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Kevin C. Nolan

Mark A. Hill

Mark F.. Seeman

Eric Olson

Emily Butcher

See next page for additional authors

Authors
Kevin C. Nolan, Mark A. Hill, Mark F.. Seeman, Eric Olson, Emily Butcher, Sneha Chavali, and Nora Hillard

Chapter 5

Scale and Community in Hopewell Networks (SCHoN)

Summary of Preliminary Results

Kevin C. Nolan, Mark A. Hill, Mark F. Seeman, Eric Olson, Emily Butcher, Sneha Chavali, and Nora Hillard

Hopewell" refers to a distinct array of social and symbolic relations that are seen in the middle-range societies of the Midwest and South during the Woodland period ca. 150 BC–AD 400 (see, e.g., Nolan et al. 2017). Participating societies were regionally distinct, but many shared an ambiguous perch between foraging and farming, a collective orientation toward protracted mortuary rituals, and a need to create and manipulate complex cultural landscapes. Hopewell also is characterized by the development of an expanded set of material symbols—effigy platform pipes, fine pottery vessels, hypertrophic weaponry, ear ornaments, sagittal head plates, and panpipes, among others—that themselves were often made of costly raw materials.

Hopewell is one of the most recognized archaeological complexes in the Americas, but there is a continuing and extensive debate regarding what in fact it was in concrete cultural terms. Interpretations have regarded Hopewell relationships as resulting from migration (Setzler 1933); commodities exchange (Struever and Houart 1972); peer-polity reciprocity (Braun 1986; Braun et al. 1982:63), the construction of ideology (Byers 2004:7, 18; Prufer 1964; Seeman 1995), and an ecological risk-management strategy (Jefferies 1996:223–224; Nolan and Howard

2010), as well as other processes. It is our contention that much of this diversity results not only from a diversity of theoretical perspectives, but also from "describing the elephant" differently by making recourse to particularly favored parts that are themselves often sampled in small amounts.

The purpose of the Scale and Community in Hopewell Networks (SCHoN) project is to sample, source, and interpret distributions of three different raw materials and their attributes associated with production within a common analytic framework and at multiple scales. In doing so, we hope to minimize some of the interpretive difficulties that characterize previous studies that have examined Hopewell questions at different scales and that consequently have arrived at different results, or at the very least, to complement such studies. Our multiscalar approach can be an important step in uniting various perspectives on Hopewell by empirically exploring social interactions with scale as an explicit variable. Further, we structured SCHoN as a solid, empirical, and accessible base not only for our own conclusions, but for those of future investigations as well. In this chapter we present our preliminary results.

SCHoN focuses on three materials: pottery, knappable stone, and copper. Further, we limit ourselves to the investigation of stylistic and material relations among sites in a single major drainage, the Scioto Valley of central and southern Ohio. The Scioto Valley, with its concentration of geometric earthworks in an elaborately constructed cultural landscape, is generally seen as the "core" area of Ohio Hopewell (Seeman 1996:306–307; Seeman and Branch 2006). For purposes of our project, we assume that what falls under the "Ohio Hopewell" rubric is a series of households and dispersed household clusters choosing to participate variably in networks at a number of related, but distinct scales. McGraw, Overly, Brown's Bottom, Lady's Run, and Balthaser all represent excavated examples of Scioto Valley households (Dancey 2009; Kanter et al. 2015; Pacheco, pers. com. 2016; Pacheco et al. 2009a, 2009b, this volume; Prufer 1965).

The three explicit spatial scales of interaction we investigate are (1) the local/community level of interaction as targeted by a series of micro-style ceramic production attributes; (2) the regional/intercommunity level as targeted by lithic raw material choices and selected macro-style attributes of chipped stone tools and ceramics; and (3) the regional/extraregional level as targeted by the distribution of copper as raw material. More specifically, and with regard to Scioto Valley Hopewell pottery, we assume that most of these containers were the results of household production, with the raw materials—temper and clay—available in the immediate vicinity (Pool 1992:297). Based on ethnographic analogy, we assume that ceramics were used primarily around the hearth, and were generally the prerogatives of women (Allen 1992:137, 140). A single study making use of information from a single site has argued that Scioto Hopewell vessels were extensively exchanged among households (Carr and Komorowski 1995). Not only is clay locally available, the learning of how to produce and how to embellish pottery takes place in the home, or work groups of neighbors. Similarity in ceramic material and production traits will indicate communities of practice shared among neighbors, and potentially more distant social connections.

In contrast to clay used in ceramics, knappable stone is often decidedly nonlocal in origin in Scioto Valley Hopewell contexts. Based on previous work, it is to be expected that the majority of these raw materials (by weight) were obtained more than sixty kilometers away from the Scioto Hopewell sites investigated here, despite the availability of perfectly good quality raw materials in the immediate vicinity (Jeske and Brown 2012:270–292; Nolan et al. 2007; Vickery 1996). The dominance of Flint Ridge flint from the east and Wyandotte flint from the west are consistent with a pattern of regional or subregional supply organized above the level of the individual household (see Flannery 1976). The shared access to materials moving in each direction indicates differential participation in medium scale social and economic networks.

Our third material investigated, copper, is an exotic material holding traditional value in eastern North American archaeology. It has been assumed previously that the bulk of Scioto Hopewell copper was obtained from western Lake Superior (Seeman 1979:292–293) 950 km or more to the northwest. Copper artifacts are almost always found in ritual contexts connoting the special prerogatives associated with their use, not only in the Scioto area, but in all areas of Hopewell participation. We assume, therefore, that copper carried social and symbolic "weight" of an interregional scale and that leadership in such interactions was confined to a relatively small group of individuals. The distribution of this material enables tracking which social groups participated most extensively in which supralocal relationships.

In sum, we posit that three explicit scales of Hopewell Interaction should be visible in the Scioto Valley sites—household, community, and region—and that a combination of micro- and macro-stylistic (style *sensu* Dunnell 1978[1]) attributes, together with raw material sourcing, should provide a more complete picture of how Hopewell networks were constituted from the bottom up, by families and then by more inclusive social groupings such as descent groups, sodalities, and finally, by a

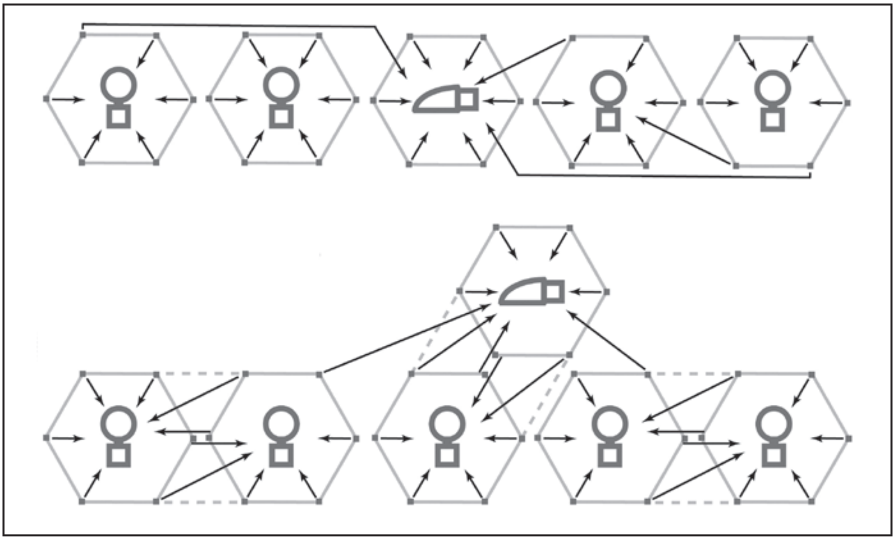

Figure 1. Schematic representation of the proximity (top) and synaptic (bottom) models of Hopewell interaction.

select cadre of regional leaders. Within the materials patterned at each of these scales, we expect to see connections and similarities in material, production method, and decoration encoding connections between individuals, sites, and regions.

EXTANT SCIOTO VALLEY INTERACTION MODELS

Two competing models dominate current views on the organization of social networks in the Scioto Valley (Figure 1). At the risk of oversimplification, we term these: 1) the *proximity model*, and 2) the *synaptic model*. We use these models to guide our own conclusions with respect to social relationships.

The *proximity model* of Ohio Hopewell communities can be traced back at least to the writings of Olaf Prufer (1964). More recently, this view has been refined by Dancey and Pacheco (Pacheco 1996; Pacheco 2010; Pacheco and Dancey 2006) viewing widely dispersed, extended-family households with upwards of 20 to 30 people under one roof bound together by social ties to nearby earthwork constructions. The latter are the centers of large-scale public action and mortuary ceremony. The earthworks themselves are part of the local cultural landscape and by extension everyday life—hunting, visiting, or the gathering together of other necessary materials—would cause people to see and relate to "their" earthwork and its associated mounds with great regularity, and no doubt, familiarity. This model does recognize contingencies and also that within a heterarchy the Hopewell-type site probably exercised some pull on other centers. In this model there is competition between centers for people and resources (Pacheco and Dancey 2006:22). It can be assumed that individual earthwork-related activities, however, may obtain a greater following or participatory draw at certain times as the result of especially ambitious and/or charismatic individual actors. In other words, proximity does not deny contingency.

The *synaptic model* is more complex, like the synaptic connections among individual neurons, suggesting that many earthwork centers themselves are paired with reciprocal obligations to each other, and that these pairs themselves were linked in a three-way alliance (Carr 2005a:85). Individual households are tied to multiple earthworks by a complex network of sodalities and clan obligations; thus, individuals from a given household or nearby households may be buried in shrine buildings well separated from their residential location. The Hopewell-type site on the North Fork Paint Creek is viewed to have apical properties in the sense that male leaders from all other inferred groupings were taken there for burial (Carr 2005a:89). The synaptic model holds that geographic proximity of households and earthwork centers is trumped by populations too low, and earthwork centers too close together, to be supported unless individuals drawn from many households, regardless of location, cooperated on the construction of more than one earthwork simultaneously (Byers 2015; Carr 2005a:94–100; Carr 2005b:296–297, 316–324; Carr and Case 2005:22;). How the insufficient populations to support individual centers are supposed to have conjured the labor to work simultaneously on at least three centers is not explained.

Our analysis, to the extent that it focuses on similarities regardless of temporal placement or geographic location, necessarily bears on these competing views. More specifically, we expect that our analysis will highlight comparatively where and on what scale(s) interaction is concentrated.

METHODS AND MATERIALS

We analyzed material from the following earthwork sites: Ater, Ginther, Harness, Hopeton, Hopewell, Hopewell East Village, Mound City, Rockhold, and Tremper; and the following non-earthwork sites: Fr-1033, Fr-801, Fr-819/820, Fr-883, Fr-941, Fr-945, Fr-992, Ro-507, Brown's Bottom, Riverbank, Lady's Run, McGraw, North 40, and the 2004 Mound City Teacher's Workshop. We analyzed up to 400 randomly selected lithics and ceramics from each site. Where less than 400 of each material were available, all available materials were included. In addition to that sample, we included all diagnostic lithics, rim sherds, and decorated ceramics. We also selected a judgment sample of available copper artifacts for Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) analysis.

For lithics we weighed and identified source of the raw material. Identification of source material employed the following categories: Ohio Flint Ridge, Upper Mercer, Burlington, Knox, Wyandotte, Knife River, Obsidian, Delaware, Brush Creek, Other, and Unknown. These were chosen for their demonstrated importance to Ohio Hopewell societies, and the reliability with which each can be identified. All identifications were conducted in comparison with known specimens under magnification. Magnification—either a 10x or 25x hand lense or a 57900-04 Boreal Zoom Stereo Microscope up to 40x—was employed in matching artifacts to known samples.

For ceramics we identified temper type, size, and density; surface treatment (plain, cordmarked, burnished, slip, simple stamp, complicated stamp, other); decoration; minimum thickness; maximum thickness; color; and chemical composition. Temper size and density were measured using the respective soil characterization charts in the Munsell Soil Color Chart. Color was measured using Munsell Soil Color. Micro and macro-stylistic attributes employed were: cord twist, hard incising, soft incising (trailing), dowel impressed, cord impressed, short rocker stamping, tall rocker stamping, dentate rocker stamping, dentate linear stamping, punctates (including various orientations), and rim strip. Most stylistic attributes are presence/absence, and not mutually exclusive. Cord spacing was also recorded when available.

We conducted chemical compositional analysis with an Olympus Delta Premium portable XRF (pXRF) analyzer. Sherd color and chemical composition were measured on the exterior and interior surfaces, and the core (where available). All measurements of chemical composition were conducted with the pXRF in the portable workstation (unless the sherd was too large), using soils mode with a 30 second count time for each of three beams (90 seconds per reading). During calibration, counts per second (cps) ranged from ~62,000 to >70,000 cps. This is two to three times the count rate of earlier Olympus models. Several soil and mineral standards (Royal Glass Mountain II [RGM2], Montana Soils I SRM 2710a, Montana Soils II SRM 2711a) and a blank (SiO_2) were read at the beginning and end of each analytical session, and at least once every four hours of run time. Here we report only the results of readings of sherd core.

RESULTS

Below we present the descriptive results of our analyses. We first summarize the attribute frequencies for ceramics. Next, we summarize the use of lithic resources by diagnostic and non-diagnostic samples. Use of material is then summarized by site type. Finally, we briefly present a summary of the results of our copper sourcing study which is published in full elsewhere (Hill et al. 2018; see also Hill et al. 2016).

CERAMICS

Our ceramic sample includes 2,822 sherds from 21 sites. In the summary below it is important to remember we are reporting observation counts of attributes, not sherd counts. Especially with sherds made by Hopewell peoples, plain and cordmarked surface treatments (for example) are not mutually exclusive. The majority of the ceramics at all sites include plain and cordmarked (Table 1). Slip is present at seven sites, but does not total more than five percent of sherds at any site. Brushing occurs at seven sites as well, and does not total over four percent in any case. While twist determinations were not able to be made in all cases, S-twist makes up the majority of the observations (86.9%, N = 298). Z-twist was only recorded at 7 sites, and, with one exception, not exceeding 40%. Site 33FR883, a repeatedly investigated Middle Woodland habitation site in Franklin County is the outlier with 75% Z-twist, though the sample is small.

Grit makes up the majority (~94%) of the temper types at all sites (Table 2). Grit/grog tempering is present at Tremper only, while grog is present at Tremper and Harness. Grit/sand is found at Rockhold, Harness, and Brown's Bottom. Limestone tempering is present only at Brown's Bottom, Harness, Hopeton Triangle, and Riverbank. Overall, the site assemblages feature very fine tempering. However, Ater, 33FR883, Tremper, Brown's Bottom, Harness, Riverbank, Rockhold, and Hopeton Triangle (in decreasing frequency order) feature relatively large proportions of fine tempering. Course tempering is only present at Tremper, Lady's Run, and Overly. The majority of the temper densities are between 0–10% and 11–20%. Density measuring 30 or higher is only seen at Brown's Bottom, Lady's Run, Tremper, Rockhold, and Ater, although these make up a very small portion of the sample. Rockhold featured a wide range of sherd thicknesses (Figure 2). The sherds at Ater, Balthaser, and Hopeton Triangle also tended to be thicker.

Only 8.2% of sherds observed had at least one decorative element (Table 3). The most frequent decorations are cord impression (30.7% of observations), trailing (21.3%), and hard incising (10.5%; Table 3). Harness, McGraw, Hopewell Mound Group East Village, Brown's Bottom, and Mound City featured the most variety of decorations.

Exterior colors are predominately 10 YR or 7.5 YR in hue (mean, excluding 2.5 Y, 7.46, ranging from 2.5 YR to 2.5 Y), with an average value of 4.9 (from 2–8), and mean chroma of 3.3 (from 1–8). Sherd cores are moderately redder on average (mean 7.18 YR), with values averaging 4.9, and mean chroma of 3.2. Interior surface colors are generally less red (mean hue = 7.84), with mean values of 4.5, and a mean

Table 1. Frequency of Surface Treatments for Analyzed Sherds by Site.

Site	Total Sherds	Plain	CM	Burnished	Slip	Brushed	Simple Stamp	Comp Stamp	Surface-Other	Z	S	Decorated
33FR706	7	2	5	3	0	0	0	0	0	0	0	1
33FR801	2	2	0	0	0	0	2	0	0	0	0	1
33FR883	74	33	41	0	0	0	0	0	0	3	1	0
33RO507	1	1	0	1	0	0	0	0	0	0	0	0
Ater	90	26	57	26	0	1	0	0	0	0	5	0
Balthaser	55	34	18	6	2	0	0	0	0	0	4	3
Browns Bottom	451	93	324	46	10	5	9	0	0	4	20	8
Ginther	1	0	0	0	0	0	0	0	0	0	0	0
Harness	137	60	38	108	3	0	20	11	0	7	11	50
HMG East Village	101	32	57	8	0	0	0	0	0	0	8	11
Hopeton Triangle	37	11	26	0	0	0	0	0	0	0	6	0
Hopewell	8	8	0	0	0	0	0	0	0	0	0	8
Lady's Run	485	121	301	229	0	17	3	0	40	11	66	9
MC N40	209	81	93	60	10	1	0	0	5	0	46	38
McGraw	434	234	175	204	13	17	6	6	19	5	34	62
MCTW 2004	63	13	41	12	1	0	1	1	2	1	7	3
Mound City	28	12	15	9	0	0	0	0	0	0	0	9
Overly	163	20	133	33	0	0	0	0	0	8	33	14
Riverbank	126	37	79	64	0	3	0	0	0	0	11	10
Rockhold	114	109	2	23	0	0	0	0	0	0	0	2
Tremper	236	159	9	82	12	7	2	0	0	0	7	4

Table 2. Frequency of Temper Type, Size, and Density Categories by Site.

Site	N	Grit	Grit/ chert	Grit/ grog	Grit/ pyrite	Grit/ sand	Grit/ unk	Grog	Lime-stone	Sand	Unk	Very Fine	Fine	Med	Coarse	0-10	11–20	21–30	30+	Total Wt
33FR706	7	5	0	0	0	0	0	0	0	2	0	5	1	1	0	2	4	1	0	20.2
33FR801	2	2	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	13.2
33FR883	74	74	0	0	0	0	0	0	0	0	0	29	36	9	0	45	20	9	0	781.3
33RO507	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	4.2
Ater	90	82	0	0	6	1	0	0	0	1	0	16	64	10	0	28	51	10	1	875
Balthaser	55	54	0	0	0	0	0	0	0	1	0	37	15	3	0	37	17	1	0	1030.55
Browns Bottom	451	430	0	0	0	13	0	0	6	1	0	258	177	15	0	254	143	38	15	4575.88
Ginther	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0.5
Harness	137	105	0	0	1	12	0	1	2	1	0	77	43	2	0	54	53	15	0	1822.6
HMG East Village	101	95	0	0	0	0	0	0	4	3	0	89	12	0	0	75	26	0	0	1054.76
Hopeton Triangle	37	28	1	0	0	0	0	0	8	0	0	14	12	11	0	28	8	1	0	292.7
Hopewell	8	8	0	0	0	0	0	0	0	0	0	8	0	0	0	0	8	0	0	105.66
Lady's Run	485	463	7	0	0	1	0	0	2	4	6	316	134	31	1	344	119	18	1	4926.43
MC N40	209	208	1	0	0	0	0	0	0	0	0	143	58	8	0	160	49	0	0	2293.2
McGraw	434	420	0	0	10	0	0	0	0	1	3	299	128	7	0	298	123	13	0	6777.4
TW04	63	59	0	0	0	0	2	0	0	0	0	43	12	6	0	50	11	0	0	454.17
Mound City	28	28	0	0	0	0	0	0	0	0	0	22	6	0	0	23	4	1	0	358.5
Overly	163	162	0	0	0	0	0	0	0	0	0	101	45	15	1	147	14	1	0	1545.05
Riverbank	126	119	1	0	0	0	0	0	3	2	0	80	44	1	0	105	20	0	0	1851.48
Rockhold	114	111	1	0	0	1	0	0	0	1	0	19	40	55	0	11	72	29	2	3499.34
Tremper	236	197	0	16	0	0	0	7	0	0	16	7	97	126	6	91	106	31	8	1999.8

chroma of 2.7. A detailed analysis of the implications of these data for reconstructing firing and finishing environments (see Nolan 2005) on a site basis is beyond the scope of this chapter. Here we focus on looking for variable connections among sites in their preparation techniques. In this view, the Munsell color constellation of the sherds is a proxy measure for similar production environment and practices.

To assess the degree of similarity and difference among sites, we conducted a discriminant function analysis (DFA) using sites as classes. The DFA resulted in a 16.6% successful reclassification rate, and a 15.1% success cross-validated. This poor performance provides a unique opportunity to investigate the degree of similarity among sites. Using the frequency of misclassification at each site and the richness of the number of sites to which each site's sherds are miss-assigned, we can begin to examine the network of connections among the sites in the sample.

Table 4 presents the site summary of cross-validated success rate, and the misclassification richness rates. Ater with a misclassification richness of 13 is most similar to Balthaser, Riverbank, and Lady's Run. Balthaser is most similar to Mound City, 33FR883, and Hopewell. Brown's Bottom has a very low success rate and maximal richness. Many non-earthwork sites follow a similar pattern of low classification success and near maximal misclassification richness (Table 4). When looking at site types, non-earthwork sites have a mean cross-validated classification rate of 9.6, while earthworks have a rate of 27.7. The richness values are not drastically different on average by type, but earthworks average 64.7% of maximum while non-earthworks average 76.5% of maximum richness.

Further employing the results of the DFA, plotting the site centroids we see a central cluster, a Rockhold/Tremper cluster, a MCTW04/East Village cluster, and Riverbank isolated at the top of the graph (Figure 3a). An interesting finding is that while Lady's Run and Harness are very similar, Brown's Bottom is most similar to Mound City and Hopewell. It must be noted that Hopewell only has a very small sample. A further interesting point is that these similarity patterns are not based strictly on geographic proximity.

To facilitate a brief summary of the chemical composition data we here only present the results of the DFA analysis. Again there is substantial overlap among sherds from all sites; however, the DFA performs considerably better at discriminating among sites. The DFA successfully assigns a sherd to its site still only 46.7% of the time (44.2% cross-validated). Again, Ater (31.3% success, Table 4) is similar to Lady's Run and also MCTW04. Balthaser (40.9% success) is most similar to Mound City. Brown's Bottom (34.5%) is most similar to Lady's Run, then Hopeton. Harness

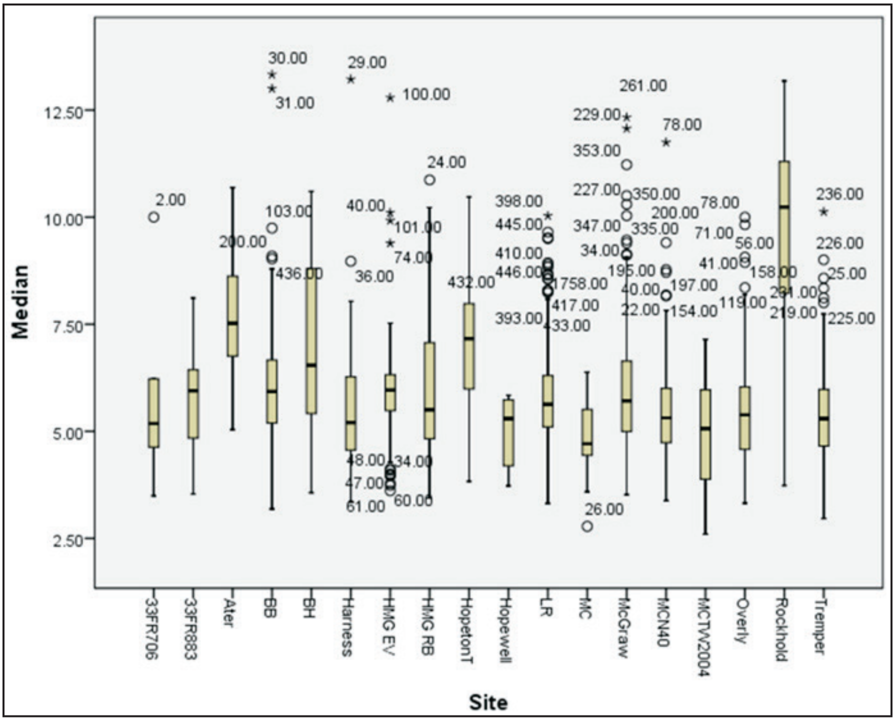

Figure 2. Box plot of sherd thickness by site.

(38.7%) is most similar to Lady's Run, Hopewell East Village, and North 40. Hopewell (57.1%) is most similar to McGraw, and Ater. McGraw (65.6%) is most similar to Lady's Run, and Mound City (32.1%) is most similar to MCTW04 and Balthaser, then Overly. N40 (23.2%) is most similar to Riverbank, six other sites over 5%. Overly (15.5%) is most similar to N40 and Mound City, four other sites over 5%. Tremper (71.4%) is most similar to Mound City (6.1%). The rest of the site relationships are displayed in Figure 3b. What the DFA function plot reveals is that most of the sherds from most of the sites are very similar, with a few notable exceptions. McGraw, 33FR706, and Harness are quite isolated from the other site centroids, while Hopewell (N=8) and Rockhold form a cluster distinct from the main body.

LITHICS

The frequency of diagnostics for each raw material category by site is presented in Table 5. There are a total of 1075 (4613.27 g) diagnostic artifacts with 471 (3,844.9 g) from earthwork sites. Flint Ridge (FR) constitutes the majority of diagnostics for

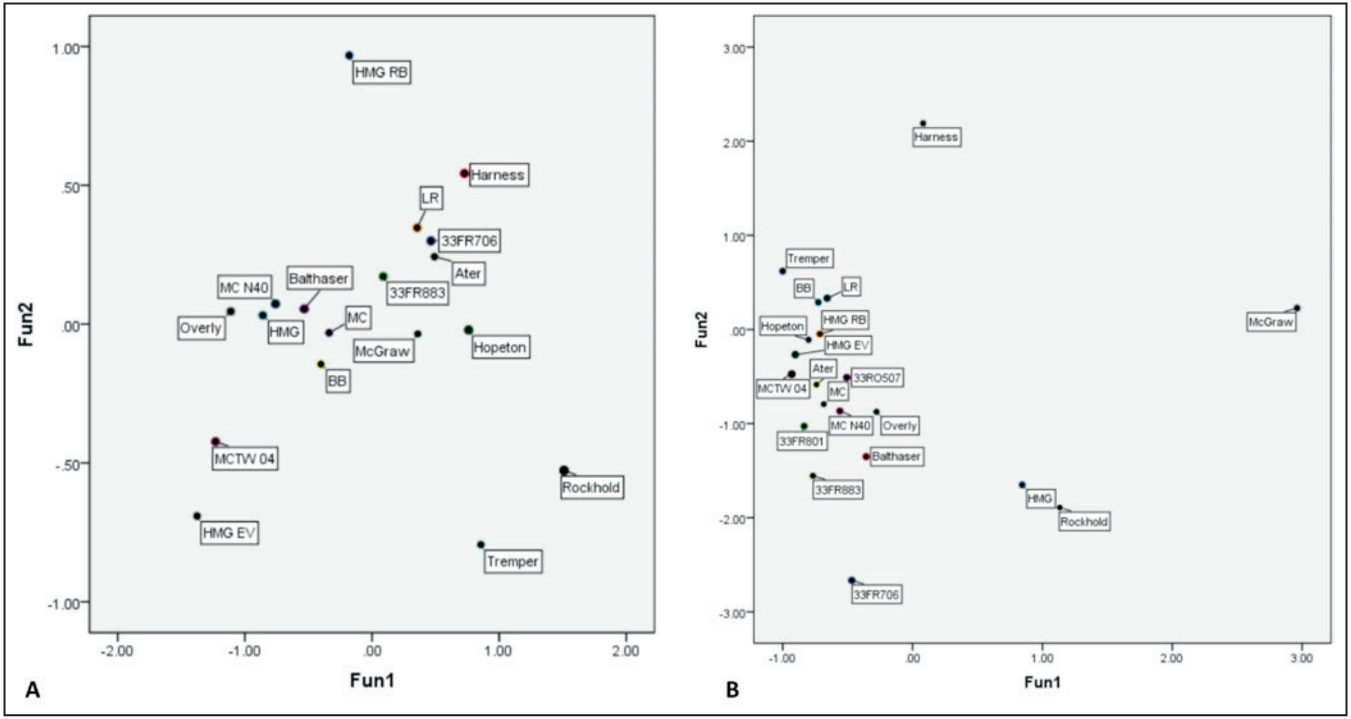

Figure 3. Discriminant function plots of site centroids for sherd color (left) and sherd core chemical composition (right).

the whole sample by count with 58.9% , but only 24.6% by weight. Wyandotte (Wy) and Upper Mercer (UM) make up 13.5% and 11.4% of the count, and 8.27% and 9.4% of the weight, respectively. Percentages of Upper Mercer are highly variable but do make up a large percentage of diagnostics at Mound City Teacher's Workshop 2004 (MCTW04), Ater, Tremper, and Mound City; and by weight at MCTW04, Ater, Mound City, and Lady's Run. Flint Ridge is absent from the diagnostics at Mound City, though the sample is small. Tremper also has little Flint Ridge. Wyandotte is found at Ginther, McGraw, Hopeton, Mound City, Lady's Run, Tremper, Brown's Bottom, North 40 (N40), MCTW04, Harness, and Hopewell. Burlington was identified at Hopewell, Lady's Run, Ginther, and Brown's Bottom.

Within earthworks contexts, Flint Ridge makes up a plurality of the count and weight, (excluding three obsidian outliers at Hopewell weighing over 360 g) averaging over 3.4 g per artifact (Figure 4). Similarly, Wyandotte diagnostics at earthworks (337.76 g) exhibit a 1:3 count:weight (wt) ratio. Upper Mercer artifacts are the largest on average (1:3.8) within earthwork contexts. With the exception of Knife River Flint, which features just under a 1:1 ratio, all other materials follow a pattern of the weight being at least two times that of the count.

Within non-earthwork contexts, Flint Ridge, Wyandotte, and Burlington feature a ratio below 1:2 (Figure 4). Upper Mercer diagnostics outside the earthworks exhibit a 1:3.4 ratio. Delaware and Brush Creek feature a nearly 1:1.85 ratio. Unknown material types featured an opposite trend, with the count (n=51) being much larger than the weight (36.76 g).

A total of 4,631 (12,150.43 g) non-diagnostic lithics were included in our analytical sample, 1,354 (4,458.52 g) of which come from earthwork sites. Of the non-diagnostic lithics (Table 6), Delaware makes up the largest portion of the sample size (30.3% by count and 24.2% by weight) with Upper Mercer (20.97% by count, 19.94% by weight) and Flint Ridge (19.48% by count, 19.36% by weight) being the next most common materials (Figure 5). Within earthwork contexts, Flint Ridge and Upper Mercer account for the majority of the count (n=386 and n=261, respectively). However, the weight is 2.9 to 3.5 times that of the count. Large artifacts are also seen in Wyandotte and Delaware in particular. Non-diagnostics from non-earthworks follow a similar pattern. Here, Delaware shows the most striking proportional difference, with the count being 1,405 and the weight totaling 2,938.46 g. Delaware also makes up the majority of the non-diagnostics at non-earthwork sites. It should be noted that Delaware is a decidedly "local" raw material, with large cobbles available in the Paint Creek and Scioto River gravels of central and southern Ohio.

Table 3. Frequency of Decoration Application Technique by Site.

Site	Incised	Trailed	Dowel	Cord-imp	Rocker-short	Rocker-tall	Dentate Rocker	Dentate linear	Punctates	Applica-tion- Other	Rim Cross-hatched	Rim Dentate	Rim Parallel incise	Rim punctate	Total
33FR706	1														1
Balthaser						1							1	2	4
Brown's Bottom	2	1	1	1					4	1					10
Harness	5	6		17	2	9		11	1		3		2	3	59
HMG EV				2	1		4	4	2	2	1				16
Hopewell	2	8			4						1				15
Lady's Run				3								1		1	5
MC N40	3	6		30									1		40
McGraw	15	35		1	3	9	2		3				3	3	74
MCTW 2004				2						1					3
Mound City		1		4	2	2			1						10
Overly				11	1				1						13
River-bank			1	9					1						11
Rockhold				2											2
Tremper									4						4
Total	28	57	2	82	13	21	6	15	17	4	5	1	7	9	267

Table 4. Cross-Validation Success Rates and Misclassification Richnesses For Discriminant Function Analyses of Sherd Color and Sherd Core Chemical Composition by Site, Organized by Site Type.

Site	Color CrssVal	Rich-ness	Site Type Cross Val	Averages Richness	XRF CrssVal	Rich-ness	Site Type Cross Val	Averages Richness
Ater	26.2	13	**27.71**	**11**	31.3	8	**40.21**	**8.5**
Harness	35.3	14			38.7	12		
HMG EV	33.7	13			0	1		
Hopeton	3.2	11			29.7	11		
Hopewell	0	6			57.1	3		
Mound City	14.3	10			32.1	8		
Rockhold	61.8	10			61.4	10		
Tremper	47.1	11			71.4	15		
Balthaser	30.9	11	**9.63**	**13**	40.9	8	**43.27**	**12.4**
BB	1.6	17			34.5	15		
Fr706	0	5			71.4	1		
Fr883	41.9	6			56.6	11		
LR	1.5	17			36.8	15		
McGraw	1.2	17			65.6	17		
N40	0.5	16			23.2	17		
Overly	10	15			15.5	15		
Riverbank	5	13			58.5	13		
TW04	3.6	13			29.7	12		
Mean	17.7	12.1			41.9	10.7		

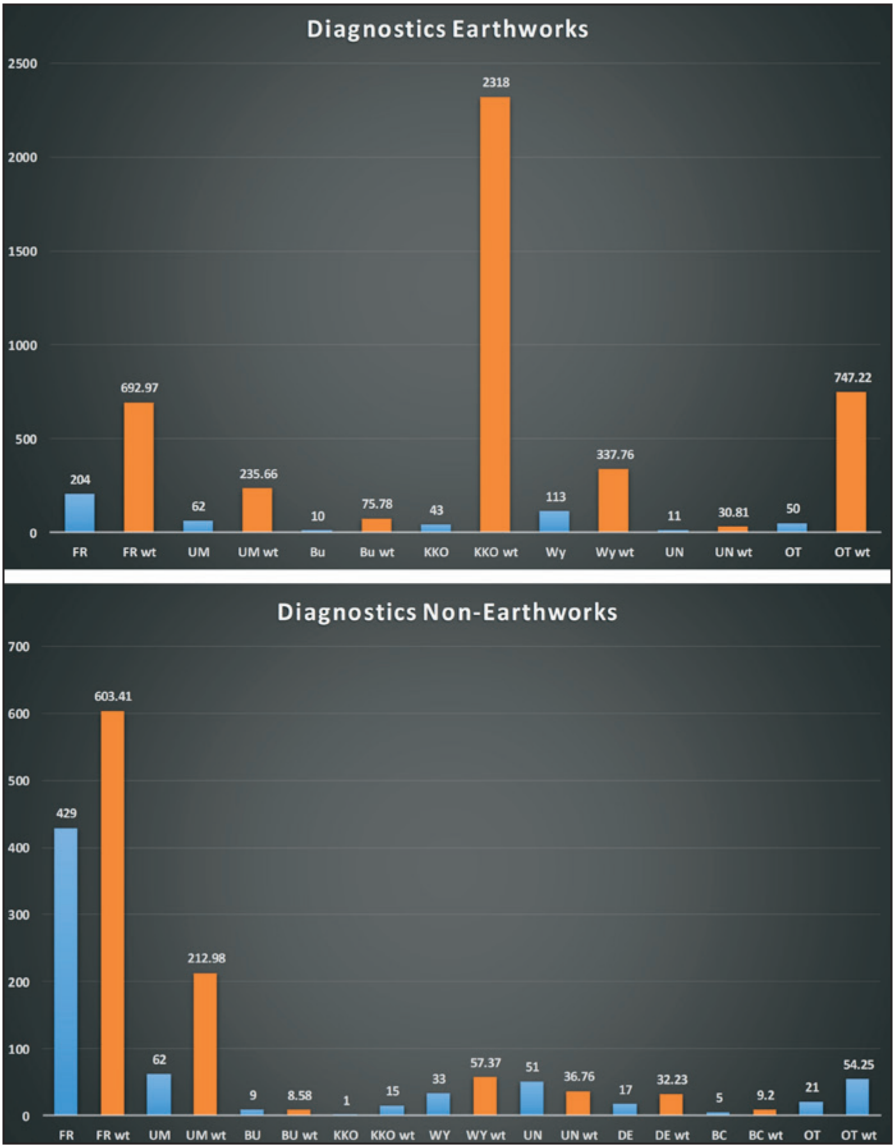

Figure 4. Frequency of toolstone source use for diagnostic artifacts from all earthwork sites (top) and all non-earthwork sites (bottom).

Table 5. Frequency of Toolstone Source Usage for Diagnostic Artifacts by Site.

Site	Bu	wt	FR	wt	KKO*	wt	Ot†	wt
Franklin County Sites			3	4.8			6	18.6
33Ro507			1	7			1	5.5
Brown's Bottom	7	6.58	137	138.33			1	0.53
Lady's Run	2	2	68	74.6			4	3
McGraw			168	342.93	1	1.09	3	12.82
N40			32	21.06			6	13.8
Riverbank			18	13.1				
Teacher's Workshop			2	1.59				
Subtotal	9	8.58	429	603.41	1	15	21	54.25
μ	0.6	0.57	53.625	75.43			3.50	9.04
σ	1.84	1.74	65.44	118.01			2.26	7.07
Ater			14	36.5	1	1.2		
East Village			27	15.69				
Ginther	8	17.6	98	294.2	2	2.1	8	17.6
Harness			4	48.7	1	39.5	2	17.4
Hopeton			19	13.6	5	3.81	4	2.8
Hopewell	2	58.18	35	216.58	22	2230.47	3	38.65
Mound City							3	14.34
Rockhold			3	16.7			1	4.7
Tremper			4	51	11	26.1	8	137.8
Subtotal	10	75.78	204	692.97	42	2303.18	29	692.97
μ	1.11	8.42	25.5	77	7.00	383.86	4.14	77
σ	2.67	19.55	31.52	104.35	8.27	904.78	2.79	104.35
Total	19	84.36	633	1296.38	43	2318.18	50	747.22
μ	4.75	21.09	39.56	81.02	6.14	329.18	3.85	22.12
σ	3.20	25.58	51.70	109.07	7.88	838.52	2.48	36.18

*KKO = Knox, Knife River, and Obsidian combined.
†Ot = Delaware, Brush Creek, and other low frequency materials.

Site	UM	wt	Un	wt	Wy	wt	Total	wt
Franklin County Sites	3	14.1					12	37.5
33Ro507							2	12.5
Brown's Bottom	8	39.7	23	14.2	3	9.3	179	208.64
Lady's Run	14	33.19	8	4.3	5	6.3	101	123.39
McGraw	22	100.36	15	16.36	21	28.76	230	502.32
N40	11	11.7	2	0.6	3	12.3	54	59.46
Riverbank	1	0.5	3	1.3			22	14.9
Teacher's Workshop	3	13.43			1	0.71	6	15.73
Subtotal	62	212.98	51	36.76	33	57.37	606	974.44
μ	8.86	30.4257	10.2	7.35	6.6	11.47	75.75	121.81
σ	7.47	33.63	8.81	7.41	8.17	10.57	86.87	168.17
Ater	12	60.4					27	98.1
East Village	2	0.42	2	0.88			31	16.99
Ginther	18	55.7			80	261.6	214	648.8
Harness	2	13.7			1	4.3	10	123.6
Hopeton	12	5.7	5	1.3	20	27.86	65	55.07
Hopewell			4	28.63	1	2.88	67	2575.39
Mound City	3	21.14			7	22.82	13	58.3
Rockhold							4	21.4
Tremper	13	78.6			4	18.3	40	311.8
Subtotal	62	235.66	11	30.81	113	337.76	471	3811.35
μ	6.89	26.18	3.67	10.27	18.83	56.29	55.50	476.42
σ	6.81	30.47	1.53	15.90	30.79	101.07	68.36	874.84
Total	124	448.64	62	67.57	146	395.13	1077	4785.79
μ	8.86	32.05	7.75	8.45	13.27	35.92	63.35	287.29
σ	6.70	30.99	7.52	10.29	23.27	75.50	74.41	617.27

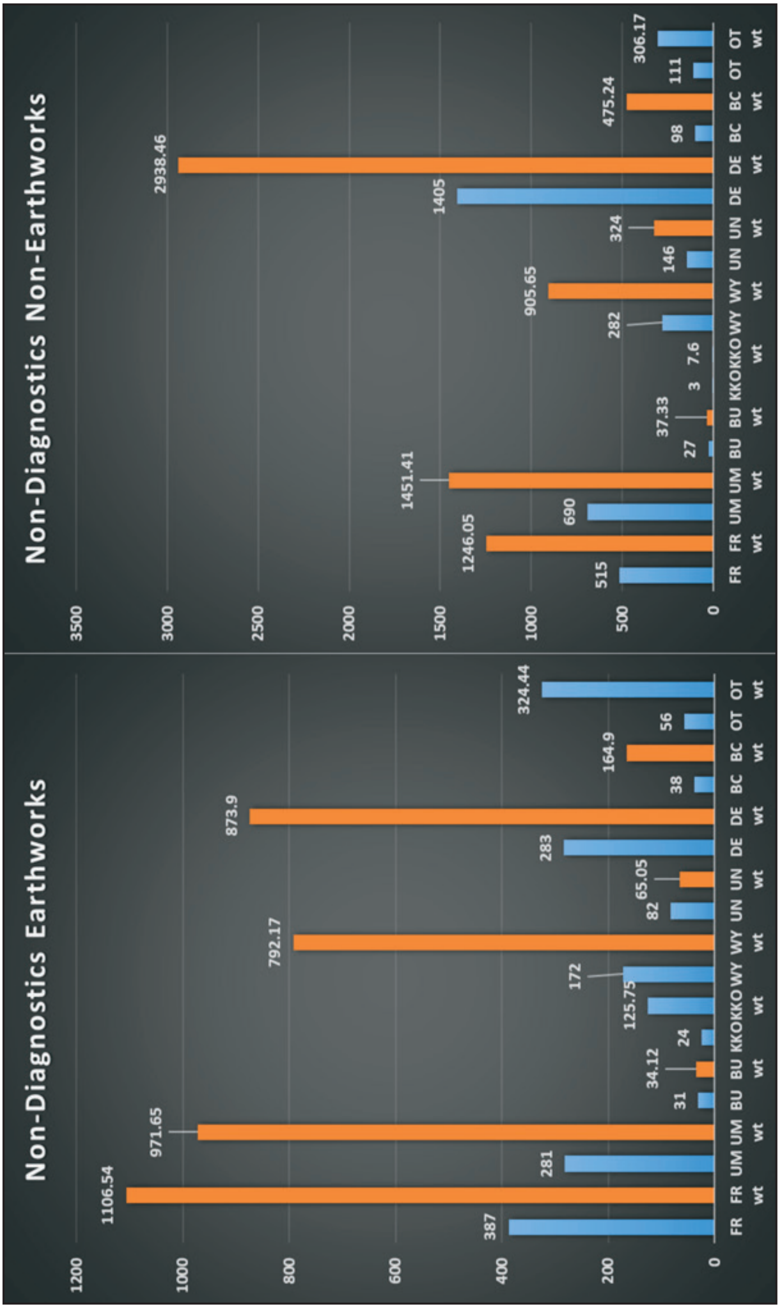

Figure 5. Frequency of toolstone source use for non-diagnostic artifacts from all earthwork sites (left) and all non-earthwork sites (right).

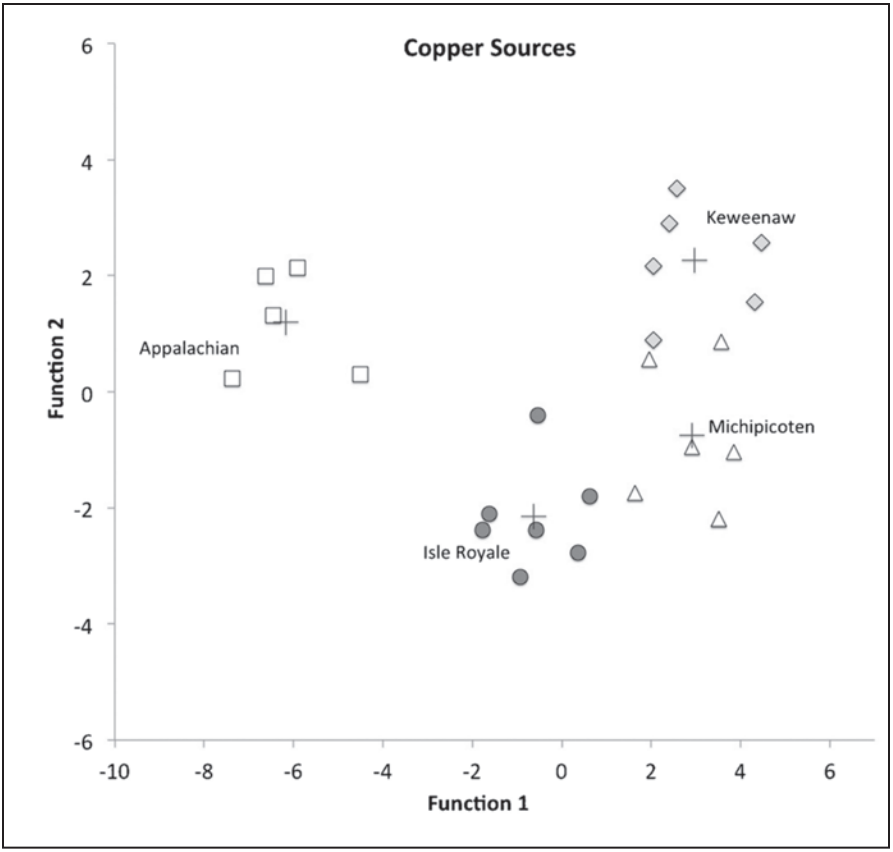

Figure 6. Results of copper source classification. Open symbols are associated with source samples, including: circles=Isle Royale, squares=Appalachian, diamonds=Keweenaw, and triangles=Michipicoten (after Hill et al. 2018:Figure 3).

COPPER

A total of 52 artifacts and 24 samples from known copper sources were analyzed at the Elemental Analysis Facility (EAF) at the Field Museum with an Analytik Jena (Germany) ICP-MS. A New Wave UP213 laser is connected to the ICP-MS for direct introduction of solid samples. Hill et al. (2018) provide a full discussion of these results. Here we summarize the source identification. Similar to the sherd color and composition analysis described above, Hill et al. (2018) performed a DFA with knowns (source samples) and unknowns. Nine artifacts were identified as outliers with elevated iron and nickel levels. The remaining 43 arti-

Table 6. Frequency of Toolstone Source Usage for Non-diagnostic Artifacts by Site.

Site	Bu	wt	FR	wt	Knox	wt	KRF	wt	Ob	wt
33Fr1033			12	4.9						
33Fr706			1	0.7						
33Fr801	1	1.6	1	0.1						
33Fr810	2	1.9	3	4.6						
33Fr819			2	8.8						
33Fr820	4	1.1	5	6.5	1	0.5				
33Fr883			9	1.1						
33Fr941			1	0.7						
33Fr945	2	0.8								
33Fr994			1	0.8						
33Ro507			23	29.3						
33Ro532			8	20.1						
33Ro550			2	6.7						
Ater			16	64.3						
Brown's Bottom	2	2.43	79	177.16						
East Village	20	7.12	76	129.79						
Ginther	6	15.5	229	681.1						
Harness			5	40.3						
Hopeton	3	0.8	20	3.83	1	0.4				
Lady's Run			58	77.79						
McGraw	2	19.9	168	852.45						
Mound City			22	45.48	10	38.1			1	2.4
N40			42	32.1	2	7.1				
OSU Ballfield			1	0						
Riverbank	14	9.6	92	3.95						
Rockhold			4	24.2						
TW04			7	18.3						
Hopewell	1	2.5	6	59.14					12	84.85
Tremper	1	8.2	9	58.4						
Total	58	71.45	902	2352.59	14	46.1	0	0	13	87.25

Site	Ot	wt	UM	wt	Un	wt	Wy	wt	Total	Wt
33Fr1033	15	42.2	12	8.9					39	56
33Fr706	5	5.3	3	8.4					9	14.4
33Fr801	80	66.9	5	5.8	1	5.1			88	79.5
33Fr810	6	5.1	4	1.8					15	13.4
33Fr819	2	3.9	10	13					14	25.7
33Fr820	3	5.6	12	24			1	3.7	26	41.4
33Fr883	399	322.8	32	22.4	10	7.5			450	353.8
33Fr941	12	38.1	1	10.2					14	49
33Fr945	147	350	6	2.1			1	0.8	156	353.7
33Fr994	2	1.7	2	1.2					5	3.7
33Ro507	27	70.6	75	88.4	2	1.6			127	189.9
33Ro532	25	189.5	23	143.2			1	1.5	57	354.3
33Ro550			1	0.2					3	6.9
Ater	15	40.4	39	323.1					70	427.8
Brown's Bottom	399	776.78	76	43.55	25	25.59	2	1.24	583	1026.75
East Village	6	16.21	18	13.02	5	5.85			125	171.99
Ginther	54	326.9	57	292.7	5	15.9	49	162	400	1494.1
Harness	1	4.7	3	17.9					9	62.9
Hopeton	198	236.99	99	54	63	1.6	18	10.1	402	307.72
Lady's Run	141	293.81	142	143.67	39	38.59	33	70.54	413	624.4
McGraw	95	916.18	114	768.7	5	232	16	142.2	400	2931.43
Mound City	90	617.39	22	96.23	9	41.7	95	333.55	249	1174.85
N40	93	255.13	37	57.28	4	5.2	222	685.6	400	1042.41
OSU Ballfield	34	345.3	7	53.4	1	0.6			43	399.3
Riverbank	117	24.38	114	16.78	58	2.95	6	0.07	401	57.73
Rockhold	1	13.9					1	3.3	6	41.4
Teacher's Workshop	12	6.59	14	38.43	1	4.87			34	68.19
Hopewell	4	26.15					2	177.22	25	349.86
Tremper	8	80.6	43	174.7			7	106	68	427.9
Total	1991	5083.11	971	2423.06	228	389.05	454	1697.82	4631	12150.43

facts (as a group; Figure 6) exhibit more compositional variability than the known source samples. The DFA assigned 39.53% of artifacts to Isle Royale, 20.93% each to Southern Appalachian sources and Michipicoten, and 18.60% to Keweenaw (Hill et al. 2018:Figure 7). In sum, these results indicate that the majority of the copper artifacts at Scioto Valley Hopewell sites were coming from the Lake Superior source, but about one in five were coming from the southern Appalachians. Of note also is that many sources (including both northern and southern sources) are included in the same archaeological deposits, so this variability does not appear to be temporal (Hill et al. 2018:16).

DISCUSSION AND CONCLUSIONS

There are interesting patterns and suggestions in the data provided above. With regard to ceramic comparisons, it should be noted that sherd thickness is fairly consistent across sites with a mean generally between five and six millimeters (Figure 2). Ater, Hopeton, and especially Rockhold have means over seven millimeters. While plain sherds are only 38.5% of the total, they constitute 55.4% of the sherds at earthwork sites, while cordmarked surfaces constitute 27.1% at these same sites. Earthwork sherds also exhibit more burnishing, stamping, and decoration. Non-earthwork sites have more brushing and more S-twist. This falls in line with the greater emphasis on display (plain, burnished, and decorated) noted for the larger exotic lithics at earthworks. Interestingly, slips are present at very low but nearly identical levels at both site types (1.99% and 1.74%).

Temper also shows intriguing differences by site type (Table 2). Grit and grit/chert are more prevalent at non-earthwork sites, and grit/unknown is roughly equivalent among types. The rest of the temper types are more frequent at earthwork sites. That is, the variability in recipes for paste are greater at earthwork sites, but not outside the range present at non-earthwork sites. Very fine temper is substantially overrepresented at non-earthwork sites (29.79% greater). Medium temper is substantially overrepresented at earthwork sites (22.48% greater). Low density (0–10%) temper is approximately 29% more frequent at non-earthwork sites whereas low-moderate density temper (11–20%) is approximately 18% overrepresented at earthwork sites. The low density sherds likely represent poor quality domestic wares that would not be appropriate to ceremonial settings. The diversity in what is included in the paste at earthworks continues in density fluctuations.

With regard to surface decoration, since only 233 sherds were decorated, little can be said about the distribution among categories. Trailed and cord impressed designs are slightly more prevalent at non-earthwork sites, and dentate linear designs are slightly more prevalent at earthworks. Earthwork sites exhibit a slightly greater richness of decoration types.

We see very clear differences in the way exotic and local materials were used depending on context. In the earthwork sites, Flint Ridge and Wyandotte are represented by much larger finished Hopewell diagnostics than in non-earthwork locations. This trend is present in other exotic materials as well, but notably not Upper Mercer. This represents a distinct pattern of production for activities at earthworks (or at least selection). This pattern could imply that earthwork site collections are composed of more "pristine" objects that have not been resharpened. A nonexclusive alternative is that the earthwork samples include hypertrophic weaponry that does not get lost or made in domestic contexts. Flint Ridge (count and weight), Upper Mercer (weight), and Unknown (count and weight) are present in proportionally greater quantity at non-earthwork sites. Especially notable is the 34.84% greater proportional weight of Flint Ridge, and 12.5% greater weight of Upper Mercer (see Table 5). Obsidian is 47.4% of the weight of diagnostics at earthwork sites; however, it is only present at two sites and is absent in non-earthwork diagnostics. The rest of the categories are larger, but generally far less noticeably, and proportionally overrepresented at earthworks. All categories have larger average artifact sizes from earthworks than non-earthworks except Upper Mercer. Burlington artifacts exhibit the largest discrepancy with earthwork sites, where they are on average 6.6 g larger.

The non-diagnostic Hopewell lithics show a rather distinct pattern from the diagnostic. Only "Other," Upper Mercer, and weight of unknown material show a larger proportional representation for non-earthworks than earthworks (Table 6). The difference primarily boils down to the extreme reliance on Delaware and to a lesser extent Brush Creek (Figure 5) away from the ceremonial centers. The broad similarity in raw material among site types for diagnostics indicates a cultural bias for the use and display of certain material types and the finished products made from them at earthwork sites. Upper Mercer, while a high quality material does not seem to fit the pattern of "exotic" or otherwise special raw material usage.

We have evidence for emphasis on display (large pieces of exotic flint; plain, burnished, and decorated pottery) at earthworks with a greater diversity of temper and decoration styles. Thus, the difference between site types suggests only slight, but important, differences in material composition among site types. The diversity in paste recipes at earthwork sites seems to be more in line with the Synaptic model; however, a more detailed look at this diversity points to sources outside our Scioto Valley sample as the likely source of this variation. The non-earthwork sites are largely homogeneous in the attributes examined so far (in coarse detail). So the variety at earthwork sites is not drawn from a mix of populations from different subregions. This implies that the variation either comes from elsewhere or arises from specific cultural practices appropriate only to earthwork centers.

Turning to the two DFA analyses, we see quite a bit of overlap in the sherd distributions on the two functions (see also Nolan et al. 2016:21,23) and this is reflected in the poor performance of especially the color analyses (Table 4, Figure 5a). The abysmal performance of the classification function on sherd colors indicates widely shared and consistent practices for constructing and finishing vessels, and this pattern is especially clear at the non-earthwork sites. This is measured by the poor cross-validated classification rates and the high misclassification richness values. Interestingly, the earthwork sites are more distinctive in terms of production characters than the non-earthwork sites. This is the opposite of what would be expected if there was wide mixing of dispersed populations as in the Synaptic model. It is also not a perfect fit with the Proximity model, as there is no local signal for dispersed communities to be found in the colors of their ceremonial wares. However, it does suggest that each earthwork center had a relatively distinct preference for the ceramics on display with respect to the procedures of construction and finishing.

The chemical composition analysis is quite distinct (Table 4, Figure 3b). We see much better performance—though still worse than a coin toss—of the classification function. Here the two measures of consistency diverge slightly. The non-earthwork sites exhibit more reclassification success, but also greater richness of misclassification, nearly identical to the richness for the color DFA. So while the chemical compositions are more parochial, there is still no single shared connection outside of the site. This represents a wide sharing of information of ways of making vessels (firing environments, inclusions) for Hopewell groups living within the Scioto Valley, but the use of different and relatively distinct sources of clay with little actual exchange of actual vessels/material. Ideas regarding ceramic production spread wider than production materials or products.

That this exchange of ideas does not seem to be focused around the earthworks undermines the Synaptic model. A further blow to the Synaptic model is that the richness of composition misclassification is lower at the earthwork sites, despite having a marginally less distinct site-composition. In fact, the misclassification richness is the lowest of the four variable/site type groupings. The Proximity model fares better in this analysis. An interesting implication is that there may be more interaction taking place between dispersed populations directly, outside of aggregation at the earthwork centers. This possibility bears further analysis. Regarding the above analysis, the elephant in the room is time. Time was not an explicit variable in this analysis and therefore cannot be fully factored into our considerations here. However, some instructive indications are given. The near unity of Brown's Bottom and Lady's Run (within sight of each other on the same landform) with respect to sherd composition indicates nearly identical clay selection; however, they are on opposite sides of the main color cluster on Function 2. It is possible that sherd color is in some way measuring the passage of time. It is also possible that the differences in distinctiveness of earthwork sites is time-transgressive. If so, then the composite tabulation of average richness may be misleading. However, as a foundation, we have established a framework and database to begin to dig into these questions to rigorously sort between alternative explanations for the Hopewell phenomenon.

NOTES

1. Micro-style refers to traits that are functionally neutral (see Dunnell 1978) and that result from the application of habitual recipes learned during enculturation. The different states of a given micro-style trait are not readily visible or perceived by an outsider. In contrast, macro-style traits are neutral traits that are readily visible to the casual observer and are more typically considered "style" in common archaeological usage.

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