



INDEX OF TEXAS ARCHAEOLOGY

Open Access Gray Literature from the Lone Star State

Volume 2015

Article 17


2015

The Petrographic Analysis of Sherds from the Craig Mound at the Spiro site (34Lf40), the Moore #3/Ainsworth site (34Lf31), and the Geren site (34Lf36), LeFlore County, Oklahoma

Lori B. Love
Unknown

Steve A. Tomka
Raba Kistner, stomka@rkci.com

Timothy K. Perttula
Heritage Research Center, Stephen F. Austin State University, tkp4747@aol.com
Follow this and additional works at: <https://scholarworks.sfasu.edu/ita>

 Part of the [American Material Culture Commons](#), [Archaeological Anthropology Commons](#), [Environmental Studies Commons](#), [Other American Studies Commons](#), [Other Arts and Humanities Commons](#), [Other History of Art, Architecture, and Archaeology Commons](#), and the [United States History Commons](#)

[Tell us how this article helped you.](#)

Cite this Record

Love, Lori B.; Tomka, Steve A.; and Perttula, Timothy K. (2015) "The Petrographic Analysis of Sherds from the Craig Mound at the Spiro site (34Lf40), the Moore #3/Ainsworth site (34Lf31), and the Geren site (34Lf36), LeFlore County, Oklahoma," *Index of Texas Archaeology: Open Access Gray Literature from the Lone Star State*: Vol. 2015, Article 17. <https://doi.org/10.21112/.ita.2015.1.17>

ISSN: 2475-9333

Available at: <https://scholarworks.sfasu.edu/ita/vol2015/iss1/17>

This Article is brought to you for free and open access by the Center for Regional Heritage Research at SFA ScholarWorks. It has been accepted for inclusion in Index of Texas Archaeology: Open Access Gray Literature from the Lone Star State by an authorized editor of SFA ScholarWorks. For more information, please contact cdsscholarworks@sfasu.edu.

The Petrographic Analysis of Sherds from the Craig Mound at the Spiro site (34Lf40), the Moore #3/Ainsworth site (34Lf31), and the Geren site (34Lf36), LeFlore County, Oklahoma

Creative Commons License



This work is licensed under a [Creative Commons Attribution 4.0 License](https://creativecommons.org/licenses/by/4.0/).

**THE PETROGRAPHIC ANALYSIS OF SHERDS FROM THE CRAIG MOUND
AT THE SPIRO SITE (34Lf40),
THE MOORE #3/AINSWORTH SITE (34Lf31),
AND THE GEREN SITE (34Lf36), LEFLORE COUNTY, OKLAHOMA**

Lori Barkwill Love, Steve A. Tomka, and Timothy K. Perttula

Introduction

James A. Brown (1971, 1996:329) commissioned James W. Porter (1971:244-246) to carry out a preliminary assessment of the paste of sherds from the Spiro site (34Lf40), as well as sherds from the nearby Geren (34Lf36) and Moore (34Lf31) sites. According to Brown (1996:329), Porter's goal was to "make assessments of the clay mineralogy and petrography of thin sections," specifically with an "interest in discriminating between (1) grog and grit temper and (2) shell and grog temper with shell inclusions." Twenty-nine thin sections were prepared, 27 from sherds from the Craig Mound, and one sherd each from the Moore/Ainsworth and Geren sites, both not far from Spiro (Brown 1996:Table 2-41; Peterson et al. 1993:Figure 4; Rohrbaugh 1985).

Shortly after Ferring and Perttula (1987) completed petrographic studies of red-slipped pottery from sites in Oklahoma and Texas, Brown offered to send the thin-sections from his Spiro area studies to Ferring for more detailed petrographic studies. This he did sometime in 1987, but the 29 thin-sections were never fully studied, and they languished for years at the University of North Texas. In 2012, Ferring relocated the thin-sections and corresponding sherds and sent them to Perttula to complete the petrographic analysis of the Spiro area sherd series. The results of the petrographic analysis of a total of 23 of the 29 thin-sections are discussed in this article; there are provenience issues with the other six thin-sections (see below).

Context of the Sherds

The sherds for petrographic analysis are from a variety of burial features in the Craig Mound at the Spiro site, as well as from unknown contexts in the excavations; House 2 at the Geren site (Rohrbaugh 1985); and from a test pit at the Moore site (Table 1). The sherds with known provenience from the Craig Mound date as early as A.D. 1000-1250 (Spiro I/II), in the Evans and Harlan phases, to A.D. 1250-1350 (Spiro III, Norman phase), and to the Spiro phase (Spiro IV and IVB, ca. A.D. 1350-1450) (Brown 1996:Figure 1-51). The Geren site sherd also dates to the Spiro phase. The Moore site dates to both Spiro phase and Fort Coffee phase (ca. A.D. 1450-1660, Rogers 2006) times.

Table 1. Provenience of the sherds from the Craig Mound at the Spiro site, the Geren site, and the Moore site.

Thin-Section No.	Catalog No./ SNOMNH*	Known provenience and Feature	Likely age of the sherd
Craig Mound, Spiro site (34Lf40)			
1	860	Unknown	-
2	135	Unknown	-
3	36	Burial #034	Sub-mound feature, Spiro I/II (Brown 1966:73, 1996:75,77)
5	856	Unknown	-
10	130	Burial #140	Spiro IV (Brown 1966:202-203, 1996:Figure 1-47)
11	856	Unknown	-
12	116	back dirt in mound	-
13	856	Unknown	-
14	251	Burial #099	Spiro III (Brown 1966:156-159; 1996:Figure 1-47)
15	856	Unknown	-
16	125	back dirt in mound	-
18	166	Burial #187	Spiro III, crematory basin (Brown 1966:255-256, 1996:75, 77, 751)
19	116	back dirt in mound	-
20	856	Unknown	-
21	43	Burial #145	Spiro IVB (Brown 1966:205-207, 1996:Table 2-154)
22	856	Unknown	-
23	109	Unknown	-
24	150	Burial #094	Spiro IV (Brown 1966:151-153, 1996:749)
25	790	Unknown	-
26	86	Unknown	-
27	66	Unknown	-
Geren (34Lf36)			
28	102	House #2	Spiro phase (Rohrbaugh1985; Peterson et al.1993:Table 1)
Moore #3/Ainsworth (34Lf31)			
29	118	Test Pit #3	Spiro and Fort Coffee phases (Peterson et al. 1993:Table 1; Rohrbaugh 2012)

*catalog number preceded by the trinomial, i.e., 34Lf40/0036

The catalog numbers listed on Table 1 do not correspond in every detail with the information provided in Brown (1996:Table 2-41). For this study, we relied on our decipherment of the catalog numbers written on the sherds; unfortunately, several sherds were so fragmentary that catalog numbers could not be deciphered, and in that case, its corresponding thin section could not be determined. This is why thin sections 4, 6-9, and 17 were not examined in this study.

The petrographic thin sections are from sherds of several different defined ceramic types, as classified by Brown (1996). These include Agee Incised (n=1), Bell Plain (n=1), LeFlore Plain (n=2), Nash Neck Banded (n=1), Poteau Plain (n=5), Redland Engraved (n=1), Sanders Plain (n=9), Spiro Engraved (n=1), Williams Plain (n=1), and Woodward Plain (n=1) (Table 2). The grog, grit, and bone-tempered ceramics (n=16, 70% of the thin-sections) include Agee Incised, LeFlore Plain, Nash Neck Banded, Redland Engraved, Sanders Plain, Spiro Engraved, and Williams Plain (Brown 1996:343-379, 401-403), while the shell-tempered ceramic types identified in this assemblage (n=7, 30% of the thin-sections) are Bell Plain, Poteau Plain, and Woodward Plain (Brown 1996:389-393, 405-406). The Bell Plain type is considered to be a Mississippi Valley type (Brown 1996:392), while the others are Arkansas River basin Caddo area ceramic types or in the case of Nash Neck Banded, the Red River basin in southeastern Oklahoma and northeastern Texas (Suhm and Jelks 1962:111).

Table 2. Pottery type identifications for the petrographic thin sections from the Craig Mound, the Geren site, and the Moore site (from Brown 1996:Table 2-41).

Petrographic thin-section no.	Pottery type
Spiro site, Craig Mound	
1	Sanders Plain
2	Sanders Plain
3	Williams Plain
5	Spiro Engraved
10	Poteau Plain
11	Sanders Plain
12	Sanders Plain
13	Redland Engraved
14	Bell Plain
15	Agee Incised
16	Sanders Plain
18	Poteau Plain
19	Poteau Plain
20	Poteau Plain
21	Sanders Plain
22	Sanders Plain
23	LeFlore Plain
24	LeFlore Plain
25	Sanders Plain
26	Poteau Plain
27	Sanders Plain
Geren site	
28	Nash Neck Banded
Moore site	
29	Woodward Plain

Results of the Petrographic Analysis

Methods

The thin sections were examined with a Leica Petrographic microscope with an attached mechanical stage. A two-step process was used to examine the thin sections. The first step involved recording their general characteristics and taking photomicrographs of the thin sections. The general characteristics recorded were paste matrix descriptions, paste color, b-fabric (Stoops 2003:95), and description of edges. B-fabric refers to the orientation and distribution of inference colors in the clay matrix (Stoops 2003:95). Examining the b-fabric can provide some insight into firing temperatures. According to Quinn (2013:191) it is generally assumed that an active b-fabric is related to ceramics that have been fired at temperatures less than 850° C, while an undifferentiated b-fabric is related to ceramics that have been fired at temperatures greater than 850° C. For the samples in this study, all but sample 28 from the Geren site had a slightly active b-fabric. Sample 28 had an undifferentiated b-fabric, suggesting it may have been fired at a slightly higher temperature.

Seven of the thin sections from the Spiro site (Nos. 1, 2, 3, 5, 10, 11, and 12) were not cut transverse to the plane of the sherd so that the edges of the vessel could not be described. By cutting a sherd transverse to the plane of the sherd, a slip or other surface treatments can be distinguished or described; however, given that several of the sherds were not cut transverse to the plane of the sherd and others were ground down too thin or had the edge eroded, a discussion of a slip or other surface treatments has not been included in this article. For the photomicrographs, at least two sets (plane light and cross-polar light) were taken of each thin section at 4x and 10x magnification. Digital images were captured using a Leica DFC 295 Digital Camera attached to a Dell computer.

The second step involved point counting using the Glagolev-Chayes method. The Glagolev-Chayes method involves using the mechanical stage, which allows one to move the thin section at a given interval beneath the crosshairs in the ocular, and identifying and recording each point encountered in the crosshairs (Galehouse 1971:389-390). For the point count sampling, the microscope was set at 10x magnification, and the stage was set so that the vertical and horizontal increments were both 0.4 mm. Each point encountered was identified as either paste matrix, void, or non-plastic inclusion. Paste matrix was recorded by tally; however, for all voids and non-plastic inclusions, estimated size and shape were recorded. Non-plastic inclusions and voids were only counted once even if the same void or inclusion was encountered more than once in the crosshairs. Once the point counting was completed, non-plastic inclusions that were noted during the scanning of the slide but not included in the point counting were recorded with a general estimate of their frequency.

Initially the thin sections were point counted until 100 paste points were reached. Stoltman (1989:151-152, 2012:H-1) suggests that a minimum of 100 points (exclusive of voids) are needed to ensure reliable results and that point counting in excess of 200 points yields redundancy. With 100 paste points counted, the minimum number of points recorded was 108, and the maximum number of points recorded was 168. However, in many of these thin sections, several of the inclusions had been “popped out,” and the majority of the non-paste points recorded were voids, which do not provide much information regarding the temper in the sherds. Therefore, the point counting was repeated and increased to 200 paste points to ensure that a greater number of non-plastic inclusions were recorded. With the revised point counting, the minimum number of points recorded was 226 and the maximum number of points was 346. In the individual thin section descriptions, the percentage of voids that might represent “popped out” inclusions was recorded. The recording of missing inclusions was based primarily on the shape of the voids. The counts, measurements and

paste, voids, and non-plastic inclusion type recorded during point counting for each thin section were input into a JMP Pro 10 data table.

The maximum diameter of the inclusion/void was measured with the ocular scale to the nearest whole number. At 10x magnification, each tick mark on the ocular scale represents 0.02 mm. The raw tick mark count was recorded for each inclusion, input into JMP and converted to an actual size. Within each temper category, the distribution of sand size was noted by size category based on the Wentworth Grain Size scale (Table 3).

Table 3. Wentworth Grain Size scale used for distribution of sand size.

Size Category	Recorded Size
Silt	0.02-0.06 mm
Very Fine Sand	0.07-0.12 mm
Fine Sand	0.13-0.25 mm
Medium Sand	0.26-0.50 mm
Coarse Sand	0.51-1.0 mm
Very Coarse Sand	1.01-2.0 mm

Temper Categories

To assign temper categories to the thin-sections in the study, the recorded paste/inclusions were combined into the following simplified categories:

Recorded Paste/Inclusion	Simplified Inclusion Category
Paste	Paste
Bone	Bone
Sherd	Grog
Shell	Shell
Quartz	Sand
Polycrystalline quartz	Sand
Alkali feldspar	Sand
Muscovite	Mica
Calcium carbonate	Other
Clay pellet	Other
Hematite	Other
Opaque	Other
Organic	Other
Voids	Not included
Biotite	Mica
Calcite	Other
Chert	Sand
Mica Schist	Mica
Microcline	Sand
Secondary Calcite	Not included
Unknown	Other

A frequency distribution was created for each sherd based on the simplified inclusion category (voids and secondary calcite excluded) to determine temper categories. The “other” category was not used in temper assignments given that this category made up less than 5% of the inclusion categories. Eight temper categories were defined for these thin-sections: bone (n=4, 17%); bone and grog (n=5, 22%); grog (n=6, 26%); grog and sand (n=1, 4%); shell (n=4, 17%); shell and grog (n=1, 4%); shell, bone and grog (n=1, 4%); and micaceous sand (n=1, 4%). Grog was the most common category represented, followed by bone and grog (Figure 1).

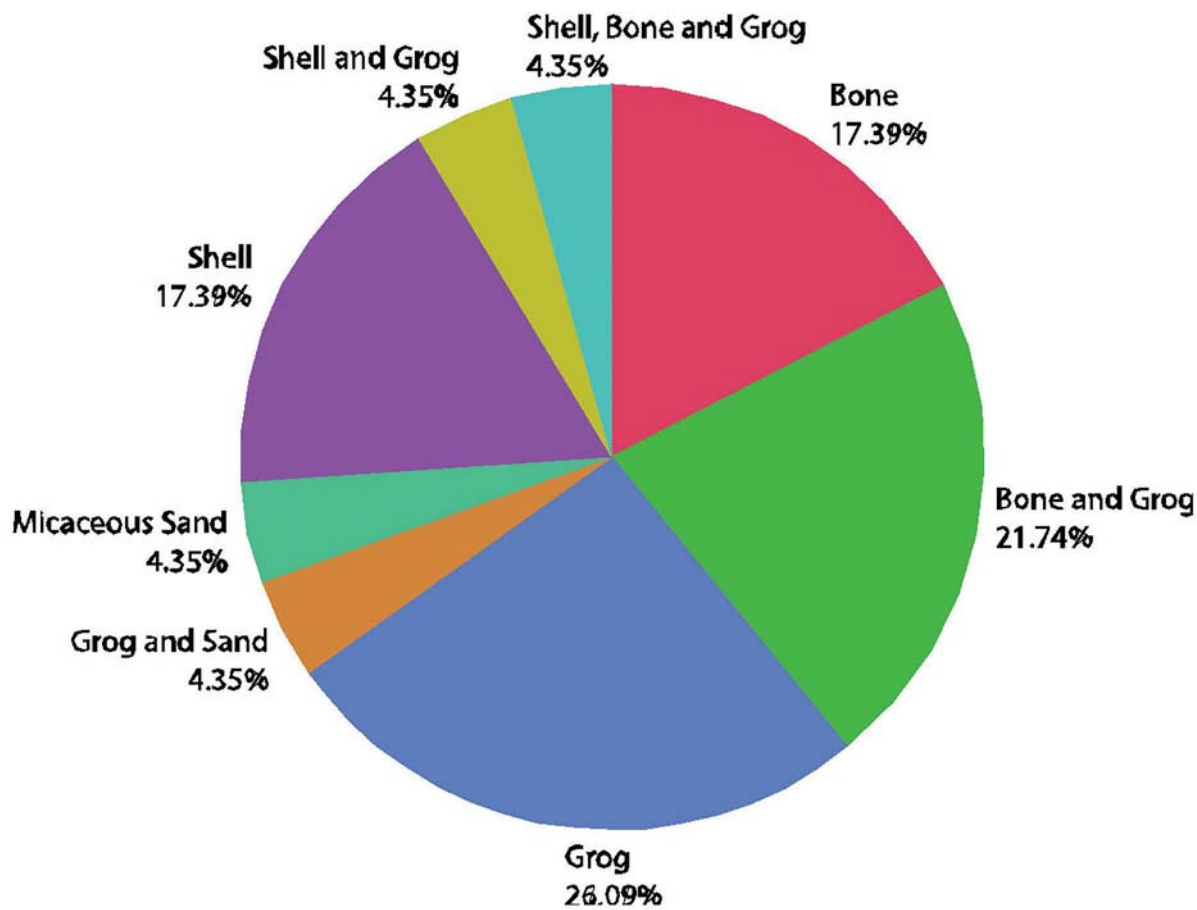


Figure 1. Distribution of temper categories.

Summary of Petrographic Analysis

Table 4 provides a general summary of the thin sections analyzed from the Spiro, Moore #3, and Geren sites. The table is divided by temper categories and provides an overview of the individual thin sections. The following is a description of the table columns:

Sherd ID: the ID number etched on the thin sections

Simplified Inclusion Categories (paste %, sand %, bone %, grog %, shell %, and mica %): lists the percentage of each category found during point counting. Note that the “other” inclusion category was omitted from this table.

Median Sand Size: represents the median size for the sand inclusions in the thin section.

Median Inclusion Size: represents the median size for all inclusions excluding sand and voids.

Platy Bone Inclusions: lists whether or not platy bone inclusions were common in the thin section. Y = platy-shaped bone was common, N = bone was generally not platy-shaped.

Platy Shell Inclusions: lists whether or not platy shell inclusions were common in the thin section. Y = platy-shaped shell was common, N = shell was generally not platy-shaped.

Common Inclusions (feldspar, mica, and hematite): lists whether or not these inclusions were common in the thin section based on visual inspection and not point counting. Y = inclusion was common, N = inclusion was not common.

Temper of Grog (sand, bone, shell, or grog): based on visual inspection, lists the temper commonly found in the grog. Y = temper type was commonly present, N = temper type was not present, P = temper type was present and the inclusions were often platy-shaped. In some of the thin sections only voids were represented in the crushed sherds; therefore, it was not possible to distinguish shell from bone, so both were recorded as being present.

Bone Temper

The bone temper category was defined on the presence of bone without grog or shell present in thin sections No. 13, 14, 19, and 26 from the Spiro site (see Table 4). The percentage of bone in this category ranged from 5.4% to 16.5%. A box plot of the bone size distribution by sherd No. is shown in Figure 2. Given the small sample size of the individual inclusions in each sherd, a statistical analysis comparing size differences was not warranted. The percentage of sand in this temper category ranged from 1.3% to 10.8%. Figure 3 shows the sand size distribution based on the Wentworth scale categories. Sand size is represented by a histogram rather than a box plot given that distinguishing silty sand from other sand categories is useful in determining whether the sand was a natural inclusion in the clay or intentionally added as temper. Since the majority of the sand in each of the thin sections is silt-sized, it is likely that the sand was a natural constituent in the clay for the samples in this category. However, the higher percentage of sand in thin section No. 19 (see Table 4) suggests this vessel was likely made with a sandier clay.

Of particular interest was the shape of the bone found in these thin sections. With the exception of thin section No. 13, the crushed bone was platy-shaped (Figure 4). This difference in bone shape could represent different ceramic vessel manufacturing processes.

Table 4. Summary of Petrographic Analysis.

Sherd ID	Site	Simplified Inclusion Categories						Mean Sand Size Index	Mean Inclusion Size Index	Platy Bone Inclusions	Platy Shell Inclusions	Common Inclusions			Temper of Grog		
		Paste %	Sand %	Bone %	Grog %	Shell %	Mica % Bone Temper					Feldspar	Mica	Hematite	Sand	Bone	Shell
13	Spiro	80.65%	2.82%	16.53%	—	—	—	1.29 ± .76	3.68 ± 1.17	N	—	N	N	Y	—	—	—
14	Spiro	88.89%	1.33%	8.44%	—	—	0.44%	1	3.59 ± 1.22	Y	—	N	N	N	—	—	—
19	Spiro	83.33%	10.83%	5.42%	—	—	—	1.27 ± .53	3.57 ± 1.16	Y	—	Y	Y	Y	—	—	—
26	Spiro	84.03%	3.36%	12.19%	—	—	—	1.50 ± .76	3.79 ± 1.35	Y	—	Y	N	Y	—	—	—
Bone and Grog Temper																	
1	Spiro	69.93%	5.25%	22.03%	1.75%	—	—	1.33 ± .72	3.83 ± 1.40	N	—	N	N	Y	Y	Y	N
2	Spiro	88.50%	4.87%	0.00%*	6.20%	—	0.44%	1.27 ± .47	4.60 ± 1.24	N	—	Y	N	Y	Y	P	N
11	Spiro	87.34%	6.99%	1.75%	3.49%	—	—	1.13 ± .34	3.85 ± 1.86	N	—	N	Y	N	P	P	N
12	Spiro	85.47%	2.56%	5.98%	5.56%	—	—	1.33 ± .52	4.39 ± 1.23	N	—	Y	N	N	P	N	N
25	Spiro	81.30%	5.59%	4.88%	7.32%	—	0.81%	1.29 ± .61	3.59 ± 1.50	N	—	Y	Y	N	Y	Y	Y
Grog Temper																	
3	Spiro	94.79%	2.84%	—	1.90%	—	—	1	4.40 ± 1.52	—	—	N	N	Y	Y	N	N
5	Spiro	88.11%	6.61%	0.44%	4.41%	—	0.44%	1.20 ± .41	4.50 ± 1.73	N	—	N	Y	Y	Y	Y	N
15	Spiro	84.03%	10.91%	—	3.36%	—	0.42%	1.27 ± .53	4.25 ± 1.29	—	—	Y	Y	Y	Y	N	N
21	Spiro	89.29%	5.36%	—	4.91%	—	0.45%	1	4.58 ± 1.68	—	—	N	Y	N	Y	P	N
23	Spiro	85.11%	5.96%	—	7.66%	—	0.85%	1.36 ± 1.08	3.95 ± 1.20	—	—	N	Y	N	Y	N	Y
27	Spiro	88.11%	6.17%	—	5.73%	—	—	1.79 ± 1.63	4.75 ± .62	—	—	N	N	Y	N	P	N
Grog and Sand Temper																	
24	Spiro	66.23%	14.24%	—	16.56%	—	—	2.60 ± 1.14	3.92 ± 1.13	—	—	Y	N	Y	Y	N	Y
Shell Temper																	
10	Spiro	83.68%	2.93%	—	—	10.88%	—	1.86 ± .90	4.59 ± .98	—	N	Y	Y	Y	—	—	—
18	Spiro	70.67%	4.59%	—	—	24.74%	—	2.31 ± 1.25	3.76 ± 1.39	—	Y	Y	N	Y	—	—	—
20	Spiro	75.76%	4.55%	—	—	19.32%	—	1.75 ± 1.06	3.94 ± 1.09	—	Y	Y	Y	N	—	—	—
29	Moore	61.16%	3.06%	—	—	35.78%	—	1	3.96 ± 1.25	—	Y	N	Y	N	—	—	—
Shell and Grog Temper																	
22	Spiro	82.99%	3.73%	—	9.96%	3.32%	—	1.56 ± 1.67	4.63 ± .98	—	Y	N	N	Y	N	Y	N
Shell, Bone, and Grog Temper																	
16	Spiro	72.46%	11.23%	2.54%	5.80%	6.88%	—	1.74 ± .82	3.73 ± 1.27	N	Y	Y	Y	Y	Y	Y	P
Micaceous Sand Temper																	
28	Geren	71.43%	13.21%	—	—	—	—	3.03 ± 1.56	3.28 ± 1.33	—	—	Y	Y	N	—	—	—

*Bone is common even though it did not show up on point counting

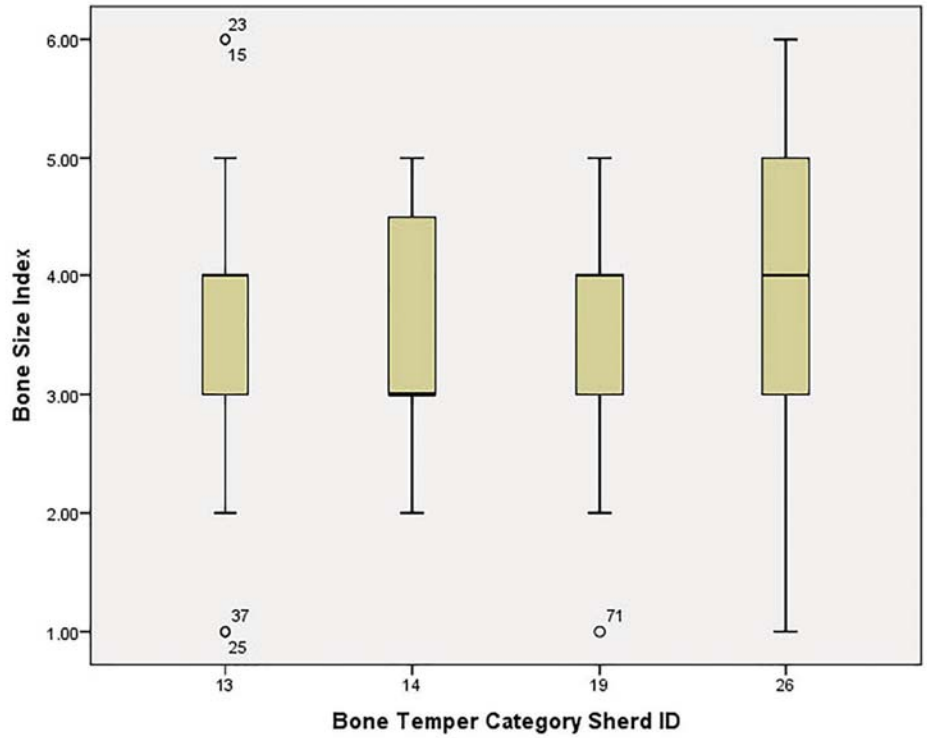


Figure 2. Box plot showing the bone size index for bone-tempered sherds by sherid No.

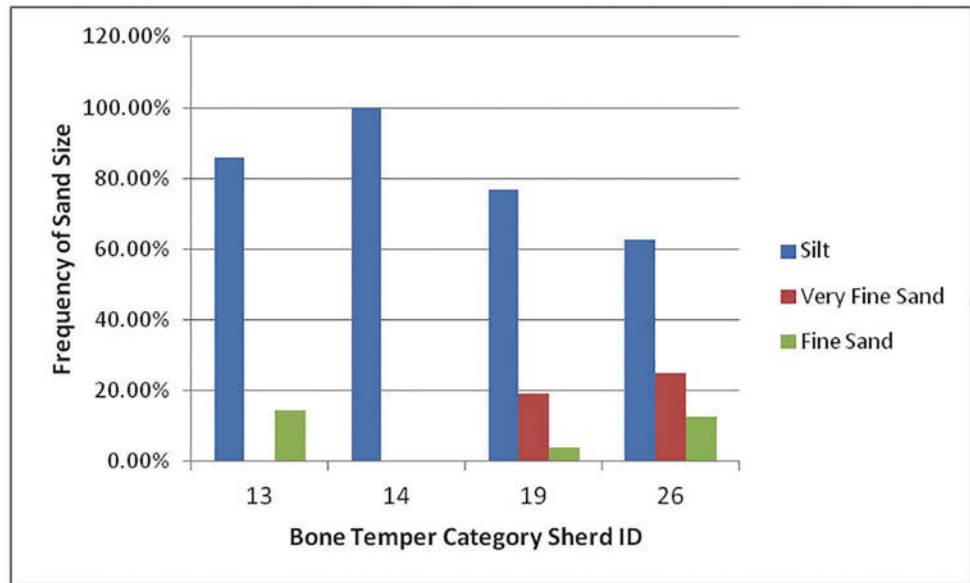


Figure 3. Distribution of sand size categories (based on the Wentworth scale) by sherid No. for bone-tempered sherds.

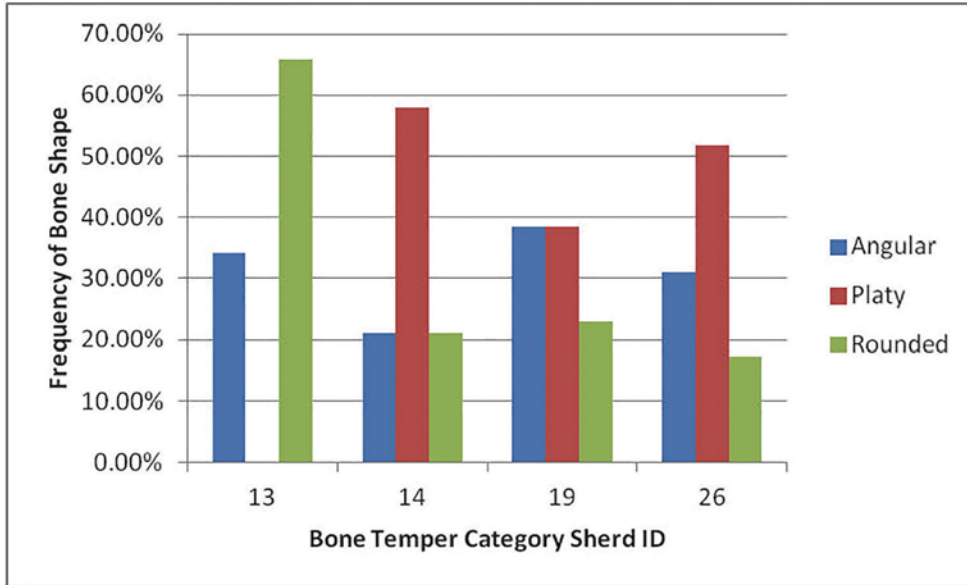


Figure 4. Distribution of crushed bone temper shape by Sherd No. for the bone-tempered sherds.

Sherd No. 13 (Figure 5a)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 2.5Y 6/6, olive yellow

B-fabric (XPL): Speckled/Slightly Active

Edge Description: One edge has a more active b-fabric. Same inclusions as rest of paste.

Comments: Most bone does not have platy shape. Some of the bone appears to have spots of hematite.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	75.5%	Paste	200	80.7%
Bone	41	15.5%	Sand	7	2.8%
Quartz	7	2.6%	Bone	41	16.5%
Voids	17	6.4%	Total	248	
Total	265				

Also present: polycrystalline quartz (common), hematite (common), charcoal (rare), muscovite (rare), alkali feldspar (rare)

Percentage of voids that might be missing inclusions: 82.4%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .24	.06	.02	.02
Bone	.06 – 1.5	.39	.34	.25
All Inclusions*	.02 – 1.5	.34	.26	.36

*Note: All inclusions includes all non-plastic inclusions but not voids

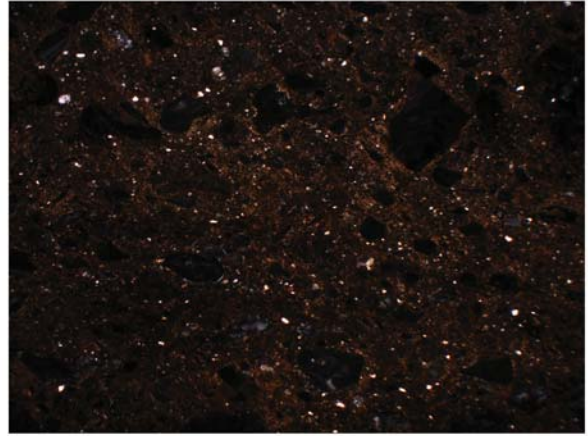
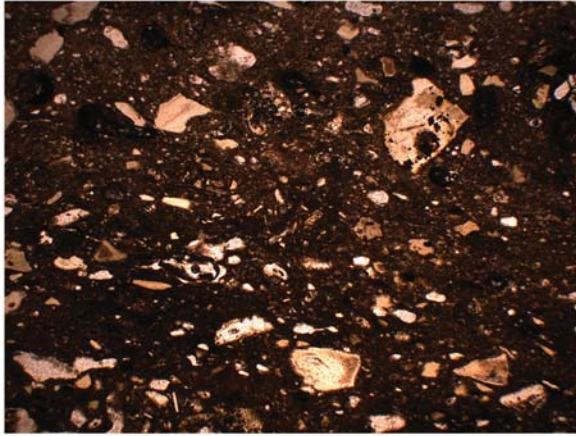


Figure 5a.

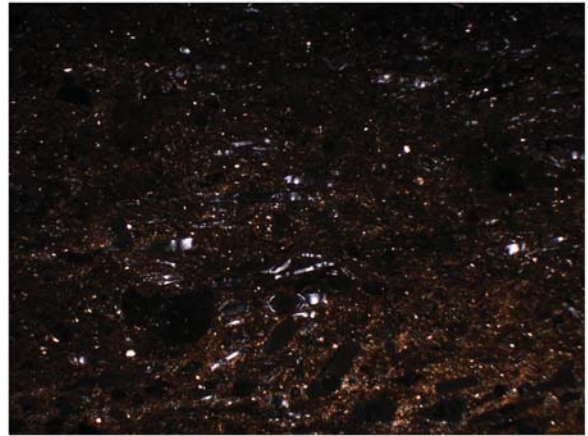
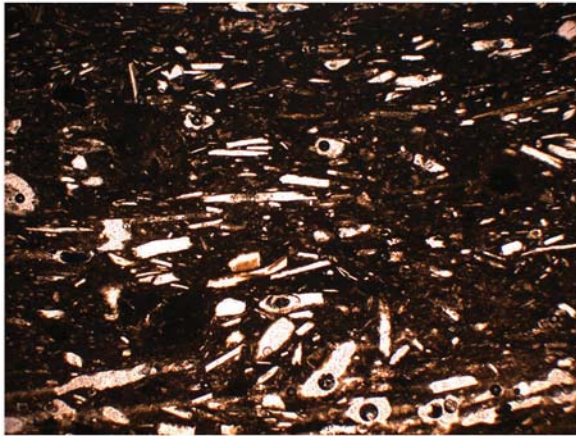


Figure 5b.

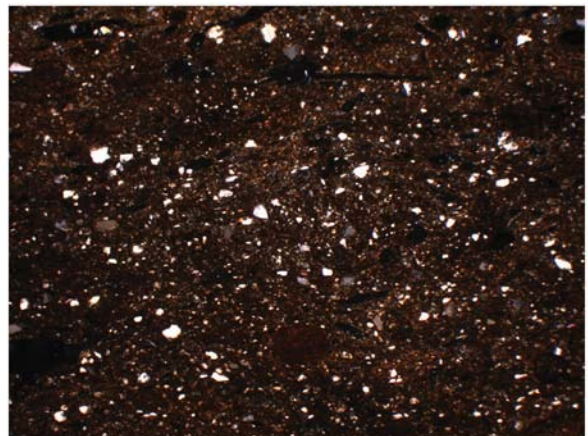
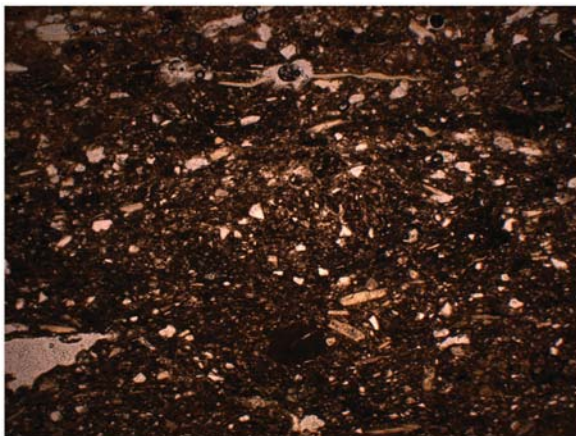


Figure 5c.

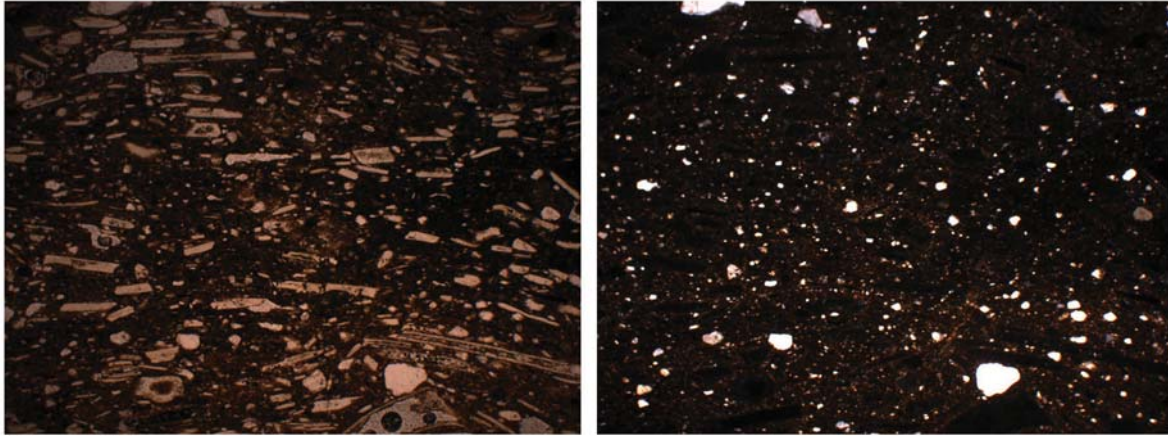


Figure 5d.

Figure 5. Photographs of bone-tempered thin sections: a, No. 13; b, No. 14; c, No. 19; d, No. 26. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Sherd No. 14 (Figure 5b)

Paste Matrix (PPL): Mottled

Paste Color (PPL): 2.5Y 4/3, olive brown with spots of 2.5Y 6/4, light yellowish-brown

B-fabric (XPL): Speckled/Slightly Active; Lighter paste is more active

Edge Description: Spots along one edge more active: same inclusions as rest of the paste

Comments: Bone mostly has platy shape. Inclusion generally oriented parallel to the rim.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	78.4%	Paste	200	88.9%
Bone	19	7.5%	Sand	3	1.3%
Quartz	3	1.2%	Bone	19	8.4%
Muscovite	1	0.4%	Mica	1	0.4%
Clay pellet	2	0.8%	Other	2	0.9%
Voids	30	11.8%	Total	225	
Total	255				

Also present: polycrystalline quartz (rare)

Percentage of voids that might be missing inclusions: 80%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .06	.04	.04	.04
Bone	.08 – .94	.34	.22	.36
All Inclusions	.02 – 1.5	.34	.26	.36

Sherd No. 19 (Figure 5c)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 10YR 5/6, yellowish brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: Both edges are rubbed a little thin and are lighter in color (2.5Y 7/6 yellow) and more active

Comments: Clay pellet may be grog without distinctive temper (sand). Most bone has a platy shape and is oriented parallel to the rim.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	79.4%	Paste	200	83.3%
Bone	13	5.2%	Sand	26	10.8%
Quartz	22	8.7%	Bone	13	5.4%
Polycrystalline quartz	4	1.6%	Other	1	0.4%
Clay pellet	1	0.4%	Total	240	
Voids	12	4.8%			
Total	252				

Also present: muscovite (common), hematite (common), alkali feldspar (uncommon), plagioclase (uncommon), shell (uncommon)

Percentage of voids that might be missing inclusions: 58.3%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.04 – .16	.06	.06	.03
Bone	.06 – .70	.31	.26	.27
All Inclusions	.04 – .70	.16	.06	.17

Sherd No. 26 (Figure 5d)

Paste Matrix (PPL): Continuous with core

Paste Color (PPL): 10YR 5/6, yellowish brown – core: 10YR 4/3, brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: Possible slip – one edge has spots (not continuous) of 7.5YR 4/6, strong brown – unlike the rest of the paste these spots do not have any bone present, just sand. The other edge is ground too thin.

Comments: A large area in the middle of the thin section is missing; this area was skipped during point counting. Most of the bone/voids are platy-shaped and oriented parallel to the rim. There are spots of hematite on the bone. Hematite is common in the thin section.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	77.2%	Paste	200	84.0%
Bone	29	11.2%	Sand	8	3.4%
Quartz	8	3.1%	Bone	29	12.2%
Hematite	1	0.4%	Other	1	0.4%
Voids	21	8.1%	Total	238	
Total	259				

Also present: alkali feldspar (common), polycrystalline quartz (rare), muscovite (rare)

Percentage of voids that might be missing inclusions: 66.7%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - .14	.07	.06	.07
Bone	.06 - 2.56	.47	.34	.49
All Inclusions	.02 - 2.56	.39	.27	.49

Bone and Grog Temper

The bone and grog temper category was defined on the basis of the presence of bone and grog with little to no shell. The bone and grog temper category represented 21.7% of the samples (see Table 4).

The percentage of bone ranged from 0% to 22%. Although thin section No. 2 had no bone sampled during point counting, bone was common in the thin section; therefore, it was placed in this temper group. A box plot of the bone size distribution by sherd No. is shown in Figure 6. Unlike the bone temper category, the majority of the crushed bone in the thin sections were not platy-shaped, which may represent differences in manufacturing processes between vessels (Figure 7). Although the majority of the crushed bone in the thin section did not have a platy shape, the bone/shell in the crushed sherds used as temper was often platy shaped in all the thin sections except in thin sections No. 1 and No. 25. In some of the thin sections, the inclusions in the crushed sherds were represented by voids instead of actual inclusions; therefore, it was difficult to distinguish between bone and shell inclusions. The mix of temper preparation techniques within the sherd has some interesting implications for recycling of broken vessels or suggests some flexibility in manufacture techniques.

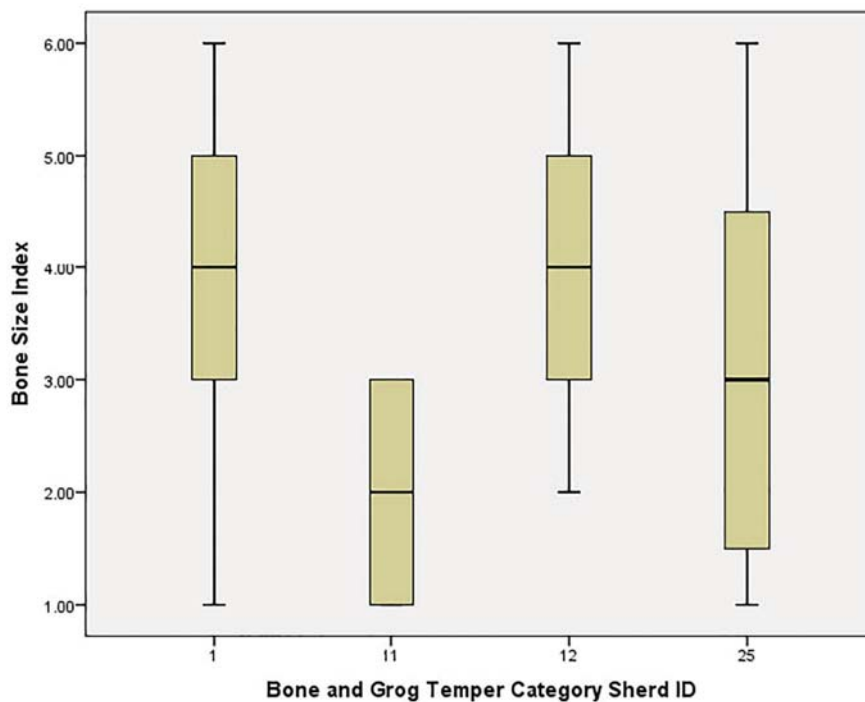


Figure 6. Box plot showing distribution of bone size by sherd No. for bone-grog-tempered sherds. Thin section No. 2 is omitted due to no bone being sampled in the point counting.

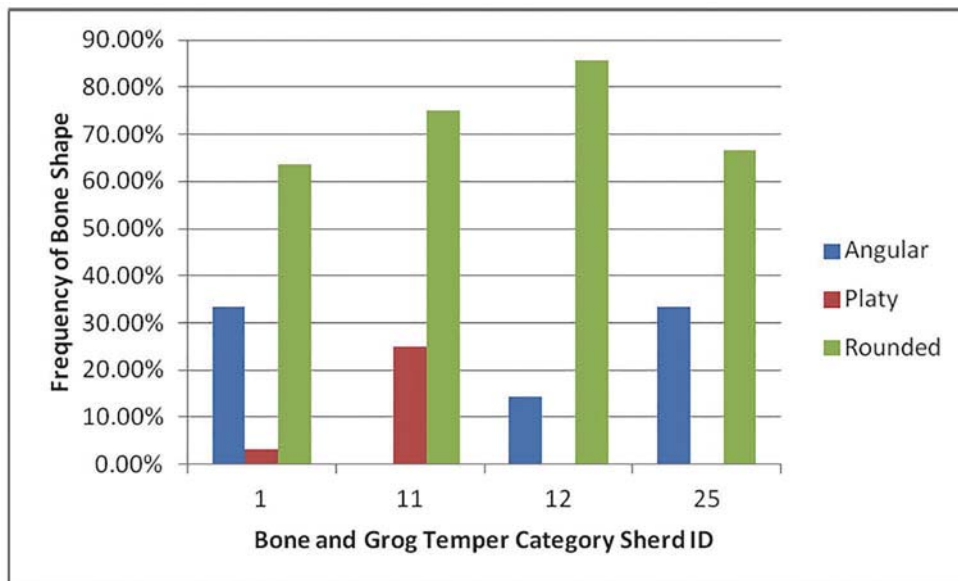


Figure 7. Distribution of the crushed bone shape by Sherd No. Thin section No. 2 is omitted due to no bone being sampled in the point counting.

The percentage of grog in this temper category ranged from 1.8% to 7.3%. A box plot of the grog size distribution based on the size index by sherd No. is shown in Figure 8. The percentage of sand in this temper category ranged from 2.56% to 6.99%. Figure 9 shows the sand size distribution based on the Wentworth scale. Given that the majority of the sand in each of the thin sections is silt sized, it is likely that the sand was a natural constituent element in the clay for all the samples in this category.

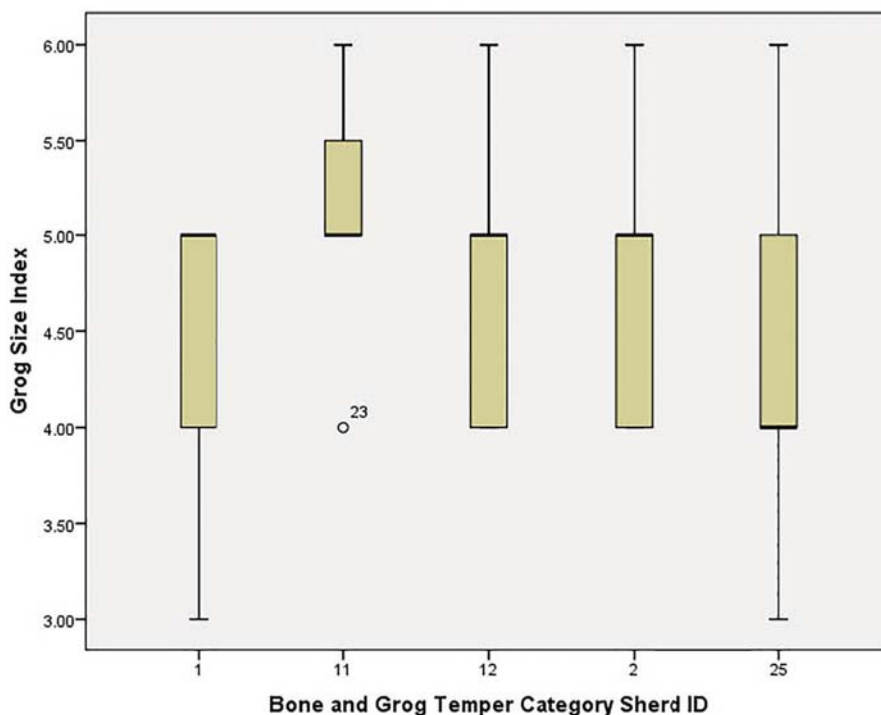


Figure 8. Box plot showing grog size distribution by sherd No.

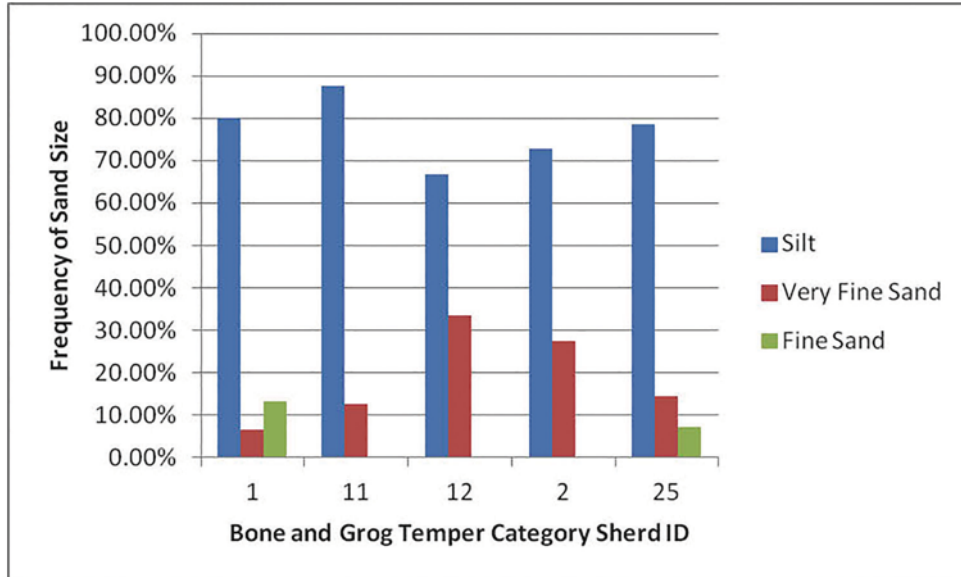


Figure 9. Distribution of the sand size category (based on the Wentworth scale) by sherd No. for bone-grog-tempered sherds.

Sherd No. 1 (Figure 10a)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 10YR 4/4, dark yellowish brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: N/A

Grog Description: Generally tempered with bone. Most bone temper was not platy-shaped. Many of the crushed sherds seemed to have the same paste as the thin section.

Comments: Most bone temper was not platy-shaped. Opaques were possibly burnt bone or hematite.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	66.2%	Paste	200	69.9%
Bone	63	20.9%	Sand	15	5.2%
Grog	5	1.7%	Bone	63	22.0%
Quartz	14	4.6%	Grog	5	1.8%
Alkali feldspar	1	0.3%	Other	3	1.1%
Opaque	3	1.0%	Total	286	
Voids	16	5.3%			
Total	302				

Also present: hematite (common), muscovite (uncommon), polycrystalline quartz (uncommon), small mafic mineral (rare)

Percentage of voids that might be missing inclusions: 12.5%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - .16	.06	.04	.04
Bone	.04 - 1.90	.52	.40	.54
Grog	.18 - .94	.56	.58	.48
All Inclusions	.02 - 1.90	.43	.32	.55

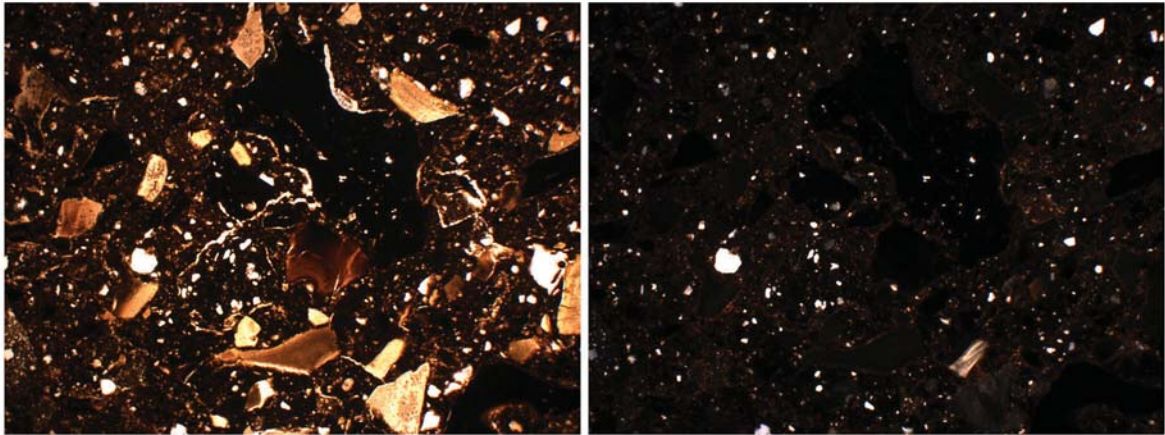


Figure 10a.

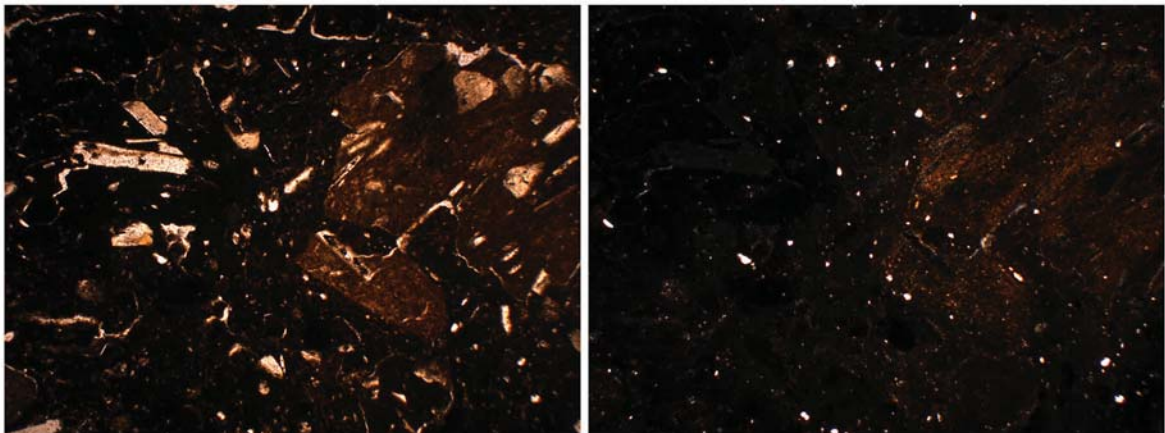


Figure 10b.

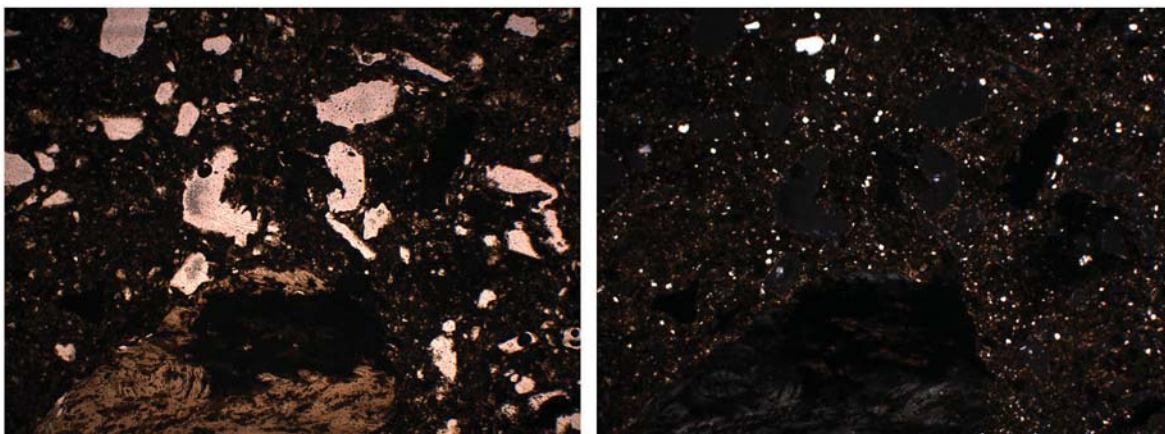


Figure 10c.

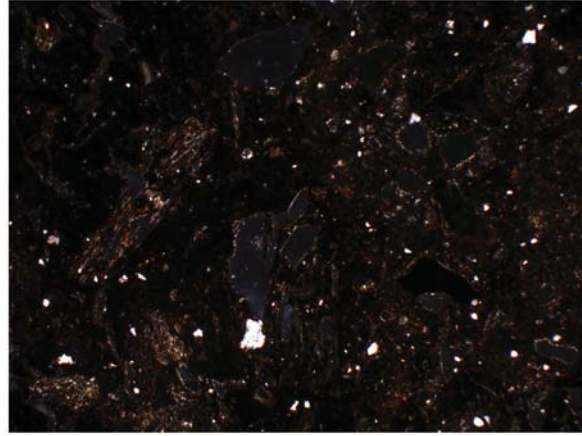
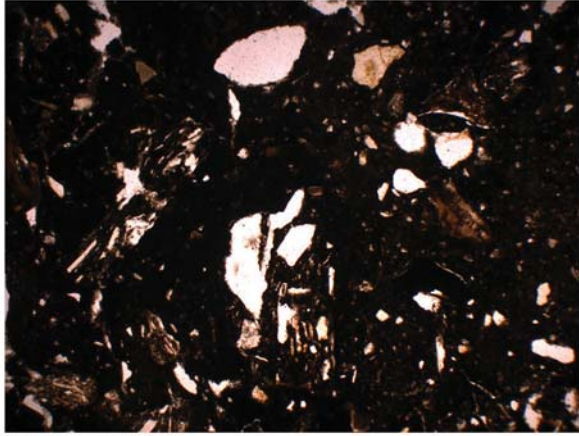


Figure 10d.

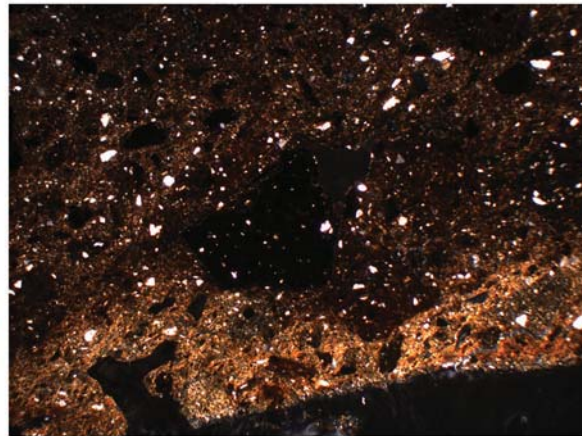
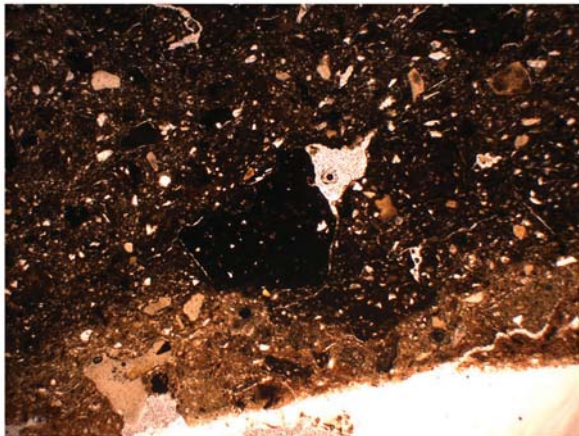


Figure 10e.

Figure 10. Photographs of bone-grog-tempered thin sections: a, No. 1; b, No. 2; c, No. 11; d, No. 12; e, No. 25. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Sherd No. 2 (Figure 10b)

Paste Matrix (PPL): Mottled

Paste Color (PPL): 2.5Y 5/4, light olive brown with spots of 2.5Y 3/3, dark olive brown

B-fabric (XPL): Speckled/Slightly Active – dark spots undifferentiated

Edge Description: N/A

Grog Description: Generally tempered with bone/shell or sand. Bone/shell temper is mostly platy. Many of the crushed sherds have the same paste as the thin section.

Comments: Secondary calcite maybe an artifact of the thin section production.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	82.3%	Paste	200	88.5%
Grog	14	5.8%	Sand	11	4.9%
Quartz	9	3.7%	Grog	14	6.2%
Alkali feldspar	2	0.8%	Mica	1	0.4%
Muscovite	1	0.4%	Total	226	
Voids	15	6.2%			
Secondary calcite	2	0.8%			
Total	243				

Also present: bone (common), hematite (common)

Percentage of voids that might be missing inclusions: 33.3%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .12	.06	.04	.08
Grog	.26 – 1.50	.72	.65	.63
All Inclusions	.02 – 1.50	.41	.26	.66

Sherd No. 11 (Figure 10c)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 2.5Y 5/4, light olive brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: N/A

Grog Description: Generally tempered with bone or possibly shell. Several of the crushed sherds had inclusions with platy structure.

Comments: Most visible bone and possible missing inclusions were not platy-shaped. Opaque might be burnt bone.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	78.4%	Paste	200	87.3%
Bone	4	1.6%	Sand	16	7.0%
Grog	8	3.1%	Bone	4	1.8%
Quartz	15	5.9%	Grog	8	3.5%
Polycrystalline quartz	1	0.4%	Other	1	0.4%
Opaque	1	0.4%	Total	229	
Voids	26	10.2%			
Total	255				

Also present: muscovite (common), alkali feldspar (uncommon), shell (uncommon), charcoal (rare)

Percentage of voids that might be missing inclusions: 76.9%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .08	.04	.04	.04
Bone	.06 – .18	.12	.11	.12
Grog	.46 – 1.14	.79	.75	.44
All Inclusions	.02 – 1.14	.26	.06	.47

Sherd No. 12 (Figure 10d)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 2.5Y 4/4, olive brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: N/A

Grog Description: Generally tempered with bone or sand. Several of the crushed sherds had platy-shaped bone temper.

Comments: Bone in thin section not platy-shaped.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	81.6%	Paste	200	85.5%
Bone	14	5.7%	Sand	6	2.6%
Grog	13	5.3%	Bone	14	6.0%
Quartz	6	2.4%	Grog	13	5.6%
Opaque	1	0.4%	Other	1	0.4%
Voids	11	4.5%	Total	234	
Total	245				

Also present: alkali feldspar (common), polycrystalline quartz (common), plagioclase (uncommon), muscovite (uncommon), charcoal (rare)

Percentage of voids that might be missing inclusions: 72.7%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - .12	.06	.05	.07
Bone	.08 - 1.38	.55	.42	.77
Grog	.28 - 1.80	.84	.72	.74
All Inclusions	.02 - 1.80	.56	.43	.77

Sherd No. 25 (Figure 10e)

Paste Matrix (PPL): Continuous (core)

Paste Color (PPL): 10YR 5/6, yellowish brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: Edges are lighter (2.5Y 7/8, yellow) and more active in XPL, but have the same inclusions as the rest of the paste

Grog Description: Generally tempered with sand, bone, or grog. Bone in crushed sherds is not platy-shaped.

Comments: Muscovite is very common. Bone is not platy-shaped. Hematite is present.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	78.1%	Paste	200	81.3%
Bone	12	4.7%	Sand	14	5.7%
Grog	18	7.0%	Bone	12	4.9%
Quartz	13	5.1%	Grog	18	7.3%
Polycrystalline quartz	1	0.4%	Mica	2	0.8%
Muscovite	2	0.8%	Total	246	
Voids	10	3.9%			
Total	256				

Also present: perthite (rare), alkali feldspar (common), small mafic mineral (augite) (rare)
 Percentage of voids that might be missing inclusions: 40%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .18	.06	.04	.03
Bone	.06 – 1.80	.39	.21	.50
Grog	.14 – 1.32	.48	.35	.42
All Inclusions	.02 – 1.80	.31	.18	.35

Grog Temper

The grog temper category was based on the presence of grog without bone or shell inclusions. However, it should be noted that thin section No. 5 did have one piece of bone sampled during point counting. As bone temper in this thin section was very rare, it was placed in this category. Also thin section No. 21 may be bone and grog tempered; however, no bone was observed in the thin section, yet there were several voids that could possibly be bone based on their shape. The grog temper category represented 26.1% of the samples (n=6), all from the Spiro site (see Table 4).

The percentage of grog in this category ranged from 1.9% to 7.7%. Figure 11 is a box plot showing the distribution of grog size based on the size index. While all of the thin sections in the bone and grog temper category had grog (crushed sherds) with bone/shell inclusions, in the grog temper category, only three thin sections (No. 5, No. 21, and No. 27) had crushed sherds with bone/shell. Only two (No. 21 and No. 27) thin sections had crushed sherd with platy bone/shell inclusions. The remaining thin sections contained crushed sherds with sand (No. 3 and No. 15) and sand and grog (No. 23).

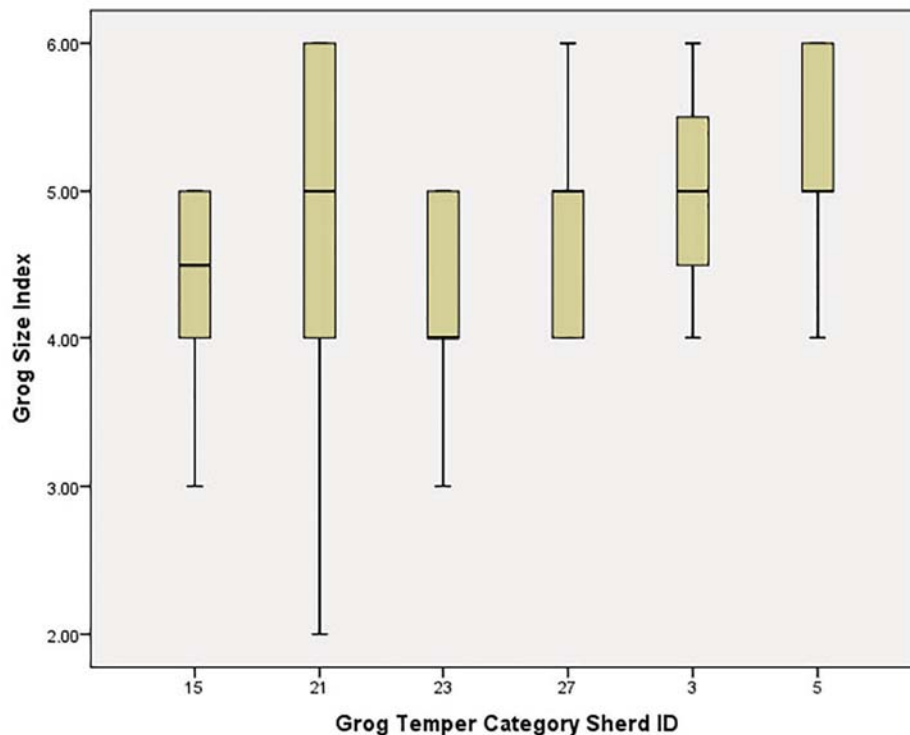


Figure 11. Box plot of the size index for grog by sherd No. for grog-tempered sherds.

The percentage of sand in the grog-tempered thin sections ranged from 2.8% to 10.9%. Figure 12 shows the sand size distribution based on the Wentworth scale. Although there is a greater range of sand sizes in this temper category, the majority of the sand is silt size suggesting that the sand was a natural inclusion in the clay.

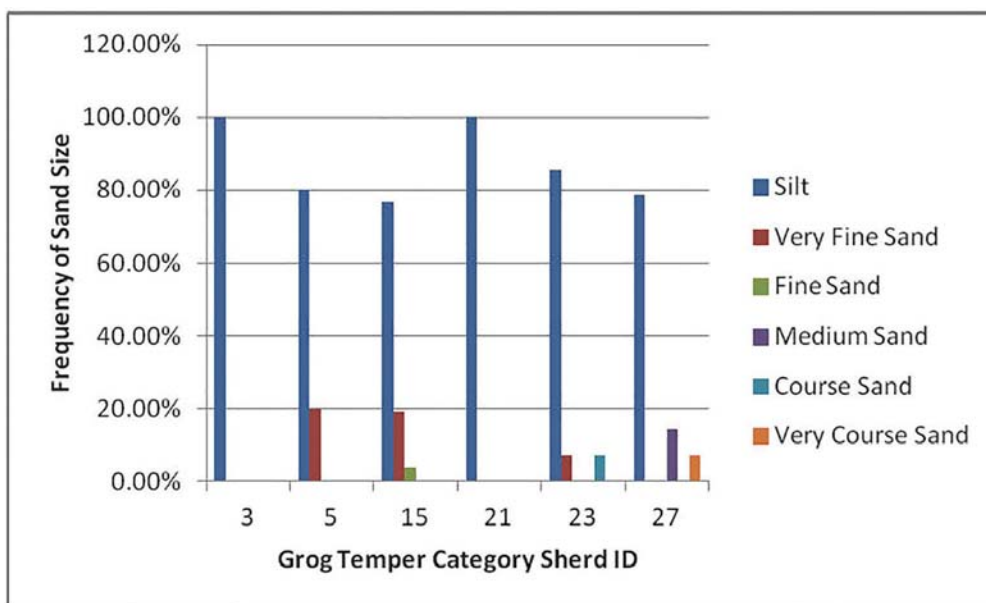


Figure 12. Distribution of sand size based on the Wentworth scale for the grog-tempered sherds.

Sherd No. 3 (Figure 13a)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 7.5YR 6/8, reddish yellow

B-fabric (XPL): Speckled/Slightly Active

Edge Description: N/A

Grog Description: Generally tempered with sand. Similar paste as thin section.

Comments: Few inclusions

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	88.5%	Paste	200	94.8%
Grog	4	1.8%	Sand	6	2.8%
Quartz	6	2.7%	Grog	4	1.9%
Hematite	1	0.4%	Other	1	0.5%
Voids	15	6.6%	Total	211	
Total	226				

Also present: muscovite (uncommon), polycrystalline quartz (rare)

Percentage of voids that might be missing inclusions: 13.3%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .06	.03	.02	.03
Grog	.36 – 1.02	.76	.83	.55
All Inclusions	.02 – 1.02	.30	.06	.70

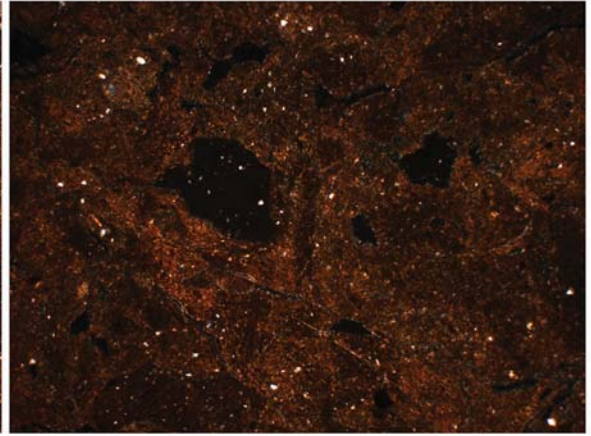
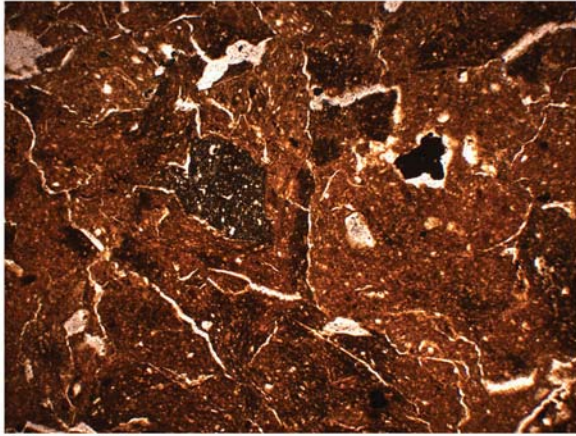


Figure 13a.

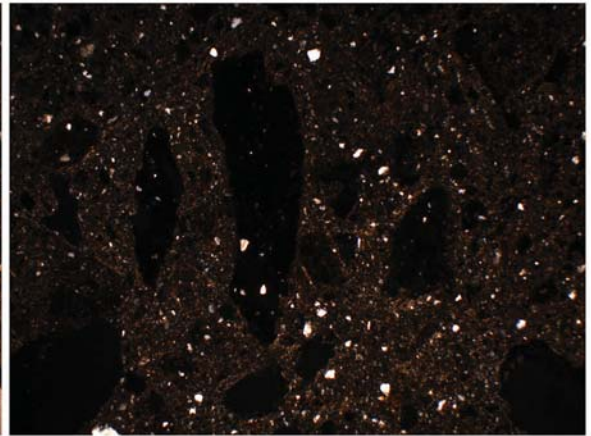
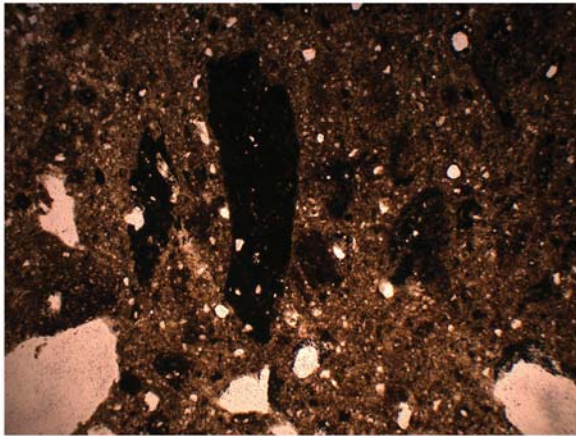


Figure 13b.

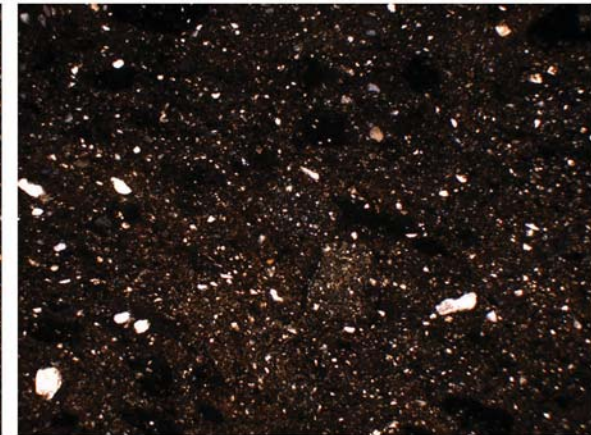


Figure 13c.

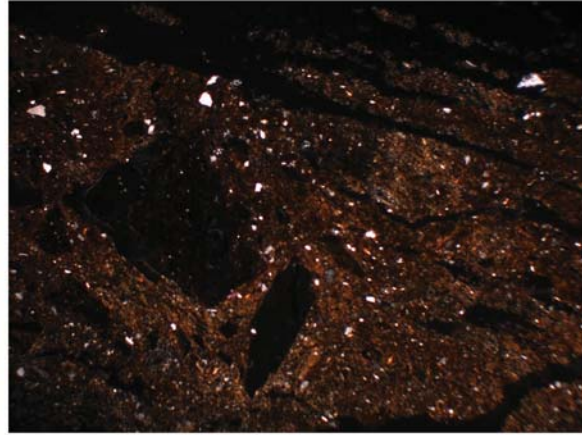
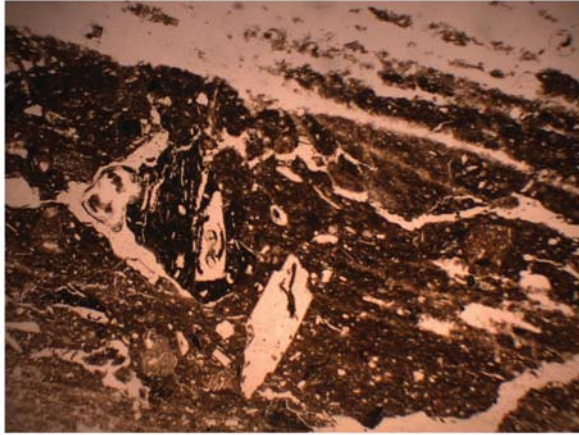


Figure 13d.

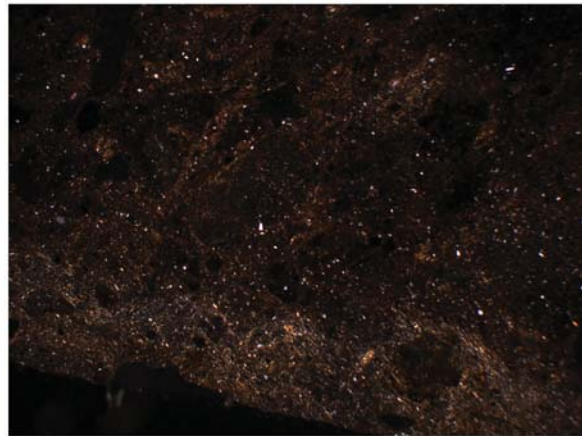
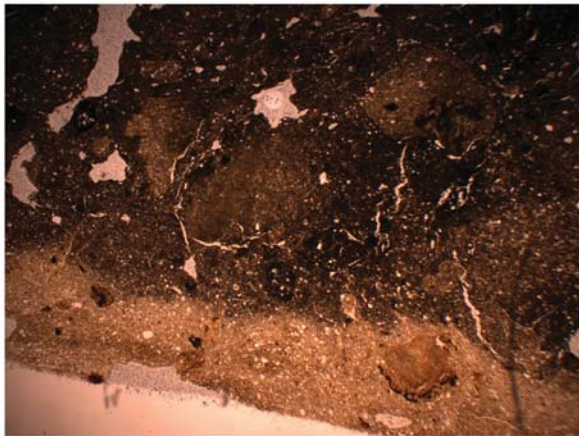


Figure 13e.

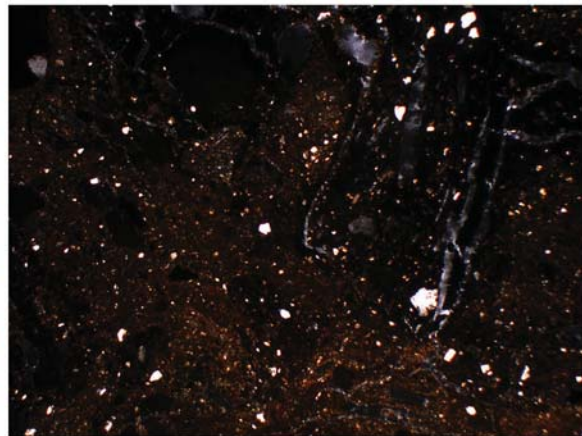
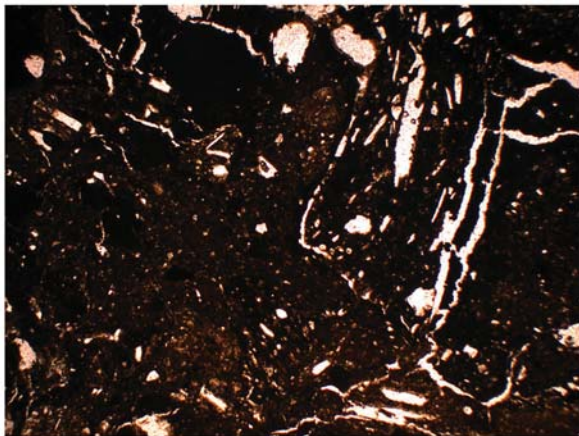


Figure 13f.

Figure 13. Photographs of grog-tempered thin sections: a, No. 3; b, No. 5; c, No. 15; d, No. 21; e, No. 23; f, No. 27. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Sherd No. 5 (Figure 13b)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 2.5Y 7/6, yellow

B-fabric (XPL): Speckled/Slightly Active

Edge Description: N/A

Grog Description: Generally tempered with sand or bone (bone is not platy).

Comments: Missing inclusions might be sand or grog. Bone is not common in the thin section. Muscovite is present.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	79.4%	Paste	200	88.1%
Bone	1	0.4%	Sand	15	6.6%
Grog	10	4.0%	Bone	1	0.4%
Quartz	13	5.2%	Grog	10	4.4%
Alkali feldspar	1	0.4%	Mica	1	0.4%
Muscovite	1	0.4%	Total	227	
Chert	1	0.4%			
Voids	25	9.9%			
Total	252				

Also present: hematite (common), polycrystalline quartz (common)

Percentage of voids that might be missing inclusions: 60%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - .12	.05	.04	.04
Grog	.48 - 1.52	.91	.85	.56
All Inclusions	.02 - 1.52	.37	.06	.68

Sherd No. 15 (Figure 13c)

Paste Matrix (PPL): Mottled

Paste Color (PPL): 2.5Y 6/6, olive yellow with spots of 2.5Y 3/3, dark olive brown

B-fabric (XPL): Speckled/Slightly Active (very slight)

Edge Description: On one side there are some dark red spots (approximately 0.06 mm thick) along the edge (possible artifact of thin section production).

Grog Description: Generally sand-tempered. The paste is the same as the paste in the thin section.

Comments: Clay pellets are discrete dark reddish-brown to black inclusions with little sand: possible hematite or grog. Muscovite is present.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	82.0%	Paste	200	84.0%
Sherd	8	3.3%	Sand	26	10.9%
Quartz	23	9.4%	Grog	8	3.4%
Polycrystalline quartz	2	0.8%	Mica	1	0.4%
Alkali feldspar	1	0.4%	Other	3	1.3%
Muscovite	1	0.4%	Total	238	
Clay pellet	3	1.2%			
Voids	6	2.5%			
Total	244				

Also present: plagioclase (rare)

Percentage of voids that might be missing inclusions: 0%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .22	.06	.04	.05
Grog	.22 – .80	.52	.50	.30
All Inclusions	.02 – 1.04	.20	.06	.35

Sherd No. 21 (Figure 13d)

Paste Matrix (PPL): Mottled

Paste Color (PPL): 10YR 5/6, yellowish-brown with spots of 10YR 3/4, dark yellowish-brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: N/A

Grog Description: Generally tempered with bone or shell – most of the inclusions are missing (represented by platy voids)

Comments: The bulk of the thin section is too thin or missing. When point counting, skipped large breaks in the thin section. Several of the voids are platy-shaped – possibly bone. Tiny muscovite is present.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	82.0%	Paste	200	89.3%
Sherd	11	4.5%	Sand	12	5.4%
Quartz	12	4.9%	Grog	11	4.9%
Muscovite	1	0.4%	Mica	1	0.4%
Voids	20	8.2%	Total	224	
Total	244				

Also present: hematite (uncommon), microcline (rare)

Percentage of voids that are possibly missing inclusions: 40%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .06	.04	.04	.04
Grog	.08 – 1.66	.84	.92	.96
All Inclusions	.02 – 1.66	.40	.06	.81

Sherd No. 23 (Figure 13e)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 2.5Y 6/4, light yellowish-brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: One edge is lighter (2.5Y 8/4, pale yellow) and more active, but also rubbed a little thin.

Grog Description: Generally tempered with sand or grog. Several have the same paste as the thin section.

Comments: Opaque possibly burnt (black) bone (rare). Small muscovite pieces very common.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	78.7%	Paste	200	85.1%
Grog	18	7.1%	Sand	14	6.0%
Quartz	14	5.5%	Grog	18	7.7%
Muscovite	1	0.4%	Mica	2	0.9%
Opaque	1	0.4%	Other	1	0.4%
Biotite	1	0.4%	Total	235	
Voids	19	7.48%			
Total	254				

Also present: mica schist (rare), alkali feldspar (rare)

Percentage of voids that might be missing inclusions: 10.5%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .60	.07	.02	.02
Grog	.18 – .78	.49	.50	.26
All Inclusions	.02 – .78	.29	.24	.50

Sherd No. 27 (Figure 13f)

Paste Matrix (PPL): Mottled with core

Paste Color (PPL): 10YR 5/8, yellowish-brown with spots of 10YR 3/3, dark brown (mostly around voids) – core: 10YR 4/4, dark yellowish brown

B-fabric (XPL): Speckled/Slightly Active – Core is undifferentiated

Edge Description: Spots of dark red to black run along one edge

Grog Description: Generally tempered with bone or shell (mostly platy voids are seen in crushed sherds)

Comments: Some platy voids running parallel to the rim may be bone.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	82.3%	Paste	200	88.1%
Grog	13	5.3%	Sand	14	6.2%
Quartz	12	4.9%	Grog	13	5.7%
Polycrystalline quartz	1	0.4%	Total	227	
Alkali feldspar	1	0.4%			
Voids	16	6.6%			
Total	243				

Also present: muscovite (uncommon), hematite (common), clay pellet (uncommon), bone (rare)

Percentage of voids that might be missing inclusions: 50%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – 1.12	.16	.04	.11
Grog	.40 – 1.20	.74	.70	.48
All Inclusions	.02 – 1.20	.44	.42	.72

Grog and Sand Temper

The grog and sand temper category was distinguished from the grog temper category by the quantity and size of sand in the thin section. Only one thin section from the Spiro site was represented in this group: No. 24. Thin section No. 24 had 14.2% sand and 16.6% grog, which is a higher percentage in either inclusion category than any of the thin sections in the grog temper category (see Table 4). In addition, the majority of the sand inclusions were in the fine sand size category (0.126 to 0.25 mm) (Figure 14). The larger sand particles may suggest that the some of the sand was intentionally added as temper to the clay.

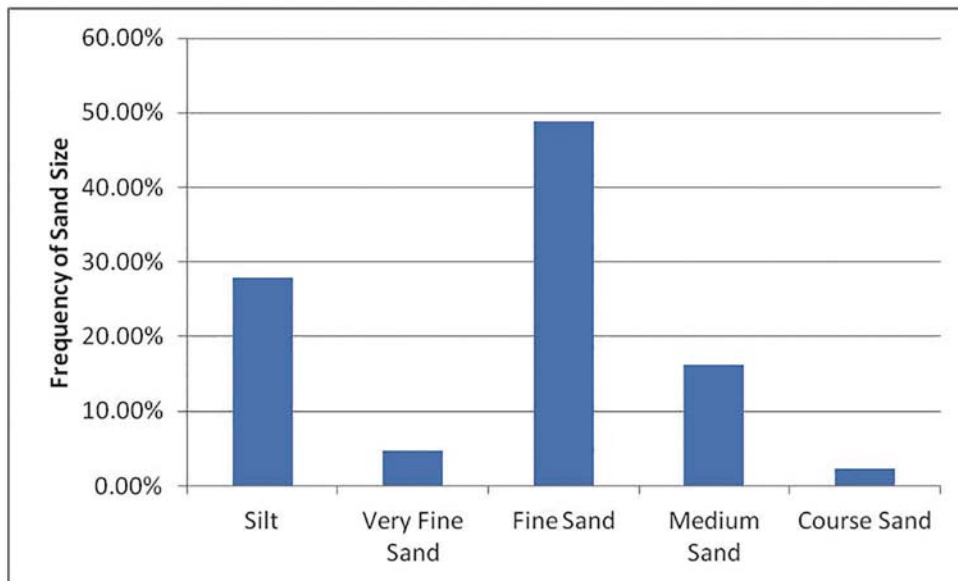


Figure 14. Distribution of sand size based on the Wentworth scale for thin section No. 24.

Sherd No. 24 (Figure 15)

Paste Matrix (PPL): Continuous (Core)

Paste Color (PPL): 10YR 5/6, yellowish-brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: Edges are more active in XPL than core

Grog Description: Generally tempered with sand or grog

Comments: Lots of hematite present. Opaques are most likely hematite.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	62.5%	Paste	200	66.2%
Grog	50	15.6%	Sand	43	14.2%
Quartz	33	10.3%	Grog	50	16.6%
Polycrystalline quartz	4	1.3%	Other	9	3.0%
Alkali feldspar	6	1.9%	Total	302	
Clay pellet	1	0.3%			
Opaque	8	2.5%			
Voids	18	5.6%			
Total	320				

Also present: bone (rare)

Percentage of voids that might be missing inclusions: 0%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - .58	.17	.18	.20
Grog	.10 - 1.64	.45	.39	.27
All Inclusions	.02 - 1.64	.31	.26	.27

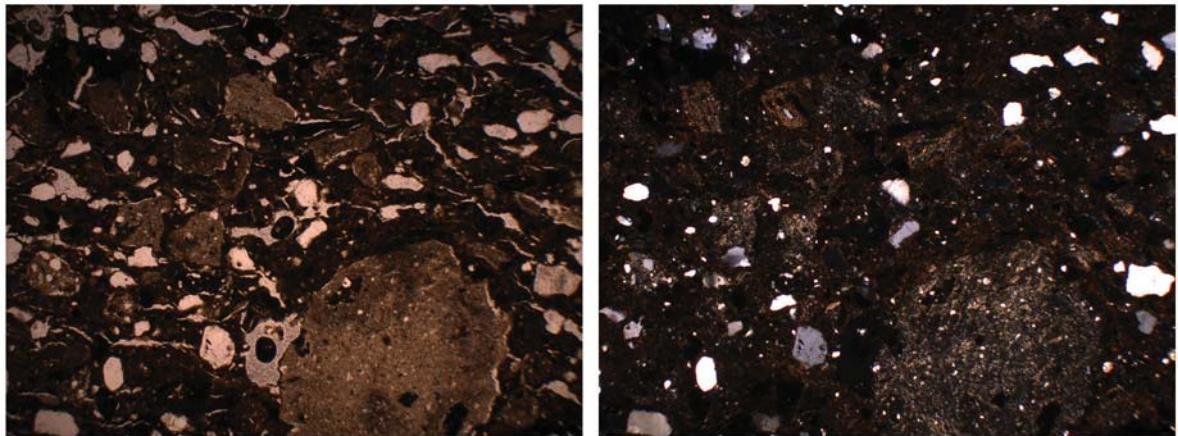


Figure 15.

Figure 15. Photographs of grog-sand tempered thin section No. 24. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Shell Temper

The shell temper category was based on the presence of shell without bone or grog. The shell temper category represented 17.4% of the thin sections, including three sherds from the Spiro site (No. 10, No. 18, and No. 20) and one sherd from the Moore #3 site (No. 29, see description below). The percentage of shell in this temper category ranged from 10.9% to 35.8%. A box plot of the shell size distribution by sherd No. is shown in Figure 16. With the exception of thin section No. 10, the shell is commonly platy-shaped (Figure 17). Given the difference in percentage, size, and shape of the shell, thin section No. 10 may likely represent a vessel made with different manufacturing processes than the other thin sections in this category. Experimental production of shell temper using burnt mussel shell typically yields easily separable shell platelets which are similar to those noted in the majority of the thin sections. It is possible that a different temper preparation technique may have been used in the case of the shell noted in thin section No. 10.

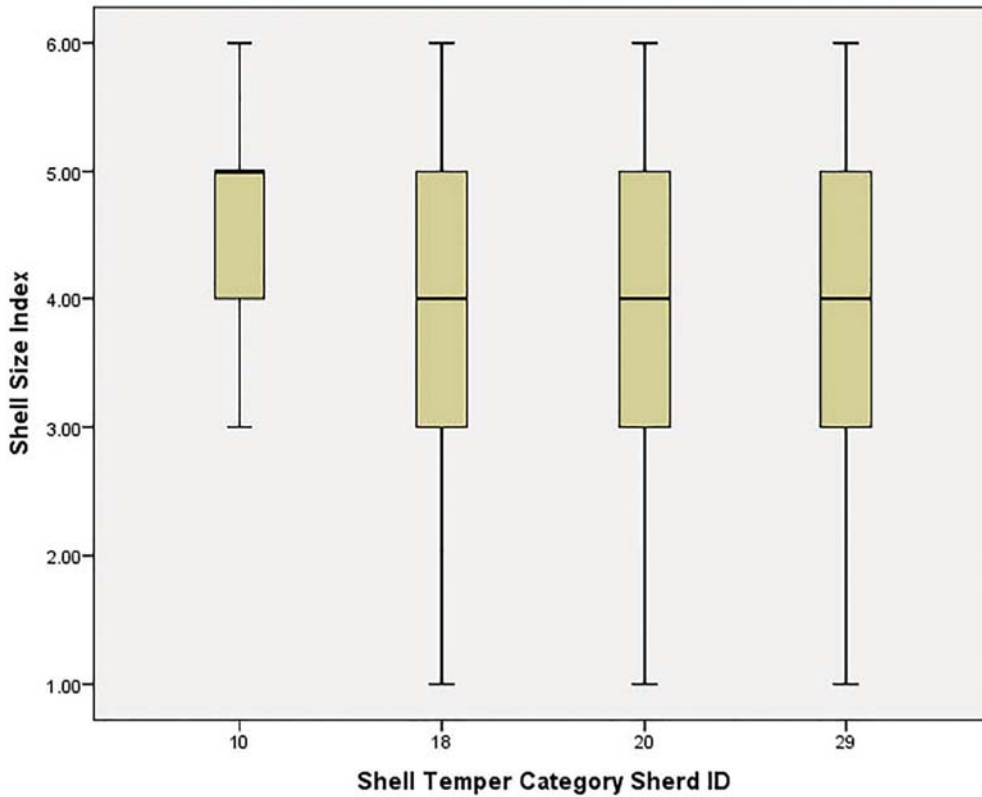


Figure 16. Box plot showing the distribution of shell size for shell-tempered sherds.

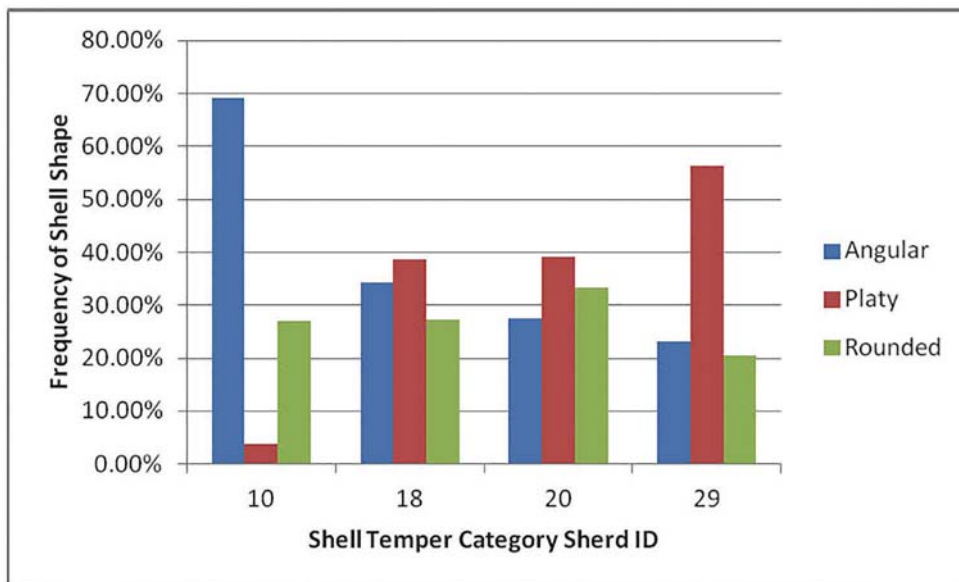


Figure 17. Distribution of shell shape by sherd No.

The percentage of sand in this category ranged from 2.9% to 4.6%. Figure 18 shows the sand size distribution based on the Wentworth scale. Thin section No. 29 from Moore #3 (see below) stands out from the other thin sections in this category in that all the sand is silt size. The other thin sections in this category have more variable sand size particles suggesting that they represent vessels made of a variety of distinct clays or they represent a range of manufacture traditions within these shell-tempered vessels.

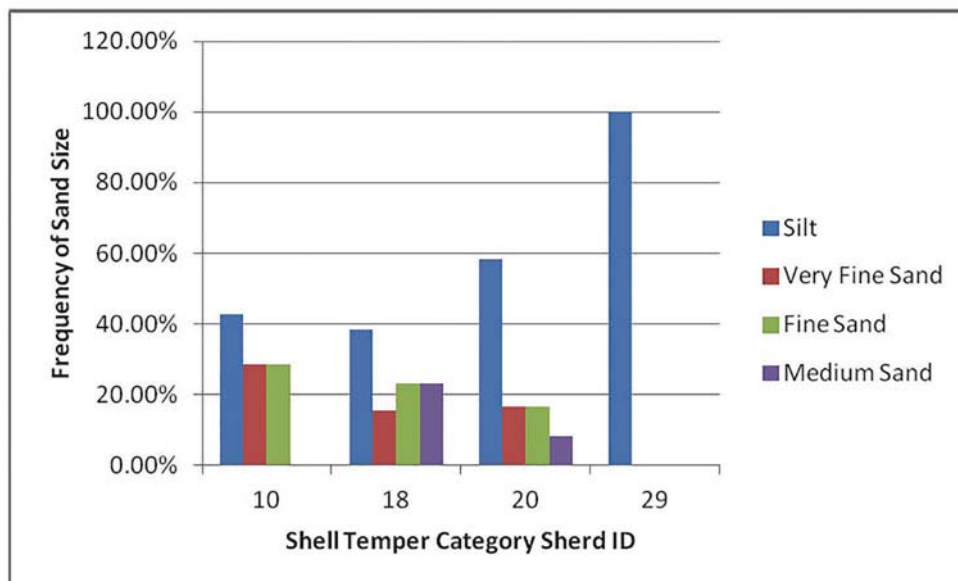


Figure 18. Distribution of the sand size category for shell-tempered sherds based on the Wentworth scale by sherd No.

Sherd No. 10 (Figure 19a)

Paste Matrix (PPL): Mottled

Paste Color (PPL): 10YR 4/6, dark yellowish-brown with spots of 2.5Y 7/8, yellow

B-fabric (XPL): Speckled/Slightly Active

Edge Description: N/A

Comments: Calcium carbonate may also be shell. Most shell is not platy-shaped. No apparent orientation for inclusions.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	82.0%	Paste	200	83.7%
Shell	26	10.7%	Sand	7	2.9%
Quartz	7	2.9%	Shell	26	10.9%
Calcium carbonate	5	2.0%	Other	6	2.5%
Hematite	1	0.4%	Total	239	
Voids	5	2.0%			
Total	244				

Also present: muscovite (common), alkali feldspar (common), polycrystalline quartz (common)

Percentage of voids that might be missing inclusions: 40%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - .14	.08	.10	.12
Shell	.18 - 1.90	.71	.58	.51
All Inclusions	.02 - 1.90	.53	.44	.50

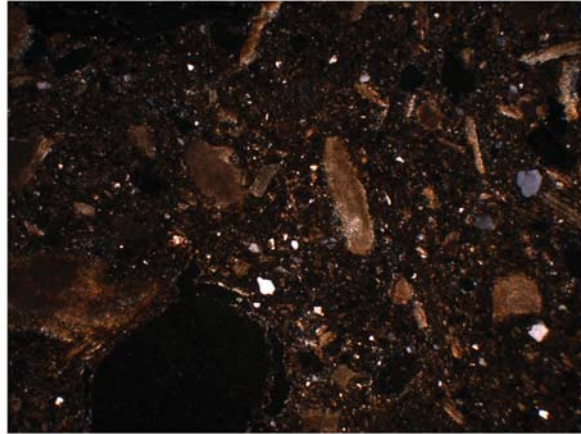
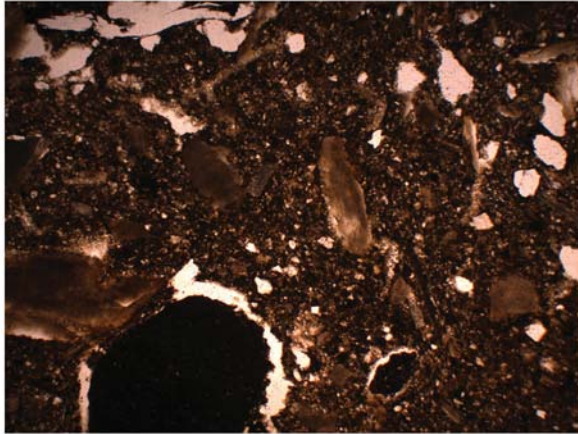


Figure 19a.

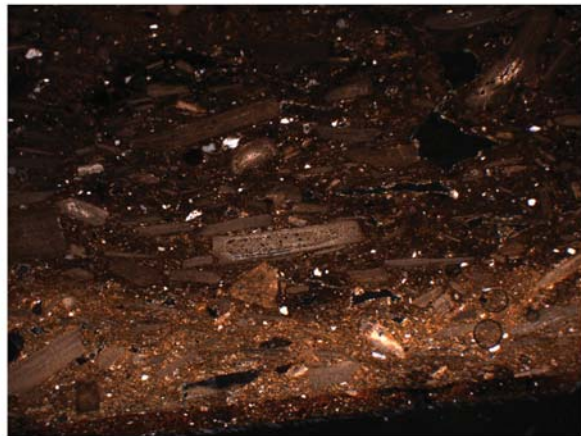
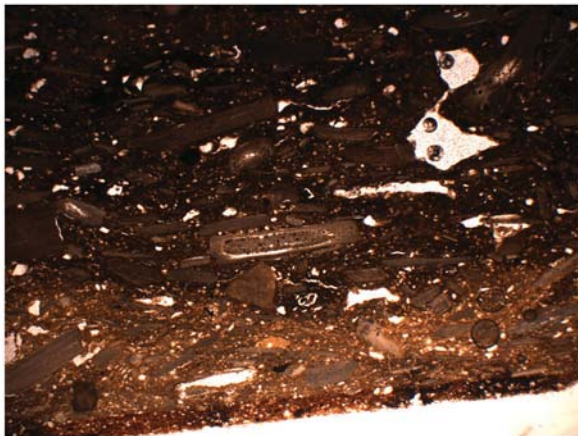


Figure 19b.

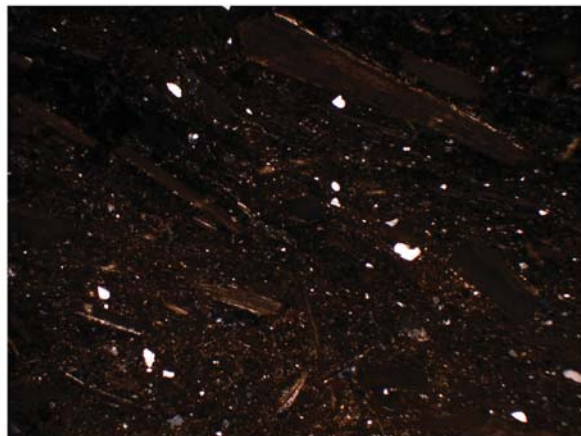
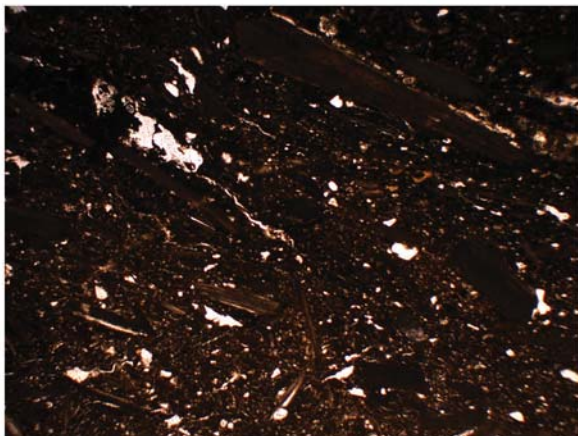


Figure 19c.

Figure 19. Photographs of shell-tempered thin sections: a, No. 10; b, No. 18; c, No. 20. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Sherd No. 18 (Figure 19b)

Paste Matrix (PPL): Zoned

Paste Color (PPL): outside edge: 7.5YR 5/8, strong brown; second layer: 10YR 7/6, yellow; core: 10YR 4/6, dark yellowish-brown

B-fabric (XPL): Outside edge: Speckled/Active; second layer: Speckled/Slightly Active; core: mostly Undifferentiated

Edge Description: Possible slip present (shell is not present in outside edge), although spots missing. The edge is mostly missing.

Comments: Most of the shell is platy-shaped and oriented parallel to the rim. The shell in half of the thin section is all dissolved (voids only)

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	63.4%	Paste	200	70.7%
Shell	70	22.2%	Sand	13	4.6%
Quartz	9	2.9%	Shell	70	24.7%
Polycrystalline quartz	2	0.6%	Total	283	
Alkali feldspar	1	0.3%			
Microcline	1	0.3%			
Voids	32	10.2%			
Total	315				

Also present: plagioclase (common), biotite (rare)

Percentage of voids that might be missing inclusions: 59.4%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .36	.14	.10	.18
Shell	.04 – 1.64	.44	.29	.47
All Inclusions	.02 – 1.64	.39	.26	.42

Sherd No. 20 (Figure 19c)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 10YR 5/6, yellowish-brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: Same as the rest of the paste

Comments: About half of the shell in the thin section has a cloudy appearance. Shell generally has a platy shape and is oriented parallel to the rim. Organic is likely a plant twig/charcoal.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	73.8%	Paste	200	75.8%
Shell	51	18.8%	Sand	12	4.6%
Quartz	12	4.4%	Shell	51	19.3%
Organic	1	0.4%	Other	1	0.4%
Voids	7	2.6%	Total	264	
Total	271				

Also present: muscovite (common), plagioclase (uncommon), alkali feldspar (uncommon), microcline (rare)

Percentage of voids that might be missing inclusions: 14.3%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - .32	.10	.05	.11
Shell	.06 - 2.0	.46	.36	.48
All Inclusions	.02 - 2.0	.39	.28	.41

Shell and Grog Temper

This temper category was distinguished from the shell temper category by the presence of grog in addition to the shell. Only one thin section (No. 22) from the Spiro site was represented in this category. Thin section No. 22 had 3.7% sand, 10% grog, and 3.3% shell. The majority of the sand (89%) was silt size. Platy shell was common (36%). The crushed sherds used as temper, were themselves tempered with shell/bone.

Sherd No. 22 (Figure 20)

Paste Matrix (PPL): Mottled

Paste Color (PPL): 2.5Y 5/6, light olive brown with streaks of 2.5Y 3/3, dark olive brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: One edge is lighter (2.5Y 7/6, yellow) and more active

Grog Description: Generally tempered with shell and some possibly bone. Some of the inclusions are platy in the crushed sherds.

Comments: Shell is generally platy-shaped and oriented parallel to the rim

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	79.1%	Paste	200	83.0%
Grog	24	9.5%	Sand	9	3.7%
Shell	8	3.2%	Shell	8	3.3%
Quartz	8	3.2%	Grog	24	10.0%
Polycrystalline quartz	1	0.4%	Total	241	
Voids	12	4.7%			
Total	253				

Also present: hematite (common), bone (uncommon), muscovite (uncommon), plagioclase (rare)

Percentage of voids that might be missing inclusions: 8.3%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - 1.46	.19	.04	.02
Shell	.14 - .84	.32	.27	.22
Grog	.22 - 1.40	.71	.64	.66
All Inclusions	.02 - 1.46	.52	.38	.69

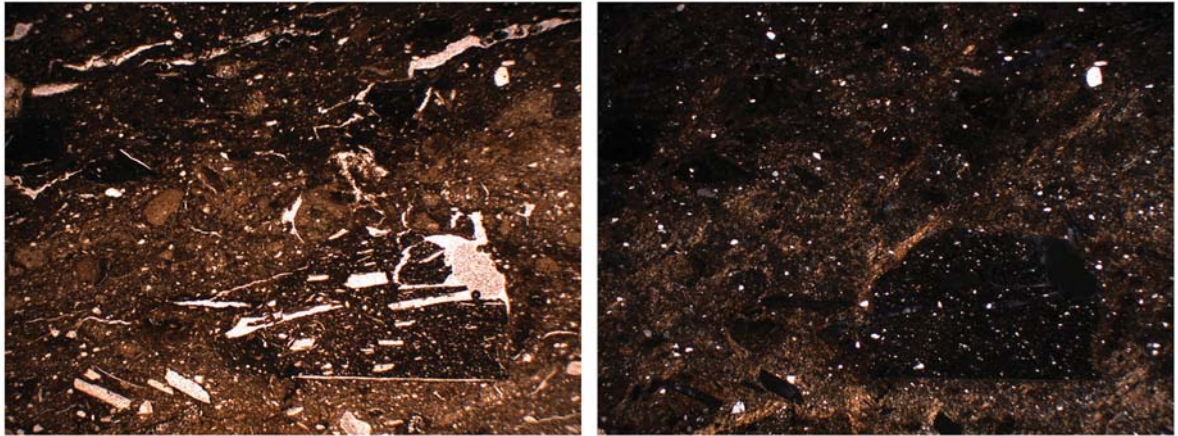


Figure 20.

Figure 20. Photographs of shell-grog tempered thin section No. 22. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Shell, Bone, and Grog Temper

This temper category was distinguished by the presence of shell, bone, and grog in the thin section. Only one thin section from the Spiro site (No. 16) was represented in this group. Thin section No. 16 had 11.2% sand, 2.5% bone, 5.8% grog, and 6.9% shell. The sand particles were commonly (48%) silt sized. The bone inclusions were angular, but the shell inclusions were generally platy in shape (Figure 21). The difference is consistent with the likelihood that bone and shell underwent different processing techniques to transform them into temper. The crushed sherds were generally tempered with sand, shell, shell and bone, or bone.

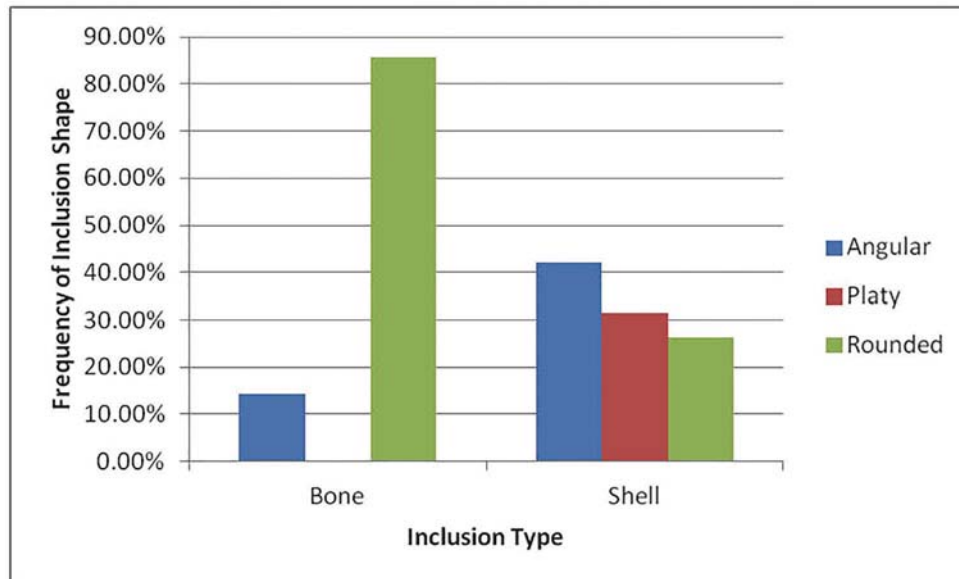


Figure 21. Distribution of bone and shell inclusion shapes for thin section No. 16 from the Spiro site.

Sherd No. 16 (Figure 22)

Paste Matrix (PPL): Continuous

Paste Color (PPL): 2.5Y 5/6, light olive brown

B-fabric (XPL): Speckled/Slightly Active

Edge Description: Both edges are rubbed too thin

Grog Description: Generally tempered with sand, shell, shell and bone, or bone. Shell is generally platy-shaped.

Comments: Calcite maybe shell or completely replaced bone. Some of the shell temper has a platy shape but not the bone.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	68.7%	Paste	200	72.5%
Bone	7	2.4%	Sand	31	11.2%
Grog	16	5.5%	Bone	7	2.5%
Shell	19	6.5%	Shell	19	6.9%
Quartz	26	8.9%	Grog	16	5.8%
Polycrystalline quartz	3	1.0%	Other	3	1.1%
Alkali feldspar	1	0.3%	Total	276	
Calcite	3	1.0%			
Microcline	1	0.3%			
Voids	15	5.2%			
Total	291				

Also present: muscovite (common), plagioclase (common), charcoal (rare), hornblende (rare)

Percentage of voids that might be missing inclusions: 21.4%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 - .20	.08	.08	.08
Bone	.06 - .36	.19	.12	.24
Shell	.06 - 1.22	.37	.28	.42
Grog	.18 - 1.22	.51	.40	.48
All Inclusions	.02 - 1.22	.26	.16	.28

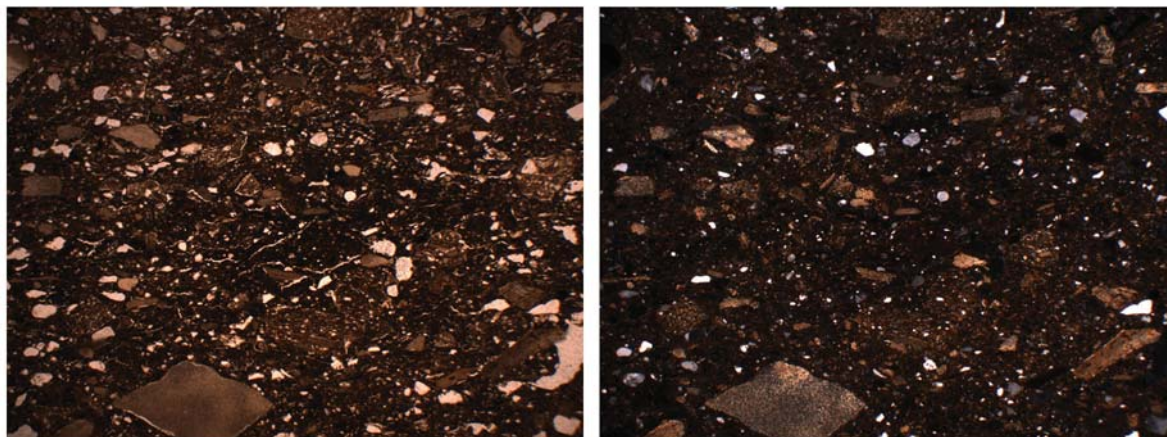


Figure 22.

Figure 22. Photographs of shell-bone-grog tempered thin section No. 16. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Sherd from the Moore #3/Ainsworth site

The one sherd (thin section No. 29) from the Moore #3 site is shell-tempered. Other paste details include (Figure 23):

Paste Matrix (PPL): Continuous

Paste Color (PPL): 7.5YR 4/6, strong brown

B-fabric: Undifferentiated

Edge Description: Edges are slightly lighter in PPL (7.5YR 5/6, strong brown) and slightly active in XPL

Comments: Most of the shell is platy-shaped and oriented parallel to the rim.

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	57.8%	Paste	200	61.2%
Shell	117	33.8%	Sand	10	3.1%
Quartz	10	2.9%	Shell	117	35.8%
Voids	19	5.5%	Total	327	
Total	346				

Also present: muscovite (common), alkali feldspar (rare)

Percentage of voids that might be missing inclusions: 0%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.02 – .06	.04	.04	.04
Shell	.06 – 1.96	.55	.42	.59
All Inclusions	.02 – 1.96	.51	.40	.60

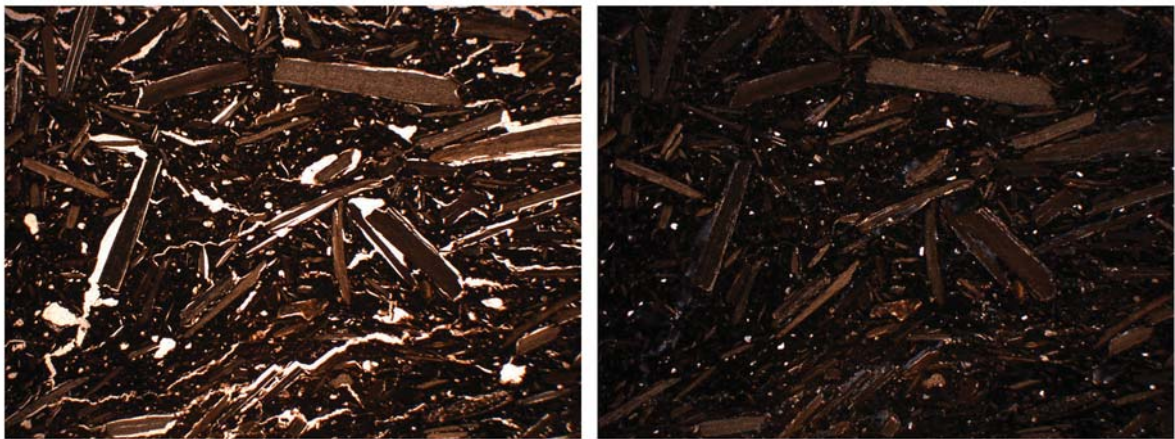


Figure 23.

Figure 23. Photographs of shell-tempered thin section No. 29 from the Moore #3 site. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Sherd from the Geren site

The sherd/thin-section from the Geren site is the most distinctive in the analyzed sample because of the presence in the paste of biotite and mica schist as temper. Thin section No. 28 from Geren had 13.2% sand and 14.6% mica. Given the variability in the sand size (Figures 24 and 25), it is possible that sand was added as temper to a very micaceous clay:

Paste Matrix (PPL): Half & Half (possibly due to one side of the thin section is ground too thin)

Paste Color (PPL): 10YR 5/6, yellowish-brown and 10YR 7/6, yellow

B-fabric (XPL): Striated/Active

Edge description: Edges same as the rest of the paste.

Grog description: N/A

Comments: In PPL most of the paste is pleochroic due to the amount of biotite. Unknown might be burnt shell or clay pellet

Point Count

Paste/Inclusion	Count	Percent	Simplified Inclusion Category	Count	Percent
Paste	200	66.7%	Paste	200	71.4%
Quartz	13	4.3%	Sand	37	13.2%
Polycrystalline quartz	20	6.7%	Mica	41	14.6%
Alkali feldspar	4	1.3%	Other	2	0.7%
Muscovite	1	0.3%	Total	280	
Hematite	1	0.3%			
Biotite	20	6.7%			
Mica Schist	20	6.7%			
Unknown	1	0.3%			
Voids	20	6.7%			
Total	300				

Also present: plagioclase (rare)

Percentage of voids that might be missing inclusions: 0%

Inclusion Size (mm)

	Range	Mean	Median	Interquartile Range
Sand	.04 – 1.22	.31	.22	.37
Mica	.02 – 1.34	.31	.20	.32
All Inclusions	.02 – 1.34	.32	.21	.34

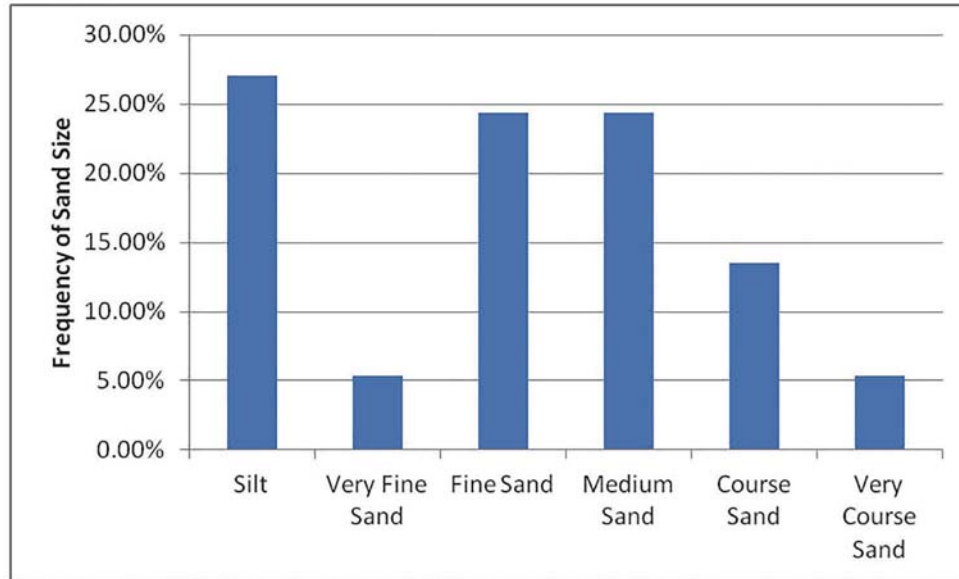


Figure 24. Size distribution for sand in thin section No. 28 from the Geren site.

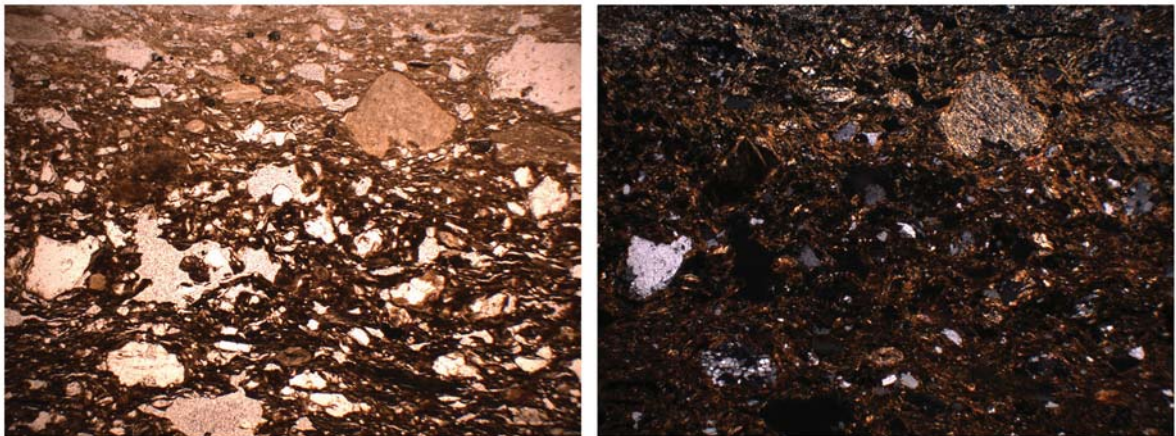


Figure 25.

Figure 25. Photographs of micaceous-tempered thin section No. 29 from the Geren site. All photographs are at 4x magnification. The plane light image is on the right and the cross-polar light image is on the left.

Summary and Conclusions

The petrographic analysis of the 23 thin sections of ceramic vessel sherds from the Spiro, Moore #3, and Geren sites in the Arkansas River basin in eastern Oklahoma has identified eight temper categories based on the percentage of inclusions recorded during point counting. It is unclear whether the temper variation is due to differences in production locale, temporal variation, or ware type (fine ware vs. utility ware), but more than likely the variation is due to all three factors. It has been established that shell-tempered ceramics in the Arkansas River basin in eastern Oklahoma generally replace grog and/or-bone-tempered ceramics after ca. A.D. 1250, although Brown (1996:157) notes the “coexistence of locally made shell tempered pottery and grog and grog-grit-bone pottery” at the Harlan site, another important mound center in the Arkansas River basin, during the Harlan phase (ca. A.D. 1050-1250). Furthermore, he notes that grogs “composed of crushed shell tempered pottery is...very distinctive of the Harlan phase at Spiro.”

With the exception of the micaceous sand temper category, the other temper categories consist of some variation of bone, shell, and/or grog. The sherds from the Spiro site with grog, bone-grog, and bone temper are from Williams Plain, Sanders Plain, Spiro Engraved, Redland Engraved, Agee Incised, and LeFlore Plain vessels (see Tables 2 and 4). The few from established contexts date from ca. A.D. 1000-1450.

Two shell-grog and shell-bone-grog sherds (thin sections No. 16 and No. 22) were classified as Sanders Plain, a grog-tempered slipped type, by Brown (1996) (see Table 2); the temper apparent in the grog is bone/shell. Brown (1996:401) does note that Sanders Plain vessels do have “grog temper in which finely divided shell is included in the grog.”

Two of the sherds (No. 19 and 26) had been classified as Poteau Plain, a slipped shell-tempered ware (Brown 1996:405), by Brown (see Table 2), but they have bone temper (see Table 4). These sherds, both of which are red-slipped, are better included in the Sanders Plain group in this assemblage. Another sherd identified through petrographic analysis as having bone temper—thin section No. 14—was classified by Brown as Bell Plain (see Table 2); this sherd was found in a Norman phase context (see Table 1). Since Bell Plain is an undecorated fine-shell ware (Brown 1996:392), sherd thin section No. 14 should be reclassified as coming from a plain bone-tempered vessel of uncertain type.

The shell-tempered sherds represented in the analyzed thin sections include Woodward Plain, from the Moore #3 site, and three sherds of red-slipped Poteau Plain (No. 10, No. 18, and No. 20) (see Table 2). They are from post-A.D. 1250 contexts at the Spiro and Moore #3 sites.

The micaceous sand-tempered neck banded sherd from the Geren site definitely stands out from all the other thin sections and may represent a fragment from an exotic or non-local ceramic vessel. However, it should also be noted that thin section No. 23 (grog-tempered), from a LeFlore Plain vessel, had a small mica schist fragment and biotite was also recorded. It is possible, therefore, that these mica fragments came from the addition of crushed micaceous sand-tempered sherds; this suggests that the micaceous sand-tempered pottery may possibly have been made in a locale not that far removed from the Spiro mound area, although that seems unlikely. Instead, we consider this sherd to have come from a non-shell-tempered Nash Neck Banded vessel made by a Caddo potter in the Red River basin after ca. A.D. 1300, among either a McCurtain phase Caddo group living in the Glover River or Mountain Fork drainages in southeastern Oklahoma (see Dowd 2012; Regnier 2013:48-51) or a Texarkana phase Caddo group on the Red River itself (see Perttula and Nelson 2003).

While we do believe that a discussion of the human behavior implicated by these petrographic differences and similarities among the sherds from the Spiro site and other eastern Oklahoma Arkansas River basin sites is what we all strive to accomplish and get to, the small size of the present sample limits such broad generalizations. For example, while differences in temper processing, such as platy versus unplaty bone inclusion, may relate to social learning or different communities of practice, however, this sample of thin sections is too diverse (temporally and by ceramic types) and lacks sufficient context to be able to discuss how they relate to human behavior. The goal of this petrographic analysis project was to provide a general characterization of the paste and temper to help guide future research on the ceramics from the region. As sample sizes increase and are more solidly provenienced, such broader conclusions would be warranted. The same thing can be said about the behavioral implications of the minor inclusions in the sherd pastes. More samples would be needed to discern the importance of the minor inclusions in considering the character of the pastes and in distinguishing sand sources.

The four most common temper categories (bone, bone and grog, grog, and shell) in the analyzed sherd thin sections were not homogeneous categories and there was considerable paste variation within each category. With a larger sample size of sherd thin sections from other Spiro area ceramic assemblages, it may be possible to further break down these temper categories into more homogeneous groups with regionally-specific temporal and/or technological characteristics. Of particular interest was the variation in bone and/or shell temper shape and the type of crushed sherds (i.e., grog) used as temper. Future petrographic research should focus on these variations as they relate to ceramic vessel manufacturing/technological processes, which in turn may provide insights into the existence of different ceramic traditions made by spatially and temporally distinct northern Caddo groups within the region.

Acknowledgments

We wish to thank Dr. James A. Brown for encouraging this belated study of the petrographic thin-sections from the Spiro, Geren, and Moore sites in eastern Oklahoma. Of course, we are particularly grateful that he sent the thin sections for study in the first place, and we are glad that we have finally been able to see the petrographic analysis completed. Thanks also to Dr. Reid Ferring for passing the thin-sections and sherds along to Perttula, and to Dr. Scott W. Hammerstedt, Dr. George Avery, and two anonymous peer reviewers for providing comments on the manuscript. Dr. Elsbeth Dowd provided Sam Noble Oklahoma Museum of Natural History provenience information for the sherds and thin sections.

References Cited

Brown, J. A.

- 1966 Spiro Studies, Vol. 2. The Graves and Their Contents. University of Oklahoma Research Institute, Norman.
- 1971 Spiro Studies, Vol. 3, Pottery Vessels. First Part of the Third Annual Report of Caddoan Archaeology-Spiro Focus Research. University of Oklahoma Research Institute, Norman.
- 1996 The Spiro Ceremonial Center. The Archaeology of Arkansas Valley Caddoan Culture in Eastern Oklahoma. 2 Vols. Memoir No. 29. Museum of Anthropology, University of Michigan, Ann Arbor.

Ferring, C. R. and T. K. Perttula

- 1987 Defining the Provenance of Red-Slipped Pottery from Texas and Oklahoma by Petrographic Methods. *Journal of Archaeological Science* 14:437-456.

Galehouse, J. S.

- 1971 Point Counting. In *Procedures in Sedimentary Petrology*, edited by R. E. Carver, pp. 385-407. Wiley-Interscience, New York.

Perttula, T. K. and B. Nelson

- 2003 Archeological Investigations of Village Areas at the Hatchel Site (41BW3), Bowie County, Texas. Report of Investigations No. 58. Archeological & Environmental Consultants, LLC, Austin.

Peterson, D. A, J. D. Rogers, D. G. Wyckoff, and K. Dohm

- 1993 An Archeological Survey of the Spiro Vicinity, LeFlore County, Oklahoma. Archeological Resources Survey Report No. 37. Oklahoma Archeological Survey, Norman.

Porter, J. W.

- 1971 Thin-Section Identifications of Spiro Sherds. In *Spiro Studies, Volume 3: Pottery Vessels*, by J. A. Brown, pp. 244-246. First Part of the Third Annual Report of Caddoan Archaeology—Spiro Focus Research. Stovall Museum of Science and History, University of Oklahoma and The University of Oklahoma Research Institute, Norman.

Quinn, P. S.

- 2013 *Ceramic Petrography: The Interpretation of Archaeological Pottery and Related Artefacts in Thin Section*. Archaeopress, Oxford.

Rogers, J. D.

- 2006 Chronology and the Demise of Chiefdoms: Eastern Oklahoma in the Sixteenth and Seventeenth Centuries. *Southeastern Archaeology* 25(1):20-28.

Rohrbaugh, C. L.

- 1985 LfGeI, the Geren Site, 34Lf36, of the Spiro Phase. *Bulletin of the Oklahoma Anthropological Society* 34:9-81.
- 2012 Spiro and Fort Coffee Phases: Changing Cultural Complexes of the Caddoan Area. Memoir 16. Oklahoma Anthropological Society, Norman.

References Cited (cont.)

Stoltman, J. B.

- 1989 A Quantitative Approach to the Petrographic Analysis of Ceramic Thin Sections. *American Antiquity* 54(1):147-160.
- 2012 Appendix H: Ceramic Thin Section Analyses. In *Early Ceramic Occupation along Blackbird Creek: Archaeological Investigations at Blackbird Creek Site (7NC-J-195D) New Castle County, Delaware*, edited by C. Bowen, pp. H1-H13. Cultural Resources Division, Versar, Inc., Springfield, Virginia.

Stoops, G.

- 2003 *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*. Soil Science of America, Inc., Madison.

Suhm, D. A. and E. B. Jelks (editors)

- 1962 *Handbook of Texas Archeology: Type Descriptions*. Special Publication No. 1, Texas Archeological Society, and Bulletin No. 4, Texas Memorial Museum, Austin.