ANALYSIS OF SLIPS AND OTHER INORGANIC SURFACE MATERIALS ON WOODLAND AND EARLY FORT ANCIENT CERAMICS, SOUTH-CENTRAL OHIO

Spencer J. Cotkin, Christopher Carr, Mary Louise Cotkin, Alfred E. Dittert, and Daniel T. Kremser

Petrographic analyses were made of 386 utilitarian pottery vessels from 23 dated components of 18 Early Woodland through early Fort Ancient period sites (ca. 1150 B.C.–A.D. 1300) in south-central Ohio. The analyses reveal that a significant percentage (11.6 percent) of the 386 vessels bear uncolored (i.e., unpigmented) pottery slips and washes, that these surface materials were common (>56 percent) among the 23 sampled components, and that they were produced throughout most of the examined prehistoric sequence, including the earliest Early Woodland, when pottery making began in the Midwest. In contrast, a literature review indicates that uncolored slips and washes are unrecorded for utilitarian wares in the prehistoric Eastern Woodlands, that both colored and uncolored slips are unknown for any ceramics of the Early Woodland period, and that colored slips or washes in the pre-Mississippian Midwest have been observed in only low frequencies. Electron microprobe analysis of seven sherds show the compositional similarity of the clays of slips to the clays of their associated vessel bodies, indicating that the slips were made from the same raw clays as the bodies, but with no or little added rock temper and/or with the sieving of the slip clay. Contextual analyses give further insights, including the possible uses of slips and washes for decoration and to decrease vessel wall permeability. Calcite and apatite coatings on the vessel surfaces also were observed and are interpreted. Results indicate greater continuity between the Midwestern and Southeastern United States in ceramic technology than previously thought, and suggest a need for caution in electron microprobe and INAA chemical studies of Midwestern ceramics.

Se realizaron análisis petrográficos a 386 vasijas de cerámica utilitaria de 23 componentes provenientes de 18 sitios de la parte sur-central de Ohio, fechados desde la fase Woodland Temprano hasta la parte inicial del periodo Fort Ancient (ca. 1150 A.C B 1300 D.C.). El análisis reveló que un procentaje significativo (11.6%) de las 386 vasijas tienen engobes y recubrimientos sin coloración (esto es, sin pigmento), que estas superficies fueron comunes (>56%) entre los 23 componentes muestreados, y que fueron producidas a lo largo de la mayor parte de la secuencia prehistórica examinada, incluyendo la más temprana que coresponde a Woodlands Temprano, cuando se inicia la manufactura de cerámica en la región del Mediooeste (Midwest) Norteamericano. En contraste, una revisión en la literatura indica que los engobes y recubrimientos sin coloración no se registraron en las vajillas utilitarias de la prehistoria de la región Woodlands del Este, que las cerámicas del periodo Woodlands Temprano no presentan engobes con color o sin color, y que los engobes o recubrimientos con color en el periodo pre-Mississippi del Mediooeste se han observado solamente en frecuencias bajas. El resultado del análisis de microsondeo de electrones practicado a siete tiestos muestra una composición similar entre las arcillas de los engobes y las arcillas de los cuerpos de las mismas vasijas, indicando que los engobes fueron hechos de las mismas arcillas que las arcillas usadas para fabricar los cuerpos de las vasijas, pero sin desgrasantes o con una pequeña cantidad de desgrasantes de roca y/o cirniendo las arcillas del engobe. Los análisis contextuales proporcionan datos adicionales, incluyendo los posibles usos de engobes y recubrimientos para decoración y para reducir la permeabilidad de las paredes de la vasija. También fueron observados e interpretados los recubrimientos de calcita y apatita sobre las superficies de las vasijas. Los resultados indican una mayor continuidad en la tecnología cerámica del Mediooeste y el Sureste de los Estados Unidos de lo que anteriormente se había pensado, y sugiere la necesidad de tomar con cautela los análisis del microsondeo de electrones y los estudios químicos INAA de las cerámicas del Mediooeste.

Archaeological ceramic vessels and sherds commonly bear various types of surface materials that can provide important information on vessel manufacture, use, and postdepositional alterations (Hally 1983; Rice 1987:147–152; Rye 1981:40–46). Slips, floated surfaces, glazes, washes, paints, smudge deposits, sooting, carbonized food residues, and mineral coatings precipitated from groundwater are among the more common kinds of surface materials that can be diagnostic.

Although some surface materials can be identified and analyzed with the naked eye or low-power

Spencer J. Cotkin ■ Department of Geological Sciences, University of Illinois, Urbana, IL 61801
Christopher Carr and **Alfred E. Dittert** ■ Department of Anthropology, Arizona State University, Tempe, AZ 85287
Mary Louise Cotkin ■ 910 Hartwell Dr., #3, Savoy, IL 61874
Daniel T. Kremser ■ Department of Earth and Planetary Science, Box 1169, One Brookings Drive, Washington University in St. Louis, St. Louis, MO 63130–4899

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microscopy, more definitive studies can be made using the methods of petrographic microscopy. Petrography is applied most commonly in archaeology to identify and quantify added and naturally occurring inclusions in the body of ceramic vessels (e.g., Ferring 1985; Ferring and Perttula 1987; O'Malley 1981; Shepard 1976; Stoltman 1989, 1991), but its use for studying surface materials has precedents (e.g., Rye 1981:54; Shepard 1976). The power of the petrographic approach is enhanced when it is coupled with microanalytic techniques such as instrumental neutron activation analysis and electron microprobe analysis, which allow the chemical analysis of bulk samples and individual constituents (Carr and Komorowski 1995; Freestone 1982; Kamilli and Lamberg-Karlovsky 1979; Mommsen et al. 1988).

Petrographic and electron microprobe methods are used here to identify the surface materials on a large sample of Woodland and early Fort Ancient utilitarian ceramic vessels from Ohio. In all, 386 sherds from 23 archaeological components were examined petrographically. Particular attention is given to characterizing the uncolored (i.e., unpigmented) slips and washes in this sample, and in documenting their frequency and distribution through time, because these coatings have rarely if ever been recognized on pre-Mississippian, utilitarian ceramics of the Eastern Woodlands. Moreover, slipping in Middle and Late Woodland contexts is generally considered to be more of a Southeastern practice, and much rarer in the Midwest. The data presented here qualify these views, and imply greater technological similarity and continuity among the ceramics of the Southeast and Midwest. Our identification of uncolored slips and washes on Midwestern ceramics also have implications for how the ceramics of the Eastern United States should probably be screened petrographically in preparation for electron microprobe and instrumental neutron activation analyses, if accurate determinations of clay chemistry are to be made. Some understanding of the function(s) of the observed slips and washes is gained through a contextual study of the functions, sizes, and styles of vessels on which these coatings occur, and whether they occur on exterior and/or interior surfaces. In addition to slips and washes, calcite and apatite coatings are each documented for a few sherds.

The present contribution is part of a broader study of ceramic technology and the development of local, utilitarian exchange patterns during the Woodland in south-central Ohio by one of us (Carr). The study has included chronometric, petrographic, electron microprobe, neutron activation, and x-radiographic analyses (Carr 1990, 1992; Carr and Haas 1996; Carr and Komorowski 1995; Carr and Riddick 1990; Elam et al. 1992). The slips, washes, and calcite and apatite coatings on the ceramics discussed here were discovered unexpectedly by one of us (M. L. Cotkin) during the course of the petrographic work, and subsequently were verified by others using reflected-light microscopy and transmitted-light petrographic microscopy (A. E. Dittert, S. J. Cotkin), as well as SEM photography and electron microprobe analysis (D. T. Kremser).

General Nomenclature of Surface Materials

In this paper, the term *surface material* is used to refer to any material that occurs on the exterior or interior surface of a vessel. Surface materials are distinct from the sherd body in color, composition, or texture. Usually there is a clear discontinuity between the surface material and the body, except in the case of "floated surfaces" (see below). Some surface materials are applied intentionally (e.g., slips, floated surfaces, glazes, paints, washes, smudge deposits), whereas others are the unintentional byproduct of some cultural activity (e.g., soot, carbonized food residues) or postdepositional process (e.g., precipitated mineral deposits).

A *slip* is a surface material that can be defined operationally by its (1) discontinuity from the vessel body, (2) fine texture, being composed predominantly of clay and silt-size particles, and (3) paucity or complete lack of temper particles like those that have been added to the paste of the vessel body. Other characteristics of a slip, which distinguish it from the vessel body in most cases, are its (4) distinctive color, (5) different clay chemical composition, and (6) orientation of particles (Rye 1981:54; Shepard 1976:191–193). These properties derive from how a slip is created (Rye 1981:36–37, 41). The clays and silts of a slip are applied as a fluid suspension to an unfired, consolidated and shaped, partially dried vessel, creating the discontinuity between the vessel body and its slip. The suspension may include some fine or coarse rock particles that are natural to the raw clay or, less commonly, added fine temper particles (Shepard 1976:253). The suspension may or may not be wet-sieved or water-settled, to remove sand or gravel-sized natural rock inclusions and plant material (Rye 1981:36–37). Often the raw clay used to make a slip is different from the raw clay used to make the vessel body, in order to achieve some aesthetic or functional end. Less frequently, the same raw clay may be used for both the slip and the body. Consequently, a vessel body and its slip may or may not differ in chemical composition and color. Also, colorants are often, but not always, added to slips.

Either the interior or exterior of a vessel, or both, may be slipped. Procedurally, a slip can be applied by dipping a vessel in a clay suspension, pouring the suspension over or into the vessel, or wiping the suspension directly on the vessel's surface. Wiping on the suspension may result in lateral discontinuities or spatially frequent irregularities in the thickness of the slip, as well as particle orientation (Rice 1987:149–151; Rye 1981:20, 41).

Slips are applied for decorative purposes, to provide a smooth surface that is pleasing in itself, useful for later burnishing and/or painting, or that serves as a vehicle for the paint. They may be applied over the whole vessel, as with colored "filmed" ceramics in the Eastern Woodlands, or discontinuously within incised or otherwise demarcated or undemarcated zones (e.g., Belmont and Williams 1981; Griffin 1952:118–119). Slips also decrease the permeability of a vessel's walls by filling their pores with fine clays and silts, although this advantage may not have been recognized by the potter (Shepard 1976:191). In turn, for cooking vessels, less permeable walls influence the flow of fluids and transfer of heat through them, and thereby affect both the heating effectiveness of the vessel and its susceptibility to thermal spalling and thermal cracking (Schiffer 1990; Schiffer et al. 1994).

A *wash,* as used here following A. E. Dittert, has all the distinguishing, and potentially indistinctive, characteristics of a slip, but is very thin. Its thinness is not attributable to postdepositional surface erosion but, rather, to the extra fluidity of the applied suspension and/or the method of application. Cross-culturally, washes often are colored, but need not be. Rye (1981:41) and Rice (1987:151) used the term in a more restrictive way, to speak of a pigment, or lime-based stucco layer, that is applied to a vessel. Rye used it for a layer added before firing, whereas Rice used it for a layer applied after firing, as in the case of "fugitive" paints.

The term, *paint*, is used here, following A. E. Dittert, to refer to a slip or a wash that specifically has pigment within it, and that is used in creating decorative elements or in filling spaces. It may be added to a vessel before or after firing.

A *floated surface* is distinct from a slip or wash. A floated surface is operationally characterized by (1) a gradient of texture and composition from its outer surface to the vessel body, rather than a distinct boundary between the floated surface and the vessel body; (2) predominantly clay and silt-size particles; (3) a complete lack of coarser particles, save those protruding into the floated surface from the vessel body; and (4) a clay chemical composition similar to that of the vessel body. A floated surface is created by wetting the surface of a vessel and carefully wiping it with a hand, stone, bone, gourd rind, or some other firm, smooth material. This action separates finer and coarser particles within the vessel body and brings the finer ones up to the surface. When a hard smoothing implement is used, the action also tends to align flat particles parallel to the vessel wall, which increases the smoothness of the surface. Floated surfaces are sometimes called "self-slips" or "puddled surfaces" (Rice 1987:151), although the term "self-slip" has other definitions as well (Shepard 1976:192). A key difference of a floated surface from a slip and a wash is that the floated surface does not involve the addition of clay and other materials to the vessel wall, whereas a slip and a wash do.

A *glaze* is a coating of glass that melted in place and fused onto the body of a vessel. Producing a glaze requires the use of a kiln to achieve both high temperatures and effective temperature control, or the use of a flux that allows fusing at lower firing temperatures. These technologies were unknown in the prehistoric Eastern United States and, thus, are not considered further here.

Surface materials that are not slips, floated surfaces, glazes, or washes are referred to here collectively as *coatings*. This category includes encrustations of soil precipitates, food residues, smudge deposits, soot, and so on.

Slips in Eastern U.S. Prehistory

This section briefly outlines the use of slips, washes, and floated surfaces on Woodland through Late Prehistoric ceramics in the Eastern United States, as currently understood. It is based on an extensive literature search, as well as personal communications with key Midwestern, Northeastern, and Southeastern archaeologists who have broad, firsthand knowledge of the ceramic records of these regions (see acknowledgments). A primary conclusion of this survey is that although colored slips and washes have been reasonably well documented, uncolored slips and floated surfaces have not. Discussion is restricted here largely to qualitative temporal trends in the occurrence of these surface materials; information on the frequencies of specific slipped ceramic types is given in the endnotes.

In the Eastern United States, colored slips or washes have been observed in only low frequencies or not at all in most archaeological phases prior to the Mississippian Period, and uncolored slips on utilitarian wares are not recorded. Cole and Deuel (1937:38) defined Woodland ceramics in part by their general absence of slips and paints.

Most Early Woodland ceramics are thought to have not been slipped with either colored or uncolored suspensions. No examples are cited in Farnsworth and Emerson's (1986) comprehensive, edited volume on Early Woodland phases over the Eastern Woodlands, or in Petersen and Hamilton's (1984) review of Early Woodland ceramics in the Northeast and Midwest, or in Petersen and Sanger's (1991:126–131) review of ceramics of the Maritime Provinces. Belmont and Williams' (1981) survey of painted pottery in the southern lower Mississippi valley concludes that what little evidence has been brought forward for painted ceramics in the Tchefuncte period (Tchefuncte Red, Phillips 1970:164) is now waning (Belmont and Williams 1981:23). However, floated surfaces were documented by Griffin (1950–1958) on Bayou La Batre Plain vessels, in the Tombigbee and Alabama drainages, and by Ford and Quimby (1945; see also Thorne and Broyles 1968:81) for Orleans punctated vessels in the lower Mississippi valley.

During the Middle Woodland, in the Eastern United States, colored slips or washes were applied over entire vessels and within zones of vessels in very low frequencies. The slipped vessels are all finer types that occur more often in mortuary than domestic contexts.

In the Midwest, in Illinois, Middle Woodland vessels with red slips or washes over their entire surface or within zones, and black negative slipped or washed vessels, are found regularly but in very low frequencies (e.g., Griffin 1952:118–119; Hoffman 1960:30; McGregor 1958:40, 42, 43). These surface treatments are seen somewhat more commonly but still in low frequencies at the Mann Site in Indiana (Kellar 1979:103–105; Mark Seeman, personal communication 1996), which has a southeastern orientation in many of its characteristics.[1] On coarser, utilitarian Middle Woodland vessels, colored slips or washes have been observed only incidentally. For example, Kenneth Farnsworth (personal communication, 1996) has seen only one or two Illinois Havana sherds with red or orange slips or washes during his three decades of fieldwork in the lower Illinois valley. No colored slips or washes are reported in the literature defining Middle Woodland utilitarian ceramic types in Ohio (Morton 1984; Prufer 1965:18–59).

In the Southeast, the practice of coloring fine vessels was more common than in the Midwest, particularly in the southern lower Mississippi valley during the early Marksville period. There, such vessels are known in rare amounts from every adequate early Marksville ceramic sample (Belmont and Williams 1981:23; Toth 1977). In the northern Yazoo Basin of the lower Mississippi, during the Door and Twin Lake phases, zoned red treatments, red films over whole vessels, and red washes over incised or stamped vessels were common (Belmont and Williams 1981:23; James Stoltman, personal communication 1996). Red slipping and washing apparently did not persist into the late Marksville period, save in the lower Yazoo during the late Issaquena, when red slips over entire vessels were applied occasionally. Along the Gulf coast of Florida, in the Crystal River area of the Santa Rosa-Swift Creek region, low frequencies of a painted, red zoned type (Pierce Zoned Red) and a black resist-dye type (Crystal River Negative "Painted") are known (Willey 1949:391–392).

Uncolored slips on fine and coarse Middle Woodland ceramics are virtually unknown in the Eastern United States. Floated surfaces, apparently made in preparation for burnishing, have been noticed on fine Hopewell series vessels in Illinois by Kenneth Farnsworth (personal communication, 1996).

During the Late Woodland, recorded colored slips and washes are, again, less frequent in the Northeast United States than the Southeast. Colored ceramics are unknown in the Late Woodland of Illinois (Kenneth Farnsworth, personal communication 1996; Griffin 1952; James Stoltman, personal communication 1996). For Ohio, none was found by Carr's (1985) ceramic inventory or is reported in recent reviews of Late Woodland ceramics (Barkes 1981; Morton 1984; Seeman 1980). This absence relates, in part, to the lack of continuity of fine, Hopewell series ceramics, which sometimes bear coloring, into the subsequent Late Woodland.

In the Southeastern United States, vessels with red slips or washes over their entirety or within zones were common in the early Late Woodland Weeden Island 1 and 2 (according to the Percy-Brose chronology in Milanich et al. 1984:79, in contrast to Willey's 1949 chronology) ceramic complex of southern Georgia and Alabama and northern Florida (Milanich et al. 1984:185; Sears 1948, 1956; Willey 1949:422), in the related Woodville and Quafalorma ceramic horizons of the Baytown Period in the southern lower Mississippi valley (Belmont and Williams 1981:26,32; Milanich et al. 1984:186; Thorne and Broyles 1968:47,57,106), and in Southeastern-oriented southern Indiana (Walthal 1980:165–172). Red and white slipped ceramics also are known from the Quafalorma horizon of the Yazoo Basin in the lower Mississippi valley (Phillips 1970:155–156). All of these vessels are fine "mortuary" wares that occur only in burial mounds, or "prestige" wares that occur proportionally more frequently in mortuary than domestic contexts (sensu Milanich et al. 1984:130; Milanich 1994:185; see also Cordell 1984:198). Plain and stamped "utilitarian" vessels predominate in village sites of the lower Mississippi valley, and plain, punctated, and incised utilitarian vessels predominate in the McKeithen Weeden Island village site. In the Weeden Island village component of Kolomoki, plain sand-tempered and Weeden Island type sherds are most common, followed by incised sherds and some punctated sherds (Sears 1948:27–30).[2] After the Baytown period (later Late Woodland) in the lower Mississippi valley, colored ceramics were absent or infrequent in most phases. The same holds for late Weeden Island in the northern Florida and southern Georgia and Alabama area (Milanich et al. 1984:80–81).

In the late Prehistoric, colored slips and washes became more popular in parts of both the Midwest and Southeast where Mississippian cultures thrived. Most Mississippian complexes, and particularly the Middle Mississippian cultures of the central Mississippi, lower Ohio, and Tennessee drainages, frequently made red slipped, black negative slipped, bichrome, and polychrome vessels (Griffin 1967:190; Walthal 1980). In Illinois, colored slips first occurred around Cairo, about A.D. 700–800 (James Stoltman, personal communication 1996), and were commonly used later at Cahokia to produce finer, smoothed vessel types (e.g., Powell Plain, Ramey Incised). Red, yellow, and black slips were produced.

In contrast, very few colored ceramics have been found in the Fort Ancient cultures of the middle and upper Ohio drainage. In the Little Miami valley, the Madisonville site produced a small bowl with black painted lines and circles on its interior (Hooten 1920:Plate 24b). Fewer than 0.3 percent of the sherds from the Anderson village (A.D. 1250–1450) on the Little Miami have colored slips or washes, and these are zoned black or red designs (Don Bier, personal communication 1996). Oehler (1973:8–9, Figure 10a) and Cowan (1986:137) report that a few sherds from negatively painted jars and hooded water bottles, which could be imports from the Lower Ohio Valley Angel Phase or the American Bottom, occur at the Turpin phase sites of Turpin Farm on the Little Miami and Stateline on the Great Miami river (A.D. 1000–1250), but not at younger sites of the Shomaker and Mariemont Phases (A.D. 1250–1650) in the area. Further up the Ohio drainage, Fox Farm salt pans with interior red (fugitive?) color are documented by 16 sherds from Hardin village, Kentucky, on the Ohio river (Hanson 1966). A few Feurt Plain sherds with fugitive red ochre on their interiors are reported for the McCune site on the Hocking river (Murphy 1975:303). Four black negative-resist carbon painted or smudged sherds and one black positive painted sherd (.042 percent of 12,000 sherds), most likely locally produced, are known from the Philo II site on the Muskingham river (Gartley et al. 1975, 1976), but not from the neighboring Philo I, Richards, and Tysinger Philo Phase sites (Jeff Carskadden, personal communication 1998). No other examples of color-slipped or washed ceramic types are reported in the definitive literature for the various Fort Ancient phases in the middle and upper Ohio drainage, including the Baum-Baldwin-Brush Creek, Anderson, Feurt-Clover, Fox Farm, Philo, and Yate-Madisonville phases (Carskadden 1999; Church 1987; Essenpreis 1982:133–158; Graybill 1981; Griffin 1943; Heilman 1980; Marwitt et al. 1984; Mills 1906, 1917; Prufer and Shane 1970:38–74; Skinner et al. 1981), as well as the

Osborne, Manion, and Gist phases (Turnbow and Henderson 1986; Turnbow and Sharp 1988: 279–294). Turnbow and Henderson (1992) report no color-slipped or washed ceramics in their intensive analysis of 4,414 sherds from six Fort Ancient components in northeastern Kentucky. In sum, it appears that colored slips and washes were very rarely produced by Fort Ancient peoples of the Middle and Upper Ohio drainage.

In the Plaquemine Mississippian complexes of the southern lower Mississippi valley, colored ceramics remained absent or rare from various phases until the Historic period (Belmont and Williams 1981:26; Thorne and Broyles 1968:45,73). The same is true in northern Florida, where colored ceramics were lacking in Weeden Island IV and V until the Mission Period, after 1700 (Griffin 1951:150; Sears 1956:46; Smith 1951:117,132,171; Vernon and Cordell 1993:424).[3]

Uncolored slips have been recognized only rarely on utilitarian ceramics of the Woodland and Mississippian Periods, in both the Midwest and Southeast (David Brose, personal communication 1996). In some locales, this situation may reflect the actual paucity of uncolored slipped vessels in the archaeological records. However, the absence of uncolored, slipped utilitarian vessels also may relate to two methodological factors: (1) the lack of systematic petrographic examination of utilitarian ceramics from these times and places, and (2), the traditional emphasis placed on tempering materials and texturing techniques rather than surface materials in defining ceramic types and chronologies in the Eastern United States (Belmont and Williams 1981:19). The study made here suggests that these latter two factors are more pertinent to the ceramics of the Ohio Woodland, and that uncolored slips are more common than previously observed.

Analytical Sample and Methods

The 386 sherds analyzed here for their surface materials come from 23 dated components of 18 Woodland and early Fort Ancient period sites in the Scioto, Muskingham, and Ohio drainages of south-central Ohio (Figure 1). The components and sherds range in time from about 1150 B.C to A.D. 1300, in a fairly even temporal distribution. Most of the sites are habitations, rather than mortuary or other ceremonial sites, and all of the sherds appear to be from utilitarian vessels rather than mortuary-ceremonial wares. Nearly all of the vessels are coarsely made, with larger average temper particle sizes, thicker walls, light colors, and only plain or simple cord-marked surface treatment, in contrast to more finely made, ceremonial-mortuary wares with smaller average particle sizes, thinner walls, dark colors by reduced firing, and polished, incised surface treatment. A few vessels in the sample (n = 12, 3.1 percent of 386 sherds) are distinguished by moderately elaborated surface treatments, darker colors, or tetrapodal bases, but have nevertheless been identified as utilitarian on the basis of functional and depositional contextual criteria.[4] These few vessels we call *elaborated utilitarian* vessels, in contrast to the *ordinary, utilitarian* vessels that predominate in the sample. Our focus on utilitarian vessels was based on the sampling constraints of a different project.

Each of the selected sherds comes from a different vessel, as indicated by their visual and x-radiographic characteristics, which were assessed by the methods of Carr (1993), and by their proveniences of deposition. Thus, the observations made about the surface materials on successive sherds are independent.

The 386 sherds studied here from each archaeological component are a portion of a much larger sample (often hundreds of sherds from tens of vessels per component) that was selected by one of us (Carr) so as to maximize the representation of ceramic variation within the component and the number of potters responsible for the vessels. The dimensions of variation considered in selecting both the larger sample and the smaller, 386-sherd sample include ones that can vary among potters: minor stylistic traits such as the direction, spacing, and width of cord marks, the wetness of paste during cord marking, and paste color; and technological features such as the mineralogy, fractional density, and modal size of temper particles, as revealed x-radiographically (Carr and Riddick 1990). In contrast to the larger sample from each component, the 386-sherd sample does not encompass the full range of utilitarian ceramic variation within the component, given the small number of sherds and vessels selected; nor are ceramic variants within the 386-sherd sample represented proportional to their frequencies within the component. Thus, it is not possible to make inferences about differences in the frequencies of surface materials among the individual components. However, comparisons are more feasible among broader

Figure 1. Map of Ohio showing the locations of Woodland and early Fort Ancient archaeological sites from which ceramic samples were selected and studied here. Letters refer to sites for which samples were used in this study and are as follows: CC—Continental Construction; DD—Darby Dan; D—Decco; DLC—Dominion Land Co.; F—Florence; G—Greencamp; H—Harness-28; HB—Howard Baum; MH— Mabel Hall; Mc—McGraw; Mu—Murphy; MC—Mound City; NC—Newark Campus; PS—Phillip Smith; ST—Scioto Trails; T—Toephner; W—Waterplant; WSC—W.S. Cole

sets of components from different time periods, which are represented by more sherds.

The characteristics reported below for each studied vessel (e.g., vessel diameter, presence of various indicators of thermal stress) are based not on the single sherd representing it within the smaller, 386-sherd sample but, rather, on the several to many sherds that were found x-radiographically to belong to it in the larger sample. These sherds sometimes came from diverse locations on the vessel, as indicated by their varying morphology, thickness, and their not conjoining. Most of the individual sherds that were examined to characterize each vessel ranged in size primarily between ca. 5 and 10 cm in some dimension on their surface, although a few were as large as a fifth of the vessel's area. Each vessel's diameter was estimated from the curvatures of multiple sherds oriented vertically according to their morphology and surface treatment.

Nearly all of the 386 ordinary utilitarian and elaborated utilitarian sherds probably came from wide-mouthed, subconoidal-to-round vessel forms that served multiple purposes, such as cooking and storage, like their correlates in Illinois (Braun 1983). The forms and functions of the vessels from which the studied sherds originated were inferred from the known record of reconstructed Woodland vessels from Ohio, their forms and use characteristics (e.g., wear marks, wall spalling and delamination patterns, crack types, carbonized food residues), and the morphology and characteristics of the sherds in comparison. Some sherds, especially from the Middle Woodland Period onward, have soot carbon coatings on their exteriors and/or carbonized food residues on their interiors (see below), giving direct evidence of their vessels having been used in cooking food or heating nonfood items. This is true of both the ordinary and elaborated utilitarian vessels.

All 386 of the sherds considered here, as well as almost all from the larger sample, come from vessels that were tempered with coarse (1–3 mm), igneous rock fragments and single-mineral crystals. Minerals commonly present include quartz, plagioclase, alkali feldspar, muscovite and biotite micas, pyroxene, amphibole, and opaques (cf. Carr and Komorowski 1995). No limestone or shell-tempered ceramics were included in the sample.

All of the 386 sherds were analyzed with a petrographic microscope for a large suite of mineralogical, textural, and technology-sensitive traits of their paste and temper. Observations were made using both plane and cross-polarized, transmitted light, at 100–200 X magnification, by two professional geologists with expertise in petrographic, microprobe, and/or SEM work (S. Cotkin, M. L. Cotkin). Surface materials in addition to carbon residues (slips, washes, and calcite and apatite coatings) were encountered unexpectedly, leading to more extensive study of the materials. The entire sample of 386 sherds was examined 3 or more times by the Cotkins to find all possible examples of slips, washes, carbon residues, and other surface materials. All sherds bearing slips, washes, paints, floats, calcite coatings, apatite coatings, or anomalies suspected to be these, totaling 53 sherds, were then examined by A. E. Dittert.[5] He was able to confirm, disconfirm, and/or clarify the nature of each coating. Dittert's observations were made twice, with a reflected-light, stereo-zoomscope at 40X magnification, and then with a transmitted-light petrographic microscope using both plane and cross-polarized light, primarily at 40X magnification and up to 400X. The two periods of observation were separated by 10 months, providing a check on the work. Unsectioned sherds were not available for making fresh breaks and examining them for evidence of the surface materials.

Description of Surface Materials

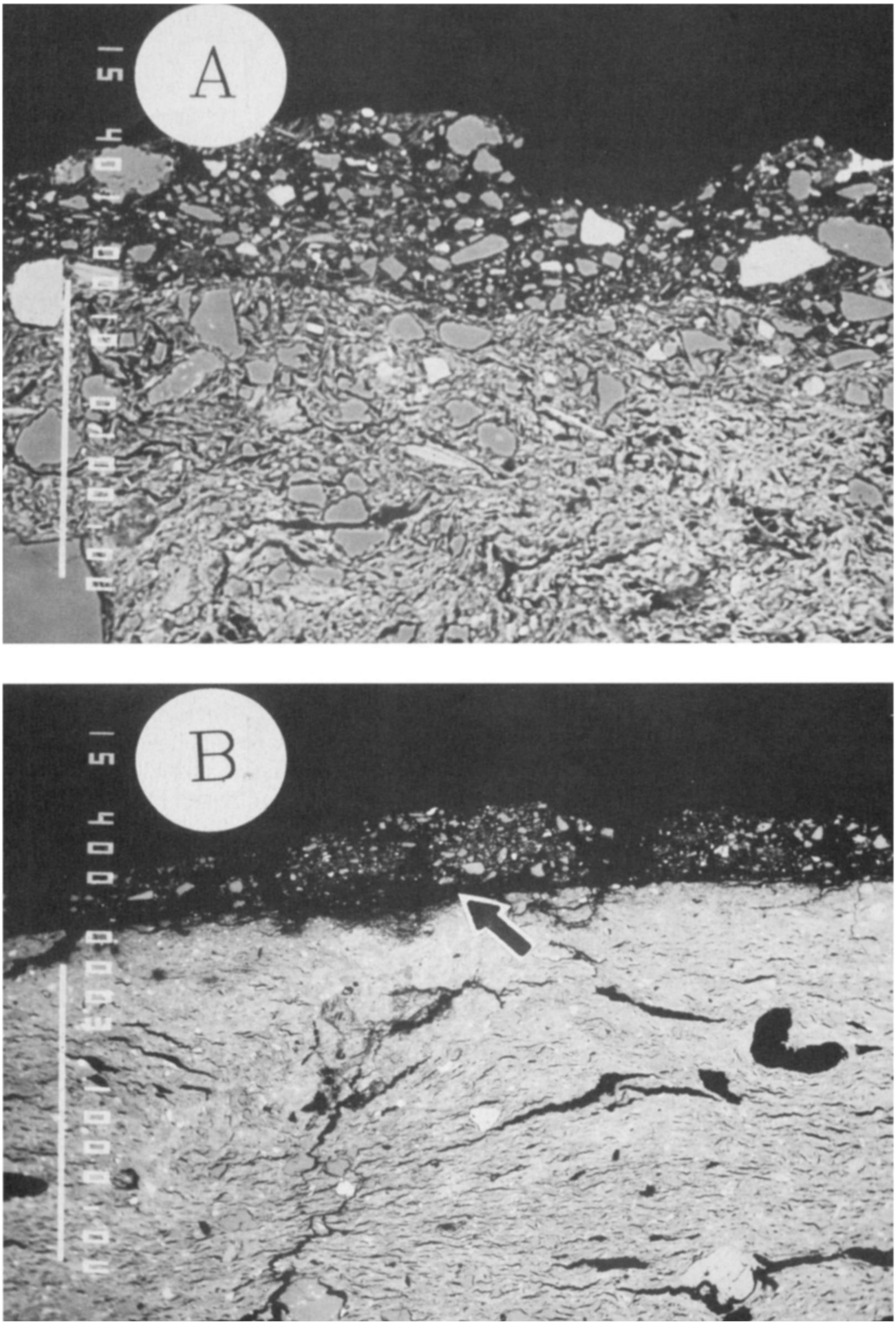
Our investigation of the 386 sherds from south-central Ohio revealed eight categories of surface materials, based on their petrographic and chemical characteristics: (1) slips, (2) washes, (3) paints, (4) floated surfaces, (5) apatite coatings, (6) calcite coatings, (7) external opaque carbon coatings, and (8) internal opaque carbon coatings. Burnishing, polishing, and rubbing surface treatments also were observed occasionally. These and the carbon coatings are not dealt with here, because they are generally well described in archaeological literature on the Woodland Period of the Eastern United States (e.g., Braun 1983; Griffin 1952; Prufer 1965). Unless otherwise specified, percentages of sherds discussed below pertain to the 386 sherd sample.

Slips

These are the most abundant form of clay surface materials in the sample, occurring on 38 to 40 (*ca.* 10 percent) of the 386 sherds. In line with the definition of slips given above, those in the sample are distinguished from their associated vessel bodies by texture and/or color, and the two phases are always separated by a well-developed discontinuity. The slips consist predominantly of clay and silt-sized quartz, together with minor amounts of silt-sized feldspar and mica (Figure 2A–C). Most of the slips lack the coarse rock particles that were added as temper to the clay of the vessel body. Approximately 60 percent of the 38 to 40 vessels with slips have slips with particles that generally are less than 0.1 mm.; these are often rounded and appear to be natural to the slip matrix. In contrast, added temper particles in the vessel bodies of these samples commonly are 1 to 3 mm. The remaining 40 percent of the vessels with slips have slips that were too dark to characterize for their particle size distribution or, less commonly, had some rock fragments that are as large as 3 mm, angular, and that could have been added or natural to the slip matrix.

In general, these petrographic observations indicate that the slips were usually made with raw clay

Figure 2 (over). Images of surface materials and their associated sherd bodies. In backscattered electron (BSE) images, bright areas are materials with high average atomic number (mostly Fe-rich minerals); dark areas are those with low average atomic numbers (mostly quartz and feldspars). Clay minerals contain some Fe and display medium gray tones. The photomicrographs were taken in plane polarized light. (A) A BSE image of a typical slip, on sample 26-194. The slip is at the top of the image and is clearly discernible from the sherd body by a discontinuity. The scale bar is 0.1 mm long. (B) A BSE image of a slip on 32-A13. A coating of organic material (black in image, marked by an arrow) occurs between the slip and the sherd body. Its origin is discussed elsewhere. The scale bar is 1.0 mm long. (C) A photomicrograph of a slip on sample 40-E01, which dates to 1150 B.C. ± 100 radiocarbon time (calibrated 1390/1330 B.C.; ETH 3312; Carr et al. 1996). The width of the image is 2.0 mm. (D) A BSE image of a calcite coating (top), which appears white in the image, on sample 47-D06. The extremely well-rounded, black areas are voids that represent grains—-probably quartz—that were plucked during thin sectioning. The scale bar is 1.0 mm long.



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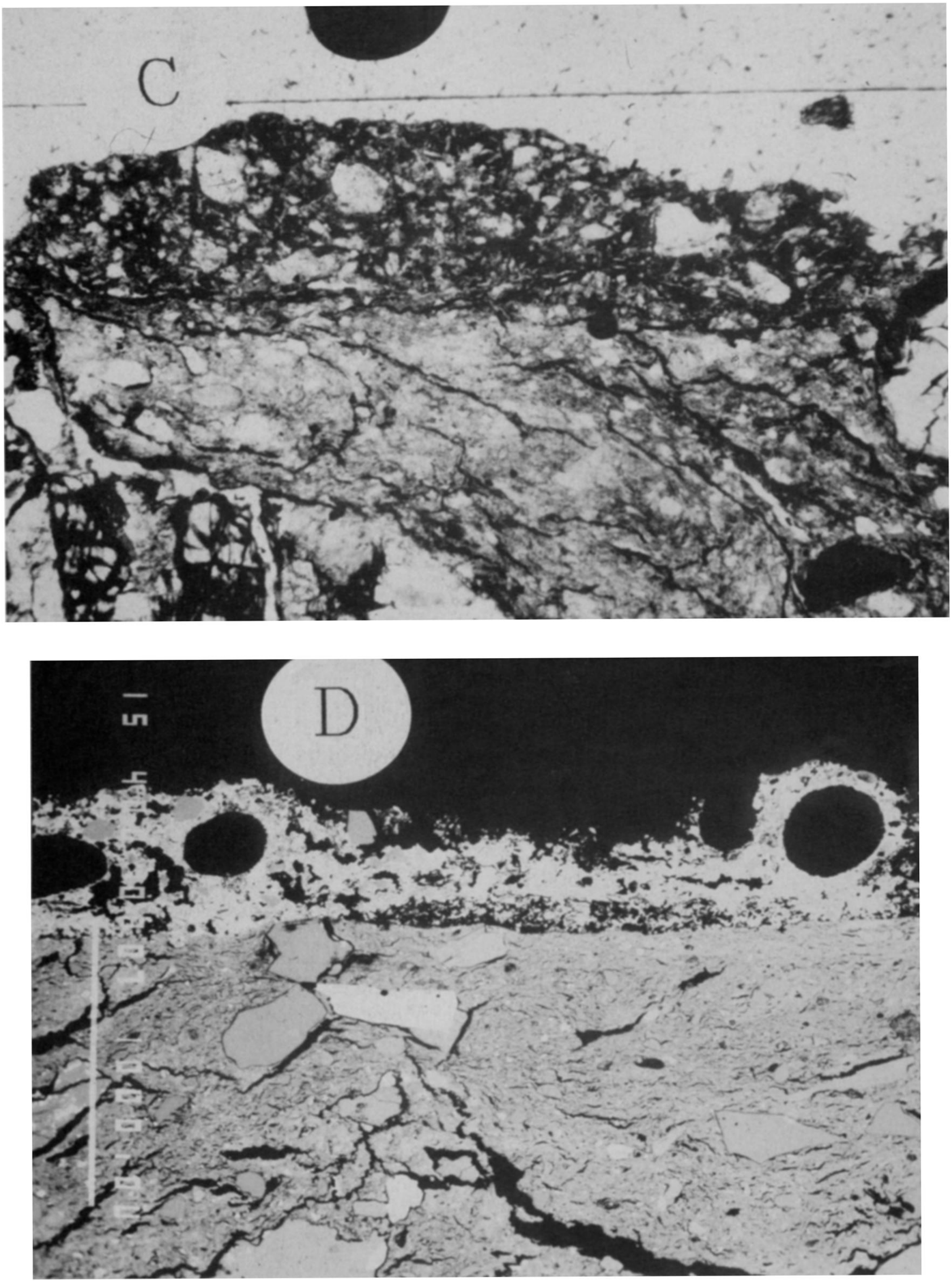

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from the same source as the vessel body, but without adding any temper, or only very fine temper. Presumably, a mass of clay was gathered, some was retained for making the slip of a pot, and the remainder was tempered, kneaded, and wedged in preparation for forming the pot. This reconstruction is supported by electron microprobe analyses of the chemical compositions of the clays and silts in the slips and those in the vessel bodies (see below). It is unclear whether the slip clays were sieved (Rye 1981:36) to remove any natural rock inclusions greater than 1 mm. in diameter; inclusions of this size occur occasionally within the slips. Long-term water-settling of the slip clays seems unlikely, given the generally similar clay and silt particle size distribution and mineralogical contents of the slips and the fine fraction of the body pastes. The hypothesis that the surface materials identified here as slips are, alternatively, soil deposits that have adhered to the vessel is not borne out by the similar clay-silt textural distributions, and the similar chemical compositions, of the slips and the fine fraction of the body pastes. The wide geographic area and diverse geomorphic environments in which the archaeological sites with slipped ceramics are located also challenge this hypothesis.

The clays in the slips are usually very similar in their color, chemistry, and mineralogy to the clays of their associated sherd bodies. This is probably the primary reason why the slips have gone unnoticed by archaeologists who have relied on macroscopic characterization of Woodland ceramics (see also Shepard 1976:191–192). Most of the slips range from a light tan to a medium brown in plane polarized light, and are the same color or somewhat lighter than their associated vessel bodies. Some slips have somewhat reddish, greenish, and grayish hues, but are within the color range of natural clays. A few slips are quite dark, and may be purposefully or incidentally colored slips.[6]

Slips are often put on vessels to create a smooth surface that can be polished, burnished, or painted (Shepard 1976:192). None of the slips observed here appears to have served these purposes.

The preservation quality of the slips varies considerably. In many samples, only small, discontinuous patches of slip are well preserved in their thickness. Commonly, the surfaces of the slips are degraded and raggedy. Occasionally, the preserved portions are restricted to pockets within cordmark depressions, but in almost all cases, at least a thin slip remnant extends onto higher parts of the vessel body surface. The maximum thickness of the slips studied here is 0.6 mm. All of the slips appear to have been fired; they are not unfired, fugitive clay slips added after firing. The poor preservation of many of the slips, as well as their similarity to their associated vessel bodies in color, distinguishes them from the markedly apparent slips found on the aboriginal pottery of the American Southwest. However, all of the surface coatings we identified as slips meet the standard criteria for defining slips (Shepard 1976:191–193), as enumerated above.

Washes

A few examples (n = 4 or 5; *ca.* 1 percent) were observed in the 386-sherd sample. Their characteristics are similar to those just described for the slips, but they are much thinner. The coatings defined as washes have flat exterior surfaces, and consequently cannot be considered eroded slips.

Paints

One example (*ca.* 0.3 percent) was found in the 386-sherd sample. It would have looked red-brown on the vessel. It consists of clays that contain fine, ruby red-colored crystals and grains, as well as fine inclusions of other minerals. The red pigment comprised ca. 40 percent of the coating's volume. It was not analyzed chemically for its composition, but is probably nonspecular hematite.

Floated Surfaces

Floated surface are rare (n = 1 or 2;*ca.* 0.3–0.5 percent) in the 386-sherd sample. Because floats can sometimes be subtle in their distinction from plain surfaces, it is possible that a few floats were not detected in the 386-sherd sample. The floats that were recognized have a characteristic gradient of texture and composition from their outer surfaces to the vessel bodies. They consist of predominantly clay and silt-size particles, and lack coarser sand and gravel-sized rock particles, save temper that protrudes into them from the vessel body. All the examples appear to have been made with a yielding wet hand, rather than a stone or other hard medium, because their silt particles are somewhat jumbled in orientation instead of well-aligned and parallel to the vessel wall. No chemical compositional analyses were made of the floated surfaces. Hand-rubbed and smoothed surfaces worked during the leather-dry stage, which were not tabulated with the wet-hand floated surfaces, also were rare (n = 3; *ca.* .8 percent) in the 386-sherd sample; however, this was so primarily because the sample was chosen to exclude fine ceremonial-mortuary wares that commonly bear them, and elaborated utilitarian wares have them only occasionally (see above). Surfaces identified as rubbed or smoothed did not evidence the separation and raising of fine particles to the vessel surface.

The hypothesis that the surface materials identified here as slips are, instead, floated surfaces, was seriously considered and rejected for several reasons. (1) All of the surface coatings that Dittert identified as slips meet the primary criteria that are standardly used to define slips and distinguish them from floated surfaces (Shepard 1976:191–193; see also Rye 1981:54), and that are enumerated above. These include the sharp discontinuity of the slip clay from the body clay, a particle size distribution predominated by clay and silt-sized particles, and the paucity or lack of the kinds of temper particles added to the vessel body. (2) None of the surface coatings identified as slips has a gradient of particle texture and/or composition that forms a continuum from its outer surface to the vessel body, which if present would indicate a floated surface where fine particles have been separated and raised from the vessel body. (3) Floated surfaces and slips were easily and modally distinguished from each other by the above criteria. (4) The examples classified as slips versus floats agree in their features with those found petrographically by Dittert in the ethnographically known slipped versus floated pottery of contemporary Southwestern Native American tribes. (5) Cordmarked vessels that were identified as having slips, which occur over the cordmarking, did not exhibit intercord peaks of the body clay that had been rounded off, which would have been the case if the body clay had been rubbed with a wet hand or similar tool to produce a float.

Apatite Coatings

These were found on only two sherds (*ca.* .5 percent) in the 386-sherd sample. They are amber to light olive-colored surfaces with very fine, pseudoisotropic grains. The grains could not be not identified petrographically, as they did not resemble developed apatite crystals in igneous rock; instead, they were identified by their composition using an electron microprobe (see below). The coatings and the vessel body join at a distinct boundary. In one case, the coating was comprised of individual, packed, rounded grains, some of which penetrated into the vessel body, as if an unfired, semi-dry vessel had placed on a "sandy" surface. Minor amounts of clay, silt, and organic material were admixed with the apatite. In the second case, the coating was solid with a granular internal structure. Like many slips, both examples of apatite coatings occur in small patches, and are thicker within the lows and thinner on the highs of a vessel body surface, probably from erosion. The coatings range to a maximum thickness of .5 mm.

Calcite Coatings

These were identified on only two sherds (*ca.* .5 percent) in the 386-sherd sample. They consist of very fine calcite crystals and minor amounts of quartz, clay, and silt (Figure 2D). On one vessel, the crystals are well packed and organized, as if they precipitated on the vessel. On the second vessel (Figure 2D), the calcite crystals are jumbled in their orientation and not so tightly packed, as if they had been applied. In both cases, the coatings are long, continuous layers. The deposits have a maximum thickness of 0.3 mm.

The interpretation of the first vessel's calcite coating as a precipitate from the surrounding soil is problematic. In moist climates, such as that in Ohio, soil calcium generally takes forms that are highly soluble and flushed from the soil by ground water (Carr 1982:160). It is possible that the calcite coating on at least the second vessel represents the attempts of a Woodland potter to use finely ground limestone to make a largely impermeable coating. Such a coating might have enhanced the liquid-holding capability of a cooking vessel or the soil-water and humidity restraining capabilities of a storage vessel. Calcite is the primary constituent of limestone, which is a common rock that was available to potters in south-central Ohio. Finely ground limestone is a major ingredient of natural (versus Portland) cement (ASTM 1955:1,24). When first wetted and subsequently desiccated, finely ground limestone will harden into a durable and largely impermeable layer, such as that found on at least one of the Ohio sherds. Rounded voids, possibly indicating quartz grains plucked from the calcite coating during its thin sectioning (Figure 2D), may have been incidental, or purposefully added, as mineral aggregates (especially sand) are commonly added to cement to produce concrete.

Chemical Studies

To further characterize the surface materials of the Ohio ceramics studied here, 10 sherds were analyzed for the chemistry of their surface materials and bodies by electron microprobe techniques.[7] Seven examples with slips, two with calcite coatings, and one with an apatite coating (Table 1) were selected. Specimens typical of these categories in their petrographically observable characteristics were chosen. Point rather than broad, raster analyses were made in order to avoid temper particles and to focus on clay constituents of the ceramic pastes and surface materials, or calcite or apatite coatings where relevant. The elemental assays, expressed in weight percent oxide, were normalized to 100 percent to eliminate several extraneous factors (Table 1, footnote), as is customary in mineralogical and ceramic research. Raw, unnormalized percent totals also are reported.

The chemical composition of the sherd bodies and slips are plotted in Figure 3, where oxides of major rock and mineral-forming elements (Ti, Al, Fe, etc.) are graphed against the most abundant oxide in rocks, clays, and ceramics, SiO_2. Such plots, known as Harker diagrams, are commonly employed in igneous geology to visually compare the composition of multiple samples of rocks of several types that are related stratigraphically or otherwise. The diagrams are equally valuable and fully analogous for visually comparing multiple samples of ceramic of several kinds—here two kinds, the slip clay and body clay.

Discussion of the Chemical Data

Inspection of Table 1 and Figure 3 reveals a number of patterns. First, most of the surface materials have lower raw unnormalized percent totals than their corresponding sherd bodies. The lower raw totals of the surface materials reflect their having more volatile constituents (mostly H_2O, but for some samples also CO_2). Two explanations of this situation are most likely.[8] (1)The slips and calcite and apatite coatings may have been more rehydrated than the ceramic bodies by groundwater while buried. Even minor amounts of weathering of a ceramic during burial can add modest amounts of H_2O to its outermost layer by rehydration of some clay minerals previously dehydrated during firing (e.g., Franklin and Vitale 1985). (2) The slips have lesser amounts of anhydrous, coarse-size quartz and feldspar grains than their associated ceramic bodies. Although care was taken in the electron microprobe analyses to aim the probe beam toward areas of the paste lacking these grains, it is likely that some were included, and that fewer were included in the assays of the slips, where they are less abundant, than in the assays of the sherd bodies, where they are more abundant. This pattern agrees with the identification of these surface materials as slips.

A second pattern found in Table 1 is that most of the surface materials have lower silica contents than their associated sherd bodies. The lower silica contents of five of the seven slips relative to their bodies most likely reflects the lower fractional volume of coarser-grained quartz and feldspar particles in the slips, and the lower probability of hitting them while probing the sherds. Again, this result accords with the identification of the surface materials of these seven sherds as slips, which have finer texture than their associated vessel bodies. The low silica contents of the three calcite and apatite coatings stem from the non-silicate nature of calcite and apatite. The minor amounts of SiO_2 in these coatings probably result from the admixture of quartz, feldspar, and clay from the sherd body or the soil in which the sherd was buried.

The third pattern in Table 1 and Figure 3 is the general overlap in the compositions of the slips and sherd bodies. This pattern corroborates two conclusions drawn from petrographic observations: (1) The slips were made with raw clay from the same source as the vessel body, but without the addition of temper, and/or with the sieving of the slip clay; and (2) no colorants were added, with the possible exception of two sherds that have high manganese concentrations (see below).

The similarity of the slips to their vessel bodies in composition and their lack of added colorants in most if not all cases, along with ethnographic information, suggest that the slips may have been applied for some practical purpose, rather than aesthetic reasons. Arnold (1985) found cross-culturally that decorative slip and paint materials are usually obtained from different sources than the clays used to make their associated vessels, often at significant distances from the potter's residence, ranging between 2 and 800 km, and usually greater than 10 km. In contrast,

Table 1. Chemical Composition of Vessel Bodies and Surface Materials as Determined by Electron Microprobe Analysis.[a]

Sample	26-194		36-162		34-B47		40-E01		28-C40	
Element	body	slip	body	slip	body	slip	body	slip	body	slip
SiO_2	58.78	61.60	57.61	54.18	55.08	51.77	62.48	60.86	58.80	55.11
TiO_2	0.50	0.94	1.00	0.71	0.85	0.48	0.67	0.60	0.58	0.65
Al_2O_3	25.45	19.73	23.60	22.59	22.48	23.74	24.38	19.08	20.49	15.71
FeO	6.05	8.98	8.95	11.06	11.21	9.90	5.38	11.63	5.81	8.20
MnO	.bd[b]	0.19	0.16	0.10	.bd	0.14	0.29	0.08	.bd	9.30
MgO	2.22	2.00	2.25	2.15	1.75	2.22	1.46	1.93	1.79	1.18
CaO	0.80	1.25	1.73	2.93	2.87	4.50	0.35	1.05	2.62	4.01
Na_2O	0.27	0.25	0.43	0.25	0.44	0.36	0.23	0.21	0.45	0.20
K_2O	5.31	3.92	2.70	4.61	2.74	4.75	4.50	4.01	5.04	2.31
P_2O_5	0.63	1.13	1.56	1.41	2.58	2.15	0.27	0.54	4.42	3.33
Normalized Total	100.01	99.99	99.99	99.99	100.00	100.01	100.01	99.99	100.00	100.00
Raw Total	90.54	75.16	86.60	72.93	80.35	71.32	82.46	84.95	86.04	69.64

Sample	32-A13[c]		33-A18		34-157		47-181		47-D06	
Element	body	slip	body	slip	body	apatite coating	body	calcite coating	body	calcite coating
SiO_2	65.32	58.20	51.57	51.70	58.47	8.19	57.19	0.75	66.39	.bd
TiO_2	0.43	0.32	0.90	0.86	0.93	0.06	1.41	.bd	0.43	.bd
Al_2O_3	18.73	20.02	25.78	16.87	23.33	5.62	18.53	.bd	19.32	.bd
FeO	6.48	7.36	10.08	8.84	5.73	1.42	15.33	0.12	5.96	.bd
MnO	.bd	.bd	.bd	2.02	.bd	0.27	0.11	0.03	.bd	.bd
MgO	1.80	3.00	2.48	3.23	2.21	3.93	2.10	1.48	2.06	0.99
CaO	2.11	5.68	2.75	7.15	3.35	44.60	1.59	57.02	1.90	55.97
Na_2O	0.13	0.18	0.21	0.13	0.68	.bd	0.60	0.03	0.21	0.02
K_2O	2.76	4.55	3.77	4.62	2.86	0.59	2.45	0.02	3.59	.bd
P_2O_5	2.21	0.69	2.48	4.58	2.46	35.32	0.69	0.42	0.15	0.22
Normalized Total	99.97	100.00	100.02	100.00	100.02	100.00	100.00	.	100.01	.
Raw Total	94.11	62.63	91.31	71.18	89.59	69.23	81.34	59.87	96.01	57.20

[a] The probe data are expressed in terms of weight percent oxide, as is customary in mineralogical literature. Analyses of ideal, volatile-free materials produce raw totals of 100 percent, with absolute analytical uncertainties ideally in the range of ± 0.5 1.0 wt. percent. However, the raw analytical totals for the sherd bodies and surface materials studied here vary from 57 to 96 percent. The low totals result from several effects, including: (1) the inability of the electron microprobe to analyze elements of low atomic weight (e.g., C and H in carbonate minerals, organic substances, as bound hydroxyls, or as molecular H_2O); (2) the microporosity of the archaeological artifacts (Freestone 1982), which decreases the number of x-rays emitted from the sample during analysis; and (3) the fine-grained nature of the materials, which enhances absorption of emitted x-rays. Thus, all analyses, except those for calcite coatings, are normalized to 100 percent (Freestone 1982), in order to facilitate comparisons among samples. By normalization is meant that the weight percent oxide values of a given sample (table column) have been proportionally increased so as to sum to 100 percent. Calcite coatings are not normalized because their raw analyses can be directly compared with the ideal composition of calcite.

Normalization is theoretically appropriate for comparing multiple samples, so long as the relative degrees of absorption or emission of generated x-rays of various wavelengths, pertaining to various elements, remains equal across samples, despite any differences in their microporosity. This condition seems to characterize this analysis. No significant (i.e., data pattern altering) correlations were found between the raw totals of samples (measures of absorption due in part to sample microporosity) and their normalized percent concentrations for the 10 elements assayed. A small bias of 2.5–3.0 percent may pertain to the calcium levels of a few samples with raw totals below 72 percent (i.e., higher microporosity).

[b] bd = below detectable level of about 0.03 wt. percent.

[c] Sherd body 32-A13 also contains 0.03 wt. percent Cr_2O_3.

the majority of clays used for vessel bodies were gathered from sources less than 5 km from the potter's residence, with many sources less than 2 km distance. Thus, special efforts are often made in order to obtain decorative materials for ceramics. The Ohio Woodland slips examined here do not appear to follow this ethnographic pattern, possibly indicating their having had a practical rather than decorative

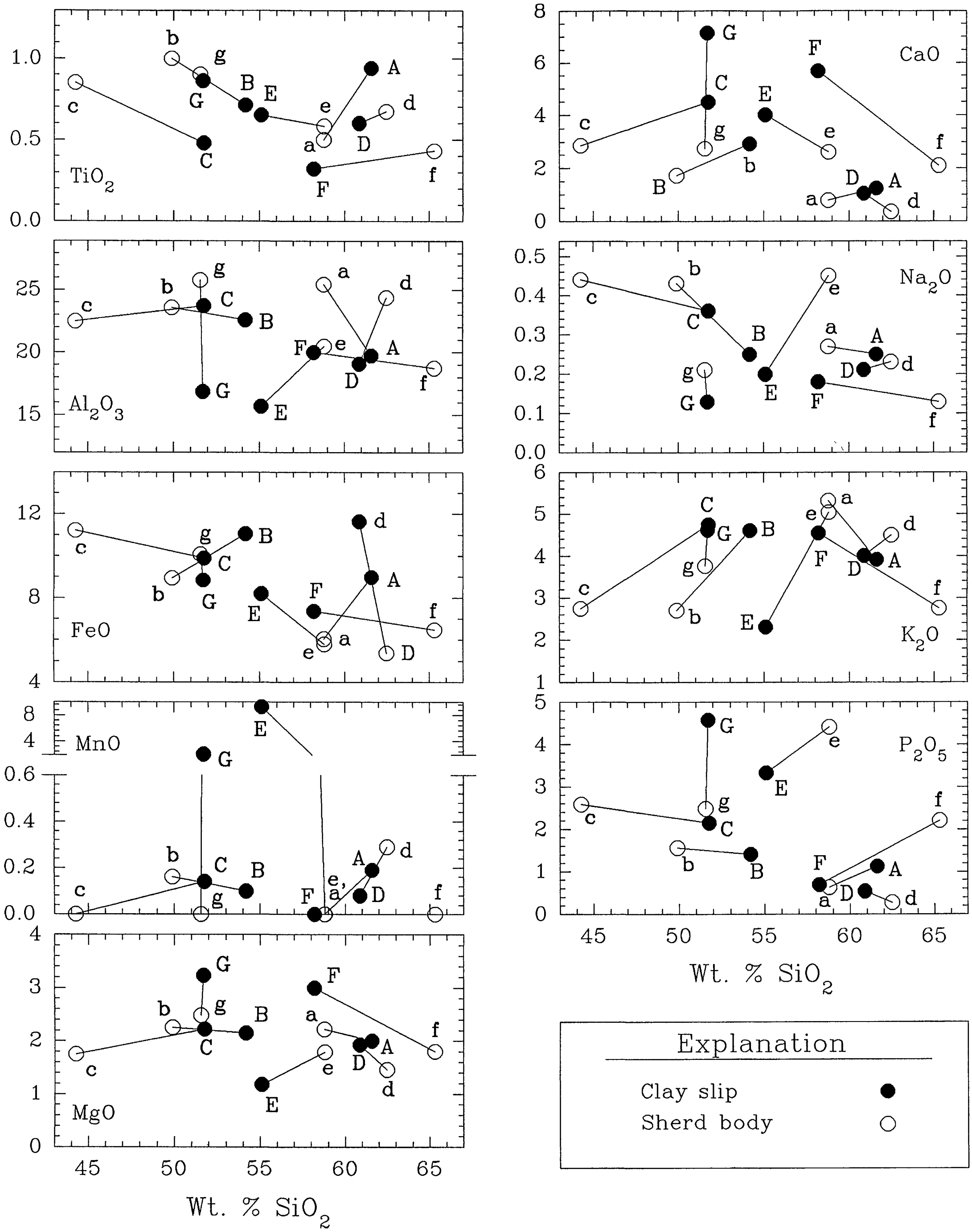

Figure 3. Harker diagrams for normalized analytical values. Weight percent SiO_2 is plotted against weight percent oxides of other major elements. For the most part, slips and their associated sherd bodies overlap compositionally. Lines connect associated slips (capital letters) and sherd bodies (lowercase letters). Letters refer to the following samples: A = 26-194; B = 36-162; C = 34-B47; D = 40-E01; E = 28-C40; F = 32-A13; G = 33-A18.

purpose. This issue is weighed further, below, with contextual data.

A fourth characteristic of the data is that the slip-body pairs show minor differences in composition that are unpatterned, varying from vessel to vessel. This is evident in Figure 3, where the lines connecting the elemental compositions of slips and their associated bodies vary in length and orientation by vessel for any given element. This lack of patterning is best explained by natural heterogeneities in the raw clay, which slightly and randomly distinguish each slip from its associated vessel body. The pattern also accords with the interpretation that slips were produced from the same clays as their associated vessel bodies.

A fifth data pattern in Table 1 concerns manganese oxide contents. Manganese is a minor component in all of the sherd bodies and most of the surface materials. It ranges in concentration from below detectable limits to 0.29 wt. percent. However, in two slips, on sherds 28-C40 and 33-A18, MnO is much more abundant, comprising 9.30 and 2.02 wt. percent, respectively. In these samples, Mn resides in a very fine-grained (< 3.0 μm diameter), disseminated phase. The small grain size precluded identification of the phase. It is unclear if the elevated MnO contents of these two slips represent the intentional addition of a manganese (black) colorant, or if Mn-rich clays were unintentionally exploited.

Sixth, the analyses of the calcite coatings in Table 1 reveal that their compositions are very close to ideal calcite ($CaCO_3$), which is 56.0 wt. percent CaO and 44.0 wt. percent CO_2. Minor chemical variations from these ideals most likely arise from mineralogical impurities (quartz and clay), from solid solution processes (i.e., the minor replacement of Ca^{2+} by Mg^{2+} and/or Fe^{2+} in the crystal structure of calcite), and from the inclusion of small amounts of calcium phosphate (Freestone et al. 1985).

Seventh, the amber-colored coating consists mostly of apatite, $Ca_5(PO_4)_3(OH,Cl,F)$. Apatite is a common but minor constituent of many rocks, and is the principal inorganic constituent of bone and teeth. It was initially thought that apatite coatings might represent granulated bony material that was deposited on vessel interiors during the cooking of foods or the processing of raw materials. However, both examples of the coatings occur on the exteriors of vessels, and contextual data (see below) suggest that the vessels probably were not used for cooking. The suggestion that the apatite coatings precipitated on the exterior of the vessels when bone was soaked in them, in preparation for working bone, is ethnographically reasonable (Carr 1982:236–237, Table 32; Semenov 1964:159). However, the idea does not seem likely, given the distinct form of the internal boundaries of the coatings (see above), and the lack of apatite precipitates filling void spaces within the bodies of the vessels. The origin(s) of the coatings remain unclear.

Other patterns in Table 1 and Figure 1 are less relevant to the nature of the surface coatings, themselves.[9]

Contextual Studies

The nature of the slips and other surface coatings were elucidated further by studying various aspects of their contexts: their frequencies and time-space distributions (Table 2, Figure 4), their locations on vessels, and the sizes and estimated functions of the vessels on which they occur. Several techno-functional and culture-historical patterns are clear, as now described.

Frequency and Time-Space Distribution

Slips and other apparently intentionally-produced coatings on ceramics are a common component of Ohio Woodland and early Fort Ancient ceramics—much more common than archaeological literature on the ceramics of the Midwest United States (see above) would lead one to expect. Of the 386 vessels sampled, 38 have slips, 2 possibly have slips, 4 have washes, 1 possibly has a wash, and 1 has a paint, totaling 46 vessels, or 11.9 percent with intentional coatings. An additional 2 vessels have calcite coatings that may have been intentionally applied, making a total 48 vessels, or 12.4 percent of the sample. Forty-five vessels (11.6 percent) have or probably have uncolored slips or washes. The one vessel with a paint comprises 0.26 percent of the sample, which compares well with the 0–1 percent frequency of color-slipped or washed ceramics that are typically reported for Woodland through early Fort Ancient times in Ohio and the Midwest[1]. (We exclude from these counts floated surfaces, which are not coatings, and apatite coatings, which may not have been intentionally produced.)

The proportion of vessels having or likely having uncolored slips and washes in the sample, 11.6 percent, is probably a reasonable estimate of the proportion of all vessels with slips in the components studied. The sherds examined here were selected so as to maximize the representation of ceramic variation along a large number of dimensions (see above), and thus to maximize the number of potters responsible for the vessels.

Table 2. Temporal Distribution and Types of Surface Materials on Ceramics in South-Central Ohio.

Assoc. No.[1]	Association	Radiocarbon and Calibrated Dates[2]		No. of vessels in sample	Number of Vessels with Various Kinds of Surface Materials[3] SL	SL?	WA	WA?	TOT	PT	FL	FL?	CC	AP
Early Woodland														
40,42	Continental Construction	1150 B.C.	1390/1330 B.C.	2	2	0	0	0	2	0	0	0	0	0
66	Mabel Hall	1165–825 B.C.	990/950–910 B.C.	2	0	0	0	0	0	0	0	0	0	0
54-60	Dominion Land Co.	490–185 B.C.	510–170 B.C.	6	1	0	0	0	1	0	0	0	0	0
48-52	Phillip Smith	410–335 B.C.	400–380 B.C.	42	2	0	0	0	2	0	0	0	0	1
46	Toephner	464–250 B.C.	410–340/320/200 B.C.	1	0	0	0	0	0	0	0	0	0	0
47	Florence	230 B.C.	350/320/200 B.C.	15	0	0	0	0	0	0	0	0	2	0
45	Darby Dan	225–75 B.C.	190–10 B.C.	3	0	0	0	0	0	0	0	0	0	0
Totals for Early Woodland				71	5	0	0	0	5	0	0	0	2	1
Percent of samples with each type of surface material					7.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	2.8	1.4
Middle Woodland														
26-28	Harness28	125 B.C.–A.D. 250	50 B.C.–A.D. 380	26	4	1	0	1	6	0	0	1	0	0
65	Mound City	A.D. 61	A.D. 130	31	0	0	0	0	0	0	0	0	0	0
11-14, 61	Murphy	A.D. 60–360	A.D. 120–450	23	2	0	1	0	3	0	0	0	0	0
64	Mound City	A.D. 180	A.D. 250/300/310	17	1	0	0	0	1	0	0	0	0	0
30-36	McGraw	30 B.C.–A.D. 481	A.D. 30/40/50–610	24	11	1	1	0	13	0	1	0	0	1
2, 3	Decco	A.D. 240–250	A.D. 347/360/374–380	8	1	0	0	0	1	0	0	0	0	0
53	Newark Campus	40 B.C., A.D. 403	A.D. 20, 540	12	2	0	0	0	2	0	0	0	0	0
Totals for Middle Woodland				141	21	2	2	1	26	0	1	1	0	1
Percent of samples with each type of surface material					14.9	1.4	1.4	.71	18.4	0.0	.71	.71	0.0	.71
Early Late Woodland														
15-22	Waterplant	A.D. 500–616	A.D. 630–730/770	44	3	0	0	0	3	0	0	0	0	0
5-9	Scioto Trails	A.D. 515–780	A.D. 636–886	33	6	0	0	0	6	0	0	0	0	0
23-25	Harness-28	A.D. 680–720	A.D. 730/770–790	45	0	0	0	0	0	0	0	0	0	0
41	Continental Construction	A.D. 790	A.D. 890	1	1	0	0	0	1	0	0	0	0	0
Totals for Early Late Woodland				123	10	0	0	0	10	0	0	0	0	0
Percent of samples with each type of surface material					8.1	0.0	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.0
Late Late Woodland														
4	Decco	A.D. 900	A.D. 1000	7	0	0	0	0	0	0	0	0	0	0
1	Decco	A.D. 1160	A.D. 1260	2	0	0	0	0	0	0	0	0	0	0
71-74	W.S. Cole	A.D. 1235–1294	A.D. 1290–1300	14	0	0	0	0	0	0	0	0	0	0
44	Greencamp	A.D. 1280	A.D. 1300	4	0	0	0	0	0	0	0	0	0	0
Totals for Late Late Woodland				27	0	0	0	0	0	0	0	0	0	0
Percent of samples with each type of surface material					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fort Ancient														
37-39	Howard Baum	A.D. 1205–1298	A.D. 1280–1306/1364/1375	24	2	0	2	0	4	1	0	0	0	0
Totals for Fort Ancient				24	2	0	2	0	4	1	0	0	0	0
Percent of samples with each type of surface material					8.3	0.0	8.3	0.0	16.7	4.2	0.0	4.2	0.0	0.0
All Samples														
Totals for all samples				386	38	2	4	1	45	1	2	1	2	2
Percent of samples with each type of surface material					9.8	0.52	1.0	0.26	11.7	0.26	0.26	0.26	0.52	0.52

[1] Associations and their number codes indicate a series of archaeological proveniences that provided a large collection of primarily coarse, utilitarian ceramics and a strong association between them and datable carbon samples. See Carr and Haas (1996).

[2] Radiocarbon and calibrated dates are reported fully in Carr and Haas (1996). Calibrations were determined by the computer program CALIB 3.0 (Stuiver and Reamer 1993), using the bidecadal curve and a lab multiplier of 1.

[3] Kinds of surface materials include slips (SL), possible slips (SL?), washes (WA), possible washes (WA?), the total number of vessels with these four surface materials (TOT), paints (PT), floats (FL), possible floats (FL?), calcite coatings (CC), and apatite coatings (AP). If a vessel has slips, possible slips, washes, possible washes, floats, or possible floats on two sides, it is counted only once, in the category that represents the most fully developed coating. For example, a vessel with a slip on one side and a wash on the other is counted only as an instance of a slip. A vessel with a possible slip on one side and a float on the other is counted only as a possible slip. In this way, the counts represent numbers of vessels rather than numbers of vessel-sides with coatings.

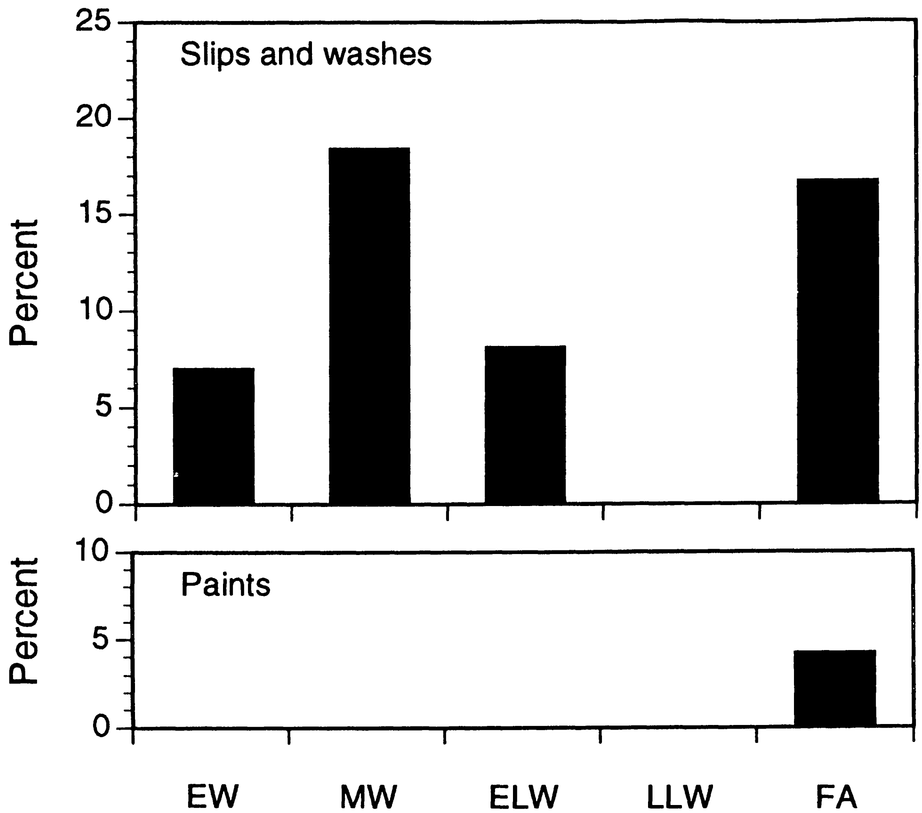

Figure 4. Distribution of surface materials by archaeological time period. In particular, the percentages of sampled sherds from the Early Woodland (EW), Middle Woodland (MW), Early Late Woodland (ELW), Late Late Woodland (LLW), and early Fort Ancient (FA) periods that have slips, washes, and paints.

The commonality of slips and washes in Woodland and early Fort Ancient components can be measured in ways other than vessel frequency. Of the 57 proveniences sampled for their ceramics, 22 (38.6 percent) have one or more vessels with slips or possible slips, and 3 (5.3 percent) additional proveniences have one or more vessels with washes or possible washes, totaling 25 proveniences (43.9 percent). Of the 23 archaeological components considered, 13 (56.5 percent) have one or more vessels with slips or possible slips. Three components have vessels with washes or possible washes, but they are among the 13 that have vessels with slips. More than half of the 10 archaeological components found to lack vessels with slips are represented by only a small sample of sherds: Mabel Hall (n = 2), Toephner (n = 1), Darby Dan (n = 3), Decco Association 4 (n = 7), Decco Association 1 (n = 2), and Greencamp (n = 4). It is not possible to infer whether these components actually lack vessels with slips, or whether the observed absence relates to inadequate sampling. Only four components were represented by samples of 11 or more sherds and would be expected, probablistically, to have 1 or more vessels with slips, but did not: Florence (n = 15), Mound City Association 64 (n = 17), Mound City Association 65 (n = 31), and W.S. Cole (n = 14). None of the three sites comprised by these components share any common location, age, or cultural affiliation.

The components with vessels bearing uncolored slips and washes, or probable ones,[10] are located in a variety of geomorphic contexts, in all adequately sampled river drainages, including the central Scioto; its tributaries—Paint Creek, Darby Creek, and the Olentangy River; and the Licking.[11] The widespread distribution of vessels with slips helps to affirm them as products of human intention rather than processes of nature.

Uncolored slips and washes vary in their frequencies over the Early Woodland through the early Fort Ancient periods, ranging between 0 and 18.4 percent (Table 2; Figure 4). The temporal distribution of frequencies of the uncolored slips and washes generally follows the known temporal distribution of color-slipped or color-washed wares in Ohio. The uncolored slips and washes documented here are most common in the Middle Woodland (18.4 percent), rare or absent in the Late Woodland, and rise in popularity again at the one early Fort Ancient period site sampled (16.7 percent) (Figure 4). Color-slipped ceramics are found in Ohio during the Middle Woodland, are unknown for the Late Woodland, and again are found in the Fort Ancient Period, although less commonly than in the Middle Woodland (see above). The generally parallel temporal distributions of uncolored and colored slips could imply that uncolored slips were applied, at least in part, for a decorative purpose—to help create a smooth, aesthetically pleasing vessel surface. Contextual data patterns support this hypothesis (see below). At the same time, slips and washes may also, or alternatively, have served to decrease the permeability of a vessel's walls (Rice 1987:232; Shepard 1976) and/or to create a smooth surface that was easier to clean. A hint at these alternative functions is raised by the fact that uncolored slips were found on 7.0 percent of the Early Woodland vessels and 8.1 percent of the Early Late Woodland vessels examined, yet no colored slips or washes were found on studied vessels of these ages, and none are reported in the literature on Early Woodland and Early Late Woodland ceramics from Ohio. Thus, at least Early Woodland and Early Late Woodland uncolored slips, and perhaps those from other periods, may have been applied for purposes other than decoration. This possibility also is investigated further, below.

Finally, it is culture-historically significant that the slipped vessels from Early Woodland contexts occur on early, thick varieties probably having a barrel or flower-pot form, and occur in 4 proveniences, some with early dates: Continental Construction Associations 40 and 42, 1150 B.C. ± 100 (calibrated 1390/1330 B.C.; ETH 3312); Dominion Land Company Association 56B, 490 B.C. ± 100 (calibrated 510/430 B.C.; ETH 3071); Phillip Smith Association 48A, 410 B.C. ± 90 (calibrated 400 B.C.; ETH 3481); and Phillip Smith Association 49A+B, 335 B.C. ± 100 (calibrated 380 B.C.; ETH 3310). All of these dates have been evaluated as acceptable (Carr and Haas 1996). Thus, it would appear that the technique of slipping pottery was an integral part of ceramic technology from the beginning, or near the beginning, of its development in Ohio, at least. Tracing the time-space distribution of this trait might prove a useful means for unraveling the question of the path(s) of diffusion of pottery making into the northern Eastern United States (c.f. many authors in Farnsworth and Emerson 1986; Peterson and Hamilton 1984).

Calcite coatings are found only in the Early Woodland, and at one site (Florence). It may be significant that at Florence, slips are not found, despite the adequate size of the sample of studied vessels from there (n = 15). Perhaps calcite coatings were used at Florence as a functional equivalent to clay slips elsewhere.

Slip Location, Vessel Size, and Vessel Function

The possible reason(s) why uncolored slips, washes, and calcite coatings were applied to vessels are clarified, somewhat, by considering their locations on vessels, the sizes of the vessels, and their evaluated functions. Five possible reasons for application are assessed here: (1) to create a smooth decorative surface; (2) to cover the coarser paste of a vessel's walls with a finer, smoother surface that is easier to clean; (3) to decrease the permeability of a vessel's walls for this direct end; (4) to decrease the permeability of a cooking vessel's walls in order to indirectly alter their susceptibility to thermal shock; and (5) to decrease the permeability of a cooking vessel's walls in order to increase the heating effectiveness of a vessel. Most of these ideas are not mutually exclusive.

Decoration. The idea that at least some slips and washes were decorative is supported by four data patterns, beyond the temporal information discussed above. First, they are located most commonly on only the exterior of vessels (n = 21; 46.6 percent of 45 slipped or washed vessels), where they would have had a visual impact, or on both sides (n = 13; 28.9 percent). They are located less frequently on only the interior (n = 8; 17.8 percent) or on an indeterminable side (n = 3; 6.7 percent) of a vessel.

Second, of the 45 vessels that were found to bear slips or washes, 12 (26.7 percent) are elaborated utilitarian wares showing other extra attention to surface treatment and/or body form. This 26.7 percent is disproportionately high compared to the percentage of the total sample of 386 vessels comprised of elaborated utilitarian wares (3.1 percent), indicating a significant association between slips or washes and elaborated utilitarian vessels.

Third, of the 12 elaborated utilitarian vessels with slips or washes, it could be determined petrographically for 10 whether the coating occurred on the exterior or interior surface. In 8 out of 10 (80 percent) of these cases, the coating occurred where it affected the visual appearance of the vessel: on either the exterior surface, or both the exterior and interior surfaces, of the vessel.

Finally, of 34 vessels observed to have slips or washes on their exterior surfaces, 26 (76.5 percent) have such coatings over rough, cordmarked surfaces, not plain surfaces as one might expect. Applying a slip, or less likely a wash, to a cordmarked vessel could have been a stylistic alternative to partial hand-smoothing the surface, or may have been a means for giving a vessel a culturally-appropriate tint or shade. An uncounted but significant number of slips are lighter in color than their associated vessel bodies.

The practices of cordmarking a vessel and then putting a slip or wash over the rough-textured surface may seem at odds, but has analogs elsewhere in the Eastern United States. In the northern Yazoo basin, in the Door and Twin Lake phases of the early Marksville Period, red washes were placed over vessels decorated by incising and six different kinds of stamps (Belmont and Williams 1981:23).

The fact that slips and washes were applied to the interiors of 21 (46.6 percent) of the 45 vessels bearing them indicates that some of these coatings were applied for other than decorative purposes. We now examine four other possibilities.

Cleaning. The hypothesis that slips and washes were intended to form a smoother, more cleanable surface loses favor when the location of slips is considered by time period. The only period in which there is a predisposition for slips to be located on one particular vessel surface is the early Fort Ancient. This was a time when greater dietary importance was placed on maize, which was cooked by boiling, and which resulted in greater percentages of pots that became carbon-caked on their interiors than had pots in previous ages. The ceramic collections from large Fort Ancient villages bear out this pattern (Carr 1985). In this situation, one would expect slips or washes to have been placed on at least the interiors of vessels, if these coatings were intended to make vessels more easily cleanable. However, of the 24 vessels dating to this period, none has interior slips or washes. All four of the vessels having slips or washes have them on their exterior surfaces, alone. In addition, none of the four vessels with slips or washes bears macroscopic indicators of having been heated and used for cooking; they lack macroscopic carbon deposits on their interiors and exteriors, delaminated walls, and spall marks. Thus, it appears that during the early Fort Ancient period, slips and washes did not have the primary function of making the surfaces of cooking or other vessels more cleanable, as diet shifted toward a focus on maize. The lack of a predisposition for slips and washes to have been applied to interior surfaces in earlier times supports this conclusion for those times, as well.

Vessel Wall Permeability. The hypothesis that slips and washes were applied to decrease vessel wall permeability as an end in itself is supported by data on the size and the probable function(s) of the studied vessels. In particular, minimizing wall permeability is essential to a long-term, dry storage vessel, in order to exclude outside air humidity or soil water (if the pot is placed within a pit) from the contents of the vessel. Minimizing wall permeability may be less crucial to new cooking vessels that are used a short time (a few hours) for boiling and simmering (Tankersley and Meinhart 1962:230), and becomes less important through the lifetime of the cooking vessel as its wall pores become clogged with food residues and soot. Minimizing wall permeability is unnecessary for cooking vessels used to roast foods, and is disadvantageous for those used to steam foods. These generalizations being true, if prehistoric Ohio potters applied fine-grained, closed-pore slips and washes to vessel walls at least in part to decrease their permeability, one would expect to find slips and washes more frequently on dry storage vessels than on cooking vessels. This pattern seems to hold for the Ohio vessels studied. On the basis of a number of functional criteria,[12] it appears that 29 of the 45 vessels (64 percent) with slips or washes were used for storage. Of the 36 vessels that have slips or washes and that are of a moderate diameter (25–45 cm) useful for cooking, soaking materials, or storage, 27 (75 percent) appear to have been used for dry storage. These data accord with the hypothesis that slips and washes were applied to the studied vessels, at least sometimes, to decrease their wall permeability as an end in itself.

Further support for the idea can be found in the fact that slips and washes occur on either the interior or exterior or both sides of vessels thought to have been used for storage. This empirical distribution agrees with the logic that, to keep the contents of a storage vessel dry, it does not matter whether the interior or the exterior of the vessel is made impermeable by slipping or washing. In contrast, which side(s) and the number of sides of a cooking vessel that are slipped has a marked effect on its thermal efficiency and its susceptibility to thermal shock (Schiffer 1990; Schiffer et al. 1994).

It also is perhaps significant that of the 34 vessels with slips or washes on their exterior surfaces, a high percentage (78.8 percent) have such coatings placed over cordmarks. Forming a vessel wall with a cord-wrapped paddle has the effect of pushing temper particles to the center of the wall, raising the finer-grained, closed-pore clay matrix to the surface (Rye 1981:85; personal observation on petrographic thin sections), compacting the paste (Rice 1987:137), and filling in small stress cracks that arise when shaping the wall (Holstein 1973:78,81), thus making it less permeable to liquids. Placing a slip or wash over a cordmarked surface can be seen as an additional step that was taken to augment vessel wall impermeability beyond that already begun with cord-wrapped paddling.

Thermal Shock. The idea that slips and washes were applied to cooking vessels to decrease the permeability of their walls, in order to indirectly alter the susceptibility of their walls to thermal shock, is not well supported by the available data. As previously noted, most of the vessels with slips and washes appear to have been used for dry storage rather than cooking. Also, slips and washes were placed in significant percentages on the exterior as well as the interior surfaces of the studied vessels. In contrast, protecting cooking vessels consistently from thermal shock through slipping requires that one or the other surface be systematically coated. Which surface should be slipped depends on whether thermal cracking or thermal spalling is more problematic (Schiffer et al. 1994), given the kinds and sizes of temper used, and the form and thickness of the vessel walls.

Thermal Efficiency. The hypothesis that slips and washes were added to cooking vessels to decrease the permeability of their walls, in order to increase their thermal efficiency, also is not well supported by the data. Again, most (64 percent) of the vessels with slips or washes appear to have been used for dry storage rather than cooking. Also, about half (n = 21; 46.7 percent) of the 45 vessels with slips or washes have them exclusively on their exteriors, whereas internal slipping is preferable for the long-term enhancement of a pottery-vessel's thermal efficiency. Exterior slipping can enhance a vessel's thermal efficiency temporarily almost as much as interior slipping, but is counteracted by the spalling that is encouraged by the exterior slip. Internal slipping increases thermal efficiency without causing spalling (Schiffer 1990:378).

Calcite Coating Locations, Vessel Size, and Vessel Function

Both vessels with calcite coatings have them on their exterior surfaces, following the most common pattern for clay slips and washes. This situation supports the idea raised earlier by the time-space distribution of calcite coatings, that they could have been a functional equivalent to clay slips. In addition, like most vessels with clay slips, the two examples with calcite coatings lack macroscopic evidence of having been used for cooking or other heating tasks. This pattern, in conjunction with the concrete-like physical nature of the coatings (see above), supports a more specific idea, that calcite coatings, like slips and washes, may have been applied to dry storage vessels to decrease the permeability of their walls. The size of the vessels does not support or refute this interpretation: both of the vessels with calcite coatings have medium sizes that would have made them usable for storage or a variety of other tasks.

Apatite Coatings

Apatite coatings were observed on two vessels, which date to the Early Woodland and Middle Woodland. In both cases, the coatings occur on exterior surfaces of vessels. The Early Woodland vessel has a medium size (26 cm in diameter) that would have been manageable for either cooking or storage. It bears no macroscopic indicators of having been used with heat. The Middle Woodland vessel has a flat bottom and is large—at least 53 cm in diameter—and bears no macroscopic signs of having been used for cooking or other heating tasks. These traits suggest a stationary vessel that was used most likely for dry storage.

Conclusions

Our analysis of a very large sample of Woodland and early Fort Ancient vessels for their surface materials has a number of findings that are culture-historically and methodologically significant.

(1) Uncolored slips, washes, and other apparently

intentionally produced coatings were added to utilitarian vessels from primarily domestic contexts in significant percentages during the Woodland through early Fort Ancient periods in south-central Ohio (ca. 1150 B.C. – A.D. 1300). All slips documented in previous archaeological literature for the East are colored, and most are on finely made vessels of the kinds most commonly found in mortuary contexts.

(2) The uncolored slips and washes found here occur in much greater frequencies than those of colored slips and washes documented in the pre-Mississippian Midwest or Eastern United States at large. Uncolored slips and washes were found on 11.6 percent of the 386 vessels examined, in 43.9 percent of the 57 archaeological proveniences sampled, and in at least 56.5 percent of the 23 archaeological components considered. In contrast, colored slips and washes range from 0 to less than 5 percent of most Woodland through Late Prehistoric ceramic assemblages in Ohio and the Eastern United States.

(3) The uncolored slips and washes occur within widely spread archaeological components located in a variety of geomorphic contexts within all adequately sampled river valleys, including the central Scioto; its tributaries–Paint Creek, Darby Creek, and the Olentangy River; and the Licking River.

(4) It appears that the technique of slipping pottery became an integral part of ceramic technology early in its development in Ohio, at least. Uncolored slips occur on the earliest pottery in our sample, dated to ca. 1150 B.C. radiocarbon time, and in significant percentages, averaging 7.0 percent, within Early Woodland components dating between 500 and 300 B.C. These Early Woodland vessels are all typologically "thick" varieties that probably had a barrel or flower-pot shape.

(5) The temporal distribution of greater and lesser frequencies of uncolored slips and washes in south-central Ohio generally follows the known temporal distribution of colored slips and washes there.

(6) The commonness of colored slips and washes in some portions of the Southeast during the Middle Woodland, Late Woodland, and Late Prehistoric periods, and the commonness of uncolored slips throughout most of the Woodland and early Fort Ancient periods in south-central Ohio, implies a greater continuity between the Midwest and Southeast United States in ceramic technology than has previously been recognized.

(7) The uncolored slips and washes found here seem to have been made of the same raw clays as their associated vessel bodies, but usually with none or little of the temper that was added to the bodies, and/or with the seiving of natural stone inclusions from the slip clay. Petrographic and electron microprobe studies of the vessels suggest this.

(8) It appears that uncolored slips and washes were applied, at least in part, for the decorative purpose of creating a smooth vessel surface. This hypothesis is supported by the facts that uncolored slips and washes are distributed in time similar to colored slips and washes in Ohio, that slips are most common on the exterior surfaces of vessels, and that slips are found in disproportionately high percentages on elaborated utilitarian vessels showing other forms of extra attention to surface treatment and/or body form.

(9) Uncolored slips and washes may have also been applied to vessels for a nondecorative purpose, specifically to decrease vessel wall permeability. Almost half of the vessels bearing these coatings have them on only their interiors, which would have been poorly visible and less likely decorated, or on both their interiors and exteriors. Additionally, most of the vessels with slips or washes lack macroscopic indicators of having been used in heating tasks, and were more likely used for dry storage. In these cases, closed-pore slips and washes could have been useful in reducing vessel wall permeability to outside air humidity, or to soil water if the vessels were placed within pits. Significantly, more than three-fourths of the vessels with slips or washes had them placed over cordmarking, which is another means for reducing vessel wall permeability. Not supported were the ideas that slips and washes were applied to cooking vessels to decrease the permeability of their walls, thereby indirectly decreasing the susceptibility of their walls to thermal shock and increasing their thermal efficiency. Some evidence was found against the hypothesis that slips and washes were applied to make vessel cleaning easier. These issues require further investigation.

(10) Only one example of a painted vessel was found the among the 386 vessels examined. It was painted red and was early Fort Ancient in age. This .26 percent of the sample, and the red color, corresponds well with the minor incidence of red or black painted ceramics reported in the literature for the Middle Woodland through early Fort Ancient Periods in the Midwest and upper Ohio River valley.

(11) Calcite may have been added intentionally

as a permeability-reducing coating, functionally equivalent to clay slips, and possibly in the form of ground and wetted limestone, on one or two vessels at one Early Woodland site. Like most slips and washes, calcite coatings occur on the exterior surfaces of vessels and on medium size vessels that possibly were used for dry storage.

(12) The occurrence of uncolored slips that vary in thickness, and that typically lack the temper found in their associated vessel bodies, suggests that caution should be taken to minimize the possibly unwanted effects of slips on ceramic chemical analyses Specifically, do bulk INAA analyses reflect the changing volumentric proportions of slips and bodies among vessels, in addition to the compositional differences among vessels in their clays and tempers? How are electron microprobe analyses of the surface clays of vessels affected by whether they were slipped or not? Suggested ways of avoiding these possible difficulties include petrographic screening of ceramics targeted for analysis, the clay and temper separation method of Elam et. al. (1992) for INAA, and potentially the acid extraction method of Burton and Simon (1993).

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Notes

1. In the Mann site's village areas excavated by Kellar in 1966–1967, of 24,801 recovered sherds, only 67 (0.3 percent) had red slips or washes over their entirety, and only 1 had a red slip or wash within zones (Kellar 1979:103–105).

2. For example, in Mounds A, B, and C of the Weeden Island McKeithen site, which were constructed between A.D. 350 and 500, of 60 vessels recovered, 28 percent were Weeden Island Red or Zoned Red. These were made of nonlocal as well as local clays (Milanich et al. 1984:123, 161). The completely red slipped vessels were primarily effigy forms and were found predominantly in Mound C, which was a burial mound. The zoned red vessels were primarily plate forms and were found mainly in Mound B, which was a headman's residence. Both of these kinds of vessels were found only very rarely in the McKeithen village ceramic assemblage (Milanich 1994:185; Milanich et al. 1984:133, 161), constituting them as "mortuary" or "prestige" wares. In contrast, in the McKeithen village component, which dates between A.D. 200–750, completely red slipped and zoned red slipped sherds respectively comprise only 2.5 percent and 0.9 percent of the total ceramic assemblage, respectively (n = 13,164; Milanich et al. 1984:63). At the Kolomoki site, red slipped vessels comprised 8.8 and 11.5 percent of the sherds found in two large refuse basins (n = 3,837; Sears 1948:27–30; see also Sears 1956:46).

The red slip of a Weeden Island vessel can occur on its exterior, interior, or both surfaces. Interior slips are found more so on plate and dish forms; exterior slips occur more so on beaker, jar, and bowl forms (Ann Cordell, personal communication 1997; Milanich et al. 1984:146–151; Sears 1956:19; Willey 1949:409–422).

3. The Mission Period saw the production of Mission Red Filmed ceramics (plates, and to a lesser extent, beakers and jars), both fully painted and painted within zones, in frequencies of ca. 1–5 percent. These ceramics were related to other historic, red-filmed ceramics in eastern Alabama and western Georgia (Griffin 1951:150; Smith 1951:117, 132, 171; Vernon and Cordell 1993:424).

4. Vessels defined here as "elaborated utilitarian" have one or more of the following traits: uniform, parallel cordmarking with widely spaced, often thin cord marking; rocker stamping; burnishing; and/or tetrapods. Occasionally they have dark brown to black surfaces but most are light colored, like the "ordinary utilitarian" vessels studied here. Nearly all of the elaborated utilitarian vessels are 25 to 35 cm in diameter and some bear carbonized organic residues on their interiors, like the ordinary utilitarian vessels, and unlike the small, 15 to 20 cm diameter, Hopewell Series vessels. In ceramic typological terms, for the Middle Woodland period for example, McGraw Plain, McGraw Cordmarked, and typologically similar vessels are defined here as ordinary, utilitarian vessels and predominate the Middle Woodland sample. Chillicothe Incised vessels are defined here as elaborated utilitarian vessels, only one example of which is included in the sample. Other kinds of elaborated, utilitarian Middle Woodland vessels, such as those with widely spaced, thin cord marks, have no standard typological name. No southeastern stamped wares are included in the sample.

5. Dittert was trained under Anna Shepard, Stanley A. Stubbs, and Florence Ellis. He has a long record of experience in working with slipped and unslipped ceramics in the Southwest United States (e.g., Dittert 1987, 1991; Dittert and Plog 1980; Hedges and Dittert 1984).

6. The lighter color of some slip clays relative to body clays does not appear to have been caused by oxidation differentials during firing, because the color differences break sharply at the boundary between the slip and vessel body, rather than form a continuum of color change. It is possible that the darker shades of the vessel bodies result from their clays having been kneaded with water enriched in fine organics, which darkened the bodies upon firing. In contrast, the slip would have been produced without organically enriched water. This hypothesis, which could be tested in part by refiring the sherds at a higher temperature than they were originally fired (Rice 1987:344–345, 427–428) was not examined further. The presence of organic additives or other colorants in the quite dark slips, likewise, was not tested by refiring.

7. The chemical compositions were determined on a JEOL 733 electron microprobe analyzer at Washington University by one of us (Kremser). An accelerating potential of 15 kV, a beam current of 20 nA, and a beam diameter spot size of 5 μm were employed as operating conditions. X-ray intensities were converted to oxide weight percents using the procedures of Bence and Albee (1968) and Albee and Ray (1970). Simple oxides and silicates were used as standards. Each reported analysis is the average of three or more spot analyses.

8. A third explanation of the lower analytical totals of the slips, in particular, is possible at least in theory. The slips may retain more hydrous phases than the vessel bodies because the slips were fired after the vessel bodies, at lower temperatures and/or for shorter times than the bodies (i.e., two-stage firing). Some roughly similar ethnographic analogs (e.g., Fontana et al. 1962:77–78), and other ceramic indicators beyond the scope of this article, suggest that this idea should be retained for now and investigated further.

9. The phosphorus contents of most of the sherds and slips are elevated relative to most geologic materials. Common geological materials such as granite and shale contain 0.1 to 0.2 wt. percent P_2O_5 (e.g., Cox et al. 1979; Boggs 1987). Most soils contain similar amounts of P_2O_5, but contents of 0.4 wt. percent P_2O_5 are not unusual (Bohn et al., 1985). In contrast, the Ohio sherds have P_2O_5 contents from 0.3 to 4.6 wt. percent.

The high percentages of phosphorus in the sherds do not reflect the phosphorus contents of local lithologic materials and their derivative clays. The geology of southern Ohio is predominated by common sedimentary rocks and glacial till. It also is unlikely that the elevated phosphorus levels in the sherds and slips derive from enriched phosphorus levels in the soils in which they were buried. It is true that phosphorus is an important element of biologic activity and its content is frequently elevated in areas of human habitation and waste disposal (Carr 1982:109–115). However, the vast majority of phosphorus in soils is insoluble, bound as iron, aluminum, or manganese compounds, or organic substances. Instead, it would appear that the elevated P_2O_5 contents of the slips and sherd bodies result from the cooking of organic substances within the vessels. This source of enrichment has been documented for the ceramics of other regions (Duma 1972).

10. The terms, slips and washes, and their counts, include the few possible slips and possible washes from this point onward in the article, for purposes of simplicity.

11. The main-stream Ohio River valley is represented by only one site (Mabel Hall) with two sherds, none of which had slips.

12. Of the 45 vessels found to have slips or washes, two (4.4 percent) are large, having estimated minimum diameters between 55 and 60 cm. They presumably had the common, wide-mouth jar, Woodland form, and were so large and immobile that they more probably were used for stationary dry storage than for the processing of raw materials requiring soaking and/or heating, or other tasks involving vessel movement. Neither of these vessels has the above-listed indicators of having been heated or used for cooking. The majority of the 45 vessels with slips or washes (n = 36; 80.0 percent) are medium-sized, having estimated minimum diameters between 25 and 45 cm. They, also, probably had the common wide-mouthed jar, Woodland form, but were manageable enough in size that they could have been used for a variety of tasks, including cooking, processing of raw materials, or dry storage. However, 27 of these 36 vessels (75.0 percent) lack macroscopic indicators of having been used in heating tasks, and again seem to have been used for dry storage.

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