Made in United States of America
Reprinted from SOUTHEASTERN ARCHAEOLOGY
Vol. 17, No. 1, Summer 1998

ANALYSIS OF EARLY MISSISSIPPIAN-PERIOD POTTERY FROM KERSEY, PEMISCOT COUNTY, MISSOURI

James W. Cogswell
and
Michael J. O'Brien

Kersey, located in Pemiscot County, Missouri, has been a site of longstanding interest in central Mississippi River Valley archaeology because of its chronological placement at the juncture between Late Woodland-period clay-tempered pottery and Early Mississippian-period shell-tempered pottery traditions. Sherds from Kersey were analyzed using a paradigmatic classification of formal and constructional attributes in addition to technological analysis of vessel pastes. Comparison of attributes of vessel form, vessel size, temper type, and presence of slipping demonstrated that shell-tempered vessels were larger than clay-tempered vessels of the same form. Further, specific vessel forms and sizes were correlated positively with the presence of red slip on either the interior (pans jars, and large bowls) or both surfaces (small bowls).

Hydrochloric acid dissolution of shell temper demonstrated no correlation between amount of temper and either vessel form or presence of slipping. Limited use of ultrasonic disaggregation to separate mineral temper in sherds from Kersey and potential source clay samples indicates that source clays have insufficient amounts of sand compared to sand-tempered pottery; therefore, given that source clays have been identified for the modern Mississippi alluvial plain, Kersey residents either intentionally added sand to local clays or they imported their pottery from elsewhere.

The almost total replacement of sand- and clay-tempered pottery by pottery tempered with shell is one of the hallmarks of the early late-prehistoric (Mississippian period) record in the central Mississippi River Valley. Indeed, the apparent abruptness of the shift from sand or clay to shell has been used not only as a temporal benchmark but also as evidence of population movement (e.g., Lynott and Price 1989; Morse and Morse 1983), the notion being that Mississippian peoples moved into various regions occupied by Late Woodland groups, disrupted the prevailing sociopolitical landscape, and either drove the Late Woodland people out of a region or "Mississippianized" them.

Recently, archaeologists have begun to shift analytical attention away from social aspects of this replacement and toward technological aspects of it (e.g., Bronitsky and Hamer 1986; Dunnell and Feathers 1991; Feathers 1989a, 1989b, 1990a, 1990b, n.d.; Feathers and Scott 1989; Million 1975, 1980; O'Brien and Holland 1990, 1992; O'Brien et al. 1994; Steponaitis 1983). Taken in the aggregate, studies resulting from this shift in attention have yielded significant data on the relative strengths of ceramic bodies tempered with sand, clay, and shell and how those bodies perform under certain kinds of stress. The basic problem these technologically oriented studies have tried to answer is this: What are the advantages of using a particular temper over another temper, given the presumed availability of local raw clays that are demonstrably suitable for prehistoric pottery manufacture? The goal of the studies reported here is to provide a more complete understanding of the technological limitations and the choices available to prehistoric potters in a portion of the Mississippi Valley. Temper selection is only one aspect of vessel manufacture and subsequent performance, and it cannot be considered in isolation from vessel form and other technological dimensions.

To this end, we examined dimensions of temper and form using sherds from Kersey (23PM42), a site in the Little River Lowland of southeastern Missouri (Figure 1). Kersey has figured prominently in the literature on the archaeological record of the central Mississippi Valley (e.g., D. Morse and P. Morse 1983, 1990; P. Morse and D. Morse 1990). Excavations conducted at the site in the mid-1960s by Richard Marshall (1965, 1966) resulted in the recovery of large quantities of clay-tempered and shell-tempered pottery, all evidently produced during a 200-year period (O'Brien and Marshall 1994). The traditional view held by archaeologists working in the region is that clay-tempered pottery is an excellent marker for the Late Woodland (sometimes referred to as the late Baytown) period (ca. A.D. 400-900) and that shell-tempered pottery dates to the Mississippian period (post-A.D. 900) (Morse and Morse 1983; O'Brien and Wood 1998).

Marshall recovered numerous sherds from Kersey, especially sherds of shell-tempered vessels that have red slip on one or both surfaces. Potential technological advantages that slipping may have conveyed to vessels have been suggested (Dunnell and Feathers 1991; Feathers 1990b:410; Morse and Morse 1980), but to date no experiments have been published on the effect of hematite-rich slip on clay- and shell-tempered vessels. Therefore, we discuss here only the archaeological manifestation of slipping. Although little work has been done on how slipping might have changed during the period A.D. 600-1100—and hence might be

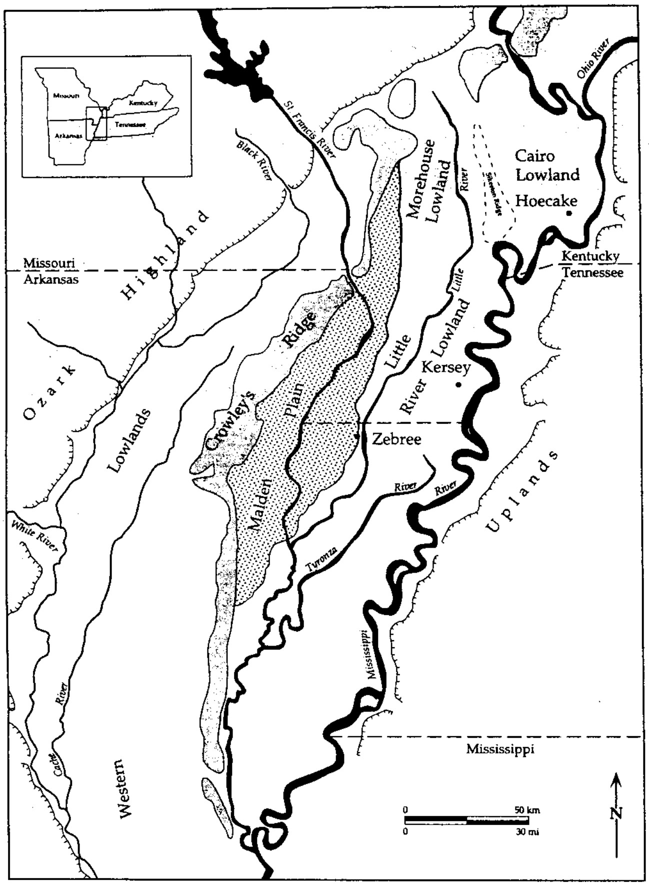

Figure 1. Map of southeastern Missouri area showing location of Kersey and other sites mentioned in the text.

further refined as a chronological tool—it has long been known (e.g., Williams 1954) that the application of red slip to vessel surfaces reached its zenith sometime during that 500-year span.

Various pottery type names have been devised to subdivide early shell-tempered slipped vessels, such as Old Town Red (Phillips 1970; Phillips et al. 1951) and Varney Red Filmed (Williams 1954), but sorting specific sherds to fit these types is as difficult now as when the types were first proposed, due in large part to a lack of explicit sorting criteria (O'Brien and Fox 1994; O'Brien and Wood 1998). If types are to have operational meaning, explicit criteria should be developed on which to base this nomenclature. We do not intend to enter into the debate on what is or is not Varney Red Filmed or Old Town Red, but our analyses may provide additional bases for discussion of how such nomenclatural issues might be clarified by a thorough analysis of the formal and technological properties of the pottery in question. Our intent here is to examine select aspects of prehistoric ceramic technology exhibited at Kersey—specifically, type and amount of temper and presence and location of slipping—and how those aspects were related to vessel forms at a site where the shift from clay tempering to shell tempering is documented at an early stage of the temper transition.

We undertook analysis of Kersey pottery with the following research questions in mind:

1. Are there differences in vessel form between slipped and unslipped vessels? Are there size differences between slipped and unslipped vessels of the same form?
2. Are there differences in the kinds of temper used to manufacture vessels that eventually would be slipped as opposed to those that would remain unslipped?
3. Among the slipped vessels, is there a correlation between form-related or technological dimensions and the presence of slip on one or both vessel surfaces?
4. Was there a consistent amount of shell temper added to vessels, or was there a wide range in the amount of crushed shell that a potter added? Is the amount of shell in a vessel correlated with vessel form?
5. What was the amount of sand present in shell-, clay-, and sand-tempered pottery? Could the sand have been a natural inclusion in each case?

We discovered several important relations among pottery form, size, and slipping during our analysis of Kersey pottery. For example, we found that vessel sizes generally were larger for shell-tempered forms than for clay-tempered forms, a finding consistent with that of Feathers (1990b) relative to vessels from the Malden Plain (Figure 1). We also found positive correlations between specific vessel forms and the presence of slipping—a feature that has been noticed by other researchers (e.g., D. Morse and P. Morse 1983, 1990; P. Morse and D. Morse 1990; Phillips 1970) working in the region. Further, experiments using hydrochloric acid to remove shell temper showed that the amount of that temper in a vessel did not correlate with either vessel form or slipping. Exploratory experiments with ultrasonic disaggregation of sherds and local raw clay samples, combined with initial sediment-size analyses, indicated that clay- and shell-tempered sherds contained sand in percentages that were consistent with percentages of sand found in local soil units mapped by the Soil Conservation Service (Brown 1971). A sand-tempered sherd from Kersey subjected to the same treatment resulted in the obvious result that this sherd exhibited a higher sand percentage than did either the clay- and shell-tempered sherds or the source clays. This indicates that at least some sand-tempered pottery found at Kersey was imported from elsewhere or that sand was added to a clay from a local source during pottery production.

Background

Marshall conducted excavations at Kersey during 1964 and 1965 as part of a contract between the Missouri Highway Commission and the University of Missouri to mitigate the impact to archaeological resources of the construction of Interstate 55 through Pemiscot County, Missouri (Marshall 1965, 1966; O'Brien and Marshall 1994). He excavated 287.5 square feet of an area termed Mound 1 to sterile soil in 1964 and an additional 1400 square feet of the mound in 1965 (Figure 2) in six inch increments; this area was the focus of our analysis. Based on examination of pottery recovered from the excavations, Marshall proposed two phases—a Baytown-period late Black Bayou phase followed by an Early Mississippian-period Hayti phase—and estimated that the site had been occupied between about A.D. 800 and A.D. 1000. Marshall (1966:115) stated that there probably was some continuity between the two phases. We believe that by "continuity" he meant that there existed some overlap in surface treatment between the clay-tempered and shell-tempered pottery. (We restrict our use of the term "clay tempering" to the use of either crushed, fired-clay objects or crushed clay-tempered sherds in the ultimate vessel paste; "shell tempering" means the exclusive addition of crushed shell to the vessel paste.) For example, in our sample we found that checkstamping, which occurred mainly on clay-tempered sherds, also occurred on shell-tempered sherds. In addition, cordmarking, which was much more common on clay-tempered sherds, also occurred on shell-tempered sherds.

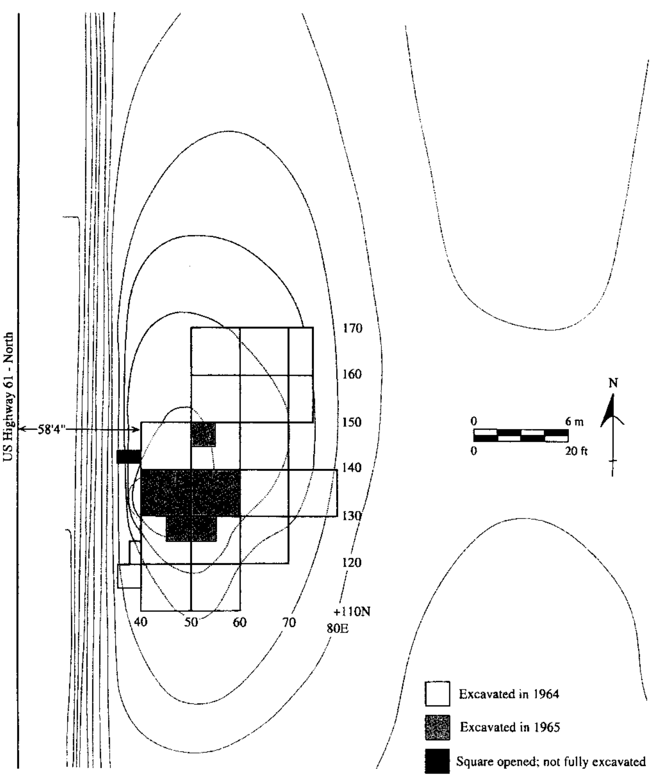

Figure 2. Plan of Marshall's 1964 and 1965 excavations of Mound 1 at Kersey.

Vessel Characteristics, Descriptions, and Definitions

We inspected the entire Kersey ceramic assemblage recovered by Marshall, consisting of over 8,000 sherds, during our analysis. Vessel temper in the Kersey assemblage consisted of clay, shell, and sand, in decreasing order of occurrence. We observed from our sample that sherds were almost exclusively tempered with a single material, which is at variance with Marshall's reports. The major exceptions were sherds from what are referred to as "Wickliffe funnels" (Phillips 1970; Williams 1954), which had clay and shell temper combined within the same sherd. Exterior surface treatments consisted of cordmarking, checkstamping with rectangular impressions, plain surfacing, grass impressing, fabric impressing, and basket impressing, again in decreasing order of occurrence. Decoration, observed but rarely, consisted of incisions and punctations in a variety of patterns on the neck and rim, predominantly on clay-tempered vessels. A few shell-tempered body sherds had curvilinear-trailed impressions that could be decorative.

Marshall recovered only three complete vessels at Kersey, and thus we primarily relied on rim sherds for our analysis of vessel form. We did not try to reconstruct vessels, except for sherds that were from the same excavation lots, nor did we attempt to derive a minimum number of vessels within or between excavation loci, a procedure that is not relevant to our analysis and which may create a further abstraction from the actual data. We limited our analysis to rim sherds that were of sufficient size that (a) they had sufficient vertical extent to provide a reliable estimate of vessel form (see below) and (b) their orifice diameters could be reliably measured within two centimeters when placed flat against a series of concentric, metric circles. Three hundred fifty-five rim sherds met these criteria. We developed a paradigmatic classification of rim sherds (see Figures 3-5 for examples of Kersey sherds that represent these classes):

Form 1: Vertical profile with expanding rim. Rim angle 86-60°.[1]
Form 2: Vertical profile with no visible curvature. Rim angle 87-93°.
Form 3: Expanding profile with no visible curvature. Rim angle 86-60°.
Form 4: Recurved profile with vertical rim.
Form 5: Recurved profile with constricting rim.
Form 6: Recurved profile with expanding rim.
Form 7: Strongly expanding profile with no visible curvature. Rim angle < 60°.
Form 8: Strongly expanding, curved profile. Rim angle < 60°.
Form 9: Constricting, curved profile. Rim angle > 93°.
Form 10: Slightly expanding, curved profile. Rim angle 86-60°.

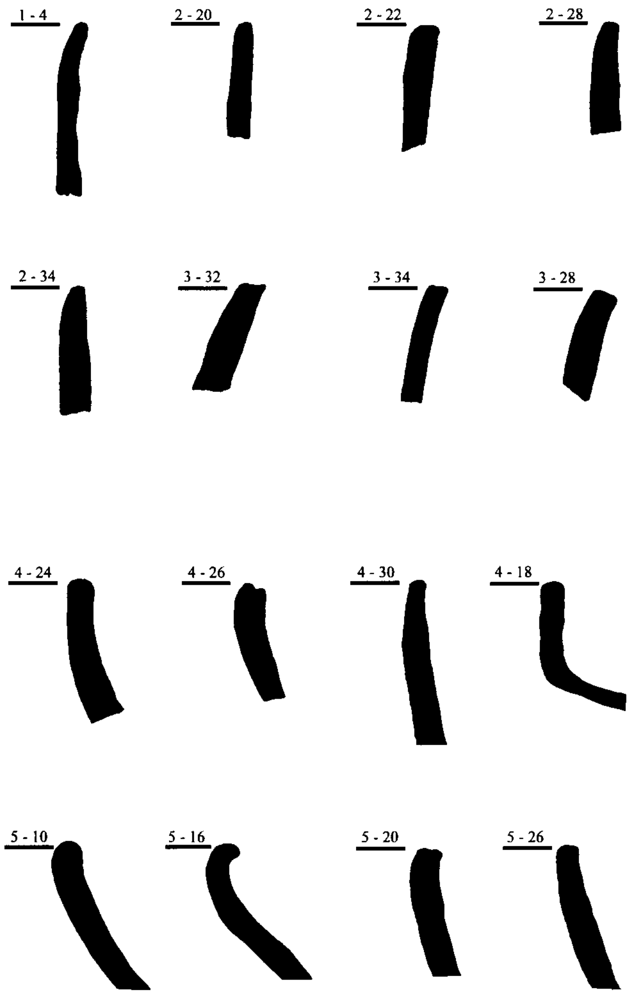

Figure 3. Examples of Kersey rim-sherd classes 1-5. The first number beside each rim profile is the rim-class designation; the second number is the orifice diameter in centimeters.

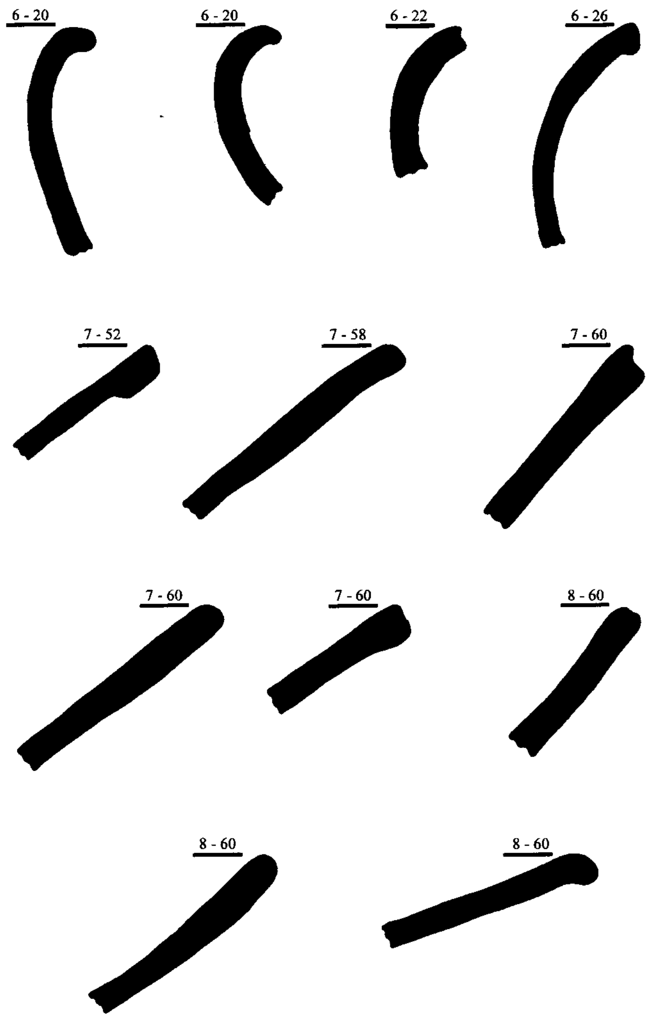

Figure 4. Examples of Kersey rim-sherd classes 6-8. The first number beside each rim profile is the rim-class designation; the second number is the orifice diameter in centimeters.

We defined four general vessel forms—bottles, jars, pans, and bowls. Inspection of basal and body sherds led us to conclude that vessel body contours below the neck followed a simple, spherical profile for shell-tempered vessels and a conoidal or rarely spherical profile for clay-tempered vessels. Therefore, vessel height could be estimated from the lower portions of rim sherds that retained body contours. This assumption is reasonable given current understanding of vessel forms for this time frame in the central Mississippi River Valley during the period under discussion (e.g., Dunnell and Feathers 1991). Bottles were defined as vessels that had an orifice diameter that was less than one-half the maximum vessel diameter and a neck-to-rim height at least equal to the base-to-neck height. Jars were defined as having a vessel height that exceeded the vessel-orifice diameter. Bowls were defined as having an orifice diameter that ranged from being equal to vessel height to three times that height. Pans were defined as vessels that had orifice diameters that were over three times the vessel height. After developing this rim classification and defining vessel forms, we inspected the Kersey rims to see if there were associations among vessel form, vessel size, and/or kind of temper.

Slipping vs. Vessel Form

Using the 105 shell-tempered, slipped rim sherds that met the size criteria, we examined the presence of slipping on one or both surfaces by vessel-form class (Table 1). Some important dichotomies resulted from this analysis. *All* slipped pan rims (n=37) were slipped exclusively on the interior, regardless of exterior surface treatment. Further, *all* slipped jar rims with recurved rim profiles, that is, rim-class 6 (n=38), were slipped exclusively on the interior. The ten slipped bowl rims in rim-class 10 present an interesting dichotomy: Seven specimens were interior-slipped, and three were slipped on both surfaces. When orifice diameters were calcu-

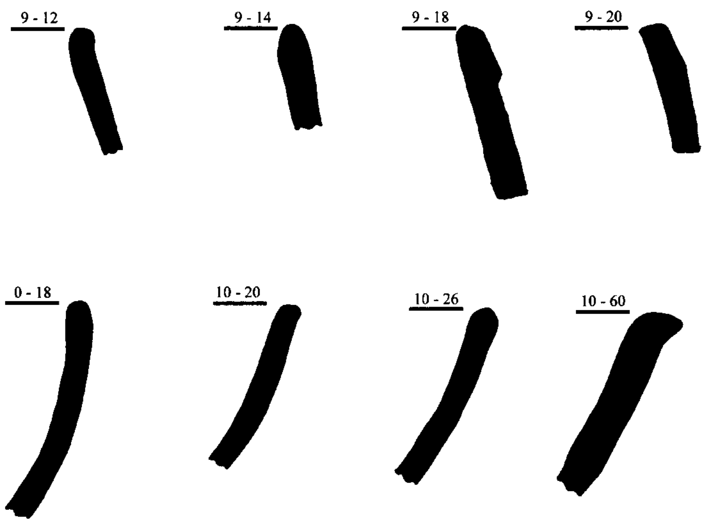

Figure 5. Examples of Kersey rim-sherd classes 9-10. The first number beside each rim profile is the rim-class designation; the second number is the orifice diameter in centimeters.

Table 1. Frequencies of Shell-Tempered, Slipped Sherds by Vessel Form and Location of Slipping.

Form		Location of Slipping Interior	Exterior	Both	Total
Bottle	1	0	1	0	1
Jar	2	0	0	0	0
	3	1	0	0	1
	4	2	0	0	2
	5	6	4	3	13
	6	38	0	0	38
Pan	7	4	0	0	4
	8	33	0	0	33
Bowl	9	0	1	2	3
	10	7	0	3	10
Total		91	6	8	105

lated, these vessels fell into two groups: The three bowls that were slipped on both surfaces fell into a small-diameter group (26 cm or less) and the seven bowls that were slipped only on the interior comprised a large-diameter group (48 cm or larger).

Exterior-slipped rim sherds were much more diverse in form. The largest number (four) came from large, globular jars with relatively small (ca. 12 cm), constricting orifices (form-class 5). This form is present in the lower Ohio River Valley and is common in central Tennessee (O'Brien 1977), but it occurs only rarely on late Baytown-period and early Mississippian-period sites in the central Mississippi River Valley. Three exterior-slipped rim sherds (not included in Table 1) were undoubtedly from the secondary orifices of Wickliffe funnels—an assessment based on their small orifice diameters (average of 6 cm), overall shape, and temper and paste characteristics.

Previous researchers have noticed the link between vessel slipping and the advent of shell-tempered pottery (e.g., Dunnell and Feathers 1991; Feathers 1990b; Marshall 1965, 1966; D. Morse and P. Morse 1983, 1990; Williams 1954). For example, Morse and Morse (1980, 1983) noted that many shell-tempered jars and bowls from Zebree, in Mississippi County, Arkansas (Figure 1), had "an added thick, often multi-layered, slip of hematite and clay applied to the interior. Bottles were slipped on their exterior surfaces. After application, this slip usually was burnished to a high polish, which probably took longer than vessel manufacture" (Morse and Morse 1983:219). They further stated (Morse and Morse 1983:220) that "The reason for applying such a thick layer is not known...[though] the reason most probably was a technological one."

Dunnell and Feathers (1991), in their examination of sherds from the Malden Plain in Dunklin County, Missouri, were more specific, concluding that slip was used to counteract the porosity of early shell-tempered vessels. Clay-tempered vessels, being less porous, did not require slips. Approximately 75 percent of all Kersey shell-tempered body sherds were slipped, but only twelve clay-tempered body sherds of the several thousand such sherds examined were slipped, and all twelve were slipped on the interior. Given that the presumed purpose of slipping was to decrease permeability, it was logical to put it on the interior of the vessel as opposed to the exterior. Our analysis of Kersey sherds corroborates the association of early shell-tempered pottery and slipping in the meander-belt portion of the central Mississippi River Valley. Table 1 shows that 99 of the 105 slipped, shell-tempered rim sherds in the Kersey sample contained slip on the interior surface or on both surfaces, while only six were slipped only on the exterior.

Clay- vs. Shell-tempered Vessel Form and Size

Although not quantified, shell-tempered bowls and jars with excurved rims exhibited more pronounced rim curvatures than did their clay-tempered counterparts—a difference that is in keeping with current understanding of the technological advantages of adding shell to the high-montmorillonite clays that are prevalent in the Mississippi River Valley (Dunnell and Feathers 1991; Feathers 1990a, 1990b; Million 1975). Our rim-sherd data show that shell-tempered-pan orifice diameters, and by extension overall vessel size, were significantly larger than those of their clay-tempered counterparts (Figure 6a). Mann-Whitney tests of clay- vs. shell-tempered vessel orifice diameters support this conclusion at the $p < .05$ level.

Taken in the aggregate, jar orifice diameters are not statistically different between the two temper types, but

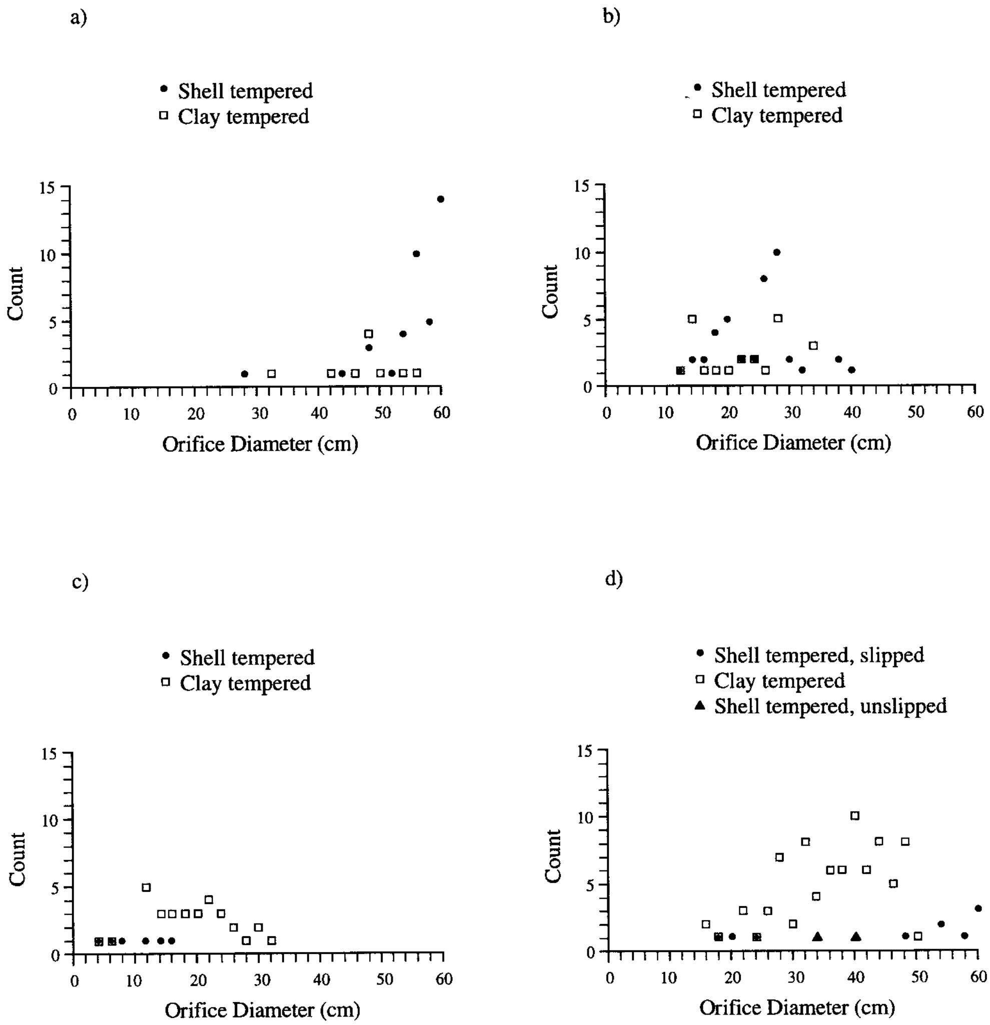

Figure 6. Plots of Kersey vessel-orifice diameters by frequency for a, clay- vs. shell-tempered pans; b, clay- vs. shell-tempered, recurved-rim jars; c, clay- vs. shell-tempered constricting-rim bowls; d, clay- vs. shell-tempered expanding-rim bowls.

this is attributable to the concatenation of a variety of rim shapes within the jar category. Analysis of jar orifice diameters by rim form shows that for rim-class 6—vessels with recurved and expanding rims—shell-tempered vessels have a mean orifice diameter of 25 cm, while that for clay-tempered vessels (Figure 6b) is only 21 cm (Mann-Whitney test; $p < .05$).[2] The constricted rims (class 5) of shell-tempered jars are not significantly more constricted than those on clay-tempered forms, despite having smaller average orifices (mean of roughly 21 cm compared to almost 23 cm). Shell-tempered bowls with constricting orifices—rim-class 9—have significantly smaller orifice diameters than do clay-tempered bowls with the same rim form (average of 13 cm versus 21 cm respectively; Mann-Whitney test, $p < .05$) (Figure 6c). As noted above, slipped shell-tempered bowls with expanding rims (rim-class 10) have a bimodal distribution. Comparison of the smaller (≤ 30-cm orifice diameter) shell-tempered class-10 bowls with clay-tempered class-10 bowls showed no statistical difference in orifice diameters, but larger (> 30-cm orifice diameter) shell-tempered class-10 bowls *were* significantly larger than the larger clay-tempered class-10 bowls (average of 54 cm versus 40 cm, respectively; Mann-Whitney test, $p < .05$) (Figure 6d).

Some of the clay- vs. shell-tempered formal differences may be attributable to differences in the final stages of the manufacturing process. Concerning pans (rim forms 7 and 8), Keslin (1964:50, 72) posited that shell-tempered pans were produced by pressing clay into a mold having a suitable partitive agent such as fabric or grass (see Phillips [1970:95] for an opposing view). After a drying period, the pan was removed from the mold. Production of cordmarked, clay-tempered pans may have proceeded in a similar fashion, but once they were removed from the mold, presumably in a semihard state, they then would have to be cordmarked. This malleation of the exterior may have affected vessel size and form, including orifice diameter. Cordmarked, clay-tempered pans may have been produced using a different procedure, but the end result is the same—Kersey cordmarked, clay-tempered pans are smaller than their their shell-tempered counterparts.

Furthermore, there may be technological reasons why clay-tempered vessels from Kersey were smaller than shell-tempered vessels. Several investigators (Feathers 1990a, 1990b; Million 1975) have noted the improved workability of high-montmorillonite clays from the Mississippi River flood plain when carbonaceous material (shell) is added to the paste. Given the clays that were available, a clay-tempered vessel might have been more difficult to form to a certain size or to a more curved form than was possible with shell-tempered clay. Data from other sherd assemblages might help sort out this issue. We currently are implementing a study of sherds from Hoecake (Williams 1974), a large Baytown-period and early Mississippian-period site in Mississippi County, Missouri (Figure 1), to complement the analysis of materials from Kersey.

Temper Observations

Temper analysis increases our understanding of how prehistoric potters produced workable vessels using available raw materials, and in the case of sand-tempered pottery, whether pottery was produced using nonlocal tempers. Previous compositional analysis of pottery clay sources in the modern Mississippi River alluvial floodplain (O'Brien et al. 1995) demonstrated that source clays are extremely homogeneous and extremely low in (quartz) sand. Pottery from Kersey provides an opportunity to address whether specific amounts of shell were added to specific vessel forms at an early point in the overall trend toward adoption of shell as temper.

One finding that resulted from our visual inspection of Kersey sherds was that the size of shell particles used as temper appeared to be larger than that seen in assemblages from later sites in southeastern Missouri. Additionally, shell appeared to occur in greater amounts than what was evident in those later sherd assemblages. Although quantitative determination of temper volume solely by visual inspection is notoriously inaccurate (see Feathers 1990b:283-287, 304), our qualitative assessment of potential chronological differences in shell-tempering practices deserved investigation. We devised the following procedure to provide data on the amount of shell present in Kersey sherds:

First, all sherds (n=69) for the study came from six-inch excavation levels of a single excavation unit, 140N 60E, the upper two levels comprising the plowzone (sherds from prehistoric pits encountered in the unit were excluded) (Figure 2). Control samples consisted of three samples of Ohio Redart Clay fired to 700° C for one hour in an oxidizing (air) atmosphere and five samples of local Mississippi River alluvial clay fired to the same temperature, conditions, and length of time. Second, sherds weighing approximately 5-10 grams were either selected or broken from larger sherds. Suitable sherds were included if they exhibited visually intact, uneroded temper on all exposed surfaces. Selected sherds then were burred with a silicon-carbide drill to remove postdepositional sediments and to ensure that an unleached sherd core was attained. Sherds and clay samples were crushed to provide maximum surface area without damaging nonshell temper, dried in a 100°C oven for 24 hours, then immediately weighed. The ground sherds and clay samples were immersed in 120 ml of 4 percent HCl acid. (Previous experiments showed that five grams of pure shell would be dissolved in 100 ml of this acid concentration; the extra 20 ml was added to ensure that all shell would be dissolved.) The solutions were stirred several times during a standard six-hour reaction time. (Again, test sherds visually had stopped reacting to the acid after three hours with two stirrings. The additional three hours and stirrings were added to insure dissolution; testing with pH paper confirmed that the solution was still acidic and that all shell had been dissolved.) Each sherd and its solution were washed into weighed filter paper in a funnel to drain and then rinsed with 200 ml of deionized water. Remaining material was returned to the drying oven for 24 hours, weighed immediately upon removal, and the total weight loss calculated. To correct for original sherd size, the total weight loss was divided by the original weight, thereby deriving percentage loss (Table 2).

Our acid leaching probably removed more than shell temper. Any material susceptible to HCl—including iron-rich limonite concretions, naturally occurring carbonates, and probably a host of other, as yet unidentified, materials—also was removed, at least in part. Shorter reaction times or a lower strength of acid solution would not have deterred removal of these nonshell inclusions, since the acid would have worked on all susceptible materials the instant it was introduced to the sherd. With this in mind, results of this acid-treatment study represent an upper boundary to the amount of shell temper added to Kersey pottery, compared to thin-section analyses, which would provide a lower boundary due to the inability of the microscopist to discern shell particles below the resolution of the optical microscope.

An unanticipated aspect of these acid-leaching experiments provided information on potential post-depositional effects on pottery. We included clay- and sand-tempered sherds in our acid-leaching experiments to create what we thought would be a baseline against which the average amount of material removed from those sherds could be subtracted from the amount of material removed from shell-tempered sherds. The adjusted amount removed from shell-tempered sherds would therefore more closely approximate the amount of shell present in the shell-tempered sherds. We origi-

Table 2. Weight Loss of Sherds and Clays as a Result of Hydrochloric-Acid Leaching.

Sample Number	Excavation Level	Surface Attributes[a]	Thickness (mm)	Slipping	Sample Type	Weight before Treatment (g)	Weight after Treatment (g)	Difference (g)	Difference (%)
1	1	ClCh	6	none	?	5.297	4.953	0.344	6.49
2	1	ClCm	10	none	?	7.229	6.594	0.635	8.78
3	1	ClCm	6	none	?	3.925	3.550	0.375	9.55
4	1	ShPl	9	none	?	4.824	4.382	0.442	9.16
5	1	ShPl	9	none	?	7.005	6.358	0.647	9.24
6	1	RsPl	8	none	?	2.812	1.878	0.934	33.21
7	1	RsPl	8	none	?	6.366	2.502	3.864	60.70
8	2	ClPl	5	both	?	2.688	1.586	1.102	41.00
9	2	ClPl	10	interior	?	4.735	4.254	0.481	10.16
10	2	ClCm	N/A	none	?	3.826	3.504	0.322	8.42
11	2	ClCm	N/A	none	?	5.749	5.378	0.371	6.45
12	2	ClCh	N/A	none	?	4.799	4.353	0.446	9.29
13	2	ShPl	N/A	none	?	2.223	1.935	0.288	12.96
14	2	ShPl	N/A	none	?	5.305	4.546	0.759	14.31
15	2	RsPl	7	both	?	3.293	1.942	1.351	41.03
16	2	Cl/ShRsPl	8	exterior	jar?	4.799	3.135	1.664	34.67
17	3	ClPl	6	none	?	3.747	3.491	0.256	6.83
18	3	ClPl	8	none	?	10.315	9.544	0.771	7.47
19	3	ClCm	6	none	?	4.830	4.442	0.388	8.03
20	3	ClCm	8	none	?	6.157	5.744	0.413	6.71
21	3	ClCh	8	none	?	6.285	5.803	0.482	7.67
22	3	ClCh	7	none	?	5.002	4.426	0.576	11.52
23	3	ShPl	6	none	?	4.056	3.285	0.771	19.01
24	3	ShPl	9	none	?	4.488	3.028	1.46	32.53
25	3	RsPl	6	exterior	?	5.477	3.007	2.47	45.10
26	3	RsPl	8	interior	?	3.180	1.875	1.305	41.04
27	3	RsGrass	9	interior	?	6.245	3.519	2.726	43.65
28	3	ShCm	5	none	?	3.203	2.081	1.122	35.03
29	3	SaCm	10	none	?	6.070	5.579	0.491	8.09
30	4	ClPl	9	none	?	4.774	4.448	0.326	6.83
31	4	ClPl	8	none	?	4.293	4.087	0.206	4.80
32	4	ClCm	9	none	?	5.715	5.466	0.249	4.36
33	4	ClCm	8	none	?	7.074	6.707	0.367	5.19
34	4	ClCh	7	none	?	4.204	4.081	0.123	2.93
35	4	ShPl	5	none	?	5.425	3.588	1.837	33.86
36	4	ShPl	6	none	?	5.384	3.375	2.009	37.31
37	4	ClIn	4	none	?	2.177	2.138	0.039	1.79
38	4	RsPl	8	exterior	jar?	6.091	3.284	2.807	46.08
39	4	RsPl	7	interior	jar?	4.946	3.340	1.606	32.47
40	4	SaPl	7	none	?	6.272	5.609	0.663	10.57
41	4	SaPl	8	none	?	3.155	2.993	0.162	5.13
42	4	SaCm	8	none	?	4.799	4.466	0.333	6.94
43	4	SaCm	4	none	?	2.394	2.254	0.14	5.85
44	4	RsCm	6	interior	?	1.399	1.061	0.338	24.16
45	5	ClPl	10	none	?	6.061	5.619	0.442	7.29
46	5	ClPl	8	none	?	8.450	8.092	0.358	4.24
47	5	ClCm	8	none	?	5.188	5.072	0.116	2.24
48	5	ClCm	8	none	?	5.154	4.812	0.342	6.64
49	5	ClCh	11	none	?	6.475	6.083	0.392	6.05
50	5	ClCh	6	none	?	5.840	5.762	0.078	1.34
51	5	ShPl	9	none	?	4.767	2.795	1.972	41.37
52	5	ShPl	6	none	?	2.808	0.959	1.849	65.85
53	5	RsPl	9	interior	?	6.074	3.615	2.459	40.48
54	5	RsPl	7	interior	?	4.080	2.442	1.638	40.15
55	5	SaCm	7	none	?	6.269	6.065	0.204	3.25
56	5	SaCm	6	none	?	4.883	4.815	0.068	1.39
57	6	ClPl	8	none	?	3.944	3.818	0.126	3.19
58	6	ClPl	12	none	?	4.973	4.748	0.225	4.52
59	6	ClCm	7	none	?	4.425	4.370	0.055	1.24
60	6	ClCm	9	none	?	9.689	9.586	0.103	1.06
61	6	ClCh	4	none	?	2.698	2.550	0.148	5.49
62	6	ClCh	8	none	?	6.902	6.665	0.237	3.43
63	6	ClIn	8	none	?	5.179	5.001	0.178	3.44
64	6	ClPo	7	none	?	7.239	6.803	0.436	6.02
65	6	ClPo	7	none	?	3.142	2.905	0.237	7.54
66	6	ShPl	9	none	?	8.299	3.301	4.998	60.22
67	6	ShPl	7	none	?	7.323	3.599	3.724	50.85
68	6	RsPl	5	exterior	?	2.372	1.231	1.141	48.10

Table 2 (concluded). Weight Loss of Sherds and Clays as a Result of Hydrochloric-Acid Leaching.

Sample Number	Excavation Level	Surface Attributes[a]	Thickness (mm)	Slipping	Sample Type	Weight before Treatment (g)	Weight after Treatment (g)	Difference (g)	Difference (%)
69	6	RsPl	5	interior	?	4.322	2.135	2.187	50.60
70	N/A	JCA37	N/A	none	clay	5.356	5.313	0.043	0.80
71	N/A	JCA38	N/A	none	clay	6.374	6.306	0.068	1.07
72	N/A	JCA39	N/A	none	clay	6.224	6.149	0.075	1.21
73	N/A	OZC005	N/A	none	clay	6.487	6.365	0.122	1.88
74	N/A	OZC009	N/A	none	clay	6.126	5.990	0.136	2.22
75	N/A	OZC016	N/A	none	clay	5.566	5.549	0.017	0.31
76	N/A	OZC017	N/A	none	clay	6.340	6.316	0.024	0.38
77	N/A	OZC018	N/A	none	clay	8.912	8.879	0.033	0.37
78	N/A	RsPl	N/A	interior	pan	7.344	2.779	4.565	62.16
79	N/A	RsPl	N/A	interior	pan	6.918	3.284	3.634	52.53
80	N/A	RsPl	N/A	interior	pan	6.755	3.506	3.249	48.10
81	N/A	RsPl	N/A	interior	pan	7.279	4.762	2.517	34.58
82	N/A	RsPl	N/A	interior	pan	7.912	3.324	4.588	57.99
83	N/A	RsPl	N/A	interior	pan	10.127	4.922	5.205	51.40
84	N/A	RsPl	N/A	interior	pan	9.606	4.718	4.888	50.88
85	N/A	RsPl	N/A	interior	pan	8.585	4.590	3.995	46.53
86	N/A	RsPl	N/A	interior	pan	5.925	4.031	1.894	31.97
87	N/A	RsPl	N/A	interior	pan	7.613	4.564	3.049	40.05
88	N/A	RsPl	N/A	exterior	jar	4.729	3.4809	1.249	26.41
89	N/A	RsPl	N/A	exterior	jar	3.832	3.152	0.680	17.75
90	N/A	RsPl	N/A	exterior	jar	5.220	3.820	1.400	26.82
91	N/A	RsPl	N/A	exterior	jar	5.781	4.025	1.756	30.38
92	N/A	RsPl	N/A	both	jar	4.750	3.363	1.387	29.20
93	N/A	RsPl	N/A	both	jar	5.640	2.832	2.808	49.79
94	N/A	RsPl	N/A	interior	jar	7.426	4.634	2.792	37.60
95	N/A	RsPl	N/A	interior	jar	5.413	2.763	2.650	48.96
96	N/A	RsPl	N/A	exterior	jar	3.660	1.473	2.187	59.75
97	N/A	RsPl	N/A	exterior	jar	5.007	1.536	3.471	69.32
98	N/A	RsPl	N/A	interior	jar	4.225	2.527	1.698	40.19
99	N/A	RsPl	N/A	exterior	jar	4.915	2.331	2.584	52.57
100	N/A	ShPl	N/A	none	pan	6.728	4.826	1.902	28.27
101	N/A	ShPl	N/A	none	pan	1.541	1.042	0.499	32.38
102	N/A	ShPl	N/A	none	jar	3.378	2.133	1.245	36.86
103	N/A	ShPl	N/A	none	jar	1.114	0.704	0.410	36.80
104	N/A	ShPl	N/A	none	jar	4.627	2.180	2.447	52.89

[a]ClCh-clay tempered, checkstamped; ClCm-clay tempered, cordmarked; ClPl-clay tempered, plain; ClIn-clay tempered, incised; ClPo-clay tempered, polished; ShPl-shell tempered, plain; RsPl-shell tempered, red slipped, plain; Cl/ShRsPl-clay and shell tempered, red slipped, plain; RsGrass-shell tempered, red slipped, grass impressed; RsCm-shell tempered, red slipped, cordmarked; SaPl-sand tempered, plain; SaCm-sand tempered, cordmarked. Samples with JCA code prefix are Ohio Redart clay samples. Samples with OZC code prefix are alluvial clays from southeastern Missouri.

nally thought that the HCl-induced weight loss from clay- and sand-tempered sherds would be relatively constant and thereby provide a check against the results from the shell-tempered sherds. However, both clay- and sand-tempered sherds showed a consistent and statistically significant decrease in weight loss with depth of burial (Figure 7). The clay control samples provided a tentative answer to the question of why this occurred. Both the Ohio Redart clay and the Mississippi River alluvial clays, which were subjected to the same acid-leaching procedure, exhibited a mean of only 1.03 percent weight loss, with a maximum loss of 2.22 percent. That these control samples experienced less weight loss than did any of the Kersey sherds supports the proposition that accumulation of use-related or postdepositional precipitates occurred in Kersey clay-tempered sherds. If sherds from lower excavation levels already had been leached of HCl-susceptible compounds, those sherds should have had less weight removed by HCl than did the clay control samples. Another unanticipated result is that the HCl-derived weight loss of clay- and shell-tempered sherds from the two uppermost excavation levels—corresponding to the plowzone—also follow the trends for the respective sherds from subplow levels. We suggest that whatever processes acted on Kersey sherds to produce this result, they must have acted relatively quickly in order to account for the commensurate effects on plowzone pottery compared to pottery from subplow levels.

Subsequent analysis of Kersey sherds by scanning-electron, wavelength-dispersive X-ray spectroscopy showed that accretions of calcium, phosphorous, and barium compounds occurred along exterior surfaces and within open pores (Cogswell et al. 1996). These accretions clearly were produced by diagenetic processes and account at least in part for the difference

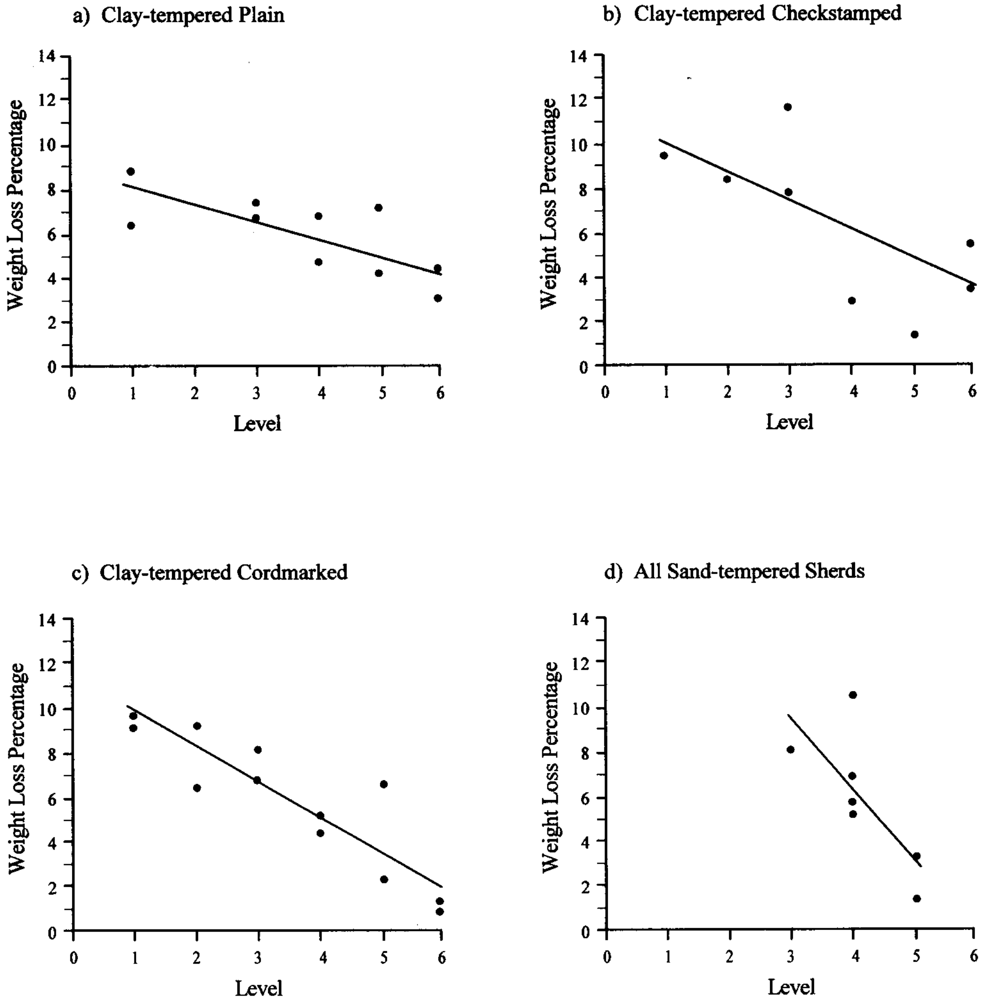

Figure 7. Percentage of weight loss of clay- and sand-tempered sherds due to HCl leaching: a, clay-tempered plain sherds; b, clay-tempered checkstamped sherds; c, clay-tempered cordmarked sherds; d, sand-tempered sherds. Excavation levels (X axis) correspond to six-inch-thick units. Linear regression line is included in each plot. Note consistent decrease in weight loss with excavation depth.

between the elements leached from clay- and sand-tempered sherds and the clay control samples. Shell-tempered sherds exhibited a reverse trend compared to the clay- and sand-tempered sherds subjected to the same HCl-leaching procedure. Weight loss due to HCl treatment increased with excavation depth, although the data points were more disparate than those shown by the clay-tempered sherds (Figure 8). We admittedly are unable to account for this reverse trend in shell-tempered sherds at present, but this finding led to additional questions: (a) Was the weight lost as a result of HCl leaching correlated with shell-tempered vessel form? and (b) Was the HCl-generated weight loss correlated with slipped vessels of different forms? Because the original experiments employed body sherds, results of those leachings provided little information relative to these questions. An additional set of sherds (n=27) was subjected to the same HCl-leaching procedure, but during this experiment vessel form was controlled. Sherd samples from shell-tempered slipped pans, slipped jars, unslipped pans, and unslipped jars were subjected to the same HCl treatment, and their adjusted weight loss was determined according to the above protocol. Mann-Whitney tests ($p < .05$) showed no difference in the amount of temper for slipped vs. unslipped sherds of the same forms as well as no difference between pan and jar forms, whether slipped or unslipped.

The serendipitous discovery that weight loss varied with depth for essentially identical clay-tempered sherds has potentially profound implications for chemically based provenience studies. The observations that (a) HCl leaching removed as much as 10 percent of sherd weight of clay-tempered sherds and (b) the same procedure removed 1 percent or less of nonprehistoric clay control samples strongly suggest that postdepositional factors are responsible. The impact of this discovery depends on the nature of the elements removed from the sherds. If the leached material is restricted to a few

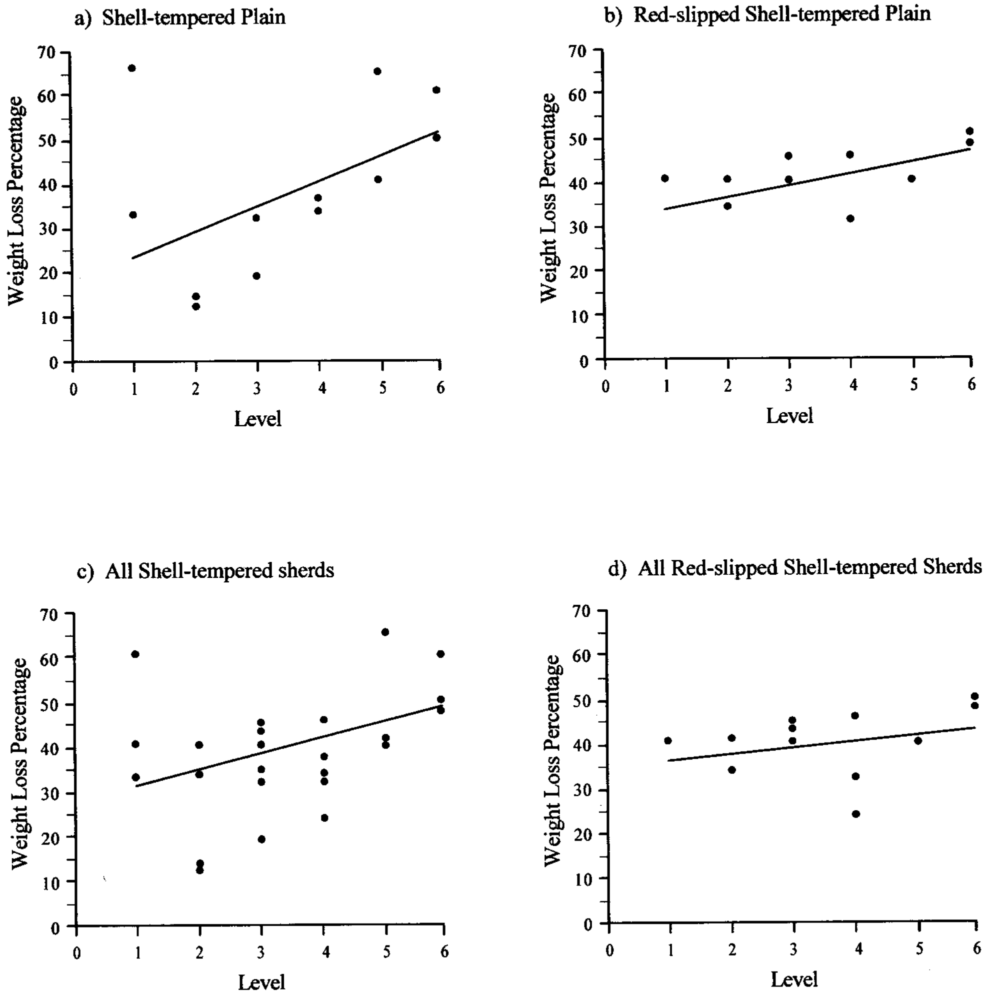

Figure 8. Percentage weight loss of shell-tempered sherds due to HCl leaching: a, shell-tempered plain sherds; b, red-slipped, shell-tempered plain sherds; c, all shell-tempered sherds; d, all red-slipped, shell-tempered sherds. Linear regression line is included in each plot. Excavation levels (X axis) correspond to six-inch-thick units. Note increase in weight loss with excavation depth.

elements, such as (a) calcium, which may be present in the raw clay as shell fragments or as caliche, or (b) potassium, phosphorus, or nitrogen, which may have been introduced by way of modern fertilizing practices, then the impact on elementally based provenience studies should be negligible. If the HCl-derived leachate is a complex mixture of elements, then chemically based provenience studies, at least for the southeastern Missouri area, will have to be based on an understanding of posited postdepositional contributions to the overall composition.

Returning to the Kersey data, we found that the percentage of HCl-leached material from the 27 rim sherds, which is assumed to be predominantly shell temper, is not statistically different among shell-tempered pans and jars, nor is it statistically different among slipped and unslipped shell-tempered vessels of the same form class (Mann-Whitney tests, $p < .05$). We conclude that prehistoric potters at Kersey were not matching amount of shell temper (a) to vessel form or (b) to the presence/absence of slipping. Any addition of shell, from approximately 10 percent to 70 percent by weight, sufficed to permit construction of suitable, adequate vessels regardless of form or the subsequent addition of slip to the vessel.

An additional reason to subject sherds to the above HCl treatment is to remove shell so that mineral temper and/or inclusions can be separated by using ultrasonic disaggregation to segregate clays and silts from larger-size components of the paste and then to characterize the paste constituents by grain-size measurements. Percentages of sand-, silt- and clay-sized particles in sherds, as well as in unfired, raw clay samples, can be determined by using procedures such as the Bouyocos hydrometer method (Bouyocos 1962), but our program (the impetus for which was provided by Gaines and Handy [1977]) employed a Heat Systems model W-385 ultrasonic disaggregator generating 425 watts at 20 kHz through a half-inch-diameter disruptor horn.[3] The disaggregated sample was washed through a 0.0625 mm mesh screen to separate silts and clays from sand- and larger-sized particles. The fine, i.e., clay and silt, fractions and the coarse, i.e., sand and larger, fractions were dried in a 105°C oven before weighing.[4] Only three samples—one shell-tempered sherd, one clay-tempered sherd, and one sand-tempered sherd—were disaggregated in time to be included here.[5] Four unfired, raw-clay samples from two Portageville clay soils and two Hayti clay soils (Brown 1971) from Pemiscot County and within five miles of the Kersey site, also were subjected to the same procedure (each requiring 40 minutes for disaggregation) for comparison. Table 3 presents the results. Note that the amounts of sand in the clay-tempered and shell-tempered sherds were very low and very similar. The percentage of sand in these samples was well within the amount of naturally occurring sand in backswamp clays found in Pemiscot County (Brown 1971); our samples of Portageville and Hayti clay samples produced sand percentages within those calculated by the Soil Conservation Service (Brown 1971).[6] The sand-tempered sherd contained approximately 50 percent sand by weight.

Table 3. Weights of Sherd and Clay Samples Prior to and after Disaggregation.

Sample	Temper	Sample Weight	Fraction[a]	Fraction Weight	Fraction-Weight Percentage
1	clay	3.314	Fine	3.288	99.2
			Coarse	0.026	0.8
4	shell	1.844	Fine	1.821	98.8
			Coarse	0.023	1.2
29	sand	4.379	Fine	2.318	52.9
			Coarse	2.061	47.1
B078	raw clay[b]	11.727	Fine	11.273	96.1
			Coarse	0.454	3.9
B079	raw clay	13.272	Fine	13.270	99.9
			Coarse	0.002	0.02
B080	raw clay	16.410	Fine	16.101	98.1
			Coarse	0.309	1.9
B082	raw clay	16.204	Fine	15.985	98.6
			Coarse	0.219	1.4

[a]Fine fractions passed through a 0.0625-mm-mesh screen; coarse fractions were retained by that screen.
[b]Clays used for this analysis were from Pemiscot County, Missouri. Samples B079 and B080 are of Portageville-series clay; B078 and B082 are of Hayti-series clay (Brown 1971).

Hayti clay soils can have sand as a natural constituent in higher amounts than in Portageville clay soils, but neither the SCS general description of sand percentages of this clay soil (Brown 1971) nor the percentage of sand in our two samples of Hayti clay come close to the amount of sand that was present in the sand-tempered sherd. Other Pemiscot County soil types that might contain the necessary amount of sand to be comparable to the sand-tempered sherd are probably unsuitable for pottery manufacture in their unprocessed state because of the high amounts of associated silt (Brown 1971). We therefore interpret this sand-tempered sherd to be a case (a) of sand being brought to Kersey where it was incorporated into local clay used for vessel manufacture, or (b) of the sand-tempered vessel being manufactured from some as-yet unexplored sandy clay deposit, perhaps from the Western Lowlands, the Malden Plain, or from Crowley's Ridge, and brought to Kersey. Further research on sand tempering in southeastern Missouri pottery is in progress (Cogswell 1998).

Comparison of Kersey Pottery to Pottery from Other Sites

Early red-slipped pottery is present at many sites throughout the central Mississippi River Valley. The most thoroughly documented counterpart to the early Mississippian-period pottery from Kersey is the Big Lake phase assemblage from Zebree in northeastern Arkansas (Morse and Morse 1980) (Figure 1). Morse and Morse described pan forms that are extremely similar to those of Kersey, including vessels with slipped interiors. Zebree shell-tempered pan orifice diameters cluster around 60-70 cm; exterior surfaces of the vessels reflect the markings of partitive agents such as grass or dry clay rather than cordmarking. Red-slipped (on both surfaces), shell-tempered bowls from Zebree have orifice diameters of about 20 cm, which is similar to diameters on Kersey bowls. Jars from the two sites are similar in terms of recurved rims and interior red slipping (Morse and Morse 1980:18-5, 9). Morse and Morse (1980:18-9) also noted that when a slip was present on Zebree jar exteriors it "is often seen in patches, as if from a red paint covering the potters hand." This matches our observations on the occasional, haphazard application of exterior slip on Kersey jars.

One major difference occurs between Zebree and Kersey vessel forms. Morse and Morse (1980), who based their analyses on a minimum number of vessels (MNV), found that Zebree interior-slipped, recurved-rim jars comprised three size groups based on orifice diameter and vessel height: "small jars" having orifice diameters between 10 cm and 15 cm; "medium jars" having orifice diameters between 18 cm and 26 cm; and "large jars" having orifice diameters of 30 cm and larger.[7] We did not find a tripartite division of slipped jars at Kersey. Instead, we found a single-mode frequency curve with a mode of 26 cm for Kersey jar orifice diameters of equivalent rim shape (Figure 9). Our measurements were based on individual sherds and not on MNV, but we believe that the differences between Zebree and Kersey are still significant.

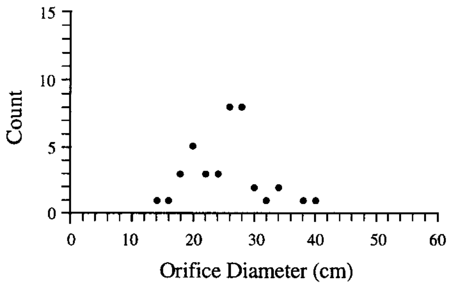

Figure 9. Bivariate plot of orifice diameters by frequency for slipped, shell-tempered, recurved-rim jars from Kersey.

Summary

Ceramic evidence from Kersey is consistent with the notion that clay-tempered and shell-tempered pottery were archaeologically contemporaneous at an early stage of the replacement of clay and sand tempers by shell in the meander-belt portion of southeastern Missouri. Our interest in Kersey focused on size, temper, form, and slipping differences between clay- and shell-tempered vessels. Expanding-rim, shell-tempered bowls and pans are significantly larger than clay-tempered bowls and pans. Clay- and shell-tempered jar forms overall show no significant difference in orifice diameter, but a more detailed analysis of jar rim shapes showed that shell-tempered, constricting-neck jars have smaller orifice diameters than equivalent clay-tempered forms. Shell-tempered recurved-and-expanding-rim jar orifice diameters, and by inference their overall size, are significantly larger than their clay-tempered counterparts. Increased vessel size may be an expression of diachronic trends toward larger household or social groups—larger families may require larger pots—but the Kersey clay- and shell-tempered ceramics are believed to be archaeologically contemporaneous, thus negating the possibility of diachronic differences in vessel sizes at this site.

Experiments using HCl leaching indicated that the amount of shell temper in a particular vessel was not correlated with vessel form or vessel slipping at this early stage of shell tempering; any amount of shell from 10 percent to 70 percent by weight was used indiscriminately. Whether wide variation in shell-tempering percentages continued into later periods or whether the amount of added shell was adjusted for vessel form/function remains to be demonstrated through additional experiments. Additional experiments using ultrasonic disaggregation of acid-leached sherds showed that amounts of sand present in clay- and shell-tempered sherds were similar to amounts expected for local backswamp clay deposits; the amount of sand in a sand-tempered sherd was much higher than that of local clays, which indicates either that this sand-tempered vessel was imported to Kersey or that indigenous potters exploited an unknown local sand or sandy-clay source to produce the vessel. Thus, there may be more archaeologically relevant implications to the presence of sand-tempered pottery at a given site than the mere fact that it was tempered with sand.

The goals and results of this report may seem mundane to readers who are accustomed to reports that assign artifact assemblages to phases, interpolate relations among sites, or discuss the socio-politico-religious organization of Mississippian-period sites. Our purpose simply is to provide an examination of the pottery recovered from archaeologically synchronic deposits at Kersey in terms of selected aspects of its technological variation and how this pottery technology related to vessel form. Examination of equivalent technological and formal relations at other sites in the central Mississippi River Valley will provide documentation of trends leading to a diachronic perspective on the use and replacement of vessel tempers and forms in this area.

Notes

Acknowledgments. We thank M. D. Glascock and H. Neff of the University of Missouri Research Reactor Archaeometry Laboratory for providing both the laboratory facilities and helpful comments during the project; the Archaeometry Laboratory is funded in part by a National Science Foundation grant (DBS-9102016). D. Glover, J. Spate, and M. Keepen contributed significant time and effort to the project; Glover also produced the figures. G. Shieh at the University of Missouri Department of Statistics provided guidance on the use of statistics. R. C. Mainfort, Jr., and two not-so-anonymous reviewers provided advice and numerous suggestions for improving the manuscript. Ohio Redart Clay is a product of Cedar Heights Clay Company, Oak Hill, Ohio.

[1]Vertical is considered to measure between 87° and 93° ; values less than 87° indicate outleaning walls, and values greater than 93° indicate inleaning walls (see Figures 3-5).

[2]There was no statistical difference in orifice diameter size between slipped and unslipped shell-tempered rim form-6 jars (Mann-Whitney test, $p < .05$). We also are aware that nonparametric tests such as Mann-Whitney employ differences between modes, not means, and our statistics were correctly employed. We discuss differences in means in the text in order to make our findings comparable to similar studies that have employed parametric statistical analyses.

[3]An output setting of "5" was employed on the machine because trial runs on other pottery samples at higher settings tended to throw droplets of sample out of the retaining beaker.

[4]No coarse-sized particle larger than what would correspond to "sand" was observed in any of the six samples.

[5]Ultrasonic disaggregation will eventually reduce a low-fired sherd into clay and silt vs. larger-size constituents, but the time involved may prohibit its wide use. Using our apparatus and procedure, the clay-tempered sherd required 45 hours for complete disaggregation. The sand-tempered sherd and the shell-tempered sherd were disaggregated in less than four hours.

[6]Sharkey clays occur several miles farther to the west and north of Kersey, but given the accessibility of Hayti and Portageville clays at a much closer proximity to Kersey, our focus was on the Portageville and Hayti clays.

[7]Morse and Morse did not state if pan exteriors were ever slipped, but by this omission we assume that they were not. Only one intact vessel was recovered (Morse and Morse 1980:18-12), and without explicit statements on how vessel heights were derived we must use vessel orifice diameters to compare Kersey jars to Zebree jars.

References

Bouyocos, G. J.
1962 Hydrometer Method Improved for Making Particle Size Analyses of Soils. *Agronomy Journal* 54:464-465.

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

Brown, B. L.
1971 *Soil Survey of Pemiscot County, Missouri.* U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.

Cogswell, J. W.
1998 *Late Woodland Sand-Tempered Pottery and Its Distribution across Dunklin, Mississippi, New Madrid, and Pemiscot Counties, Missouri.* Ph.D. dissertation, Department of Anthropology, University of Missouri.

Cogswell, J. W., L. M. Ross, Jr., M. J. O'Brien, H. Neff, and M. D. Glascock
1996 Postmanufacture Effects on the Chemical Characterization of Prehistoric Pottery: Evidence from the Central Mississippi River Valley. Paper presented at the 30th International Symposium on Archaeometry, Urbana, Illinois.

Dunnell, R. C., and J. K. Feathers
1991 Later Woodland Manifestations of the Malden Plain, Southeast Missouri. In *Late Woodland Stability, Transformation, and Variation in the Greater Southeast,* edited by M. Nassaney and C. R. Cobb, pp. 21-45. Plenum, New York.

Feathers, J. K.
1989a Effects of Temper on Strength of Ceramics: Response to Bronitsky and Hamer. *American Antiquity* 54:579-588.
1989b Ceramic Analysis, Variation and Data Base Construction: A Selectionist Perspective. In *Analysis and Publication of Ceramics: The Computer Data-Base in Archaeology,* edited by J. A. Blakely and W. J. Bennett, Jr., pp. 71-80. BAR International Series No. 551.
1990a An Evolutionary Interpretation for the Predominance of Shell Tempering in Late Prehistoric Southeastern Missouri Ceramics. Paper presented at the 55th Annual Meeting of the Society for American Archaeology, Las Vegas.
1990b *Explaining the Evolution of Prehistoric Ceramics in Southeastern Missouri.* Ph.D. dissertation, Department of Anthropology, University of Washington.
n.d. A Proposed Evolutionary Explanation for Shell Tempering in Eastern North America. Manuscript in possession of the author.

Feathers, J. K., and W. D. Scott
1989 Prehistoric Ceramic Composite from the Mississippi Valley. *Ceramic Bulletin* 68:554-557.

Gaines, A. M., and J. L. Handy
1977 Ultrasonic Disaggregation of Potsherds for Mineral Separation and Analysis. *American Antiquity* 42:252-254.

Keslin, R. O.
1964 Archaeological Implications on the Role of Salt as an Element of Cultural Diffusion. *The Missouri Archaeologist* 26.

Lynott, M. J., and J. E. Price
1989 The Late Woodland to Emergent Mississippian Transition in the Eastern Ozark Region, Southeast Missouri. Paper presented at the 54th Annual Meeting of the Society for American Archaeology, Atlanta.

Marshall, R. A.
1965 *An Archaeological Investigation of Interstate Route 55 through New Madrid and Pemiscot Counties, Missouri.* Missouri State Highway Department, Highway Archaeology Report No. 1.
1966 Highway Salvage Archaeology at Two Village Sites in Pemiscot and New Madrid Counties, Missouri, 1965. Manuscript on file, University of Missouri, Museum of Anthropology.

Million, M. G.
1975 Ceramic Technology of the Nodena Phase People. *Southeastern Archaeological Conference Bulletin* 18:201-208.
1980 The Big Lake Phase Pottery Industry. In *Zebree Archaeological Project: Excavations, Data Interpretation, and Report on the Zebree Homestead Site, Mississippi County, Arkansas,* edited by D. F. Morse and P. A. Morse, pp. 18-1 to 18-42. Arkansas Archeological Survey, Fayetteville.

Morse, D. F., and P. A. Morse
1980 (editors) *Zebree Archaeological Project: Excavations, Data Interpretation, and Report on the Zebree Homestead Site, Mississippi County Arkansas.* Arkansas Archaeological Survey, Fayetteville.
1983 *Archaeology of the Central Mississippi Valley.* Academic Press, New York.
1990 Emergent Mississippian in the Central Mississippi Valley. In *The Mississippian Emergence,* edited by B. D. Smith, pp. 153-173. Smithsonian Institution Press, Washington, D.C.

Morse, P. A., and D. F. Morse
1990 The Zebree Site: An Emergent Early Mississippian Expression in Northeast Arkansas. In *The Mississippian Emergence,* edited by B. D. Smith, pp. 51-66. Smithsonian Institution Press, Washington, D.C.

O'Brien, M. J.
1977 *Intrasite Variation at a Middle Mississippian Community.* Ph.D. dissertation, Department of Anthropology, University of Texas, Austin.

O'Brien, M. J., J. W. Cogswell, R. C. Mainfort, H. Neff, and M. D. Glascock
1995 Neutron-Activation Analysis of Campbell Appliquéd Pottery from Southeastern Missouri and Western Tennessee: Implications for Late Mississippian Intersite Relations. *Southeastern Archaeology* 14:181-194.

O'Brien, M. J., and G. L. Fox
1994 Sorting Artifacts in Space and Time. In *Cat Monsters and Head Pots: The Archaeology of Missouri's Pemiscot Bayou,* by M. J. O'Brien, pp. 25-60. University of Missouri Press, Columbia.

O'Brien, M. J., and T. D. Holland
1990 Variation, Selection, and the Archaeological Record. In *Advances in Archaeological Method and Theory,* vol. 2, edited by M. B. Schiffer, pp. 31-79. University of Arizona Press, Tucson.
1992 The Role of Adaptation in Archaeological Adaptation. *American Antiquity* 57:36-59.

O'Brien, M. J., T. D. Holland, R. J. Hoard, and G. L. Fox
1994 Evolutionary Implications of Design and Performance Characteristics of Prehistoric Pottery. *Journal of Archaeological Method and Theory* 1:259-304.

O'Brien, M. J., and R. A. Marshall
1994 Late Mississippian Period Antecedents: Murphy and Kersey. In *Cat Monsters and Head Pots: The Archaeology of Missouri's Pemiscot Bayou,* by M. J. O'Brien, pp. 141-194. University of Missouri Press, Columbia.

O'Brien, M. J., and W. R. Wood
1998 *The Prehistory of Missouri.* University of Missouri Press, Columbia.

Phillips, P.
1970 *Archaeological Survey in the Lower Yazoo Basin, 19491-955.* Harvard University, Peabody Museum of Archaeology and Ethnology, Papers 60.

Phillips, P., J. A. Ford, and J. B. Griffin
1951 *Archaeological Survey in the Lower Mississippi Alluvial Valley, 1940-1947.* Harvard University, Peabody Museum of American Archaeology and Ethnology, Papers 25.

Steponaitis, V. P.
1983 *Ceramics, Chronology, and Community Patterns.* Academic Press, New York.

Williams, J. R.
1974 The Baytown Phases in the Cairo Lowland of Southeast Missouri. *The Missouri Archaeologist* 36.

Williams, S.
1954 *An Archeological Study of the Mississippian Culture in Southeast Missouri.* Ph.D. dissertation, Department of Anthropology, Yale University.