, Nos. 4 and 5, Albuquerque.

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

Schleher, Kari L.
2010a Petrographic Analysis of Ceramics from the Montaño Site Complex, LA 33223. In R*eport on 1988 Data Recovery at the Montano Site Complex, LA 33223, City of Albuquerque, New Mexico, and Subsequent Analysis of Collections*, edited by Gerry Raymond, pp. 6-1 to 6-23. Report to Wilson and Co. and City of Albuquerque. Criterion Environmental, Albuquerque.
2010b Petrographic Analysis of Pottery Mound Ceramics. In *The Pottery of Pottery Mound: A Study of the 1979 UNM Field School Collections, Part 2: Ceramic Materials and Regional Exchange*, by Hayward H. Franklin, pp. 66-71. Maxwell Museum Technical Series, No. 12, Maxwell Museum of Anthropology, University of New Mexico, Albuquerque.
2010c *The Role of Standardization in Specialization of Ceramic Production at San Marcos Pueblo*, *New Mexico*. Ph. D. dissertation, Department of Anthropology, University of New Mexico, Albuquerque.
2017 Learning and Production: The Northern Rio Grande Glaze Ware Community of Practice at San Marcos Pueblo. In *The Archaeology and History of Pueblo San Marcos: Change and Stability*, edited by Ann F. Ramenofsky and Kari L. Schleher, pp. 107-127. University of New Mexico Press, Albuquerque.

Schleher, Kari L., and Jennifer E. Boyd
2005 Petrographic Analysis of Glaze-Painted Ceramics. In *Across the Caja del Rio Plateau III: Hunters and Farmers in the Northern Rio Grande*, edited by Peggy A. Gerow and Patrick Hogan, pp. 153-165. Office of Contract Archaeology, University of New Mexico, Albuquerque.

Schleher, Kari L., Deborah L. Huntley, and Cynthia L. Herhahn
2012 Glazed Over: Composition of Northern Rio Grande Glaze Ware Paints from San Marcos Pueblo. In *Potters and Communities of Practice: Glaze Paint and Polychrome Pottery in the American Southwest, A.D. 1250-1700*, edited by Linda S. Cordell and Judith A. Habicht-Mauche, pp. 97-106. The University of Arizona Press, Tucson.

Shepard, Anna O.
1938 Technological Notes on the Pottery from Unshagi. Appendix VI in *The Jemez Pueblo of Unshagi, New Mexico, with Notes on the Earlier Excavations at Amoxiumqua and Giusewa, Part II*, by Paul Reiter, Appendix VI, pp. 205-211. Monographs of the School of American Research, No. 6, Santa Fe and University of New Mexico Monograph Series Vol. 1, No. 5, Albuquerque.
1942 Rio Grande Glaze Paint Ware: A Study Illustrating the Place of Ceramic Technological Analysis in Archaeological Research. *Contributions to American Anthropology and History* No. 39, Publication 528 of the Carnegie Institution of Washington, pp. 129-262. Carnegie Institution, Washington, D.C.
1965 *Ceramics for the Archaeologist*. Fifth Printing. Carnegie Institution of Washington Publication 609. Carnegie Institution, Washington, D.C.

Snow, David H., and A. Helene Warren
2017 Casa Quemada: The Spanish Colonial Component. Part 3: Notes on Native Pottery from Casa Quemada (LA 4955). In *LA 4955, a Descriptive Report of the 1970 Excavations next to the Coronado Historic Site, Bernalillo County, New Mexico, with Pottery and Artifact Identifications by David H. Snow and David W. Kayser, Spanish Colonial Background for Bernalillo Area by David H. Snow, Historic Native Pottery Tempering Materials by A. H. Warren, Faunal Identifications by Arthur H. Harris, Botanical Identifications by Richard I. Ford*, by Regge N. Wiseman. Manuscript on file at Coronado State Historic Site, Bernalillo, New Mexico and Archaeological Records Management Section (ARMS), Museum of Indian Arts and Culture, Santa Fe (NMCRIS 138614).

Spielmann, Katherine A., editor
2017 *Landscapes of Social Transformation in the Salinas Province and the Eastern Pueblo World.* The University of Arizona Press, Tucson.

Tichy, Marjorie F.
1939 The Archaeology of Puaray. *El Palacio* 46(7):145-162.

Vierra, Bradley
1987 *Test Excavations at Kuaua Pueblo (LA 187)*. Laboratory of Anthropology Notes No. 396. Museum of New Mexico, Santa Fe.

Warren, A. Helene
1969 Tonque: One Pueblo's Glaze Pottery Industry Dominated Middle Rio Grande Commerce. *El Palacio* 76(2):36-42.
1980 Appendix C. Technological Notes on the Pottery of San Antonio Pueblo. In *Archaeological Investigations at San Antonio de Padua, LA 24, Bernalillo County, New Mexico*, by Al Dart, pp. 388-403. Laboratory of Anthropology Notes No. 167. Office of Archaeological Studies, Museum of New Mexico, Santa Fe.
2017 Notes on Native Pottery from Casa Quemada (LA 4955). In *LA 4955, a Descriptive Report of the 1970 Excavations next to the Coronado Historic Site, Bernalillo County, New Mexico, with Pottery and Artifact Identifications by David H. Snow and David W. Kayser, Spanish Colonial Background for Bernalillo Area by David H. Snow, Historic Native Pottery Tempering Materials by A. H. Warren, Faunal Identifications by Arthur H. Harris, Botanical Identifications by Richard I. Ford*, by Regge N. Wiseman. Manuscript on file at Coronado State Historic Site, Bernalillo, New Mexico and Archaeological Records Management Section (ARMS), Museum of Indian Arts and Culture, Santa Fe (NMCRIS 138614).
1981 The Micaceous Pottery of the Rio Grande. In *Collected Papers in Honor of Erik Kellerman Reed,* edited by Albert H. Schroeder. Papers of the Archaeological Society of New Mexico No.6, pp. 149-166. Archaeological Society of New Mexico, Albuquerque.

Warren, A. H., and Dan Warren
1995 Ceramics. In *Archeology of the Albuquerque Sector of the Elena Gallegos Project*, edited by Joseph A. Tainter, pp. 263-346. Heritage Resources Management Report No. 14. USDA Forest Service, Southwestern Region, Albuquerque.

Wilks, Maureen E., compiler
2005 *New Mexico Geologic Highway Map.* New Mexico Geological Society and New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico.

Williams, Paul L., and James C. Cole, compilers
2007 *Geologic Map of the Albuquerque 30' x 60' Quadrangle, North-Central New Mexico.* U.S. Geological Survey Scientific Investigations Map 2946. U.S. Geological Survey, Washington D.C.

Wilson, C. Dean
2005 Ceramic Artifacts. In *Archaeological Testing at Kuaua Pueblo, Coronado State Monument, New Mexico*, by Nancy J. Akins and Charles A. Hannaford, pp. 23-26. Archaeology Notes No. 310, Office of Archaeological Studies, Museum of New Mexico, Santa Fe.

Wiseman, Regge N.
2017 *LA 4955, A Descriptive Report of the1970 Excavations next to the Coronado Historic Site, Bernalillo County, New Mexico, with Pottery and Artifact Identifications by David H. Snow and David W. Kayser, Spanish Colonial Background for Bernalillo Area by David H. Snow, Historic Native Pottery Tempering Materials by A.H. Warren, Faunal Identifications by Arthur H. Harris, Botanical Identifications by Richard I. Ford.* Manuscript on file, Coronado Historic Site, Bernalillo, New Mexico and Archaeological Records Management Section (ARMS), Museum of Indian Arts and Culture (NMCRIS 138614).

MICRO-XRF COMPOSITIONAL ANALYSIS OF PAINT AND SLIP ON ANCESTRAL PUEBLO POTTERY FROM THE GOODMAN POINT LOCALITY

Donna M. Glowacki and Edward J. Stech
University of Notre Dame, Departments of Anthropology and Physics, respectively

Introduction

This report documents the compositional analysis of paint and slip on 11 Mesa Verde tradition black-on-white pottery samples from two sites in the Goodman Point community (Coffey 2014): the Harlan Great Kiva (5MT16805) and Monsoon House (5MT16808). The primary goal of this pilot project was to determine whether it was possible to identify different compositional signatures among these specimens that could inform on the organization of pottery production, and possibly circulation, at these two sites. We were particularly interested in determining what differences, if any, would be apparent between mineral and organic paints used on the pottery. Initially, this pilot project was conceived in tandem with another project that focused on the analysis of test tiles made using specified clay and paint recipes. Thus, the raw materials used to make them were known, and the analysis could reveal how elemental compositional signatures changed with alterations in the paste, slip, and paint recipes (Sluka et al. 2015). It was thought that the archaeological materials, where the constituents used to produce them were unknown, then could be compared with these knowns for stronger data interpretations. This work is being done in stages. This report documents the results of the initial characterization of the archaeological samples and the standards analyzed with them (i.e., NIST Flint Clay [SRM 97b] and Brick Clay [SRM 679]).

Sample Descriptions

The primary criterion driving sample selection was paint type, rather than pottery type, time period, or site. The selected sherds had paint types that could be clearly and confidently identified by Crow Canyon Archaeological Center ceramicists (Ortman et al. 2005). There are two types of primary source materials for producing paints. Organic (carbon)-based paints are typically made by boiling the stems and leaves of plants such as Rocky Mountain beeweed (*Cleome serrulata)* or tansy mustard (*Descurainia pinnata*), among others. The resulting plant extracts (decoction) are painted on the vessels and carbonized during firing. Mineral-based paints are derived from nodules of geologic sources with iron and manganese oxides, such as hematite, which are ground up into a powder that then gets mixed with water and organic substances that aid in adherence, coloration, and paint flow. This admixture to the mineral powder is termed a *guaco*. The minerals and *guaco* admixture gets baked onto the vessel surface during firing. See Stewart and Adams 1999 for an excellent discussion of paint types, sources, and ethnographic information. Due to their different recipes and properties, the different paints can often be visually distinguished since organically derived paints tend to soak into the slipped surface of the pot and can be polished over, whereas mineral-based paints tend to sit on the surface of the vessel and have a matte (unpolished) look to them.

The total sample was relatively evenly split between mineral (n=6) and carbon/organic (n=5) paint, for a total of eleven sherds. Four of the samples were recovered at the Harlan Great Kiva; all of these sherds had mineral paint. The remaining seven samples were recovered from Monsoon House; five of these were carbon/organic paint and two were mineral paint. The pottery types represented in the sample included Late White Painted, Pueblo II White Painted, Cortez Black-on-white, McElmo Black-on-white, and Mesa Verde Black-on-white.

Documentation of these pottery samples included creating an inventory spreadsheet with the descriptive data for each sherd (Table 1); each sherd was also photographed. One photograph was also taken of the entire sample assemblage (Figure 1). Each of the pottery samples was assigned a Notre Dame analytical ID to track the materials analyzed in the Center for Environmental Science & Technology (CEST) labs on Notre Dame's campus. These IDs consist of the letters "ND" and the consecutive number in the ND sample sequence. The ND numbers of the sample sherds were used as the tracking numbers for all aspects of the pilot project, including for the .jpg files for the sherd photos. The pottery samples analyzed in this pilot project are ND098 to ND108.

Table 1. Descriptive Data for the Pottery Samples Used in the Analysis.

	Site No	Site Name	pd	fs	item	Type	Form	Part	Finish	Qty	Wt (g)
ND098	5MT16805	Harlan Great Kiva	56	1		Cortez Black-on-white	Bowl	Body	Mineral	1	7.7
ND099	5MT16805	Harlan Great Kiva	56	1		Cortez Black-on-white	Jar	Body	Mineral	2	29.6
ND100	5MT16805	Harlan Great Kiva	56	1		Pueblo II White Painted	Bowl	Body	Mineral	1	35.2
ND101	5MT16805	Harlan Great Kiva	56	1	2	Late White Painted	Bowl	Rim	Mineral	1	8.5
ND102	5MT16808	Monsoon House	6	1	2	Mesa Verde Black-on-white	Bowl	Rim	Carbon	1	27.5
ND103	5MT16808	Monsoon House	6	1	3	McElmo Black-on-white	Ladle	Rim	Carbon	1	7.4
ND104	5MT16808	Monsoon House	12	1	3	McElmo Black-on-white	Bowl	Rim	Carbon	1	10.4
ND105	5MT16808	Monsoon House	89	1	16	Mesa Verde Black-on-white	Bowl	Rim	Carbon	1	16.7
ND106	5MT16808	Monsoon House	89	1		Mesa Verde Black-on-white	Jar	Body	Carbon	1	26.2
ND107	5MT16808	Monsoon House	89	1		Pueblo II White Painted	Bowl	Body	Mineral	1	4.1
ND108	5MT16808	Monsoon House	89	1		Late White Painted	Bowl	Body	Mineral	1	3.7

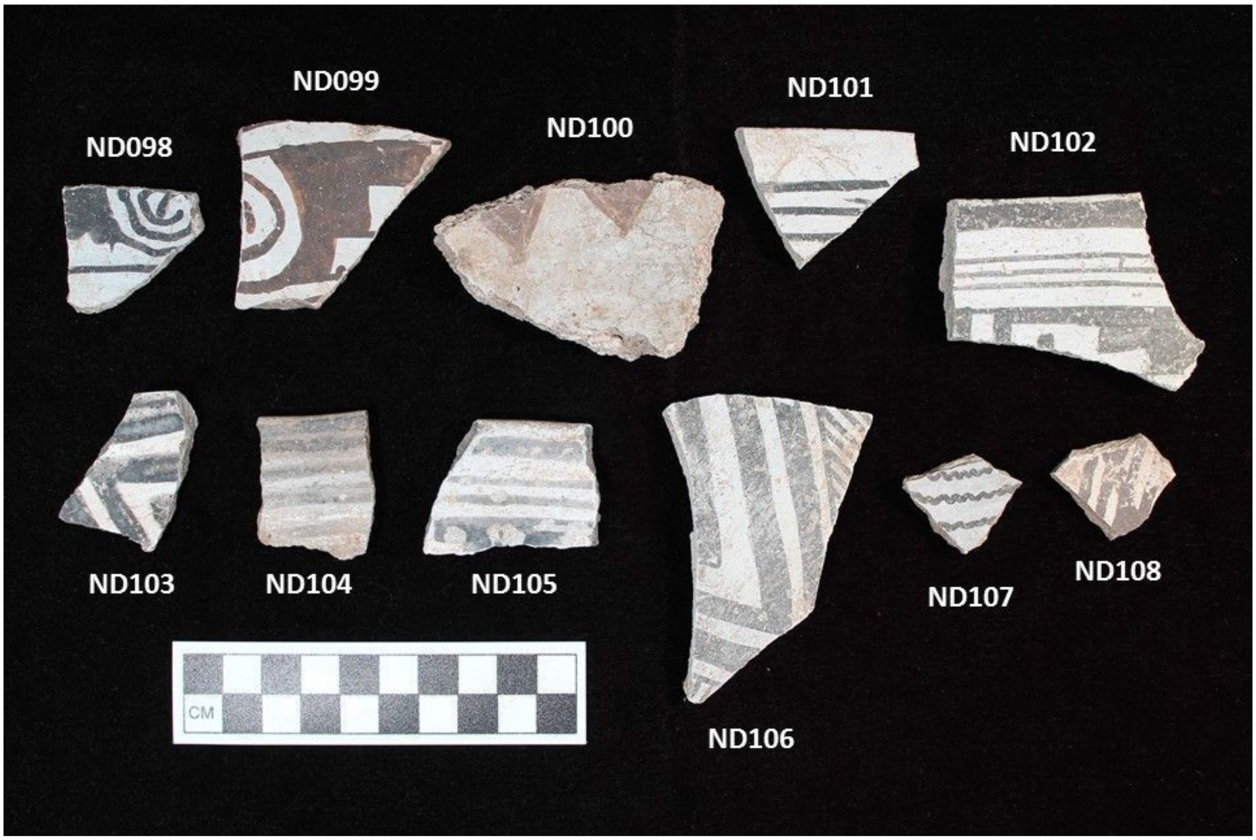


Figure 1. Photographs of the sherds sampled and analyzed. See Table 1 for type identifications. Photo by Katie Portman.

Experimental Methods

The ORBIS Micro-XRF Analyzer at CEST

XRF (x-ray fluorescence spectroscopy) is a non-destructive technique that directs a focused beam of x-rays onto a sample, thereby exciting the inner shell electrons and resulting in the secondary emission of x-rays from the sample itself (see Guthrie and Ferguson 2012 and Verma 2007 for more details). The energy and intensity of the resultant photons are dependent on the elemental composition of the exposed sample. The silicon drift detector collects secondary x-rays most efficiently in a range of approximately 3 to 10 keV that makes it an ideal tool for looking at the concentration of many elements, but it cannot measure the lower energy photons emitted from elements lighter than sodium. This restriction turns out to be an advantage because it means all of the organic compounds containing only carbon, nitrogen, and oxygen are invisible and do not contribute to background issues. The measurement apparatus of the ORBIS is housed in a chamber with an XYZ-table that allows one to move the sample in a controlled manner. The focusing elements within the system allow for measurements using spot sizes of 30 um, 1mm, or 2 mm. A camera in the main chamber allows the researcher to position the sample and has magnification as high as 75x. An included software package calculates the elemental composition from the spectrum of x-ray energies.

Set-up and Data Collection Protocols for the Samples

The operational parameters were held constant for each run with 500 uA of 50 keV electrons used to generate a 1mm beam spot. For each sample, the air was evacuated from the chamber to create a vacuum that would minimize the absorption of the lower energy X-rays to improve the statistics for these lines and thereby reduce the uncertainty for the corresponding elemental abundances. Measurements were taken on three different days; two different NIST standards (Flint and Brick Clay) in loose powder form were run at the start of each set as a systematic cross-check. Six locations were measured on each pottery sample evenly split between paint and slip (i.e., three shots each). Each position was visibly selected to minimize inclusion of atypical spots of each type (e.g., places on the sherd where pitting and erosion removed some of the paint or slip, or spots where paint was thinning). Before each exposure, the "auto-focus" mode was enabled to ensure that the distance from source, detector, and sample remained constant for each run. Unfortunately, the curvature of one of the samples, ND100, made it impossible to measure with this setup, which required its exclusion from the study. Therefore, only 10 of the original 11 samples were analyzed.

Data Analysis

The data analysis program provided with the ORBIS instrument was used to extract the concentration of 12 individual elements between sodium (Na) and strontium (Sr). This interface allowed the relative abundances to be extracted from the data using three different methods: 1) by elements; 2) by oxides; and 3) by oxides with oxygen difference. After exploring the values produced by each of these methods, we chose the oxides values with oxygen difference, which assumes that detected elements are in the form of oxides and uses the most common form to calculate penetration and self-absorption of the x-rays. Abundances calculated using this method agreed fairly well with the NIST certification concentrations provided with the samples. The use of oxides over element-based calculations was also deemed more appropriate because this is the form the elements would naturally take in ceramic samples like the ones in this study.

Using these numbers, the compositional data collected from the two NIST standards was assessed to check instrument calibration by comparing the values obtained from the ORBIS with those provided in the NIST certification for each standard. Three runs on the standards were made at the beginning of each new session on the ORBIS. The averages of these runs were relatively consistent between sessions and the differences were relatively minor and perceived as being within an acceptable range although the measured abundances were higher than the certified quantities (see Table 2). This difference may be due to the fact that the NIST analysis used a variety of analysis techniques, some of which would be better suited for qualitative measurements of all elements than XRF alone.

Table 2. Standard compositional data for Flint and Brick Clay Standards by each individual shot (i.e., run), the average of the three shots for each day of running samples, the NIST certification values, and the resulting ratio per day. Element amounts measured in weight percentage.

Flint Clay Standard											
Element	**Run 34**	**Run 35**	**Run 36**	**Run 70**	**Run 71**	**Run 72**	**Avg Day1**	**Avg Day2**	**Cert. Value**	**Ratio Day1**	**Ratio Day 2**
Na	1.54	1.63	1.15	2.26	2.58	2.44	1.44	2.43	0.05	28.8	48.5
Mg	0.63	0.72	1.08	0.87	1.06	0.65	0.81	0.86	0.11	7.36	7.82
Al	22.12	21.03	20.82	21.67	21.41	21.36	21.32	21.48	20.8	1.03	1.03
Si	22.97	23.77	23.83	22.75	22.67	22.83	23.52	22.75	19.81	1.19	1.15
Cl	0.44	0.49	0.53	0.39	0.48	0.46	0.48	0.44	0.0	N/A	N/A
K	0.68	0.66	0.68	0.66	0.67	0.64	0.67	0.66	0.51	1.32	1.29
Ti	1.82	1.79	1.75	1.78	1.69	1.74	1.79	1.74	1.43	1.25	1.21
Fe	1.02	1.05	1.27	1.07	1.00	1.47	1.11	1.18	0.83	1.34	1.42

Brick Clay Standard											
Element	**Run 31**	**Run 32**	**Run 33**	**Run 67**	**Run 68**	**Run 69**	**Avg Day1**	**Avg Day2**	**Cert. Value**	**Ratio Day1**	**Ratio Day2**
Na	2.63	3.15	3.40	2.65	2.15	3.04	3.06	2.61	0.13	23.54	20.1
Mg	1.64	1.40	1.90	2.13	2.13	1.7	1.65	1.99	0.76	2.17	2.61
Al	11.58	11.48	11.4	11.65	11.65	11.69	11.49	11.66	11.01	1.04	1.06
Si	25.53	25.30	24.59	24.73	25.29	25.01	25.14	25.01	24.34	1.03	1.03
K	2.46	2.46	2.40	2.58	2.41	2.42	2.44	2.47	2.43	1.00	1.02
Ca	0.17	0.21	0.16	0.18	0.16	0.16	0.18	0.17	0.16	1.13	1.04
Ti	0.61	0.60	0.61	0.63	0.61	0.61	0.61	0.62	0.58	1.05	1.06
Fe	9.08	9.33	9.76	9.48	9.31	9.30	9.39	9.36	9.05	1.04	1.03

In the case of the Flint Clay standard, sodium and magnesium were highly variable relative to the NIST certification numbers. Likewise, in the Brick Clay standard, the detected amounts of sodium and magnesium were significantly different from those on the NIST certification. This discrepancy seems most likely due to the low energies of the emitted x-rays from these elements. For the rest of the certified elements, the Brick Clay data collected were similar to the Flint Clay.

However, ratios of the average of the runs to the values provided for the NIST standard are better for Brick Clay than they are for Flint Clay (i.e., they are closer to 1). The Brick Clay distribution of elements is slightly closer to that of the samples because of its higher iron and potassium content. Therefore, the Brick Clay standard is probably a better standard to use with our samples. The goal of these measurements is not to make absolute quantitative determination of the elemental compositions of the samples, but rather to compare the relative abundances between samples and between paint and slip. As a result, the consistency between the different sets of runs on the NIST standards is more important than the absolute agreement with the certified values. Our evaluation of the standards indicates that the setup and procedure should provide reliable and comparable data among the data collection sessions.

Based on the results of this evaluation, it is also clear that the CEST ORBIS unit setup and the related software greatly overestimated the content of sodium and magnesium. Sodium, in particular, was significantly different from the NIST certified amount. The low energy of the corresponding x-rays from these elements means they are easily absorbed and a small number of associated events is multiplied by a large number to determine their concentration. In any case, something is amiss in this calculation for sodium and magnesium that results in the unusually high numbers. Consequently, neither sodium nor magnesium were used in our analysis of the paint and slip compositional data. The calculated chromium values were also higher than the certified values, but in both standards the amount of chromium was very small so this discrepancy may have been purely a statistical problem resulting from the low signal to noise ratio due to the small concentration. Although chromium was included in the XRF readings, it was not detected in sufficient quantities to be meaningful and was not used in data interpretation.

The paint and slip compositional data collected from each of the 10 sherds (see Table 3) were evaluated to determine if there were any inconsistencies in these data and/or problems with instrument set-up. For these data, we first assessed the detection levels and removed from consideration all elements that were not found in sufficiently high quantities. This left nine elements with sufficient data for comparison: aluminum (Al), silicon (Si), phosphorus (P), sulfur (S), chlorine (Cl), potassium (K), calcium (Ca), titanium (Ti), and iron (Fe). To assess consistency among the shots taken for each sample, the three shots per slip and paint were averaged and their standard deviations calculated. This calculation allowed examination of the degree of dispersion among the samples to determine if there were any outliers among the shots. Upon examination of the degree of dispersion, there were no significant disparities among shots, so all the data collected for each sample was used. However, one way to refine these data in the future might be to revisit the inclusive approach used here by using a conservative threshold based on standard deviation. Since our assessment of the standards and the pottery data indicated internal consistency among the data collected, the following analysis and results are based on the average of the three shots that were taken per sample to characterize both the paint and slip with the error bars displayed corresponding to the standard deviations.

Table 3. Sherd XRF compositional data for both paints and slips. Values are the average of three shots on the slip and paint per sherd.

Elemental Abundance (Weight %)										
ND ID	**Type**	**Al**	**Si**	**P**	**S**	**Cl**	**K**	**Ca**	**Ti**	**Fe**
098	Paint	9.98	26.10	0.58	0.19	2.12	1.21	0.93	0.54	11.76
098	Slip	12.67	31.39	0.15	0.18	0.84	1.51	1.05	0.58	1.79
099	Paint	8.59	22.06	0.74	5.62	2.01	1.12	2.52	0.71	8.32
099	Slip	9.29	30.19	0.22	4.05	0.83	0.80	1.54	0.62	1.29
101	Paint	9.95	27.11	0.33	0.13	1.98	1.45	1.30	0.65	10.24
101	Slip	12.72	31.57	0.16	0.09	0.95	1.31	0.85	0.70	1.74
102	Paint	11.35	27.05	0.55	0.24	1.47	2.79	2.73	0.45	6.13
102	Slip	15.19	28.62	0.15	0.17	0.60	3.02	1.29	0.35	1.61
103	Paint	12.69	29.03	0.26	0.45	0.68	6.15	1.04	0.27	1.31
103	Slip	14.73	28.90	0.69	0.08	0.59	3.17	0.86	0.29	1.48
104	Paint	11.07	29.57	1.08	0.18	0.69	4.06	1.81	0.51	2.45
104	Slip	11.87	29.56	1.56	0.07	0.67	2.64	1.64	0.51	2.23
105	Paint	10.91	26.62	1.48	0.67	0.48	9.41	1.84	0.35	1.39
105	Slip	13.39	30.17	0.28	0.07	0.56	3.65	0.80	0.43	1.56
106	Paint	13.40	27.59	0.38	0.76	0.62	5.01	1.77	0.55	1.70
106	Slip	13.22	28.76	0.71	0.17	0.66	3.39	1.89	0.57	1.87
107	Paint	10.06	28.75	0.69	0.13	1.75	2.65	1.80	0.73	5.66
107	Slip	11.47	31.64	0.43	0.11	0.85	2.46	1.04	0.55	1.93
108	Paint	8.39	19.61	1.68	0.07	0.96	1.56	2.74	0.44	20.83
108	Slip	15.02	27.06	0.46	0.09	0.73	2.19	2.80	0.63	2.55

Results

The amounts of aluminum and silicon among all the samples were similar, with the slip samples containing slightly higher amounts of aluminum. This nominal difference is not surprising as clays are aluminum silicates (Figure 2), and the paints are made using a variety of source materials. A comparison of all the pottery data, both slips and paints, shows important differences among the samples involving the elements silicon, phosphorus, chlorine, potassium, calcium, titanium, and iron (all but aluminum and sulfur from the original nine elements). In particular, the substantial variation in amounts of iron and chlorine provide helpful vectors of comparison with other influential elements to understand data structure and groupings (i.e., they were used as an X-axis variable). Notably, the paint used on bowl ND108 differs significantly in the amounts of both of these elements, which suggests that substantially different raw materials may have been used to paint it. Not surprisingly, comparisons among all samples generally show strong compositional separation between the paint and slips. For the most part, paints are higher in iron than the slips. However, the paints for bowls ND103, 104, 105, and 106 (all Pueblo III bowls from Monsoon House), had more similarities with the slip compositions from all samples, than the paints on Pueblo II period bowls ND98, 99, 101, 102, and 107 (Figure 3). The compositional correspondence of these paints with the slips likely relates to the use of organic (carbon) paint on the Pueblo III bowls versus mineral paint on the Pueblo II bowls. A closer examination of the slips and paints separately is required to better understand production diversity among the bowls sampled.

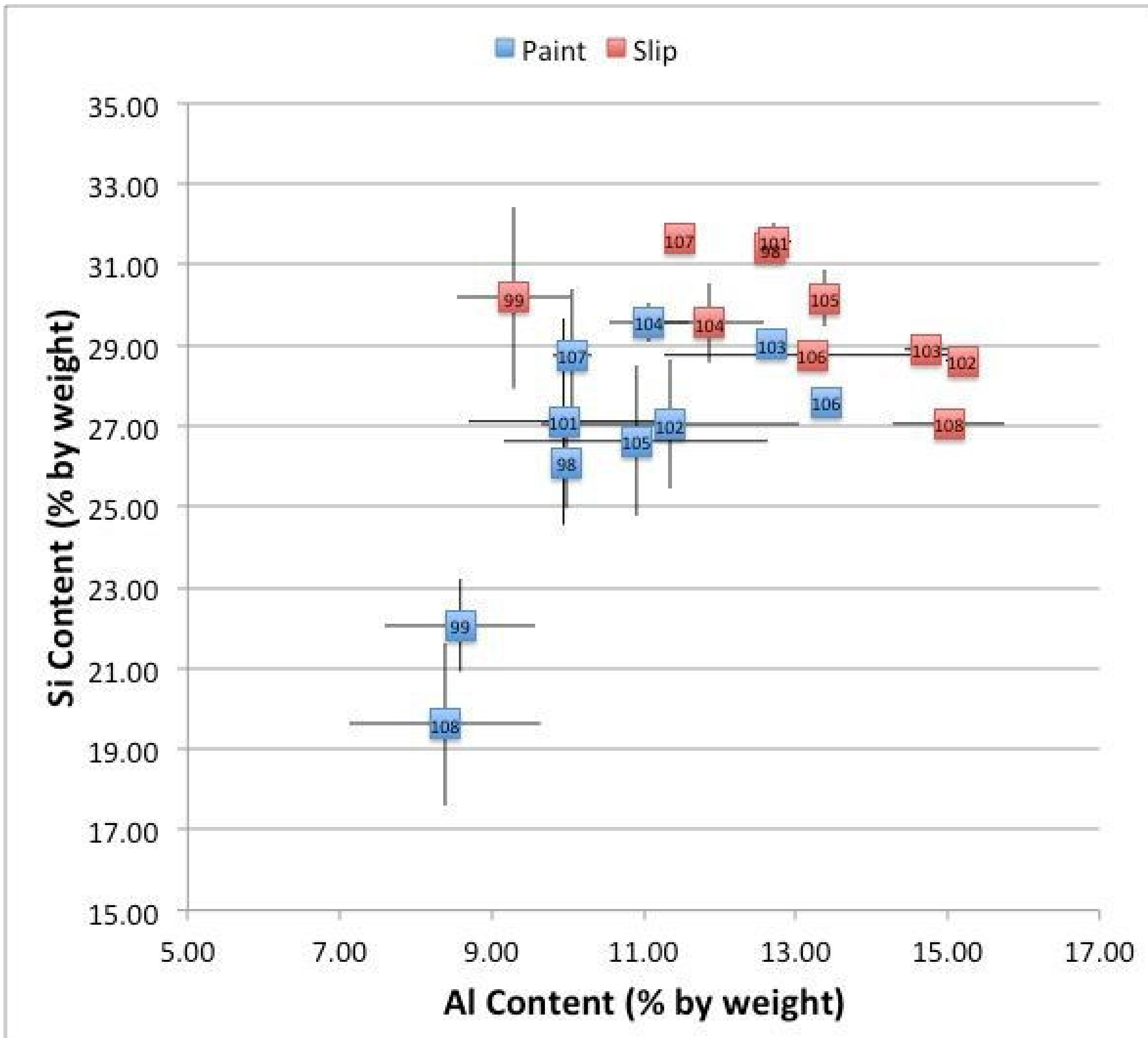


Figure 2. A biplot of aluminum (Al) and silicon (Si) content for all the samples. For the most part, the relative amounts of each are similar with the slips having more Al and Si than the paints.

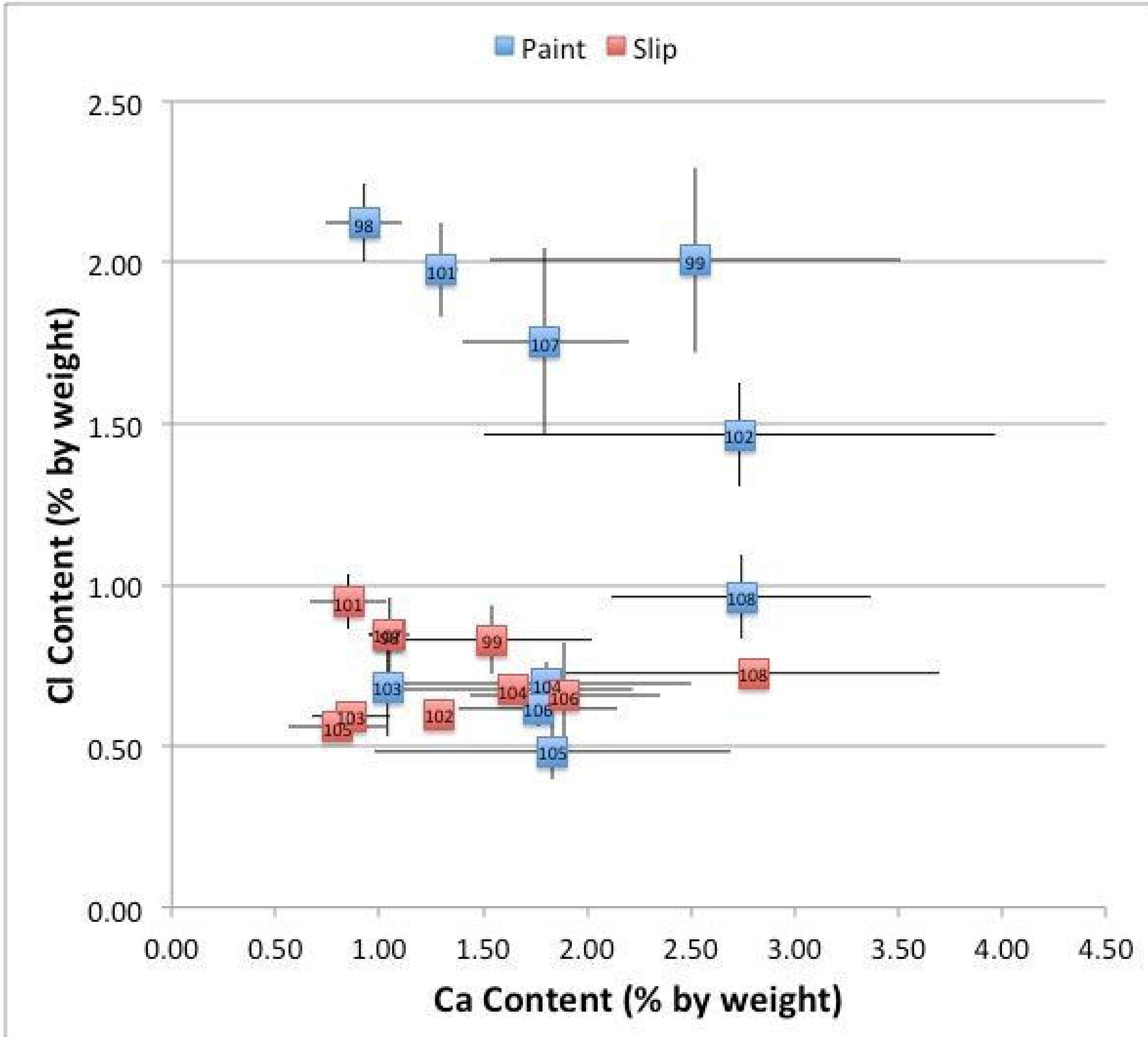


Figure 3. Biplot of calcium (Ca) and chlorine (Cl) for both paint and slip samples. Note that paint samples ND103-106 are more similar to the slip samples than the other paint samples.

Slip

Compositional variability among the slips shows both spatial and temporal patterning. Spatially, the slip used on the bowls from Harlan Great Kiva was different from that used on the Monsoon House bowls, regardless of time period. This level of variation is perhaps most evident in the titanium vs potassium biplot (Figure 4) where the slip on bowls ND98, 99, and 101 (all from Harlan Great Kiva) have both lower amounts of potassium and slightly higher titanium than those from Monsoon House. Temporally, different slips were used on the Pueblo II period bowls than the Pueblo III period bowls. This dimension of difference is also evident in the titanium and potassium biplot (Figure 4) where the two Pueblo II period bowls from Monsoon House (ND107 and 108) are more similar to the Harlan Great Kiva Pueblo II period bowls than the Pueblo III period bowls from Monsoon House. It is also apparent in a biplot of chlorine and potassium

(Figure 5). However, despite a broad similarity among the slips used on the Pueblo II period bowls, it was likely not the exact same slip source used for the Monsoon House Pueblo II bowls and those from Harlan Great Kiva, even if the raw materials came from similar geological strata.

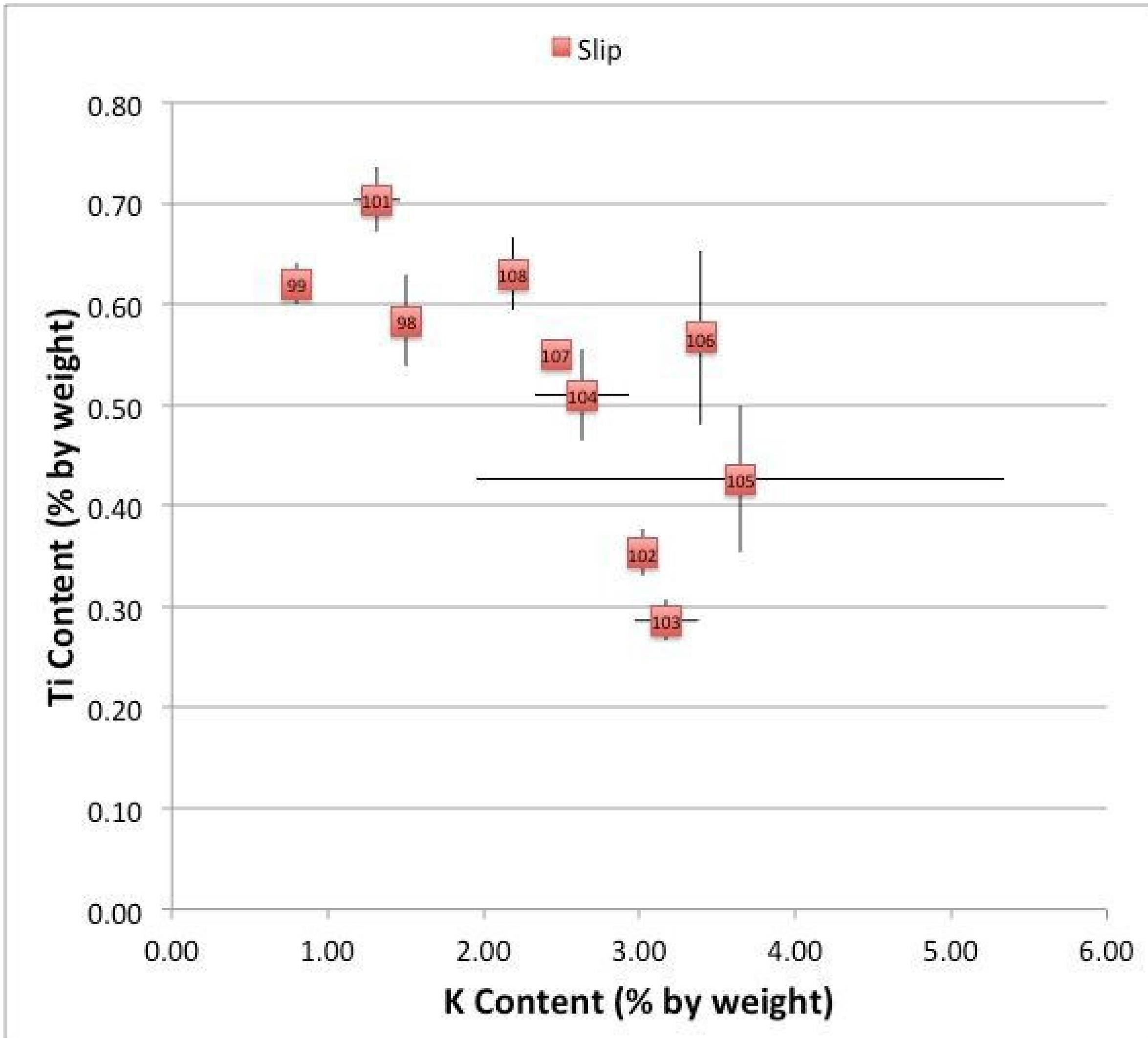


Figure 4. Biplot of potassium (K) and titanium (Ti) showing the compositional distribution of the slip samples. Note how the slip samples ND98, ND99, and ND101 from Harlan Great Kiva have lower K and higher Ti than the slips sampled from Monsoon House.

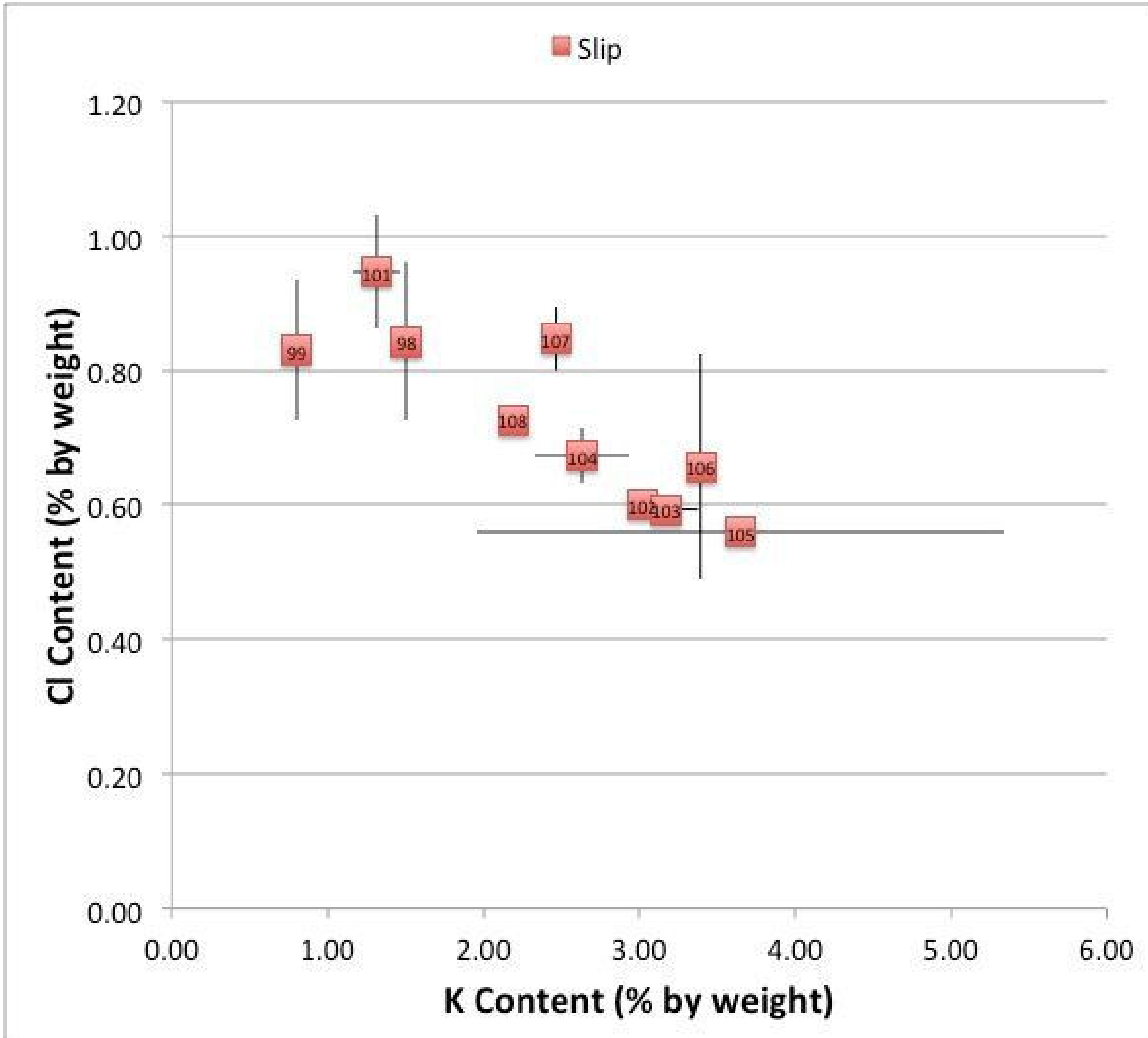


Figure 5. Biplot of potassium (K) and chlorine (Cl) shows differences among the slip samples that correspond with both spatial and temporal variation.

Among the Pueblo III period bowls, all of which are from Monsoon House, potentially two broadly similar but different slip sources may have been used. ND104 and 106 seem to have some compositional affinity with the slips used on the Pueblo II period bowls from Monsoon House (i.e., these samples generally cluster with the other Pueblo III bowls, but are also closer to the Pueblo II slips than the rest of the Pueblo III bowls). This potential affinity is apparent in the comparison of titanium and calcium (Figure 6). Because of sample size and other vagaries, this supposition is tenuous, but the possibility merits further assessment should the sample sizes be increased in the future. However, if the paint compositions also differ for these same bowls, it might corroborate the possibility.

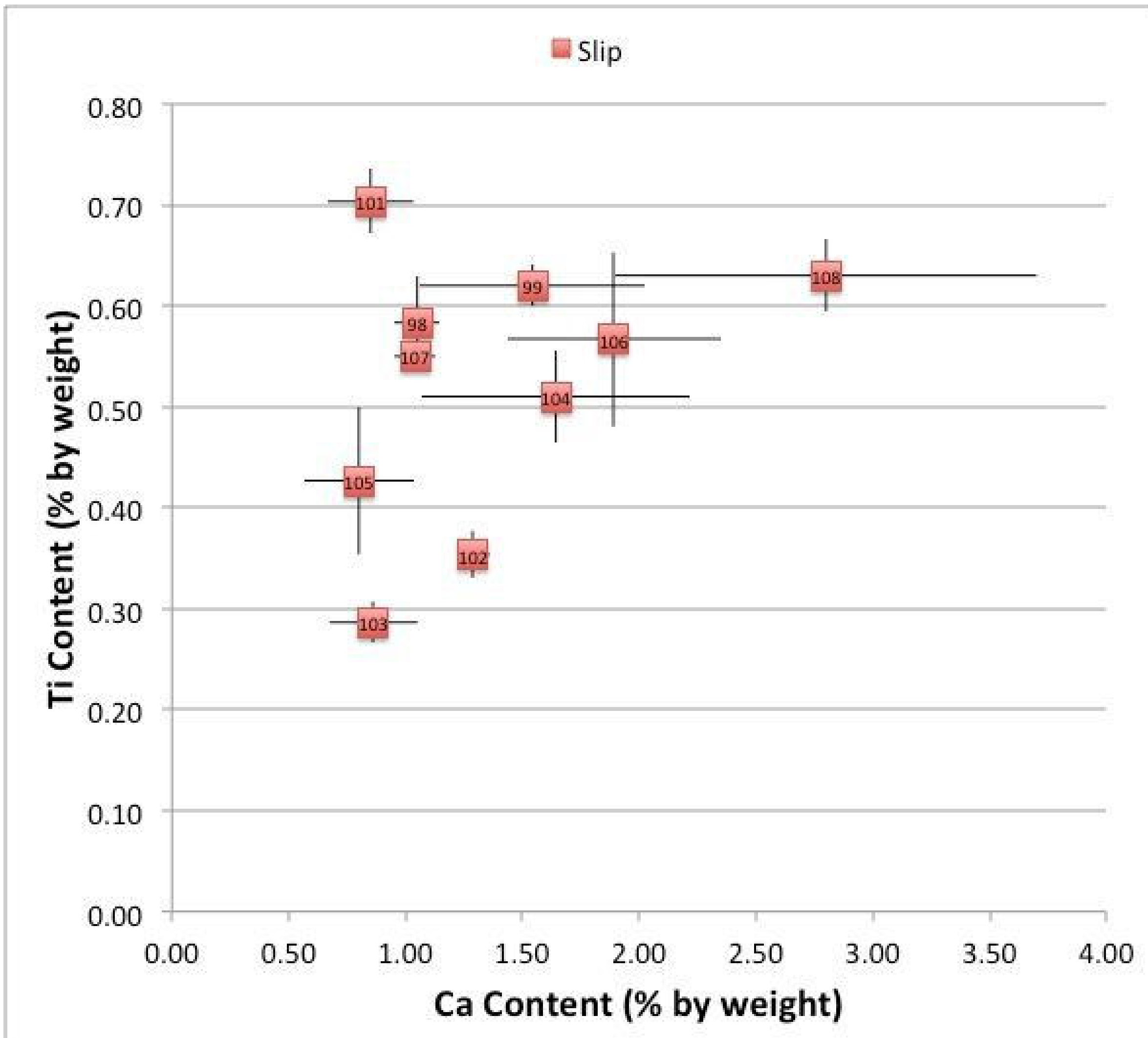


Figure 6. Biplot of calcium (Ca) and titanium (Ti) content showing the affinity that the slip on Monsoon House bowls ND104 and ND106 have compositionally with those samples from Harlan Great Kiva.

The slip on one Pueblo II period bowl from Monsoon House (ND108) is significantly different from the rest of the slips tested (i.e., it seems to be an outlier). This strong difference is most evident in the higher amounts of calcium and iron (Figure 7). A substantially different slip source was used on this bowl. Although it could be that a potter at Monsoon House was using a markedly different slip source than was used on the other sampled bowls, given the significant difference, it seems more likely that this vessel or the slip was obtained from somewhere else (i.e., the bowl or the slip is non-local).

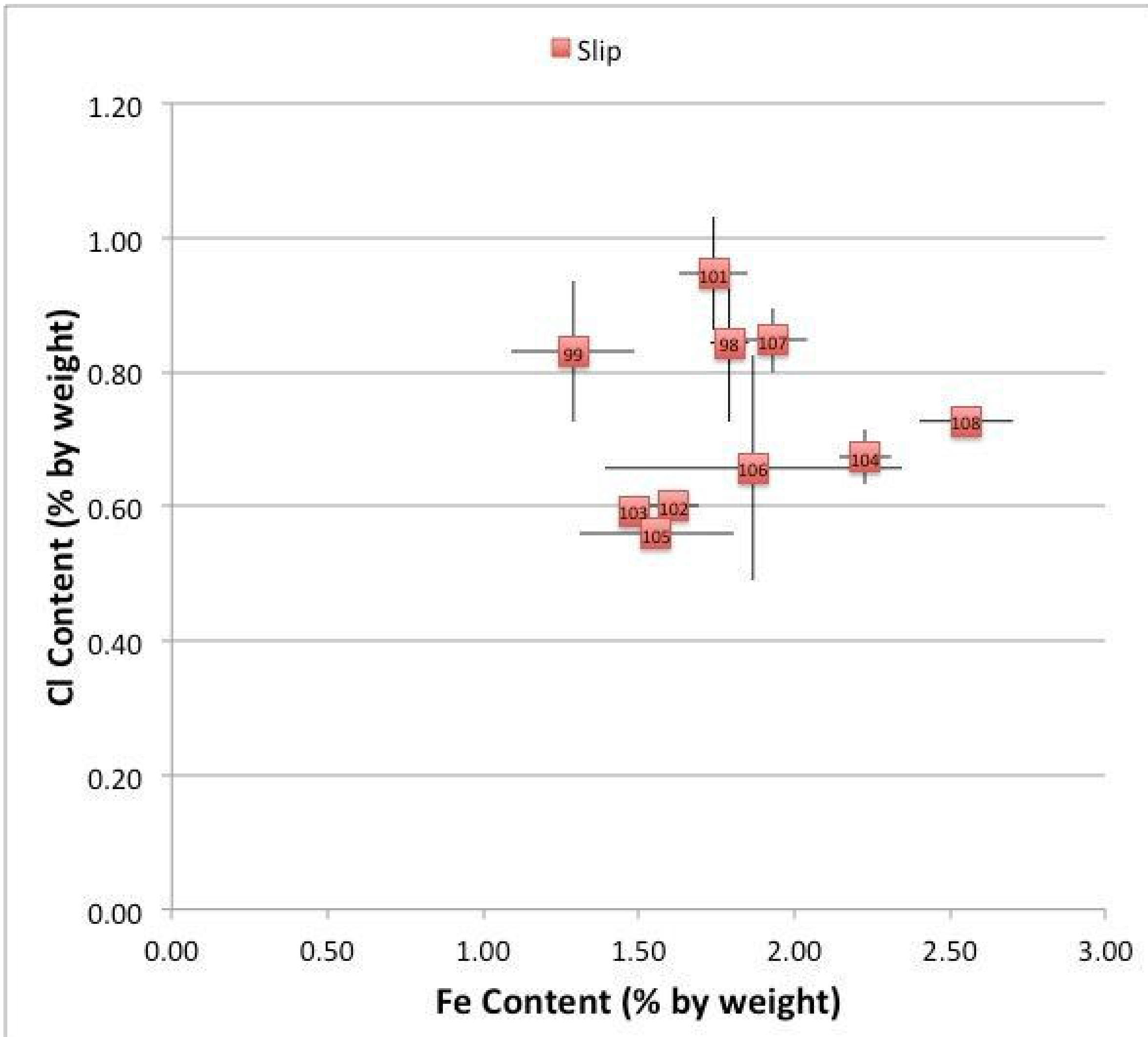


Figure 7. Biplot of iron (Fe) and chlorine (Cl) content of the slip samples that shows how different ND108 is from the rest of the slips, especially with respect to the amount of Fe in the sample.

Although biplots can show compositional separation among the samples, it requires selecting specific elements to compare and illustrate data trends, which can sometimes be perceived as a fallacy of selective attention (cherry picking) that creates confirmation bias to support a hypothesis. Using a three-axes graph to display the concentrations of three elements simultaneously provides a visual multivariate comparison that is less prone to such perceptions. A three-way comparison of the amounts of chlorine, iron, and calcium in the slips shows that: 1) the slips from the Pueblo III period bowls from Monsoon House are distinguished by lower amounts of chlorine (ND102-106); 2) the slips used on Pueblo II period bowls from both Harlan Great Kiva and Monsoon House tended toward relatively higher amounts of chlorine, but lower amounts of iron and calcium (ND98, ND101, and ND107); 3) the slip on bowl ND108 is substantially different from the rest of the slips with the highest amounts of iron and calcium; and 4) the slip used on one of the Harlan Great Kiva bowls (ND99) was notably different than the others from that site due to lower amounts of iron and higher amounts of calcium (Figure 8). Though not shown in this graph, for both its slip and paint, the ND99 bowl also has unusually high amounts of sulfur compared with the rest of the samples (see Table 3). The three-way comparisons generally confirm the patterning in slip composition detected in the biplot comparisons.

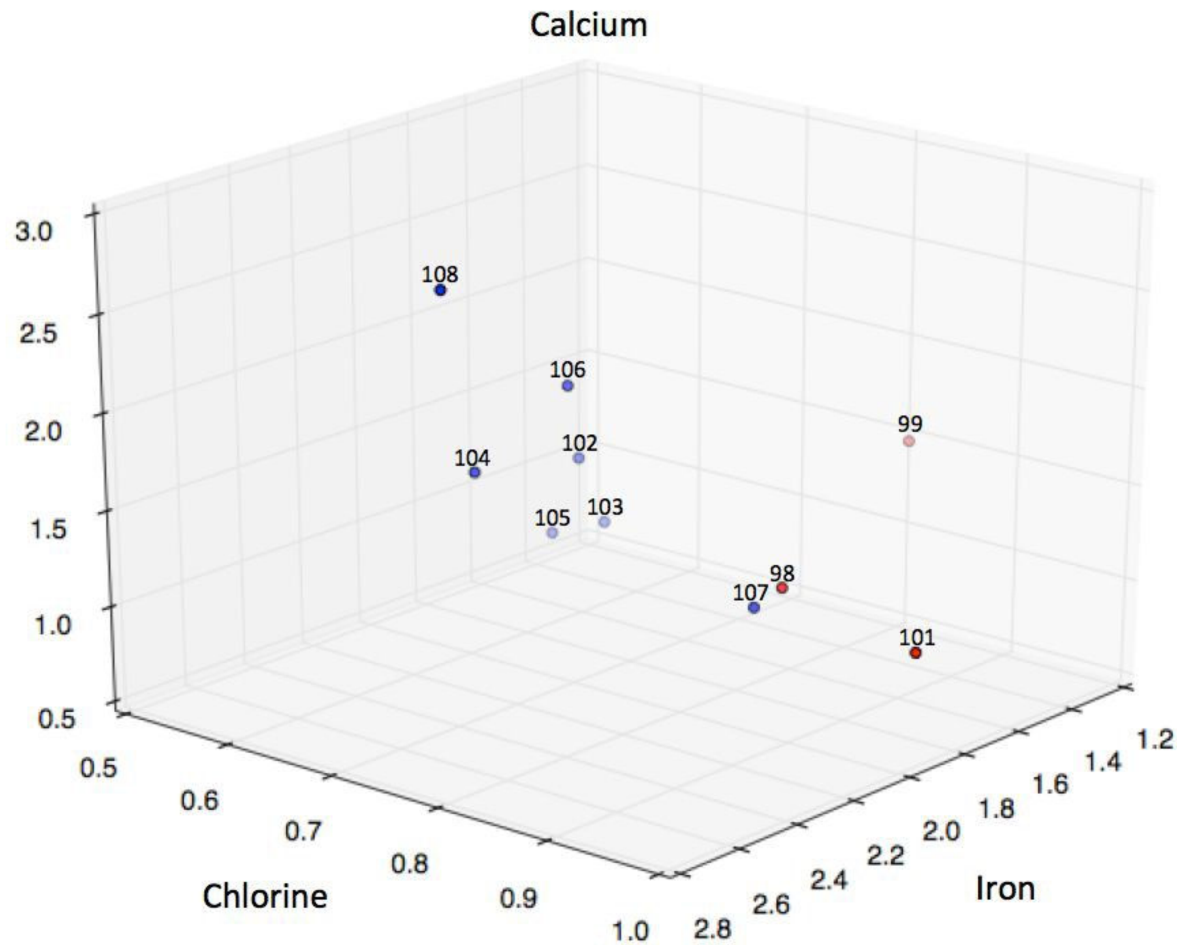


Figure 8. 3-way plot of chlorine, iron, and calcium for the slips. Note that ND103 and ND105 are similar and slightly different from ND104 and ND106.

Paint

The paint compositions were generally more variable than the slip compositions, suggesting that more diverse sources were used to produce them. Much of this variation is related to differences in the paints that were visually identified as being mineral based, both among the mineral paint samples themselves and when compared to the organic-based (carbon) paints. The organic paints, with the exception of ND102, were compositionally more similar to each other (Figure 9). As with the slips, there is both spatial and temporal variation in paint compositions. Paints used on the bowls from Harlan Great Kiva were different from those used on the Monsoon House bowls. This finding is perhaps unsurprising since the bowls sampled from the Harlan Great Kiva were Pueblo II period bowls with mineral paints, and the bowls from Monsoon House were predominantly Pueblo III period bowls decorated with organic paint (except for ND107 and ND108).

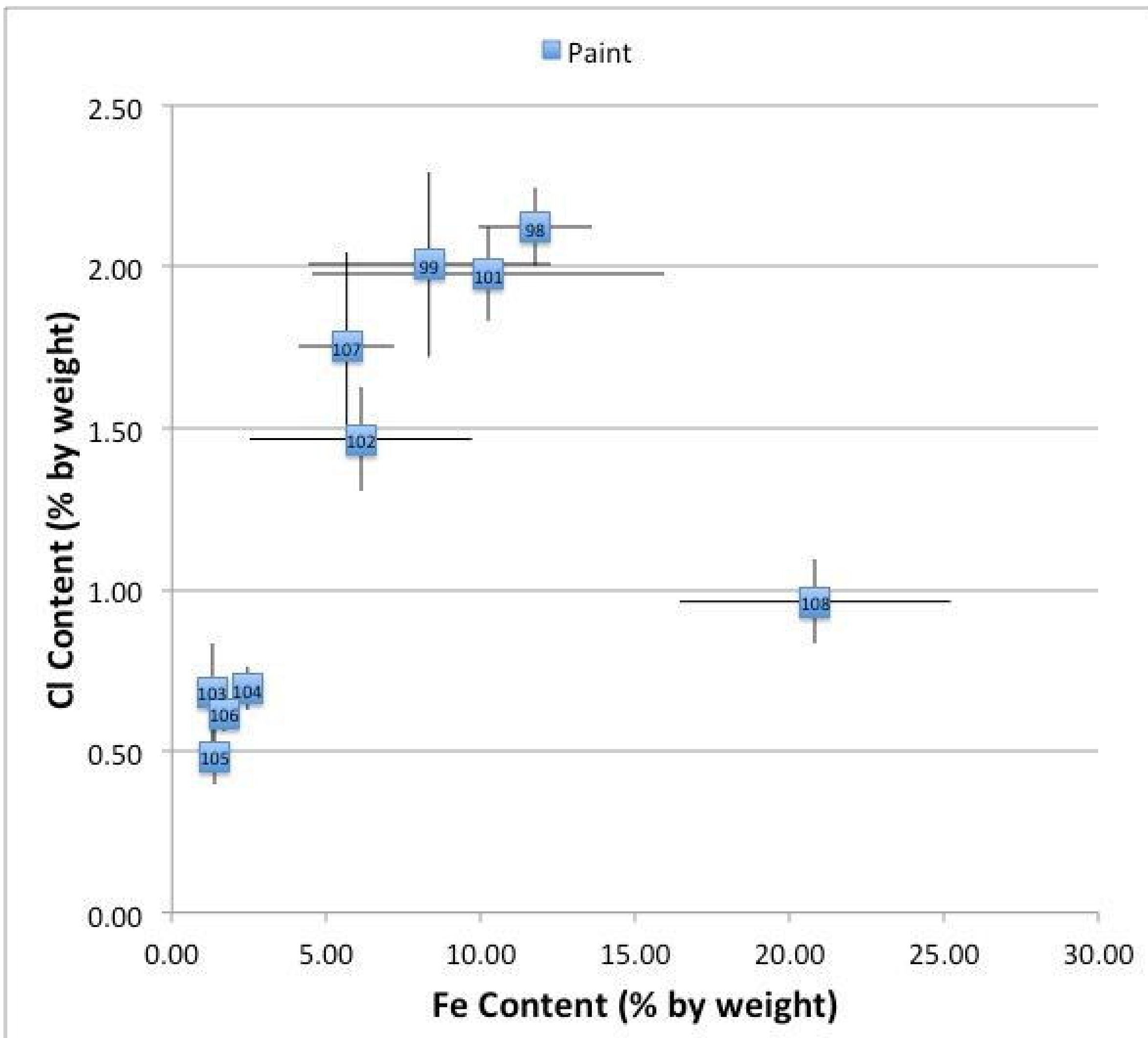


Figure 9. Biplot of iron (Fe) and chlorine (Cl) showing the distribution of paint samples that group by organic- and mineral-based paints. The organic-based paints have lower Cl and Fe content than the mineral-based paints. The paint on sample108 is clearly different than the rest of the paints sampled.

A 3-way graph of iron, chlorine, and potassium (Figure 10) complements the groupings among the paint samples evident in some of the biplots. These trends are: 1) ND108 is distinctive among the paints; 2) the mineral-painted bowls from Harlan Great Kiva have similar compositions (ND98, 99, 101); 3) two painted bowls from Monsoon House, one identified as mineral paint (ND107) and one as organic (ND102), are similar to each other (and the other mineral paints in general); and 4) the organic painted bowls from Monsoon House are more similar to each other than they are to the mineral painted bowls (ND103, 104, 105, and 106).

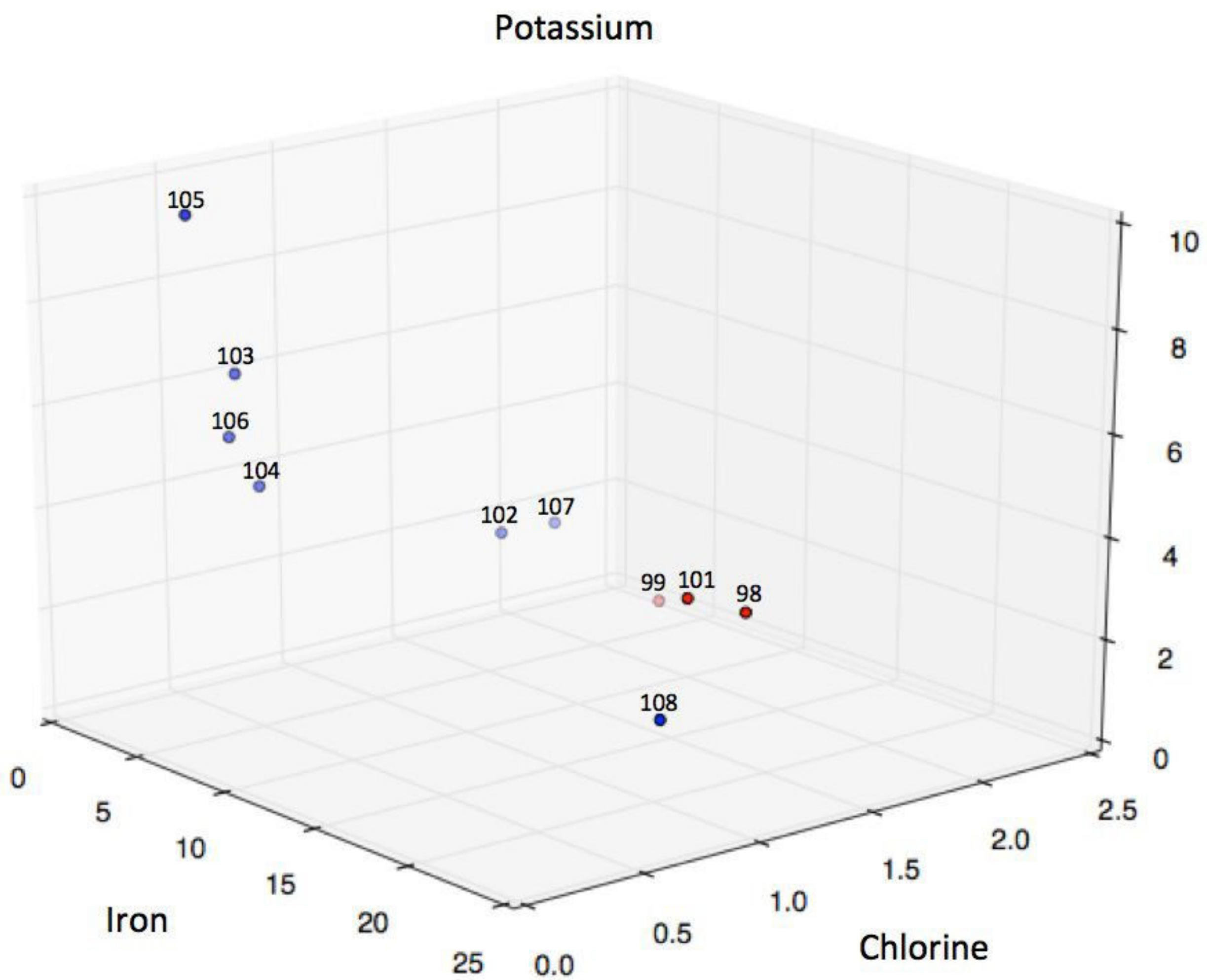


Figure 10. This 3-way plot shows the percent abundance by weight of potassium, chlorine,and iron for all of the paint samples.

Bowls visually identified as having mineral paint are distinct from and more diverse than those identified as having organic (carbon) paint (e.g., Figure 9). The source of this variation could relate to the use of different raw materials to produce the mineral paints (e.g., the use of mineral concretions with differing compositions such as hematite versus manganese nodules), or the use of similar mineral sources, but different binding material to help the paint adhere to the vessel surface (e.g., Sluka et al. 2015; Stewart and Adams 1999). Iron, in particular, seems to be an important element for distinguishing mineral versus organic (carbon) paints. Mineral painted bowls ND098 and ND101 from Harlan Great Kiva and ND108 from Monsoon House had the highest iron amounts in the entire sample (>10 percent by weight). These samples had markedly different amounts of iron compared with the other seven samples. The next highest amounts of iron were found in samples ND099, ND102, and ND107 (between 5 and 8 percent by weight; see Figure 11).

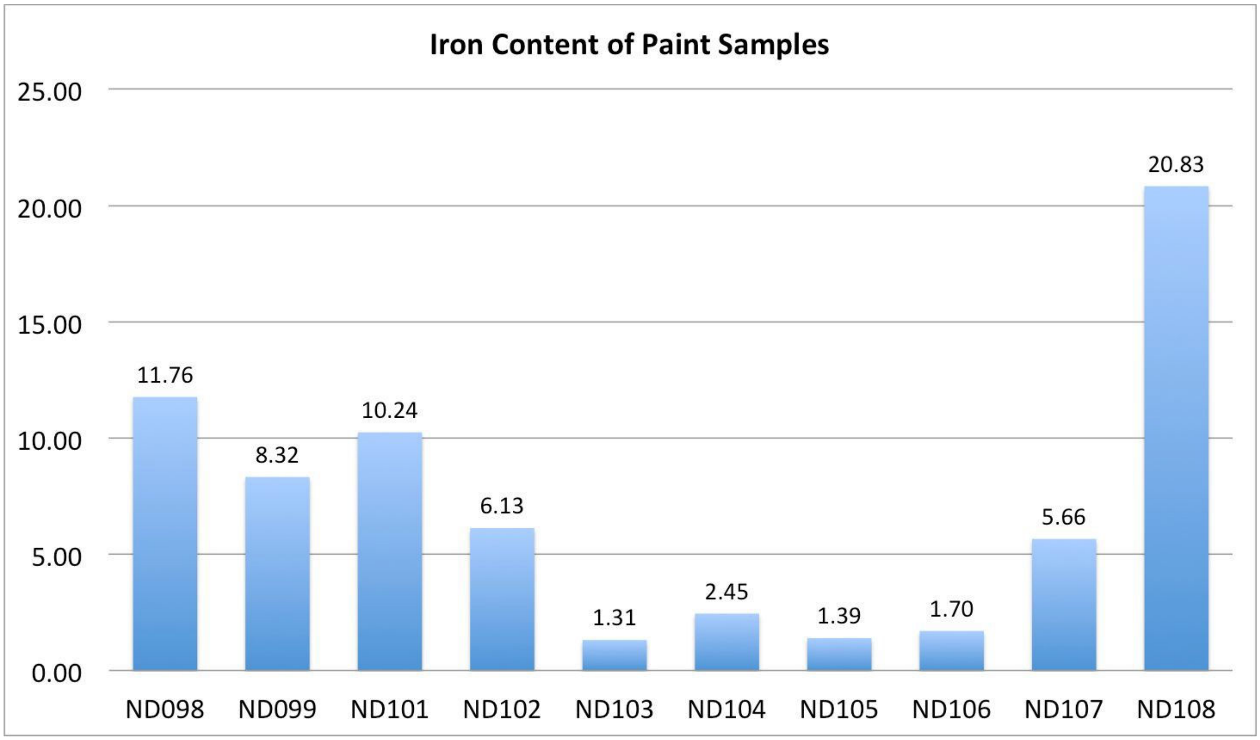


Figure 11. Iron content (% by weight) of the paint samples. Notice the clear distinction between mineral and organic paints.

As noted, the mineral paint used on sherd ND108, a Pueblo II period bowl from Monsoon House, is significantly different than the rest of the analyzed paint compositions (Figures 9 and 10). This marked difference is driven by its exceedingly high amounts of iron (20.8 percent by weight), which is nearly double the amount of the two next highest iron concentrations in the sample (i.e., ND098 has 11.7 percent by weight, and ND101 has 10.2 percent by weight; see Figure 11). Consequently, this Pueblo II period bowl (ND108) has both substantially different paint and slip suggesting it was most likely produced at another village and imported to Monsoon House (see discussion of slip on ND098, above).

Bowl sherds ND102-106 were identified visually as being organic (carbon) painted bowls made during the Pueblo III period. All of them were recovered from Monsoon House. As noted, these samples were generally more similar to each other compositionally than the mineral paints. Yet some compositional differences are evident. For example, these sherds had the lowest amounts of iron (< 2.5 percent by weight), except for ND102, which had more than 6 percent by weight. Although the organic painted bowls had higher amounts of potassium than the mineral paints, ND105 has significantly higher potassium levels than all of the other the paint samples analyzed (more than 9 percent by weight). And, ND102 had the lowest amount of potassium of the organic painted bowls (2.8 percent by weight), which was more in line with ND107, a Pueblo II period bowl from Monsoon House painted with a mineral-based recipe. Thus, even among the more homogenous organic paints analyzed in this sample there are important differences in the organic paint recipes used.

Some of this variation may relate to subtle differences in organic paint recipes used by different potters. For example, among the bowls with organic paint, sherds ND104 and 106 seem more similar to each other and as do sherds ND103 and 105 (see Figure 12). This subtle difference among specific elements may hint at there being different potters who made these bowls, or at least there being different recipes used to make the paints. This inference is somewhat substantiated by the fact that the slips used on ND104 and 106 were also similar to each other and different from those used on samples ND103 and 105 (Figure 13).

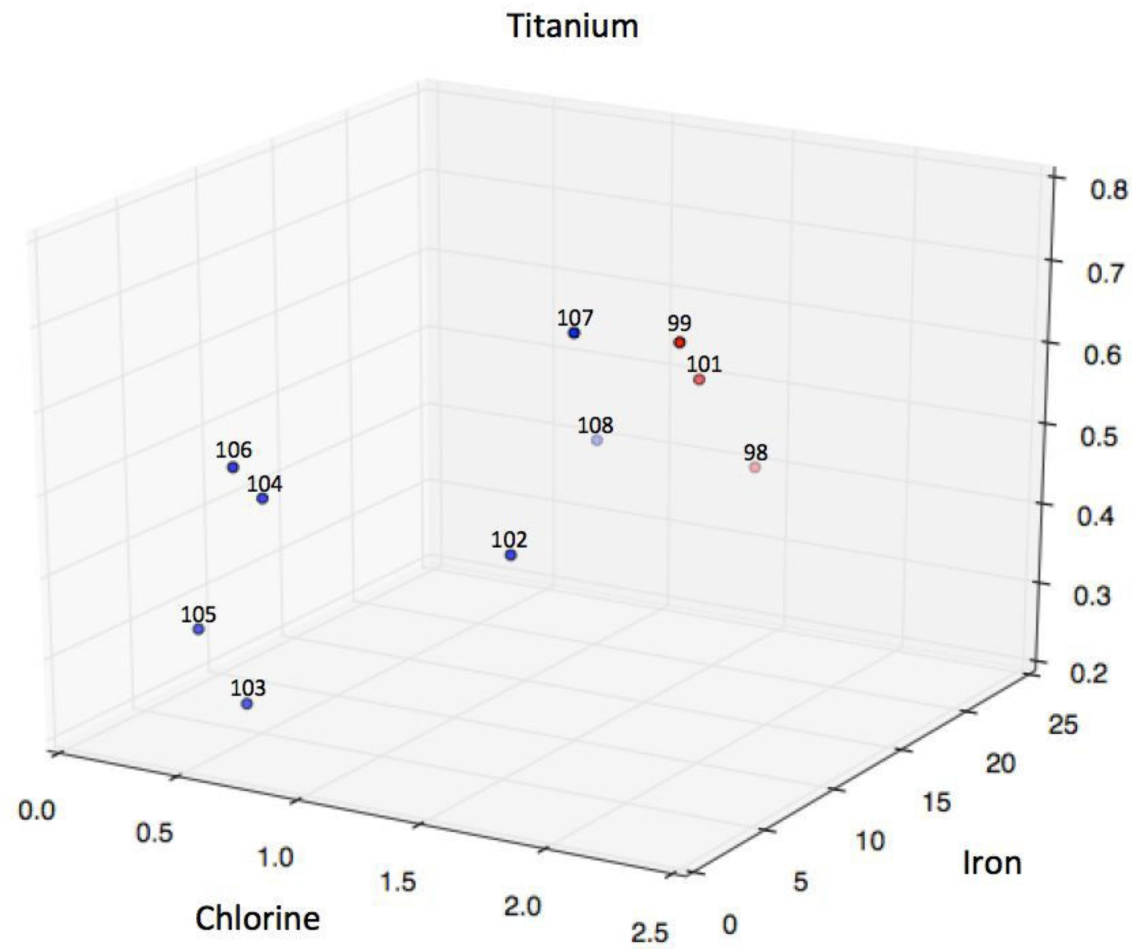


Figure 12. Plot of chlorine, iron, and titanium for the paints. Note how ND103 and ND105 are more similar to each other, as is the pairing of ND104 with ND106.

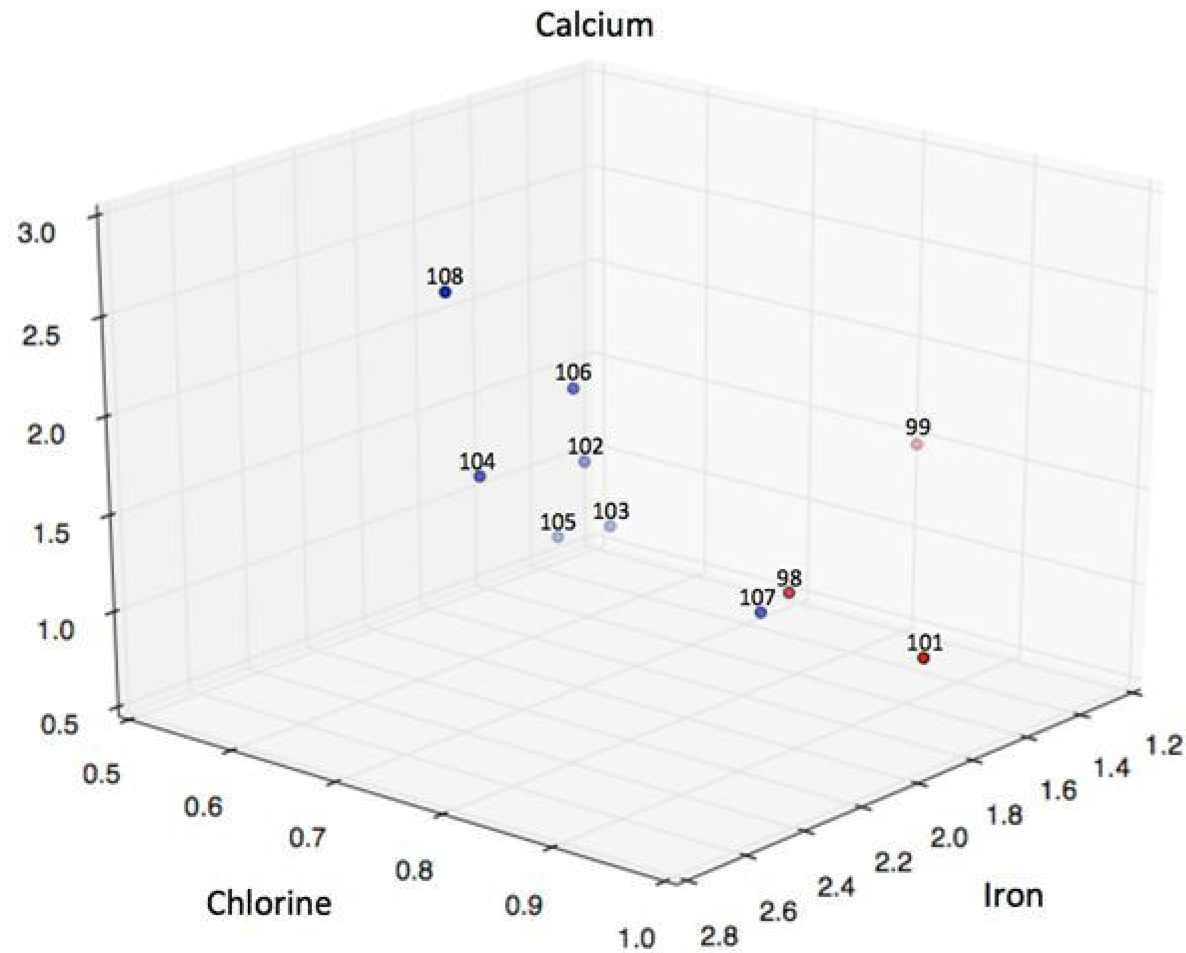


Figure 13. A 3-way plot of chlorine, iron, and calcium for the slips. Note that ND103 and ND105 are similar and slightly different than ND104 and ND106.

However, the primary source of variation among the sherds identified as having organic paint is that ND102 is substantially different from the organic painted samples and more similar to those identified as having mineral paint, especially ND107, a mineral-paint Pueblo II period bowl from Monsoon House (see Figure 10). Thus, although it could be that a very different organic paint recipe was used on this bowl, our results suggest the paint used on this bowl (ND102) was visually misidentified, and either had a "mixed" paint (i.e., contained relatively equal parts of both mineral and organic ingredients) or was a predominantly mineral-based paint. Typically, trained archaeologists and ceramicists assess paint type visually; however, it is challenging to accurately assign correct paint types by visual inspection alone. For example, one study has shown an 84 percent accuracy rate of such assessments (Stewart and Adams 1999). Thus, it is not surprising that ND102 may have been misidentified. If this inference is correct, that ND102 is most similar to ND107, and they are both from the same site, would also suggest that the mineral paint recipe used by some potters at Monsoon House differed from that used by the potters who made the bowls analyzed from Harlan Great Kiva.

Conclusions

This pilot project using an ORBIS Micro-XRF has demonstrated compositional differences in the slips and paints used on black-on-white bowls from two sites in the Goodman Point community. The use of the Flint and Brick NIST standards allowed for an assessment of the effectiveness of the ORBIS set-up for each element and for the comparison of data collected during different XRF sessions. Consequently, the elements sodium, magnesium, and chromium were eliminated from the analysis.

Although the sample size is small (n=10), different compositions among the slips and paints used on bowls from different sites and time periods were detected. Among the slips, for example, the Pueblo II period bowls from the Harlan Great Kiva have different slip compositions than the Pueblo II period bowls from Monsoon House. Some intrasite variation in slip is also apparent among the Pueblo III period bowls, all of which are from Monsoon House (e.g., ND 104 and 106 have a slightly different slip recipe than the other Pueblo III bowls from the site).

Paint compositions were more variable than the slips, especially among the mineral-based paints in the sample. Although the recipes used to paint the sampled Pueblo II period bowls were broadly similar, there appears to be slight variation correlated with whether the bowls were from the Harlan Great Kiva site or Monsoon House. The differences in paint composition among these samples and paint types inherently reflect temporal and spatial variation since all the bowls from Harlan Great Kiva were Pueblo II period bowls with mineral-based paints and the majority from Monsoon House were Pueblo III period bowls with organic-based paints. Yet there are also detectable differences in paint type recipes (e.g., among the bowls with organic-based paints). Our analysis also detected one potentially mis-identified paint type visually assigned to one of the bowls (i.e., ND102), which is more likely either mixed or mineral-based paint.

Based on the slip and paint compositions, production of the sampled bowls was largely local, with the exception of one Late White Painted bowl from Monsoon House (ND108). The slip and paint used on this particular bowl is so different that either a local potter was using markedly different raw materials or the bowl came from a non-local source (i.e., another village).

Acknowledgments. We would like to thank members of the Crow Canyon Archaeological Center staff, including Jamie Merewether, Kari Schleher, Susan Ryan, and Paul Ermigiotti, for their assistance with obtaining and selecting the samples analyzed and facilitating their use in this pilot project. The compositional analysis using the ORBIS Micro-XRF was facilitated and funded by the University of Notre Dame's Center for Environmental Science & Technology (CEST).

References Cited

Coffey, Grant
2014 The Harlan Great Kiva Site: Civic Architecture and Community Persistence in the Goodman Point Area of Southwestern Colorado. *Kiva* 79(4):380-404.

Guthrie, James M., and Jeffery R. Ferguson
2012 *XRF Technical Overview*. Electronic document, https://archaeometry.missouri.edu/xrf_technical.html), accessed July 2017. Archaeometry Laboratory, University of Missouri Research Reactor.

Ortman, Scott G., Erin L. Baxter, Carole L. Graham, G. Robin Lyle, Lew W. Matis, Jamie A. Merewether, R. David Satterwhite, and Jonathan D. Till
2005 *The Crow Canyon Archaeological Center Laboratory Manual, Version 1*. Crow Canyon Archaeological Center, Cortez, Colorado.

Sluka, Victoria, Chase M. Anderson, Donna M. Glowacki, and Edward J. Stech
2015 *Reducing Human Error and Identifying Unknowns: X-Ray Fluorescence as a Tool for Identifying Paint Composition of Mesa Verde Black-on-white Pottery*. Poster presented at the 80th Annual Meeting of the Society for American Archaeology, San Francisco.

Stewart Joe D., and Karen R. Adams
1999 Evaluating Visual Criteria for Identifying Carbon- and Iron-Based Pottery Paints from the Four Corners Region Using SEM-EDS. *American Antiquity* 64(4):675-696.

Verma, Hem Raj
2007 *Atomic and Nuclear Analytical Methods: XRF, Mössbauer, XPS, NAA and Ion-Beam Spectroscopic Techniques*. Springer Publishing, New York.

This report is on file with Crow Canyon Archaeological Center and the Bureau of Land Management Canyon of the Ancients Museum and Visitor Center.

EXHIBITS AND EVENTS

In (hopefully) the waning days of the Coronavirus pandemic, museums are opening up.

The Museum of Indian Arts and Culture on Museum Hill in Santa Fe has three exhibits of interest:

“A Place in Clay” will be open through May 16, 2022. This exhibition honors Kathleen Wall of Jemez Pueblo, and her distinguished title of Living Treasure for 2020.

“Clearly Indigenous: Native Visions Reimagined in Glass” will be open through June 16, 2022. This is a groundbreaking exhibit of works in glass by 33 indigenous artists, plus leading glass artist Dale Chihuly who introduced glass art to Indian Country. The stunning art in the exhibit embodies the intellectual content of Native traditions expressed in glass.

“Painted Reflections: Isomeric Design in Ancestral Pueblo Pottery” will be open through March 12, 2023. Never before the subject of a museum exhibition, Painted Reflections explores the designs painted on ancestral and contemporary Pueblo pottery, offering new insights into the study of Pueblo art through an analysis of the visual structure of ceramic design.

The El Paso Museum of Archaeology, 4301 Transmountain Road in El Paso, has a new exhibit. “Working Ancient Themes into New Combinations: A Tribute to Lucy M. Lewis, Acoma Potter from the James P. And Dorothy S. Barufaldi Collection of Native American Pottery” will be open through September 12, 2022. Lucy Lewis (ca. 1895-1992) was born at Acoma Pueblo, New Mexico, and began making pottery at the turn of the century, mainly teaching herself by observing her great aunt Helice Vallo. Lucy received many accolades and awards for her pottery and became known as one of Acoma’s leading “matriarch” potters. She is known for working ancient themes and patterns she observed from ancient Ancestral Pueblo and Mimbres pottery sherds into new combinations on her pottery. Four of Lucy’s daughters and a granddaughter also became renowned potters in their own rights. Over the years, Lucy Lewis pottery has been collected and displayed by museums the world over. Her artwork is also prized by private collectors such as James P. and Dorothy S. Barufaldi, whose collection makes up the entirety of this exhibition which also includes some pieces made by Lucy’s relatives and descendants.

The 2022 Pecos Conference will be held (tentatively) August 11-14 at Rowe Mesa near Pecos, NM. Registration opens in May. Check the website (www.pecosconference.org) for details as they become available.

Albuquerque Archaeological Society
Publications: 1968-2003 in PDF Format
Available as a 2 CD Pack for $15.00
(See order form on the last page of this volume)

CONTENTS

King, Dudley W., and Richard A. Bice
1992 *Subfloor Channels in Prehistoric Ruins: Anasazi Region of the Southwest*. Albuquerque Archaeological Society, Albuquerque.

Olson, Nancy H., and Richard A. Bice, edited by Alan M. Shalette
1995 *The Albuquerque Archaeological Society: The First Twenty-Five Years, 1966-1991.* Albuquerque Archaeological Society, Albuquerque.

Bice, Richard A.
1997 *Field Guide to Mid-Rio Grande Pottery.* Technical Note No. 4. Albuquerque Archaeological Society, Albuquerque.

Bice, Richard A.
1998 *Prehispanic Pueblo Pottery,* second edition, Albuquerque Archaeological Society, Albuquerque.

Bice, Richard A., Phyllis S. Davis, and William M. Sundt
1998 *The AS-8 Pueblo and the Cañada de las Milpas, a Pueblo III Complex in North-Central New Mexico*. Albuquerque Archaeological Society, Albuquerque.

Bice, Richard A., Phyllis S. Davis, and William M. Sundt
2003 *AS-5, Indian Mining of Lead for Use in Rio Grande Glaze Paint*, Report of the AS-5 Bethsheba Project Near Cerillos, New Mexico. Albuquerque Archaeological Society, Albuquerque.

SUBMISSIONS TO *POTTERY SOUTHWEST*

The availability of Pottery Southwest in electronic format creates opportunities for communicating with a wide audience in a sophisticated manner. It is currently published two or three times a year on a flexible schedule. Included are sections for Major Papers, Comments & Responses, Queries, Book Reviews, and Current Exhibits & Events. Following is a brief list of guidelines to follow in preparing submissions:

Style: Please adhere to the Society for American Archaeology's *American Antiquity* Style Guide for submissions. Refer to the *Chicago Manual of Style* for any questions regarding punctuation.

Author Information: Major papers should be approximately 15-20 pages including bibliographies and endnotes, but may be shorter or longer. Comments & Responses, Queries, Book Reviews, and Current Exhibits & Events should be short, in the 500- to 1,500-word range. Authors are responsible for the accuracy of their work.

Page Set-up: All submissions must be in Microsoft Word format. Top, bottom, left, and right margins must be 1 inch. Do not use any headers and footers in your submission. Text font should be Times New Roman, 12 point. Figure and table labels and tables should be Times New Roman, 10 point. Paragraphs should be single spaced. Do not use the tab key, enter key, or the space bar to line up text, especially in tables. Bibliographies must follow the *American Antiquity* style guide.

Spelling, Grammar, and Punctuation: Please spell check and grammar check your work before submission.

Images: Images must be in .jpg format. Images should be submitted as a separate file **as well as inserted** into the document.

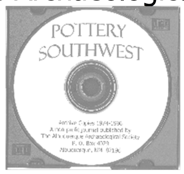
Inserts: Please do not import spreadsheets, pie charts, etc. from Excel into the Word document. They must be converted to Word format for submission, or converted to .jpg format. Do not use text boxes.

Deadlines: The deadline for the Fall 2022 issue is August 15, 2022. Papers submitted after this date will be considered for future issues. Depending on the number of submissions, papers submitted by these dates may be held for future issues.

Returns or Rejections: *Pottery Southwest* reserves the right to reject or return for revision, any material submitted on the grounds of inappropriate subject matter or material of poor quality or of excessive length, or if the material contains defamatory or illegal references. Manuscripts may also be returned for reformatting when they do not comply with the style provisions. Papers under consideration for publication elsewhere will not be accepted.

Questions, comments or inquiries should be sent to the editors at psw@unm.edu.

ORDER FORM
for Pottery Southwest Vols. 1-23, 1974-1996 Archive CD,
Pottery Southwest Five Years in Cyberspace Archive CD Vols. 24-28,
Prehistoric Southwestern Pottery Types and Wares by Norman Oppelt,
and/or Albuquerque Archaeological Society 2-CD Sets



TO: Albuquerque Archaeological Society
P. O. Box 4029
Albuquerque, NM 87196

PLEASE PRINT CLEARLY

No. & Choice of PSW CDs	**POTTERY SOUTHWEST CDs**	**Price per CD**	**Total**
[____] Vol. 1-23 [____] Vol. 24-28	Name: ______________________ Address: ______________________ City: ______________ State: ______ Zip Code: ______ E-Mail: ______________________	$5.00 for AAS members & students $7.50 for non-members	
No. of Oppelt CDs	**PREHISTORIC SOUTHWESTERN POTTERY TYPES AND WARES by Norman Oppelt**	**Price per CD**	
[____]	Name: ______________________ Address: ______________________ City: ______________ State: ______ Zip Code: ______ E-Mail: ______________________	$5.00 for AAS members & students $7.50 for non-members	
No. of AAS CD Sets	**ALBUQUERQUE ARCHAEOLOGICAL SOCIETY 2-CD SETS**	**Price per 2-CD Set**	
[____]	Name: ______________________ Address: ______________________ City: ______________ State: ______ Zip Code: ______ E-Mail: ______________________	$10.00 for AAS members & students $15.00 for non-members	
	Shipping		**$4.00**
	AMOUNT ENCLOSED:		**$______**