Technological Analysis of Ceramic Surface Treatments at the Wymer-West Knoll (20BE132), A Mississippian Site in Southwestern Michigan

Greve-Brown

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TECHNOLOGICAL ANALYSIS OF CERAMIC SURFACE TREATMENTS AT THE
WYMER-WEST KNOLL (20BE132), A MISSISSIPPIAN SITE
IN SOUTHWESTERN MICHIGAN

by

Suzannah Greve-Brown

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Anthropology

Western Michigan University
Kalamazoo, Michigan
April 1997
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Suzannah Greve-Brown
1997
ACKNOWLEDGEMENTS

Numerous people deserve thanks for providing assistance and encouragement while I worked on this project.

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Thanks are also due to Western Michigan University's Graduate College, for providing me with the funding to acquire two of the radiocarbon dates from the site.

A heartfelt thanks to everyone who braved the summer heat during the WMU 1991 field school to excavate the Wymer-West knoll. The camaraderie, good humor and skill shown by all will never be forgotten.

While I gratefully acknowledge the assistance of the above mentioned people, I must emphasize that I am solely responsible for any errors noted herein.
Acknowledgments--Continued

Finally, many thanks are due to my family for their interest and support, and to my husband, Sean, for his limitless encouragement and patience.

Suzannah Greve-Brown
Red-slipped and blackened, burnished, shell-tempered ceramics from the Wymer-West knoll are described and analyzed. Such ceramics have not been previously recognized or detailed in southwestern Michigan. Similar ceramics do occur, however, at Mississippian sites in the upper Illinois and the Mississippi River valleys. The Wymer-West knoll ceramics are thus considered to be possible trade items. An X-ray fluorescence spectroscopy test is utilized in order to compare the red-slipped ceramics with ceramics having other surface treatments. A petrographic thin section analysis is also used to distinguish the potentially imported ceramics from shell-tempered, cordmarked ceramics presumably produced at the site. Results indicate that at least one shell-tempered, red-slipped vessel was probably not locally produced. A summary of the occurrence of red-slipped and blackened, burnished ceramics from selected sites in the upper Illinois and the Mississippi River valleys is presented in the concluding chapter.
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CHAPTER I

INTRODUCTION

Site Location and Description

The Wymer site (20BE132) is located in Berrien County, Michigan on the south side of the St. Joseph River, about 14 miles southeast of where the St. Joseph empties into Lake Michigan (Figure 1). The site is distributed across two knolls which are separated by a swale. The Wymer-East knoll was completely excavated in 1981 as part of the US-31 Highway Mitigation Project (Garland 1990b). Archaic through Middle Woodland components were represented on the East knoll, but evidence of the Mississippian occupation represented on the West knoll was notably absent (Garland 1990a:271). The Wymer-West knoll, which is the subject of this study, was outside of the planned highway right-of-way, and was not investigated in depth during the US-31 project (Garland and Mangold 1980; Garland 1990b). References in this text to "the Wymer site" or "Wymer" will refer to the Wymer-West knoll, unless otherwise indicated.

The property on which the Wymer site is situated has long been leased by nearby Andrews University for agricultural purposes. The western edge of the West knoll has evidence of a nineteenth century homestead. Farming activities have probably taken place in the Wymer site locale at least since that time. The Wymer-West knoll and
Figure 1. Location of the Wymer West Knoll Site and Other Sites Mentioned in the Text.
surrounding fields are usually planted in corn, and the site exhibits a deep plow zone. The highest portion of the West knoll has recently been left fallow following excavations by archaeologists at Andrews University who tested the site in the 1970s.

The Wymer-West knoll is situated above the modern floodplain of the St. Joseph River which is located approximately 300 meters north of the site. The West knoll is bordered to the north by an east-west farm road which actually cuts the northern edge of the knoll. A steep, wooded bluff leading to the Eidson site (20BE122) rises south of the West knoll, and a small, unnamed creek borders the western edge (Garland 1990b:237; Figure 50). The boundaries of the Wymer-West knoll have not been precisely delineated. The landform has been estimated to occupy about 3 hectares (Garland and Mangold 1980). The controlled surface collection conducted in 1991 places the Mississippian site area at about 1.3 hectares.

Faunal and botanical collections recovered from the Wymer-West knoll indicate that occupants of the site practiced a mixed economy of hunting and gathering, coupled with maize horticulture. A preliminary examination of the faunal collection revealed the presence of deer and smaller mammals, sturgeon and other fish, and turtles. Kathryn Parker's analysis of the flotation samples from the site confirmed the presence of Eastern Eight-Row maize in a number of pit features, along with nutshell from a variety of tree species (Parker 1991). Parker noted that the few seeds and tubers represented in the collection were derived from wild plants.
History of Excavations

Andrews University initially undertook excavations of the Wymer-West knoll during the late 1970s under the direction of Robert Little. Limited test excavations, geomorphological trenching and surface collection of the Wymer-West knoll also took place in the late 1970s and early 1980s in conjunction with the US-31 Highway Mitigation Project, under the direction of Dr. Elizabeth Garland (Garland and Mangold 1980; Garland and Clark 1981; Garland 1990b). The most recent excavations at the Wymer-West knoll were conducted by Western Michigan University's 1991 summer field school, directed by Dr. Elizabeth Garland, followed by further limited testing in 1992.

Statement of Problem and Research Objectives

The Wymer-West knoll ceramic assemblage is characterized by shell-tempered jars with sharply everted rims. These vessels are almost completely undecorated, and are randomly cordmarked on their exterior bodies. The introduction of shell tempering and the distinctive rim morphology represent a divergence from the grit-tempered ceramics of the region, and suggest the intrusion of a new cultural group into southwestern Michigan. Distinctions between the Wymer ceramics and shell-tempered wares at other sites in the region were noted by Garland (1991) and possible relationships with the Middle Mississippian were suggested. Included in the Wymer assemblage were a small number of distinctive sherds that will be emphasized in this study. These ceramics have plain exterior surfaces which are treated with what appears to be a thin wash of red slip. A slip is "a
fluid suspension of fine clay and water, used to coat a (ceramic) body before firing. . ." (Rice 1987:482). The red color in a fired slip is often the result of the oxidation of iron in the fine clay mixture. A few other sherd surfaces are blackened or blackened and burnished (or polished). In combination, the presence of red slipping and blackware are suggestive of Middle Mississippian contacts or influence at the Wymer site. Red slipping has not been reported in Late Woodland period sites in southwestern Michigan and black, burnished ceramics are very uncommon (E. Garland, personal communication).

Three Late Woodland period dates have been obtained from the Wymer-West knoll (Table 1). The two Beta dates, with calibrated ages between A.D. 1000 and A.D. 1150 are from features containing Mississippian, shell-tempered ceramics. Feature 91-66 also contained Eastern Eight-Row maize. The latest date of A.D. 1410 is from a feature with maize but no ceramics. It is believed that the earlier dates most closely reflect the main period of Mississippian occupation or influence. It was thus hypothesized by the author that, if the occupation of the Wymer-West knoll represented a site unit intrusion of a Mississippian group with some Late Woodland influences (especially in the form of cordmarked ceramics), then the red-slipped and blackened, burnished ceramics from the site were probably not imported. Alternatively, if the occupation of the site represented an indigenous Late Woodland group with some Mississippian influences, then the red-filmed and blackened, burnished ceramics may have been imported in special functional contexts. Two experiments were specifically
Table 1
Wymer-West Knoll Site Late Woodland Period Radiocarbon Dates

<table>
<thead>
<tr>
<th>Sample</th>
<th>Uncorrected</th>
<th>Calibrated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Stuiver &amp; Reimer 1993)</td>
</tr>
<tr>
<td>Beta - 46414</td>
<td>A.D. 890±80</td>
<td>A.D. 1000</td>
</tr>
<tr>
<td>1060±80 B.P.</td>
<td>(Garland 1991)</td>
<td></td>
</tr>
<tr>
<td>Feature 91-66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta - 46413</td>
<td>A.D. 1020±80</td>
<td>A.D. 1070, 1090, 1120,</td>
</tr>
<tr>
<td>930±80 B.P.</td>
<td>(Garland 1991)</td>
<td>1140, 1150</td>
</tr>
<tr>
<td>Feature 91-51B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISGS - 2264</td>
<td>A.D. 1380±70</td>
<td>A.D. 1410</td>
</tr>
<tr>
<td>570±70 B.P.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feature 91-62</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

designed to test these hypotheses: an X-ray fluorescence spectroscopy test and a petrographic thin section analysis.

The X-ray fluorescence spectroscopy test was used to measure the surface iron content of six sherds which were believed to have been treated with a red slip or a red pigment (Appendix C). The objective of the test was to contrast the results from the apparently red-slipped or pigmented sherds with other sherds which were oxidized or unslipped, to see if there were significant, quantifiable differences between them. The process during firing which leads to oxidation of ceramic surfaces or color development of a reddish slip or pigment is similar, so it was important that one not be confused with the other. Thus, it was hoped that such differences would be significant enough that they would confirm the presence of the slipping or pigmentation by showing its unique composition. "Plain"
or untreated surfaces were also measured in order to determine the
degree of contrast in iron content between them and the slipped or
pigmented surfaces. This type of test was utilized because the X-ray
fluorescence spectrometer measures only the surface mineral content
of the object being analyzed. Iron content was measured because it
was assumed to be responsible for the relatively strong, reddish color
development of the suspected slips and pigments.

A selected sample of the red-slipped and blackened, burnished
ceramics were also thin-sectioned and subjected to a petrographic
analysis (Appendix C). The analysis was utilized to test the hypothe­
ses that the ceramics represented either locally produced or imported,
Middle Mississippian vessels. This analysis resulted in a percentage
representation of specifically selected categories that composed each
sample. The categories included temper, temper void, pore space,
mineral inclusion, and paste matrix. Such results from the red­
slipped and blackened, burnished sherds were to be compared with
results from relatively "typical," shell-tempered, cordmarked ceramics
(suspected to have been locally produced) to see if their overall
composition was significantly different. The analysis differed from
conventional petrographic studies of ceramics in that it placed empha­
sis on describing and detailing the temper particles and pore spaces,
rather than the mineral inclusions and paste matrix. These attributes
of the ceramics were chosen to be analyzed because they represent
related technological traits that affect vessel function, a topic that is
addressed in a separate report (Greve-Brown 1996).
Red-Slipped and Blackened, Burnished Ceramics

Not all of the red-slipped and blackened, burnished ceramics that were recovered from the Wymer-West knoll were involved in the tests described above, as some of surface treatments were poorly preserved and some of the sherds were too small to be useful. However, all such ceramics are characterized here in order to illustrate the variation in and extent to which each surface treatment category is represented at the site. Appendix C provides detailed information about those ceramics that were utilized in the technological experiments.

Red-slipped ceramics are represented at the site by at least seven vessels. The first two vessels (AU24, AU25) are tempered with shell and the rim cross-sections are sharply everted (See Appendix A). The exterior rim and lip regions are plain and well-smoothed, and are covered with a thin wash of red slip (MUNSELL 5YR 5/6 yellowish red). The slip terminates where the inner lip edge meets the interior rim. Body sherds could not be directly associated with these rims, but as plain and red-slipped body sherds were rare for the assemblage, it is possible that the vessel bodies were cordmarked, undecorated and not slipped. However, plain, red-slipped vessels are common at Mississippian sites, while cordmarked jars with red slipping on the exterior rim and lip are rare (Bluhm-Herold et al. 1990; McNaulaghy 1991; Vogel 1975) (See Chapter IV). Only five shell-tempered body sherds in the assemblage, none of which can be associated with specific rim sherds, exhibit red slipping. The lip of one of the red-slipped vessels appears to be slightly finger-impressed, but
is otherwise plain, and is rounded in cross-section (Vessel AU24).
The lip of the second vessel is plain and is flattened in cross-section.
This second vessel has a thin, (about 2.0 mm wide) indented bevel
running parallel about the interior rim-neck juncture of the vessel
(Vessel AU25).

A third red-slipped vessel (r.s. #6) is represented by only a
small portion of the rim, and the vessel rim orientation is unknown.
Both the interior and exterior surfaces of the rim are covered with a
red slip. The lip of the vessel is rounded, but lip treatment is
uncertain, due to the eroded condition of the lip surface. This rim
portion was too fragmentary and eroded to be of use in any further
analysis.

Amongst the five shell-tempered body sherds which exhibit red
slipping, two are red-slipped on the exterior surface, two are red-
slipped on the interior surface, and one has a red slip on both the
exterior and interior surfaces (Table 2). Only the red-slipped body
sherds which were selected for experimentation were compared with
Munsell soil color charts. The colors of those that were compared
(r.s. #4, r.s. #5) matched MUNSELL 5YR 6/6, reddish yellow. The
remaining slipped surfaces appear similar in color. Figure 2 illus-
trates the distribution of red-slipped ceramics at the site (note that
Vessel AU25, which was found during a general surface collection of
the site, is not included on the map).

No shell-tempered rim sherds in the ceramic assemblage evi-
dence blackening or burnishing. However, three exterior blackened
and burnished body sherds appear to be from two separate vessels
Table 2

Total Shell-Tempered, Red-Slipped and Black-Surfaced Sherds
From the Wymer-West Knoll Site

<table>
<thead>
<tr>
<th>#</th>
<th>Provenience</th>
<th>Exterior Surface Treatment</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>r.s.#1</td>
<td>Feature 91-58, PZ</td>
<td>cordmarked</td>
<td>1</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>r.s.#2</td>
<td>Feature 91-58, E1/2</td>
<td>cordmarked</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>r.s.#3</td>
<td>Unit D, PZ</td>
<td>cordmarked, smoothed</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>r.s.#4</td>
<td>Unit B31, locus 1</td>
<td>plain</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>r.s.#5</td>
<td>Unit B31, locus 1</td>
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<td>1</td>
</tr>
<tr>
<td>r.s.#6</td>
<td>Unit B62, N1/2</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>AU24</td>
<td>Unit Do, locus 2</td>
<td>plain (rim)</td>
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<td></td>
<td></td>
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<td>1</td>
</tr>
<tr>
<td>AU25</td>
<td>General Surface</td>
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Table 2--Continued

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<th>Provenience</th>
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<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>Total</th>
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<tbody>
<tr>
<td>b.s.#1</td>
<td>Unit H, level 2</td>
<td>plain</td>
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<tr>
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<td>Unit H, level 2</td>
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<tr>
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<td>Feature 91-64, W1/2</td>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>12</td>
</tr>
</tbody>
</table>

A = Exterior Red Slip  
B = Interior Red Slip  
C = Exterior/Interior Red Slip  
D = Exterior Blackened, Burnished  
E = Exterior Blackened, Burnished/Interior Blackened  
F = Exterior Blackened/Interior Blackened
Figure 2. Distribution of Red-Slipped and Black-Surfaced Ceramics in the Excavated Area of the Wymer-West Knoll Site.
(Table 2). Two of the sherds fit together, and have a slightly rough, unburnished interior surface which is light buff in color (b.s. #1, #2: [T.S. #035]). The surface treatment of these sherds generally resembles that of the ceramic type Powell Plain (Griffin 1949; Vogel 1975:90-93). The third sherd is different from the previous two in that it is blackened on the interior. Interior surface burnishing is not readily apparent (b.s. #3). One additional shell-tempered sherd in the assemblage is plain, smooth and blackened on both the exterior and interior surfaces, but exhibits no evidence of burnishing on either surface (b.s. #4; [T.S. #012]). The provenience of these sherds is also indicated in Figure 2.

The second chapter of this thesis provides a discussion of the X-ray fluorescence spectroscopy experiment, followed by a chapter detailing the preparation and analysis of the petrographic thin sections. The final chapter presents an overview of the regional and inter-regional relationships of the red-slipped and blackened, burnished Wymer ceramics to Mississippian ceramics from other sites. The final chapter also summarizes the X-ray fluorescence spectroscopy and the petrographic thin section analyses, and the author's conclusions and suggestions for future research are detailed.
CHAPTER II

X-RAY FLUORESCENCE SPECTROSCOPY

Introduction

X-ray fluorescence spectroscopy analysis is based on the fact that the elements that are present in a given sample will emit distinctive wavelengths of light when the electrons in the sample are excited through exposure to radiation (Rice 1987:393,482). This type of analysis is useful in the examination of pottery surfaces that are slipped, glazed, painted or otherwise treated with a coating or pigment, as the procedure examines only the surface composition of the specimen. The surface treatment of particular interest on the Wymer ceramics was an apparent slip. A slip is a mixture of fine clay suspended in water that is applied as a thin coating to a pottery vessel surface prior to firing (Rice 1987:149). X-ray fluorescence testing can determine major and trace elements that are present in the surface treatment of a ceramic sample. The spectrometer can also be calibrated to produce a quantifiable reading of a particular mineral that is determined to exist in the surface coating of a particular sample (Rice 1987:394).

The objective of using X-ray fluorescence analysis on certain of the Wymer-West knoll test samples (hereafter referred to as T.S.) was to determine whether or not some of the selected sherds had
their surfaces treated with a red slip. The reddish colors of the suspected slips were believed to be the result of a high iron (Fe) or iron oxide content in the materials used to treat the sherd sample surfaces. Iron is a commonly occurring element in colorants used on pottery surfaces (Rice 1987:148; Rye 1981:41; Shepard 1965a:36-37). Sherds that had either a plain, oxidized or red pigmented surface were also included in the analysis for comparative purposes. It was hoped that the test would reveal distinguishable compositional differences amongst the surfaces tested, thus firmly establishing the uniqueness of the red slip. The spectrometer was used to check each sample surface for iron content, and then to compare the untreated opposite surface of each sample in order to see if there was a significant difference. Comparisons were also subsequently made between the sampled surfaces of the plain, oxidized and red pigmented sherds. It is important to note that X-ray fluorescence testing does not determine the type of iron that is present in a sample, but simply presence or absence. The spectrometer then determines and represents the amount of iron detected in a graphed peak or numerical reading.

Three of the samples (T.S. #033, T.S. #034, T.S. AU25) exhibited an exterior surface that was covered with an apparent thin film or slip (MUNSELL 5 YR 5/6 yellowish red) which did not penetrate the sherd. The texture and coloration of the apparent slip was distinguishable from the opposite surfaces of the samples, which showed no noticeable surface treatment. The texture of the suspected slipped surface was smooth and chalk-like to the touch, but the
apparent slip was stable and did not rub off. This texture contrasted with the surface texture of a typical shell-tempered sherd, which was generally cordmarked and further roughened by small pits resulting from the former presence of the temper particles.

It should be noted that T.S. #033 and T.S. AU25 were shell-tempered rim sherds, with the apparent slip treatment occurring on the exterior rim and lip of the samples. The lip and outer rim areas on the majority of the Wymer-West knoll vessels were undecorated and bore no surface treatment, but usually showed evidence of smoothing where the rim coil was attached to the body. Test Sample #034 was a body sherd which was initially cordmarked and then smoothed over, perhaps to facilitate the adhesion of the slip. This sample was tempered with a mixture of shell and grit, and was included in the testing for comparative purposes.

A sherd (T.S. #020) from the collection which was consistently oxidized or fired to a reddish color throughout was included in the X-ray fluorescence testing in order to compare the results with those of the sherd samples which were apparently slipped. A concern in the initial analysis of the assemblage was that a lightly oxidized sherd surface not be mistaken for one which was covered with a slip. The color of the proposed slipping was subtly different from that of the oxidized sherd (MUNSELL 5 YR 5/6 yellowish red), but could not be distinguished as different through Munsell color comparisons. Oxidized sherds in the Wymer-West knoll assemblage were visibly different in that the oxidation penetrated the surface(s) of
the sherds, while on those sherds which appeared to be slipped, the coating was a thin film which covered the surface only.

Three sherd samples with an apparent dark red pigment on their interior surfaces (T.S. #026, #027, #032) were also subjected to X-ray fluorescence analysis. Test Sample #026 was a shell-tempered body sherd with the temper leached out. The sherd was in a somewhat friable condition and the apparent red pigment remaining on the sherd's interior surface was faint, so no attempt was made to assign a Munsell color to the supposed pigment.

Test Sample #027 was a shell-tempered body sherd with the temper leached from the sherd. The sherd sample was in an extremely friable condition, with the interior surface being rough and pitted. However, a quantity of an apparent red pigment (MUNSELL 10 R 4/6 red) was obvious on the interior surface.

Test Sample #032 was a shell-tempered body sherd, again with the shell leached out. The interior surface of this sample was consistently covered with a dark red (MUNSELL 10 R 3/6 dark red), pigment-like substance, except in a few small pitted or eroded areas.

It was initially unknown whether the observed red pigmentation was a purposeful ceramic surface treatment, or was a residue from the mixing of pigment or some other colored substance in the vessel. The latter is probable, since the red pigmentation occurs on the interior surfaces of the sherds. However, the layer of pigment on some surfaces is a smooth, even coating, so it is also possible that the pigment was purposefully applied by the potters. It is not known what purpose the pigment might have served. Perhaps it
influenced the functional performance of the vessels, or was a special coating on a ceremonial vessel.

The final of the eight samples used in the X-ray fluorescence testing was T.S. #028, a shell-tempered body sherd chosen to be representative of a typical sherd from the Wymer-West knoll assemblage. Both surfaces of this sherd were analyzed through X-ray fluorescence, in order to obtain comparative results from a sherd on which neither surface was judged to be slipped, pigmented or oxidized.

X-Ray Fluorescence Spectroscopy Testing

The samples were analyzed using a Philips Universal Vacuum X-Ray Spectrometer. The process of analysis begins when a sample is exposed to primary X-rays from a Tungsten tube. The irradiation causes an excitation and rearrangement of electrons in the atoms that compose the exposed surface of a sample. This results in an energy output in the form of fluorescent or secondary X-rays. A beam of these X-rays is assembled and then analyzed by a lithium fluoride crystal. The crystal diffracts the beam, which finally is processed through a Philips rate meter. The result is a numerical count which is representative of the number of atoms of the element of interest that are present in a given sample. The type of analysis performed by the Philips Universal Vacuum X-Ray spectrometer is termed "wavelength dispersive" because of the action of the diffracting crystal. An alternative method, nondispersive X-Ray fluorescence, uses a less complex but faster instrument to determine the wave-
length of X-rays. However, the nondispersive method is less precise than the wavelength dispersive approach (J. Grace, personal communication 1995; Rice 1987:393,394,395).

The Philips Universal Vacuum X-Ray Spectrometer cannot detect elements below Atomic Number 11 (sodium - Na), and is best for detecting those elements with an atomic number of 20 (Calcium - Ca) or above. When one of these elements is detected by the spectrometer, it can also be represented on a printed graph as a peak occurring between 30° and 117° (J. Grace, personal communication 1995).

Dr. John Grace, Professor of Geology at Western Michigan University, supervised the X-ray fluorescence testing, and executed necessary calibrations and adjustments to the machinery. Mr. Scott Taube, an Anthropology and Geology student at WMU, ran the spectrometer and other equipment, and assisted in all other aspects of the experiment. The X-ray fluorescence testing of the Wymer-West knoll sherd samples was begun by first determining the elemental composition of T.S. #028. Test Sample #028 was chosen to be analyzed in such a manner because it was judged to have a plain exterior surface which had not been slipped, pigmented, or heavily oxidized, and in overall characteristics and appearance it generally represented a "typical" sherd from the assemblage. The amount of iron (Fe) detected on the surface of a "typical" sherd was of particular interest for comparison with the iron present in sample surfaces covered with an apparent slip.

T.S. #028 was subjected to a spectrometer range run from 0° to 115°. The results of the analysis were output to a Bristol strip
chart recorder, which recorded several graphed peaks at various degree settings. The objective of the range run was to determine which elements, other than iron, were significant in the composition of a typical sherd surface. Two expected peaks (36°, 42°) were produced by the spectrometer's Tungsten Tube, and two other resulting peaks (K beta 77.8°, K beta 94°) proved to be spurious. The remaining two peaks produced during the range run (K beta 76.5°, K alpha 84.7°) suggested a possibly significant amount of Titanium (Ti) in the sample. Titanium is a minor element which may be present in some pottery (Rice 1987:390). However, other results of the range run suggested that the peaks thought to represent Titanium might also simply have been spurious lines.

Four samples at a time could be placed in the spectrometer. The samples were mounted in separate compartments of a small cylindrical chamber that fit in an opening on top of the spectrometer. A window in the bottom of each compartment exposed the portion of the sample that was to be analyzed. Each sample was secured in place to avoid movement during testing, and was aligned so as to expose only the surface in question. A knob on top of the chamber containing the sherds allowed rotation from sample to sample by a measured turn. Test Samples #033, AU25, #034, and #032 were the first four samples to be analyzed. The first three samples initially had their exterior surfaces, judged to be covered with a reddish slip, examined, while the fourth sample had an apparent red pigment on its interior surface looked at first.
The spectrometer was calibrated at 57.24°, the peak for iron, in order to examine the samples for iron content. Each sample was irradiated for 30 seconds, and the spectrometer's detection of iron atoms counted per second was output to the Philips rate meter, producing a numerical reading. The rate meter can normally be calibrated to start and stop according to the time interval desired, but on the day of testing, very humid weather inhibited repeated attempts to automatically produce the desired interval. Innovation and several more practice runs resulted in the time being reasonably kept by a watch with a second hand, and the rate meter being manually started and stopped by Mr. Taube. These adjustments introduced a certain margin of error into the proceedings. However, the margin was judged to be small enough that it was not expected to produce a significant negative impact on the results. The subsequent consistency of repeated readings taken from the same sample supported this conclusion.

The first four samples analyzed were each subjected to five 30 second intervals of testing, during which the spectrometer analyzed their exposed surfaces for iron content. Another problem encountered in the analysis of the initial set of samples was that different rate meter readings for the same sample seemed to produce a broader numerical range than expected. The problem was found to be in the positioning of the chamber which held the samples. The chamber locks in place once it is moved to a particular position, and early attempts at advancing it caused the samples to be slightly out of position. This problem was recognized and corrected, and the rate
meter readings subsequently became much more consistent. Three of the samples (T.S. #033, #034, #032) affected by this initial problem had an aberrant high and low reading thrown out, while the three readings retained from each sample proved to be consistent and useful results. Results from the fourth sample (AU25), which were examined after the experiment, proved to be so divergent that they could not be used. Test Sample AU25 was a rim sherd used only in the X-ray fluorescence testing. While it was unfortunate to lose the comparative information that this sample would have provided, all other sherd samples which were to be subsequently thin-sectioned produced usable results. The initially encountered problems were identified and worked out, and subsequent sample runs required only three readings each to produce consistent and usable results. The complete results are detailed in Appendix B.

Rate meter readings were recorded for each spectrometer run performed on the first four sherd samples. Next, three background readings, set slightly below (56.9°) and above (57.75°) the expected peak for iron, were taken from the same surface as the original iron counts. Three runs were performed on each sample at 56.9° and 57.75° respectively. This was done to examine the possibility that other closely occurring mineral peaks might be confusing the iron count readings. Later examination of across the board test results showed that such was not the case (Appendix B).

T.S. #033, AU25, #034, and #032 were removed from the spectrometer after the above mentioned testing, and remounted in the compartments so as to expose their opposite surfaces. The opposite
surfaces of each sample were visually judged to be "plain," versus slipped or pigmented, and comparative readings were desired. Each sample was once again subjected to three spectrometer runs analyzing the sherd surfaces for iron content. The results were output to the Philips rate meter, and the counts were recorded. Three readings taken above and below the iron peak setting were also noted for each sample in the manner that was described above (Appendix B).

The second set of sherds to be examined by the spectrometer included T.S. #027, T.S. #026, T.S. #028, and T.S. #020. Test Sample #027 and T.S. #026 each had a red pigment on their interior surfaces, while the opposite surfaces were judged to be plain. Test Sample #028 was a sherd, as mentioned, that was plain (versus slipped, pigmented or oxidized) on both surfaces, and was included in the testing for iron count comparisons. This sample was also generally representative of a typical sherd from the overall assemblage. Test Sample #020 was obviously oxidized on both its exterior and interior surfaces. Heavy oxidation is seen on some of the Wymer-West knoll sherds, although it is not a common characteristic of the assemblage. This sample was also included in order to compare the test results with the other sample readings. These four samples were tested using the same procedures and spectrometer settings as those described for the first set of sherds. Test Sample #027 and T.S. #026 had their interior, red pigmented surfaces initially analyzed, and then their exterior, plain surfaces. The interior surfaces were analyzed first on both T.S. #028 and T.S. #020. Three iron counts
and three background counts, both above and below the iron peak, were once again recorded for each surface of each sample. See Appendix B for the overall test results. Table 3 shows the average iron and background counts for each sample tested. The numerical readings shown in Table 3 are rounded up to the nearest whole number.

Test Results and Discussion

The results from the X-ray fluorescence spectroscopy analysis revealed some interesting comparisons and contrasts amongst the sherd samples that were examined. Test Sample AU25 was a shell-tempered rim sherd with an apparent red slip applied to the exterior rim and lip. Unfortunately, as mentioned, problems with the initial manipulation of the spectrometer made the iron count readings taken from the exterior surface of this sample unusable. There was such a variation in the five readings taken from the sample that it was felt that an average would not be truly representative of the iron count (see Appendix B). The interior or "plain" surface of this sample produced an iron count reading which fell within the same general range as the reading from the interior surface of T.S. #033, another rim sherd which bore an exterior red slip. Results from the interior surfaces of both red-slipped rim sherds (T.S. AU25, T.S. #033) show the paste of these sherds to contain a relatively high amount of iron when compared with the results from other "plain" surfaces that were tested. The significance of this difference is uncertain, though it may represent the usage of a different paste, or a differential
Table 3

X-ray Fluorescence Test Results: Average Iron (Fe) and Background Counts

<table>
<thead>
<tr>
<th>T.S.#</th>
<th>Provenience</th>
<th>Sherd Type</th>
<th>Wt. (g)</th>
<th>Thickness (mm)</th>
<th>Surface</th>
<th>Surface Treatment</th>
<th>Fe - Peak</th>
<th>Background</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ext.</td>
<td>red slip</td>
<td>57.24°</td>
<td>56.9°</td>
<td>57.75°</td>
</tr>
<tr>
<td>AU25</td>
<td>general</td>
<td>rim</td>
<td>3.5</td>
<td>*</td>
<td>ext.</td>
<td>red slip</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>surface</td>
<td></td>
<td></td>
<td></td>
<td>int.</td>
<td>plain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#033</td>
<td>Unit Do,</td>
<td>rim</td>
<td>4.5</td>
<td>*</td>
<td>ext.</td>
<td>red slip</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Locus 2</td>
<td></td>
<td></td>
<td></td>
<td>int.</td>
<td>plain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#034</td>
<td>Unit S,</td>
<td>body</td>
<td>6.7</td>
<td>9.05</td>
<td>ext.</td>
<td>red slip</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PZ</td>
<td></td>
<td></td>
<td></td>
<td>int.</td>
<td>(oxidized)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#026</td>
<td>Fea. 91-66</td>
<td>body</td>
<td>2.7</td>
<td>4.325</td>
<td>int.</td>
<td>red pigment</td>
<td>9829</td>
<td>2918</td>
<td>2481</td>
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<tr>
<td>#026</td>
<td>Sec. WA</td>
<td></td>
<td></td>
<td></td>
<td>ext.</td>
<td>plain</td>
<td>11160</td>
<td>2395</td>
<td>2553</td>
</tr>
<tr>
<td>#027</td>
<td>Fea. 91-66</td>
<td>body</td>
<td>2.4</td>
<td>5.15</td>
<td>int.</td>
<td>red pigment</td>
<td>17904</td>
<td>4534</td>
<td>3359</td>
</tr>
<tr>
<td>#027</td>
<td>Sec. WA</td>
<td></td>
<td></td>
<td></td>
<td>ext.</td>
<td>plain</td>
<td>9819</td>
<td>2372</td>
<td>2371</td>
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<tr>
<td>#032</td>
<td>general</td>
<td>body</td>
<td>1.7</td>
<td>4.65</td>
<td>int.</td>
<td>red pigment</td>
<td>17249</td>
<td>3611</td>
<td>3069</td>
</tr>
<tr>
<td>#032</td>
<td>surface</td>
<td></td>
<td></td>
<td></td>
<td>ext.</td>
<td>plain</td>
<td>12158</td>
<td>2437</td>
<td>2882</td>
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</table>
Table 3—Continued

<table>
<thead>
<tr>
<th>T.S.#</th>
<th>Provenience</th>
<th>Sherd Type</th>
<th>Wt. (g)</th>
<th>Thickness (mm)</th>
<th>Surface</th>
<th>Surface Treatment</th>
<th>Fe - Peak Background</th>
<th>Back-ground Back-ground</th>
</tr>
</thead>
<tbody>
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<td>#020</td>
<td>Fea. 91-65,</td>
<td>body</td>
<td>2.9</td>
<td>4.575</td>
<td>int.</td>
<td>(oxidized)</td>
<td>22079</td>
<td>5552</td>
</tr>
<tr>
<td>#020</td>
<td>S 1/2</td>
<td></td>
<td></td>
<td></td>
<td>ext.</td>
<td>(oxidized)</td>
<td>22006</td>
<td>4056</td>
</tr>
<tr>
<td>#028</td>
<td>Unit B62,</td>
<td>body</td>
<td>2.5</td>
<td>6.125</td>
<td>int.</td>
<td>plain</td>
<td>9228</td>
<td>2986</td>
</tr>
<tr>
<td>#028</td>
<td>Locus 3 (pit feature)</td>
<td></td>
<td></td>
<td></td>
<td>ext.</td>
<td>plain</td>
<td>9044</td>
<td>2986</td>
</tr>
</tbody>
</table>
affect on the iron content due to firing conditions. It should be kept in mind that the comparisons made between the ceramics discussed here are relative to the selected group examined in terms of high or low iron content, since they are being compared only with each other and not with an outside, fixed high or low measurement for iron. The background counts taken on both surfaces of T.S. AU25, and on both surfaces of all remaining samples tested showed that no other significant mineral peaks were interfering with the iron count readings. The averaged results of the background counts can be seen in Table 3 and will not be discussed further.

T.S. #033 was a shell-tempered rim sherd with an apparent thin, reddish slip on the exterior rim and lip. The sample evidenced relatively high iron count readings for both the exterior and interior surfaces. While the apparently slipped exterior surface of the sample had a higher iron count than did the opposing interior surface, the exterior iron count was lower than that taken from the "plain" interior surface of T.S. AU25. The fact that a plain surface from one of two apparently red-slipped rim sherds would produce a higher average iron count reading than would the slipped surface itself was contradictory to the expected outcome of the experiment. It was expected that the suspected slips would produce an iron count which would be obviously higher than the plain surfaces with which they were contrasted. However, such was not the case. The similarity of the readings from both samples, and the test result of a higher average iron count derived from a plain surface versus one thought to
be slipped may thus suggest a homogeneity in the clay used to prepare both the vessel paste and the slip.

T.S. #034 was the third sample thought to have a red slip on it's exterior surface. This sample was a body sherd tempered with a mixture of shell and fine black grit. The sherd was oxidized on both surfaces, with the oxidation slightly penetrating the sherd below both surfaces. The interior of the sherd between the oxidized surfaces was dark grey (MUNSELL 5YR 4/1). The exterior surface of the sherd had been cordmarked and then lightly smoothed over. The suspected slip on that surface could be distinguished from the oxidation on both sherd surfaces by its color and chalky texture. The average iron count reading derived from the exterior surface of T.S. #034 was several thousand counts higher than those readings taken from the other sample surfaces that were believed to be slipped. The average iron count reading taken from the interior, oxidized surface of the sample was comparatively high. Both average readings were in turn comparable to those taken from the exterior and interior surfaces of T.S. #020, a thin body sherd which was consistently oxidized throughout.

The results from the spectrometer analysis of the exterior surface of T.S. #034 suggest that the iron content of both the oxidized surface and the apparent slip were counted. The lower average iron count from the interior surface which was oxidized but not slipped supports this conclusion. The average iron count results from T.S. #034 are closely comparable to those taken from T.S. #020, but are several thousand counts higher than those results derived
from the other samples with apparently red-slipped surfaces. These results show a trend of higher average iron counts present in the oxidized sample surfaces.

Oxidation of iron during firing does not begin until organic matter present in a clay paste is burned out. Organic or carbonaceous material in a ceramic vessel begins to burn and oxidize when the vessel is heated during firing. As firing heat increases, carbon gradually burns and escapes from the inner portions of a vessel wall to the surfaces in the form of carbon dioxide (CO₂) gas. The firing atmosphere, temperature range and length of firing are all factors which will affect this process, as will the quantity of organic matter present in the paste. The size of the clay particles which compose a vessel's paste will also help to facilitate or hinder the rate at which carbon is removed during firing. This is because pastes composed of fine particles have a lesser total pore structure than do coarse pastes, and a restricted pore structure provides less room for the burning and removal of carbon to occur (Rice 1987:334).

The majority of the sherds in the Wymer-West knoll assemblage are shell-tempered. The shell-tempered sherds are generally characterized in cross-section by thin, light-colored surfaces contrasted with a thick grey or black interior band. This composition suggests that firing conditions did not allow for the shell temper and other organic matter present in the sherds to completely burn out (Rice 1987:334). The fired condition of the sherds is consistent with the variable and relatively rapid firing conditions believed to have been achieved in open-pit firings at Wymer-West. Some consistently ox-
idized sherds or sherds with thicker reddish zones of oxidation are noted in the Wymer-West knoll assemblage, but such sherds are uncommon. Most shell-tempered sherds in the collection exhibit the type of cross-section described above. These carbon-rich interiors indicate one strong limiting factor in the occurrence of oxidation of the ceramics during firing. Preserved shell can also be noted in certain cross-sections, suggesting that not only was oxidation and removal of organic material often incomplete, but in some vessel portions the firing conditions barely allowed it to begin at all.

An examination of the compositions of T.S. #020 and T.S. #034 will help to explain why the state of iron oxidation is more advanced in these two samples. Test Sample #020 is a very thin, cordmarked body sherd originally believed to be shell-tempered. The thinness of the sherd (average thickness 4.575 mm) and the appearance of small linear voids oriented parallel in cross-section initially suggested that shell was the tempering agent. However, examination of a thin section of the sample (See Chapter III of this thesis) revealed no shell temper particles or voids. Instead, the thin section of T.S. #020 showed abundant small, rounded or irregular minerals in the paste matrix. These minerals appeared to be natural inclusions in the paste, and no obvious added tempering agent was identified.

The paste which composes T.S. #020 is fine-grained, and pore spaces are difficult to recognize in the sample's thin section. Porosity testing resulted in a percentage apparent porosity (representative of pore spaces open to the sherd surfaces) of 37.5% for this sample (Greve-Brown 1996).
T.S. #034, as described above, is a body sherd tempered with a mixture of shell and fine black grit. The sherd is oxidized to a reddish color on both surfaces, with the oxidation slightly penetrating the sherd on both sides. The exterior surface is additionally covered with a thin reddish slip. A thick, dark grey zone lies between the two oxidized surfaces. The color of this zone suggests a carbon-rich interior in which firing conditions did not allow for the oxidation and burning off of all present organic materials. The thin section of this sample (see Chapter III) further revealed that some of the shell temper was indeed still intact within the interior of the sherd. Shell temper was burned off in the oxidized zones of the sherd, leaving small linear voids behind.

The paste of T.S. #034 is generally very fine grained and homogeneous, with no natural mineral inclusions obvious in thin section (see Chapter III). Only one small rounded pore could be identified in this sample’s thin section. Test Sample #034 is nearly twice as thick as T.S. #020, with an average thickness of 9.05 mm. The volume of T.S. #034 is also nearly twice that of T.S. #020 (4 cubic cm. versus 2 cubic cm. respectively). However, porosity testing showed that the two samples share the same percentage apparent porosity: 37.5% (Greve-Brown 1996).

The primary factors which seem to have led to the consistent oxidation of iron seen throughout T.S. #020 are the relative thinness of the sherd, in combination with the apparent lack of organic material within the paste of which the sherd was made. Many other sherds in the Wymer-West knoll assemblage are equally thin, but
they contain significant amounts of organic material in the form of shell temper. Test Sample #020 contained no shell temper, in fact, no identifiable tempering agent is evident in the sherd. The open, variable and probably rapid conditions under which the Wymer-West knoll vessels were fired allowed a nearly complete oxidation of iron in T.S. #020. Other equally thin, shell-tempered sherds did not evidence iron oxidation under similar firing conditions because their organic content was not fully oxidized and burned out.

The exterior and interior surfaces of T.S. #034 show evidence of iron oxidation, with the zones of oxidation extending slightly below each surface. Open, variable firing conditions apparently allowed for partial iron oxidation to take place in the sample. The thickness of the sherd and the preservation of some shell temper show that firing conditions were not favorable for the complete oxidation of iron to take place.

Both T.S. #020 and T.S. #034 are composed of a relatively fine-grained clay paste, suggesting a restricted pore structure which would be less favorable for the oxidation and burning off of organic materials. Pore spaces are difficult to identify in the thin sections of these samples, but testing for the percentage apparent porosity showed the result of 37.5% in both samples. The overall results from the 35 technological sherd samples tested for percentage apparent porosity ranged from 22.5% to 55%, with the above two samples falling slightly above the middle of this range. Sherd samples shown to be more porous than T.S. #020 and T.S. #034 evidenced little or no iron oxidation, but such samples also contained and retained a higher
organic content than did either of these samples (Greve-Brown 1996). The similar aspects of paste structure seen in both T.S. #020 and T.S. #034, despite their differences in size, thickness and overall composition, appear to have contributed to the oxidation which occurred in both samples upon firing. These aspects include a lack or burning off of carbonaceous materials, a similar pore structure, and a similar and relatively high average iron content, evidenced in the readings taken from the oxidized surfaces of the samples.

Many intricate factors of ceramic composition and firing have been discussed as being involved in the oxidation of iron during the firing of pottery vessels. The same factors which contribute to the oxidation of iron in a clay body also apply to the color development of iron compounds evident in clay slips. The apparent clay slips seen on the exterior surfaces of the two rim sherds, T.S. AU25 and T.S. #033, and on T.S. #034 are all the same color (MUNSELL 5YR 5/6 yellowish red) and have a similar fine-grained, chalky texture. The surface coating appears ephemeral but is stable and does not rub off. Shepard (1965a:38-39) points out that the characteristics of iron oxide (paints) can vary greatly, and that fired ferric oxide paint may appear coarse and powdery, showing no visual evidence of firing. The "chalky" texture exhibited by the suspected Wymer slips raised the question of whether or not they had been fired. Their permanence, and the oxidation of iron seen in the apparent slip colors indicates that they have, indeed, been fired.

The process of preparing a slip begins with drying and grinding the clay that is to be used. Large, undesirable inclusions in the
clay can be removed during the grinding process. A well dried, ground clay can then have water added to it, and the water will eventually be absorbed and the clay particles dispersed. This process is known as slaking, and can take any amount of time between a few hours and a few days, depending on the clay used. More water is then added and the mixture is stirred, so that the clay particles become suspended in the water. Sieving or straining of the clay and water mixture may be employed at this point, in order to remove both organic and inorganic inclusions that were too small to pick out by hand. Alternatively, undesirable inclusions might simply be allowed to settle to the bottom of the container in which the slip was mixed, and the desired suspension mixture could then be skimmed or drained off (Rye 1981:36-37).

The thin, fine-grained texture of the slipping suspected on the exterior surfaces of T.S. AU25, T.S. #033 and T.S. #034 shows that nearly all larger inclusions, including organic materials such as plant remains, were probably removed when the mixture was prepared. This texture, along with the relatively high average iron counts derived from the samples during X-ray fluorescence testing imply a fine, well-distributed iron content. Based on the previous discussion of iron oxidation during firing, it can easily be seen how a thin surface slip with low organic content and high, well-distributed iron content would readily oxidize during firing.

T.S. #028 was the shell-tempered sherd judged to be a typical representation of the majority of shell-tempered body sherds in the collection. The sherd was chosen for x-ray fluorescence testing in
order to compare the average iron count readings from its unslipped, unpigmented surfaces with other readings from those sherds that did evidence a slipped or pigmented surface. The average iron count readings from T.S. #028 also provided an interesting comparison of its lightly oxidized exterior surface (MUNSELL 10YR 7/3 very pale brown) with sherd surfaces that were heavily oxidized. The light-colored, thin surface zones of the sherd covered a thicker, darker colored interior zone. Light brown sherd surfaces, either cord-marked or cordmarked and smoothed over on the exterior surfaces, and dark, thicker carbonaceous interior zones are common characteristics of the shell-tempered sherds in the Wymer-West knoll assemblage. Plain smooth interior surfaces of a light brown or light gray color are also common in the collection (Greve-Brown 1996).

The average iron count readings taken from the exterior and interior surfaces of T.S. #028 were similar. The readings were also comparable to other average iron count readings from other sherd sample surfaces that were judged to be plain. All average iron count readings taken from plain surfaces were low in comparison with readings taken from surfaces judged to be slipped, pigmented (with the exception of the interior surface of T.S. #026), or strongly oxidized. Comparisons of the average iron count readings from T.S. #028 with readings from slipped, pigmented or heavily oxidized sherd surfaces show that in almost all instances, the treated or heavily oxidized surfaces contain twice or more of the average amount of iron as do the plain sherd surfaces.
The final three technological sherd samples remaining to be discussed are those which had an apparent red pigment on their interior surfaces. These samples were T.S. #026, T.S. #027 and T.S. #032. Test Sample #026 was a shell-tempered body sherd in which the shell tempering was evidenced by thin linear voids visible in cross-section. The sherd's exterior surface was cordmarked then smoothed, and was pink (MUNSELL 7.5YR 7/4) in color. The core of the sherd was black (MUNSELL 7.5YR 2/0). An apparent but faint reddish pigment was evident on portions of the interior surface of the sherd. The interior surface was slightly pitted but was otherwise smooth and compact. No attempt was made to classify the color of the suspected pigment because it was faint and sparsely distributed. The unpigmented portions of the interior surface of T.S. #026 were reddish yellow in color (MUNSELL 7.5YR 6/6).

The second of the three sherds suspected to have a red pigment on its interior surface was T.S. #027. This sherd was a shell-tempered body sherd in which the temper was again evidenced only by the presence of thin, linear voids seen in the cross-section. The exterior surface of T.S. #027 was cordmarked, and was brown in color (MUNSELL 7.5YR 5/4). The core of the sherd was a dark grey (MUNSELL 5YR 4/1). The interior surface of the sherd was somewhat rough and pitted, but a suspected red pigment (MUNSELL 10R 4/6) was obvious across portions of the surface. This sherd was from the same provenience as T.S. #026, but general differences noted in the temper size, surface textures and presence or absence of smoothing between the sherds suggest that they are from two separate vessels.
Test Sample #032 was the final of the three sherds which had a suspected red pigment on the interior surface. Test Sample #032 was a shell-tempered body sherd in which the temper's presence was evidenced by thin, linear voids in cross-section. The exterior surface of the sherd was cordmarked then well-smoothed, and was grayish brown (MUNSELL 10YR 5/2) in color. The core color of the sherd was a very dark grey (MUNSELL 7.5YR 3/0). The interior surface of the sherd was smooth with some small natural inclusions protruding, and was evenly covered with an obvious dark red (MUNSELL 10R 3/6) pigment. The suspected pigment covered the entire interior surface of the sherd, except where small pits had been left by erosion. Test Sample #032 was from the Wymer-West general surface collection. However it's morphological similarities to the shell-tempered assemblage as a whole, and it's similarity to another apparently red pigmented sherd found in Feature 91-66 link it to the same component as the other shell-tempered sherds.

The average iron count readings from the exterior surfaces of T.S. #026, T.S. #027 and T.S. #032 were similar to or just slightly above those taken from both surfaces of T.S. #028. Such results were to be expected, as all of the sherd surfaces were judged to be plain, as opposed to pigmented. The average iron count reading from the apparent lightly and sparsely pigmented interior surface of T.S. #026 was also comparable to the readings taken from other plain surfaces. This result tended to suggest that the spectrometer was mainly analyzing the plain, largely exposed interior surface of the sherd. The results from T.S. #026 also suggest limits in detecting
surface coatings that the analyst should be aware of when choosing samples for x-ray fluorescence.

The average iron count readings taken from the interior surfaces of T.S. #027 and T.S. #032 were consistent with the larger amounts of apparent pigment observable on them. The readings were significantly higher than those from plain surfaces, and were closer in iron content to those from slipped or oxidized surfaces than to those from plain surfaces. The readings indicated, as suspected, that iron was a strong constituent of the apparent pigment observed on the two samples.

Pigments can be organic or inorganic. When used on unglazed pottery, such as is seen at the Wymer-West knoll and at many other prehistoric sites, pigments must generally meet two criteria: they must produce a color which is acceptable to the potter when fired, and they must be somewhat permanent after firing (Shepard 1965a: 31). All organic pigments other than carbon will burn during firing (Rice 1987:148; Rye 1981:40; Shepard 1965a:31), limiting the fired colors of these substances to grey or black (Rye 1981:40). Minerals can also burn off or undergo chemical changes during firing, altering the expected color outcome (Shepard 1965a:31). Other than carbon, manganese and the iron oxides are the only other pigment substances that would maintain their color on an unglazed pottery vessel after firing at the temperatures commonly achieved in prehistoric firings (Rice 1987:148; Rye 1981:40; Shepard 1965a:31).

The red interior pigmentation seen on some of the Wymer-West knoll sherds is thus believed to have been an intentional surface
coating applied prior to the firing of the vessels on which it appeared. The identification of iron as a significant constituent of the pigments and their red, apparently oxidized color suggests that firing has taken place. The preservation of the pigments during prehistoric usage, after deposition, and during contemporary tests involving washing and extended heating, soaking and boiling (Greve-Brown 1996) also suggests that the pigments were rendered permanent during the firing process. Fine clay naturally present in the pigment used is suspected to have facilitated the relatively permanent bonding of the pigment to the vessel surfaces during firing. The pigment remained intact during the contemporary testing procedures, helping to illustrate how the surface coating survived the wear and tear of prehistoric subsistence or ceremonial activities. Loss of pigment preservation on some samples is thus primarily attributed to leaching of iron caused by acidic soils at the Wymer-West knoll site or to simple erosion.

Summary and Conclusions

Rye (1981:48) notes that the incidence of major elements occurring in a ceramic body will usually show a contrast of approximately 20 to 30 percent, even when the clay pastes are derived from separate deposits. The contrast of average iron counts from the Wymer-West knoll sherd surfaces possessing a red pigment versus those sherd surfaces that were judged to be plain were close to 50 percent when the differences were compared, with the sole exception of iron count readings from T.S. #026, on which the pigment sub-
stance was poorly preserved. The significant contrast between average iron counts derived from pigmented versus plain surfaces, and the differing visual characteristics which distinguish the two tend to support the idea that the pigment substance was a unique and distinct surface treatment employed by prehistoric potters at the Wymer-West knoll site.

The average iron count readings derived from oxidized surfaces and from surfaces that were judged to be slipped were dramatically higher than the average iron count readings taken from the plain surfaces of T.S. #028. While a small apparent differentiation in average iron count was noted between the oxidized and apparently slipped categories, the average iron count readings from the two surface categories lay within a similar range. Both sherds with oxidized surfaces and surfaces suspected to be slipped produced similar average iron count readings when their opposite, respective oxidized or plain surfaces were analyzed.

It is difficult to explain the dramatic contrast in average iron content seen in surfaces that were either oxidized or apparently slipped when compared with the readings from the plain surfaces of T.S. #028. The differences may denote the usage of clay pastes from two or more different sources, or may alternately represent a broad range of average iron content in clay derived from one source. However, based on Rye's quoted percentages by which major elements in clays, even from different sources, should vary, both of these explanations are problematic. Clay paste sourcing and paste analysis, coupled with determination of absolute iron values and of amount of
iron variation within each clay source may be useful in future re-
search for explaining the noted variations in iron content.

The similarity of average iron count readings between the plain
and apparently slipped surfaces of T.S. #033 can be easily explained
by the suggestion that the same or similar clay source may have
been used to prepare both the body paste and the slip. If the ex-
terior surface of T.S. #033 does contain a slip, the differential color
development between the two surfaces with a similar iron content
may be explained by the fact that the fine clay particles of the slip
contained less organic material and could oxidize more readily. Other
aspects of preparation and firing may also have influenced the visual
differences noted.

It is more difficult to reconcile the similarities between the
average iron counts derived from those sherd surfaces that were ox-
idized compared with those suspected to be slipped. The similarities
could again be attributed to the use of similar clay pastes for body
and slip preparation, but the similar average iron count readings
between the two categories make it difficult to confidently distin-
guish slipped from oxidized surfaces. Test Sample #034 is a good
case in point. The sherd possesses a possible red slip on part of
the exterior surface, but the rest of that surface and the interior
surface as well are oxidized. The average iron count readings from
this sherd's surfaces are similar to each other and to the readings
from both oxidized surfaces of T.S. #020. The combination of appar-
ent slipping and oxidation on the exterior surface of T.S. #034 may
have complicated the spectrometer's reading of iron content from that
surface. Test Sample #034 is less comparable to the other two sherds with apparent red slipping, and to the shell-tempered assemblage in general, as it is a thick body sherd tempered with both shell and grit.

The strong surface oxidation seen on T.S. #020 is primarily concluded to be due to the sherd’s relative thinness and it’s lack of organic content, factors which allowed oxidation to occur during firing. The oxidation of the surfaces on T.S. #034 is viewed as primarily being the result of variable firing conditions. The two samples share a lack or burning off of carbonaceous material during firing, a similar level of apparent porosity and a similar, relatively high iron content. These factors are concluded to have been intricately involved in the oxidation process of both sherds. The high organic content of the majority of the ceramics in the Wymer-West knoll assemblage, especially in the form of preserved shell temper, is believed to be a main factor which prevented oxidation from occurring more often or more dramatically. The rapid, variable firing conditions posited to have existed at the site also are believed to have prevented more consistent and dramatic oxidation of ceramic surfaces.

The two rim sherds with an apparent exterior red slip were T.S. AU25 and T.S. #033 (Appendix A). Both sherds were shell-tempered rim sherds with similar morphologies. The average iron count readings derived from the surface with the suspected slip (T.S. #033; the readings from the red-slipped surface of T.S. AU25 were unusable) did not dramatically distinguish that surface from the
plain, opposite surfaces or from the surfaces of the sherds that were oxidized. However, the placement, color and texture of the apparent slipping on both rims is distinctive from simply oxidized surfaces, and does suggest that potters purposefully applied a slip to the rim sherds. The restriction of the apparent slip coating to a thin layer on the vessel surfaces, versus the penetration below the vessel surface of oxidized zones also supports this view.

The dramatic contrast between red pigmented versus plain surfaces determined through X-ray fluorescence testing suggests that the pigmented surfaces represent a distinctive surface coating which is relatively high in iron content. The permanence and oxidized color of the red pigmentation supports the conclusion that the coating was purposefully applied before firing, versus deposited on post-fired vessels. It is unknown what purpose the red pigmentation of some vessel surfaces may have served, although it may have had some functional value. Ceremonial use of vessels with such a surface coating must also be considered. The relationship of the red pigmented to the red-slipped ceramics, if any, is unknown.
CHAPTER III

PETROGRAPHIC THIN SECTION ANALYSIS

Introduction

Petrographic thin sections of Mississippian ceramics have most commonly been used by archaeologists to characterize the paste matrix composition of sampled vessels or sherds. Such studies have necessarily included the location of potential clay paste sources, and comparison of the clay source composition with that of the prepared thin sections (Milner 1984a; Porter 1964, 1966). Research projects which have employed such methods have produced results that aided in the descriptive characterization of ceramic types and in the distinction of locally produced ceramics from outside trade wares. Subjective or quantifiable data concerning aspects of the clay paste, natural inclusions, and temper have been commonly recorded in thin section studies. Petrographic thin sections have also been used for such purposes as examining the effects of firing on ceramic paste matrix (Tankersley and Meinhart 1982) and reclassifying a ceramic type which was mistakenly categorized based on its stylistic attributes (Stoltman 1989).
Research Objectives

The objective of thin section analysis of a collection of sherds from the Wymer-West knoll assemblage was two-fold. The first purpose of the thin section analysis was to identify and characterize the temper, porosity, mineral inclusions, and paste matrix of the ceramics chosen for sampling. The second objective was to use the quantified information to compare sherds thought to have been locally produced with sherds that were suspected to have been imported to the Wymer-West knoll. Plain-surfaced sherds which exhibited surface treatments of either exterior red slipping or blackening and burnishing were particularly considered as possible trade items, as such ceramics had not been previously found or described in the region. It was hypothesized that, if the occupants of the Wymer-West knoll were an intrusive Mississippian group who adopted some Late Woodland practices (especially in the form of cordmarking ceramics), then the red-slipped and blackened, burnished ceramics were probably not imported. Alternatively, it was hypothesized that, if the occupants of the site were an indigenous Late Woodland group with some Mississippian influences, then the red-slipped and blackened, burnished ceramics may have been imported in special functional contexts. The thin sections were further used, in a separate study, to characterize the technological attributes of the shell-tempered assemblage, and to examine the functional possibilities of the represented vessels based on their technological attributes (Greve-Brown 1996).

The author purposefully chose in this study to provide only a general description of the clay paste matrix and mineral inclusions
seen in thin section. While the tremendous benefits of clay paste analysis are readily acknowledged, the time and expense of clay sourcing and of preparing thin sections for a more detailed paste analysis made such an approach not feasible in this research.

Ceramic Sample

Thirty-five sherds were chosen to serve as the basis for the thin section and other analyses (Chapter II of this thesis; Greve-Brown 1996). The sherds were derived from well-documented site contexts, including ten feature and two unit proveniences. One sherd from the general surface collection, which had physical characteristics that strongly suggested its connection to other ceramics found in excavation, and one shell and grit-tempered sherd from the plow zone of Unit S were also included in the sample for comparative purposes.

Several criteria were considered important in the selection of sherds that would be thin sectioned. The majority of the sherds used were chosen to be representative of the "typical" cordmarked, shell-tempered pottery found at the site, in order to provide a representative sample of the ceramics which were believed to have been produced at the site. Unusual sherds which showed variations of manufacturing and firing were also included in the sample. These sherds, including the potentially imported, red-slipped and blackened, burnished ceramics were to be compared against the more "typical" vessels. Sherds were selected with consideration for their compositional integrity and good preservation of surface treatments. Sherds were chosen to be large enough for thin sectioning (about the size of
a quarter or larger) and the other experiments (Chapter II of this thesis; Greve-Brown 1996), but varying sizes and thicknesses were also included in the sample in order to adequately represent vessel variation and the frequency of breakage amongst vessels with different compositions. The number of sherds in the sample was considered adequate after ceramics from all proveniences were examined, and well-preserved sherds of the appropriate size were selected to represent both the typical shell-tempered assemblage and the recognized variants. Certain proveniences could not be sampled because the ceramics from those contexts were too small or poorly preserved to identify sherd traits and to perform the intended experiments.

The sample of 35 Wymer-West knoll sherds that were thin sectioned included 29 shell-tempered sherds (Appendix C). The majority of the shell-tempered sherds had cordmarked exterior surfaces, which were either randomly marked with a cord-wrapped paddle or parallel-impressed with a cord-wrapped stick. Some of the cord-impressions exhibited a net-like weave, which may also have been produced by rolling with a cord-wrapped stick. The author produced a similar pattern through experimentation by wrapping a dowel with a length of cordage and rolling the wrapped dowel across a leather-hard clay surface (see Hurley 1979:104,105, Cord Number 261). It is possible that such parallel or net-like impressions represent decorative motifs on the ceramics, although the limited quantity and small size of sherds with such surface impressions make it difficult to confirm this possibility. Certain of the cordmarked sherd surfaces also evidenced varying degrees of smoothing. Interior surfaces on the cordmarked,
shell-tempered sherds were generally plain, but three of the sherds sampled represented a portion of the collection that bore a red pigment across the interior surface (T.S. #026, T.S. #027, T.S. #032) (Appendix C).

Three less typical sherds, suspected to represent imported vessels, were also included in the sample (Appendix C). These included a short, everted rim sherd with a thin red slip across the exterior rim and lip (T.S. #033); a body sherd with both surfaces plain, smooth and blackened (T.S. #012); and a body sherd with two plain surfaces, the exterior of which was blackened and burnished (T.S. #035). The latter of the three sherds resembles the Mississippian ceramic type Powell Plain (Garland 1991).

The other six sherds which were included in the thin section sample for comparative purposes (Appendix C) included a grit-tempered sherd of the Early Woodland type Marion Thick (T.S. #001); two grit-tempered, smoothed, cordmarked sherds (T.S. #009, T.S. #013); one cordmarked, smoothed sherd with a sandy paste in which no obvious tempering agent was recognized (T.S. #031); one cordmarked, smoothed sherd tempered with shell and grit which was oxidized on both surfaces and appeared to have a thin red slip on the exterior surface (T.S. #034); and a cordmarked, evenly oxidized sherd in which the tempering agent could not be determined (T.S. #020). Two of the grit-tempered, cordmarked, smoothed sherds (T.S. #009, T.S. #013) were originally believed to contain a mixed temper of shell and grit, based on the appearance of their thin, laminar cross-sections which
apparently contained linear, shell-like voids. However, thin sectioning later revealed that the sherds were tempered solely with grit.

It was impossible to determine the percentages of vessel categories that were sampled during thin sectioning because most body sherds could not be refitted or associated with particular rim sherds. The rare rim sherds that could be refitted with other rim sherds or with body sherds were not used in thin sectioning, but rather were preserved for the information on vessel structure that they represented. However, the majority of the rim sherds in the collection were shell-tempered, everted rims from cordmarked jars, and the majority of the sherds used in the thin sectioning were shell-tempered, cordmarked body sherds. The information derived from the shell-tempered thin sections was therefore assumed to be a representative if unquantifiable sampling of the typical shell-tempered vessels found at the site.

Only two shell-tempered, everted rim jars with a red slip across the exterior rim and lip are represented in the ceramic collection, and one of the rims was thin sectioned, providing a 50% sampling of jars with such a rim treatment. No rims were recovered from the Wymer-West knoll that could be associated with the three shell-tempered, exterior blackened, burnished sherds in the collection. Two of the three sherds fit together and one of those two was thin sectioned. The third sherd possessed characteristics that suggested it was derived from a separate vessel, so assuming that the three unique sherds represented two distinct vessels, 50% of the shell-tempered, blackened, burnished vessel category from the site was also sampled.
However, the author readily admits that, because of the small size of the total sample, the percentage of sherds sampled is not statistically significant.

Other sherds representative of vessels with variant traits could not be confidently classified with regard to percentages of categories sampled, both because they could not be definitely associated with rim sherds, and because they could be associated with numerous similar body sherds in the collection, but not refitted and grouped to determine vessel count.

The process of preparing the thin sections is described in detail in a separate report (Greve-Brown 1996).

Point Counts and Thin Section Analysis

Point counting, a standard procedure used in geology to analyze thin sections of rock specimens, utilizes a method of counting and measuring a fixed number of minerals in each sample examined. Point counting has been adopted by archaeologists in order to analyze the mineralogy of ceramic thin sections (Rice 1987:376, 379; Rigby 1953), and was advocated and utilized for that purpose as early as the 1930s by pioneer ceramic technologist Anna Shepard (1936, 1965b). Some researchers have insisted that the point counting procedure derived from geology must be rigidly adhered to when studying thin section mineralogy (Middleton et al. 1985). However, others have found that a modified point count procedure may be better suited to the research questions and objectives of some ceramic analyses (Stoltman 1989).
Middleton et al. (1985:64-71) examined various procedures used to sample grains in thin section which are usually utilized in geology, including the standard point count procedure and a number of its common variants. The researchers noted that thin section analysis was most often used in order to derive a grain-size distribution figure which could be statistically manipulated. The grain-size distribution, in other words, expresses the relative area occupied by each determined size category of grain in a particular thin section. Various grain sampling procedures used to analyze thin sections were evaluated in terms of their accuracy and their potential towards biased results. Middleton and colleagues concluded that the typical point count procedure used in most textural analyses, which measures grains that are intercepted on a two-dimensional grid, should not be altered to fit individual researcher's needs for three reasons: the physical meaning of the results would be lost, biases would be introduced, and comparisons could not be made with other point count studies. These conclusions, however, are not always applicable to the study of ceramic thin sections, unless the researcher is doing a mineralogical analysis of ceramic pastes in which a standard petrographic point count procedure will yield meaningful data.

Time and financial constraints precluded a mineralogical paste analysis of the ceramic thin sections from the Wymer-West knoll. The analysis was instead focussed on obtaining representative percentages of the temper, pore spaces, mineral inclusions and paste matrix that were present in each thin section. Such an analysis was more feasible within the time and budget available to the author, and based on
previous research (Stoltman 1989), was believed to be an appropriate and useful method for addressing the question of imported versus locally produced ceramics at the Wymer-West knoll.

Crushed shell was the primary tempering agent identified and used in the Wymer-West knoll ceramics. A few sherds were tempered with grit, or with a mixture of shell and grit, but these sherds were either in the minority, or were unassociated with the main, shell-tempered component. Shell has a laminar or layered composition, and generally has a long, thin, needle-like appearance when viewed in a ceramic cross-section. Shell temper seen in thin sections which are cut parallel with the vessel wall can appear as angular or irregular, somewhat rounded fragments which usually have one axis noticeably longer than the other. While shell as a tempering agent may be crushed by the potter to a somewhat uniform size range, shell is unique in that it is not a rock or mineral with a standard manner of cleavage, but rather is a crushed organic substance which may exhibit a considerable range of shapes in thin section. The range of shapes possible with shell temper in ceramic thin section complicates the derivation of a "grain-size" distribution more commonly pursued in paste characterization studies.

Pore spaces observed on the surfaces of ceramics or in ceramic cross sections may simply appear as small, rounded openings. However, pores viewed in thin sections cut parallel with the vessel wall exhibit a wide variety of shapes and sizes. Some closed pores may be small and relatively round, while other pores may be long, thin and irregular in shape, with various spidery appendages leading off in
different directions (see Rice 1987:Figure 12.3). The many possible sizes and shapes of pore spaces in ceramic thin sections also complicate the documentation of pores with a standard petrographic point count procedure which records a grain-size distribution.

The presence of shell (or grit) temper, shell (or grit) voids, pore spaces, mineral inclusions, and paste matrix were noted during thin section analysis of the Wymer-West knoll specimens. Analysis of the thin sections was designed to derive percentages of each of these categories represented in a standardized area of a slide during a standardized counting procedure. The analysis was also designed to derive a range and average size for the temper, voids and pore spaces examined in each thin section, and so measurements were taken to that end. A variant of a technique developed by Stoltman (1989), whose technique was modeled from the standard point counting procedure, was found to be quite useful when paired with the mentioned research objectives.

Stoltman developed a variant of point counting which allowed him to express as percentages the individual particles occurring in the categories of temper, sand, silt, and matrix in a given thin section. Particles intercepted during the procedure were measured to distinguish silt (not exceeding 0.0625 mm), grit, and sand categories (exceeding 0.0625 mm). Grit and sand were further distinguished on the basis of contrasting size, shape, and composition. Sand was typically smaller, rounded in shape, and simple in composition. Grit, in contrast, was larger on average, was angular, and was more complex in composition. Stoltman's approach varied from a standard petro-
graphic point count in that it did not detail categories of all mineral-size distributions, but rather focussed on obtaining represented percentages of those categories of inclusions that had particular relevance to his research. The categories, expressed as percentages, provided a quantitative ratio of sherd composition which could be easily compared with the results from similar studies (1989:148,149).

It must be noted that standard point count procedures determine the relative area of a slide covered by each size category of inclusion, and not a numerical count of each grain examined (Middleton et al. 1985:71).

Stoltman (1989:149) suggested that concerns about biasing the grain sizes derived from a given thin section could be addressed by making the point count interval utilized (or the amount of measured space between intercepts) the same as or greater than the largest particle noted in the ceramic sample. This would prevent the larger grains from being intercepted and measured more than once. Stoltman utilized a 1-mm point count interval, and assigned the particles intercepted during each point count to one of five categories (matrix, silt, sand, grit temper, or void).

Stoltman (1989:151-152) conducted tests to determine the sources and amounts of error in his procedure. He did comparative tests on thin sections from the same ceramic vessel, and concluded that results derived from sherds from the same vessel should differ from each other by less than seven percent. He also concluded from the tests that sampling error in thin section analyses was generally minimal, providing that at least 100 point counts were taken from each thin
section. Other tests to determine the appropriate number of point counts necessary when sampling a thin section have suggested anywhere from 50 to 200 counts to be adequate, providing that the points counted are well distributed throughout the thin section (Wandibba 1982:75).

Stoltman also repeated twice the point counts of a number of the thin sections analyzed, in order to check for error occurring in the counting procedure. He concluded that the accuracy of each point count could be expected to meet or exceed a level of 95% and he suggested, depending on the particular analysis being done, that a single point count of each thin section could provide data that was both significant and dependable (1989:152-3,157).

The standard point count procedure generally used for mineralogical analysis of ceramic thin sections, as previously explained, yields a grain-size distribution figure which can be statistically manipulated (Middleton et al. 1989:64). Such a point count procedure is especially useful when conducting a mineralogical paste analysis of ceramic thin sections. However, in the case of the Wymer ceramic thin sections, a percentage representation of specific categories (temper particle, temper void, pore space, mineral inclusion, paste matrix) in each sample was sought by the author. Stoltman's described method of point counting was ideally suited to this purpose, and a variant of the standard point count procedure was thus adapted from Stoltman's (1989) variation on the original. The technique used with the Wymer-West knoll thin sections was similar to Stoltman's in that objects examined with the microscope during the point count
were assigned to one of five categories, and the total in each category was expressed as a percentage, providing a quantitative, comparable ratio of sherd composition for the specimen examined. Like Stoltman's procedure, the point count used with the Wymer-West knoll thin sections yielded a numerical result, rather than a representation of the relative area covered by various size grades of inclusions. The procedure used on the Wymer thin sections was also like that which was used by Stoltman in that it focussed on categories which were specifically significant to the research design, rather than on obtaining an across the board estimate of all thin section constituents. Temper particles and voids, and pore spaces were measured when they were intersected during the point counting. While Stoltman measured particles in his analysis to distinguish and categorize sand and grit, the measurements taken from particles in the Wymer thin sections were rather for the purpose of obtaining a size average and range for each category represented in a given sample. The measurements were taken for comparative purposes as well, in order to characterize the shell-tempered assemblage as a whole.

It was decided that a counting interval of 100 counts per thin section would suffice to yield desired and meaningful information from the Wymer-West knoll thin sections. This decision was based on a review of sampling theory and on procedures found useful by other researchers (Middleton et al. 1985; Stoltman 1989; Wandibba 1982), as well as on the size of the thin section samples and on the sizes and shapes of the inclusions which they contained. The accuracy of results from the counting interval used, and the time it would take to...
analyze each thin section were also considered. A point count was performed once on each thin section, based on Stoltman's findings of the high accuracy level and meaningful information provided by just one count (1989:152-153,157).

A 1 mm and 2 mm counting interval were sampled on T.S. #002, a shell-tempered sherd sample (T.S. #001, a grit-tempered, Marion Thick sherd was counted after the interval was decided for the more common shell-tempered ceramics). The thin section of T.S. #002 was cut parallel with the body of the sherd, but the shell temper appeared as long, narrow, linear inclusions or voids in the thin section. One hundred counts were made on the specimen, using each counting interval once, and the results were recorded in the appropriate categories. The 1 mm counting interval did not significantly alter the number of temper particles or voids, pore spaces or paste matrix locales that were intersected during the 2 mm counting interval, although the smaller interval did detect two mineral inclusions that the larger one did not. Both intervals were counted while moving back and forth across a horizontal plane, parallel with the direction of the long axis of the shell temper. The 2 mm counting interval was next tested by moving up and down across a vertical plane, or perpendicular to the orientation of the long axis of the shell temper in the thin section. The counts in the main categories of interest again remained largely similar, except for the fact that the horizontal movement intercepted two small mineral inclusions. The larger counting interval of 2 mm was ultimately decided upon for two reasons.
The difference in results produced by the 1 mm and 2 mm point count intervals was insignificant, with the main difference being the intersection of two mineral inclusions during the 1 mm count. The category of mineral inclusions was not of particular interest in the analysis, and the 2 mm interval produced results in the more significant categories which were very similar to the results obtained from the 1 mm interval. The larger counting interval was also preferable in that it produced far less multiple intercepts. In other words, large inclusions were much less likely to be intercepted twice. Inclusions that were intercepted twice were counted only once, since a numerical percentage, rather than an area measurement was desired.

A 0.5 mm interval had to be used on 12 of the 35 thin sections prepared, because the area of those thin sections was too small to allow for a larger counting interval. A concern with using the smaller interval on several of the thin sections was that it would introduce a strong bias, and thus, make the results incomparable to those obtained with the larger counting interval. A smaller counting interval had been shown to intercept smaller minerals that the 2 mm interval did not. However, no significant differences were noted between the two counting intervals when it came to the results recorded in the categories of temper, temper void and pore space. Objects recorded in the three categories generally tended to be larger than the natural mineral inclusions in the paste, and so were intercepted by both counting intervals. It seemed reasonable to assume then, that the 0.5 mm interval would also produce similar results in those categories.
Another concern with the use of the 0.5 mm interval was that it would result in frequent multiple intercepts, or in repeated occurrences under the cross hairs of the larger objects in a thin section. Since the objective of the point count was to assign each constituent in a thin section to a category, and to represent the amount of each constituent present as a percentage out of 100 (counts), objects that were intercepted more than once were counted only once. Thus, even though 100 counts were taken on each sample, in a few cases the total of the category percentages from a thin section will add up to slightly less than 100. Multiple intercepts, however, did not have a significant effect on the overall results.

A final concern with the use of the smaller, 0.5 mm counting interval on some of the thin sections was that the tighter sample of objects in the thin section would not be an adequate representation of the vessel from which it came. However, it was assumed that though vessel composition might vary from part to part, potters tended to prepare a relatively uniform paste mixture. This is a fairly basic assumption which justifies the practice of thin sectioning in order to characterize ceramic assemblages. Given the small-size area of the thin sections on which the 0.5 mm counting interval had to be used, the point counts done represented a sampling of nearly the entire area of each thin section. None of the sherds thin-sectioned could be shown to be derived from the same vessel, so it was impossible to judge if those slides on which the smaller counting interval was used produced biased results which did not represent their parent vessels.
Comparisons of results from the 2 mm and 0.5 mm counting interval did not show any dramatic differences in the main categories of interest. It was believed that the 0.5 mm counting interval used to sample some of the Wymer-West knoll thin sections produced meaningful and comparable results that did not contain a significant degree of bias. The 2 mm interval was preferred, and was used whenever possible for the previously stated reasons. The counting interval used with each sample is noted in the individual descriptions of the thin sections (Appendix D).

There appeared to be no significant differences in the amounts of intercepts recorded in each category when a vertical, up and down motion was used instead of a horizontal, back and forth motion, and the horizontal pattern of movement facilitated the easiest means of measuring the longest axes of shell temper particles. When the thin section slides were mounted on the microscope platform, the manner in which the shell-tempered samples were cut generally led to the longest axes of the temper being oriented parallel with the direction of the horizontal movement. Thus, the temper particles could be measured by simply moving the cross-hairs of the microscope from one side of a particle to the other, and noting the distance moved on a scale printed on the edge of the stage.

A typical point count proceeded as follows: the ceramic thin section slide to be analyzed was secured in position on the rotatable stage which was mounted on the petrographic microscope platform. A plastic template with a rectangular opening which isolated the area in which the point count would be done was secured over the thin sec-
tion. The template was centered over the thin section, in order to avoid dealing with feathered edges or with going off the edge of the sample. The two knobs which allowed horizontal and vertical movement of the stage on which the slide was mounted were initially calibrated to cause the desired increment to be moved for the point count procedure. The actual point count began by starting at the upper left-hand corner of the template covering the thin section and using the calibrated knobs to move to the first count in the first line of the slide. An audible "click" of each knob designated a movement of one increment. Each item intercepted by the cross-hairs seen in the ocular of the microscope after moving one measured increment was identified and tabulated in the appropriate category. Temper particles, temper voids and pore spaces were also measured along their longest axes and the measurements were recorded. Ten counts were taken while using the horizontal-control knob to move to the right across the first line. The vertical control knob was then used to move down a line, and another ten counts were taken while moving to the left across the sample. Ten counts in each of ten lines were taken while moving in this horizontal, back and forth motion across each thin section. A point count of one thin section took approximately one hour to complete using the outlined procedure.

A manual tabulator with rotating dials was used during the point count to tally the items noted. The tabulator had several rotating dials which could be set and reset at zero, along with corresponding, typewriter-like keys which could be depressed to advance each dial by one increment. Five general categories were
recorded during the point counts of the Wymer-West knoll thin sections: temper particle, temper void, pore space, mineral inclusion and paste matrix. The keys of the tabulator were accordingly labeled with the following categories: shell void, shell temper, pore space, mineral inclusion, paste matrix, grit temper and grit void. The tabulator provided a fast and accurate means of tallying the objects counted in each thin section.

It is necessary and appropriate to define exactly what was meant by the terms used to designate the categories that were examined and recorded from the thin sections. The term "temper" commonly refers to an aplastic material which potters use to facilitate clay workability and to reduce vessel shrinkage during the drying and firing of ceramics (Rye 1981:31; Shepard 1965a:25). Temper may also modify other properties of a clay (Rice 1987:407) and in the case of shell tempering, like that seen at the Wymer-West knoll site, may be chosen by potters for its effects on vessel performance. The term "temper" was used in this case to designate a substance judged by the analyst to have been purposefully added by Wymer potters to the clay which was utilized during ceramic manufacture. Temper particles may be difficult to identify in some thin section analyses. However, the distinctiveness of shell temper in thin section was readily identifiable in this case. Grit temper, prepared by crushing stone, was also relatively easy to identify in the few thin sections which contained it. Grit temper was distinguishable from natural inclusions by it's size and angular shape (natural inclusions tended to be smaller and rounded).
"Temper void" refers to an opening seen in thin section where a temper particle was judged by the analyst to have been. Shell voids are quite common in shell-tempered ceramics, due to the fact that shell may undergo chemical changes and dissolve during firing, or be leached from sherds after deposition. Shell voids were distinguishable from pore spaces or other voids by their shape, which was generally thin, elongated and linear or elongated with rounded edges. Shell void, rather than shell temper, was used as an identifier if a particle of shell was partially or completely decomposed. Grit void was included as a category because grit temper particles have the tendency to be plucked from sherds during the grinding of thin sections. Plucking of grit did not appear to be a particular problem during the thin sectioning of the Wymer-West knoll sherds, and no grit voids were recorded during point counting.

The term "pore space" was used to refer to natural pockets or spaces occurring within the paste matrix of a ceramic vessel. Pore spaces were easily distinguished from temper voids in thin section, based on their distinctive shapes.

"Mineral inclusion" was a term which designated a particle in the ceramic paste matrix that was judged by the analyst to have been a natural part of the raw clay that potters selected to use in the manufacture of their vessels. Natural mineral inclusions were generally much smaller than added temper particles, and were quite rounded in appearance. No systematic attempt was made to identify the types of natural mineral inclusions seen in the thin sections, since a mineralogical analysis was not part of the study.
"Paste matrix" was a term used to designate fired clay particles viewed under the microscope. This category was used when an intercept revealed no temper particles, temper voids, pore spaces or mineral inclusions. The percentage of paste matrix intercepted in each thin section gives a general idea of the density of the other vessel constituents.

The shell temper particles or voids observed during a point count of each thin section were measured across their longest axis (Milner 1984b:173:Appendix I), and an average temper size and size range was calculated for each sample. Grit temper particles were also measured and their measurements summarized in the same manner. Shell voids were, in most cases, readily distinguishable from pore spaces due to their shape and sparse content of tiny shell remnants. Shell voids were treated the same as preserved shell for the sake of taking measurements, but were recorded separately from preserved shell during the point counts. The general shape and arrangement of shell in each thin section was also described. The thin sections were further used, in some instances, simply to confirm the type of temper present. Two of the sherds sampled were originally believed to be tempered with both shell and grit because they had thin, laminar cross-sections which evidenced shell-like voids. The thin sections, however, revealed that both sherds were tempered solely with grit. The amount of temper noted in a standard-size area of a given sample was recorded as a percentage identified out of 100 counts.

Pore spaces were, in most cases, readily distinguishable from shell temper voids based on their shape. It was generally noted
whether pores seen in thin section were open or closed (i.e. open to a sherd surface or sealed off within the interior of the sherd). However, because most of the sherds that were thin-sectioned were cut parallel to the vessel wall, and represented broken pieces of a vessel, an open or closed pore seen in the thin section did not necessarily represent the same in an intact vessel. Pore shapes were also recorded. For example, loop and channel pores (thin, elongated pores with larger rounded ends) and closed, rounded or irregular shaped pores were common to the collection (see Rice 1987:350). Pore spaces were measured across their longest noted axis, and a pore size average and/or range was prepared for each thin section examined. The number of pores identified in a standard size area was expressed as a percentage amount intercepted during a 100-point count.

Clay paste matrix and inclusions judged to be natural were noted when they were intercepted during a thin section point count. Natural inclusions in the paste were measured across their longest visible surface, and a size average was recorded for the inclusions examined in each thin section. Clay paste matrix and natural inclusion content were expressed separately as a percentage of a 100-point count of a given thin section area. Thin section analysis also contributed to the general description of the paste matrix and the shape of natural inclusions.

Thin Section Analysis and Point Count Results

The results of the analysis and point counts of the 35 Wymer-West knoll ceramic thin sections are detailed in the following section.
Table 4 summarizes the percentages of the various elements of the ceramic composition that were present in each thin section. Appendix D contains the complete results of the thin section analysis of each ceramic sample. Sherd sample interiors were plain unless otherwise noted. All particles, voids and pore spaces were measured across their longest axes. The ranges and averages given for shell temper in each thin section combine measurements taken from both intact shell temper particles and shell temper voids.

Discussion

The specific characteristics of the categories of temper, pore space, paste matrix and mineral inclusions are discussed in detail in a separate report, and are utilized in a discussion of ceramic technology and vessel function (Greve-Brown 1996). However, this discussion will utilize the thin section results detailed here primarily to compare those vessels that are suspected to represent ceramics produced at the Wymer-West knoll with vessels that may have been imported to the site. The locally produced vessels were presumed, at the beginning of the analysis, to be those shell-tempered vessels with cord-marked, undecorated surfaces. The vessels believed to have been locally produced were also expected to evidence a relatively obvious amount of sand particles in thin section, since these particles were evident to the naked eye when intact samples were examined. The sand was believed to be the natural result of deriving clay for ceramic production from the St. Joseph River, an environment in which a large amount of sand and gravel would commonly be found.
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* Damaged during thin section process; not used in analysis.
The relative consistency and similarity of the results derived from those samples support the initial assumption. The specific ceramics considered as possible imports were T.S. #033, a rim sherd with an exterior red slip, and T.S. #035, a body sherd with a blackened, burnished exterior surface.

Some variation is evident in the overall compositions of the thin sections of the 27 shell-tempered sherds that produced usable results, but a typical range of variation can be noted for the majority of the samples. Shell temper ranges from 0% to 23%, with the majority of the samples (20) falling between 4% and 13%. Pore spaces range from 0% to 27%, but most of the samples (24) lie within a range of 0% to 9%. Mineral inclusions occur in a range of 0% to 12%, with the majority of the samples (22) falling between 2% and 12%. The paste matrix of the vessels falls between 62% and 98%, with most of the samples (20) lying between 71% and 89%. Figure 3 illustrates and compares the overall and majority percentage ranges for each of these categories in which thin section results were recorded. The mean of each percentage distribution is also given. The overall measured size range for shell temper was from 0.25 to 4.25 mm, with the majority of the sherds (16) containing crushed shell temper particles which measured 2.0 mm or smaller. The average overall size of shell temper particles measured in the thin sections was 1.06 mm.

The thin section of T.S. #033 was derived from a shell-tempered, relatively short, sharply everted rim sherd which exhibited a red slip on the exterior rim and lip. The initial appearance of the sherd
Figure 3. Overall Percentage Ranges Compared With (*) Majority Percentage Ranges of Shell Temper, Pore Spaces, Mineral Inclusions, and Paste Matrix in Shell-Tempered Thin Sections.

(N = Number of thin sections)
suggested a vessel that was highly unusual when compared with the rest of the shell-tempered, cordmarked and otherwise undecorated ceramics at the Wymer-West knoll. The paste composition of this sample was also visibly unusual in that it contained very little sand, while the paste of ceramics suspected to have been locally produced was quite sandy. The overall composition of the sherd as seen in thin section further supported the uniqueness of the sample. The amount of shell temper present in T.S. #033 was relatively sparse (3%) when compared with the range of temper seen in the majority of shell-tempered sherds. The average size of the temper (.67 mm) was also quite fine when compared with the average size determined from all of the shell temper that was measured (1.06 mm). Test Sample #033 also contained no identifiable pore spaces, and mineral inclusions in the sample (3%) were relatively small and sparse. The ratio of paste matrix to other constituents in the sample was significantly higher (96%) than that seen in more typical sherd samples. The unusual physical appearance and the overall composition of T.S. #033, as seen in thin section, thus suggests that the vessel may have been imported to the site. Although a very similar red-slipped rim sherd (T.S. AU25) was not thin sectioned, the results derived from T.S. #033 present the possibility that this second vessel was also imported to the site.

The thin section of T.S. #035 was prepared from a shell-tempered body sherd which was blackened and burnished on the exterior surface. The sherd could not be associated with any rim sherds from the ceramic assemblage, so the type of vessel that it represents is
unknown. The surface treatment of the sherd, however, resembles that seen on the Mississippian ceramic type, Powell Plain (Griffin 1949; Vogel 1975). This surface treatment especially distinguished T.S. #035 from the typical shell-tempered, cordmarked ceramics at the Wymer-West knoll, and suggested that the vessel may have been imported to the site. However, overall compositional information from the thin section of the sample was not particularly conclusive. Although shell temper (5%), and mineral inclusion (3%) percentages in T.S. #035 fall in the low range of what occurs in more typical sherds, and the percentage of paste matrix in the sample is at the high end range (88%) of what is typical, the overall results are not so divergent as to conclusively suggest that the vessel was imported. The pore space percentage in the sample (4%) is about average. It is interesting that the average size of shell temper particles in the sample (.69 mm) indicates a relatively fine temper which is closer in size to that seen in T.S. #033 than to the collection's overall average shell temper size (1.06 mm). Unfortunately though, the sum of the evidence derived from the thin section of T.S. #035 does not provide conclusive proof that the represented vessel was imported. All of the category percentages derived from the thin section do fall within the ranges established as normal for the more typical ceramics from the site, and so may suggest that the vessel was locally produced. It is thus difficult to determine if another exterior blackened, burnished sherd in the assemblage with characteristics that suggest a second blackened, burnished vessel might also represent either a local or imported vessel, since it was not thin sectioned. This sherd is different from
T.S. #035 in that it has a blackened, unburnished interior surface, rather than a plain one.

T.S. #012 represents a third shell-tempered vessel with both surfaces plain, blackened and well-smoothed. However, burnishing is not evident on this sherd. The thin section analysis of this sample revealed an overall composition which fell within the typical range established for locally produced vessels. This sample is mentioned because, although it was not originally suspected to represent an imported vessel, its surface treatment may suggest that the Wymer potters were attempting to produce a local copy of a blackened, burnished vessel.

T.S. #026, T.S. #027 and T.S. #032 are the three ceramic samples with an interior red pigment coating which were utilized in the X-ray fluorescence testing. Unfortunately, T.S. #027 ground very poorly during the preparation of the thin sections, and was not usable in the subsequent analysis. The amount of shell temper in T.S. #032 is relatively abundant (13%), while the percentage of pore spaces (2%) and mineral inclusions (1%) is relatively sparse. However, the ratio of paste matrix (84%) to the rest of the constituents in the sample, and the average size of the shell temper (1.5 mm) are not particularly divergent from the results seen in potentially locally produced ceramics. It is difficult to determine, based on these results, if T.S. #032 represents a local or an imported vessel. The overall compositional results from T.S. #026, however, are more clearly distinguished from the established "typical" ranges. The results from the thin section analysis of T.S. #026 more closely match those derived from T.S. #033 (the
red-slipped, imported vessel) than they do the typical compositional
ranges established for locally produced vessels. Test Sample #026 has
very sparse shell temper (2%) with a very small size average (.38
mm). No pore spaces were intercepted during the analysis of the
sample, minerals were present but sparse (4%), and the percentage of
paste matrix was relatively high (94%). These results taken together
suggest that the vessel represented by T.S. #026 may also have been
imported to the Wymer-West knoll.

The red-slipped (T.S. #033) and blackened, burnished (T.S. #035)
ceramic sherds are the ceramic samples that were originally hypothe-
sized to represent vessels that were imported to the Wymer-West
knoll. However, the local versus imported status of a few other sam-
pies has been considered here either because of their similarity in
appearance to the original sherds in question, or because of the un-
usual results derived from thin sectioning. Although no hypotheses
about the following sherd samples were originally put forth, the dis-
tinctive results obtained from the analysis of their respective thin
sections deserve brief mention.

T.S. #004, a shell-tempered sherd with broad, parallel exterior
cordmarking, contains an unusually high percentage of shell temper
(23%) and a related low percentage of paste matrix (63%). The pore
(8%) and mineral (6%) percentages seen in the sample, however, fall
within the range of typical. The relatively large, average size of the
shell temper in T.S. #004 (2.025 mm) may explain, in part, why the
temper and paste percentage ratios appear comparatively unusual.
T.S. #007, a shell-tempered, cordmarked sherd, presents a similar case. The percentage of shell temper (7%) and mineral inclusions (4%) in the sherd are not unusual, but the percentage of pore spaces (27%) and paste matrix (62%) are. The relatively large size of the pore spaces present in this sample (2 - 6 mm) helps to explain why the pore space - paste matrix ratio diverges from the norm, that is, because the pores are large and abundant, and so take up more space.

It is thus suggested that accidents or intentional manipulations during the ceramic manufacturing process, rather than imported vessels from an outside source can be used to explain the unusual, overall compositions seen in the thin sections of T.S. #004 and T.S. #007.

T.S. #028, a shell-tempered sherd with a cordmarked, smoothed exterior, evidences a fairly normal amount of shell temper in thin section (6%). The shell particles (1.0 mm) are close in average size to the overall average shell particle size measured in all samples (1.06). However, the pore spaces (1%) and mineral inclusions (2%) in the sample are sparse, and the percentage of paste matrix is relatively high (91%).

T.S. #029, a shell-tempered sherd with a woven, cross-hatched impression on the exterior, is from the same feature provenience as T.S. #028, and exhibits a similar overall composition to it. The percentage of shell temper in T.S. #029 is also typical when compared to local sherds (5%), but the pore spaces (1%) and mineral inclusions (2%) are sparse, and the percentage of paste matrix is high (92%).
The average size of shell temper particles in T.S. #029 (0.83 mm) is smaller than that seen in T.S. #028.

The borderline low pore space and mineral percentages, and the borderline high percentages of paste matrix seen in T.S. #028 and T.S. #029 push the samples closer in composition to the vessels believed to have been imported to the Wymer-West knoll than to those believed to have been produced at the site. Test Sample #029 also exhibits an atypical surface treatment and a relatively fine, average shell temper particle size, as do other vessels believed to be imports. However, the overall results from these two samples are not as clearly divergent from the normal ranges previously established as are the results from some of the other thin sections. It is thus probable but not conclusive that T.S. #028 and T.S. #029 represent imported vessels.

T.S. #030, a shell-tempered sherd with a woven, cross-hatched impression on the exterior surface, has a relatively high percentage of shell temper (18%), no detected pore spaces, mineral inclusions within the range of average (11%), and a borderline low percentage of paste matrix (71%). The average size of the shell temper particles in the sample (1.21 mm) is not particularly large or small. It is possible that this sherd represents an imported vessel, given it's divergent overall composition and unusual surface treatment, but it is also possible that the sample composition simply represents an intended or accidental variation of manufacture.

The hypothesis that the blackened, burnished vessel (T.S. #035) recovered from the site was imported could not be confidently confirmed or disproved, as the results of the thin section analysis of
that vessel were inconclusive. Results from a second shell-tempered sherd on which both surfaces are blackened and well-smoothed (T.S. #012) indicate that the represented vessel was probably produced at the Wymer-West knoll. Test Sample #012 was not burnished, but otherwise strongly resembled the other three blackened, burnished sherds found at the site. The results from T.S. #012 therefore lend credence to the original hypothesis that the Wymer-West knoll occupants represented a Mississippian site-unit intrusion, since Mississippian-like vessels were potentially being produced at the site. The presence of shell-tempered, cordmarked ceramics at the site also supports the idea that the site occupants were producing Mississippian ceramics with some Late Woodland influences, especially in the form of cordmarking.

The overall thin section results from T.S. #033, the shell-tempered rim sherd with an exterior red slip, strongly supported the idea that the represented vessel was imported to the site. The results obtained from T.S. #026, a shell-tempered sherd with an interior red pigment were also divergent enough to support the idea that the represented vessel was probably an import. The possibility that such ceramics were imported lends credence to another portion of the original hypothesis, namely, that red-slipped (or pigmented) vessels may have been imported to the site in special functional contexts. Several other samples produced unusual results, some of which suggested additional possible imports which were not recognized or focussed on at the beginning of the analysis. However, none of the results were conclusive enough to do more than suggest that
these vessels were imported. It appears that other ceramic samples which exhibited unusual, overall compositions were more the result of accidental variations or intended manipulations during the manufacturing process.
CHAPTER IV

RED-SLIPPED AND BLACK-SURFACED CERAMICS IN SPACE AND TIME

Southwest Michigan

The two shell-tempered vessels found at Wymer which have red slipping on the plain exterior rim and lip regions appear similar to the type Cahokia Red Filmed (Category NN) in that they are globular jars with short, everted rims, and plain, red-slipped exteriors (Vogel 1975:99-101). Three shell-tempered body sherds with blackened, burnished exterior surfaces found at the Wymer-West knoll are representative of at least two vessels. No rim sherds were associated with the body sherds, so the types of vessels that they represent are unknown, but the surface finish of one vessel is strongly reminiscent of the ceramic type Powell Plain (Griffin 1949:49-51; Vogel 1975:90-93). The other vessel is different from Powell Plain in that it has a blackened interior surface. Cahokia Red-Filmed and Powell Plain ceramics are of course found at the type site, but this discussion of the distribution of red-slipped vessels will focus on the area between the Wymer site region and the middle and upper portions of the Illinois River valley, since evidence indicates that such is the area.
from which the Middle Mississippian occupation or influence seen at the Wymer-West knoll was most likely derived.

Mississippian-related sites in southwestern Michigan were first compared. No comparable shell-tempered, red-slipped or blackened, burnished ceramics were recovered at the nearby Moccasin Bluff site (Bettarel and Smith 1973). Three sites in the Kalamazoo River valley, located to the north of Wymer, were also examined for comparable ceramics. These included the Schwerdt (McAllister 1980), Elam (Garland 1989), and Allegan Dam (Spero 1979) sites. Although the ceramic assemblages from these sites contain relatively large amounts of shell-tempered ceramics, the assemblages evidence traits which are primarily derived from Upper Mississippian cultures and generally post-date the currently known extent of the main component at the Wymer-West knoll. Once again, no comparable red-slipped or blackened, burnished ceramics were found at the sites.

Indiana and Illinois

The Griesmer and Fifield sites (Faulkner 1972) in Indiana were next examined for shell-tempered ceramics with the emphasized surface treatments, but again no comparable vessels were found.

The occurrence of shell-tempered, red-slipped and black-sur­faced ceramics at more distant sites with which the ceramics from the
Wymer West Knoll were compared are summarized in Table 5. Ceramics from the site of Cahokia (Vogel 1975) are limited in the table to those of the types Powell Plain and Cahokia Red Filmed, since those are the types that the blackened, burnished and red-slipped ceramics from Wymer most closely resemble.

Red-slipped vessels are represented in minor quantities at both the Anker and Oak Forest sites in northeastern Illinois. Two shell-tempered, red-slipped bottles presumed to be trade items were recovered from Anker. Two interior red-slipped body sherds and a single rim sherd with a red-slipped exterior were found at Oak Forest. However, the ceramic assemblages at both of these sites also post-date the currently known time range of the main assemblage at the Wymer-West knoll, and appear to be mainly Upper Mississippian or Oneota in nature (Bluhm and Fenner 1961:145; Bluhm and Liss 1961:106).

Red slipping occurs on the exterior surfaces of seven shell-tempered body sherds at the Hoxie Farm site, which is located in the upper Illinois River Valley, but not at the Huber site, from which ceramics similar to those at Hoxie Farm were derived. The Hoxie Farm ceramics are referred to as "Upper Mississippian" and exhibit such combined decorative motifs as incising and punctates (Bluhm-Herold et al. 1990:26-28,34). The red-slipped Wymer ceramics, in contrast, exhibit no decorative motifs.
<table>
<thead>
<tr>
<th>Site and Reference</th>
<th>Ceramic or Vessel Type</th>
<th>#</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Assoc. Decor- C-14 Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anker (Bluhm and Liss 1961:106)</td>
<td>bottle</td>
<td>2</td>
<td>r.s.</td>
<td>-</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Oak Forest (Bluhm and Fenner 1961:145)</td>
<td>rim sherd</td>
<td>1</td>
<td>r.s.</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>body sherd</td>
<td>2</td>
<td>-</td>
<td>r.s.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hoxie Farm (Bluhm-Herold, et.al. 1990:34)</td>
<td>body sherd</td>
<td>7</td>
<td>r.s.</td>
<td>-</td>
<td>-</td>
<td>no</td>
</tr>
<tr>
<td>Fisher (Griffin 1966:278)</td>
<td>body sherd</td>
<td>1</td>
<td>b.s.</td>
<td>-</td>
<td>-</td>
<td>yes</td>
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</table>
Table 5--Continued

<table>
<thead>
<tr>
<th>Site and Reference</th>
<th>Ceramic or Vessel Type</th>
<th>#</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Assoc. Decoration Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rench (McConaughy 1991:101,102, 105,108-112)</td>
<td>rim sherd (Powell Plain)</td>
<td>16</td>
<td>b.s.(8)</td>
<td>b.s.(1)</td>
<td>b.s./b.s.(1)</td>
<td>A.D. 950-1020</td>
</tr>
<tr>
<td>Rench (McConaughy 1991:101,102, 105,108-112)</td>
<td>body sherd (Powell Plain)</td>
<td>3</td>
<td>b.s.</td>
<td>-</td>
<td>-</td>
<td>Same as Above</td>
</tr>
<tr>
<td>Rench (McConaughy 1991:101,102, 105,108-112)</td>
<td>Cahokia Red (Filmed jar)</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>r.s./r.s.</td>
<td>Same as Above</td>
</tr>
<tr>
<td>Rench (McConaughy 1991:101,102, 105,108-112)</td>
<td>Cahokia Red (Filmed bowl)</td>
<td>1</td>
<td>r.s.</td>
<td>-</td>
<td>-</td>
<td>Same as Above</td>
</tr>
<tr>
<td>Site and Reference</td>
<td>Ceramic or Vessel Type</td>
<td>#</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>Assoc. C-14 Decor. Dates</td>
</tr>
<tr>
<td>--------------------</td>
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<td>--------------------------</td>
</tr>
<tr>
<td>Rench (McConaughy 1991:101,102, 105,108-112)</td>
<td>Cahokia Red Filmed (shoulder sherd)</td>
<td>3</td>
<td>r.s.(2)</td>
<td>-</td>
<td>r.s./r.s.(1)</td>
<td>no</td>
</tr>
<tr>
<td>Rench (McConaughy 1991:101,102, 105,108-112)</td>
<td>Cahokia Red Filmed (body sherd)</td>
<td>50</td>
<td>r.s.</td>
<td>-</td>
<td>-</td>
<td>no</td>
</tr>
<tr>
<td>Dickson Mounds (Harn 1980:21)</td>
<td>Powell Plain Filmed (jar)</td>
<td>2</td>
<td>b.s.</td>
<td>-</td>
<td>-</td>
<td>no</td>
</tr>
<tr>
<td>Cahokia (Vogel 1975:77, 80,90,92,93, 99,100)</td>
<td>Cahokia Red Filmed (Category G - bowl)</td>
<td>113</td>
<td>b.s.(6)</td>
<td>-</td>
<td>-</td>
<td>no</td>
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</table>
Table 5--Continued

<table>
<thead>
<tr>
<th>Site and Reference</th>
<th>Ceramic or Vessel Type</th>
<th>#</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Assoc. Decoration Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cahokia (Vogel 1975:77, 80,90,92,93, 99,100)</td>
<td>Cahokia Red Filmed (Category J - bowl)</td>
<td>22</td>
<td>r.s.</td>
<td>-</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Cahokia (Vogel 1975:77, 80,90,92,93, 99,100)</td>
<td>Cahokia Red Filmed (Category NN - jar)</td>
<td>26</td>
<td>r.s.</td>
<td>-</td>
<td>-</td>
<td>no</td>
</tr>
<tr>
<td>Cahokia (Vogel 1975:77, 80,90,92,93, 99,100)</td>
<td>Powell Plain, var. rolled lip (Category AA -jar)</td>
<td>61</td>
<td>r.s.(26)</td>
<td>-</td>
<td>-</td>
<td>no</td>
</tr>
<tr>
<td>Cahokia (Vogel 1975:77, 80,90,92,93, 99,100)</td>
<td>Powell Plain var. extruded lip (Category BB - jar)</td>
<td>64</td>
<td>r.s.(27)</td>
<td>-</td>
<td>-</td>
<td>no</td>
</tr>
</tbody>
</table>
Table 5--Continued

A = Exterior Red-Slipped or Black-Surfaced  
B = Interior Red-Slipped or Black-Surfaced  
C = Exterior/Interior Red-Slipped or Black-Surfaced
One shell-tempered sherd with a blackened, smoothed and slightly burnished surface was found at the Fisher site in Illinois, but the sherd exhibited an engraved design on the surface. The approximate date of this sherd is unknown, but it is suggested that the sherd indicates connections with Cahokia and the Spoon River focus, so the represented vessel probably occurred relatively early in the Mississippian sequence (Griffin 1966:278).

The Rench site is located on the western bluffs of the Illinois River, approximately 20 kilometers north of Peoria, Illinois (McConaughy 1991:101). The ceramic assemblage from the site is primarily composed of grit and sand-tempered Canton Ware, which was locally produced at the site during the Late Woodland period. However, the assemblage also contains imported, Middle Mississippian ceramics of the types Powell Plain and Cahokia Red Filmed (McConaughy 1991:108,111).

Four radiocarbon dates from the Rench site range from A.D. 810 to A.D. 1020. The earliest of the four dates was derived from a pit containing Cahokia Red Filmed ceramics. Since these ceramics were believed to be from the same period as the structures from which the other dates were derived, the early date was assumed to be spurious. The remaining three dates range from A.D. 950 to A.D. 1020 (McCon-
McConaughy 1991:101,102,105), a time period which overlaps with the occurrence of Middle Mississippian ceramics at the Wymer-West knoll.

Thirty-seven percent of the ceramics at the Rench site were Mississippian, with the majority representing the type Powell Plain (McConaughy 1991:108). The three blackened, burnished body sherds found at Wymer are generally similar in surface treatment and surface finish to the Powell Plain ceramics found at Rench, and to the original type description (Griffin 1949:49-51; Vogel 1975:90-93).

Two vessels of the type Cahokia Red Filmed were also present at the Rench site. These differed slightly from the two similar vessels found at Wymer. The first vessel had a flattened, extruded lip similar to one vessel from Wymer, but the first Wymer vessel (Vessel AU25), and a second one with a rounded lip (Vessel AU24), were red-slipped on the exterior rims and lips only (see Appendix A), while the interior surface of the vessel from Rench was slipped as well. Another Cahokia Red Filmed vessel from Rench was slipped only on the exterior rim and lip, but the rim itself was straight, versus everted or extruded (McConaughy 1991:110,111).

Thin section comparisons of paste compositions in the Mississippian ceramics and other ceramics known to have been produced at the Rench site suggested that the Powell Plain and Cahokia Red Filmed vessels were imported, perhaps from the American Bottom. Both
ceramic types are characterized as having an evenly combined paste-temper mixture with little sand content. Ceramics local to the Rench site contrastingly evidence pastes made from sandy clays found in the site area (McConaughy 1991:110,111). The thin sectioning of one red-slipped rim sherd from the Wymer-West knoll which was similar to the type Cahokia Red Filmed (T.S. #033; Vessel AU24) also revealed that the vessel was probably imported. It had a paste composition which, similar to the Rench imports, contrasted with locally produced vessels in its lack of sand content. However, comparisons of point count results from the vessel with results derived from the Cahokia Red Filmed vessels at the Rench site show that the Wymer vessel was probably not obtained from the Rench site, and therefore did not likely originate from the American Bottom region. The Wymer vessel contains a higher paste matrix content (96%) and significantly lesser amounts of shell temper (3%) than the Rench vessels (74% ± 6.2 average paste matrix; 26% ± 6.4 average shell temper content). The shell temper present in the Wymer vessel is also finer (0.67 mm average) than that seen in the Rench vessels (2.37 mm ± 0.32) (McConaughy 1991:110,111:Table 6.5).

A comparison of the thin section of the blackened, burnished sherd from the Wymer-West knoll (T.S. #035) with thin section results from Powell Plain ceramics from the Rench site also revealed that the
represented Wymer vessel was probably not imported from Rench. The Rench ceramics (McConaughy 1991:110:Table 6.4) averaged a lower paste matrix (73% ± 4.8), a very sparse average sand content (0.4% ± 0.6), a much higher average shell temper content (26.6% ± 5.2) and a significantly larger average shell temper particle size (2.73 mm ± 0.26) than the Wymer vessel (paste matrix 88%; mineral inclusions 3%; shell temper 5%; shell temper average size 0.69 mm).

Blackened, burnished, Powell Plain ceramics were also identified at the Dickson Mounds site (two jars) (Harn 1980:21). Dickson Mounds is located west of the Illinois River near its confluence with the Spoon River in Fulton County, Illinois (Harn 1980:1,4). A relatively early time range of occurrence for Powell Plain is suspected at Dickson Mounds, although the most specific mention of the earliest occupation of the site is "before A.D. 1200" (Harn 1980:23).

Shell-tempered, blackened, burnished and red-slipped vessels of various types occur, of course, at the definitive Mississippian site of Cahokia, and at numerous culturally associated sites in the outlying region surrounding it. Vogel (1975:45-49) demonstrated that relatively short rims occurred early in the ceramic sequence at Cahokia Tracts 15A and 15B, and that rim heights increased through time. Vogel also demonstrated that blackened, burnished vessels and vessels with red filming occurred early in the Mississippian ceramic sequence at
Cahokia, and that along with an increase in vessel rim height, these surface finishes concurrently decreased through time. The mean rim height for red-filmed vessels at Cahokia Tracts 15A and 15B was 14.5 mm (Vogel 1975:53-55). The two red-slipped vessels from the Wymer-West knoll had similar rim height ranges between 11 and 13 mm, falling close to the mean rim height of the relatively short-rimmed, red-slipped vessels from Cahokia. The presence of such vessels at the Wymer-West knoll, especially when accompanied by blackened, burnished vessels and an overall shell-tempered assemblage which has been associated, thus far, with dates of A.D. 1000-1150 supports the idea that initial Mississippian influence on or occupation of the Wymer-West knoll occurred relatively early in the Mississippian sequence. Vogel's conclusions, along with concurring dates associated with similar blackened, burnished and red-slipped ceramics at other sites, also support the idea that the ceramics from Wymer are a relatively early manifestation of Mississippian culture at the site.

Summary and Conclusions

This study has examined the presence of shell-tempered, red-slipped and blackened, burnished ceramics recovered from the Wymer-West knoll site in southwest Michigan. Red-slipped ceramics have not been previously found or described in the region in which they were
discovered, and blackened, burnished ceramics are extremely rare. The surface finish on these ceramics initially distinguished them as unusual from the majority of the ceramic assemblage, which is also shell-tempered, but is predominantly cordmarked and undecorated.

An X-ray fluorescence spectroscopy test was utilized in an attempt to positively define and distinguish the apparently red-slipped surfaces on two rim sherds (Vessel AU24, also T.S. #033; and Vessel AU25, also T.S. AU25). The X-ray fluorescence spectroscopy test was used to measure the surface iron content of these sherds and others with which they were contrasted. The objective of the test was to compare the results from the sherds with a suspected red slip to other red pigmented, oxidized or unslipped sherds to see if there were significant, quantifiable differences amongst them. The process during firing which leads to oxidation versus color development of a reddish slip is similar, so it was deemed important to not confuse the two. It was hoped that the test would reveal differences significant enough that they would confirm the presence of the slip-ping by showing its unique composition. The test was chosen because the X-ray fluorescence spectrometer measures only the surface mineral content of the object being analyzed. Iron content was measured because it was assumed to be responsible for the relatively strong, reddish color development of the suspected slips.
The results of the X-ray fluorescence spectroscopy test were not particularly conclusive. The average iron count readings taken from oxidized surfaces and from surfaces that were suspected to be slipped were significantly higher than the average iron count readings derived from the plain surfaces of T.S. #028. Although a small apparent difference in average iron count was noticed between the oxidized and apparently slipped categories, the readings from the two surface categories were not so strongly divergent as to confidently distinguish between them.

The results derived from T.S. AU25 were unfortunately unusable. The average iron count readings derived from the other rim sherd with a suspected red slip (T.S. #033) did not dramatically distinguish that surface from the plain, opposite surfaces of the two rim sherds or from the surfaces of the sherds that were oxidized. However, the placement, color and texture of the apparent slipping on both rims is distinctive from simply oxidized surfaces, and does suggest that potters purposefully applied a slip to the rim sherds. The restriction of the apparent slip coating to a thin layer on the vessel surfaces, versus the penetration below the vessel surface of oxidized zones also supports this view.

The obvious contrast between red pigmented versus plain ceramic surfaces determined through the X-ray fluorescence testing
supported that the pigmented surfaces represent a uniquely distinguishable coating which is relatively high in iron content. The permanence and oxidized color of the pigment also supports the conclusion that the coating was purposefully applied before firing, versus a residue which was deposited on post-fired vessels. It is unknown what purpose the red pigment coating may have served, although it may have played some functional role, or may indicate a ceremonial vessel. The relationship of the red pigmented to the red-slipped ceramics, if any, is unknown.

A sample of the red-slipped and blackened, burnished ceramics were also thin-sectioned and utilized in a petrographic analysis. The thin section analysis resulted in a represented percentage of the specifically focussed on categories that composed each sample. The categories included temper, temper void, pore space, mineral inclusion and paste matrix. The results from the red-slipped and blackened, burnished sherds were subsequently compared with results from relatively "typical", shell-tempered, cordmarked ceramics (suspected to have been locally produced) to see if the overall compositions were significantly different. The analysis differed from conventional petrographic studies of ceramics in that it focussed on describing and detailing the temper particles and pore spaces, rather than the mineral inclusions and paste matrix.
The results of thin section analysis from one exterior red-slipped rim sherd (T.S. #033) tend to suggest that the represented vessel (Vessel AU24) was imported. However, the thin section analysis results from the blackened, burnished ceramic sample (T.S. #035) were inconclusive.

Vessel AU24 (T.S. #033), represented by a short, sharply everted rim sherd with a thin wash of red slip on the exterior rim and lip exhibited in thin section an overall composition that was significantly divergent from the composition of locally produced ceramics so as to suggest that the vessel in question was imported. A second red-slipped vessel, Vessel AU25 (T.S. AU25), was not thin sectioned, but is morphologically quite similar to Vessel AU24, and may possibly also have been imported to the site.

Results from the thin section analysis of T.S. #035, the exterior blackened, burnished sherd, were on the borderline of what was considered average for locally produced vessels. The average size of the shell temper particles in the sample (.69 mm) was also closer in size to the relatively fine shell temper particles in T.S. #033, the vessel suspected to have been imported (.67 mm), than it was to the overall average of all shell temper particles measured in the majority of what was believed to be the locally produced assemblage (1.06 mm). However, the overall thin section results derived from T.S. #035 were
not so divergent as to be able to confidently determine that the represented vessel was imported. Thus it is concluded that the vessel might have been locally produced, but it cannot be completely ruled out that the vessel was possibly imported to the site. A second vessel with a blackened, burnished exterior and a blackened interior was not thin sectioned due to the small size of the sherd that represented it. It is impossible to determine, based on the results from T.S. #035, if this second vessel was locally produced or imported.

Other thin-sectioned ceramics which were not hypothesized, at the outset of testing, to represent potentially imported vessels also produced divergent compositional results in several instances. Some of these divergent results could be traced to evident variations in composition which may have occurred accidentally or been purposefully produced during the manufacture of the vessels. Such results were not viewed as evidence of imported vessels, but rather as variation in production. Other results slightly exceeded the boundaries determined to be normal for locally-produced vessel composition, but not so much as to confidently state that such vessels were imported to the site. It was thus considered probable but not conclusive that some such vessels were imports. One exception was T.S. #026, one of the sherd samples which exhibited a red pigment on the interior surface. The overall compositional results derived from this sample
during the thin section analysis supported the conclusion that the represented vessel was probably imported to the site.

Neither of the ceramic categories in question contained any ceramics which could confidently be shown to have been locally produced. However, one shell-tempered sherd with both surfaces blackened and well-smoothed was suggested, through the thin section analysis, to have been locally produced (T.S. #012). These results may indicate that the Wymer potters attempted to make a blackened, burnished vessel at the site. Such evidence is not overwhelming, but does lend credence to the idea that the Wymer-West knoll inhabitants were not only potentially importing Mississippian ceramic vessels with unusual surface finishes, but also were potentially producing or attempting to produce local copies of such Mississippian vessels.

It was hypothesized at the outset of this thesis that, if the occupation of the Wymer-West knoll represented a site-unit intrusion of a Mississippian group with some Late Woodland influences (especially in the form of cordmarked ceramics), then the red-slipped and blackened, burnished ceramics from the site were probably not imported. Alternatively, if the occupation of the site represented an indigenous, Late Woodland group with some Mississippian influences, then the red-slipped and blackened, burnished ceramics may have been imported in special functional contexts. The X-ray fluorescence
spectroscopy analysis was utilized in an attempt to distinguish and characterize red-slipped ceramic surfaces from other ceramic surface treatments. A petrographic thin section analysis was subsequently used to compare and contrast the composition of ceramics with unusual surface treatments with less exotic looking, cordmarked ceramics which were believed to have been produced at Wymer.

It appears, after examining all of the evidence, that portions of both hypotheses are probably true. The very fact that the Wymer potters were successfully producing a predominantly shell-tempered ceramic assemblage in the region and during the time period in which they occupied the site is strong evidence that they represented an early site-unit intrusion of a Middle Mississippian group of people. The predominance of random cordmarking as a surface treatment in the Wymer assemblage is also strong evidence that ceramic production at the site was subject to Late Woodland influence. One shell-tempered sherd with both surfaces blackened, and smoothed (T.S. #012) does appear to represent a vessel that was locally produced. The presence of such a vessel at the Wymer-West knoll suggests that at least one distinctive, Mississippian-like vessel may have been made on-site, rather than imported.

However, other red-slipped and blackened, burnished sherds appear to represent vessels that were potentially imported to the site.
If such vessels were indeed imported to the site, then it appears that the Wymer inhabitants were probably both producing Mississippian ceramics on site, and importing ceramics from other Mississippian groups. The majority of the shell-tempered ceramics in the Wymer assemblage are predominantly undecorated jars, which are suspected to have served utilitarian purposes. Given the paucity of vessels at the site with red-slipped or blackened and sometimes burnished surfaces, it seems probable that any such locally produced or imported vessels were made or obtained for special functions. It appears less likely, given the aforementioned evidence, that the Wymer inhabitants represented a Late Woodland group of people with some Mississippian influences. The presence at the site of Eastern Eight-Row maize, a crop which was likely grown by the Wymer group, further suggests that the site inhabitants were not indigenous, Late Woodland people.

The techniques that were utilized in this study emphasized the ceramic collection not just as a mode of stylistic expression, but also as a carefully tested and constructed product of the prehistoric potter, designed for stability and proper performance in a functional context. Additional research that the author has completed on the Wymer-West knoll assemblage (Greve-Brown 1996) examines the role that shell temper, salt and porosity played in the production and function of the vessels from the site. The red-slipped, and black-
ened, burnished ceramics were included in this research, but because vessels with such surface treatments were represented only by small sherd fragments, it was not possible to derive meaningful information relating surface treatment to vessel function. Red-slipped and blackened, burnished ceramics from Mississippian sites are commonly believed to have been used in special functional contexts. Future studies on intact vessels with such surface treatments could thus contribute to the understanding of the functional value, if any, of the surface treatments, and subsequently, could generate hypotheses about the special functional activities in which the vessels may have been used.

A great deal more research is needed in order to better characterize and understand the Middle Mississippian occupation of the Wymer-West knoll, and the occupant's relationships with other Middle Mississippian and indigenous Late Woodland groups. The conclusions about locally produced versus imported ceramics at the site, while intriguing, are also tentative. Further analysis, including clay paste sourcing in the Wymer vicinity, coupled with a mineralogical thin section analysis could help to more clearly distinguish which vessels were produced at the site, and which were imported. The determination of absolute iron values and the range of variation of iron, both in raw material sources and in fired ceramic samples, could also be
ascertained through clay paste sourcing and mineralogical thin section analysis. Such information would assist in the problem of quantitatively distinguishing red-slipped ceramic surfaces from oxidized, pigmented and plain ceramic surfaces.

The technique used in this study to examine the Wymer ceramic thin sections differed from a traditional mineralogical analysis in that it produced quantitative results in categories such as temper and pore space, rather than identifying and representing the size distribution of mineral inclusions. This technique was utilized not as an alternative to mineralogical analysis, but rather as an additional means of obtaining meaningful and readily comparable data about ceramic composition. The preparation of thin sections for such an analysis is fairly accessible and inexpensive. If more such ceramic thin section collections were prepared and studied, especially from Middle Mississippian sites in the Kankakee and Illinois River valleys, it would greatly contribute to both the quantitative comparison of ceramic assemblages, and the overall understanding of Middle Mississippian occupation and interaction in the Midwest.
Appendix A

Red-Slipped Vessel Data and Rim Profiles
**VESSEL AU24 (also T.S. #033)**

<table>
<thead>
<tr>
<th>Vessel Type:</th>
<th>Untyped; similar to Cahokia Red Filmed (Category NN) (Vogel 1975:99-101).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight/grams:</td>
<td>5.1 / 1 sherd.</td>
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<tr>
<td>Provenience:</td>
<td>Unit Do, locus 2.</td>
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</table>

**Thickness:**
- **Lip (range/mm):** 5.2 - 5.6 mm.
- **Below Rim (range/mm):** 9.8 - 10.8 mm.

**Lip cross-section:** Rounded.
**Lip treatment:** Red slip; slightly finger-impressed.
**Rim cross-section:** Everted, thinning towards the lip (9-5.2 mm).
**Rim attitude (°):** 35°
**Rim height (mm):** (Outside) 11-13 mm; (Inside) 14.5-15.6 mm.
**Internal orifice dia. (cm):** n/a
**Body:** n/a
**Base:** n/a

**Exterior rim:** Plain and well smoothed; covered with a thin wash of red slip.
**Interior rim:** Plain and smooth. An angular transition of nearly 90° occurs between the rim and the neck.

**Temper Type(s):** Shell.

**Paste Color (Munsell) ext.:** 5YR 5/6 yellowish red
**int.:** 10YR 5/3 brown
**core:** 10YR 3/1 very dark grey

**Appendages:** yes: no: x

**Comments:** Results of the thin section analysis on this sample suggested that this red-slipped vessel was an import. The red slip on the exterior rim and lip was carefully applied and does not extend onto the interior rim. The red slip is worn off of the surface in certain areas. The slight upward and outward curvature of the rim suggests that it may have had broad, gradual undulations in both directions (up-down/in-out).

Rim profile (actual size):
VESSEL AU25 (also T.S. AU25)

Vessel Type: Untyped; similar to Cahokia Red Filmed (Category NN) (Vogel 1975:99-101).
Weight/grams: 3.6 / 1 sherd.

Thickness:
- Lip (range/mm): 4.5 - 5 mm.
- Below Rim (range/mm): 8.3 - 10 mm.

Lip cross-section: Flattened.
Lip treatment: Red slip.
Rim cross-section: Everted, thinning toward lip (9.5-4.5 mm).
Rim attitude (°): 50°
Rim height (mm): (Outside) 11.7-13 mm; (Inside) 15-16 mm.

Internal orifice dia. (cm): n/a
Body: n/a
Base: n/a

Exterior rim: Plain and well smoothed; covered with a thin wash of red slip.

Interior rim: Plain and well smoothed. An angular transition of nearly 90° occurs between the rim and the neck. A thin, indented bevel (about 2 mm wide) interrupts the rim-neck junction.

Temper Type(s): Shell.

Paste Color (Munsell) ext.: 5YR 5/6 yellowish red
int.: 5YR 5/3 brown
core: 10YR 3/1 very dark grey

Appendages: yes: no: x

Comments: The red slip on the exterior rim and lip was carefully applied so as to stop just where the edge of the lip meets the interior rim. The slight upward and outward curvature of the rim suggests that it may have had broad, gradual undulations in both directions (up-down/in-out).

Rim profile (actual size):
Appendix B

X-Ray Fluorescence Test Results
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<th>Background 57.75°</th>
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Appendix C

Data on the Ceramic Test Samples Used in the X-ray Fluorescence and the Petrographic Thin Section Analyses
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<th>Thin Section Analysis</th>
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Appendix D

Petrographic Thin Section Analysis Results
T.S. #001: Early Woodland, cordmarked, Marion Thick body sherd; Feature 91-51A, East 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (11%) Grit; Range: 0.25-4.0 mm; Average: 2.47 mm.

Temper Void(s): (0%)

Pore Space(s): (2%)

Mineral Inclusion(s): (5%)

Paste Matrix: (82%)

Comments: Difficult to positively identify pore spaces because the thin section revealed a surface which was riddled with cracks. Hence, results may be biased away from the 'pore space' category, and toward that of 'paste matrix'. This thin section was impregnated with blue-dyed epoxy, which had no significant positive or negative impact on the identification of the constituents detailed above.

T.S. #002: Cordmarked, smoothed body sherd; Feature 91-51A, West 1/2, Zone A.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (8%) Shell; Range: 0.5-1.75 mm; Average: 1.14 mm.
The orientation of the shell temper in this thin section is unusual. The shell is oriented perpendicular to the plane of the vessel wall. A 1 mm point count interval tested on this sample showed no significant difference in the percentages represented in each category. The 1 mm counting interval did intercept two mineral inclusions that the 2 mm interval did not. The mineral inclusions noted in the thin section were mostly small and rounded, measuring 0.25 mm or less.

T.S. #003: Cordmarked, smoothed body sherd; Units C, D, L and M; Feature 91-51B, East 1/2.

Thin Section Cut: Parallel with vessel wall.
Point Count Interval: 2 mm.
Temper: (1%) Shell; Range: 1.0-1.25 mm; Average: 1.125 mm.
Temper Void(s): (3%)
Pore Space(s): (9%) Irregular shaped, closed pores and blind alley pores present. Pore spaces measure approximately 3 mm.
Mineral Inclusion(s): (2%) Small and rounded in shape, measuring 0.25 mm or less.

Paste Matrix: (85%)

Comments: This thin section was impregnated with blue-dyed epoxy. The epoxy highlighted pore spaces and shell-temper voids, but negatively altered the refractive qualities of mineral inclusions.

T.S. #004: Cordmarked body sherd with broad, shallow, parallel cord-marks, possibly from a cord-wrapped stick; Feature 91-58, East 1/2.

Thin Section Cut: Parallel with vessel wall.
Point Count Interval: 2 mm.
Temper: (4%) Shell; Range: 0.75-3.25 mm; Average: 2.025 mm.
Temper Void(s): (19%)
Pore Space(s): (8%) Closed or blind alley pores measuring approximately 2.0 mm or less.
Mineral Inclusion(s): (6%) Small, rounded and relatively abundant, measuring 0.5 mm or less. The paste of this sample was quite sandy when examined with the naked eye, and the high sand content is recognizable in the thin section.
Paste Matrix: (63%)
Comments: This thin section was impregnated with a blue-dyed epoxy. However, impregnation was uneven, and most of the blue dye was not evident after final grinding was completed.

T.S. #005: Cordmarked body sherd with broad, shallow, parallel cord-marks, possibly from a cord-wrapped stick. The average thickness of the sample (7.975 mm) suggests a basal sherd; Feature 91-59A, South 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (3%) Shell; Range: 0.5-2.5 mm; Average: 1.09 mm.

Temper Void(s): (3%)

Pore Space(s): (5%) Mostly small, closed and well rounded, measuring 0.25 mm or less. Some very thin, irregularly shaped, blind alley pores partially evident on edges of the thin section.

Mineral Inclusion(s): (5%) Small, well rounded and relatively abundant, measuring 0.5 mm or less.

Paste Matrix: (84%)

Comments: This thin section was impregnated with a blue-dyed epoxy. However, impregnation was uneven, and most of the blue dye was
not evident after final grinding was completed.

T.S. #006: Cordmarked, smoothed body sherd; Feature 91-61, South 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (0%) Shell; Range: 0.5-2.0 mm; Average: 1.125 mm.

Temper Void(s): (5%)

Pore Space(s): (4%) Closed, well rounded and loop and channel pores ranging from 1.0-2.0 mm.

Mineral Inclusion(s): (6%) Small and rounded, measuring 0.5 mm or less.

Paste Matrix: (85%)

Comments: No preserved particles of shell temper were intercepted during the point count of this thin section. The range and average measurements for shell temper were derived from identified shell voids. This thin section was impregnated with a blue-dyed epoxy. However, impregnation was incomplete, and most of the blue dye was no longer evident after final grinding.

T.S. #007: Cordmarked body sherd; Feature 91-61, South 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 0.5 mm
Temper: (0%) Shell; Range: 0.25-1.5 mm; Average: .71 mm.

Temper Void(s): (7%) All of the voids recorded had a similar thin, elongated, slightly curved shape.

Pore Space(s): (27%) Relatively large, rounded and irregular in shape, measuring 2.0-6.0 mm.

Mineral Inclusion(s): (4%) Relatively small and mostly rounded, with a few angular shapes, measuring 0.25 mm or less.

Paste Matrix: (62%) Effects of differential firing are evident in that most of the thin section paste matrix is dark grey in color, while a small portion is pale brown.

Comments: No preserved particles of shell temper were intercepted during the point count of this thin section. The range and average measurements for shell temper were derived from identified shell voids.

T.S. #008: Cordmarked, smoothed body sherd; the average thickness of the sample (9.35 mm) suggests a possible basal sherd; the sample also fit together with two other similar sherds to form what appeared to be a basal portion of a vessel; Feature 91-64, East 1/2.

Thin Section Cut: Parallel with the vessel wall.

Point Count Interval: 2 mm.

Temper: (10%) Shell; Range: 0.25-2.0 mm; Average: 0.69 mm.
Temper Void(s): (1%)
Pore Space(s): (2%) Closed, rounded and loop and channel pores, ranging from 0.5-1.5 mm.
Mineral Inclusion(s): (8%) Small and rounded, measuring 0.5 mm or less.
Paste Matrix: (79%)
Comments: The paste matrix is a very dark grey and much of the shell is preserved and more randomly aligned in the thin section of this thicker sherd.

T.S. #009: Cordmarked, smoothed body sherd; Feature 91-64, East 1/2.

Thin Section Cut: Parallel with vessel wall.
Point Count Interval: 2 mm.
Temper: (12%) Grit; Range: 0.25-3.0 mm; Average: 1.5 mm; grey, angular and platy in appearance.
Temper Void(s): (0%)
Pore Space(s): (1%) Very few evident. Those present are closed and are long, thin and irregular in shape, measuring approximately 3.0 mm.
Mineral Inclusion(s): (2%) Relatively small, rounded inclusions are sparsely distributed, and measure 0.25 mm or less.
Paste Matrix: (85%) Very compact and well fused, with far fewer natural inclusions than are commonly
evident in the typical shell-tempered paste matrix.

Comments: This sherd sample was originally identified as having once contained a mixture of shell and grit temper. The relative thinness of the sherd and the laminar appearance of it's cross-section, along with the apparent presence of shell voids in the cross section suggested the presence of shell temper. Thin sectioning, however, revealed that the sherd was tempered solely with grit. This sherd sample was impregnated with a blue-dyed epoxy, but impregnation was incomplete, and most of the blue dye was no longer evident after final grinding.

Bears strong similarities to T.S. #013.

T.S. #010: Cordmarked body sherd; Feature 91-64, West 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (8%) Shell; Range: 0.25-2.25 mm; Average: 1.0 mm.

Temper Void(s): (3%)

Pore Space(s): (6%) Closed; thin, long and irregular or loop and channel, measuring from 0.25-0.75 mm.
Mineral Inclusion(s): (11%) Small, rounded and relatively abundant; measuring 0.5 mm or less.

Paste Matrix: (72%) Mottled light grey and light brown areas evidence uneven oxidation during firing.

Comments: Shell temper is well preserved in this sample.

T.S. #011: Cordmarked body sherd; Cord-marking is in a cross-hatched pattern, and may have been produced by impressing with a woven net or a cord-wrapped stick; Feature 91-64, West 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 0.5 mm.

Temper: (0%) Shell; Range: 0.75-3.0 mm; Average: 1.63 mm.

Temper Void(s): (8%)

Pore Space(s): (1%) One very large, irregular, blind alley pore leading off of thin section measures approximately 3.5 mm.

Mineral Inclusion(s): (5%) Small, angular inclusions measuring 0.25 mm or less; rounded inclusions measuring from 0.5-1.0 mm.

Paste Matrix: (71%)

Comments: No preserved particles of shell temper were intercepted during the point count of this thin section. The range and average measurements for shell temper were derived
from identified shell voids. A single large pore space was intercepted 15 times during the point count, and one shell void was intercepted twice. Multiple intercepts were counted only once, so the total percentage derived from 100 counts is less than 100 in this case.

T.S. #012: Plain, well-smoothed body sherd which is a consistent very dark grey (MUNSELL 5YR 3/1) throughout; both the exterior and interior surfaces of this sample are plain, well-smoothed and compact; Feature 91-64, West 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 0.5 mm.

Temper: (0%) Shell; Range: 0.75-1.0 mm; Average: 0.85 mm.

Temper Void(s): (5%)

Pore Space(s): (2%) Relatively small and closed; rounded or loop and channel, measuring approximately 1.0 mm or less.

Mineral Inclusion(s): (12%) Small and rounded, or angular and platy, measuring 0.5 mm or less; inclusions are relatively abundant and many are very small.

Paste Matrix: (81%) Very dark grey and compact.

Comments: No preserved shell temper particles were intercepted during the point count of this
thin section. The range and average measurements for shell temper were derived from identified shell voids. Most of the shell temper originally present in this sample was not preserved.

T. S. #013: Cordmarked, smoothed body sherd; Feature 91-64, West 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 0.5 mm.

Temper: (18%) Grit; Range: 0.5-2.5 mm; Average: 1.67 mm; grey, angular and platy in appearance.

Temper Void(s): (0%)

Pore Space(s): (1%) Single pore intercepted is closed, rounded and measures approximately 0.5 mm.

Mineral Inclusion(s): (1%) Relatively sparse, small and rounded, measuring 0.25 mm or less.

Paste Matrix: (80%) Very compact and well fused, with far fewer natural inclusions than are commonly evident in the typical shell-tempered paste matrix.

Comments: This sherd sample was originally identified as having once contained a mixture of shell and grit temper. The relative thinness of the sherd and the laminar appearance of
it's cross-section, along with the apparent presence of shell voids in the cross section suggested the presence of shell temper. Thin sectioning, however, revealed that the sherd was tempered solely with grit. This sherd sample was impregnated with a blue-dyed epoxy, but impregnation was incomplete, and most of the blue dye was no longer evident after final grinding. Bears strong similarities to T.S. #009.

T.S. #014: Cordmarked body sherd with tightly spaced, parallel cord marks, possibly from a cord-wrapped stick; Feature 91-64, West 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (18%) Shell; Range: 0.25-4.25 mm; Average: 1.125 mm.

Temper Void(s): (0%)

Pore Space(s): (0%)

Mineral Inclusion(s): (0%)

Paste Matrix: (82%) Paste is tightly fused and evidences areas of differential firing. A well-defined split divides the thin section between a dark grey and pale brown area of the paste matrix. This might possibly be where two separate coils of clay were joined together(?).
Comments: Most of the shell temper is preserved in this thin section. Mineral inclusions are quite sparse and none were intercepted during the point count. Mineral inclusions noted in the thin section were very small and rounded, measuring 0.25 mm or less. No pore spaces were intercepted or otherwise identified. The pale brown portion of this thin section contains several small, rounded particles (0.5 mm or less) of a reddish brown substance. The overall composition of this sample, especially the heavy shell tempering, the lack of pore spaces and the sparseness of mineral inclusions appears atypical when compared with the composition of other shell-tempered samples.

T.S. #015: Cordmarked body sherd; Feature 91-64, West 1/2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (0%) Shell; Range: 0.75-2.75 mm; Average: 1.67 mm.

Temper Void(s): (8%)

Pore Space(s): (2%) Sparse; thin, linear and irregular closed pores, measuring approximately 1.5 mm.
Mineral Inclusion(s):  
(3%) Small and rounded, measuring 0.5 mm or less.

Paste Matrix:  
(87%) Very dark grey and tightly fused.

Comments:  
No preserved shell temper particles were intercepted during the point count of this thin section. The range and average measurements for shell temper were derived from identified shell voids. Most of the shell temper originally present in this sample was not preserved. Several very large voids in the thin section may represent pore spaces or erosional damage. Since neither supposition can be confirmed, the voids were not counted in any category. This sherd sample was impregnated with a blue-dyed epoxy, but impregnation was incomplete, and most of the blue dye was no longer evident after final grinding.

T.S. #016: Cordmarked, smoothed body sherd; Feature 91-64, West 1/2.

Thin Section Cut:  Parallel with vessel wall.

Point Count Interval:  2 mm.

Temper:  
(9%) Shell; Range: 0.25-1.0 mm; Average: 0.57 mm.

Temper Void(s):  
(1%)
Pore Space(s): (2%) Sparse; closed, rounded or irregular, measuring from 0.25-1.25 mm.

Mineral Inclusion(s): (11%) Small and rounded, measuring 0.5 mm or less.

Paste Matrix: (77%) Paste is tightly fused and evidences areas of differential firing. A well-defined split divides the thin section between a dark grey and pale brown area of the paste matrix. This might possibly be where two separate coils of clay were joined together(?).

Comments: Most of the shell temper is preserved in this thin section. This sherd sample was impregnated with a blue-dyed epoxy, but impregnation was incomplete, and most of the blue dye was no longer evident after final grinding.

T.S. #017: Cordmarked body sherd; Feature 91-65, "deep plow zone" (upper portion of feature).

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (4%) Shell; Range: 0.5-2.5 mm; Average: 1.17 mm.

Temper Void(s): (3%)
Pore Space(s): (4%) Closed, rounded pores measuring approximately 1.0 mm; loop and channel pores measuring 2.75-3.0 mm.

Mineral Inclusion(s): (12%) Relatively abundant; small and rounded or irregular, measuring 0.25 mm or less.

Paste Matrix: (77%) Paste is tightly fused and evidences areas of differential firing. Paste color grades from a dark grey to a reddish brown. This might possibly be where two separate coils of clay were joined together(?).

Comments: The abundant, small, natural inclusions noted in this thin section are apparently the abundant, fine sand particles noted when the sherd specimen was initially examined. Shell temper is rather sparse in this thin section. Does a high ratio of sand reduce the amount of shell temper necessary in this paste?

T.S. #018: Cordmarked, smoothed body sherd; Cord-marking is in a cross-hatched pattern, and may have been produced by impressing a woven net or a cord-wrapped stick; Feature 91-65, "deep plow zone" (upper portion of feature).

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.
Temper:  (8%) Shell; Range: 0.5-3.25 mm; Average: 1.85 mm.

Temper Void(s):  (1%)

Pore Space(s):  (0%)

Mineral Inclusion(s):  (2%) Small and rounded or irregular, measuring 0.25 mm or less.

Paste Matrix:  (89%) Tightly compacted and ranging in color from dark grey to pale brown. These areas of differential firing may represent a point at which two different coils of clay were joined together(?).

Comments:  No pore spaces were intercepted during the point count of this thin section, and pore spaces overall were relatively sparse. A few closed, loop and channel pores noted in the thin section measured approximately 4.0 mm.

T.S. #019: Cordmarked body sherd; deep parallel cord-marks may have been made with a cord wrapped paddle or possibly with a cordwrapped stick; Feature 91-65, "deep plow zone" (upper portion of feature).

Thin Section Cut:  Parallel with vessel wall.

Point Count Interval:  0.5 mm.

Temper:  (0%) Shell; Range: 0.75-2.0 mm; Average: 1.25 mm.

Temper Void(s):  (7%)
| **Pore Space(s):** | (6%) Closed, rounded or loop and channel, measuring 1.0 mm or less. |
| **Mineral Inclusion(s):** | (4%) Relatively small and rounded or more angular with rounded edges, measuring from 0.5-0.2 mm or less. |
| **Paste Matrix:** | (83%) Dark grey and tightly fused. |
| **Comments:** | No preserved shell temper particles were intercepted during the point count of this thin section. The range and average measurements for shell temper were derived from identified shell voids. Most of the shell temper originally present in this sample was not preserved. Mineral inclusions were quite small but relatively abundant in this sample. |

*T.S. #020: Cordmarked body sherd; Feature 91-65, South 1/2.*

| **Thin Section Cut:** | Parallel with vessel wall. |
| **Point Count Interval:** | 0.5 mm. |
| **Temper:** | (0%) Unknown. |
| **Temper Void(s):** | (0%) |
| **Pore Space(s):** | (0%) |
| **Mineral Inclusion(s):** | (15%) Small and rounded or irregular; a few inclusions angular with rounded edges; all inclusions measured 0.5 mm or less. |
| **Paste Matrix:** | (85%) Reddish light brown (oxidized) in color and appears tightly compacted or |
fused, in comparison to an initial impression of the sample, in which the paste seemed rather soft and easily exfoliated. No pore spaces were intercepted during the point count of this thin section, and none were otherwise noted during a general examination of the specimen. No recognizable tempering agent was identified during the point count or during the general examination. The sherd from which this sample was derived was oxidized to a consistent color throughout, and the paste was visibly quite sandy. Relatively abundant, rounded and assumably natural inclusions were subsequently noted and recorded during the point count. All of the particles fell within the size range of medium to coarse sand. Small, rounded, limestone-like inclusions were also noted in the thin section. The rounded nature of all of the inclusions suggests that they were natural to the paste mixture, although it is impossible to rule out that they may have been purposefully added by the potter. In any case, no obvious prepared temper was evident in this thin section, and the
presence of this and other similar sherd specimens at the site suggests that certain vessels may have been successfully fired without the addition of prepared temper. Did the abundant natural inclusions in this paste negate the need for temper?

T.S. #021: Cordmarked, smoothed body sherd; Feature 91-65, North 1/2.

Thin Section Cut: Parallel with vessel wall.
Point Count Interval: 0.5 mm.
Temper: (0%) Shell; Range: 1.0-1.5 mm; Average: 1.25 mm.
Temper Void(s): (0%)
Pore Space(s): (0%)
Mineral Inclusion(s): (2%) Many quite tiny; rounded to angular, measuring 0.5-0.25 mm or less.
Paste Matrix: (98%) Tightly compacted; evidences areas of differential firing. A well-defined split divides the thin section between a very dark grey and pale brown area of the paste matrix. This might possibly be where two separate coils of clay were joined together(?).
Comments: No shell or other identifiable temper particles were intercepted during the point count of this thin section. Shell temper
particles were present in very sparse quantity, and the range and average measurements were derived from shell temper that was measured during a general examination of the thin section. No pore spaces were evident in this sample. Mineral inclusions were quite abundant, but were small enough that the individual particles were often not intercepted during the point count. The inclusions again appear to be a natural part of the paste matrix, although the possibility that potters purposefully added sand or other natural-looking inclusions to their paste cannot be entirely ruled out. The ratio of high natural-appearing inclusions to low amounts or total lack of an obvious added tempering agent may suggest that a higher amount of natural inclusions in a mixture contributed to successful firing, while reducing the amount of prepared temper that was necessary in the paste mixture.

**T.S. #022:** Cordmarked, smoothed body sherd; Feature 91-65, North 1/2.

**Thin Section Cut:** Parallel with vessel wall.

**Point Count Interval:** 2 mm.
Temper: (1%) Shell; Range: 0.25-1.0 mm; Average: 0.60 mm.
Temper Void(s): (5%)
Pore Space(s): (3%) Closed, loop and channel, measuring from 1.25-2.5 mm.
Mineral Inclusion(s): (8%) Small, rounded or irregular, measuring 0.5 mm or less.
Paste Matrix: (83%) Tightly compacted and shows evidence of differential firing. A well-defined split divides the thin section between a dark grey and pale brown area of the paste matrix. This might possibly be where two separate coils of clay were joined together(?).
Comments: The shell temper particles in this thin section were relatively fine, and most are no longer preserved.

T.S. #023: Cordmarked body sherd; deep, parallel, evenly spaced cord impressions may have been applied with a cord-wrapped stick; Feature 91-66 (0-30.0 cm), Section WA.

Thin Section Cut: Parallel with vessel wall.
Point Count Interval: -
Temper: Shell
Comments: This thin section contained abundant small, natural inclusions, and ground quite poorly and unevenly. The resulting thin section
was not usable for a point count, and only general information could be derived from the sample. Most of the shell temper originally present in the specimen was no longer preserved. Shell voids and pore spaces were difficult to distinguish because of the uneven manner in which the thin section ground, and no measurements for those categories could be determined. The relatively abundant mineral inclusions in the thin section were generally rounded, measuring 0.25 mm or less. The paste matrix was uniformly dark grey and tightly compacted.

T.S. #024: Cordmarked body sherd; Feature 91-66 (0-30.0 cm), Section WA.

Thin Section Cut: Parallel with vessel wall.
Point Count Interval: 2 mm.
Temper: (1%) Shell; Range: 1.0-1.5 mm; Average: 1.08 mm.
Temper Void(s): (7%)
Pore Space(s): (13%) Closed, rounded pores - 0.75 mm; closed, irregular pores - 3.5 mm; blind alley pores - 4.5 mm.
Mineral Inclusion(s): (3%) Small and rounded, measuring 0.5 mm or less.
Paste Matrix: (76%) Tightly compacted; evidences areas of differential firing as color grades from light gray to pale brown.

Comments: This thin section was impregnated with a blue-dyed epoxy. However, impregnation was uneven, and some of the blue dye was no longer evident after the final grinding was completed. Blue-dyed epoxy thus highlights temper voids and pore spaces on one half of the thin section, but not on the other half.

T.S. #025: Cordmarked body sherd; Feature 91-66 (0-30 cm), Section WA.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 0.5 mm.

Temper: (2%) Shell; Range: NONE; Average: 0.25 mm.

Temper Void(s): (0%)

Pore Space(s): (7%) Closed and irregular, measuring 1.5 mm or less.

Mineral Inclusion(s): (11%) Relatively abundant; mostly small and rounded with a few small, angular shapes; all measuring 0.5 mm or less.

Paste Matrix: (80%) Tightly compacted; evidences areas of differential firing as color grades from medium gray to pale brown.
Comments: This thin section represents another instance where the percentage of shell temper particles present is relatively low, and the percentage of small, natural-appearing mineral inclusions present is relatively high. There may be some correlation between the level of natural inclusions in this paste, and the subsequent amount of shell temper that is needed in the mixture.

*T.S. #026: Cordmarked, smoothed body sherd; traces of a reddish pigment on the interior surface of this sherd; Feature 91-66 (0-30.0 cm), Section WA.

Thin Section Cut; Parallel with vessel wall.
Point Count Interval: 0.5 mm.

Temper: (2%) Shell; Range: 0.25-0.5 mm; Average: 0.38 mm.
Temper Void(s): (0%)
Pore Space(s): (0%)
Mineral inclusion(s): (4%) Relatively abundant; small and rounded to angular, measuring 0.5 mm or less.

Paste Matrix: (94%) Tightly compacted; evidences areas of differential firing as color abruptly changes from pale brown to dark gray then back to pale brown. This might possibly
Comments:

represent an area where several separate coils of clay were joined together(?).

This sample was not thin sectioned so as to view the reddish pigment on its interior surface because of the fact that the pigment was so faint. Natural-appearing mineral inclusions were relatively abundant in this specimen, but many were small enough that they were not intercepted during the point count. Shell temper particles were small and sparsely distributed in relation to each other. No pore spaces were intercepted during the point count, and few were otherwise noted.

*T.S. #027: Cordmarked body sherd; a red pigment evenly coats the interior surface of this sherd; Feature 91-66 (0-30.0 cm), Section WA.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: -

Temper: Shell

Comments: This thin section was not ground so as to view the pigment on the interior surface, because it was decided that the pigment had been adequately defined during x-ray fluorescence testing. The specimen was therefore ground parallel with the vessel
wall in order to derive comparable data on temper, porosity and the other categories detailed. However, this sample ground quite poorly and unevenly and was not usable for a point count. Thus, only general information could be derived from the sample. Most of the shell temper originally present in the specimen was no longer preserved. Shell voids and pore spaces were difficult to distinguish because of the uneven manner in which the thin section ground, and no measurements for those categories could be determined. The relatively abundant mineral inclusions in the thin section were generally rounded, measuring 0.25 mm or less. The paste matrix was a mottled grey and pale brown in color.

*T.S. #028: Cordmarked, smoothed body sherd: Unit B62, Locus 3 (pit feature).

Thin Section Cut: Parallel with vessel wall.
Point Count Interval: 2 mm.
Temper: (1%) Shell; Range: 0.25-2.5 mm; Average: 1.0 mm.
Temper Void(s): (5%)
Pore Space(s): (2%) Relatively sparse; loop and channel, measuring approximately 1.5 mm.

Mineral Inclusion(s): (1%) Relatively sparse; small and rounded, measuring 0.5 mm or less (most are much smaller).

Paste Matrix: (91%) Tightly fused and a uniform dark gray in color.

Comments: The amount of natural mineral inclusions in the paste of this sample appears quite minimal when compared with other shell-tempered specimens, which commonly contain a larger amount of sand particles.

T.S. #029: Cordmarked, smoothed body sherd; cord marking is in a cross-hatched pattern and may have been produced with a cord-wrapped stick; Unit B62, Locus 3 (pit feature).

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (1%) Relatively sparse; Shell; Range: 0.5-1.0 mm;

Average: 0.83 mm.

Temper Void(s): (4%)

Pore Space(s): (1%) Very few noted; one closed, irregular shape intercepted during point count measured 1.0 mm.
Mineral Inclusion(s): (2%) Relatively small, rounded or irregular and evenly dispersed, measuring 0.5 mm or less.

Paste Matrix: (92%) Very fine-grained, well fused and oxidized to a fairly consistent light reddish yellow color.

Comments: Most of the shell temper was no longer preserved in this thin section. Shell voids evidenced a fine, sparse temper, and pore spaces were equally sparse.

T.S. #030: Fabric- or net-impressed body sherd; The cord-impressions on this sherd evidence a loosely woven textile. The average thickness of the sherd (7.425 mm) may indicate that the sherd is from the basal portion of a vessel. Unit Do, Locus 3 (pit feature).

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (1%) Shell; Range: 0.5-3.5 mm; Average: 1.21 mm.

Temper Void(s): (17%)

Pore Space(s): (0%)

Mineral Inclusion(s): (11%) Relatively abundant; rounded or irregular in shape, measuring 0.25 mm or less.

Paste Matrix: (71%) Tightly fused and very dark gray to brown in color.
Comments: Shell voids indicated relatively heavy tempering in this thin section. Mineral inclusions were also abundant, but no pore spaces were evident.

T.S. #031: Cordmarked, smoothed body sherd; Unit Do, Locus 3 (pit feature).

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 2 mm.

Temper: (0%) Unknown.

Temper Void(s): (0%)

Pore Space(s): (18%) Closed, elongated loop and channel pores, ranging from 3.0-5.0 mm.

Mineral Inclusion(s): (15%) Relatively abundant; small, rounded or irregular shaped minerals range from 0.5-1.0 mm.

Paste Matrix: (67%) Mottled color ranges from reddish yellow to dark gray.

Comments: No recognizable tempering agent was identified during the point count or the general examination of this thin section. The paste mixture of this sample was noted to be quite sandy with other small natural-appearing inclusions during initial examination. Relatively abundant, generally rounded and assumably natural inclusions were subsequently noted and recorded.
during the point count. All of the particles fell within the size range of coarse sand. The rounded nature of all of the inclusions suggests that they were natural to the paste mixture, although it is impossible to rule out if they may have been purposefully added by the potter. In any case, no obvious prepared temper was evident in this thin section. The presence of this and other similar sherd specimens at the site suggests that certain vessels may have been successfully fired without the addition of prepared temper. Did abundant natural inclusions in this paste negate the need for temper? A mineral inclusion identified in this thin section and visible even to the naked eye deserves special mention. The inclusion was angular on two sides, with the remaining edges ragged but more rounded. The mineral was visible in plain light under the microscope and to the naked eye as a bright amber-colored inclusion identified as Portlandite (CaOH₂), a form of calcium hydroxide. The inclusion measured 1.0 mm across its longest axis. Calcium hydroxide is
commonly known to be the end result of a chemical reaction that occurs in shell when it is fired above a certain temperature. The formation of calcium hydroxide is also commonly known to contribute to spalling and vessel failure in shell-tempered ceramics after firing (Shepard 1965a:30). Interestingly though, no evidence of shell tempering was noted in this thin section, and no evidence of the presence of calcium hydroxide was seen in any other shell-tempered thin section.

*T.S. #032: Cordmarked, smoothed body sherd; cord marking is nearly obliterated by smoothing on the exterior of this sherd, and the interior surface is evenly covered with a dark red pigment; General Surface.

Thin Section Cut: Parallel with vessel wall.
Point Count Interval: 2 mm.
Temper: (0%) Shell; Range: 0.25-4.0 mm; Average: 1.5 mm.
Temper Void(s): (13%)
Pore Space(s): (2%) Relatively sparse; those noted were loop and channel pores measuring from 2.0-6.0 mm.
Mineral inclusion(s): (1%) Small and rarely intercepted during point count; rounded or irregular shapes measuring 0.5 mm or less.

Paste Matrix: (84%) tightly fused and primarily very dark gray in color, with some small patches of pale brown.

Comments: No preserved shell temper particles were intercepted during the point count of this thin section. The range and average measurements for shell temper were derived from identified shell voids. Most of the shell temper originally present in this sample was not preserved. Very few pore spaces were noted in this specimen. This thin section was not ground so as to view the pigment on the interior surface, because it was decided that the pigment had been adequately defined during x-ray fluorescence testing. The specimen was therefore ground parallel with the vessel wall in order to derive comparable data on temper, porosity and the other categories detailed.

*T.S. #033: Plain, everted rim sherd; this rim sherd is relatively short and sharply everted with a red slip on the exterior rim and lip; the lip cross-section is even and rounded and evidences a
slight finger impression; Unit Do, Locus 2. This rim is Vessel AU24
(See Appendix A for complete description).

Thin Section Cut: Perpendicular through vessel wall.

Point Count Interval: 0.5 mm.

Temper: (0%) Shell; Range: 0.5-1.0 mm; Average: 0.67 mm.

Temper Void(s): (3%)

Pore Space(s): (0%)

Mineral Inclusion(s): (1%) Relatively sparse and small, measuring 0.25 mm or less.

Paste Matrix: (96%) Very fine-grained, tightly fused and homogeneous.

Comments: This thin section was cut perpendicular through the vessel wall in order to obtain a slice for thin sectioning while preserving most of the rare rim sherd. It was not felt that the red slip would be visible in thin section because it was applied very thinly, and was rubbed or eroded away in places. Thus, the thin section was impregnated with a blue-dyed epoxy in order to better highlight the fine shell voids noted during an initial examination of the sherd. Epoxy impregnation was excellent, and aided in the point counting of the few evident shell voids. Shell voids showed that temper was
well aligned in a parallel orientation with the vessel wall. The blue dye interfered with the refractive qualities of the minerals seen in the thin section, but the point count revealed that only a very few, relatively tiny mineral inclusions were present. The physical appearance and composition of this sherd is atypical when compared with other shell-tempered sherds from the assemblage.

*T.S. #034: Cordmarked, smoothed body sherd; oxidized on both surfaces, with a yellowish red slip across the exterior surface; Unit S, Plow Zone.

Thin Section Cut: Perpendicular through vessel wall.
Point Count Interval: 0.5 mm.
Temper: (9%) Shell; Range: 0.75-3.5 mm; Average: 1.56 mm; AND (12%) Grit; Range: 0.5-2.25 mm; Average: 1.625 mm.
Temper Void(s): (1%) Shell.
Pore Space(s): (0%)
Mineral Inclusion(s): (0%)
Paste Matrix: (78%) Fine-grained and homogenous.
Comments: Only one small, rounded pore was noted in a general examination of this thin section, and no natural mineral inclusions were
intercepted during the point count or otherwise noted. A slight trace of the red exterior slip may be seen along one edge of the thin section. This sherd is highly unusual for the assemblage.

T.S. #035: Plain, exterior blackened, burnished body sherd (plain interior, not blackened or burnished); resembles the Mississippian type Powell Plain; Unit H, Level 2.

Thin Section Cut: Parallel with vessel wall.

Point Count Interval: 0.5 mm.

Temper: (4%) Shell; Range: 0.5-1.0 mm; Average: 0.69 mm.

Temper Void(s): (1%)

Pore Space(s): (4%) Relatively small and rounded, measuring 0.5 mm or less.

Mineral Inclusion(s): (3%) Relatively small and rounded to angular, measuring 0.25 mm or less.

Paste Matrix: (88%) Well fused and dark gray in color.

Comments: Some shell temper is preserved in this thin section. Temper is generally fine and sparsely distributed. The surface treatment of this sherd is quite unique for the assemblage, but the thin section data suggests that it has a similar composition to that of other shell-tempered sherds in
the collection, and that it may have been locally produced.

(* indicates that the sample was subjected to X-ray fluorescence spectroscopy analysis prior to thin sectioning.)
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