Given, Borrowed, Bought, Stolen: Exchange and Economic Organization in

Postclassic Sauce and its Hinterland in Veracruz, Mexico

by

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ABSTRACT

This study analyzed archaeological residential inventories from the center
of Sauce and its hinterlands to address the possible appearance of markets and the
structure of exchange during the Middle Postclassic period (A.D. 1200-1350) in
south-central Veracruz, Mexico. Economic development is rarely the result of a
coherent strategy either on the part of managing or consuming elites or on the part
of the average consumer. Instead, a combination of strategies and overlapping
exchange systems provided the context, rather than any one explanation, for how
commercial market exchange develops. Identifying the context is challenging
because economies have multiple exchange mechanisms, which require clearly
defined expectations that separate spatial and network (distributional) data. This
separation is vital because different exchange mechanisms such as centralized
redistribution versus central-place marketing produce similar spatial patterns.
Recent innovations in identifying exchange mechanisms use network
(distributional) instead of spatial expectations.

Based on this new body of knowledge, new quantitative methods were
developed to distinguish between exchange through social networks versus
market exchange for individual items based on comparisons of household
inventories, later combining this information with spatial and contextual analyses.
First, a Bayesian-inspired Monte Carlo computer simulation was designed to
identify exchange mechanisms, using all household items including cooking
utensils, serving dishes, chipped stone tools, etc., from 65 residential units from
Sauce and its hinterland. Next, the socioeconomic rank of households, GIS

spatial analyses, and quality assessments of pottery and other items were used to evaluate social and political aspects of exchange and consumption.

The results of this study indicated that most products were unrestricted in access, and spatial analyses showed they were acquired in a market near Sauce. Few restrictions on most of the polychromes, chipped stone, and assorted household items (e.g., spindle whorls) lend strong support to commoner household prominence in developing markets. However, there were exceptions. Dull Buff Polychrome was associated with the Sauce center; analyses showed that its access was restricted through social networks. "Cookie-cutter" style figurines and incense burners also showed restriction. Restricted items found in Sauce and wealthier residences indicate enduring political and social inequalities within market development. For Sauce, a combination of elite and commoner household interests was crucial in supporting the growth of commercial exchange rather than a top-down directive.

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CHAPTER 1. EVALUATING ECONOMIC ORGANIZATION IN POSTCLASSIC VERACRUZ

The "Given, Borrowed, Bought, Stolen…" of the title refers to a stanza from a children's counting divinatory game in answer to the query, "How shall I get it?" [1] This simple phrase captures the coexistence of vastly different means and social contexts for acquiring goods within the same society. Exchange is basic to the study of ancient human society precisely because it can reveal these multidimensional aspects of social, economic, and political relationships (Renfrew 1975:4). Exchanges of material objects are only a fraction of complex social and political exchanges, but they can still provide important insights about societies (Homans 1958; Oka and Kusimba 2008; Renfrew 1975). When durable materials are involved, archaeologists can analyze exchange systems, but the study has always been challenging. Archaeologists have long understood the methodological complexities for interpreting patterns of material artifacts in exchange systems and have devised comparative frameworks in which the issue can be examined (Adams 1975:456-457). Comparative archaeological research on ancient complex societies has demonstrated convincingly that different types of exchange systems coexisted and played complementary roles in the economic and social development of polities and regions (Sherratt 2004:98-100). Among these types, the archaeological study of market exchanges and market systems has been neglected until fairly recently (Garraty 2010).

The reasons for this neglect are complex and at least partly due to ideological separations among social science disciplines early in the 20th century

(Swedberg 2005). A central problem in evaluating economic organization is that the exchange circuits for artifacts are shaped by a mix of social, political, and commercial factors, and this combination is often difficult to disentangle (Granovetter 2005:87; Smith 2004:77). In this dissertation, I propose to apply and test ideas to detect market exchange archaeologically while simultaneously considering other forms of social network exchange. In identifying exchange mechanisms and the spatial structure of exchange, I reconstruct the social and political components of the economic organization of a small center. My focus is Sauce and its hinterland residences located within south-central Veracruz, dating to the Middle Postclassic period (A.D. 1200-1350). This period is a critical time just before the consolidation of the powerful political and economic force of the Aztec imperial state that was to eventually conquer the region.

Postclassic Mesoamerican Research Framework

Markets are identified as an important economic feature of Postclassic Mesoamerica ethnohistorically, and archaeological studies have evaluated the impacts of marketing on product exchange systems (e.g., Berdan 1985; Blanton 1996a; Hirth 1998; Hodge and Minc 1990; Minc 2006; Nichols, et al. 2002; Smith and Berdan 2003a; Stark and Ossa 2010). Recent economic research on Postclassic period (A.D. 900 – 1520) Mesoamerica has focused on the intersection of the vigorous periodic markets and the consumption and availability of everyday items and luxuries to consumers from a range of socioeconomic levels (Garraty 2006; Smith and Berdan 2003b:7). How this system developed in

concert with the political forms leading up to the Aztec Triple Alliance Empire has been one of the enduring topics for the Postclassic period (Berdan, et al. 1996). The complexity and complementarities of regional economic specializations as viewed through craft production within the central Mexican highlands has been one successful and detailed arena of investigation (Nichols, et al. 2002). More recently, researchers emphasize the degree of local variation and complexity even within polities and smaller communities (Smith and Berdan 2003b). Therefore, a significant aspect of studying the larger Postclassic period changes will require better information from households within smaller centers and their hinterland residences. Modest to small sized polities rather than large highland capitals (e.g., Monte Albán, Teotihuacan, and Tenochtitlan) were probably the primary political form through much of Mesoamerican history (Stark 2007b:85), particularly the Postclassic period (Smith 2003a:58-59). Currently, many of the synthesized datasets have focused on larger scaled regional data rather than households within these smaller polities, although there are exceptions (Smith 1992).

A significant amount of research on the Mesoamerican Postclassic commercial network has been based on major regional studies and site level reporting (see Hodge and Smith 1994). Therefore, much of the well-published research on Postclassic period dynamics has focused on the polity or city-state as the primary unit of analysis (Berdan 2003:313; Minc 2006), and many regionally based studies, such as Hodge and Minc (1990), were based on site level sampling.

Insights from the regional studies show an important aspect of exchange, especially highlighting fluctuations in regional and interregional relationships (see Smith 2010). However, households have long been recognized as the primary unit for analyzing Mesoamerican political economies and for identifying the type of exchanges (Brumfiel and Nichols 2009; Feinman and Nicholas 2004:173; Hirth 2010:97; Smith 2004:85). Households are important for identifying exchange because they are the most likely decision-making unit for obtaining products and allocating resources (Hirth 1993b:121). Therefore, regional scale information alone is not sufficient to identify some of the key ways in which exchange systems are organized. Instead, new conceptual and theoretical perspectives for studying exchange archaeologically argue for a multiscalar approach that incorporates both regional and household scale data (Feinman and Nicholas 2010:97).

More recent research on Postclassic period Mesoamerica adopts the multiscalar approach and integrates site and household level analyses to investigate political economies via exchange and consumption patterns (Feinman and Nicholas 2004, 2010; Masson and Friedel 2002; Smith and Berdan 2003a). The strength of the research presented here is that it incorporates both a polity and household scale dataset to analyze a small center and its hinterland. Using a sample of Middle Postclassic period residences drawn from the Proyecto Arqueológico La Mixtequilla survey projects (PALM I, II) directed by Dr. Barbara Stark and from Stuart Speaker's (2001) related survey project, I designed

fieldwork for a more intensive surface sample, the Sauce Archaeology Project

(SAP). I collected and analyzed 65 residential inventories that sample the center

of Sauce and its rural hinterland. An overview of the research is described in the

following section.

Economic Organization of Sauce and its Hinterland

Sauce and its hinterland residences are located in the Blanco delta, in the

western lower Papaloapan basin (WLPB) (Figures 1.1, 1.2). Sauce is the only

center identified in Stark's PALM survey during the Middle Postclassic period,

and its economy is of interest because the area displayed significant economic and

political shifts. Recent research has suggested that the rise of market exchange as

a political and economic strategy was one factor in Postclassic changes in both the

WLPB and the rest of Mesoamerica (Blanton, et al. 1993; Curet, et al. 1994;

Garraty and Stark 2002; Santley 1994; Smith and Berdan 2003b; Stark 2007a, b;

Stark, et al. 1997). For the major highland states, archaeologists have identified

market exchange starting in the prior Classic period (Feinman and Nicholas

2010). For lowland Veracruz, we are beginning to advance our knowledge of

market exchange (Garraty 2009; Stark 2007b; Stark and Ossa 2010). Increases in

craft productivity co-evolving with less powerful states are recognized as

contributing factors in commercial economic development in Postclassic

Mesoamerica (Blanton, et al. 1993:208-209), and the Gulf area has relatively

small states. Sauce is a strategic case with which to evaluate economic

organization because the scope of prior archaeological work allows for a detailed
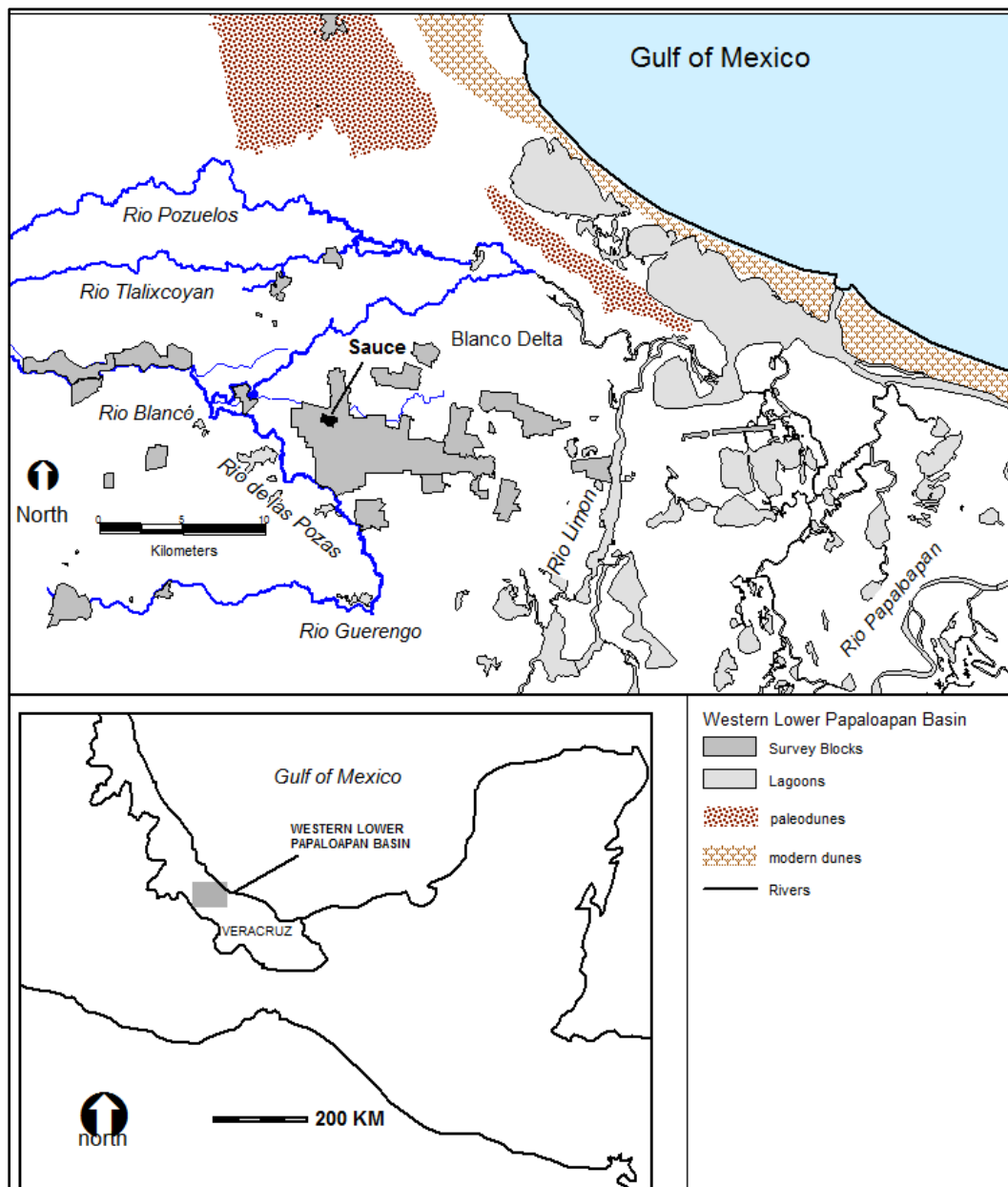
Figure 1.1 Map showing Sauce center and PALM and Speaker survey blocks in the western lower Papaloapan basin in south central Veracruz, Mexico.
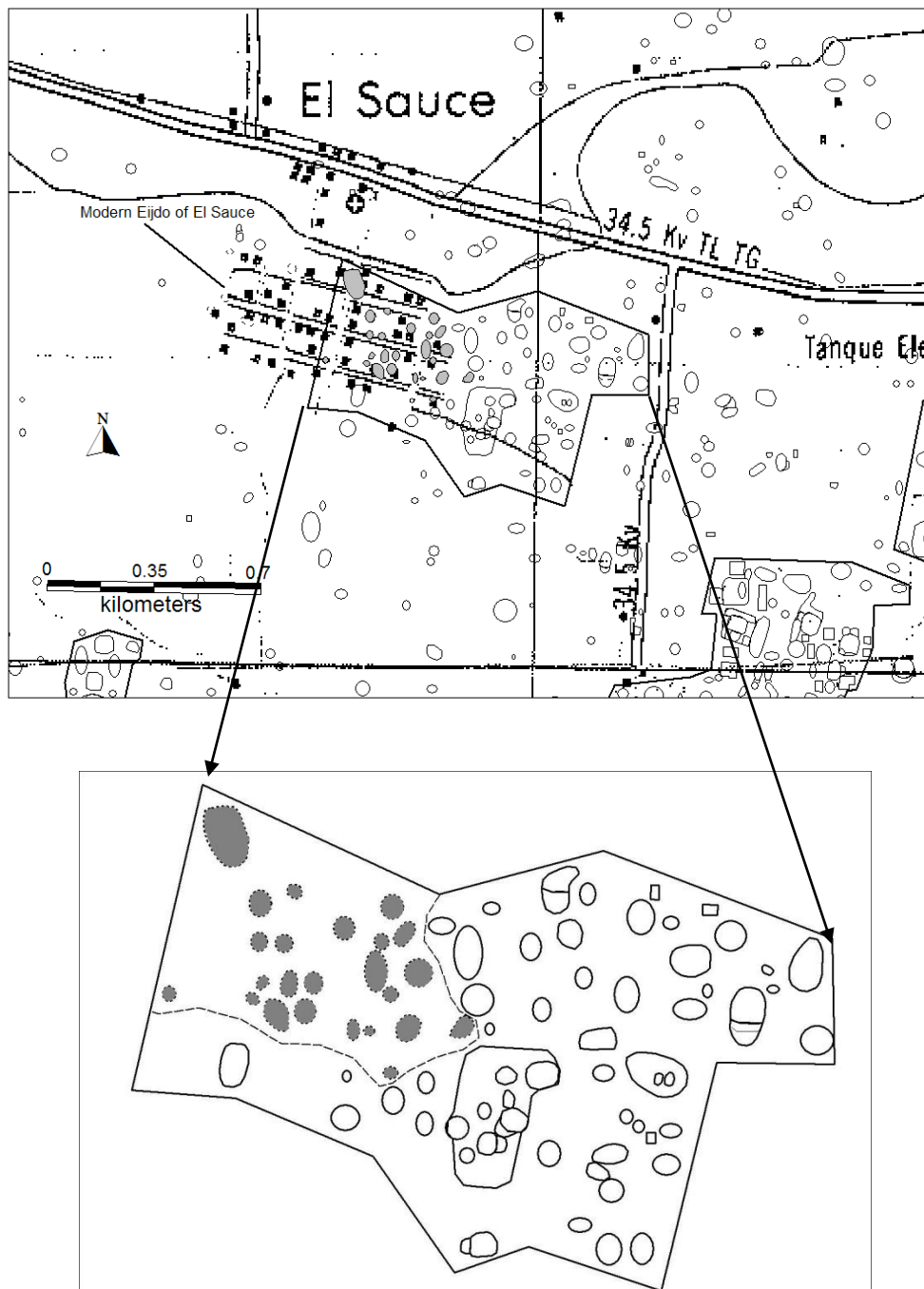
Figure 1.2 Map showing Sauce, including the modern community (ejido) and the settlement nucleus (surrounded by a line). Lower inset is an enlargement of the Sauce core. Grey fill indicates mounds that are located within the ejido. Maps are a compilation from Stark's PALM projects and INEGI map Joachin E14B69.

project focusing on residences from both a center and its rural hinterland (Curet, et al. 1994; Garraty and Stark 2002; Heller 2000; Stark and Garraty 2004:139-140).

Classic period economies in south-central Veracruz provide the political and economic capital of the settlement system of the WLPB (Stark 1999b). Despite its importance as a regional capital, there are no obvious associations with large scale craft production in amounts sufficient to be detected through surface collections (Drucker 1943; Heller and Stark 1998:126; Stark 1992, 2007a, b). By the Late Classic period (A.D. 600-900), there is a change in local economies. The new local capitals, such as Azuzules and Nopiloa, overlapped with and replaced Cerro de las Mesas as regional captials and showed greater evidence of associated craft production, and possibly increased commerce (Curet, et al. 1994; Stark 2007a, b; Stark, et al. 1997; Stark and Garraty 2004). Specifically, Azuzules in the Blanco delta and Nacastle-Patarata in the mangroves, produced, respectively, orange slipped bowls and fine paste orange ceramics, while Nopiloa had more intensive blade production (Stark 2007a:241-244). The association of WLPB centers with craft production is a trend that continues into the Postclassic period despite large shifts in settlement patterns and material culture (Curet, et al. 1994; Garraty and Stark 2002; Stark 2008a).

In its local setting in south-central Veracruz, Sauce was the new focus of governance for the Middle Postclassic period, and it had a distinctive new material culture, including comals (griddles), highland style decorated ceramics,

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clear grey obsidian from Pico de Orizaba, and a new blade technology with

ground platforms (Curet, et al. 1994; Heller 2000; Stark and Garraty 2004).

Sauce also specialized in crafts, such as blade production and activities using

obsidian scrapers (Heller 2000; Stark 2007a:242); comal production was located a

few kilometers away in a rural setting (Curet 1993). Although some aspects of

craft production at Sauce may have been encouraged by elites, it is not yet clear

whether the goods being produced were dispersed via open exchange systems,

such as a market, versus restricted social networks, and how local exchange

articulated spatially with the settlement system (Stark 2007b), although for certain

items, such as obsidian, market exchange has been identified as the most likely

mechanism (Stark and Garraty 2010). These vital questions are the substance of

this dissertation, using new advances in defining and identifying exchange

archaeologically. In the following sections, I explain the key concepts and

definitions that are adopted throughout in order to situate the conceptual and

methodological advances in identifying exchange archaeologically.

Key Concepts and Definitions for Exchange

Concepts and terms such as market, market exchange, marketplace,

redistribution, and social network exchange are central to my research. Here, I

provide basic definitions for these concepts and the framework I will use to

evaluate them, but more detailed definitions are developed in Chapter 2.

The concepts I discuss apply to both network exchange (i.e., non-spatial)

and spatial exchange systems. I use the term network to refer to any group of

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consumers, producers, or middlemen that participate in the exchange of an item.

The group exchanging the item, however they are defined by status, kinship, or

region, constitute the network. Therefore, network exchange is defined as the

exchange of items among groups of people whose spatial locations are not

necessarily known. The mechanism of exchange, whether by markets or social

networks, can be identified by network based expectations.

Market Exchange. I define commercial market exchange as a set of

economic transactions where products are exchanged by barter or for media of

exchange and in which considerations of supply and demand are prominent (Pryor

1977; Smith 1976; Smith 2004:78-80). By market exchange, I refer to the process

or institution of market exchange rather than a specific place where markets

occur, such as a marketplace. A marketplace is the physical location where

market exchanges are facilitated or perhaps regulated; a marketplace is a formal

setting, perhaps as the ones described for the great marketplaces of the Postclassic

period capitals of Tenochtitlan and Texcoco (Hirth 1998:454-458).

Social Network Exchange. Social network exchanges of products occur

via social and/or political connections. Although market exchanges often have

political and social aspects, I define social network exchange as exchange in

which the social and/or political connection is exclusively required for the

exchange to take place. Elite exchanges, including gift-giving, preciosity

acquisition, and redistribution have long figured in anthropological

interpretations, and I consider them to be sub-categories of social network

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exchange. High ranking groups have special privileges, obligations, and prestige

concerns that often involve the exchange and administration of goods (Davenport

1986; Helms 1993; Schneider 1991). Social network exchange could involve the

restriction of specific goods to particular social groups or the control of goods via

redistribution. Therefore, social network exchange might include gift-giving

among elites or kin networks. Redistribution is the controlled distribution of

items via the political elite, typically along social networks. For redistribution, as

opposed to gift-giving, we might expect most households to have access to a

redistributed item, but the control and administration of its distribution would

probably result in political or social elites having higher quantities (after Stark and

Garraty 2010:44).

Conceptual and Methodological Advances in Identifying Exchange

The spatial fall-off patterning of product frequencies can identify how

centers and settlements articulate with the economy, but there are complications

to its interpretation based on archaeological datasets. Spatial fall-off refers to the

pattern of the decrease of product frequencies away from a potential product

source. Spatial fall-off patterns can appear the same for redistributive systems

and central place market exchange (Renfrew 1977:88), which poses an

interpretative challenge for archaeologists. Additionally, greater concentrations

of product frequencies do not always point to a central place, but can also be the

results of preferential access by elites, or specialized activities, further

complicating efforts to identify exchange mechanisms through spatial distance

decay alone (Renfrew 1977:85-86).

Recent advances in evaluating exchange archaeologically use the end

consumption point, i.e., residential inventories, to infer exchange mechanisms

(Hirth 1998; Smith 1999, 2004). The premise of Hirth's (1998:455) distributional

approach is that markets provide products restricted in access by cost alone.

Social exchange networks, such as elite gifts or kin networks produce flows of

products that are restricted by the status, kinship, and political affiliations of

residential groups. After identifying exchange mechanisms for different products

via their circulation among residential groups, one can use the spatial fall-off of

products to identify how the economy articulated with the settlement system. I

apply the distributional and spatial distance decay methods developed by Hirth

(1998) and Renfrew (1977), respectively, to evaluate the evidence for marketplace

exchange and other types of exchange and the role of Sauce within the region's

economy. Residential inventories can be used to identify product exchange

mechanisms based on whether access was open or restricted. Spatial distance

decay of product frequencies can show how Sauce articulated with its hinterland.

Therefore, I collected a sample of non-perishable residential inventories from

Sauce and its hinterland to define the role and spatial organization of market and

social network exchange, such as elite gift-giving and kin network exchanges.

Research Framework

Residential Units. I obtained new intensive surface collections from a regional sample of previously identified Middle Postclassic period residential mounds. Stratified random sampling of residential mounds was undertaken from five concentric rings extending in increments of 2.5 km from the Sauce center to capture both the distributional (access by households) and spatial fall-off of products. I chose residential mounds, representing surrogate households, as the base units for the exchange analyses. For each residential mound, one area measuring 5 x 5 m was cleared of vegetation and collected to obtain artifact inventories that were statistically comparable among the 65 mounds. The differentiation of exchange systems only requires the comparison of artifact distributions among domestic units; however, delineating social aspects of exchange systems requires information about socioeconomic rank for those domestic units. Therefore, an important component of SAP was obtaining socioeconomic information about the residential units themselves. I developed a method for assessing socioeconomic rank for all of the individual residential mounds based on a measure of residential mound size weighted by the proportion of Postclassic materials. The resulting mound size rank groups were applied in analyzing the social aspects of the exchange systems for Sauce and its hinterland residences.

Household Inventories. Exchange systems were evaluated using the nonperishable artifacts collected from the residential mounds. These data were

considered representative samples of household inventories. I used all household items, including cooking utensils, serving dishes, chipped stone tools, etc., from the 65 residential units collected from Sauce and its hinterland to define the roles of market and social network exchange and to better understand their spatial organization. The distributions of products from residences were analyzed separately for each artifact class, including all pottery types (decorated bowls, comals, and spindle whorls), chipped stone implements, and lapidary items, including preciosities such as greenstone.

Scenarios for Commercial Development

This project builds upon current research in economic anthropology by using community and residential product consumption practices to model economic organization within a region that may have been in economic transition (Kepecs and Kohl 2003:18-19; Smith 2004:92-94). In my conceptualization, economic transitions do not necessarily represent abrupt breaks driven by changes in political economy within regional economies, as might be represented by the transition from hunting and gathering subsistence to agriculture. Instead, the transition from relative household self-sufficiency to increasing reliance on markets for provisioning is not expected to happen abruptly, but to occur over time. Reliance on other households to produce and supply important items such as pottery or chipped stone tools to a larger population may occur gradually. Household interdependence need not be the result of top-down elite strategies, although elites could also help sponsor these activities. Recent theoretical

perspectives on market development suggest a combination of elite and commoner household interests may be crucial for development, rather than a top-down directive (Blanton and Fargher 2010). Based on a large dataset of cross-cultural comparisons of complex societies, Blanton and Fargher (2010) found that increasing commercialization and market exchanges in their examples was correlated with urbanism and agricultural intensification, although they do not interpret these two factors as the causes. Instead, Blanton and Fargher (2010:218-223) suggest that a combination of political change, intensification, urbanism, and household participation in regional markets is what drove commercial development in most of their case studies.

For south-central Veracruz, Stark (2007b: 105) proposes that beginning at least by the Late Classic period (A.D. 600-900) economic changes were underway following the political break-up of the Cerro de las Mesas political realm into competing smaller centers. These economic changes include the increase of a cotton textile industry (Stark, et al. 1997) and more intensive craft production associated with centers (Stark 2007b:105). Stark (2007b) proposes that market exchange with the support of local markets by the ruling authorities of these newer, smaller centers is the likely reason for the craft associations. Based on these previous observations, I also consider the evidence of craft production in association with the exchange access of artifacts for my study. Most of the data I collected was not conducive to an in-depth study of craft production. However, some production evidence was recovered from the household inventories,

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including pottery molds and chipped stone production indicators. My analyses of

chipped stone in particular, relied on evaluations of the distributions of chipped

stone production indicators and artifacts to evaluate whether exchange was

administered or controlled by political elites. Evidence linking craft production to

the Sauce center could support its control or sponsorship by political elites. In

contrast, craft production found in areas away from Sauce could support

commoner participation in craft production and/or the activities of itinerant

producers.

Market exchange existed prior to the Late Classic period (Stark and Ossa

2010), but its potential rise in regional importance for the newer smaller centers

was probably accompanied by attendant processes of commercialization, in which

increasing amounts of goods are available via openly accessed exchange. In

testing for commercial scenarios, I compare the availability of basic necessities,

such as cooking vessels and obsidian tools, and more socially expressive finely-

made goods versus the spatial distribution patterns of each type. Additionally, the

availability and consumption of luxury goods are considered a distinguishing

characteristic of the Postclassic Mesoamerican economy and a key component of

commercialization (Blanton, et al. 1993:212-213; Smith 2003b:123).

Comparative product values have been used to determine that luxuries were being

marketed in Postclassic period Mesoamerica, which indicates increasing

commercialization (Smith 2003b:123).

I recognize that there are many complications to considering the relative value of material objects because each society typically has its own set of rules or guidelines by which an item's value is established and also whether it can be exchanged and under what circumstances (e.g., Appadurai 1986). Despite these challenges, I apply a basic measure of pottery production costs based on labor inputs to consider Sauce's product values in terms equivalent to each other (Feinman, et al. 1981). A cost analysis can be helpful in determining whether similar sets of items such as decorated serving vessels were being marketed in the same way that basic necessities such as cooking vessels were circulating. Pervasive commercialization of most pottery with fewer restrictions on fancier pots would highlight the participation of commoner households in market exchange. Alternatively, exclusive associations of fancier items with wealthier residences close to Sauce could indicate enduring political features in local economic development.

In the following sections, I outline my research objectives for the Sauce Archaeological Project, including my specific goals and expectations for identifying different kinds of exchange systems and sociopolitical contexts. Next, the results of my research for different artifact types are organized by chapter. Finally, I discuss the broader findings of my research of Sauce's economic organization and emphasize the methodological contributions of this study for revaluating ancient exchange systems and economic organization.

Research Objectives

I test theoretical ideas and apply new methods to improve the
identification of exchange and to better understand the development of
commercialization within complex societies. I develop an explicit analytical
method to deal with the mix of social, political, and commercial factors that shape
economic organization. In this study, I define the relative role and organization of
both market and social network exchange to describe the economic organization
of Sauce and its hinterland. My project has the following main research
objectives and expectations:

Define the Role and Spatial Organization of Market Exchange.

Markets are important in Postclassic Mesoamerica (Berdan 1985; Blanton
1996b; Hirth 1998; Hodge and Minc 1990; Minc 2006; Nichols, et al. 2002;
Smith and Berdan 2003a; Stark and Ossa 2010), but identifying market exchange
archaeologically has proven difficult because archaeological approaches have not
directly measured the impact that market exchange should have on residential
product inventories (Hirth 1998:454). Hirth (1998:461) proposed a
"distributional" method for identifying market exchange based on the assumption
that within market systems, residence inventories will be relatively similar to each
other due to a centralized flow of resources and general access to market
exchange. M. Smith (1999) emphasizes an aspect of Hirth's original idea,
highlighting the fact that differences in relative artifact amounts among residences
could be the result of wealth and social rank rather than restricted non-market

exchange. M. Smith (1999:528) suggests that within an open market system, as opposed to other kinds of exchange transactions, fewer commodities will show an *exclusive* association with wealthy residences. Generally, non-exclusive access to goods for residences from all income levels would indicate market exchange, although the wealthiest residences may have a better supply.

Expectations. For market exchange *distributional expectations*, I expect to find graduated differences among residential inventories in the relative percentages of each product compared to total amounts of ceramics (Smith 1999). I expect residences from all socioeconomic wealth levels to have access to a product that was being exchanged through markets, in some amount, taking sampling error into account. We can conceptualize this statistically by comparing inventories. In comparing percentages of a particular product among residences, I expect a relatively smooth and gradual variation in percentages (such as 20% to 19% to 18% and so on). For market exchange *spatial expectations*, I expect that a solar market system would apply if the spatial distribution of marketed products declines (absolute quantities per residence) from the center of Sauce as distances reach the limit to which residents would be willing to travel to obtain products (Renfrew 1977; Smith 1974:176-177). A solar market is defined as a correspondence between markets and administrative hierarchies and typically produces spatial fall-off patterns of products from one probably isolated central place which acts as the sole market center for its surrounding residences (C. Smith 1976:37). Alternatively, multiple nodes of higher product frequencies with no

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overall drop-off from Sauce could indicate the presence of overlapping market zones.

Define the Role and Spatial Organization of Social Network Exchanges.

Elite networks, systems of patronage, and administered exchange may be part of a society's political economy and typically co-exist with other kinds of exchange (Davenport 1986:98-99). In earlier periods within Veracruz, fine ceramics probably traveled through social networks via gifts and down-the-line trade. Many of the finely decorated ceramics identified by Medellín Zenil (1960) in Veracruz during the Middle Postclassic period could be the result of similar social exchange. In the case of particular kinds of goods that may have required special importation (such as obsidian for Sauce), exchange in social networks could be via redistribution. In redistributive exchange everyone may have some of it, but the control of its distribution is linked to residences with higher socioeconomic status as demonstrated by its occurrence in higher amounts with these higher status residences (after Stark and Garraty 2010). A rigid class system might also produce distributional disparities based on class based restrictions in access to products. Elites, political patrons, and rigid class systems are not the only sources for products exchanged outside of market exchange. Kin networks, self-sufficient residential production, and house-to-house exchange also may account for a portion of residential provisioning. For example, Sheets (2000:218) found that people at the Classic period site of El Cerén in El Salvador produced

products for internal consumption and also engaged in house-to-house or localized exchanges with neighbors or kin networks.

Expectations. For social network *distributional expectations*, I expect that products will be present in greater amounts within elite residences, kin networks, or self-sufficient residences, yet in much lower amounts or absent in others due to restricted exchange circuits (Hirth 1998). This mix of presence and absence and extreme differential amounts can also be imagined quantitatively. In comparing relative percentages of a particular product among residences, I expect an abrupt or stairstep pattern (such as a drop from 20% to 10%) between groups of residences engaged in gift-giving, kin network exchange, or self-sufficient household production and those that were not. I owe the characterization of a stairstep pattern for identifying social network distribution to George Cowgill, who suggested this expectation to describe variation among relative percentages. For *spatial expectations* for elite gifting, abrupt drop-offs and/or absence of products are expected to occur more often on the basis of residential wealth. S*patial expectations* for products that were exchanged via kin networks, house-to-house exchanges, or were the result of self-sufficient production, would appear as spatially distinct distributions associated with the mound or group of mounds that made up the kin network or house-to-house exchange group.

Chapter Synopses

In Chapter 2, I describe the two major theoretical and methodological issues, the formalist/substantivist debate, and the equifinality problem for

distinguishing different exchange mechanisms using spatial patterns, which have

made archaeological research on the study of exchange and economic

organization challenging and anthropologically controversial. I situate my study

within the context of new perspectives that offer practical resolutions for the

archaeology of market systems and exchange systems in general (after Stark and

Garraty 2010). I also further define and explain the terms introduced in Chapter 1

to discuss exchange and exchange systems. Specifically, I define market and

social network exchange and give brief descriptions of how they can be

distinguished archaeologically based on new conceptual advances and methods

(Hirth 1998; Minc 2006; Smith 2004; Stark and Garraty 2010). In the second

portion of Chapter 2, I give a diachronic overview of Mesoamerican political

economies beginning from the Classic period leading up to the Postclassic period.

Next, I introduce different scenarios that have been applied to explain Postclassic

period political and economic transitions, comparing and contrasting central

Mexico and the lowlands. I particularly focus on the Late Classic period

transitions and prior research in the Gulf lowlands that has identified the potential

role of local political elites in sponsoring economic development (Stark 2007b).

Finally, I summarize the background research undertaken for the Middle

Postclassic period Sauce center and its hinterland residences and the potential of

my research for understanding local change and broader trends within Postclassic

period Mesoamerica.

In Chapter 3, I give an overview of the field methods and sampling

strategies adopted for the Sauce Archaeological Project. First, I describe the prior

settlement pattern data from Stark's PALM I and II and a related survey by Stuart

Speaker (2001), which provide the basis for SAP sample design. Settlement

features from both datasets were sampled to select locations for SAP's intensive

surface collections. I emphasize that the prior use of intensive full coverage

survey methods combined with a "site-less" approach enabled the design and

implementation of a more detailed study targeting the Middle Postclassic period

settlements. Part of the prior survey design is based on an appreciation of the

geographical setting of the western lower Papaloapan basin, which I describe

briefly. In addition to the antecedent body of work established by the prior field

projects, I describe the characteristics of archaeological remains of the western

lower Papaloapan Basin that made a project like SAP feasible. The low-lying flat

terrain makes the earthen mounds which represent the majority of archaeological

features easier to see. Additionally, findings from subsurface testing, excavations,

and surface collecting within the previous projects suggested that differences

between surface and subsurface artifact densities were within acceptable ranges of

similarity. Next, I describe my three sampling priorities and the strategies used to

achieve them: (1) selecting residential mounds from a range of socioeconomic

situations using a system of five concentric 2.5 km rings for sampling, (2)

selecting mounds that dated to the Middle Postclassic period, and (3) selecting

mounds from the poorest residences. Finally, I discuss my use of intensive

surface clearing and collection of plow zones to minimize sampling error and maximize abundant artifact collections.

In Chapter 4, I establish the baseline data used in the exchange analyses. In this chapter, I establish the line of inferential reasoning for selecting my base unit of analysis, the residential mound, establish the chronology for my main datasets, and define and describe a measure for socioeconomic rank of households to be used in the exchange analyses. As described in Chapter 1, the residential inventories taken from individual mounds sampled from Sauce and its hinterland are the basis for testing expectations that link distributional and spatial patterning to different exchange systems. Therefore, I evaluate the residential mounds as surrogate households and establish them as the base unit for the exchange analyses in my study. Next, I introduce the datasets of pottery and chipped stone that provide the chronology associated with the 65 residential mound collections. The results of the chronological analysis are summarized for each group of mound collections for each of the five sampling rings described in Chapter 3. Based on the chronological associations of the materials recovered in the 65 mound collections, I establish that most of the Postclassic materials had a specific association with the Middle Postclassic period rather than the Late Postclassic period. Therefore, I use pottery types that have more general Postclassic period associations in the exchange analyses as there is a much lower likelihood that the residential mounds have substantial Late Postclassic period materials. My expectations for identifying different forms of exchange require the identification

of socioeconomic rank of residences in order to decide whether access is being restricted along a socioeconomic axis. Therefore, I require a means of establishing socioeconomic rank for each of the residential mounds selected in the study and the measure must be independent of the artifacts I analyze. In the final section of Chapter 4, I describe a method for assessing socioeconomic rank for all of the individual residential mounds based on a weighted measure of residential mound size. I suggest that despite methodological issues, residential size can be used as a proxy for socioeconomic rank that is independent from the artifact inventories. Finally, I discuss the insights and implications of the residential mound dataset for the study of exchange.

In Chapter 5, I evaluate different network exchange mechanisms for the distribution of pottery for 65 residential mound collections from the center of Sauce and its hinterland. In the first part of this chapter, I introduce the pottery descriptions and statistics to explain how the network analysis can be interpreted and applied. In the second section, I undertake a visual distributional analysis, an exploratory data analysis that uses bar charts to compare pottery percentage variations among the residential collections. Weighted mound volumes are used in the visual distributional analysis to map potential socioeconomic associations with exchange. Next, I describe my development of a Bayesian Monte Carlo computer network simulation. The purpose of a network simulation is twofold: (1) to test whether the observed patterns of exchange in the visual distributional analysis are valid or, instead, the result of sample sizes and (2) to apply

quantifiable statistical measures to the open and restricted percentage expectations for exchange. For the network simulation, I describe two statistical methods, including variance and the ratio of pottery presence to the total residential collections; these two measures were applied to the empirical and simulated dataset to evaluate exchange. Finally, I discuss the results of the combined visual distributional analysis and network simulation, which demonstrate that a combination of open and restricted exchange networks, including markets and social networks, were operating within Sauce and its hinterland. These insights provide the basis for the spatial and contextual approach in Chapter 6 that includes more overtly social and political analyses of how the different exchange networks were organized.

In Chapter 6, I use the spatial dataset combined with the production cost value of the pottery categories being exchanged to identify three key interrelated factors in understanding this mix of local exchange systems: spatial organization, political aspects, and the degree of commercialization. I analyze how the different pottery types were distributed within the region in combination with their associations with the weighted mound size groups (socioeconomic rankings) and how these pottery types may have been perceived socially. These two aspects: spatial and contextual, were analyzed separately for pottery that was exchanged openly versus that which was restricted, based on the analyses of Chapter 5. First, I establish the explicit methods by which pottery types were evaluated for establishing a measure of their potential social importance. Second,

I establish the basic spatial patterns for the mound size ranks for the study area. In the third section, I apply the pottery type value and the mound ranking to a spatial and contextual analysis of pottery types. Finally, I discuss the results of the analysis which indicate Sauce's role as a central place for market exchange in the local economy based on the distribution of most pottery from its vicinity and the center's association with pottery production. Some spatial exceptions occur, in ring 4, which I interpret as a location of potential elite residences rather than indication of a secondary market zone. I argue that the apparent availability of most of the decorated pottery indicates widespread participation of the local population in commercialized market exchange rather than solely the result of elite direction.

In Chapter 7, I evaluate exchange mechanisms and spatial patterns of chipped stone materials for 65 residential mound collections from Sauce and its hinterland. These materials included obsidian artifacts (formal tools, blade parts, production indicators), and chert (mostly bifaces and points). I take the perspective that chipped stone materials have a different set of rules and exchange parameters than the pottery, because they represent a household item which everyone had without the potential for as much stylistic variation allowing choices of different types (such as one might find for decorated serving pottery), which has implications for the analysis. I apply a production-distribution approach to evaluate the SAP obsidian inventories based on a new method described by Stark and Garraty (2010) for differentiating exchange systems in

cases where access to a material is widespread. I adopt methods based on recent research on obsidian production-exchange systems in Mesoamerica to establish where and how production of chipped stone artifacts was taking place (De León, et al. 2009; Hirth 2009a). First, I introduce the obsidian dataset and its type analysis categories. Second, I summarize prismatic production evidence and its implications for economic organization. For this chapter, production analysis is a necessary step in identifying different exchange mechanisms for an artifact category such as chipped stone. Third, I consider the exchange mechanisms and spatial and contextual components of the three chipped stone datasets: formal tools, blade segments, and all blade parts.   Finally, in the fourth section, I consider chert and its potential implications for Sauce's economic organization.

In describing the results for Chapter 7, I argue that market exchange was the main exchange mechanism that explains the distribution of chipped stone. The association of the largest concentration of primary production indicators with Sauce and ring 1 along with the highest densities of obsidian blade parts supports the notion that the political elites of that center probably had some role in supporting or encouraging the market exchange of this staple item even if they did not direct its exchange in the form of redistribution.   However, the production evidence also suggests that a combination of local producers along with itinerant producers were responsible for provisioning Sauce and its hinterland.

In Chapter 8, I evaluate exchange mechanisms for the scarce artifact categories that include spindle whorls and spinning tools, groundstone tools,

incense burners, figurines, and special pottery forms (like figurine molds). The scarce artifact categories do not have typologies with enough chronological distinctions to be ascribed solely to the Middle Postclassic period, and they have very small samples that make statistical characterizations difficult. However, the scarce artifact categories include household items that probably played important social, economic, and ritual roles, so the goal of this chapter is to describe the basic spatial and type associations based on current information about each category. I analyzed how the scarce artifacts were distributed within the region spatially and whether high densities are associated with the mound size ranks that were established in Chapter 4.

Spindle whorls and figurines were the only two categories that were analyzed using Postclassic types. I take the perspective that SAP's intentional sampling bias towards Middle Postclassic materials minimized some of the chronological mixing of other items. First, I considered the items that were probably more frequently used and owned by most households, such as spindle whorls, groundstone tools, etc. Second, I considered more special-use items such as pottery molds that were probably not used by every household. The results of the analyses offered further support for both market exchanges and central place markets located within or near the Sauce center. There are also some indications of restrictions or preferential consumption of some items, such as the Postclassic figurines and possibly the incense burners. I also found larger amounts of groundstone and spindle whorls associated with ring 2 than for other artifact

types. Future research to establish more refined chronological control and larger samples will be required to confirm most of these patterns.

In Chapter 9, I summarize and synthesize the results of the exchange analyses for all of the different artifact types and describe the complex picture of Sauce's social, political and economic life. I organize my summary discussion of the results of Sauce's economic organization around several key elements, including exchange mechanisms, political implications of spatial patterning of market and social network exchange, social aspects of market exchange, and the degree of commercialization. I also discuss Sauce's organization from the perspective of small polity dynamics and exchange system development from the standpoint of Veracruz and within Mesoamerica. In the next section, I discuss the methodological contributions of the research undertaken in this dissertation and its basis in new conceptual breakthroughs in describing and defining exchange mechanisms and exchange systems archaeologically. Next, I discuss the broader theoretical implications of recognizing and dealing with complexity in ancient economies with some insight from recent research on Old World exchange dynamics. I conclude by emphasizing the conceptual potential of analytically separating variables of exchange from spatial data for advancing theoretical ideas about complex society exchange systems and economic development.

Summary of Results

Middle Postclassic period Sauce followed the large centers of the Late Classic period in the western lower Papaloapan Basin in Veracruz. Data from a

sample of 65 residential mounds taken from the center and a surrounding

hinterland that extends 12.5 km eastwards support Sauce's role as a central place

for market exchange in the local economy. Sauce's associations with craft

production indicate its political elite supported or tolerated these crafts. Active

market exchange participation and association with central places may well have

begun earlier, as the Late Classic centers indicate associations with craft

production and show similar fall-off spatial patterns for items such as obsidian

(Stark and Ossa 2010).

I evaluate different exchange mechanisms using a set of established

expectations for differentiating between open and restricted access described in

Chapter 5. Open access correlated with market exchange and restricted access

identified social networks. For dealing with items that every household had

access to, such as clear grey obsidian blades (although all households had pottery,

they did not have every pottery category), I adopt a slightly different approach.

For my expectations for the chipped stone, restricted access is expected to

correlate with redistributive principles along social networks, which would show

greater access for households with higher socioeconomic ranks or potentially

spatial associations for groups of related-kin households (after Sheets 2000).

The results of the exchange analyses indicate that a mix of market and

social network exchanges characterized Sauce's economic organization, but the

majority of household materials were probably attained via market exchanges. I

used two new methods to analyze the pottery, a visual distributional approach and

a network simulation. Both methods led to almost identical conclusions about whether a pottery type was exchanged via markets or social networks, which inspires some confidence in the results. The majority of the pottery types that were numerous enough to be considered for the network analysis of Chapter 5 were openly exchanged. I adopted the regional production-distribution approach (after Stark and Garraty 2010) to evaluate the more likely exchange mechanisms for the chipped stone dataset. The chipped stone datasets included formal tools from repurposed blades, blades and blade parts, and chert. Generally, the exchange mechanism appears to be open exchange, probably through a combination of market exchange via a central place and some itinerant or local knapping specialists.

For the exchange analyses, only a few artifact types were identified as restricted in access. For Sauce, restricted exchanges were expected to be the result of social network exchanges, which could include elite gift, patronage, kin, and house-to-house exchange. Restricted types included Dull Buff Polychrome, Postclassic "cookie cutter" figurines, and incense burners. Dull Buff Polychrome showed restricted access based on the results of the network simulation. The figurines and incense burners were identified as being potentially restricted based on their association with collections from residential mounds with higher mound size ranks (1-3) for the outer rings (4-5). I concluded that the associations of figurines and incense burners with residences in ring 4 could be the result of a set of elite residences. For now, the figurines and incense burner samples are too

small to be certain of their circulation patterns. However, the Dull Buff
Polychrome distribution was sufficiently unusual to support preferential access.

Dull Buff Polychrome is found within all rings, but its relative amounts
among collections are sufficiently disparate for its empirical distribution to never
match the network simulation. Dull Buff Polychrome could have been exchanged
via elite gift exchange, but given the remarkably high densities of this type in a
handful of residences it seems likely that these vessels could also have been
curated and kept at these residences rather than widely circulated. Dull Buff's
unusual distribution may also reflect its association with Sauce's political elite
since it is found in largest quantities in the Sauce center and also with a group of
elite residences identified for ring 4.

The spatial distributions of the decorated pottery indicate that the highest
quantities are found in Sauce and in ring 4. Based on the spatial patterning for
some of the pottery types, ring 4 has much higher quantities for some of the
guinda complex (a set of red slipped types).   The chipped stone also shows some
higher amounts in ring 4. The maps of the residences with high amounts do not
indicate spatial clustering for one set of residences that dominated the higher
artifact quantities, although the same four collections were consistently higher for
all pottery types. Three of these four collections were associated with Classic
period centers with associated larger architecture in ring 4: Sabaneta, Villa Nueva,
and Moral. Some wealthier residences, perhaps on the order of elite estates like
those described for Tikal in the Maya lowlands, appear to have been located in

ring 4.   It is possible that the pattern of higher quantities of decorated pottery may indicate a second center located nearby. However, a second center dating to the Middle Postclassic period was never located within the PALM survey, nor within Stuart Speaker's survey blocks along the eastern edge of prehistoric settlement. Based on current data, I cannot entirely rule out the possibility of a second center or possibly temporal differences producing some of these patterns, but I think these alternatives are not likely.

Finally, the widespread availability of most of the decorated pottery, chipped stone, and scarce artifacts demonstrates the apparent universal participation of the local population in commercialized market exchange.   By the Middle Postclassic period, the highly decorated pottery types that were of potential greater value, based on labor production costs, were being openly exchanged through market exchange associated with Sauce. Even rare and probably imported pottery types such as Tres Picos Polychrome showed signs of being openly available, since they were not restricted either to the Sauce center or to residences with higher socioeconomic rank.

What was the local context for Sauce's commercialization? Generally, small polities and competitive city-state interactions under the broad umbrella of "exchange," which could range from material goods to social interactions, are linked to the growth of commercial exchange cross-culturally and for Postclassic central Mexico as well (Smith 2003c:37). For Veracruz, it seems likely that small polities were also the context in which Postclassic period commercialization

occurred (Gutierrez 2003; Venter 2008). Local investment in trade by newcomer

elites and the increasing importance of local exchange networks for household

provisioning in Sauce were important in further developing local market

exchanges. As Stark (2007b) suggests, if Sauce's political elites were

newcomers, they would have incentives to support market exchange as a means to

prestige and income.

The evidence for commercialization is not limited to the Postclassic

period. There are hints that elaborate pottery created in Veracruz was already

established as items of value and importance (Stark 1999a). It is likely that an

independent and enthusiastic set of consumers existed among the local

populations already, not all of whom were identified by their residences as either

political elites or having high socioeconomic status. It was through these

consumers that the existence of multiple markets that were at least partly

independent of political control by either Sauce or other local polities came into

being.

In conclusion, the results of this study indicate that Sauce's economic

organization included multiple types of exchange, including markets and social

networks. Furthermore, the spatial variations in the distribution of marketed

items identify multiple overlapping market zones, making it unlikely that Sauce

was the center of a solar market configuration. Instead, Sauce's economic

organization may indicate the existence of independent markets within the region

prior to the founding of Sauce and outside the direct control of its political elite. I

suggest that the observed commercialized market exchange was more the result of bottom-up processes from most residences rather than top-down directives from political elites, and that some of the patterns probably began in the Classic period. The high degree of commercialized products was the end result of a combination of local commoditization and participation from households.

Finally, the multiple exchange mechanisms and networks identified for Sauce and its associated residences are typical of most complex societies, based on comparisons with recent studies of exchange, trade, and production in the Old world. This dissertation has developed both quantitative and qualitative methods to tackle this complexity. As our conceptual frameworks and methods get more refined, we will be able to identify more diversity in economic organization within Mesoamerica and other complex societies. The ability to identify different exchange mechanisms will greatly enhance our ability to generate new theoretical avenues to explain the social, political, and economic processes behind economic organization and development over time.

CHAPTER 1 NOTES

[1] The most familiar line of the poem begins, "Tinker, Tailor, Soldier, Sailor…" (Opie and Opie 1980:404). The full verse is a children's counting fruit stones or divinatory game and many different versions are described by Opie and Opie (1980:404-405).

CHAPTER 2. THE ARCHAEOLOGY OF ECONOMIC ORGANIZATION
WITH INSIGHTS FROM MESOAMERICA

The term "economic organization" appears to emphasize economic processes at the expense of social, cultural, and political factors; however, the vital questions about the structure of exchange, production, and consumption are deeply social, political, and regionally specific. Therefore, the study of the organizational properties of exchange systems yields important insights into the social and political aspects of economic organization and the processes behind economic development.

As described briefly in Chapter 1, market exchange as a vital part of exchange systems was often ignored by anthropologists in favor of approaches that appeared to emphasize more social aspects of exchanges (Oka and Kusimba 2008:354; Schneider 1991). More recently anthropologists have recognized that commercial market systems are also a key part of the processes of development and integration for ancient states, as opposed to being the result of these processes (after Minc 2006:82-83; Smith 2004). Rather than characterizing all of the debates and issues concerning the anthropology of exchange systems, I focus only on how specific ideas about exchange systems and political economies have been applied within the Mesoamerican literature and how they inform my main research focus.

The first section of this chapter briefly covers two major theoretical and methodological debates, the formalist/substantivist debate and the problem of

equifinality for identifying exchange via spatial patterns, and places this study

within the context of new perspectives on these issues. In the second section, I

expand on the terms used in Chapter 1 to discuss exchange and exchange systems.

I also discuss new concepts for defining and identifying exchange systems

archaeologically, such as markets, social networks and kin and home based

provisioning. The second half of this chapter deals with interpretive frameworks

of economic organization applied within different regions of Postclassic period

Mesoamerica. In the third section, I summarize the Classic period antecedents

and prior research on the Postclassic period Gulf lowlands. In the final sections I

briefly outline the Gulf lowlands with a focus on its potential for new ideas about

exchange systems and the political and social systems in which they are created.

Finally, I summarize the background research undertaken for the Middle

Postclassic period Sauce center and its hinterland residences and the research

project's potential for understanding local change and broader trends within

Postclassic period Mesoamerica.

Recent Perspectives on an Old Debate

Research asking economically significant questions was separated from

social and political questions due to two major theoretical and methodological

issues based on the formalist/substantive debate and the problem of equifinality in

spatial exchange patterns (Blanton and Fargher 2010:208; Garraty 2010:3-4; Stark

and Garraty 2010:33). Recent conceptual breakthroughs make the study of

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exchange systems a productive endeavor for investigating and describing Postclassic period Mesoamerica (Feinman and Nicholas 2010; Garraty 2010; Stark and Garraty 2010).

The formalist/substantivist debate, in which the perspective of an individual atomistic economic agent is pitted against that of socially embedded agents, is a significant theoretical issue in economic anthropology (Wilk and Cliggett 2007). Newer perspectives on this multi-disciplinary debate recognize that exchange systems and institutions operate in a milieu in which multiple groups, individual actors, and diverse rules act simultaneously (Garraty 2010:15; Swedberg 2005:248). There is room in our theoretical toolkit for using both formal and substantivist insights without privileging one over the other. Each perspective covers different aspects of exchange systems and in combination they provide complementary insights that may but do not necessarily contradict one another (Stark and Garraty 2010:57-58).

The major methodological issue is how to describe this sociopolitical and economic complexity using archaeological datasets. One of the main problems is the difficulty in identifying different exchange systems and regional organization is Mesoamerica's milieu of multiple and overlapping exchange systems (Berdan 1980; Minc 2006:83; Sheets 2000). Methodological advances in identifying exchange systems have spurred new ideas that can help evaluate the mix of exchange systems that characterizes all economies (Hirth 1998; Renfrew 1977;

Stark and Garraty 2010). The research undertaken in this study builds on these advances by developing and testing new explicit quantitative methods for evaluating exchange and economic organization.

New Directions in Defining and Identifying Exchange Systems

Multiple exchange systems co-exist within societies and include many different configurations (Granovetter 1985). This level of complexity extends even to the ways in which the same type of object is circulated within a society. For example, in early medieval Europe religious relics circulated through gift-giving, theft, and markets simultaneously (Geary 1986:182-185). Additionally, exchange between all levels or scales of social groups can be undertaken and represented through many different media, some materially represented, and others only present via subtle social signals. For the purposes of the research presented here, I focus on the aspects of exchange systems that are archaeologically detectable in the form of material correlates, such as household items.   By exchange system, I refer to the ways in which goods move within or among populations. My concept does not require a specific spatial scale for analysis. Theoretically, an exchange system could range in scale from long-distance exchange between regions to local exchanges between and within a center and its hinterland residences, to house-to-house exchanges. Furthermore, multiple scales of analysis are often *required* to differentiate between different kinds of exchange systems, as I explain below. I differentiate exchange systems

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by developing archaeological expectations based on how the method of transfer is reflected within the social unit (such as a household) that consumes the exchanged items.

Issues in Defining and Describing Exchange Systems

In exchange research, market exchanges, social network exchanges, kin-based exchanges, and household self-sufficiency can each be considered. However, recent advances in describing exchange systems have noted significant intergradations between the different recognized types such as markets versus social networks (Stark and Garraty 2010). The difficulty lies in the fact that exchange systems cannot be defined along only one axis, such as the transfer mechanism. Instead, a complex combination of transfer actions and institutional frameworks are what describe and contextualize our views of exchange systems. This complexity is difficult to generalize for cross-cultural comparisons and has contributed to the view that the study of exchange is hopelessly embedded within specific cultural contexts without which it cannot be understood anthropologically. Recently, new ways of separating transfer mechanisms from institutions have revolutionized how archaeologists can define and analyze exchange systems and economic organization. These ideas have given rise to methods that use a combination: network expectations with additional insights from spatial and contextual patterns considered separately.

Defining Exchange Mechanisms

I expand on the brief definitions of market exchange and social network exchange that were introduced in Chapter 1 with a focus on how network expectations were derived. Hirth's (1998) insights suggest the form of abstraction I use for conceptualizing how products move through social, political, and economic networks, allowing them to be identified archaeologically using network expectations.

Market Exchange as Open Access. For the purposes of my study, I adopt Pryor's (1977) general definition of market exchange as a set of economic transactions where products are exchanged in barter or for media of exchange and in which considerations of supply and demand are prominent. Theoretically, access to items that are being exchanged via market exchange is open to all would-be consumers, with restrictions based only on physical distance and price. Market exchange is expected to be reciprocal and the negotiation of price is the socially determined value of an object that allows it to be interchangeable with other priced objects in a transaction (Swedberg 2005:249). In the case of market exchanges, price tends to be determined by information about supply and demand that is socially mediated.

Social Network Exchange as Restricted Access. Social network exchange is defined as the exchange of products exclusively via social and/or political channels (Schneider 1991). Theoretically, access to items being exchanged via

elite networks, systems of patronage, and administered exchange is restricted to

members of a group. For non-market exchanges, the object values are not

negotiable through the open exchange of other priced objects or a monetary

system (Kopytoff 1986). This means that if networks are restricted, then only

consumers with specific characteristics participate in the exchange of the item.

These item restrictions could be based on any number of relationships ranging

from kin groups, elite gift-giving, to patron/client relationships. Redistribution is

defined as the acquisition and distribution of a particular item or class of items

through a central authority. Redistribution is a special case of social network

exchange in which everyone may have some quantity of a redistributed item, but

its distribution in much higher amounts is attached to social networks (such as

residences with higher socioeconomic status or social connections) (after Stark

and Garraty 2010). Kin networks, self-sufficient residential production, and

house-to-house exchange also may account for a portion of residential

provisioning and are expected to show the same pattern of abrupt changes in

relative percents among households.

Spatial and Contextual Components of Exchange

        An important part of the anthropological challenge for archaeologists to

interpret and understand ancient economies is to be able to model the social

contexts in which items are exchanged and how they were socially constructed.

Spatial and contextual data are vital in understanding the circumstances of

exchange and their social and political articulation with residential provisioning. Using examples from two regionally based datasets, Minc (2006) and Stark and Garraty (2010) describe important ways in which spatial and contextual data about consumers, products, and the circumstances of production can be used to identify exchange.

Minc (2006:82-86), describes methods for evaluating exchange based on a combination of expectations for commodity flows in combination with distinct spatial patterns for different models of market systems. Although Minc (2006) is specifically focused on different kinds of market systems, her ideas can be applied to evaluating exchange systems in general. Minc's (2006:84) key insight is that some of the data about exchange systems will be network based, some will be spatially based, and some will be based on contextual information about the consumers. For example, one could view socioeconomic rank as an added contextual variable in describing how the exchange of a particular item was organized. In Minc's (2006) conceptualization, the definition of how items are being exchanged is based on how they articulate with consumers and producers (or source) separately.

Stark and Garraty (2010), describe a related spatial and contextual method for identifying exchange based on the articulation of production with product distribution. Stark and Garraty (2010:43-45) propose a regional production-distribution approach for distinguishing market exchange from central

redistribution and command economies in archaeological regional datasets where an item is known to have quotidian use, widespread availability, and specialized production and/or importation. The general assumption is that an item will show different spatial patterns of production and access based on how it is being managed in both production and exchange. Therefore, insights about an item's production are used in addition to its distribution to distinguish between different systems of exchange.

In both methods, the authors suggest that scale and circumstances of production can tell us how items were distributed. As Stark and Garraty (2010:44) suggest, the widespread distribution of a quotidian artifact (such as utilitarian pottery) among most households at a regional scale in combination with the specialized production of the same utilitarian pottery, supports market exchange over redistribution because it is unlikely that states were willing to invest in quotidian distribution and most lacked the logistical ability to do so even if elite individuals had incentives to meddle (Stanish 2010). Therefore, spatial and contextual information, when used in combination with network expectations, can help describe exchange systems more accurately than any one component (spatial, network, contextual) would alone.

Identifying Exchange Archaeologically

The significant problem in identifying exchange archaeologically was demonstrated graphically by Renfrew (1977) who showed that different types of

exchange systems could produce the same spatial patterns of artifacts. Different

processes producing similar patterns are defined as equifinality, a term which

refers to a situation in which the final results look the same, although the

processes that produced them were different. This problem of equifinality made

the comparative study of ancient exchange systems much more difficult and went

without an analytical solution for about two decades. A solution was finally

reached by Hirth (1998) in an article describing what he called "the distributional

approach." The distributional approach focuses on modeling archaeological

correlates of the end result of exchanges, the household inventories (Hirth 1998).

Residences from all socioeconomic wealth levels should have access to a

product that is marketed, limited only by price and distance from the market

(Hirth 1998; Smith 1999). Price restrictions could mean that for practical

purposes, an item is restricted to only the very wealthy or spendthrifts, the key

distinction here is that the items are not socially or politically exclusive.

Generally, if products were being marketed, their spatial distribution could show

whether products were decreasing in amounts away from the center, as in a solar

market system, or whether some other market system applies (Smith 1976:37-38).

For social networks, products will show higher frequencies in a subset of

residences and be mostly absent or low in frequencies in others, according to ties

in the social network. If products were being exchanged via elite gift-giving, the

spatial distribution of products should be linked to elite residences and their

clients. If contiguous kin networks were used to distribute goods, the spatial

distribution among residences would be discontinuous, likely appearing in

spatially clustered residences (if co-residence of kin is indicated) in some areas

and absent from others. These basic definitions and their expectations for

different exchanges should be construed as logical models based on the defined

expectation of how goods would be distributed if they were either restricted or

open in access.

Most researchers now acknowledge that consumer access can range from

open to restricted rather than being just one or the other (Hirth 1998; Smith 1999).

However, there is some utility in modeling differences in exchange systems based

on idealized models of consumer access such as market versus social network

exchange.   Hirth (2010:229) suggests that the application of definitions of market

exchanges versus non-market exchanges has utility because, "they describe the

central or modal tendencies of economic interaction". Once the abstract exchange

mechanism is identified, spatial and contextual data can be used to differentiate

between different institutional forms. By considering each artifact type separately

for exchange mechanisms, spatial data can help identify the regional

configuration, such as distinguishing between solar markets or overlapping

market systems. A solar market would have boundaries, which were probably

administrative, while for overlapping markets, administration would be less

prominent. Contextual information could help identify social networks based on

spatial association in a center (perhaps identifying political elite affiliations) or linked to socioeconomic rank (such as the inventories of high status residences).

In summary, some recent theoretical advances have been made in how archaeologists define different exchange systems and the criteria they apply (Hirth 1998; Hirth 2010; Minc 2006; Smith 2004; Stark and Garraty 2010). A significant innovation is the idea that researchers should consider exchange mechanisms separately from spatial aspects of exchange and production. Specifically, for exchange mechanisms, researchers have noted that consumer access can and should be considered separately from the circumstances of production and distribution. Spatial models for exchange systems are not new (see Smith 1976; Smith 1974); however, recent approaches have used contextual and spatial patterns together to highlight the organizational features of exchange systems (Feinman and Nicholas 2010; Minc 2006; Stark and Garraty 2010). For example, Feinman and Nicholas (2004, 2010) demonstrate that both household and community level specialization provided goods to regional exchange systems which provisioned households across five different sites in Classic period Oaxaca.

In the following sections, I outline an overview of Mesoamerican political economies and change through the Postclassic period. I begin by discussing the highland Mesoamerican political economies and the major theoretical ideas about Postclassic changes in central Mexico. I focus on examples drawn from central Mexico because many of the important ideas about Postclassic transitions have

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been drawn from this body of archaeological research. Next, I consider the
Lowland Mesoamerican political economies and their potential for advancing our
ideas about how economic development may have worked and how
commercialization developed in Mesoamerica.

Highland Mesoamerican Political Economies and Postclassic Transitions

In the Middle and Late Postclassic periods (A.D. 1200 – 1521) highland
Mesoamerica saw significant social, political, and economic changes. These
include the increase of small polities (replacing the larger Classic period states in
some cases), increases in long distance trade, and greater commercialization of
exchange of portable objects (such as ceramics, metal, etc.), among many other
changes (Blanton, et al. 1993:208-216; Smith and Berdan 2003a:6-7). The causes
and contexts of these Postclassic changes are complex, but there are some clues as
to how these processes occurred. Some increase in long distance exchanges and
the development of more commercialized markets were linked to population
growth, the independence of trade from large polities (at least initially), and a
growing body of consumers with a vested interest in the availability of a wide
variety of commodities (Blanton, et al. 1993). We need not consider the
Postclassic changes as representing a huge break with the Classic period
economies, however, but more as a change in the degree and extent of an
increasingly commercialized set of local and interregional networks, as I explain
below.

Long distance trade networks existed in the Classic period highlands
(Blanton, et al. 1993), and at least some of this exchange was not representative of
centralized state control or of elite exchange (Kabata 2010). Instead, it is likely
that some independent trade networks coexisted with ones controlled by political
elites in centralized states (Blanton, et al. 1993:221). Also, local exchanges in
many Classic period states may have been larger in geographical extent and more
market oriented than has been previously identified (Feinman and Nicholas
2010:94-95). Blanton et al. (1993:214-217) have argued that market development
in Mesoamerica started at least by the Classic period although household evidence
for this has been scanty. Recently, Feinman and Nicholas's (2004:187-188)
examination of residences from two Classic period Valley of Oaxaca sites, Ejutla
and El Palmillo, found that residents participated in exchange networks for
utilitarian and elite goods covering the extent of the valley system. They suggest
that three types of evidence indicate market exchange as a likely mechanism: the
scale of the exchanges, apparent regional specialization in particular products, and
the need of interdependent households for goods produced outside the domestic
unit (Feinman and Nicholas 2004; 2010:92).

It is not reasonable to generalize about the nature of Classic period
exchange for all of the highlands based on a few examples. However, these two
Oaxacan Classic period sites demonstrate how the scale and interdependent nature
of market and intraregional exchanges were more developed than previously

known and that some of this development predated and probably outlasted the Classic period Monte Albán state (Feinman and Nicholas 2010:92-93). Other major Classic period states have not been examined to identify exchange systems from the perspective of domestic provisioning, so we lack the literature to discuss them adequately here. It is quite likely, based on the evidence of craft specialization (Sullivan 2007) and given the general availability of major pottery categories (Robertson 2001), that Classic period Teotihuacan was provisioned via market exchange in addition to other means. Based on the scale of its craft production (Sullivan 2007), the organization of its building construction, building materials acquisition, and the acquisition of farther flung resources (Kabata 2010; Murakami 2010), the Teotihuacan state may have had guild-like institutions in operation. It is unclear at this time what impact potential institutional acquisition structures may have had on domestic provisioning in addition to potential markets.

Precisely how potential trade and exchange network contractions and expansions in the Classic period highlands were related to specific political systems and forms is less clear. From a synthesis of comparative examples, there is no simple relationship between political systems and particular kinds of exchange mechanisms or networks (Garraty 2010: 21-22; Smith 2004). Instead, the degree to which trade and exchange was centralized by polity control appears to vary widely on a case by case basis and is not based solely on the degree of

political centralization within the polity (Blanton and Fargher 2010; Garraty 2010; Smith 2004).

Highland Mesoamerican political systems may offer a guide for modeling exchange systems and network fluctuations. Joyce Marcus (1989: 206; Murakami 2010) suggests that the centralized polities of Classic period Mesoamerica, such as Teotihuacan and Monte Albán, may not have been as stable or centralized as imagined; in fact, the centralization and stability of these states could have expanded and contracted, with their latent factionalism notoriously difficult to identify archaeologically. A similar cycle of centralization and decentralization in the organization of exchange systems and networks within Mesoamerica intersected in complicated ways with political systems. One imagines that factions within these political states had different and vested interests in exchange networks both local and long-distance that outlasted any political cohesion with each other.

Besides factions, the development of social institutions that crosscut and outlasted the political units within which they originated probably played a very important role over time in the development of the Postclassic economies. More recent conceptualizations of exchange systems (including markets) focus on the social institutions themselves (Feinman and Nicholas 2010: 88; Garraty 2010). Social exchange institutions could include the use of commoditized products, such as the shell beads used as money in Postclassic period Yucatán, which

probably helped expand trade networks (Friedel, et al. 2002:79-81). For medieval

Europe, the increasing monetization of trade is identified as one of the key

ingredients in the thirteenth century expansion and development of commercial

markets at the local, regional, and interregional scale (Spufford 2002:12).

The creation of commodities that act as fungible products is an intensely

social process that is only sometimes attached to the power of state polities or

institutions like banks; often it involves the mutual social recognition of shared

values surrounding the intrinsic value of the materials themselves, such as the

complex ways concepts of rulership were connected to the value of shell in the

Yucatan (Friedel, et al. 2002:45-48).[1] A similar process has been identified for

cacao in the Classic period lowlands (McAnany 2004:158). In addition to objects,

the development of cooperative moral codes that increased trust among potential

consumers and sellers also played a role in the development of exchange systems

too, although they are much harder to identify archaeologically without historical

records (Abbott 2010).

For the Epiclassic and Early Postclassic periods (A.D. 700 -1200), some

researchers argue that long distance trade networks were more decentralized and

focused in coastal zones away from highland capitals and states (Smith and

Heath-Smith 1980). However, the difficulties in correlating ceramic-based

chronologies between regions in central Mexico, much less the Gulf, make intra

and interregional comparisons complicated (Crider 2010). For now, one can

speculate that the processes behind the increasing local economic exchange among polities and concomitant increases in intra-regional participation began during these periods (Nichols, et al. 2002). In the following section, I limit my discussion to the major ideas that developed regarding central Mexican economic organization and development during the Postclassic period.

Explanations for Postclassic Central Mexican Transitions

Blanton et al. (1993:212-214) contend that following the collapse of major Classic states, consumers and specialists alike continued to have a vested interest in specialized craft production and supported its continuation. Blanton et al. (1993:12-14) suggest that market activities became more autonomous due to the lack of strong state interference, resulting in the development of commercialized Postclassic market institutions. The political setting for this development is the replacement of former Classic and Early Postclassic period large territorial states by smaller polities or city-states by the beginning of the Middle Postclassic period (A.D. 1200) based on settlement pattern data and inferences drawn from ethnohistoric sources about later periods (Hodge 1997; Nichols, et al. 2002). This is a simplified version of a complex history that includes Classic period fragmentation followed by political consolidation in the Epiclassic and Early Postclassic by Tula and Cholula and possibly others, followed by another break-down of these states in the Postclassic period. In Blanton's interpretation, the

Postclassic political changes were to have far-reaching impacts on local

economies within Highland Mexico and possibly farther afield as well.

Berdan et al. (2003:96-97) describe a Mesoamerican commercial

framework in which rulers and elites maintained their control of the land, labor,

and tribute systems and social networks that formed the primary bases of political

power. For Postclassic Mesoamerica, land and labor were not readily sold, as

evidenced by the difficulties faced during post conquest times when Spanish

authorities tried to get locals to calculate valuations of land plots using one of the

standard commodity products, cotton cloth (Hicks 1994). It is also clear that one

of the major economic forces within the Aztec empire was tribute, not saleable

services or crafts, although the trade guilds were a potentially growing economic

force (Smith 1990, 2003b). However, during this period there is good evidence

for the development of more integrated and extensive commerce in saleable goods

such as pottery (Hodge and Minc 1990).

By the Middle Postclassic period (A.D. 1200 – 1350) the central Mexican

landscape was populated with many city-states and, in the later part of the period,

loose confederacies of these city-states (Charlton 2000; Hodge 1994; Nichols, et

al. 2002). By the Late Postclassic period (A.D.1350- 1521), the confederacies of

central Mexico had coalesced into an imperial power that practiced a mosaic

strategy of imperialism (after Schreiber 1992) with a patchwork of hegemonic and

direct forms of imperial administrations dependent on the context (Berdan 1996; Charlton 2000; Hassig 1988; Ohnersorgen 2001).

From what is known from ethnohistoric and archaeological data, the formation and activities of the Postclassic interregional exchange systems were only loosely linked to formal state institutions (Smith and Berdan 2003b:6-7). We know that Postclassic Mesoamerican states intervened militarily in support of trade and also to obtain goods (Charlton 2000; Durán 1993; Nichols, et al. 2002). Many past agrarian state economies worked similarly, such as Rome, which produced and traded most basic products at the regional scale and intervened militarily to protect vital trade interests and obtain important commodities (Fulford 1987, 1992; Garnsey and Saller 1987; Woolf 1992).   The relationship between polity and trade was probably fairly complex and situation dependent. For example, Garraty (2006) describes the development of commercial markets during the Postclassic and early Colonial periods for central Mexico as a co-evolutionary process, in which state directed strategies and market processes interacted with each other to produce integrated political economies.

In summary, Postclassic transitions within central Mexico were not homogenous and did not produce identical results for each region; instead, the degree of political control of craft production and specialization varied widely by region (Smith and Berdan 2003b:12). More recent conceptualizations of the role of politics in commerce during Late Postclassic times place emphasis on co-

evolution between political elites and market forces (Garraty 2006). In the Gulf region, far from the recognized heavy trade and political interaction zones of the central Mexican city-states, the Postclassic transition for this rich resource zone (Stark and Arnold III 1997) may differ from a trajectory based on political independence described for the commercial exchange systems of the central Mexican zones (Smith and Berdan 2003b).

Lowland Mesoamerican Economic Organization and Postclassic Transitions

A selection of lowland Classic period economies provides the starting point for considering Middle Postclassic economic organization in south-central Veracruz. In my examples, I refer to the Maya lowlands, the Tuxtlas region (southern Veracruz), and south-central Veracruz. The Maya in particular have provided many important models and data for political economies, and for this reason, they are one of the most important examples used in this study. Rathje's (1971, 1973) model of state development in the Preclassic Maya lowlands was based on resource complementarities between regions as a source for interaction, trade, and political development (after Sanders 1956) and has received many updates since then (Hanson 2002: 368). In addition to theory building, methods for identifying economic activities archaeologically were part of active research projects in the lowlands. For example, work undertaken by Rathje, Sabloff, and others examined the archaeological correlates for exchange and trade in their study of the Postclassic island site of Cozumel, identified as having the

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characteristics of a port-of-trade by ethnohistoric sources (Rathje and Sabloff 1973; Sabloff and Freidel 1977: 371-373). Important studies of exchange, trade, and political economies in the Maya region have continued in subsequent decades, and their potential for interpretive syntheses of economic change in Mesoamerica has been noted (Masson 2002: 18-19). There is considerable variation among the different lowland areas and polities, which precludes defining a normative "lowland" model in contrast to those coming from highland Mexican research. However, it is useful to consider some of the major trends identified in this rich body of work that can be applied to understanding the context for Sauce's economic organization.

The Classic period lowlands (A.D. 300-900) are characterized by large centers and some larger territorial states, although there was some political and economic fragmentation at times in some regions (Sharer 1994; Stark and Arnold III 1997a: 26). The relative size of some of these centers and accompanying territories is rather small by comparison to states like Teotihuacan, with some having territorial extents estimated at about 30 km (McAnany, et al. 2002: 126). For the Classic period, there is an apparent lack of craft production on a large scale associated with centers, in contrast to the evidence for Teotihuacan. Why was craft production not typically associated with large urban zones in the lowlands in amounts sufficient to be detected by survey and surface collections? Partly this was because much of the craft production of serving, cooking, and

storage vessels carried out in the Classic Maya realm was household level

production (Ball 1993: 265; Freidel 1981: 377; McAnany 1993; Sheets 2000).

Additionally, with few exceptions (Inomata 2001), the manufacture of sumptuary

goods such as elaborate polychrome vases, shell and jade also was carried out in

households (Ball 1993; Friedel, et al. 2002; Reents-Budet 1994), although there is

some indication of larger scale production in selected sites (Dahlin and Ardren

2002; Demarest 1997).

There are methodological complications in identifying household level

production. It is difficult to detect without intensive methods such as excavation

(Feinman and Nicholas 2010). In fact, more detailed excavation studies in

Mesoamerica have typically turned up much higher levels of craft production than

initially identified from survey and surface collections (Brumfiel and Nichols

2009). Therefore, part of the lack of large amounts of craft production identified

with the lowland urban zones could be the result of two major sampling

difficulties. The first is vegetation cover, which makes regional scale collections

for residences more difficult. The second has been a focus on recognized "sites"

rather than individual residences, a long-term bias described by Lohse and Valdez

(2004:2-3). Recent studies focused on identifying Classic period commoner

households using residential scale research have identified the presence of

household level chipped stone production (Yaeger and Robin 2004: 154), spindle

whorl concentrations (Arroyo 2004: 85), and the presence of luxury items in

probable "commoner" or at least non-royal elite residences, such as Plumbate pottery, ear spools, beads, and greenstone (Ortíz 1996 cited in Arroyo 2004:85). These recent studies indicate that commoner household level production may have been typical for the Classic period Maya. There is also an intriguing possibility that commoners or at least lesser elites also had access to sumptuary items, although this has not been evaluated for many areas.

The lack of large scale craft production may also be related to the lack of political gain attached to supporting it. As Hendon (1991) suggests, most rulership for these economies was based on genealogy and ties to land and labor. The evidence for south-central Veracruz may reflect this political reality. During the Early Classic period, Cerro de Las Mesas, covering ca. 1.5 sq km in its monumental core, was the political and economic center of the settlement system of the western lower Papaloapan basin (Stark 1999b). Despite its importance as a regional capital, craft production was not directly associated with Cerro de las Mesas in amounts sufficient to be detected through surface collections (Drucker 1943; Heller and Stark 1998: 126; Stark 1992). Similarly configured large Maya capitals, such as Tikal and Palenque, also do not appear to have large-scale craft industries associated with their urban zones (Fry 1980). Both Tikal and Palenque's system of ceramic production and exchange consisted of localized craft industries, serving only parts of the settlements (Fry 1980; Rands and Bishop 1980). Therefore, although elite sponsorship of luxury goods thrived in Classic

Maya centers (Haviland 1992; Hendon 1991; Inomata 2001), that sponsorship did not accompany a substantial quotidian craft industry comparable to central Mexico (Charlton 1994).

The absence of large scale production has been used to infer that the Maya region was not engaged in the same kind of commercial networks that characterized their counterparts in central Mexico. Furthermore, the focus on elite exchanges and prestige-goods economies as an impetus for political development, while compelling (Foias 2002: 235-237; Freidel, et al. 2002), often overlooked complementary evidence for humble household origins for economic development. The existence of household level production for many items within the Maya region does not preclude the existence of large scale exchange systems and the provisioning of many households based on market exchange. Site level pottery exchange systems associated with some of the major capitals such as Tikal and Palenque indicate that widespread exchange, including commoner households, was probably involved (Fry 1980; West 2002). McAnany (2004: 145-146) suggests that most researchers have recognized that Maya economies included many different exchange systems, including market exchanges; however, most of the research on political change and development was focused on elite interactions and top-down approaches. Interest in identifying top-down development trajectories extended to the few cases in the lowlands where elite administration of exchange and craft production was identified.

At the site of Cancuén, Demarest (1997: 3) found large quantities of obsidian processing, and Dahlin (2000:295-296) suggests that the site of Chunchucmil was a significant major trade center based on the material correlates for specialized production and market exchange (Dahlin, et al. 2007). Cancuén's location along the navigable portion of the Pasión River also makes it plausible as a regional supplier of chipped stone (Demarest 1997:3). Chunchucmil's position as the Maya port closest to major Maya centers combined with access to the Candelaria, Usumacinta, and Grijalva rivers, makes it plausible as a major regional trade center (Dahlin 2000:295-296). Despite these exceptions, it is apparent that among the Classic Maya most political elites did not directly control or administer the distribution of most quotidian products.

Another notable exception to low level production in the Classic period Gulf lowlands is found in the Tuxtla Mountains of Veracruz at the site of Matacapan. Arnold et al. (1993) identified significant pottery manufacture in the Comoapan area, located near the southern edge of the site, and suggest that production was large enough in scale and intensity to be directed towards two markets, one for local utilitarian goods, and one for long-distance trade. Comoapan utilitarian vessels were used locally in the Tuxtlas, and coarse necked jars, not found locally, could have acted as containers for the transport of elite commodities such as liquidambar or honey out of the region (Arnold III, et al. 1993). Recent analysis of Coarse Orange ceramics (as possible products of

Comoapan) shows considerable regional complexity in their distribution, but the patterns match expectations for solar market organization (Pool and Stoner 2008). Therefore, the regional patterns are consistent with some form of political control related to large-scale production (though not for the dendritic form of distribution that Santley suggested originally) at the scale of a solar market (Pool and Stoner 2008).

Although the Matacapan case apparently shows a relationship between large scale production and polity control, that was probably an exceptional case. Generally, for the lowland economies, dispersed production did not coincide with economically autonomous small residential groups or decentralized political economies (Masson 2002: 2-3). Instead, localized distribution and production of utilitarian ceramics, combined with more extensive distributions of decorated serving vessels around polities such as Tikal and Palenque, could suggest central place markets existed for decorated serving vessels (Fry 1980; West 2002) alongside gift-giving associated with the fanciest painted vessels (Reents-Budet 1994). Ongoing research at Calakmul uncovered an extensive mural painting on the exterior walls of a large structure within levels dating to the Classic period (Carrasco Vargas, et al. 2009); the scenes could be depicting the distribution of goods. A recent interpretation of the epigraphic evidence by Tokovine (2010) supports the view that market exchange and/or a marketplace are being depicted in the Calakmul mural painting. New studies focused on household inventories

for comparison to the regional scale data would help evaluate market exchange more decisively. The current data offer some evidence that market exchange of decorated serving, storage, and cooking vessels may have existed alongside social network exchange (gift-giving) despite the absence of large scale craft production at the major regional capitals.

In summary, the economy of Cerro de las Mesas in south-central Veracruz, with no obvious associations with large scale craft production and access to decorated pottery over an extensive area, was configured similarly to the Classic Maya lowlands (Stark 1999a, 2007a, b, 2008a). In direct contrast to the situation documented for the highland Mexican zones, Cerro de las Mesas did not engage in large scale craft production nor was there any evidence of an economic relationship between this large polity and any other local secondary urban centers. If we can overcome the view that household production is counter-indicated for polity scale market exchange for these regions, we will probably identify earlier instances of market exchange co-existing alongside social networks that distributed fancy pottery (Reents Budet 1994) and the restricted access of obsidian in selected cases (Aoyama, et al. 1999) for the Maya lowlands. For example, recent research on chipped stone exchange for south-central Veracruz identified market exchange as the likely distribution mechanism by the Early Classic period (Stark and Ossa 2010). As Braswell (2010: 138) notes, the type of exchange mechanism and its scale does not closely correspond to polity size. The

growth of large territorial states and their subsequent decline in the Classic period does not appear to be causally linked to changes in exchange.

Finally, based on current interpretations, a combination of elite sponsorship and consumer demand for fine ceramics via social network exchange resulted in their distribution up and down the Gulf Coast from the Late Classic through the Early to Late Postclassic periods in such major centers as Quauhtochco, Cempoalla, Quiahuistlan, Tajín and others (Lira López 1990). Currently, the evidence from the lowlands suggests a variation in the model put forth for market development in the central Mexican highlands, in which producer and consumer driven interest helped develop exchange systems in the Late Classic period and Postclassic period.

Late Classic Changes in South-central Veracruz

By the Late Classic period (A.D. 600-900), new local centers, such as Azuzules and Nopiloa, replaced Cerro de las Mesas and showed greater evidence of associated craft production, and possibly increased commerce (Curet, et al. 1994; Stark 2007a, b; Stark, et al. 1997; Stark and Garraty 2004). Late Classic period centers such as Azuzules in the Blanco delta and Nacastle-Patarata in the mangroves, likely produced, respectively, orange slipped bowls and fine paste orange ceramics, while Nopiloa had more intensive blade production (Stark 2007a: 17-20).

What was the local background for this development in south-central Veracruz? Helms (1993) describes a political model of economic development where the creation and acquisition of finely crafted goods are connected to political power. In this system, ruling authority is linked to distant realms or cosmological significance via acquired or created crafts. However, Stark (1999a: 154-155) argues that Helms's political model is not a good fit for the data on fine ceramics from the western lower Papaloapan basin during the Classic period. Stark's (1999a) analysis of the decorative traditions of elaborate Late Classic ceramics shows that most stylistic traditions appear to be autochthonous rather than derivative from distant places. The availability of some fine ceramics, such as Río Blanco molded bowls of this time (Von Winning 1996) is likely to be exceedingly restricted and their distribution is unknown (Stark 1999a:155). Stark (1999a) suggests that the wider spatial distributions of the elaborate ceramics indicate elite social network exchange rather than royal restrictions. In Veracruz, local innovations and longstanding traditions of elaborate ceramics may have helped create a population of consumers that was increasingly interested in the acquisition of decorated pottery in general.

Research on economic shifts suggests that the support of economic specialization at the polity or regional scale in turn generates increasing local market dependence at a *greater spatial scale* than hitherto required, beginning a cycle of commercial economic development (Smith 1976: 53-55). In some cases,

this central place arrangement will lead to a solar market, which is defined as a correspondence between markets and administrative hierarchies, often for the purposes of the political administration of exchange (C. Smith 1976:37). Under these conditions, the support of solar markets based in the Late Classic south-central Veracruz centers also could have provided tax income and conferred legitimacy on less well-established dynasties (Stark 2007b: 110-112). There is a clear break in social and political continuity between the Late Classic and Postclassic periods for south-central Veracruz. Despite this known disjunction, similar tax and legitimacy issues could have motivated the new political power at Middle Postclassic Sauce.

Postclassic Veracruz

Postclassic Veracruz is characterized by small polities and widespread exchange systems. Brief descriptions of the evidence from northern and southern Veracruz set the stage for my consideration of south-central Veracruz. In northern Veracruz, in the region identified as the Huasteca, settlement pattern research on the Postclassic period indicates that the area was divided into many smaller polities (Gutierrez 2003). Some of the major Postclassic period pottery complexes from this area, such as Huasteca Black-on-White and Tancol Polychrome indicate multiple production zones and widespread circulation (Zaragoza Ocana 1999). Based on the scale of the distribution across political boundaries, I interpreted the spread of this pottery as being due to market

exchange among consumers from multiple polities (Ossa 2000). In southern

Veracruz, the Tuxtlas region is identified in ethnohistoric records as having

significant Postclassic occupations (Esquivias 2002; Santley and Arnold III 1996:

240), and recent work has identified a Postclassic presence in the Tuxtlas during

the earlier portion of the Postclassic (Arnold III 2002: 9-10). The Catemaco

valley in particular experienced significant changes in settlement patterns during

the Postclassic period, with the large Classic period centers of Matacapan and

Picayo replaced by smaller centers, and imported black obsidian replaced by clear

grey obsidian (Venter 2008: 26).

The Postclassic period Gulf lowlands of south-central Veracruz underwent

similar dramatic shifts in settlement patterns and material culture (Daneels 1997;

Stark and Arnold III 1997b). The Late Classic centers of Azuzules, Nopiloa, and

Zapotal were replaced by a much smaller center, Sauce, within the WLPB. Sauce

was first tested and dated by Drucker (1943) and its surface materials evaluated

by Curet et al. (1994) and ascribed to the Middle Postclassic period (A.D. 1200-

1350). A separate Early Postclassic period (A.D. 900-1200) complex has not yet

been identified for the region (Curet et al. 1994). Dating for Middle Postclassic

period settlements is currently based on ceramic crossties identified originally by

Drucker (1943:82-87) and corroborated and refined by ceramic seriations based

on Stark's research projects (Curet, et al. 1994; Johns 2003). Postclassic

Highland style ceramics, including decorated polychromes, appear alongside Gulf

polychromes, and could indicate new political and social relations within Gulf communities (Curet, et al. 1994; Pool 1995; Stark and Arnold III 1997b: 29).

Craft activities within the Sauce community may indicate that elites encouraged crafts and marketplaces (Brumfiel and Earle 1987; Stark and Garraty 2004). Regional survey located comal production about 2 km southeast of Sauce, prismatic blade production in the Sauce central core, and possibly a bichrome bowl production area approximately 6 km east of the center (Curet 1993; Heller 2000; Stark 2007a; Stark and Garraty 2004). As Stark (2007a) suggests, elites have a powerful motivation to support the generation of "free-floating" resources by taxing market revenues (Eisenstadt 1969: 124-126). From ethnohistoric sources, we know that control of market activities and market taxes in central Mexico were re-allocated as part of the Aztec imperial regime (Blanton 1996a: 52). It is plausible that similar processes were beginning in Middle Postclassic period Veracruz if local elites favored markets as part of strategies aimed at generating wealth outside of the traditional forms of landholding and labor. As Curet et al. (1994) and Stark (2008a) note, Sauce's elite may well have been newcomers to the region, and would therefore have strong reasons to support new avenues for wealth and power, such as control over a local solar market.

Sauce provides a unique opportunity to examine Postclassic economic change in detail in this region because there is an extensive survey that has identified both the center and surrounding rural residences. Sauce is both a test

case for application of Hirth's (1998) method for assessing market exchange and an opportunity to determine the extent to which highland Mexican economic changes were part of a broader Mesoamerican market development.

   Pilot Study Results. Prior survey collections are insufficient for the full scope of my investigation, but they allowed a test of spatial market expectations for two common household items. With 130 residential collections from prior survey that were identified as Middle Postclassic, I examined two basic household items that are reasonably abundant, comals and clear grey obsidian blades. I calculated the number of residential collections per ring that had percents of blades and comals (separately) above the median amount of each artifact type, with the median established on the basis of all the 130 collections for the main Middle Postclassic period sample population, described in Chapter 3. I found more collections above the median amounts closer to Sauce. The drop-off spatial pattern was quite strong, despite being affected by a comal production area in ring 2, which probably accounts for that ring's higher percentage of comals than elsewhere (Curet 1993). I found a pattern of comals and blades declining with distance by ring 3, or about 7.5 km from Sauce. This drop-off by 7.5 km is consistent with a solar market if the distributional patterning shows open access to these products for residential mounds (C. Smith 1976:37), although distances of up to 12 km were identified for ceramics in the Basin of Mexico (Minc 2006: 99).

In summary, my preliminary look at the spatial and distributional circulation of comals and blades indicated that some market exchange was centered at Sauce. Despite the encouraging results, more intensive collections from residential mounds were necessary to address how a fuller range of products was exchanged, including scarce decorated vessels. To address both common and uncommon categories, larger collections were needed. Therefore, the more intensive collections of SAP were undertaken to better evaluate the economy.

CHAPTER 2 NOTES

[1]I do not suggest that shell beads are directly commensurate with the hyper developed and monitored modern currencies. However, Freidel et al. (2002) assemble some evidence to show that shell beads were used as currencies in apparently increasing amounts in Postclassic period Yucatan.

CHAPTER 3. FIELD METHODS AND SAMPLING STRATEGIES

The Proyecto Arqueológico La Mixtequilla (PALM) I and II, undertaken by Dr. Barbara Stark, provided the main inspiration and basis for the Sauce Archaeological Project (SAP). Fieldwork was focused on the center of Sauce and its hinterland residences in the Blanco delta, an area occupied during the Middle Postclassic period (A.D. 1200-1350) (Figure 3.1). Prior settlement pattern data from Stark's PALM I and II and a related survey by Stuart Speaker (2001) were sampled to locate archaeological features for the intensive surface collections obtained for SAP. The PALM survey covered 49 sq km for the main survey block, which includes Sauce and its hinterland, and Speaker's surrounding, but non-contiguous survey blocks added 22 sq km (Speaker 2001: 2; Stark 1999b, 2006) (Figure 3.1). Data about the chronology, society, economy, and the location of residential features from both projects formed the basis for SAP's study.

Residential mounds were identified in PALM and Speaker's adjacent survey within a 12.5 km radius from Sauce to capture the spatial patterning of artifact inventories. The PALM survey block extends mostly to the east of Sauce based on where prehistoric settlement was located. Prior field reconnaissance indicated that the Blanco and Rio de las Pozas formed natural boundaries to the heavily settled areas within the Blanco delta region. New intensive surface collections were obtained from a stratified random sample of 55 (40 percent) of the 130 PALM residential mounds that had robust amounts

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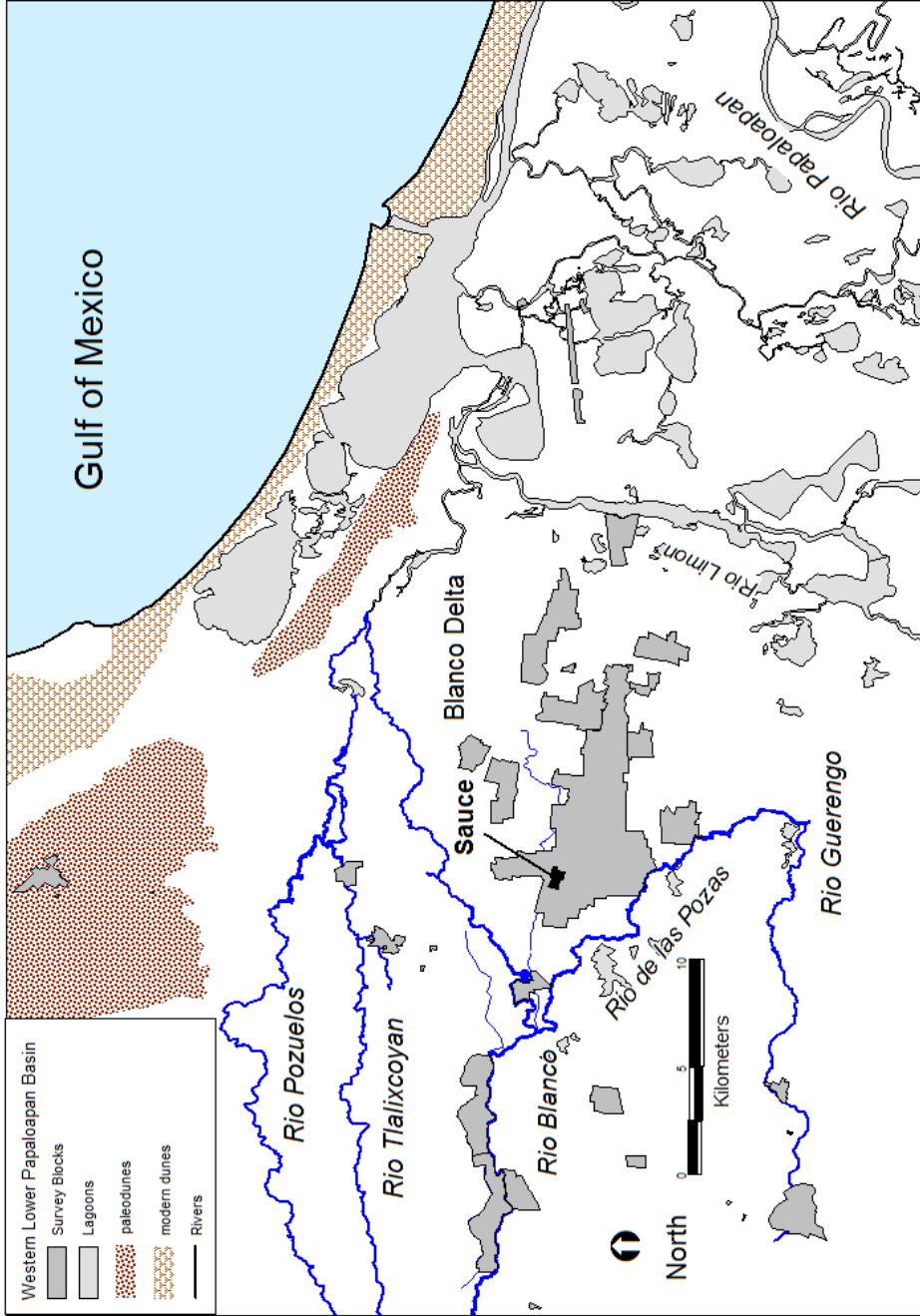
Figure 3.1 Map of Mesoamerica showing the western lower Papaloapan basin and Sauce. PALM and Speaker survey limits and major geographical features are identified.

of Middle Postclassic materials (minimum of 4 or more Middle Postclassic period

sherds). These collections were called Robust in the study. The sample was

distributed across five concentric rings (Figure 3.2, Table 3.1) extending in

increments of 2.5 km from Sauce. An additional 10 collections were sampled

from a pool of 120 mounds that were collected under conditions of excellent

ground visibility, yet had small Postclassic collections. This sampling was done

to obtain better representation of what may have been residential mounds from the

lowest socioeconomic wealth level. These collections were called Scant in the

study (at least one Middle Postclassic pottery sherd). The total sample was 65

residential collections (Figure 3.2, Table 3.1).

Table 3.1 Middle Postclassic residential mounds per ring.

Ring	Radius from Sauce (km)	Middle Postclassic Mounds per ring	Number of Robust Collection Mounds Sampled per ring	Number of Scant Collection Mounds Sampled per ring	Total Number of Mounds sampled per ring
		(diagnostic sherds >= 4)			
1	2.5	41	11	2	13
2	5	26	11	2	13
3	7.5	26	11	2	13
4	10	16	11	2	13
5	12.5	21	11	2	13
		Total = 130	Total = 55	Total = 10	Total Sample = 65

Data about the Blanco residential features were not the only springboard

provided by prior projects. The field methods of the prior surveys, which located,

mapped, and recorded thousands of residential features using the same techniques
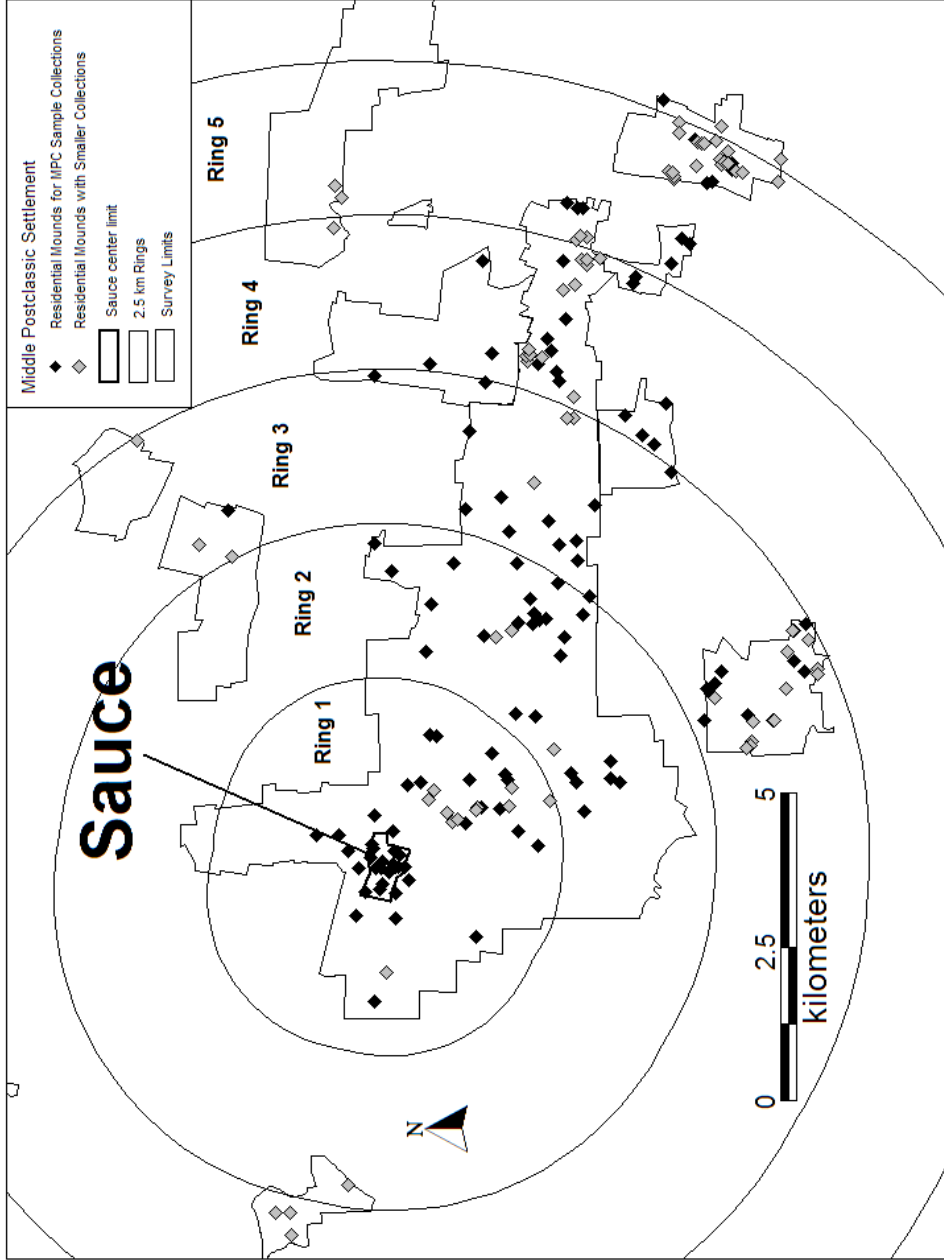
Figure 3.2 Map showing Middle Postclassic residential mound sample population in the Blanco delta, including Sauce at the core and the PALM survey blocks.

and artifact classifications, enabled sampling by this research project and other

future research projects that target particular kinds of features. Therefore, I

describe how these prior surveys were carried out before I explain how SAP field

methods and sampling strategies were designed. First, I outline the geographical

setting, next describe the prior field methods, and finally describe the field

methods and sampling strategies applied to SAP.

Geographical Setting

The setting for this study is the western lower Papaloapan Basin located in

south-central Veracruz, Mexico (Figure 3.1). This area of low-lying land is a

floodplain of the Blanco River, which bifurcates into the Blanco River branch

heading northeast and the Pozas River channel heading southeast, till both

branches end in the Limon River, an estuary which eventually leads to the mouth

of the Papaloapan River (Speaker 2001:41-42; Stark 1999:197). The PALM

survey area is remarkable for having few changes in topography. The area has

elevation ranges from 0 to 40 m ASL (Stark and Ossa 2007), with most of the

main survey block located within the range of 0 to 20 m ASL. The low-lying

terrain and the paucity of local rocks for building materials mean that the majority

of archaeological features were constructed of earth. The low topographical

variation makes the identification of low residential mounds easier.

Regional Survey

Regional survey is often the first step of field research taken in many long

term archaeological projects. Regional survey can be used to consider

archaeological research questions that, due to their scale, cannot be answered by

excavation alone (Banning 2002; Ruppé 1966). Ideally, archaeological research questions will determine how a region and its boundary are conceptualized for any given survey (Parsons 1990: 20-11; Plog, et al. 1978: 385). For a project with questions focused on the economic organization of a small town and its hinterland, the scale of the PALM survey made Sauce a good choice. PALM's application of full coverage survey set the groundwork for a more intensive project concerning households.

Full Coverage Survey and PALM Methods

Full coverage survey is defined as any archaeological survey of an area that leaves no gaps in coverage. However, full coverage survey can mean different things in different projects (Parsons 1990:11). For most modern surveys, full coverage usually means a combination of what is practical for sampling purposes and what is required to answer research questions. All archaeological surveys are samples. Therefore, the degree to which survey methods are *systematic* and the *intensity* of the survey are what matters for determining how a survey's data may be applied to research questions (Kintigh 1990a: 238).

Fish and Kowalewski (1990) define a systematic approach as one in which a survey applied field methods consistently. Consistency in field methods allows survey data to be compared statistically (Orton 2000). Most regional field surveys undertaken in recent years are systematic. The intensity of a survey is generally defined by the spacing of the sampling design, in other words, how far apart were the transecting lines of survey coverage? Transect spacing, i.e.,

spacing of personnel, can vary a great deal, and the difference can be significant depending on the size of the sites and/or archaeological features of a survey region.

PALM and Speaker's regional surveys applied full coverage methods that featured systematization combined with a high sampling intensity. As an added feature, both surveys adopted the same field methods, which make their combined datasets statistically comparable. Transects were set at 20 meters apart, when topographic and ground visibility allowed (Stark 2006:160). Generally, the surveys adopted a "site-less" approach focused on features—individual mounds or artifact concentrations, with separate mapping of monumental complexes (Speaker 2001:129).

Mounds in both monumental centers and fields were collected systematically, with measured areas for collections allowing density comparisons when warranted by ground conditions and with grab samples in others, if vegetation allowed only spotty exposures, such as animal burrows or footpaths. This flexible approach was used to maximize the effectiveness of effort and artifact collections (Stark 2006:158).

In PALM I if crew members thought they could collect a minimum of 100 rim sherds, then collections from measured collection squares were obtained. In PALM I, if the totals from the initial collection square were too low, the collection square was extended to obtain the minimum. If artifact density was very poor, then a collection was not taken at all, but this led to

underrepresentation of poor households (Stark and Hall 1992). In PALM II, collections were made from all features, even if the artifact density was poor. In cases where ground visibility was low (such as a dense grass coverage in a pasture), grab samples were obtained by collecting all rims, all decorated or special forms, all figurines, all chipped stone, all rare groundstone categories such as azes, bark beaters, and palettes (Stark and Garraty 2008). All other groundstone such as manos, metates, and unidentifiable pieces were counted in the field and recorded rather than collected. For the PALM seasons, vegetation clearing was not practiced, but ground visibility was recorded on an ordinal scale. The collection of all rims and decorated sherds allowed me to perform a reliable targeting of Middle Postclassic period mounds based on the prior surveys. In summary, the methods of full coverage survey that were employed in both PALM and Speaker's surveys provided information per residential feature to allow my selection of a prospective household sample from the Middle Postclassic for my field project.

Multistage Survey and Intensive Surface Collection

Ideally, a regional survey is the first step of a multistage research program in which the first survey phase establishes baseline data. Next, secondary phases may be undertaken that are designed for specific questions. Mesoamerican regional surveys have benefited from applying secondary survey methods to answer focused research questions. For example, several researchers have used sampling designs using intensive surface collections to pinpoint household activities and craft production locales (Brumfiel 1980; Charlton 1994; Curet 1993;

Nichols 1994). Researchers then performed intensive surface collections or a sample of features selected for excavation to bolster their dataset.

For the SAP project, the use of intensive surface collections was a good strategy based on what is known about the reliability of the surface collections from PALM. One challenge for my intensive sampling is the minimum unit, households. For some regions, surface data appear as artifact smears across a landscape with no discernable analytical unit, such as a structure (like a residence or mound). Fortunately, for the PALM study area, the local archaeological features take the form of individual residential mounds that are easily recognizable as discrete domestic units that can be sampled via surface collections (Speaker 2001: 132).

The second challenge for surface sampling is horizontal variation in artifact distributions across a mound surface. However, prior research experience from Stuart Speaker's project within the same region demonstrates that horizontal variation is not large enough to cause significant problems for SAP's proposed program of intensive surface collections. Speaker's project collected artifacts from mound surfaces within the region by using collection units placed in different locations on each mound to check for potential differences in the horizontal variation of artifacts (Speaker 2001:110). The differences between the materials for the separate collection units per single mound were not significant enough to warrant separate analyses, so the materials were summarized together. Based on Speaker's experience, I was confident that the variations in artifacts across a mound's surface would not be sufficient to warrant the placement of

more than one unit per mound. Additionally, I was also confident that one unit would be a fairly accurate sample of the entire mound's surface artifacts.

The third challenge to the effectiveness of surface sampling is potential differences between surface and subsurface artifacts. For the PALM study area, prior research experience demonstrated that surface/subsurface differences show a lot of variation in some cases, based on auger sampling and surface collections taken prior to the excavation of test pits (Howell 2001: 45). Howell (2001:46) found that the correlation between the artifact density of the surface and the excavation test units was the highest between the surface and depths of 30 cm. He (Howell 2001) acknowledges that deeply buried deposits would not be represented by surface collections; however, the top 30 cm of the excavation units from PALM proved to have artifact proportions and contexts similar to the surface collections. Since the SAP project is focused on the last part of the prehispanic occupation, the Postclassic period, it is likely that surface collections are more accurate representations of the most recently deposited Postclassic features than for earlier periods with deeper deposits.

In summary, the special characteristics of the local archaeological features described in the previous section combined with a research focus on the Postclassic period make a research project based on intensive surface collections feasible and effective. In the following sections, I outline the specific sampling strategies and collection methods employed in SAP.

Sampling Strategies

Residential mounds in the WLPB represent a combination of trash, debris, wattle-and-daub construction, and also potential fill and platform construction materials that are typically from multiple periods of occupation (Hall 1994: 34-35). From prior survey, the mean and standard deviation of mound length is 42.2 m +/- 21.0 m and width is 32.8 m +/- 16.1 m[1]. These measurements indicate mounds are of substantial sizes and that there is considerable size variation.

Due to time constraints, it was not practical to clear and collect 65 entire mound surfaces in the four months allotted for fieldwork. My solution was to collect one representative measured collection square per residential mound. Based on prior survey, mounds with measured collection squares with ground conditions of excellent visibility showed a fair amount of variability in the amounts of materials collected; collections had a mean of 7 rim sherds per square meter and a median value of 2.6 rim sherds per square meter including all periods of occupation. For this study, it was important to select mounds that dated to the correct time period and to maximize the amounts of collected materials. In the following sections I describe the methods used to accomplish those goals.

Selecting Middle Postclassic Period Mounds

The first sampling priority was selecting mounds that date to the Middle Postclassic period. Domestic mounds were re-used in this low-lying terrain, likely because they provide some elevation and structural foundation in an area that becomes very wet during the rainy season. The challenge was to select a sample of PALM mounds that were representative of the Middle Postclassic

period to provide a robust sample and minimize chronology admixture problems.

A map based on the PALM survey settlement patterns (Figure 3.3) shows that

mounds with Middle Postclassic pottery are scattered across the Blanco delta,

with high densities clustered around Sauce, tapering off toward the east, with

some increase in the southeastern corner of the survey. The Middle Postclassic

diagnostic ceramics used were based on the chronological studies of the PALM

pottery typology and are listed in Table 3.2 (Curet, et al. 1994; Garraty and Stark

2002; Stark 1995). A more detailed description of Middle Postclassic PALM

pottery types can be found in Appendix A. Pottery types have numbers and

letters, with an acronym in addition to names.

Table 3.2 Middle Postclassic diagnostic pottery types.

Pottery Types	Pottery Type Descriptive Names
7g, some e BLRD	Black-on-Red Incised
9n,o RBU	Red-on-Buff
10n RORS	Red-on-Orange
18b ACEN	Acula Red-on-Orange, Incised Frieze Motif
23n RWH	Red-on-White
24 WBR	Framing White-and-Black-on-Red Polychrome
26 WBR	Splashy White-and-Black-on-Red Polychrome
30o RFRI	Polished Red Incised Frieze
41a BUFF	Hard Buff
45a DULL	Dull Buff Polychrome
45d TPIC	Tres Picos Polychrome
45e TOTO	Totonac Polychrome
45f MONT	Cerro Montoso
45g FUG	Fugitive Polychrome
45h,i BAND	Banded Polychrome
45j FRIS	Frieze Polychrome
45k ISLA	Isla de Sacrificios
57b BLOR	Black-on-Orange (black rim and horizontal bands)
57c BLOR	Black-on-Orange (complicated designs)
58 HARD	Hard
60f PINC	Incised Buff

A total of 677 collections from mounds in the PALM dataset have Middle

Postclassic diagnostic rims (n = 1 to 39 rims) (see Table 3.3), but over half have

only 1 or 2 diagnostic rims. One or two sherds are too few to adequately address

the research questions asked in Chapter 1. Also, the distribution of Middle

Postclassic diagnostic ceramic counts is so skewed that the mean diagnostic total

is 3.28 and the median is 2 (see Table 3.3). However, there is a noticeable drop-

off in the number of collections around 3-6 Middle Postclassic diagnostic pottery

rims (see Table 3.4). Therefore, collections with a minimum of 3-6 counts were

potential candidates for sampling.

Table 3.3 Basic statistics of Middle Postclassic diagnostic ceramic rims for PALM collections.

Number of Cases	677
Mean	3.28
Median	2
Std. Deviation	4.315
Variance	18.623
Skewness	3.943
Std. Error of Skewness	0.094
Range	38
Minimum	1
Maximum	39
50th Percentile	2
75th Percentile	4
90th Percentile	7

Table 3.4 Cumulative number and percentage of Middle Postclassic period collections.

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Middle Postclassic Pottery Rim Count	Cumulative Number of Collections	Cumulative % of Total Collections
39	1	0.10%
34	2	0.30%
32	3	0.40%
30	4	0.60%
26	6	0.90%
24	7	1.00%
23	8	1.20%
22	10	1.50%
21	12	1.80%
20	13	1.90%
18	14	2.10%
17	15	2.20%
16	18	2.70%
14	23	3.40%
13	24	3.60%
12	27	4.00%
11	32	4.80%
10	36	5.30%
9	49	7.30%
8	63	9.40%
7	80	11.90%
● 6	105	15.60%
▼ 5	131	19.50%
★ 4	177	26.30%
3	244	36.30%
2	374	55.60%
1	673	100.00%

In deciding what minimum Middle Postclassic pottery count per mound was necessary to select a mound for my study, it was important to find out if there was spatial clustering of the collections with larger amounts of Middle Postclassic pottery outside of the Sauce center, which was already expected to have the largest collections. Therefore, I mapped out alternative samples of collections

with Middle Postclassic pottery with 4, 5, or 6 counts and above. Since collections of 4 counts and above would include counts with 5 and 6, I mapped 5 and 6 on top of the 4 map layer so that I would be able to see if adding the collections with one or two more sherds would over-represent within some rings. Adding one or two sherds did not demonstrate noteworthy spatial clustering of more abundant collections (see Figure 3.4).

Since there was no obvious problem or temporal pattern with spatial clustering, I focused the SAP sample on PALM collections that had a minimum of 4 Middle Postclassic rim sherds. In selecting mound collections with at least 4 or more diagnostics, I was confident in selecting Middle Postclassic occupations without making the sampling populations per ring too small. For example, if I selected for collections with 5 or 6 Middle Postclassic period sherds, I would have eliminated anywhere from 39 to 72 collections from my potential sample, leaving an uncomfortable margin for the vicissitudes of field collecting conditions. Finally, for those PALM collections that have a minimum of 4 or more Middle Postclassic rim sherds, I selected only the 130 collections in which no diagnostic sherds from the Late Postclassic were present and the category that was labeled "general" Postclassic (not diagnostic of either the Middle or Late Postclassic) was abundant. As a result of this selection process, I sampled 55 residential mounds (40 percent) from the 130 residential features, using divisions by distance as described in the previous section (see Table 3.2).
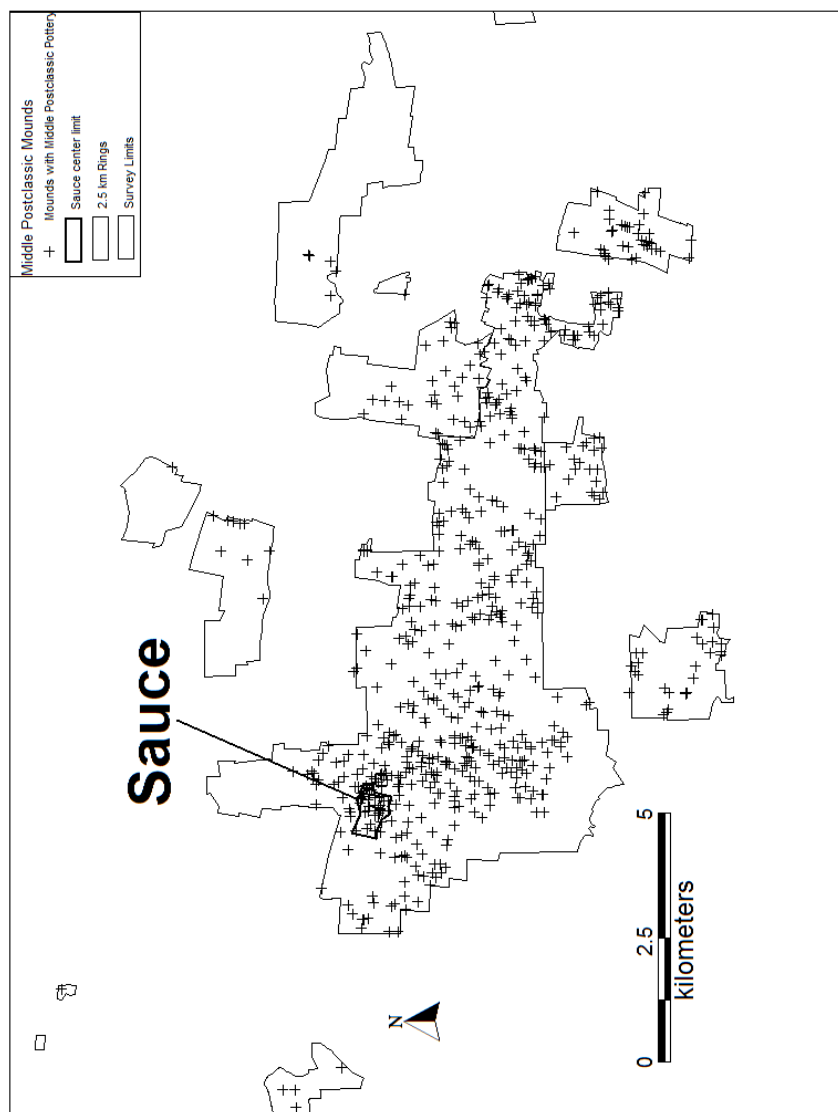
Figure 3.3 Map showing all PALM mounds with Middle Postclassic pottery in the Blanco delta, including Sauce at the core and the PALM survey blocks.
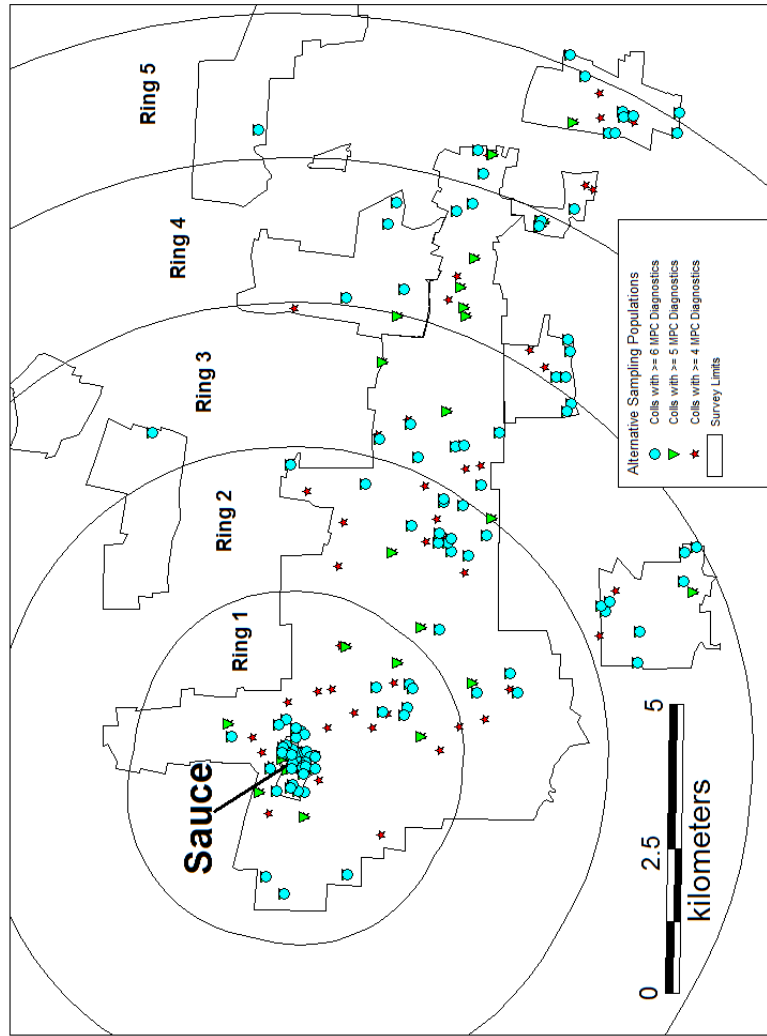
Figure 3.4 Map showing PALM mounds grouped by amounts of Middle Postclassic pottery counts.

Sampling Residences from a Range of Socioeconomic Situations

The second sampling priority was the selection of residential mounds from a range of socioeconomic situations. In Mesoamerica, socioeconomic differentiation is not divisible into a dichotomy of elites and commoners; instead, differences in consumption among residences often show a gradient of status, with clearer indicators of divisions derived from residential size and the central location of the residence (Feinman, et al. 2006: 171; Hirth 1993b: 123; Kowalewski and Feinman 1992: 261; Smith 1987). In a previous study undertaken by Garraty and Stark (2002), decorated pottery was found in higher percentages relative to overall pottery in closer proximity to Sauce. I adopted a system of stratified random sampling to capture this potential spatial socioeconomic diversity, partitioning the region into five rings extending in 2.5 km increments out to a maximum of 12.5 km from Sauce (see Figure 3.4) for random selection of mounds, with the same number of mounds sampled from each ring (see Table 3.1). The concentric ring distance of 2.5 km was arbitrary, but it was crafted to target drop-off patterns between clusters of Middle Postclassic settlements (see Figure 3.2). Concentric rings extending from a center are also a reasonable way of evaluating potential market exchange patterns (Hirth 2010). The rings do not contain the same densities of mounds. Due to the disparity of mound population per ring, choosing equal amounts of mounds per ring enabled better sampling of the outer and more sparsely populated rings and reduced sampling errors for the overall sample (Orton 2000:30).

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Sampling the Poorest Residences

The third sampling priority was to ensure the inclusion of some of the poorest socioeconomic residences. Although the sample described above affords a reasonable way of capturing a range of socioeconomic wealth levels, one persistent challenge has been identifying the poorest households (Garraty and Stark 2002; Stark and Hall 1993). Stark and Hall (1993: 249-250) found only a weak relationship between mound size and quantities of decorated Late Classic rims and surface rim density. They suggest that because decorated sherds also double as temporal markers, those mounds that were lower, smaller, and with fewer sherds were less accurately dated from surface remains, meaning that the poorest households may have been underrepresented (Stark and Hall 1993:268-269).

One way to ensure sampling some of the lowest socioeconomic residences uses information about ground conditions under which collections were made. Some mounds had excellent ground visibility, yet did not have abundant pottery. Therefore, collections were sampled from 120 residences that had excellent ground visibility yet produced few Postclassic diagnostics[2]; I included approximately 8 percent of the 120 mounds (10 mounds), with the sample distributed evenly among the five rings, randomly sampling 2 mounds per ring (Figure 3.2, Table 3.1). This sample is categorized as Scant in contrast to the sample of 55 mounds, which I termed Robust. Adding these 10 mounds brought the total number of residential mounds I examined to 65 (Table 3.1). By

intentionally sampling for poorer households in addition to the general

population, I hoped to improve the evaluation of access to locally produced items.

Random Sampling of Mounds by Rings

Mounds were drawn up into a table by sample population, under either the

"Robust Collection" or "Scant Collection" categories per ring, and then ordered

randomly in the following manner. The website Random.org puts a range of

numbers into a random order; I assigned my mound lists using the website list

function[3].

To aid in fieldwork, field guides were created with the randomized lists of

sample populations, and, during fieldwork, residential locations were taken in the

list order. If permission was refused or there was some other problem with the

mound such as brick-making, then the next mound in the list was selected until

the sample was complete for both the Robust and Scant populations per ring. In

viewing the final SAP sample (Figure 3.5), the ring 1 sample is clustered at the

Sauce center because of several landowner permission refusals for the few

mounds away from the center in ring 1. Also, the Middle Postclassic mounds

eastwards of Sauce in ring 1(Figure 3.2) may be more sparse in number because

the land was occupied by the Classic period center of Cerro de las Mesas, which

could have inhibited later reuse because of prior historic or mythic associations.

Surface Vegetation Clearing and Collection Strategy

Intensive vegetation clearing methods were applied in SAP in order to

obtain abundant artifact collections. One major factor in the need for vegetation
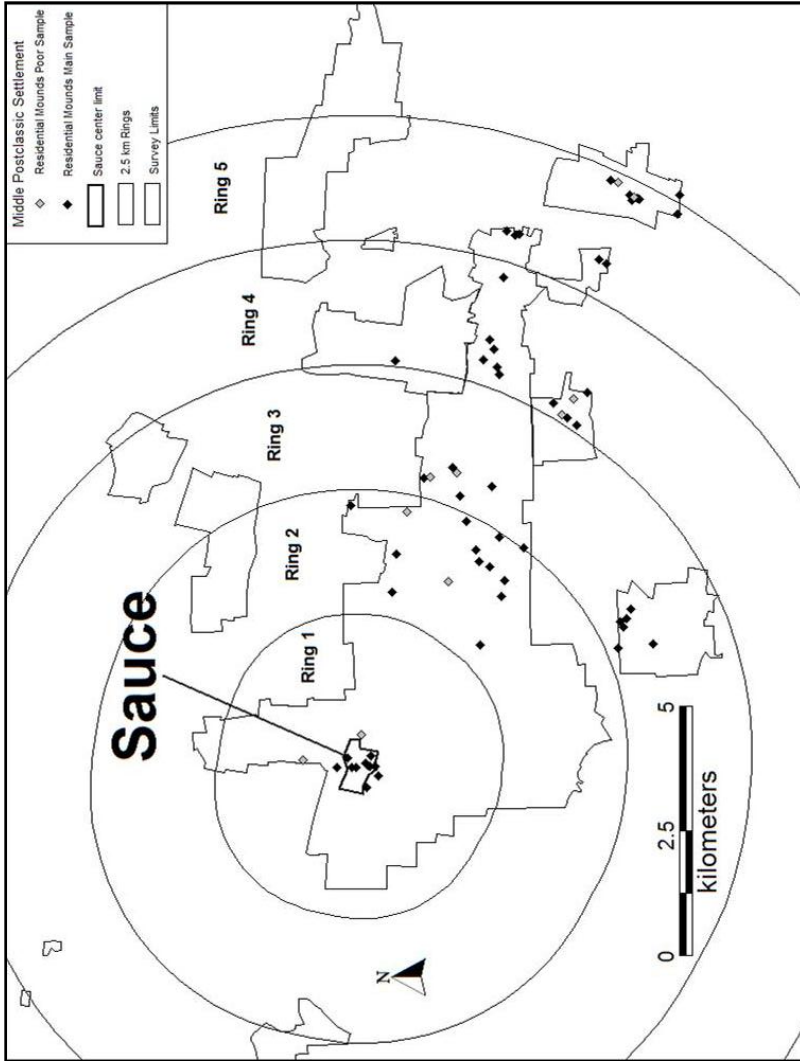
Figure 3.5 Map showing SAP collections.

clearing has been that in the past decade or so, the number of plots allotted to cattle ranches has increased and ranching practices appear to produce tougher and denser surface grasses on packed hard earth (i.e., sod) in which it is much more difficult to obtain surface artifacts. Intensive surface collection strategies that utilize rakes to loosen roots and remove vegetation have been successfully implemented in agricultural fields and ranch pastures (Arnold and Santley 1993: 235-236; Jochim, et al. 1998; Knipper, et al. 2005; Pool and Ohnersorgen 2003: 8). This approach was adopted for the SAP collections.

If it was possible, grass was removed in the form of sod to be replanted after collection; however, in most cases field crew members used machetes to clear the ground surface of any vegetation (see Figure 3.6). Next, crew members broke up the root structure of any remaining vegetation with spades to facilitate plant removal and artifact collection (see Figure 3.7). These field strategies helped create similar field conditions for the intensive collections, even in areas which had dense pasture due to cattle ranching. In most cases, the collection area was reseeded as sod was too broken up, or if the landowner preferred, he or she was given the seed.

Initially, 10 x 10 meter areas were planned for the measured collection units. However, ground conditions made the 10 x 10 meters area too large a unit to be feasible in practice. We consistently got permission to clear 5 x 5 meter squares, but landowners resisted the idea of larger squares. Additionally, ground clearing and root removal was quite difficult in some cases due to the extreme

Figure 3.6 Photo showing vegetation clearing by SAP crew member.

Figure 3.7 Photo showing vegetation clearing and root structure breakdown by SAP crew member.

Figure 3.8 SAP Collection square outlined in white using a digital drawing tool.

Sauce Archaeological Project. COLLECTION OR FEATURE FORM (1/08)

FEATURE or COLLECTION # (from PALM): _____ **Field # (PALM):** _____

Name: _____ **Date** _____ **Zone** _____ **Sample Population** (circle one): **MAIN or POOR**

Dimensions of measured collection area: _____ x _____ m.

Dimensions of feature: _____ x _____ m. Any dimension missing data & why? _____

Visual comparative guess of instrument calculated height _____ *m*

Height method (circle one): angle measurement, vertical reading (>.5 but < eye ht), visual<.5m.

Height variables vertical: _____ m. Level intercept: _____ m. (subtract intercept height from eye ht)

Show calc:

Height variables angle: _____ m. Eye ht _____ m. Angle _____ deg. Slope dist _____ m.

Show calc: (convert deg. to decimal). (Slope formula: slope distance times sin of angle [angle sighted to eye ht])

Ground visibility prior to clearing (circle): **NONE, POOR** (e.g., scattered patches of ground, close cropped grass), **MOD** (considerable openness, but some veg.), **EXC** (plowed, or minimal veg. obstruction)

Vegetation on Feature, its stage of growth: _____

Items collected (circle): pottery, figurine, incensario, clayball, obsidian, chert, whorl, celt, grnd stone: _____ , other (describe): _____

# of bags collected: Pottery & Figs _____ Whorls/Disks _____ Grnd Stone _____ Obsidian _____ other _____

Items observed, not collected (give no.): Pebbles (up to 6.5 cm) _____ Cobbles (>6.5 cm) _____ Other _____

Comments (on a rise? soil change? modern occupation? disturbance or potholes? cobbles maybe architectural?): _____

Sketch below or on back, show dimensions if paced and any concentrations of remains (describe). Locate associated features/collections, bajos, ramps, terraces, modern canals, roads, houses etc. *Show North. Show Elevation Reading Points.*

Figure 3.9 SAP collection/feature form.

hardness of the ground and the amount of time the pasture had been left to grow, meaning that collecting and clearing just one collection typically took half a day's labor. In the end, the SAP project relocated all of the required 65 residential mounds and then collected each of them using 5 x 5 meter collection squares (Figure 3.8). The documentation of each collection was based on PALM methods as described below.

Mound Collection Documentation

SAP documented mounds based on PALM's feature/collection form (Figure 3.9). Each collection square had its dimensions measured using a GPS unit equipped with a satellite real time correction that enabled submeter accuracy. The mounds themselves were not remeasured, although mound height was taken using an inclinometer and tape measure. Based on comparisons of mound dimensions from SAP to the PALM and Speaker datasets, there has been some destruction and erosion of mounds since the earlier projects. Therefore, the construction of mound size/volume rank groups for the analysis of socioeconomic rank, which is explained in Chapter 4, was undertaken using the older set of measurements where possible.

Field Method Legacies and Long-term Research

The Sauce Archaeological Project is possible because of prior surveys by PALM and Stuart Speaker. In particular, the use of intensive full coverage survey methods combined with a "site-less" approach enabled the design and

implementation of a more detailed study targeting the Middle Postclassic period

settlements. Equally important for SAP was the careful recording and mapping of

archaeological features that made the relocation of mounds feasible.

In addition to the body of work established by the prior field projects, the

characteristics of archaeological remains of the western lower Papaloapan Basin

made a project like SAP feasible. The low-lying terrain makes the earthen

mounds easier to identify. Additionally, findings from subsurface testing,

excavations, and surface collecting within the previous projects suggested that

differences between surface and subsurface artifact percentages for Postclassic

period materials were manageable. All of these local factors made a project that

was based on residential inventories from the Middle Postclassic period possible.

In Chapter 4, I discuss the properties of the residential mounds, for chronology,

socioeconomic rank, and as an analytical tool for the SAP study.

CHAPTER 3 NOTES

[1]Hall's (1994) original measurements based on just the PALM I central block survey and not including PALM II or Stuart Speaker's data were not that different with mound length at 41.9m +/- 15.6 m and width at 33.6m +/- 12.5 m.

[2]The specific criteria used to select the Scant sample included collections with excellent ground visibility that had Postclassic pottery less than or equal to 9 sherds where the Middle Postclassic pottery was greater than zero. By setting the Postclassic pottery at a very low amount in combination with requiring that the Middle Postclassic pottery amounts were greater than zero (most collections had only 1 or 2 sherds), ensured that even Scant collections had some Middle Postclassic component.

[3]I used the web address: http://www.random.org/lists/ to obtain a randomized order for my lists of mound samples per ring for sampling purposes. The random order within this website is based on atmospheric noise rather than the use of a pseudorandom numeric algorithm.

CHAPTER 4. RESIDENTIAL MOUNDS: SURROGATE HOUSEHOLDS, CHRONOLOGY, AND SOCIOECONOMIC RANK

Residential inventories from Sauce and its hinterland are the basic units for testing expectations that link distributional and spatial patterning to different exchange systems. Additionally, expectations for identifying different forms of exchange require the identification of socioeconomic rank of occupants, in order to decide whether access is being restricted along a socioeconomic axis. In this chapter, I establish the chronology and evaluate socioeconomic rank for the residential mounds.

In the first section, I evaluate the residential mounds as surrogate households as the base unit for the exchange analyses. In the second section, I introduce the pottery and chipped stone that provide the chronological data and assess the chronological periods associated with the 65 residential mound collections. The results of the chronological analysis are summarized for each mound in the five rings described in Chapter 3. In the third section, I describe a method for assessing socioeconomic rank for all of the individual residential mounds based on a measure of residential mound size. Finally, I discuss the insights and implications of the residential mound dataset for the study of exchange.

Residential Mounds as Surrogate Households

The household is defined as a domestic social unit in which the members are participating in an activity or task oriented residential group, and who are

often, though not always, related kin (Wilk and Netting 1984). The household has long been recognized as the primary unit of production, consumption, and reproduction (Hirth 2009b; 2010: 231; Santley and Hirth 1993: 3-4; Wilk 1991; Wilk and Ashmore 1988). Although size and composition vary greatly, households are often cross-culturally the primary unit that engages in exchange and production activities and acts as a decision-maker (Blanton 1994; Hirth 2009b; 2010: 231-232). Despite its vital function in social and economic life, the household turns out to be a difficult concept to apply and use archaeologically. Hirth (1993a: 23-24) identifies two major problems with using the concept of household. The first problem is the identification of a household via material remains such as domestic living spaces without any historical information about social definitions. The second problem is that most concepts of a household as a decision making unit are essentially synchronic portraits of what are diachronic archaeological accumulations representing many periods of occupation (Hirth 1993: 24). For the SAP study, these two issues can be mitigated due to the nature of the local archaeological remains and sampling design aimed at controlling chronology.

In the Blanco delta, residential mounds were dubbed "tells in miniature," (Hall 1994). These earthen mounds can be considered a rough proxy for residential units, although they are typically larger than the traditional Maya houselot and may represent multiple buildings and extended residences (Stark and Hall 1993: 261-262). In the absence of historical records, it is not possible to identify households as they might be defined socially; however, I can identify

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spatial units which *could* indicate co-residency (Hirth 1993: 24). Co-residency

can be a proxy for a cooperative domestic unit that acts as a household (Blanton

1994: 6-7; Hirth 1993:24). Co-residence is a difficult concept to apply to all

cases; Wilk and Netting (1984) point out that many notions of households cross-

culturally do not have all household activity sharing units living together. In

Mesoamerica, we do have some evidence from bioarchaeological mortuary data

to support co-residence of related kin in many domestic situations from Classic

period Teotihuacan in central Mexico (Storey 1992) to Late Formative to Early

Classic at the site of K'axob in Belize (McAnany, et al. 1999). Although the

earthen mounds probably represented multiple associated structures, they are

individually far enough apart from each other that each mound likely represents a

domestic residential unit that will be used analytically as a surrogate for

households (after Speaker 2001:130).

Artifacts and Residential Mound Chronology

The sampling design for mound selection described in Chapter 3 was

aimed at identifying mounds that primarily dated to the Middle Postclassic period.

The goal of this chapter is to describe and test the chronology of the most

abundant materials from SAP collections: pottery and chipped stone (mostly

obsidian). I focus on the Middle Postclassic period and evaluate the degree to

which other periods appear to be intermixed. The degree of intermixing of

materials from the Postclassic subdivisions proved important in deciding which

Postclassic pottery types can be used in the exchange analyses of the following

chapters. First, I describe the two most abundant artifact categories; next I

characterize the major chronological associations for each of the mound

collections ring by ring.

Pottery Forms, Wares, and Types

Pottery was the most common material collected, with up to a couple of

thousand sherds in some of the larger collections.   All pottery was typed,

counted, and weighed with the exception of non-diagnostic utility wares, which

were weighed and counted, but not typed beyond a very basic description of plain

or slipped/slip color. The PALM typology was applied to the analysis of SAP

collections (Stark 1995, 2008b). Pottery types included all time periods

established by PALM, with a typology based on paste and surface treatment, and

sometimes form (e.g., comals). Due to difficulties of ascribing most plain wares

to a time period, I summarize only the decorated ceramics, buff comals, and those

plain wares identified exclusively as Middle Postclassic for this analysis. Along

with SAP, I also include PALM data for the Postclassic period breakdowns

(Middle, Late, and general) to establish a more complete chronological profile for

the collections. SAP collections included both rim and body sherds in their counts

while PALM collections were rims only. Although PALM collections were not

done in the same format as SAP, they can provide some additional materials to

evaluate the chronological association for the collections. Tables provide the

complete breakdown of all pottery types and periods by collections (Appendix A).

Chipped Stone Materials and Artifact Types

Most of the chipped stone is imported obsidian because no local materials

were suitable for tools (Heller and Stark 1998: 121). Obsidian was the main focus

of the chipped stone analysis because it can be ascribed to periods on the basis of

color and texture associations with geologic sources and blade technology (Heller

and Stark 1998). All of the obsidian was characterized by a combination of

artifact form (blade, core, shatter, etc.) and color. Almost all of the 65 collections

had obsidian artifacts. The vast majority of these were blades or fragments of

blades and detritus related to blade production. Lynette Heller did the typing for

SAP obsidian, providing continuity with PALM procedures. Chert was also

found in small quantities (7 pieces) and was analyzed according to a typology

developed for PALM.

Evaluating the Middle Postclassic Chronology

To tabulate the pottery chronologically, I use the chronological

associations for types created by Barbara Stark with some additions by

Christopher Garraty for the PALM projects (Garraty and Stark 2002; Stark 1995).

These associations are based on seriation (Curet et al. 1994), the 1987 excavations

(Stark 2001a), and the material patterns at the Late Postclassic settlement of

Callejon del Horno recorded during the PALM II seasons. General time

associations between periods and pottery types were also supplemented by the

application of unmixing statistical methods (Kohler and Blinman 1987) to PALM

Postclassic materials (Garraty and Stark 2002). I adopt the time period

associations with the understanding that the methods for assessing the chronology

of PALM pottery show tendencies of time association only.

The periods that were identified in the SAP pottery are: general Preclassic

(600 B.C. –A.D. 300), Early to Middle Classic (A.D. 300-700), Late Classic

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(A.D. 600-900), general Classic (A.D. 300-900), Middle Postclassic (A.D. 1200-1350), Late Postclassic (A.D. 1350-1521), and general Postclassic (A.D. 1200-1521) (See Appendix A for the full list of PALM types and period associations). A more complete description of the Postclassic pottery complex can be found in Chapter 5.

To tabulate the obsidian chronologically, I used the period associations established by Barbara Stark and Lynette Heller with the understanding that they show tendencies only. Dark grey and black obsidian blades predominate in the Classic period (Heller and Stark 1998). For the Middle Postclassic period, clear grey obsidian from Pico de Orizaba (Veracruz) predominated, but dark grey and black obsidian continued to be imported from Zaragoza-Oyameles (Puebla) in much reduced amounts (Heller and Stark 1998: 122; Stark, et al. 1992). Green obsidian predominates in the Late Postclassic. Also, a new prismatic blade technology that included ground platforms distinguishes the Middle Postclassic period collections from the Classic period collections (Heller and Stark 1998). Although ground platforms may help distinguish any overlap between dark grey and black obsidian blades from the Classic and the Middle Postclassic periods, I did not use dark grey and black obsidian blades with ground platforms to identify Postclassic period materials in this analysis.[1] There are very few bifaces or other non-blade obsidian objects among the collections, making blade-related artifacts a better choice for chronological analysis. Table 4.1 shows all the artifact types that were blade-related; these items are described in shorthand as "blades" for the rest of the chronology analysis (Table 4.1). These categories and their group artifact

type designation were originally designed by Lynette Heller as generally useful
categories for analysis; for consistency with PALM, I did not alter the categories
or their relationships while analyzing SAP data.

Table 4.1 Blade-related artifact type categories.

Artifact Type	Group Artifact Type
Prismatic Pressure Blades: Proximal (all receive platform code)	Prismatic Blades
Prismatic Pressure Blades: Medial	Prismatic Blades
Prismatic Pressure Blades: Distal	Prismatic Blades
Prismatic Pressure Blades: Whole	Prismatic Blades
Prismatic Blades w/Platform Reversal Scars	Prismatic Blades
Blades: Shatter (includes indeterminate sections and small blade fragments)	Blade Related
Ribbon Blades: Very Small, Delicate	Blade Related
Notched Blades (can include percussion or macro blades; code as retouched)	Blade Tools
Percussion Blades: Proximal (for blades <2.5 cm wide)	Prismatic Blades
Percussion Blades: Medial	Prismatic Blades
Percussion Blades: Distal	Prismatic Blades
Percussion Blades: Whole	Prismatic Blades
Stemmed Blades	Blade Tools
Blades/Flakes Retouched to Points/Punches	Blade Tools
Projectile Points on Prismatic Blades	Blade Tools
Scrapers on Transverse Core Tab	Blade Tools
Scraper (all formal scrapers) from blades	Blade Tools
Scraper Fragments from blades	Blade Tools
Scraper on Longitudinal Core Fragment	Blade Tools

The results for pottery and obsidian are shown by individual rings in order
to clarify the chronological spatial patterns. The pottery was tabulated showing
counts and the blades were shown by counts and weights. The goal was to
evaluate whether the collections could represent the Middle Postclassic period
occupation. I adopted specific criteria using both counts and ratios to diagnose
collections that required greater scrutiny and care in deciding chronological
associations. Collections that had SAP Middle Postclassic pottery sherds within 3
counts of Late Postclassic counts (such as 3 counts to 1 counts, Middle Postclassic

to Late Postclassic) or cases in which the ratio of Middle Postclassic to Late Postclassic pottery was 2 to 1 (i.e., Late Postclassic pottery counts were half of the Middle Postclassic counts, such as 5 to 10 sherds), were evaluated by considering PALM pottery counts and SAP obsidian. PALM pottery rim counts are labeled and shown alongside SAP pottery rim and body counts in the data tables. These chronologically ambiguous collections are analyzed in more detail in this chapter and identified in the chronology tables by having their relevant Postclassic pottery data highlighted in grey. Of those grey highlighted collections, those collections that were considered doubtful for the Middle Postclassic period after the chronological analyses of this chapter were specially marked during the exchange analyses to see if they are the source of aberrant patterns-- these are indicated by an asterisk next to the collection number in the chronology tables. Collections that are identified as being too limited in Middle Postclassic materials and thus slated for removal from the analyses are indicated by an "X" next to the collection number in the chronology tables.

Ring 1. The most abundant categories of pottery are general Classic and general Postclassic types. Classic period sherds are plentiful because Classic period mounds were reoccupied during the Postclassic period. In general, the Middle Postclassic period types outnumber the Late Postclassic types (see Table 4.2). These data suggest that the Postclassic residential collections are relatively unmixed in ring 1 (although there are some exceptions, as I explain below). The data on obsidian blades indicate a similar pattern. Blades were used as a time

indicator because they do not conflate production information related to cores and flakes (see Table 4.1).

Table 4.2 Pottery totals for each period per collection for ring 1.

Collection	SAP Sample Population	SAP general Preclassic	SAP Early -Middle Classic	SAP general Classic	SAP Late Classic	SAP Middle Postclassic	SAP Late Postclassic	SAP general Postclassic	PALM Middle Postclassic	PALM Late Postclassic	PALM general Postclassic	PALM total Postclassic
124	Robust	2	3	28	0	25	0	45	26	0	65	91
210	Robust	1	3	12	0	23	25	47	5	0	31	36
224	Robust	4	3	54	0	31	3	124	5	0	35	40
225	Robust	0	5	167	9	92	3	223	9	0	21	30
1152	Robust	0	1	105	3	15	14	191	8	0	36	44
1175	Robust	0	1	34	1	29	4	66	5	0	16	21
1751	Robust	1	0	48	3	29	7	114	6	0	17	23
1753	Robust	0	1	44	0	13	7	53	5	0	16	21
1759	Robust	0	0	2	0	1	0	15	4	0	2	6
1817	Robust	1	5	151	11	83	7	137	7	0	38	45
1821	Robust	0	1	32	0	5	1	68	6	0	10	16
114	Scant	8	17	36	2	4	1	14	2	0	4	6
X861	Scant	0	8	26	2	0	5	34	1	0	8	9

For ring 1, clear grey blades predominate, with hardly any green blades (see Table 4.3). The obsidian, combined with the pottery data, suggests that most of the Postclassic materials are probably linked to the Middle Postclassic occupation of the region. It is possible that some of the types of pottery which were in the general Postclassic category could have come from the Late Postclassic period, but the generally higher amounts of Middle Postclassic pottery and obsidian compared to those from the Late Postclassic means that I can safely evaluate the general Postclassic types as part of my network and spatial analyses.

There are some chronological exceptions. Collections 210, 1152, and 1759 from the Robust sample show similar amounts of Middle Postclassic and Late Postclassic pottery from SAP; for PALM these three collections have Middle Postclassic pottery but no Late Postclassic pottery. For these three Robust collections, the PALM data offers some support for a Middle Postclassic period association. In addition, collections 210, 1152, and 1759 had only clear grey blades and no green blades, further pointing to a Middle Postclassic period occupation, so they can be considered in the exchange analyses (see Table 4.3).

For the Scant sample, collection 114 has 4 sherds of Middle Postclassic pottery compared to 1 Late Postclassic sherd for SAP; PALM data show 2 Middle Postclassic sherds and zero Late Postclassic sherds. Additionally, collection 114 has 6 clear grey obsidian blade counts compared to 1 green blade. Based on these data, collection 114 has stronger Middle Postclassic period associations and will be included in the analyses. For collection 861, from the Scant sample, the chronological case is more ambiguous. Collection 861 has almost no Middle Postclassic pottery; most of the Postclassic pottery is Late Postclassic or general Postclassic (see Table 4.2). Collection 861 has a few more clear grey blades than it does green blades (and generally low counts of artifacts overall) but these are not enough to support Middle Postclassic dating for the exchange analyses (see Table 4.3). Therefore, Scant collection 861 will not be used in the analyses. Because the Scant sample was designed to find potential "poor folks", the sampling design described in Chapter 3 targeted collections that had excellent ground visibility but low amounts of Postclassic materials. These collections are

more likely to be low in material amounts and, although Scant collections were required to have at least one Middle Postclassic sherd, this requirement does not assure candidates for Middle Postclassic period occupation.

Table 4.3 SAP Blade counts and weights (g) for each color per collection for ring 1.

Coll	Sample Population	Black/Dark Grey Blades Counts	Black/Dark Grey Blades Weights	Clear Grey Blades Counts	Clear Grey Blades Weights	Green Blades Counts	Green Blades Weights
124	Robust	4	2	33	17.2	0	0
210	Robust	0	0	14	7.4	0	0
224	Robust	0	0	42	35.3	0	0
225	Robust	6	3.3	131	62.6	3	2.5
1152	Robust	0	0	47	20.9	0	0
1175	Robust	2	1.2	36	9.8	0	0
1751	Robust	6	3.3	51	27.6	5	2.9
1753	Robust	1	0.7	22	10	0	0
1759	Robust	0	0	3	3.7	0	0
1817	Robust	9	8.7	65	35.5	1	1.4
1821	Robust	1	0.8	5	2.8	0	0
114	Scant	5	6	6	1.9	1	0.4
861	Scant	6	3.5	7	2	2	1.9

Ring 2. The pottery from ring 2 shows a pattern very similar to ring 1 in having high counts of both general Classic and general Postclassic types. Ring 2 also has mostly Middle Postclassic diagnostic types rather than Late Postclassic types although there are some exceptions. Three of the Robust collections, 395, 687, and 1341 have the same amounts (in some cases none) of Middle Postclassic and Late Postclassic pottery (see Table 4.4). One Robust collection, 1466, has only 2 Middle Postclassic sherds and no Late Postclassic pottery. One Scant collection 1427 has Late Postclassic pottery in amounts greater than or equal to the Middle Postclassic ceramic types (see Table 4.4). For the four Robust collections, 395, 687, 1341, and 1466 PALM Middle Postclassic pottery is present

in greater amounts than the Late Postclassic pottery (which is zero counts in all

cases). Additionally, for two of the Robust collections, 395, and 687, clear grey

blades are present while green are not, which lends support to a Middle

Postclassic period component (see Table 4.5). The Robust collection 1341 is a

little more equivocal because it has both clear grey and green obsidian blades,

although it has twice as many clear grey as green obsidian blades (see Table 4.5).

I will use 1341 in the analyses, although it will be specially marked in case it is

the source of unusual patterning. Finally, the Scant collection 1427 does have,

between SAP and PALM pottery, a total of one Late Postclassic sherd and one

Middle Postclassic sherd and no clear grey or green obsidian blades. Therefore,

collection 1427 will be set aside from my analysis because of doubt that it

represents the Middle Postclassic period.

Table 4.4 Pottery totals for each period per collection for ring 2.

Collection	SAP Sample Population	SAP general Preclassic	SAP Middle Classic	SAP general Classic	SAP Late Classic	SAP Middle Postclassic	SAP Late Postclassic	SAP general Postclassic	PALM Middle Postclassic	PALM Late Postclassic	PALM general Postclassic	PALM total Postclassic
395	Robust	0	1	2	0	0	0	8	7	0	100	107
687	Robust	0	0	14	0	1	1	51	9	0	27	36
691	Robust	0	7	42	10	10	0	52	4	0	21	25
1002	Robust	0	2	72	0	21	1	54	11	0	30	41
1003	Robust	0	0	28	0	14	0	44	9	0	52	61
1013	Robust	0	2	38	3	17	0	106	10	0	75	85
1286	Robust	1	1	32	9	21	2	78	4	0	19	23
*1341	Robust	0	9	11	6	0	0	45	4	0	13	17
1370	Robust	1	7	39	17	8	2	45	4	0	23	27
1466	Robust	0	5	23	1	2	0	26	7	0	25	32
1617	Robust	0	2	37	25	7	0	69	4	0	25	29

Collection	SAP Sample Population	SAP general Preclassic	SAP Middle Classic	SAP general Classic	SAP Late Classic	SAP Middle Postclassic	SAP Late Postclassic	SAP general Postclassic	PALM Middle Postclassic	PALM Late Postclassic	PALM general Postclassic	PALM total Postclassic
1314	Scant	0	2	48	3	16	1	102	1	1	5	7
X1427	Scant	0	0	1	10	0	1	11	1	0	8	9

Table 4.5 SAP blade counts and weights (g) for each color per collection for ring 2.

Coll	Sample Population	Black/Dark Grey Blades Counts	Black/Dark Grey Blades Weights	Clear Grey Blades Counts	Clear Grey Blades Weights	Green Blades Counts	Green Blades Weights
395	Robust	0	0	1	0.2	0	0
687	Robust	9	11.7	15	12.9	0	0
691	Robust	19	13	5	1.2	0	0
1002	Robust	1	0.3	8	6.3	0	0
1003	Robust	0	0	12	7	0	0
1013	Robust	3	1.1	27	14.4	0	0
1286	Robust	1	0.5	24	28.3	0	0
1341	Robust	7	3.4	6	2.2	3	5.6
1370	Robust	17	8.2	20	9.5	0	0
1466	Robust	6	4.5	2	0.4	0	0
1617	Robust	6	7.1	12	6.6	2	1.5
1314	Scant	2	1.6	3	3.8	3	2.7
1427	Scant	2	1	0	0	0	0

Ring 3. The general Classic and general Postclassic period diagnostics in ring 3 are still the prevailing pottery types. Generally, there are fewer counts of Middle Postclassic pottery types overall in ring 3 (see Table 4.6). For roughly half of the collections, Middle Postclassic pottery predominates with no Late Postclassic pottery. For the rest of the collections, although there is no Late Postclassic pottery (with one exception), the Middle Postclassic pottery counts for SAP are small enough to require some further evaluation. For the Robust

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collections 1628, 5271, and 5275, Middle Postclassic pottery counts were either zero or one for SAP; for PALM collections, Middle Postclassic pottery was found in greater amounts (4-7 sherds) with zero Late Postclassic pottery. Additionally, for the obsidian, Robust collections 1628, 5271, and 5275 had clear grey obsidian blades in much larger amounts than green obsidian blades, which were zero for all but one collection, 5275, which had 18 clear grey blades to 2 green blades. These three Robust collections have a convincing case for mostly Middle Postclassic period occupation based on the PALM and obsidian datasets. For the Robust collection 5260, the data was more equivocal although PALM data and the obsidian lend support for a mostly Middle Postclassic occupation. For SAP, collection 5260 had 6 Middle Postclassic sherds compared to 2 Late Postclassic sherds; for PALM, there were 7 Middle Postclassic sherds compared to no Late Postclassic sherds. Collection 5260 had 8 clear grey obsidian blades and no green blades.

Finally, for the two Scant collections 1685 and 1692, the pottery numbers were very low (see Table 4.6). Both of these collections had no Middle or Late Postclassic pottery for SAP; for PALM they had 2 and 1 Middle Postclassic sherds, respectively, and no Late Postclassic pottery. The Scant collections also had low obsidian blade counts; no counts for collection 1685 and 2 clear grey blades compared to 1 green blade for collection 1692 (see Table 4.7). Both Scant collections are too small in overall sample size to be considered in the network simulation in Chapter 5 in any case. For the spatial and contextual analyses, both

collections will be used, with collection 1692 marked in case it is the source of unusual patterning.

Table 4.6 Pottery totals for each period per collection for ring 3.

Collection	SAP Sample Population	SAP general Preclassic	SAP Middle Classic	SAP general Classic	SAP Late Classic	SAP Middle Postclassic	SAP Late Postclassic	SAP general Postclassic	PALM Middle Postclassic	PALM Late Postclassic	PALM general Postclassic	PALM total Postclassic
725	Robust	0	1	40	56	14	0	18	5	0	14	19
1022	Robust	0	0	35	0	22	0	42	11	0	39	50
1628	Robust	0	2	26	3	0	0	27	6	0	29	35
1679	Robust	0	1	83	3	28	0	126	6	0	24	30
1690	Robust	0	8	86	6	5	0	13	4	0	4	8
5185	Robust	4	7	39	2	7	0	58	4	0	1	5
5260	Robust	1	14	52	6	6	2	30	7	0	5	12
5271	Robust	0	0	9	0	1	0	28	7	0	8	15
5275	Robust	0	0	8	14	1	0	25	4	0	13	17
5282	Robust	1	0	77	4	19	2	99	22	0	11	33
5284	Robust	0	4	30	102	3	0	47	9	0	6	15
1685	Scant	12	1	19	3	0	0	19	2	0	7	9
*1692	Scant	0	7	42	1	0	0	10	1	0	2	3

Table 4.7 SAP blade counts and weights (g) for each color per collection for ring 3.

Coll	Sample Population	Black/Dark Grey Blades Counts	Black/Dark Grey Blades Weights	Clear Grey Blades Counts	Clear Grey Blades Weights	Green Blades Counts	Green Blades Weights
725	Robust	15	9	9	3.7	0	0
1022	Robust	0	0	0	0	0	0
1628	Robust	5	3.4	4	1.9	0	0
1679	Robust	5	2.5	31	16.6	0	0
1690	Robust	60	24.4	12	3.6	0	0
5185	Robust	10	6.9	8	2.6	0	0
5260	Robust	15	11.9	8	2.5	0	0
5271	Robust	1	0.8	5	1.5	0	0
5275	Robust	12	4.5	18	6.2	2	0.6
5282	Robust	9	4.5	22	8.1	0	0
5284	Robust	18	14.1	8	4.3	0	0

Coll	Sample Population	Black/Dark Grey Blades Counts	Black/Dark Grey Blades Weights	Clear Grey Blades Counts	Clear Grey Blades Weights	Green Blades Counts	Green Blades Weights
1685	Scant	4	2.9	0	0	0	0
1692	Scant	6	2.2	2	1.3	1	0.8

Ring 4.   The general Classic and general Postclassic pottery in ring 4 have the highest abundance. Middle Postclassic pottery predominated with very small amounts of Late Postclassic pottery. Generally, ring 4 had slightly larger amounts of Middle Postclassic pottery diagnostics than ring 3 (see Table 4.8). Most of the collections had greater amounts of Middle Postclassic pottery than Late Postclassic pottery for both SAP and PALM (see Table 4.8). There were some exceptions to these patterns that will be evaluated more carefully. The Robust collection 1099 had 9 Middle Postclassic period sherds and 6 Late Postclassic period sherds for SAP; for PALM, there were 4 Middle Postclassic sherds and no Late Postclassic sherds. The obsidian for collection 1099 had 15 clear grey blade counts compared to no green blades. Based on PALM and obsidian data, collection 1099 has stronger Middle Postclassic period associations and will be considered in the analyses although it will be specially marked in case it contributes to distinct patterns based on having potentially greater Late Postclassic intermixing within the general Postclassic pottery category.

The two Scant collections have low amounts of all materials (see Tables 4.8, 4.9). In the case of Scant collection 6510, the pottery data are equivocal in that SAP has 1 Middle Postclassic sherd compared to 2 sherds for the Late Postclassic; for PALM there is 1 Middle Postclassic sherd and no Late Postclassic

sherds. The obsidian for collection 6510 is more decisive, showing 8 clear grey

blade counts compared to 1 green blade. For 6510, there is not enough bias

towards Late Postclassic to eliminate it from the analyses, but this collection will

be marked for extra scrutiny in cases of unusual patterning. The Scant collection

6521 has almost no pottery, with only 4 sherds labeled general Postclassic (see

Table 4.8). Collection 6521 does have one sherd in the PALM data that dates to

the Middle Postclassic period; there is no obsidian for this collection. Therefore,

although collection 6521 is very low in materials, it will not be eliminated from

consideration in the spatial and contextual analyses for Chapter 6, despite being

too scanty for consideration in the network analyses of Chapter 5.

Table 4.8 Pottery totals for each period per collection for ring 4.

Collection	SAP Sample Population	SAP general Preclassic	SAP Middle Classic	SAP general Classic	SAP Late Classic	SAP Middle Postclassic	SAP Late Postclassic	SAP general Postclassic	PALM Middle Postclassic	PALM Late Postclassic	PALM general Postclassic	PALM total Postclassic
777	Robust	0	13	55	16	19	0	31	5	0	12	17
778	Robust	0	0	3	2	5	0	25	5	0	9	14
790	Robust	0	1	8	0	3	0	36	5	0	17	22
1051	Robust	0	0	0	2	3	0	52	4	0	1	5
*1099	Robust	0	2	56	10	9	6	98	4	0	15	19
1306	Robust	0	12	115	8	35	0	67	6	0	25	31
6489	Robust	0	0	23	1	12	0	94	4	0	13	17
6494	Robust	0	0	5	4	7	1	56	7	0	34	41
6507	Robust	0	4	76	10	37	0	134	6	0	19	25
6514	Robust	0	4	20	1	11	1	27	4	0	15	19
6636	Robust	4	12	135	21	37	0	146	6	0	12	18
X6510	Scant	0	0	29	1	1	2	22	1	0	3	4
6521	Scant	0	0	1	0	0	0	4	1	0	0	1

Table 4.9 SAP blade counts and weights (g) for each color per collection for ring 4.

Coll	Sample Population	Black/Dark Grey Blades Counts	Black/Dark Grey Blades Weights	Clear Grey Blades Counts	Clear Grey Blades Weights	Green Blades Counts	Green Blades Weights
777	Robust	18	10.9	6	2.7	0	0
778	Robust	7	3.2	1	0.8	0	0
790	Robust	10	5.3	5	2.6	0	0
1051	Robust	12	4.8	5	1.9	0	0
1099	Robust	17	16.2	15	5	0	0
1306	Robust	37	22.5	32	9.4	0	0
6489	Robust	4	1.8	17	5.4	0	0
6494	Robust	4	1.6	7	3.5	2	1.1
6507	Robust	12	8.9	52	24.9	2	2
6514	Robust	11	8.1	9	4.2	0	0
6636	Robust	27	17.6	11	5.8	2	1.6
6510	Scant	15	5.7	8	5.1	1	0.5
6521	Scant	3	2.1	0	0	0	0

Ring 5. Ring 5 showed the most extreme patterning in terms of chronology. The most prevalent pottery was general Postclassic, followed by general Classic, and then Late Classic. Of the Postclassic period pottery diagnostics, Middle Postclassic was the most prevalent, though less abundant than in the previous zones (see Table 4.10). Ring 5 was the hardest to collect; the collections near the Lobato *ejido* within the easternmost survey block (see Chapter 2, Figure 2.1), had hard ground which made collecting difficult. An extra collection was taken for this ring (12 collections, instead of the usual 11) because one Robust collection, 5477 turned out to be heavily disturbed by brick-making. One other collection, 5460 from the Scant sample also proved to have very few materials. Collections 5477 and 5460 will be eliminated from the analyses entirely due to low to no Postclassic materials. Obsidian blades were sparse in ring 5, not an entirely unexpected result; other analyses of PALM materials have shown that

blades drop off in amounts farther away from Sauce for the Middle Postclassic period (Stark and Ossa 2010). Clear grey blades appeared to predominate in most cases over green blades (see Table 4.11). Three collections had almost no blades.

All but three of the collections for ring 5 had similar Middle Postclassic and Late Postclassic pottery amounts in SAP (see Table 4.10, highlighted in grey). For the Robust collections, 1511, 1514, 1517, 5452, 5476, 5477, 6816, and 6818, the PALM data have more abundant Middle Postclassic pottery and no Late Postclassic pottery, supporting a Middle Postclassic occupation despite the sparse SAP samples. Additionally, these Robust collections had mostly clear grey obsidian with zero or very low amounts of green obsidian (see Table 4.11). The one potential exception, collection 5456, has 1 Late Postclassic period sherd in SAP compared to 4 Middle Postclassic; PALM data shows zero Late Postclassic period pottery compared to 8 Middle Postclassic period sherds, which supports a stronger Middle Postclassic period occupation. However, collection 5456 has 2 clear grey blades and 2 green blades, which makes the Middle versus Late Postclassic classification equivocal. Therefore collection 5456 will be specially marked for extra scrutiny in case of unusual patterning.

Table 4.10 Pottery totals for each period per collection for ring 5.

Collection	SAP Sample Population	SAP general Preclassic	SAP Middle Classic	SAP general Classic	SAP Late Classic	SAP Middle Postclassic	SAP Late Postclassic	SAP general Postclassic	PALM Middle Postclassic	PALM Late Postclassic	PALM general Postclassic	PALM total Postclassic
*1511	Robust	0	1	3	20	0	0	31	6	0	13	19

Collection	SAP Sample Population	SAP general Preclassic	SAP Middle Classic	SAP general Classic	SAP Late Classic	SAP Middle Postclassic	SAP Late Postclassic	SAP general Postclassic	PALM Middle Postclassic	PALM Late Postclassic	PALM general Postclassic	PALM total Postclassic
1514	Robust	0	6	32	42	2	0	38	5	0	19	24
1517	Robust	0	0	1	1	0	0	13	4	0	9	13
5452	Robust	0	0	11	46	0	0	37	4	0	0	4
*5456	Robust	0	0	16	6	4	1	76	8	0	1	9
5457	Robust	0	0	5	0	7	0	31	7	0	1	8
5462	Robust	0	0	28	0	8	0	45	5	0	1	6
5464	Robust	0	0	17	0	5	0	85	14	0	0	14
5476	Robust	0	0	4	0	2	0	26	7	0	1	8
X5477	Robust	0	0	0	0	0	0	0	6	0	0	6
6816	Robust	0	1	47	5	10	5	42	4	0	8	12
6818	Robust	0	7	77	14	5	3	92	4	0	14	18
5432	Scant	0	0	5	6	0	0	60	2	0	0	2
X5460	Scant	0	0	2	0	0	0	1	1	0	0	1

Table 4.11 SAP blade counts and weights (g) for each color per collection for ring 5.

Coll	Sample Population	Black/Dark Grey Blades Counts	Black/Dark Grey Blades Weights	Clear Grey Blades Counts	Clear Grey Blades Weights	Green Blades Counts	Green Blades Weights
1511	Robust	42	53.8	2	0.8	2	2.3
1514	Robust	25	19.1	2	2.3	0	0
1517	Robust	0	0	0	0	0	0
5452	Robust	15	6.4	2	0.5	0	0
5456	Robust	12	4.5	2	0.7	1	0.1
5457	Robust	1	0.4	2	0.4	0	0
5462	Robust	2	0.8	7	1.7	0	0
5464	Robust	2	1.6	12	4.9	1	0.4
5476	Robust	0	0	7	1.5	0	0
5477	Robust	0	0	0	0	0	0
6816	Robust	12	6.6	12	6.6	0	0
6818	Robust	33	18.4	29	8	0	0
5432	Scant	5	2.3	5	1.6	0	0
5460	Scant	0	0	0	0	0	0

Chronology Conclusions

Postclassic pottery in roughly 35 of the 65 SAP collections, apart from general Postclassic, mostly falls into the Middle Postclassic category. The obsidian blade colors also match this temporal interpretation; clear grey blades, which are identified predominantly with the Middle Postclassic period, are more abundant in the collections than the green blades associated with the Late Postclassic period. Furthermore, the minimal temporal inter-mixing of Late Postclassic materials with these 35 SAP collections allows me to include the general Postclassic pottery in the exchange analyses. For the remaining 30 SAP collections, chronological associations based on SAP pottery alone were more ambiguous and the PALM data were used in addition to consider their chronology. Of these 30, 4 collections were considered to have too few Middle Postclassic materials (or too much Late Postclassic material) to be used and will not be included in the exchange analyses.[2] Five additional collections were marked for special consideration during the exchange analyses because of their potential intermixing with Middle and Late Postclassic materials. The other 21 SAP collections from the original ambiguous group were found to have sufficiently convincing Middle Postclassic period associations based on PALM and obsidian data to be included within the main exchange analyses. In the following sections, I will consider methods for obtaining an independent measure of socioeconomic rank based on residential mound size.

Residential Mound Size and Socioeconomic Ranking

Archaeologists, like most social scientists, rely almost entirely on proxies to measure such challenging topics as socioeconomic rank. Unfortunately, there is no single set of criteria that is reliable in most cultural contexts with which to assess socioeconomic rank. Kowalewski and Feinman (1992: 261) suggest that a mitigating strategy for archaeological applications is to establish some means of rank assessment independent from the material dataset that is the main focus of an analysis that requires information about socioeconomic rank. For this study, I use residential features to assess rank because they are independent of residential inventories.

Due to preservation issues and/or the lack of a historical record, in many cases archaeologists rely on very simple measures such as residence size rather than house layout or more complex interior décor that may be more socially inscribed. Based on insights from energetic analyses, residential size is a function of labor investment (Abrams 1994; Carmean 1991). If residence size directly reflects labor, then differences in residence size could be linked to differential access to resources and/or purchasing power which in turn could help identify socioeconomic rank. Of course, no one single measure such as residence size can be completely reliable, even for the purposes of general assessment. As Cowgill (1992: 206-218) points out, even such important signifiers as dwelling space size do not reliably provide indicators of socioeconomic rank. Politically important people do not always live in palatial residences, nor do wealthy people. Also, socioeconomic rank expression can be restricted to portable objects rather than

structures (Kamp 1993) or to even more subtle signals that defy archaeological

detection through either portable objects or structures.

The best way to understand the intersection of socioeconomic rank and

residential structures is to understand the complete settlement context in which

they act as potential stratification markers. Residential size has been used in other

places in Mesoamerica as a means of ascertaining some independent measure of

rank (Kowalewski and Feinman 1992) and has general utility even if exceptions

occur (see Murakami 2010).[3] In cases like Xochicalco, in central Mexico, good

residential preservation allowed Hirth (1993b: 127-139) to consider residential

socioeconomic ranking by evaluating how residence size correlated with elite

architectural features and décor. Hirth (1993b: 134) identified some patterns;

decorative stonework and other construction materials probably indicative of

status were more associated with the larger structures although it was not a one-

to-one correlation. For SAP, I don't have the residential information to undertake

detailed architectural analyses because houses have decayed; however, as Stark

and Hall (1993: 252) point out, mound size in the PALM study area has some

relationship to labor investment and household size. Based on these concepts and

what is known about the region, I develop residential mound size as an

independent measure of socioeconomic wealth for SAP analyses.

One important consideration in using mound size is that most mounds

were not created and used in a single period. Therefore, any calculation of mound

size in this region requires a correction for antecedent occupation. To address this

factor, I weight each residential mound volume by its relative proportion of

Postclassic period diagnostic pottery. For example, if 38 percent of the pottery were Postclassic, then 38 percent of the residential mound volume will be the Postclassic residence size. I use weighted residential mound volumes to establish comparative residential wealth in the exchange analyses of Chapters 5-8.

Calculating Mound Volume

Mounds are roughly ellipsoid in their surface areas. The mounds with greater height typically have more volume. Mound height, length, and width were recorded in each case and can be used to calculate mound areas and volumes. The first step was picking a shape that could be used to approximate the shape of the mounds with the goal of grouping the mounds by size. An elliptical cone was one approximate shape that was considered, which would require the height, length, and width in order to calculate. However, despite having collected these variables, the mound surfaces are irregular and curved, so that any solid shape that was used would not be quite right. A solution was reached by the late Warren Gaines, who helped Barbara Stark and the PALM project, and designed and wrote a computer program to capture some of the variation. Gaines's computer program incorporated a series of different mound profile curves chosen by Barbara Stark to represent a series of different mound profile types (8 in total) and calculated the volume of each mound by adding volumes of slices of a truncated cone stacked one on top of the other. The basic idea was that the top of each stacked cone could incorporate a different curved profile by allowing for the gradual incline of narrower truncated cones to approximate what the mounds actually look like in real life. For SAP, the program was revised and rewritten to

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run using an updated version of the Visual Basic programming language and the mound data were re-run in the program to generate new mound volumes (see Appendix B).

There were five mounds (6489, 1370, 1286, 1753, 114) for which there was at least one measurement that was missing. In most of the missing data cases the mounds were obviously large, but had some dimension cut or obscured which did not allow for a measurement to be taken. However, these missing mounds all had some way of estimating height. Therefore, their heights were used as a guideline for placement into an ordinal ranking system.

Weighting Mound Volume by Postclassic Pottery

The percentage of total Postclassic pottery was used to determine a related proportion of the mound volume. The mounds were then ordered according to their adjusted volumes. Figure 4.1 shows a continuum in volumes, a result that is what one would expect from accumulated mound deposits. However, there are breaks in the percentages that are useful cut-off points for ordinal size groups (see Figure 4.1). The set of largest mounds, shown as Group 1 in Figure 4.1, has considerable variation compared to the variation within the other groups. The source of the larger variation in size among the larger mounds is unknown because no data were collected on the size or composition of buildings.

Mound Volume, Socioeconomic Rank, and Pottery Densities

The final step was to ascertain if higher amounts of goods were associated with the groups with greater mound volume. Although the mound volume

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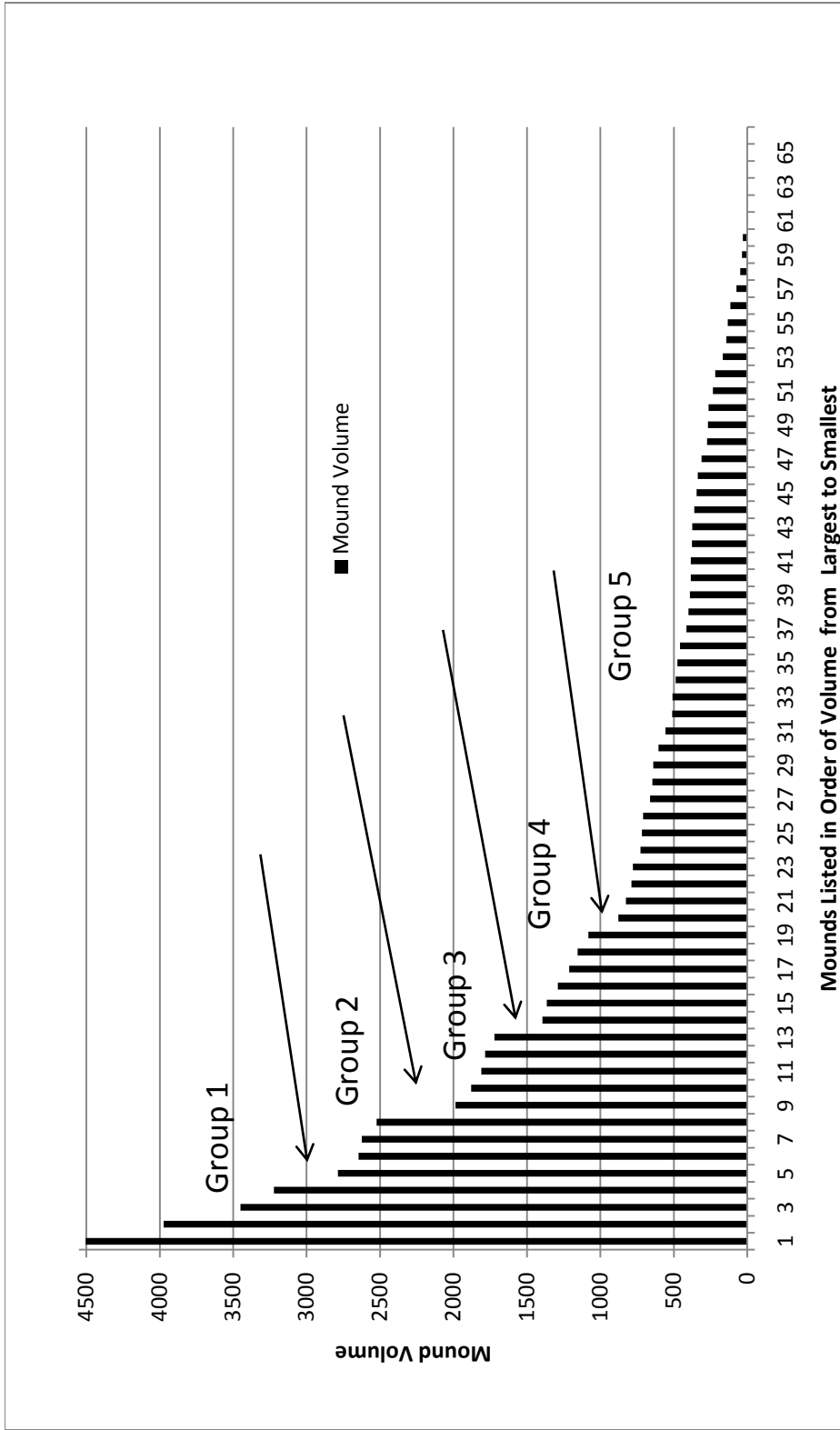
Figure 4.1 Mound volumes weighted by Postclassic pottery percentages.
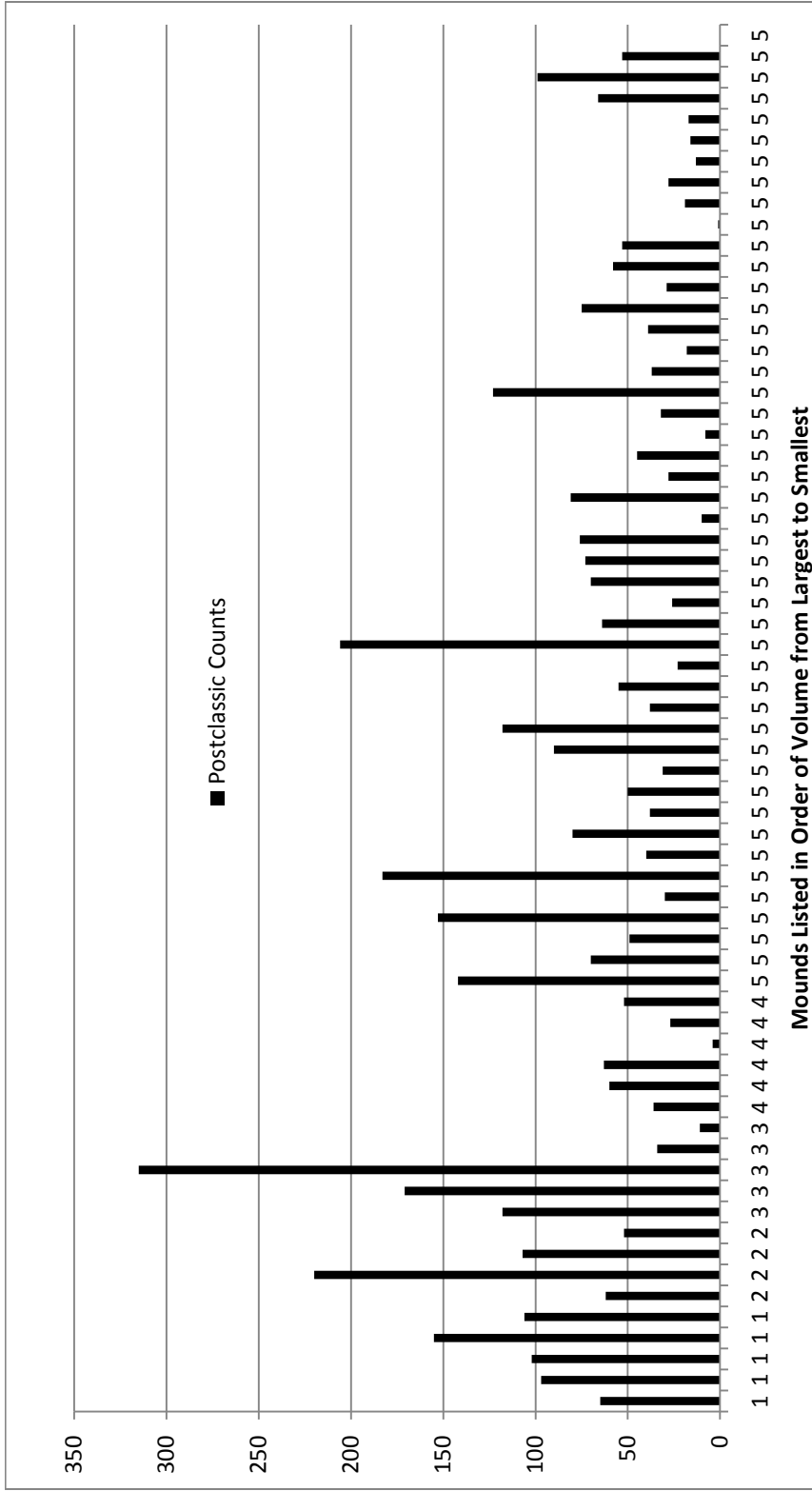
Figure 4.2 Postclassic pottery counts per mound listed by mound size rank groups.

measure was adopted as a means of establishing independent assessments, rather than wealth artifact categories, I use the artifact density as a secondary cross-check.[4] Since all collections were obtained in 5 x 5 m cleared squares, the raw counts of Postclassic ceramics can be considered an area-based density measure. Since the volumes of the mounds are weighted by Postclassic ceramics to create the weighted mound volume rankings, these rankings are a function of the relative *percents* of Postclassic ceramics within each individual mound. Therefore the higher counts of any particular pottery type being analyzed for exchange will not be doubly reflected in the mound size rankings because the relative percentages of a pottery type is calculated *among* the different mounds for exchange analyses while the Postclassic pottery percentage is calculated per individual mound and used to weight each individual mound volume. This means that the percents calculated for pottery types among mounds and the weighting measure of Postclassic pottery per individual mound are independent of each other.

Figure 4.2 shows that mound volume is only loosely correlated with high pottery densities. However, the association here is stronger than the very weak correlation that Stark and Hall (1993:266) determined for mound size variables and pottery for Late to Terminal Classic residences for PALM. This could be the result of a difference in methods. Stark and Hall (1993) did not weight their mound size variable by Late to Terminal Classic pottery. For the SAP study, the largest three mound Groups have higher pottery densities on the whole, although

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not strictly in the same order of the weighted mound volumes. It is also clear that there are plenty of occurrences of higher pottery densities within the lowest volume Group 5 while Group 4 has mostly low counts/densities. The differential pottery densities could be partially a feature of sampling conditions and not just higher socioeconomic rank. However, ground condition comparability was mitigated by the breaking up of the topsoil and removal of vegetation for every collection, as described in Chapter 3.

Therefore, it is plausible that the difference among residential mound collections in artifact densities may reflect some socioeconomic facet of the former residents. In fact, higher densities of pottery could be indicative of a combination of higher socioeconomic rank and/or larger households with more residents. Hirth (1998: 458) acknowledges that the inventories of high and low status households will vary due to differences in their relative purchasing power even under market exchange conditions. Although Hirth (1998:460) found that residences in Xochicalco had the same percents of fancy decorated ceramic imports regardless of obvious differences in status based on residential style and size, he did not suggest that was true for all cases. Smith's (1999) commentary on Hirth stresses that in many cases purchasing power will have an appreciable effect on product distributions even if that was not the case for Xochicalco and that any distributional approach would have to account for this possibility empirically. In other words, even under market exchange conditions, higher socioeconomically

ranked households might still have larger quantities of any marketed item. These larger quantities could show up as larger percents of a particular type of decorated pottery, for example, in those households that had more purchasing power. Therefore, the possibility of relative differences in purchasing power supports the association between the weighted mound size ranks and socioeconomic rank for SAP residential mounds.

For Groups 1-3 from SAP, Postclassic pottery densities are higher on average (4.71 sherds per sq m compared to the 2.28 sherds per sq m for Groups 4-5), which supports the general idea that the mound volumes in the largest groups are capturing higher socioeconomic rankings. However, the range of material densities in the category that had the smallest mounds (Group 5) is greater when compared to the other mound size rank groups. The reasons for this range within Group 5 can be explained by the sample. The majority of collected mounds fit into the arbitrary cut-off chosen for Group 5 because most of the mounds were relatively small by comparison to the largest mounds.

In summary, although there are considerable variations within each of the mound size groups, particularly Group 5, the data show that higher densities of pottery are associated with the larger mound size rank groups. The variations within the mound size rank groups are probably due to a number of factors besides just sampling; differences in the duration of mound occupation and the number of occupants could be determining some of the higher pottery densities in

addition to socioeconomic rank. In spite of these problems, I will use the mound

size rank groups as a proxy measure that can be assessed independently of the

pottery or other artifacts, to estimate an aspect of socioeconomic rank for the

residential mounds.

Insights and Implications for Exchange Analyses

Reconstruction of the multiple forms and structure of exchange requires

data about the residential inventories of household items for Sauce and its

hinterland. Aspects of exchange systems and their social and economic contexts

are reflected materially within residential inventories and also by the residences

themselves. The analyses of this chapter were aimed at establishing chronological

and socioeconomic characteristics of the residential mounds in support of the

exchange analyses. The analytical tools constructed in this chapter provide the

basis for the exchange analyses in the following chapters.

Most archaeological datasets are used for multiple analyses; e.g., data

about different material type counts or percents per analytical unit are frequently

used to address multiple topics simultaneously, such as chronology, production,

and exchange. For the SAP analysis goals, materials were grouped together by

period to make general assessments for a chronological group. In the 65 mound

collections, I have ascertained that most of the Postclassic materials were Middle

Postclassic rather than the Late Postclassic. This means that I will be able to use

pottery types that have more general Postclassic period associations in the

exchange analyses as there is a low likelihood that the residential mounds have much Late Postclassic period material. There are a few mounds that were chronologically ambiguous and marked for special consideration during the exchange analyses or, in a few cases, removed from the analyses altogether because of difficulties in assigning them to the Middle Postclassic period.

The differentiation of exchange systems requires the comparison of artifact distributions among domestic units; however, delineating social aspects of exchange systems requires information about socioeconomic rank for those domestic units. If the same residential inventory dataset was used to assign socioeconomic rank and to evaluate exchange, there would be a danger of circularity. For example, one might conflate higher consumption, or simply a larger sample size of an artifact type (e.g., a pottery type) with higher socioeconomic rank. By developing a measure for socioeconomic rank based on a mound volume rank measure, I provide a means of assessing residential mounds independently of their artifact densities. The mound size ranks established in this chapter will be applied in analyzing the social aspects of Sauce exchange systems.

CHAPTER 4 NOTES

[1]There were 23 pieces of Black/Dark Grey proximal blades among the 65 collections scattered throughout the rings. The blade pieces are proximal ends of prismatic blades because these are the only portions that can show the ground platform identified as Postclassic. The low amounts of this artifact type, coupled with the necessary bias towards only proximal blade parts, would not add much to the broad chronological patterns being evaluated for this chapter, so they were not included in the chronology analysis. However, these blade parts are analyzed as part of the chipped stone in Chapter 7.

[2]One collection, 5477, was already marked for elimination due to modern brick-making destruction and extremely low material counts from a heavily disturbed context. I do not include this collection as one of the 65 SAP collections (technically it is collection 66), but it is included in the Table for ring 5.

[3] Murakami (2010) found that some of the larger apartment compounds in Teotihuacan were associated with larger numbers of residents. Therefore, Murakami (2010) found that per capita labor for building construction was a better measure of rank based on residence construction because although these compounds were larger, they were used by more people and required less labor investment per person than smaller compounds associated with elites.

[4]A previous analysis of the PALM dataset found only a weak correlation between mound size variables such as height and area dimensions and pottery densities for mounds whose materials were mostly dated to the Late to Terminal Classic period (Stark and Hall 1993). However, SAP collections were taken using more intensive surface collection methods which may help avoid some of the sampling variations observed by Stark and Hall (1993).

CHAPTER 5. POTTERY NETWORK ANALYSIS

The purpose of this chapter is to evaluate different network exchange mechanisms for the distribution of pottery for 65 residential mound collections from the center of Sauce and its hinterland. The information about exchange gleaned from household inventories has some limitations. As previous chapters have discussed, multiple mechanisms of exchange co-exist in ancient states, including market exchange, gift-giving (elite or otherwise), and kin exchange. Multiple mechanisms of exchange are not the only factors in identifying pottery exchange networks, intended use and function will also impact household inventories, as I explain below.

Recognizing exchange variables for pottery also requires some understanding of the effect of functional variation on inventories, as these are an important aspect of exchange and can impact the evaluation of exchange mechanisms. Pottery includes decorated serving vessels, cooking vessels, and items that could have had very specific or special purpose use (such as spinning support bowls). Most of the pottery I analyze fits into the category of decorated serving, cooking, and storing vessels, which the exception of the comals, which are special-use cooking griddles. My expectations for evaluating exchange accommodate potential differences in household inventories based on use (in addition to exchange) by using several different methods, both according to individual collections and summaries by ring. I examine special function, high use, and other non-exchange related activities to recognize different exchange

mechanisms. By applying a suite of different scales of analyses, I can maximize

my understanding of exchange.

Broadly speaking, my goal is to develop explicit models of how many

non-perishable materials were being exchanged in Sauce and its hinterland. The

ways in which we can consider and evaluate exchange will be developed through

a set of clear guidelines that can be both quantitatively and qualitatively

considered. As described in Chapters 1 and 2, Hirth's (1998) conceptual

innovation provides the fundamental starting point for this study. For the network

analysis of this chapter, I identify whether items being exchanged are open or

restricted in access. In Table 5.1 I summarize the network models, expectations,

and two methods, the visual distributional analysis and network simulation.

Table 5.1 Summary of Expectations and Methods for Testing Network Exchange Models.

General Expectations for Open versus Restricted Network Exchange
1. *Open Exchange* produces graduated differences, a relatively smooth and gradual change between percentages among residential inventories if these percentages were viewed in a chart of all values.
2. *Restricted Exchange* produces a more abrupt or stairstep pattern between percentages among residential inventories if these percentages were viewed in a chart listing all values.
Methods for Analyzing Network Exchange
1. *Visual Distributional Analysis* is an exploratory data analysis that is a first step in analyzing exchange.   a. Create bar charts of relative percentages for each individual pottery type above 100 sherds and show them two ways (1) per collection ordered by weighted mound volume (for socioeconomic rank) (2) ordered by percent amount.   b. Create bar charts of relative percentages of the aggregate grouped pottery types for those pottery types that were less than 100 counts and show them per collection.   c. Both sets of bar charts will be used to look for open versus restricted exchange. Socioeconomic rank defined by weighted mound volumes will also be noted for the exchange expectations. These results will be combined with the network simulation results.

2. *Network Simulation* is a computer-based Bayesian inspired Monte Carlo simulation that is designed to quantify and compare relative differences in percentages of pottery types for diagnosing open versus restricted exchange. This approach is inspired by Bayesian methods described in Iversen (1984) and by Monte Carlo probabilistic approaches to statistical parameter testing by Kintigh (1990b). Two statistical methods, including variance and the ratio of pottery presence to total residential collections will be applied to the empirical and simulated dataset to evaluate exchange.
   a. Calculate a weighting number for each residential mound collection based on the amounts of pottery for that mound. This weighting factor is used to create simulated pottery type distributions and acts as a Bayesian *prior* distribution for the simulation.
   b. Run a Monte Carlo simulation in the Java computer language to populate hypothetical residential mound collections with individual pottery types in the same amounts found empirically and apportion them according to their weighting number.
   c. Calculate variance for the empirical dataset and set the simulation for one million runs to obtain a comparison.
   d. Calculate the ratio of pottery presence/residential collections for each pottery type for the empirical dataset and set the simulation for one million runs to obtain a comparison.

In the first part of this chapter, I introduce the pottery descriptions and statistics. These data form the basis for understanding how the network analysis is interpreted and applied. In the second section, I undertake a visual distributional analysis to evaluate exchange mechanisms on the basis of pottery percentage variations among the residential collections using the weighted mound volumes to map potential socioeconomic associations with exchange. Finally, I apply a Monte Carlo computer network simulation to the dataset. The purpose of the network simulation is twofold: (1) to test whether the observed patterns of exchange in the visual distributional analysis are valid, or the result of sample sizes, and (2) to apply quantifiable statistical measures to the open and restricted percentage expectations for exchange. The results of the combined visual distributional analysis and network simulation demonstrate that a combination of

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open and restricted exchange networks, including markets and social networks, were operating within Sauce and its hinterland. These insights provide the basis for future research that includes social and political analyses of how the different exchange networks were organized. In Chapter 6 I add explicit spatial and contextual analyses of exchange, including the potential values of the different pottery types.

Pottery Statistics

As stated in the previous chapter, the pottery from the residential mound collections mostly dates to the Middle Postclassic period, with some that fit into the broader general Postclassic period, not restricted to either the Middle Postclassic or Late Postclassic. I concluded that most of the general Postclassic materials could be analyzed as part of the Middle Postclassic period collections. The general and Middle Postclassic period complex of decorated and undecorated pottery and their descriptive statistics will be summarized below.

Postclassic Pottery Complex

The Postclassic period pottery typology was designed by personnel in the PALM projects and the Postclassic complex is described in detail by Stark (1995: 17) who credits Sergio Vázquez Zárate with helping develop the Postclassic typology. The PALM pottery typology is generally based on a types and variant approach, with some exceptions, the types are classification devices aimed at answering specific questions and not necessarily "emic" types (Stark 1995:17). Stark (1995:17) notes that the PALM pottery types are based on contrasting manufacturing steps, and the variants within each type are based on different

decorative elements within surface treatments and painting designs. Specifically, the attributes within the PALM typology were aimed at capturing production steps that would offer insights into the place and date of manufacture. The pottery types were generally found to be of chronological utility, although the variants within each type often, but not always, share the same chronology. Based on pottery seriation using data from both residential excavations and systematic surface collections from the PALM projects, the majority of the pottery types considered here date somewhere within the 150 years of the Middle Postclassic period (A.D. 1200-1350), although we do not know the time span for each (Curet, et al. 1994; Stark and Garraty 2004).

Some of the PALM pottery types may represent long distance trade goods while others were probably locally produced. However, chemical compositional analyses for the Postclassic period pottery have only been carried out on the Late Postclassic materials in the Gulf Lowlands, so sources for these Middle Postclassic pottery types remain unknown (Skoglund, et al. 2006). Despite this lack of direct knowledge about locations of production, many types are recognized as being important in interregional and Veracruz trade, including the *guinda* complex, which encompasses various bichromes and polychromes (Smith 1990; Stark 1995: 18-20). The *guinda* complex refers to the Black-on-Red bichromes and the Black-and-White-on-Red Polychromes which PALM has in greater abundance than other contemporaneous Veracruz centers such as Quauhtochco and Cempoalla (Table 5.2) (Smith, M. 1990; Stark 1995:18-20). Other PALM pottery types, such as the Complicated Polychromes with or without

a white underslip, appear to share stylistic motifs in common with Cholula Polychromes (Drucker 1943:82-83; Stark 1995:20). Although all of the decorated types described here are of interest, in some cases their sample size was not sufficient to include them. The PALM pottery being considered for the network exchange analysis includes only those types which were abundant enough to be analyzed, as I explain below.

Pottery Statistics

The total of Middle and general Postclassic period pottery minus the Late Postclassic period pottery is 4,510 sherds. In Table 5.2 and in the figures, this total will be referred to as the Middle Postclassic pottery. Many of the Postclassic pottery types and their variants are too low in numbers to be considered in the network exchange analyses due to statistical considerations. There are 65 collections from different residential mounds so if the total amount of sherds for a pottery type is less than or equal to 65 it is impossible that all households will have some of that pottery type even if it was not restricted in access. Therefore, the statistical power of the tests will be low where overall sample sizes are low (Stevens 1986: 5). To increase the power of the statistical testing, the visual distributional and network simulation analyses will be focused only on those pottery types that have at least 100 sherds. I include a table of all of the SAP Postclassic pottery types, including their code name, full type classification name, and a brief description of each type; those types abundant enough to be used in the network analyses are highlighted in grey (Table 5.2).

Each pottery type code name is based on a number code that is usually applied to related types (Table 5.2), in most cases this number code is accompanied by a lowercase letter, which indicates variants or subdivisions within the number type (Stark 1995:20). For example, in the case of the 7s COMP and 7t COMP types, both are Complicated Polychrome, but there is a difference in treatment (in this case, whether there is a white underslip or not) that determines whether a sherd is 7s COMP or 7t COMP. The capitalized letters that follow the number and letter code are acronyms that were adopted for the descriptive names of the pottery types, such as Complicated Polychrome or Black-on-Red. These acronyms act as a mnemonic for abbreviated listings in tables. These acronym names can be shared among variants of a type, such as the three Black-on-Orange variants (57a BLOR, 57b BLOR, and 57c BLOR). Therefore, it is the unique combination of the number, letter (not all types have or need letters), and acronym that make up the unique identifiers for the PALM pottery types. In Table 5.2, the pottery type description field spells out the acronym for the name, which is mostly descriptive and adds some characteristics of the variant if necessary to distinguish between other types that share the same acronym (such as for the Black-on-Orange types). A full description of the typology with accompanying illustrations can be found in Appendix A.

Table 5.2 Postclassic period pottery type counts and percents.

Pottery Types Code Names	Pottery Type Descriptions	Counts	Percents
7a,b,c,d,f, some 7e BLRD	Black-on-Red	1571	34.83
7w MISC	Miscellaneous Poly chrome	1295	28.71
7s COMP	Complicated Polychrome, Lacking White Underslip	201	4.46
1a-g COMA	Buff Comales	192	4.26

Pottery Types Code Names	Pottery Type Descriptions	Counts	Percents
26 WBR	Splashy White-and-Black-on-Red Polychrome	189	4.19
45a DULL	Dull Buff Polychrome	158	3.50
7g, some e BLRD	Black-on-Red Incised	138	3.06
19 ESCO	Escolleras Chalk	125	2.77
7t COMP	Complicated Polychrome with White Underslip	106	2.35
57c BLOR	Black-on-Orange complicated designs	85	1.88
21a,b,c,m,o,p SELL	Fondo Sellado	82	1.82
9n,o RBU	Red-on-Buff	42	0.93
18b ACEN	Acula Red-on-Orange, Incised Frieze Motif	38	0.84
45d TPIC	Tres Picos Polychrome	35	0.78
11p,u ROR	Red-on-Orange	35	0.78
57a BLOR	Black-on-Orange black rim only	32	0.71
24 WBR	Framing White-and-Black-on-Red Polychrome	30	0.67
7m-o LPOLY	Coarse Polychrome	28	0.62
45c MPOL	Miscellaneous Polychrome	25	0.55
23n RWH	Red-on-White	18	0.40
45h,i BAND	Banded Polychrome	13	0.29
45j FRIS	Frieze Polychrome	13	0.29
35e,f QUIA	Quiahuistlan	12	0.27
38m FGRY	Fine Grey	11	0.24
57b BLOR	Black-on-Orange black rim and horizontal bands	10	0.22
41a BUFF	Hard Buff	9	0.20
10n RORS	Red-on-Orange	7	0.16
58 HARD	Hard	4	0.09
30o RFRI	Polished Red Incised Frieze	2	0.04
45k ISLA	Isla de Sacrificios	2	0.04
45f MONT	Cerro Montoso	1	0.02
60f PINC	Incised Buff	1	0.02
Middle Postclassic pottery		**4510**	**100.00**

Aggregated Variant Pottery Types. In addition to including pottery types whose totals are greater than 100, there are other fruitful ways of grouping some of the pottery types that can improve the power of some of the statistical evaluations. Therefore, variants of the Postclassic period pottery types, including

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some of the Black-and-White-on-Red, Complicated Polychromes, and Black-on-Orange will also be considered as aggregate pottery types (Table 5.3).

Table 5.3 Aggregated variant pottery types.

Aggregated Variant Pottery Types	Pottery Types	Pottery Type Descriptions	Counts	Percents
7 COMP	7s COMP;	Complicated Polychrome, Lacking White Underslip;	307	6.81
	7t COMP	Complicated Polychrome with White Underslip		
WBR	24 WBR;	Framing White-and-Black-on-Red Polychrome;	219	4.86
	26 WBR	Splashy White-and-Black-on-Red Polychrome		
57 BLOR	57a BLOR;	Black-on-Orange (black rim only)	127	2.82
	57b BLOR;	Black-on-Orange (black rim and horizontal bands)		
	57c BLOR	Black-on-Orange (complicated designs)		
		Middle Postclassic pottery	**4510**	**100.00**

Visual Distributional Analysis

I use the visual depiction of each different pottery type's percentage per residential mound for all 65 collections to develop preliminary assessments of whether exchange is restricted or open. The expectations are as follows: if the changes between percentages of a pottery type among residential inventories are relatively smooth and gradual, then its exchange is open; if the changes are abrupt and many collections lack the pottery type, then its exchange is restricted. The total amount of Postclassic pottery per residential mound collection is of great importance to the distributional analyses. Each collection must be sufficiently large because many of the decorated pottery types being analyzed are between 2

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to 4 percent of the total Postclassic pottery apiece (Table 5.2). Therefore, if residential mound collections fall under 20 sherds, these rarer types are not likely to be found due to sampling vagaries even if they weren't restricted in access. To address this issue, I will refer to Figure 5.1, which shows the Postclassic counts of all pottery materials ordered by the weighted mound volumes from larger to smaller, to address potential residential mound collection sample size issues for each pottery type.

In Chapter 4, a total of five collections (1341, 1692, 1099, 1511, and 5456) were identified as being ambiguously associated with the Middle Postclassic period. These collections were specially marked during the analyses to see if they were the source of aberrant patterns. In the charts, these collections are indicated by grey bars for their percentage values and by an asterisk when they have zero values for a pottery type.

Finally, the weighted mound volumes established as proxies for socioeconomic rank in Chapter 4 are incorporated into the visual depiction (Figure 5.2). I show each individual residential mound's percentage ordered by the weighted mound volumes from larger to smaller volumes listed in order from left to right. Although the weighted mound volumes are a continuum of sizes, at the halfway point in Figure 5.2 somewhere between Groups 1-3, and Groups 4-5 is the point at which the changes in weighted volumes becomes fairly smooth and gradual. This halfway point in Figure 5.2 is a useful division to classify the mounds as large versus small for the purposes of discussion. I will refer to the

145
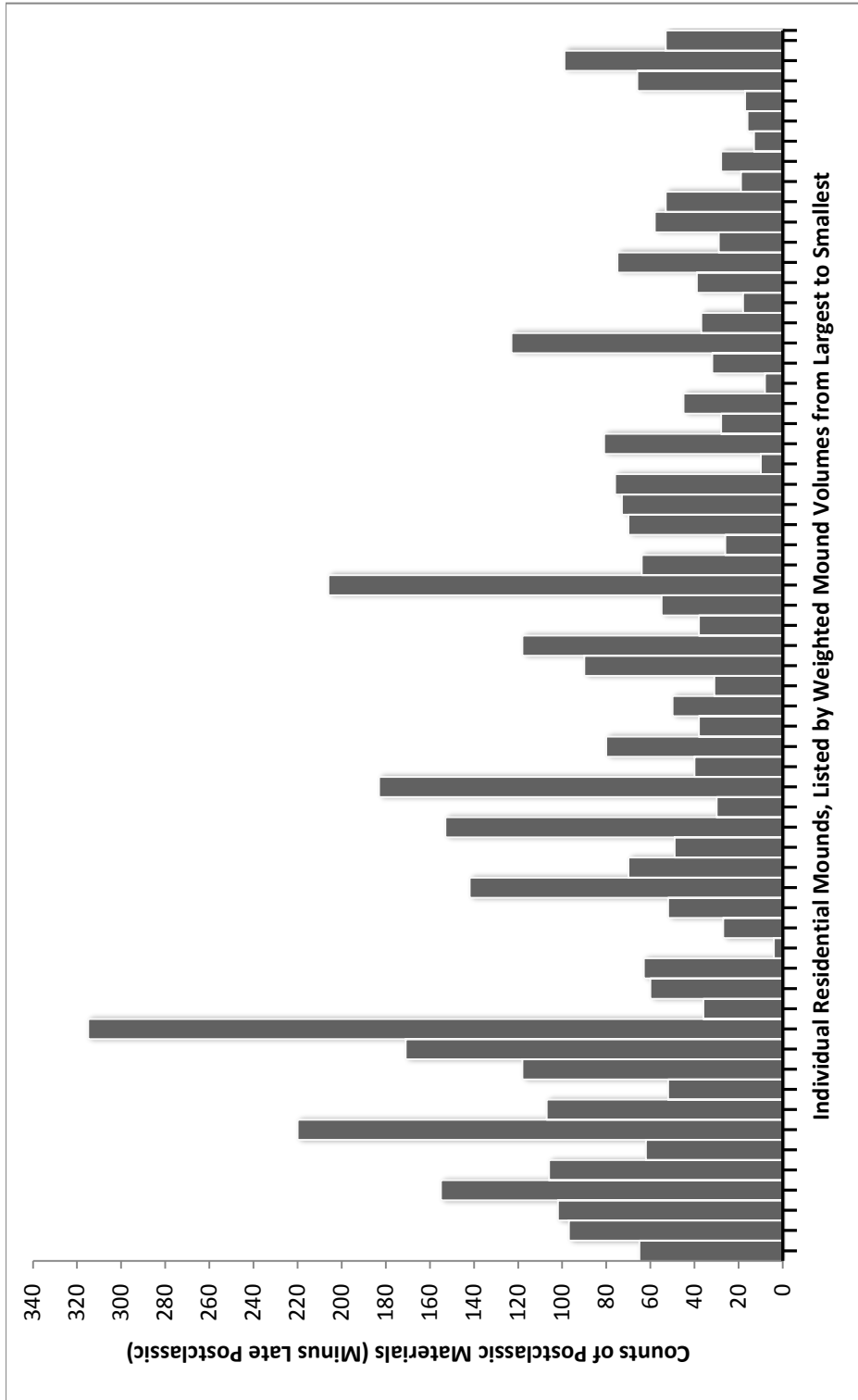
Figure 5.1 Postclassic pottery counts, excluding Late Postclassic

left half of the figure as the "larger" mounds and the right half as the "smaller" mounds.

   Black-on-Red and Miscellaneous Polychrome. The two most numerous pottery types, Black-on-Red (7a, b, c, d, f and some e BLRD) and the Miscellaneous Polychromes (7w MISC), were found in almost every residential mound collection. The Black-on-Red pottery type shows only a few minor gaps in residential collections, two of which were associated with chronologically ambiguous collections (Figure 5.3). The variations in percents are not markedly different for the larger mounds than the smaller mounds. Overall, the gradual changes in percentages show remarkable similarities among the differential mound volumes despite the occasional spikes (Figure 5.4).   Finally, most residences have Black-on-Red, which is a good indicator that access was open for this type.

   For the Miscellaneous Polychromes (7w MISC), every residential mound collection had at least a few of this type, which is a good general indicator of open access (Figure 5.5). Some of the particularly high percents, especially in the smaller mounds (on the right side of the chart) are based on the fact that many of the much smaller eroded pottery collections were from smaller mounds (Figure 5.5). Miscellaneous Polychrome was often the only type that could be identified in eroded collections. Other pottery types when eroded were probably identified as Miscellaneous Polychrome, which elevates its percents in some of the smaller collections (Figure 5.6). Generally, Miscellaneous Polychrome appears to be openly exchanged.

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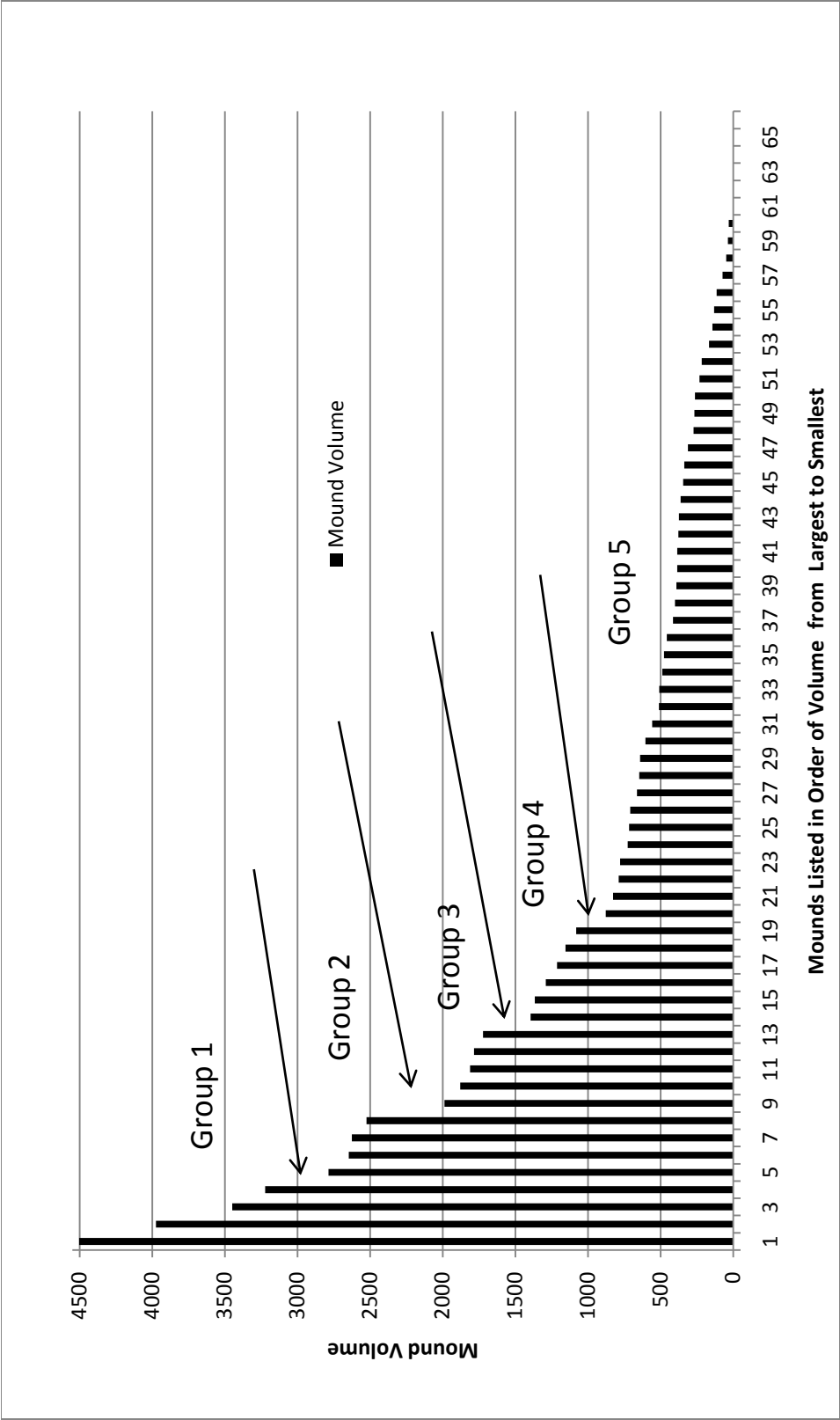
Figure 5.2 Mound volume weighted with Postclassic pottery percentages.
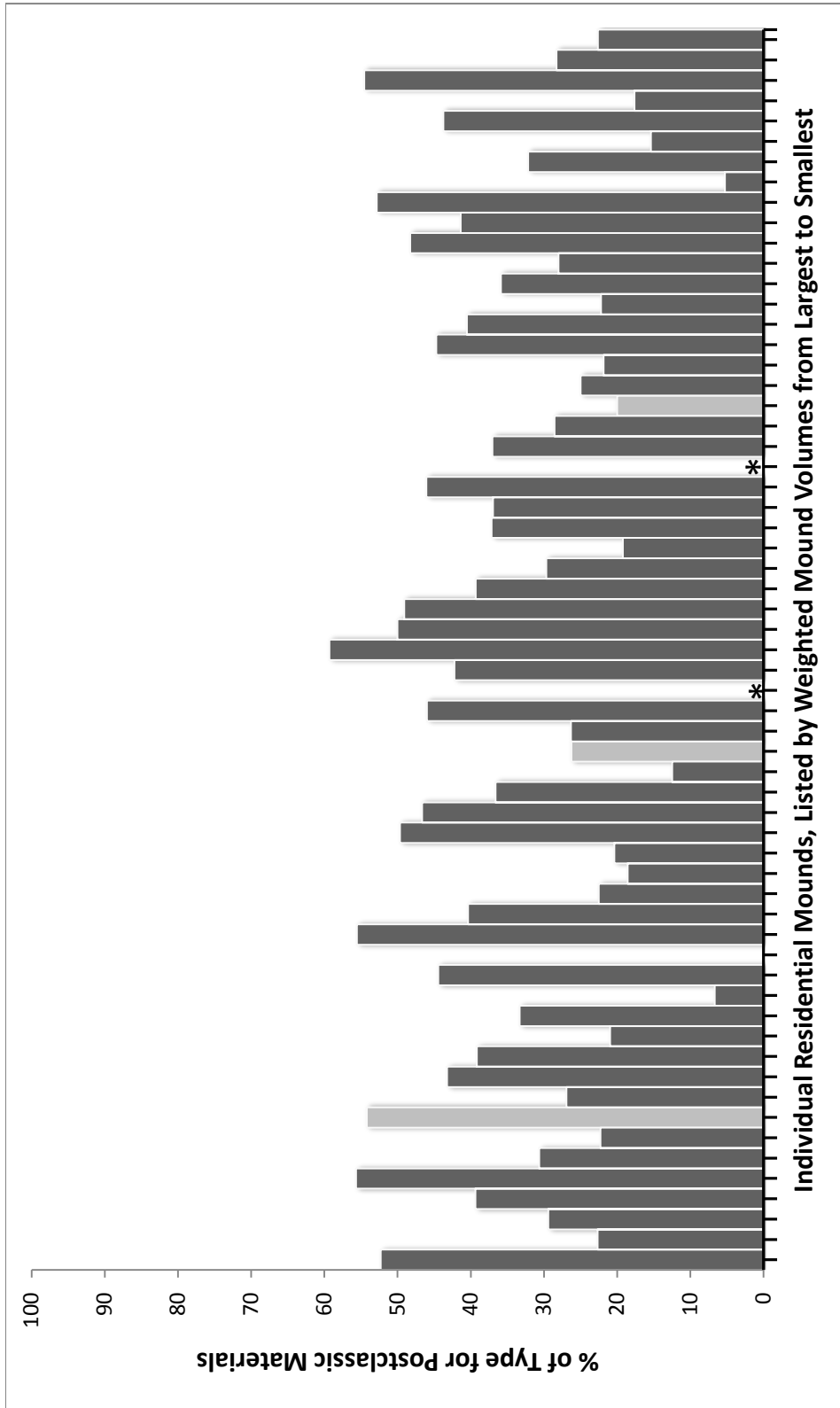
Figure 5.3 Black-on-Red percents.
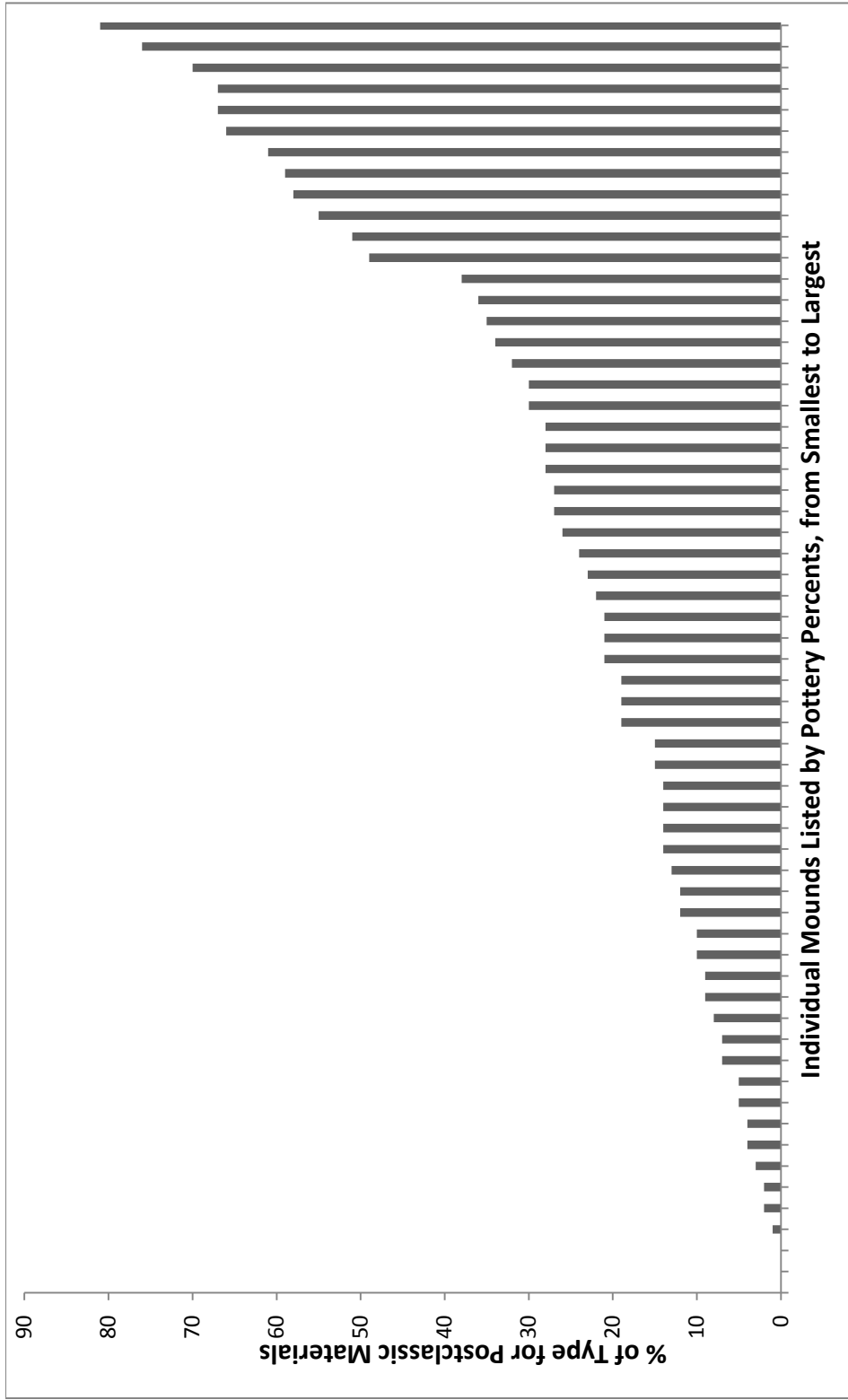
Figure 5.4 Black-on-Red percents in order of amount.

Buff Comals. Buff comals were found in almost every residential mound (Figure 5.7). This is to be expected as they are an everyday cooking item that many people would have owned (Nelson 1991:166). Some residences were missing comals, possibly due to some sampling vagaries, as this was not the most numerous of the pottery categories, with a total of 192 sherds (see Table 5.2). Additionally, two of the collections missing comals were from chronologically ambiguous samples. The overall patterning suggests that the exchange network for this item was open rather than restricted. The two collections (395, 1002) that show unusually high percents of comals are very close to a recognized likely production area for comals (see Curet 1993) and so are anomalies in the pattern (Figure 5.8).

Complicated Polychromes. The two versions of Complicated Polychrome have some patterns that contrast with the previous pottery types. Complicated Polychrome, Lacking White Underslip (7s COMP) appears to be more consistently present among the higher half of the weighted mound volumes (see Figure 5.9). This pattern is possibly a case of differential access based on socioeconomic rank because Figure 5.2 shows a general scarcity of this pottery at smaller mounds. However, there are enough gaps to suggest that the Complicated Polychrome, Lacking White Underslip, could be partly restricted or perhaps expensive enough to be absent from many residential mound collections with low artifact counts that are also associated with smaller mounds with lower socioeconomic ranking (Figure 5.10).
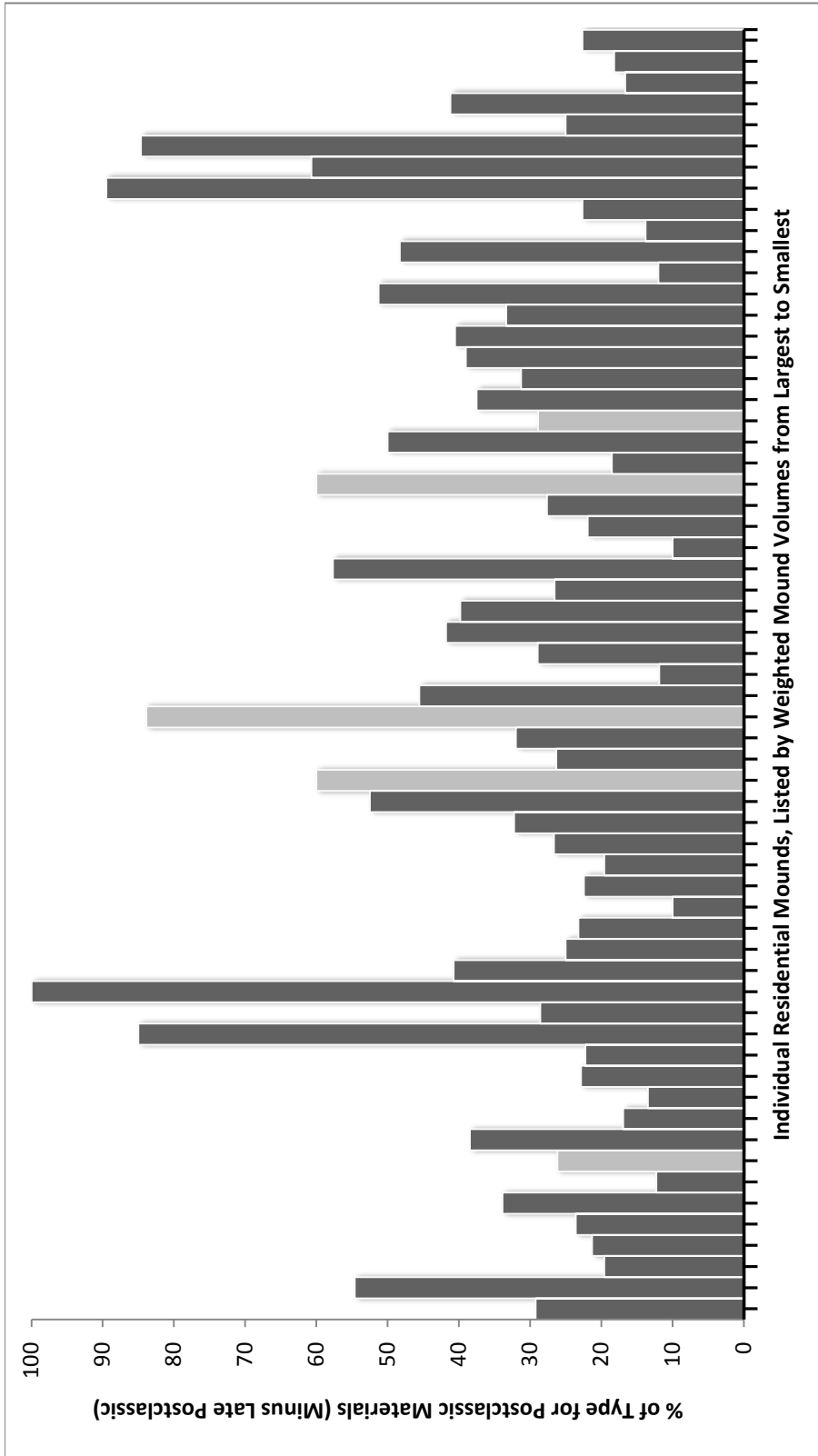
Figure 5.5 Miscellaneous Polychrome percents.
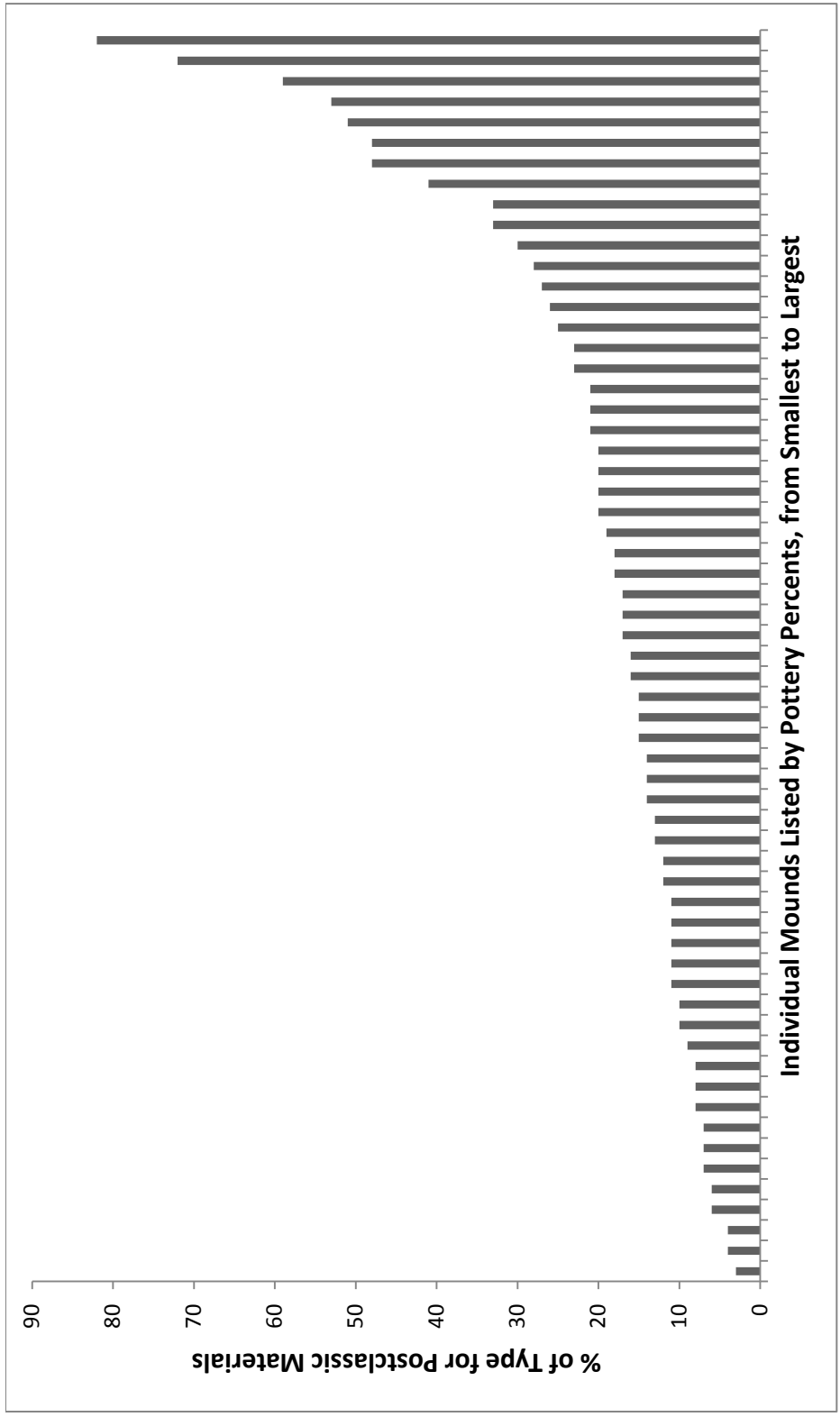
Figure 5.6 Miscellaneous Polychrome percents in order of amount.
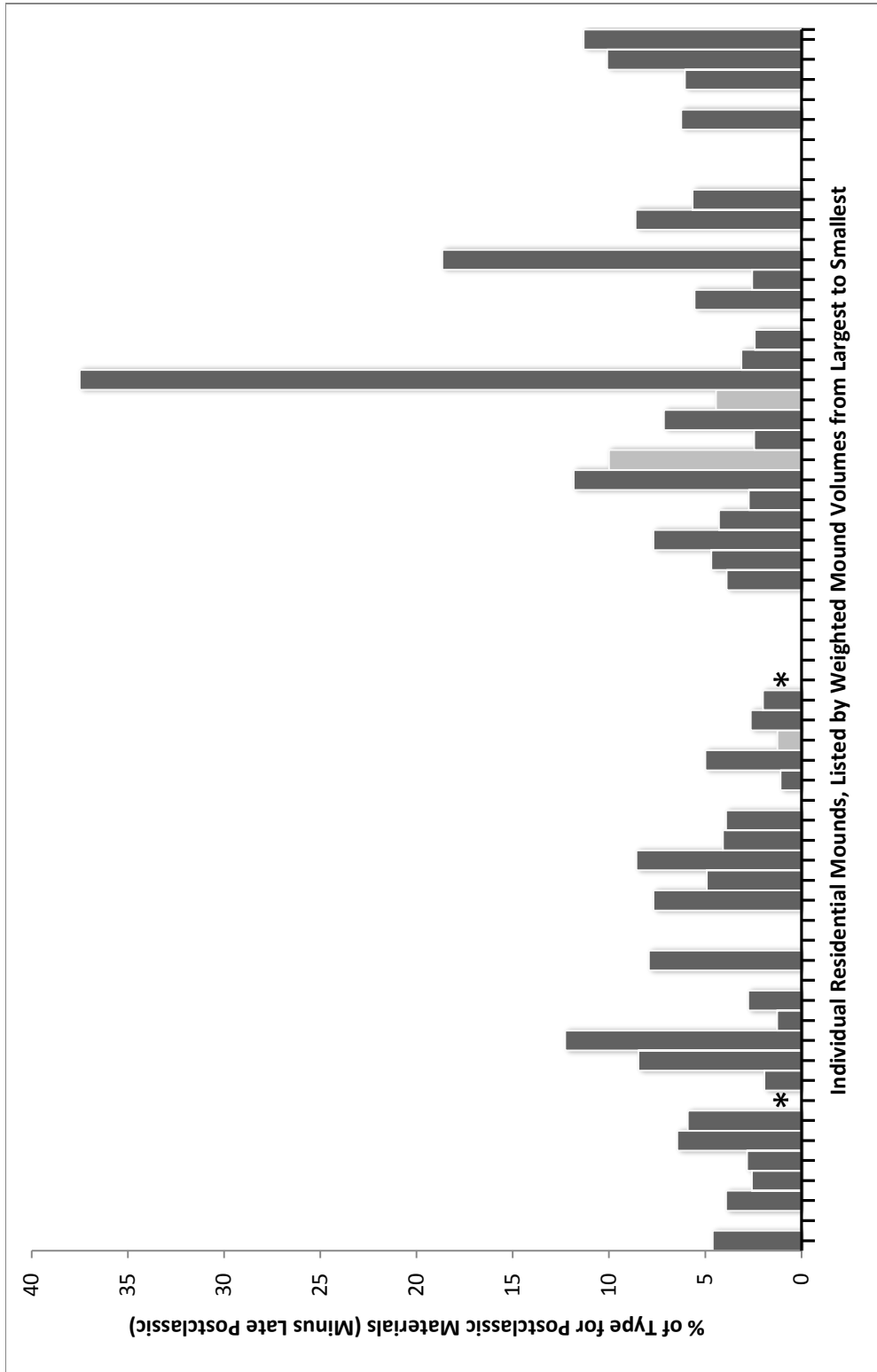
Figure 5.7 Buff Comal percents.
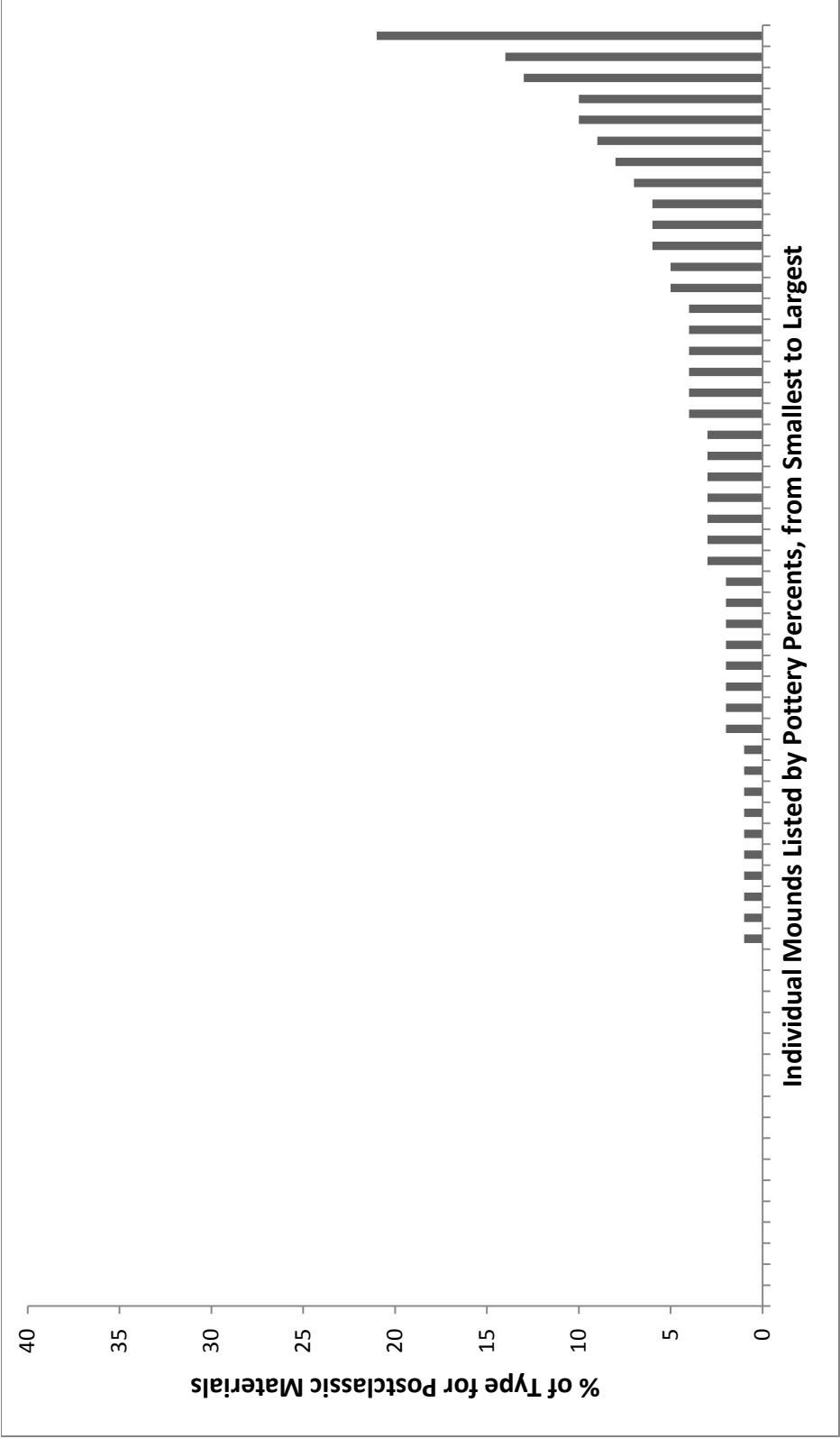
Figure 5.8 Buff comal percents in order of amount.
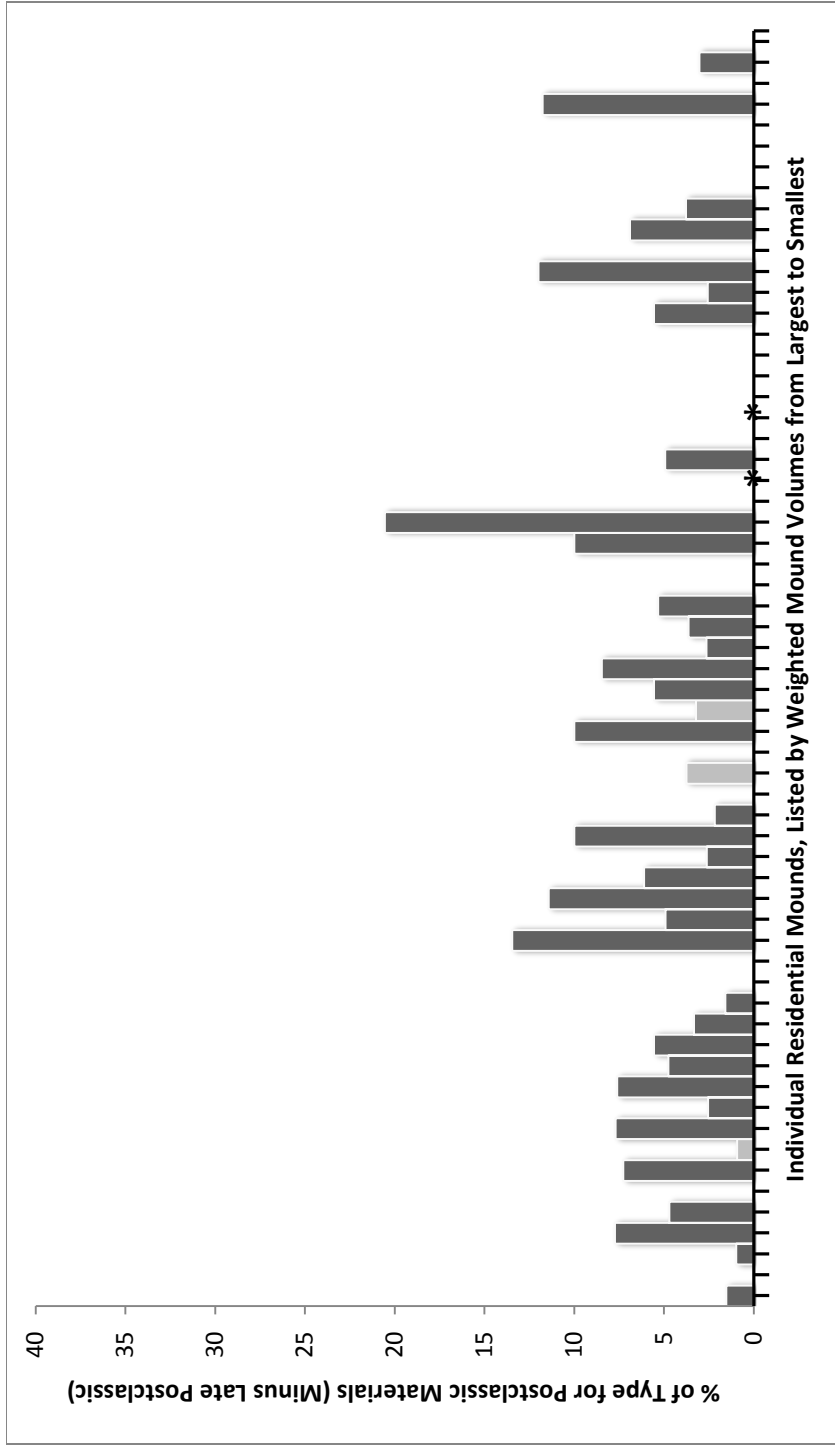
Figure 5.9 Complicated Polychrome, lacking White Underslip percents.
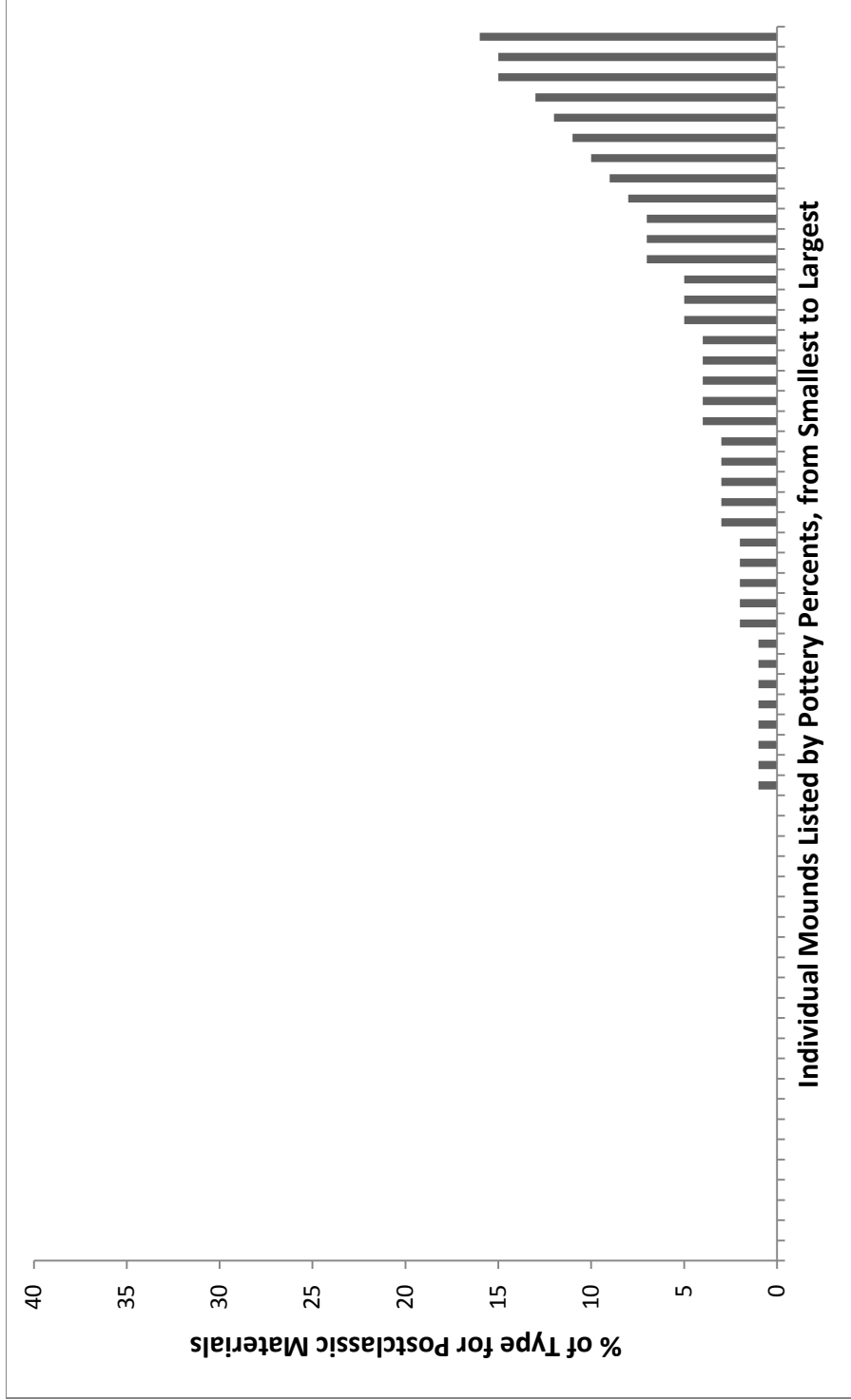
Figure 5.10 Complicated Polychrome, lacking White Underslip percents in order of amount.
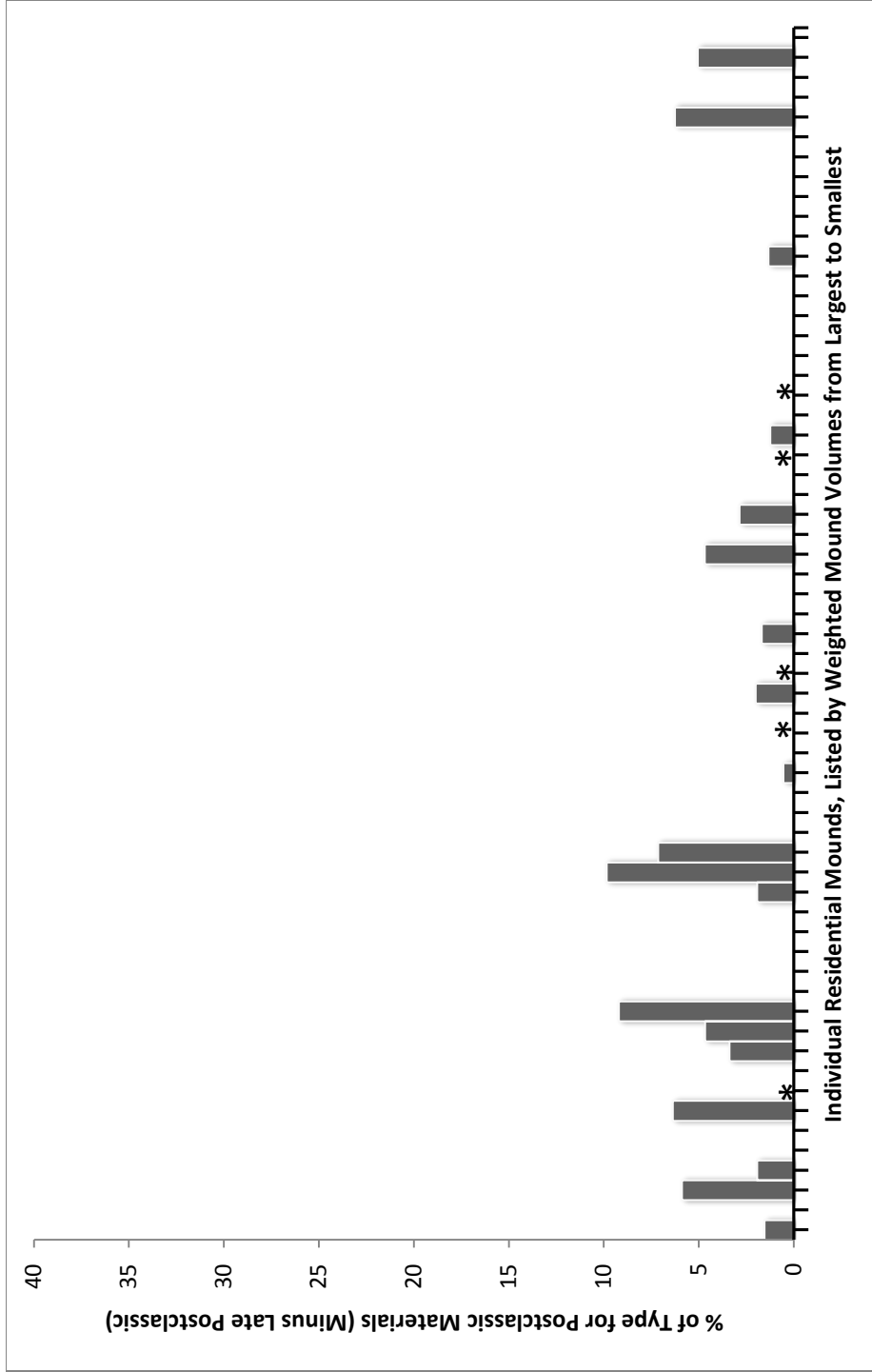
Figure 5.11 Complicated Polychrome, with White Underslip percents.
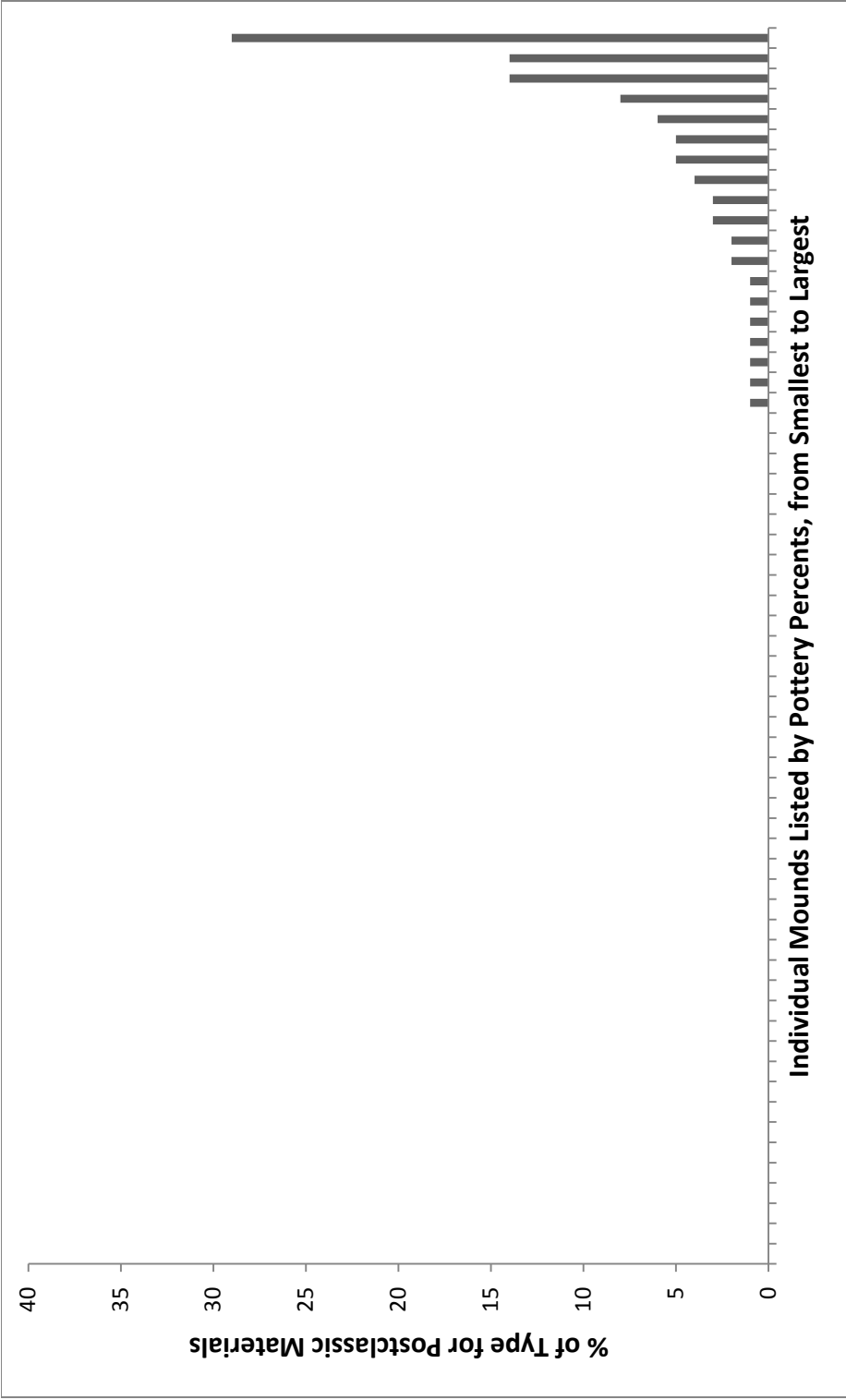
Figure 5.12 Complicated Polychrome, with White Underslip percents in order of amount.
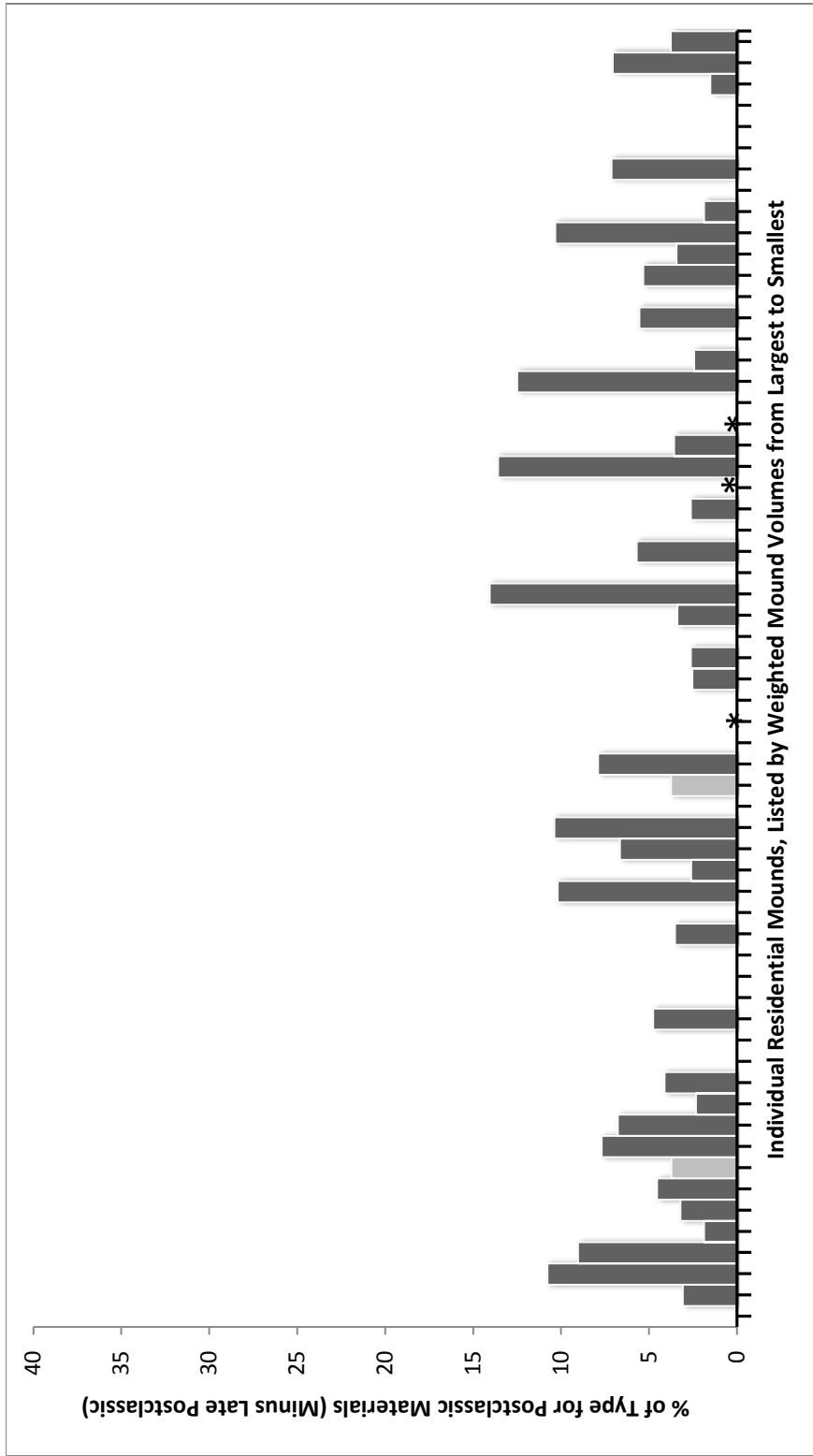
Figure 5.13 Splashy White-and-Black-on-Red percents.

Complicated Polychrome with White Underslip is rarer than its

counterpart, Complicated Polychrome, Lacking White Underslip (Table 5.2).

Due to the much lower total, 106 sherds, it is much harder to generalize about the

distributional patterns. More of this pottery type is located at the larger mounds,

possibly suggesting restricted access (Chart 5.11). None of the five

chronologically ambiguous collections have this type, but the low artifact count

makes it difficult to make too much of this pattern. Like its counterpart, there are

enough gaps in presence to be investigated more thoroughly by the network

simulation to see if these represent real differences in distribution that could

indicate restricted access (Figure 5.12).

Splashy White-and-Black-on-Red. The polychrome Splashy White-and-

Black-on-Red appears in the majority of residential mound collections (Figure

5.13). Additionally, gaps in presence do not appear to be strongly correlated with

the smaller mounds, although the larger mounds all have this pottery type (Figure

5.2, 5.13). There are some considerable spikes in percents, but these may owe

more to the vagaries of sample size than to differential distributional patterns

(Figure 5.14). Overall, inspection of the chart strongly supports open access

exchange for this pottery type.

Black-on-Red Incised. For Black-on-Red Incised, the patterning is more

consistent with open access rather than restricted access (Figures 5.15, 5.16).

Although there are gaps in the presence of this type, many gaps appear to be

correlated with those residential collections with much lower Postclassic counts in

general; four of the five chronologically ambiguous collections have none of this

type (Figure 5.2). Additionally, although many of the residential collections from the larger weighted mound volume groups have this type; it is by no means obviously restricted to them (Figure 5.15).

Dull Buff Polychrome. By comparison to the previous pottery types, the Dull Buff Polychrome percentages are much more abrupt in changes among collections, and they are absent from many collections altogether (Figures 5.17, 5.18). Interestingly, one of the chronologically ambiguous collections has a small percentage of this type. Dull Buff is a pottery type spatially associated with the Sauce center (Garraty and Stark 2002: 13), and access to this type appears to be different from the other polychromes; Dull Buff may represent a pottery type to which access was largely restricted to social network exchange rather than market exchange.

Escolleras Chalk. For Escolleras Chalk, the patterning shows more restriction compared to the rest of the pottery types, but does not quite match the patterning for Dull Buff Polychrome (Figures 5.19, 5.20). For one thing, correlation of this type with the residential collections from the larger mounds is not apparent. There are some interesting gaps in percentages among collections that might represent restricted network exchange, although twice as many collections had this type than had Dull Buff Polychrome (Figure 5.20). Intriguingly, two of the collections with the highest percentage of this type were from the chronologically ambiguous collections; a total of four of the five chronologically ambiguous collections had some percentage of this type. These

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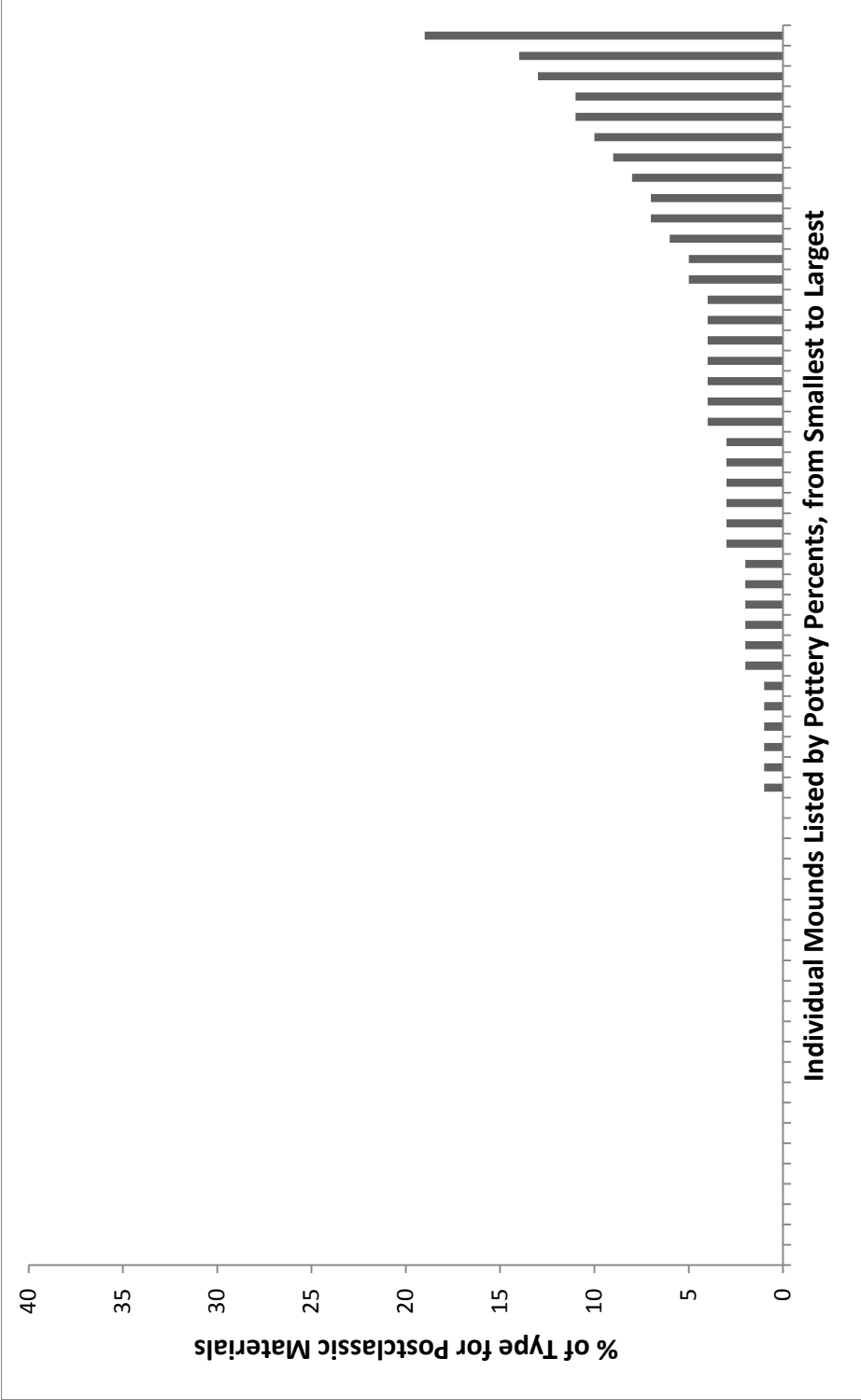
Figure 5.14 Splashy White-and-Black-on-Red percents in order of amounts.
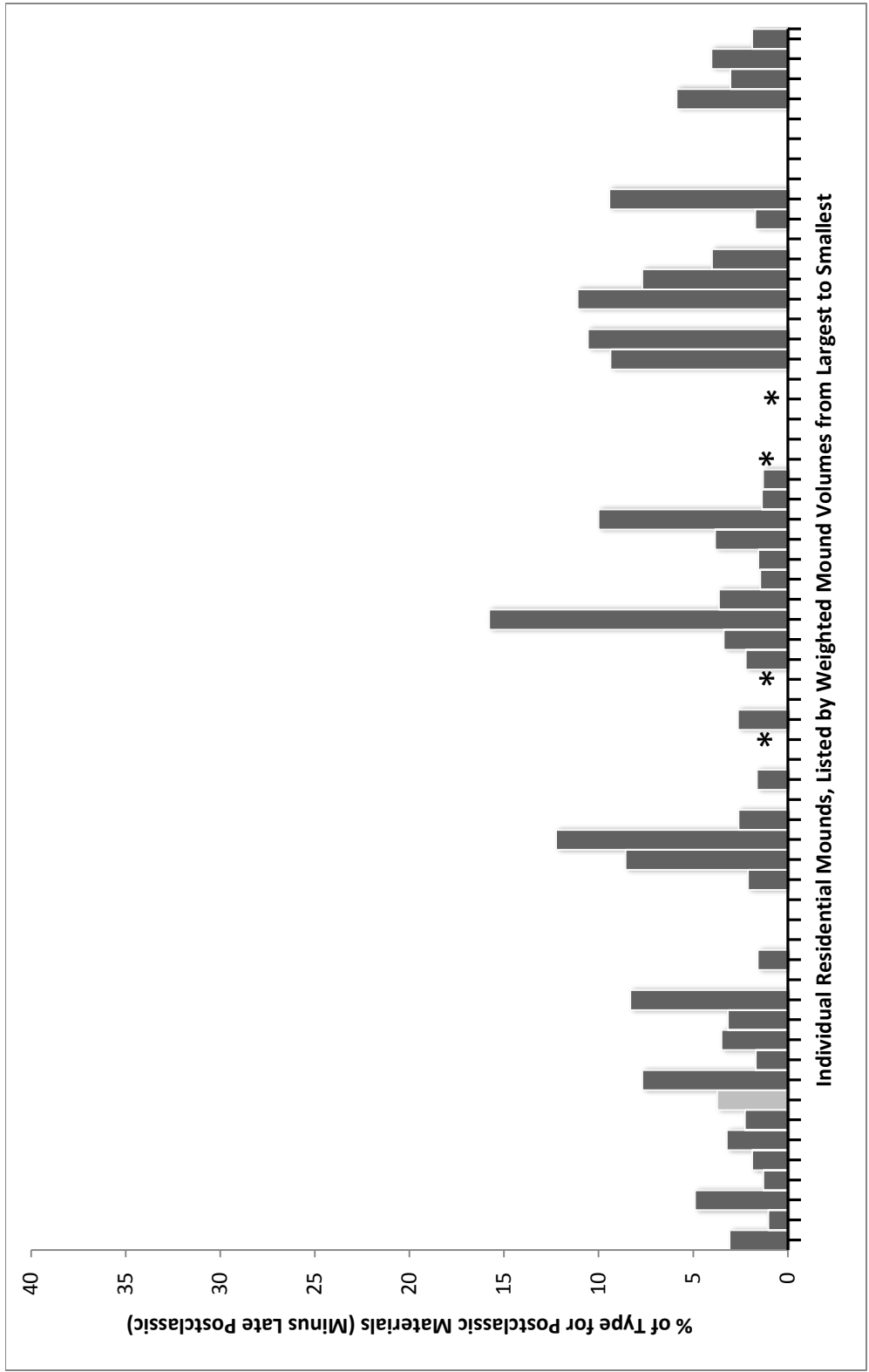
Figure 5.15 Black-on-Red Incised percents.
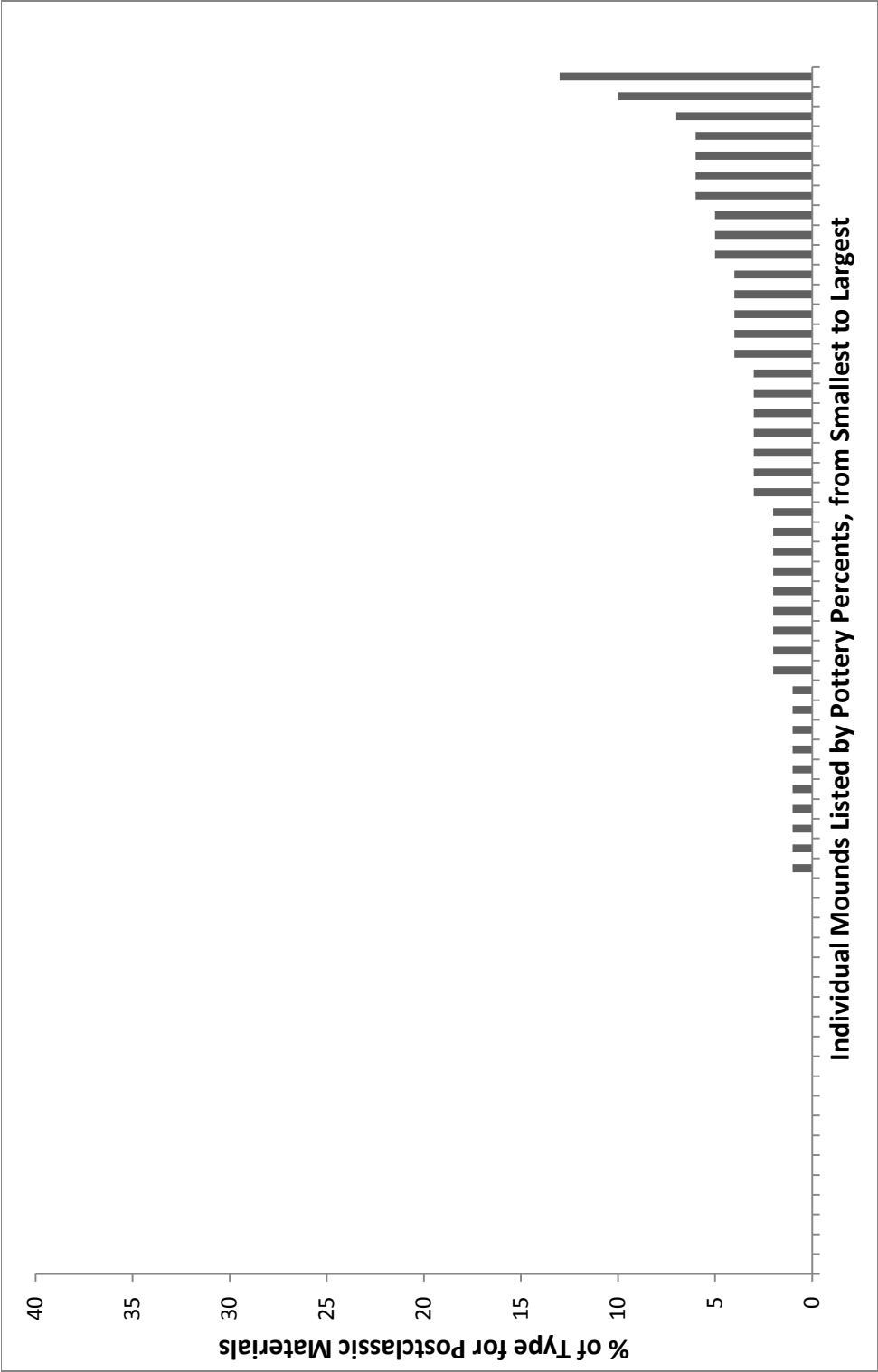
Figure 5.16 Black-on-Red Incised percents in order of amounts.
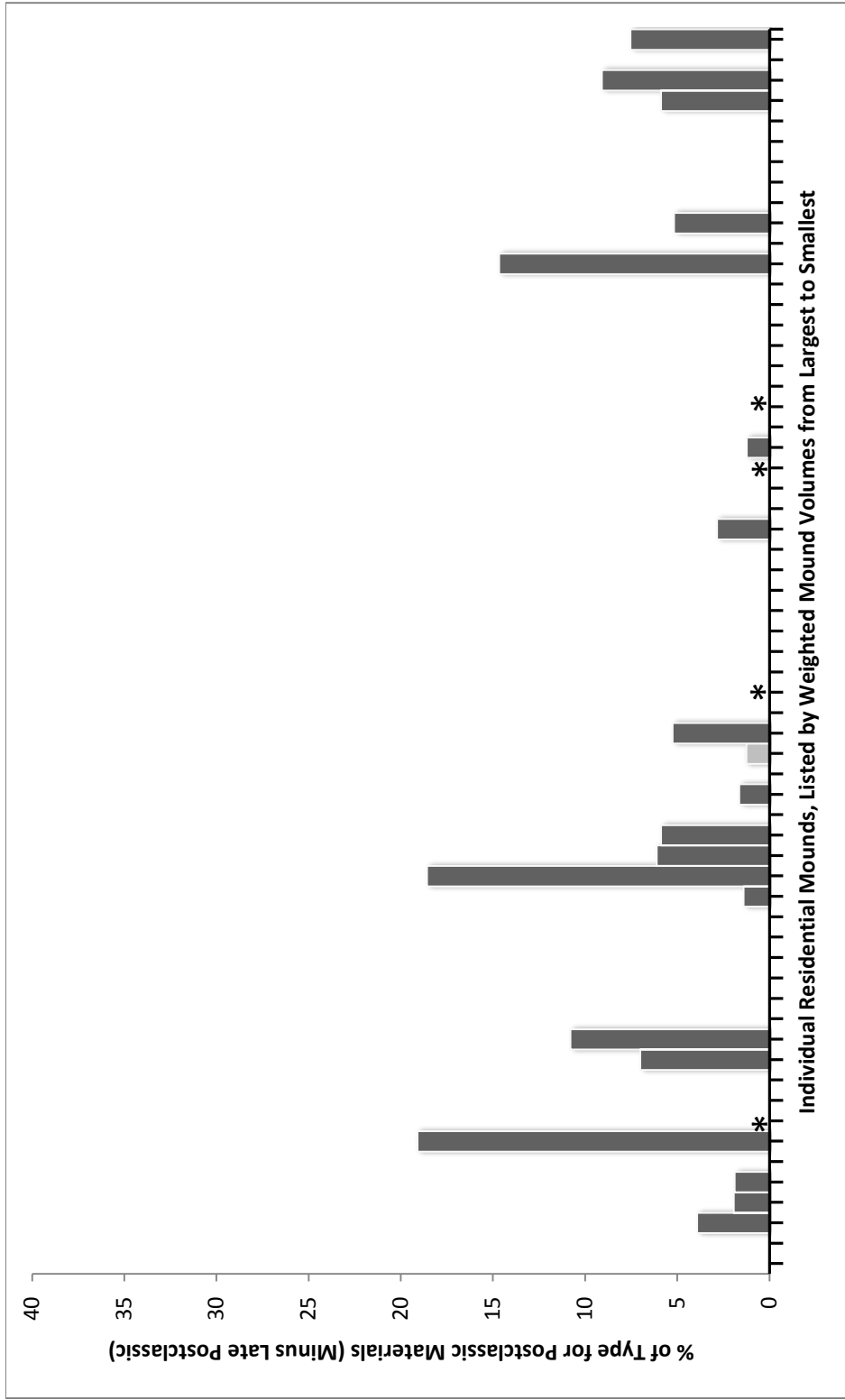
Figure 5.17 Dull Buff Polychrome percents.
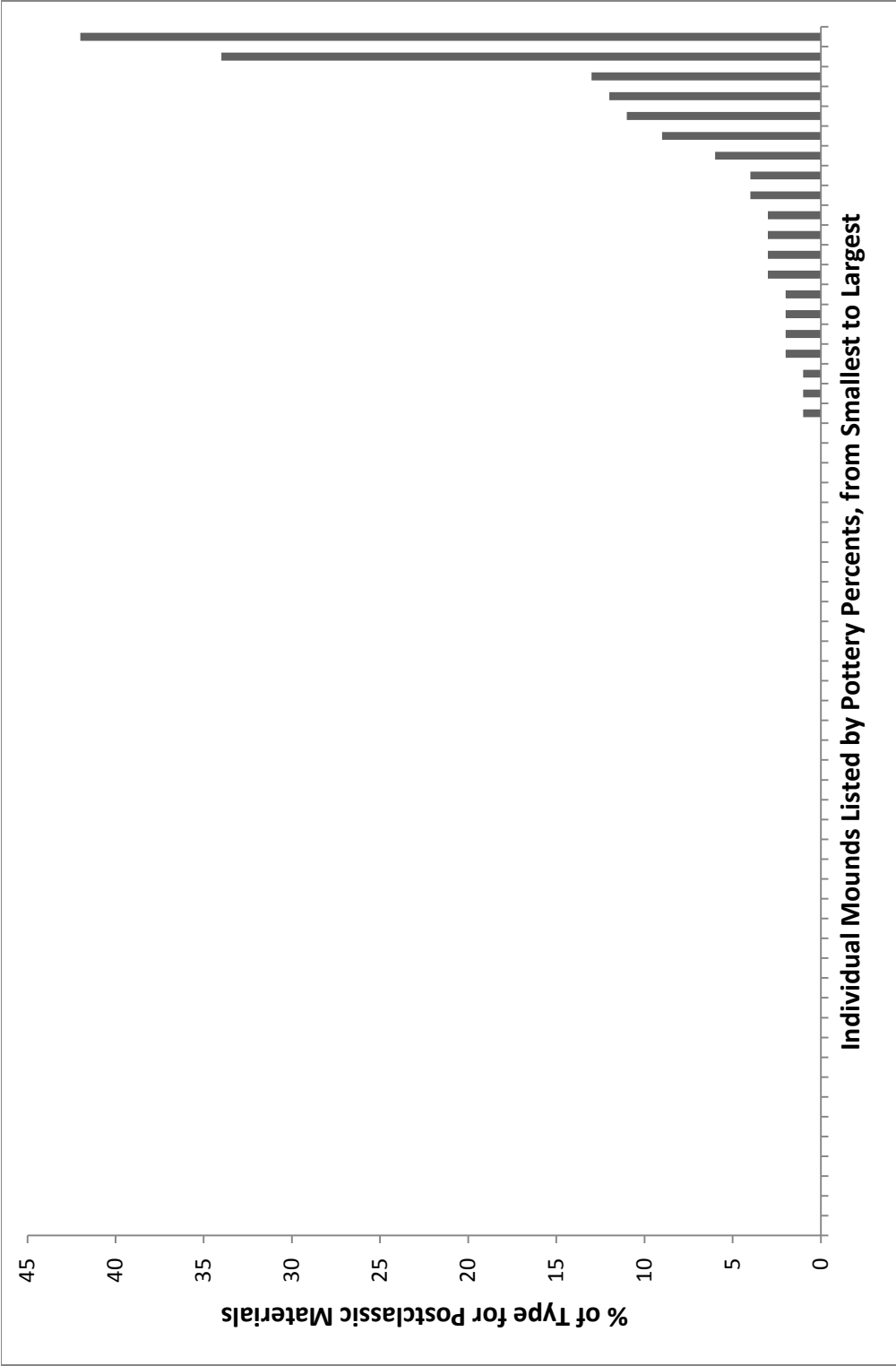
Figure 5.18 Dull Buff Polychrome percents in order of amounts.
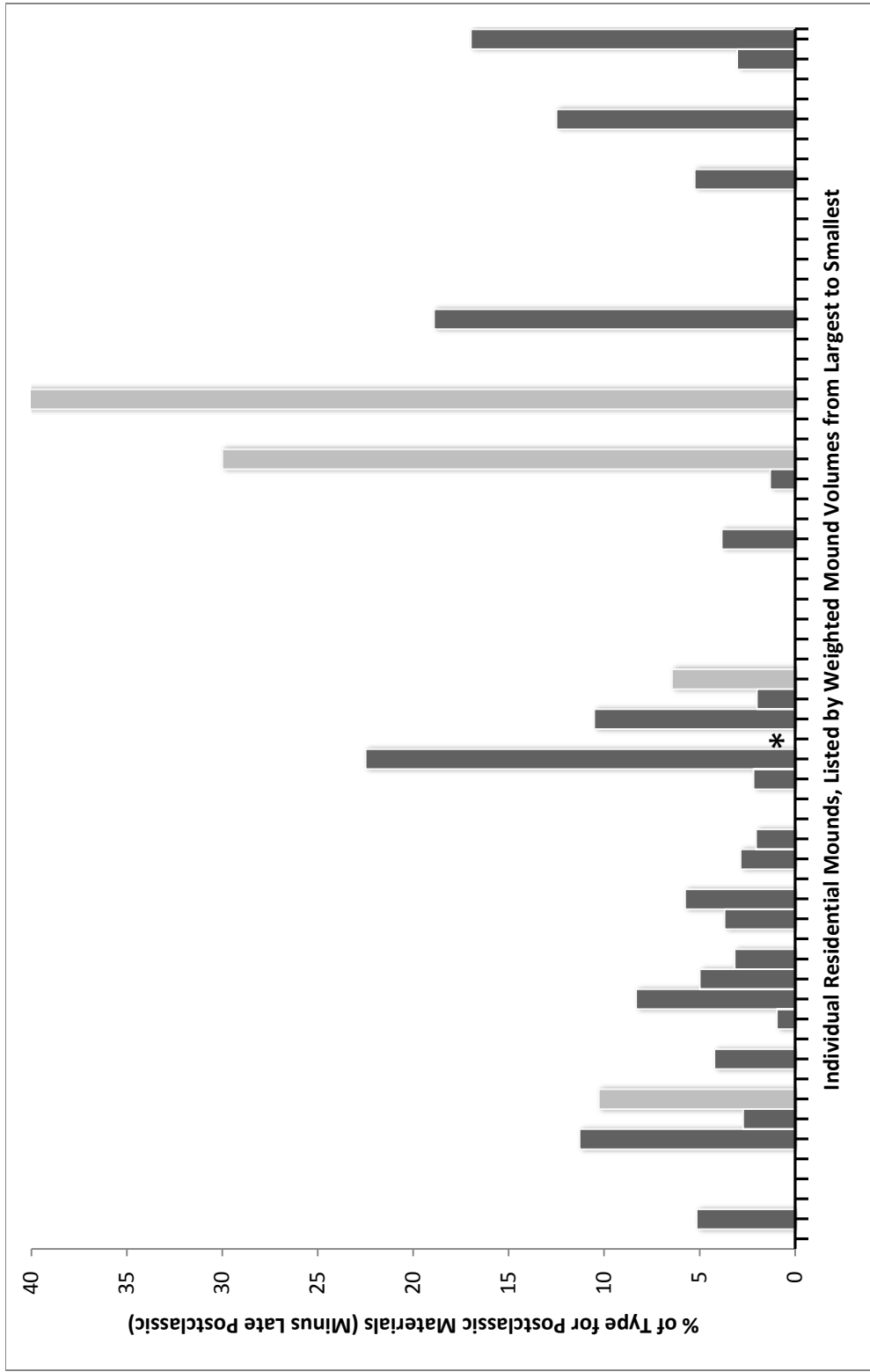
Figure 5.19 Escolleras Chalk percents.
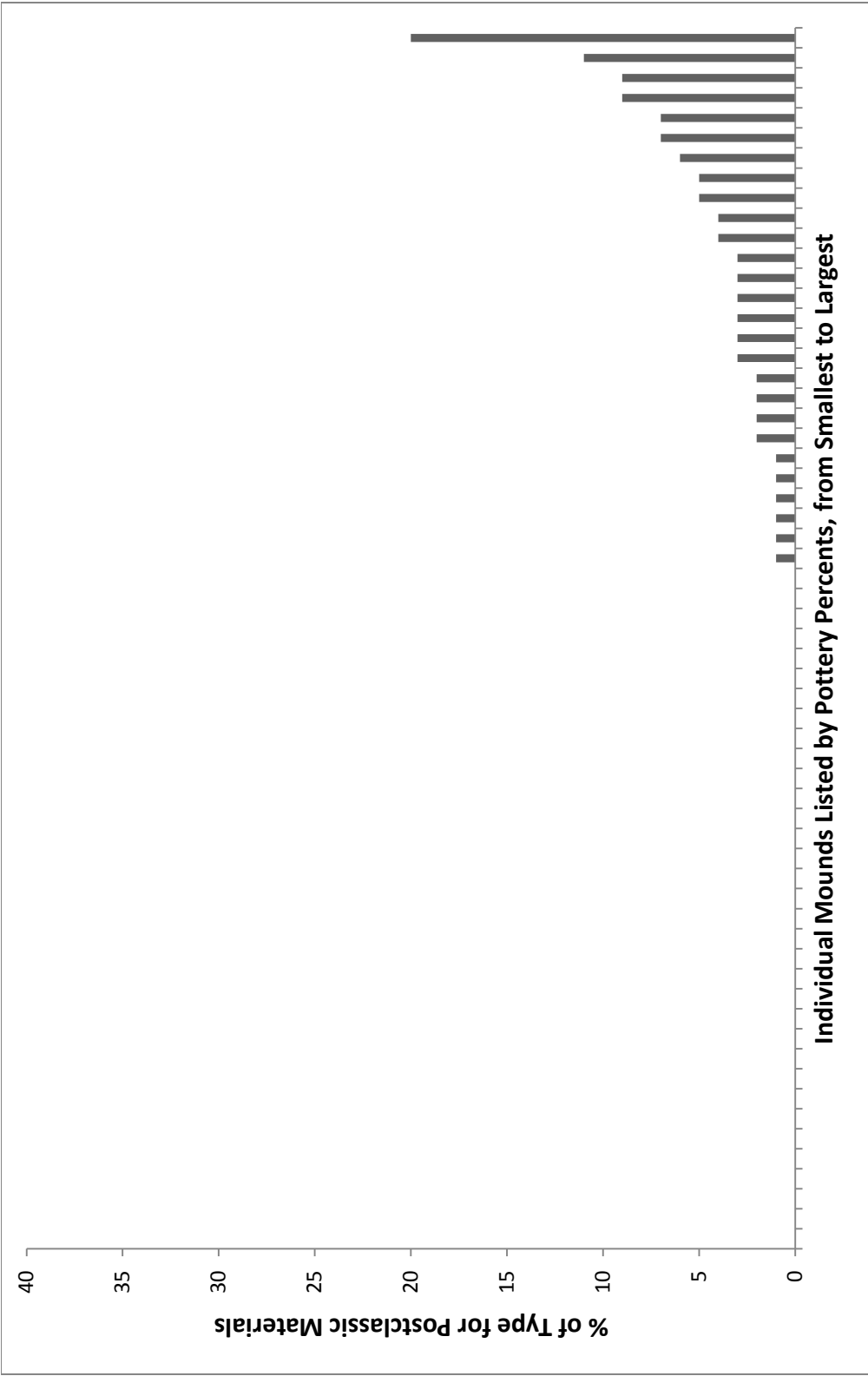
Figure 5.20 Escolleras Chalk percents in order of amounts.

findings lend some credence to a chronological component being a factor in the Escolleras Chalk patterns.

Aggregated Variant Pottery Types

The aggregated variant pottery types were created to increase sample sizes (Table 5.3). The first group is White-and-Black-on-Red, and includes both the Splashy White-and-Black-on-Red and the Framing White-and-Black-on-Red polychromes. For this category, access appears to be widespread, as was the case for the other *guinda* category, Black-on-Red (Figures 5.21, 5.22). There are some gaps in presence, but they appear to be correlated with the smaller collection sizes and at least three were from the chronologically ambiguous collections (Figure 5.21).

For the combination of two Complicated Polychrome categories (Table 5.3), patterning between the two categories is similar, and their consideration as one group does not appear to change the patterning. For this group there are gaps that cannot be explained by low counts within the residential mound collections nor can they completely be explained by chronology since only two of the chronologically ambiguous collections had none of this group (Figure 5.23). The presence and higher percents of this type in the larger mounds could indicate a strong socioeconomic component to possession of this pottery type (Figures 5.23, 5.24). It is not clear from the direct distributional analysis whether this type is restricted or not, but the simulation may provide more insights.

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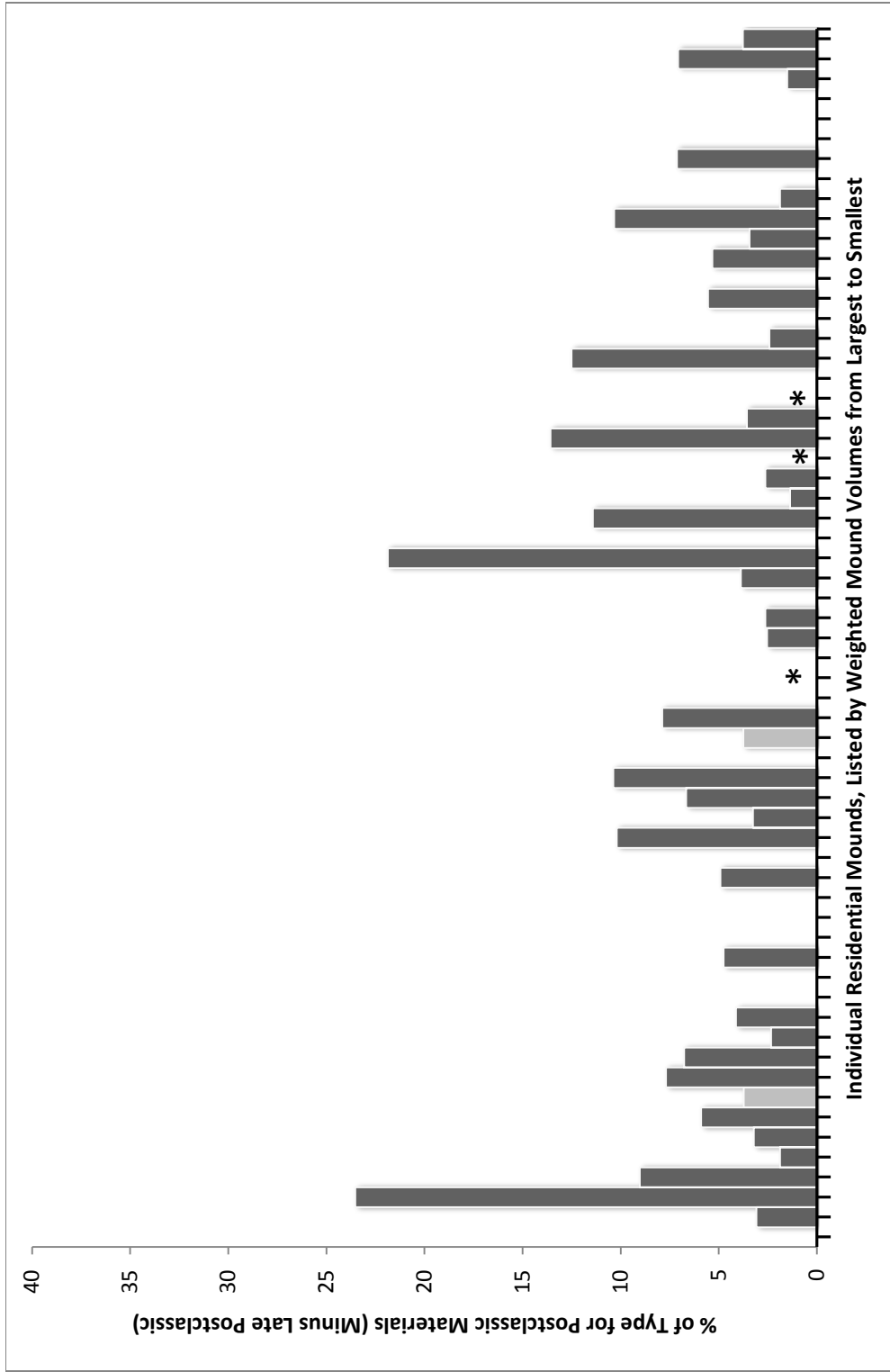
Figure 5.21 White-and-Black-on-Red percents.
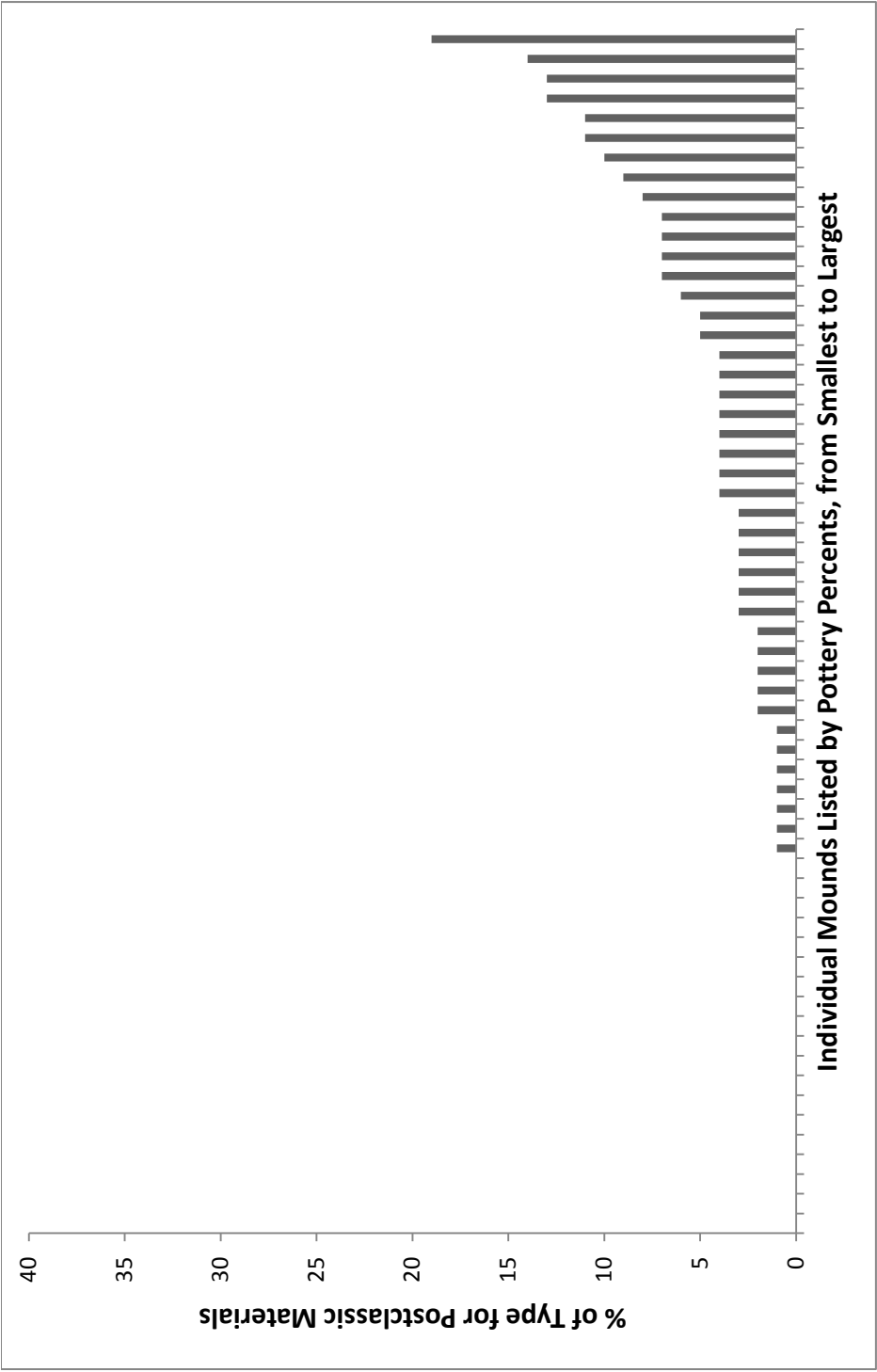
Figure 5.22 White-and-Black-on-Red percents in order of amounts.

X-axis label: Individual Mounds Listed by Pottery Percents, from Smallest to Largest

Y-axis label: % of Type for Postclassic Materials
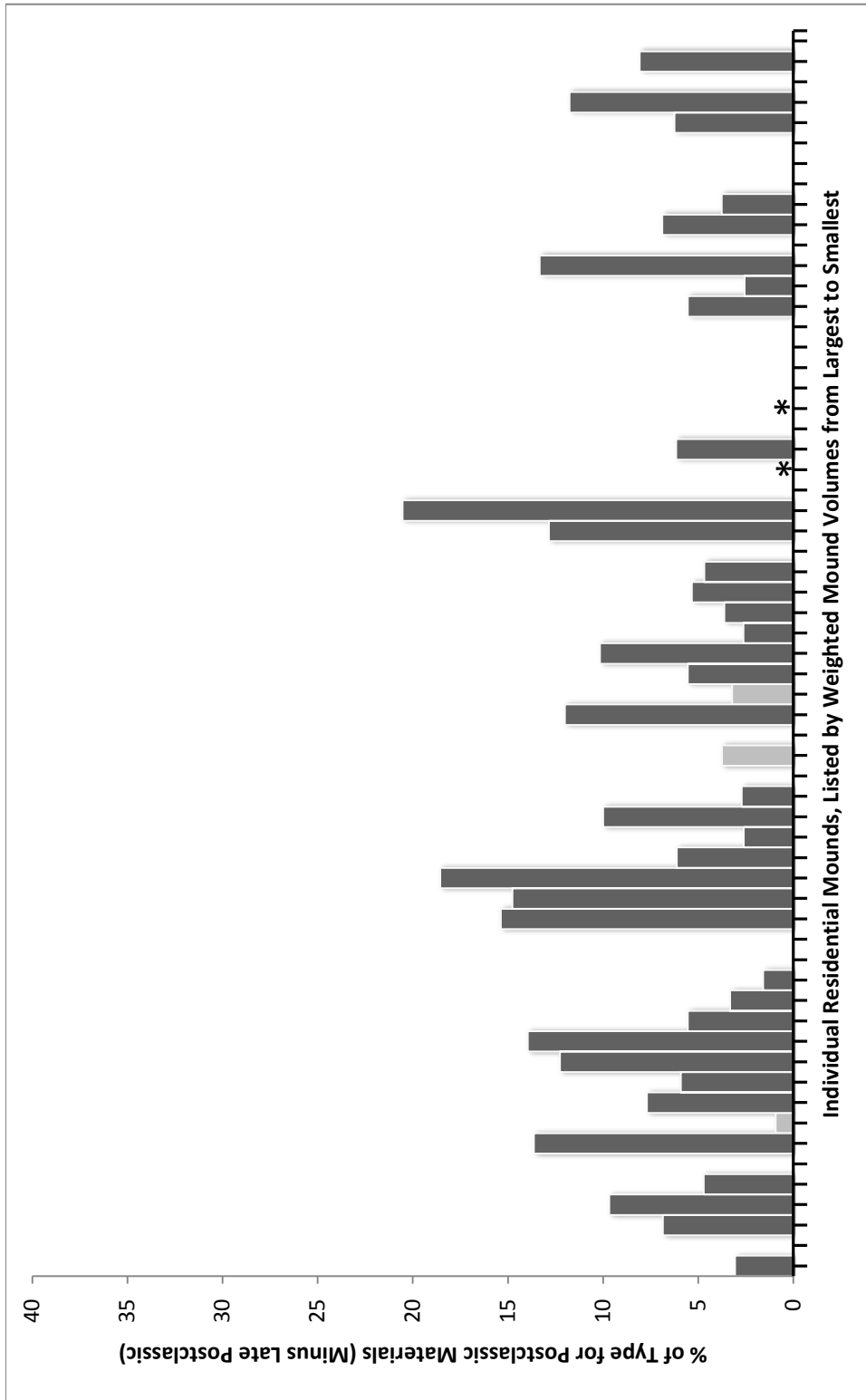
Figure 5.23 7 Complicated Polychrome percents.

Finally, the last pottery group category is a set of Black-on-Orange variants (Table 5.3). Of these variants, Black-on-Orange with complicated designs has the largest quantity, 85 sherds. The other two variants of Black-on-Orange are so small, at 32 and 10 sherds apiece, that they could not be considered alone. For the pooled set, there are gaps that are not explained by low sample sizes. The patterning here is remarkably similar to Complicated Polychrome, in that this group appears to be differentially abundant in the larger mounds (Figure 5.25). The absence may have a small chronological component as well since four of the five chronologically ambiguous collections were missing this type. Although this group appears to be open in exchange based on gradual percent amount changes (Figure 5.26), gaps in the smaller mounds may indicate a socioeconomic component to access, although we cannot be certain based on visual methods alone.

Summary

From my initial visual distributional analyses, the data support the interpretation that a mix of market and social network exchange characterized Sauce's economic and social organization. To test this possibility more rigorously, I use a simulation to establish a relative probabilistic framework within which each of the pottery type distributions may be compared with each other.

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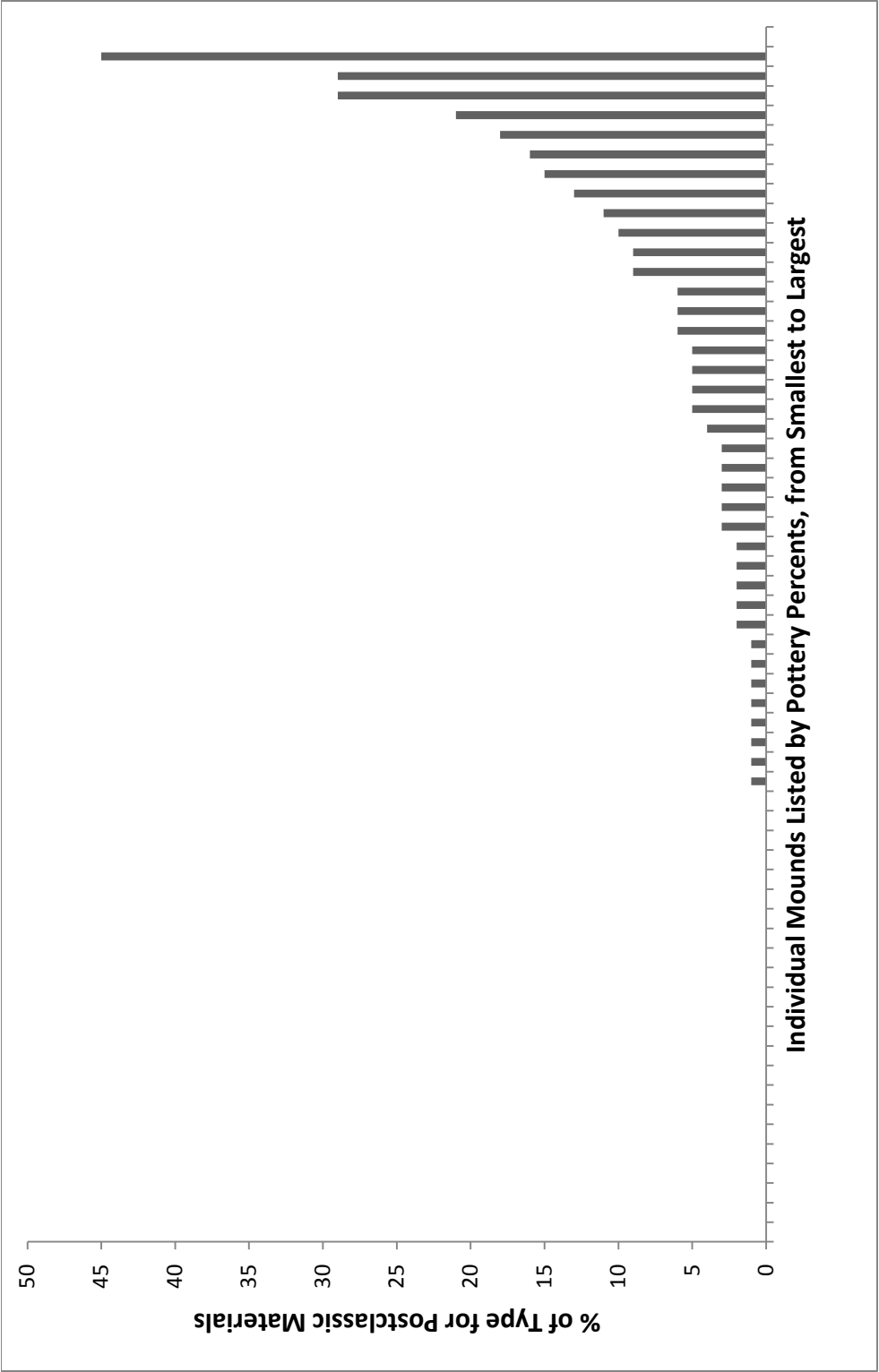
Figure 5.24 7 Complicated Polychrome percents in order.
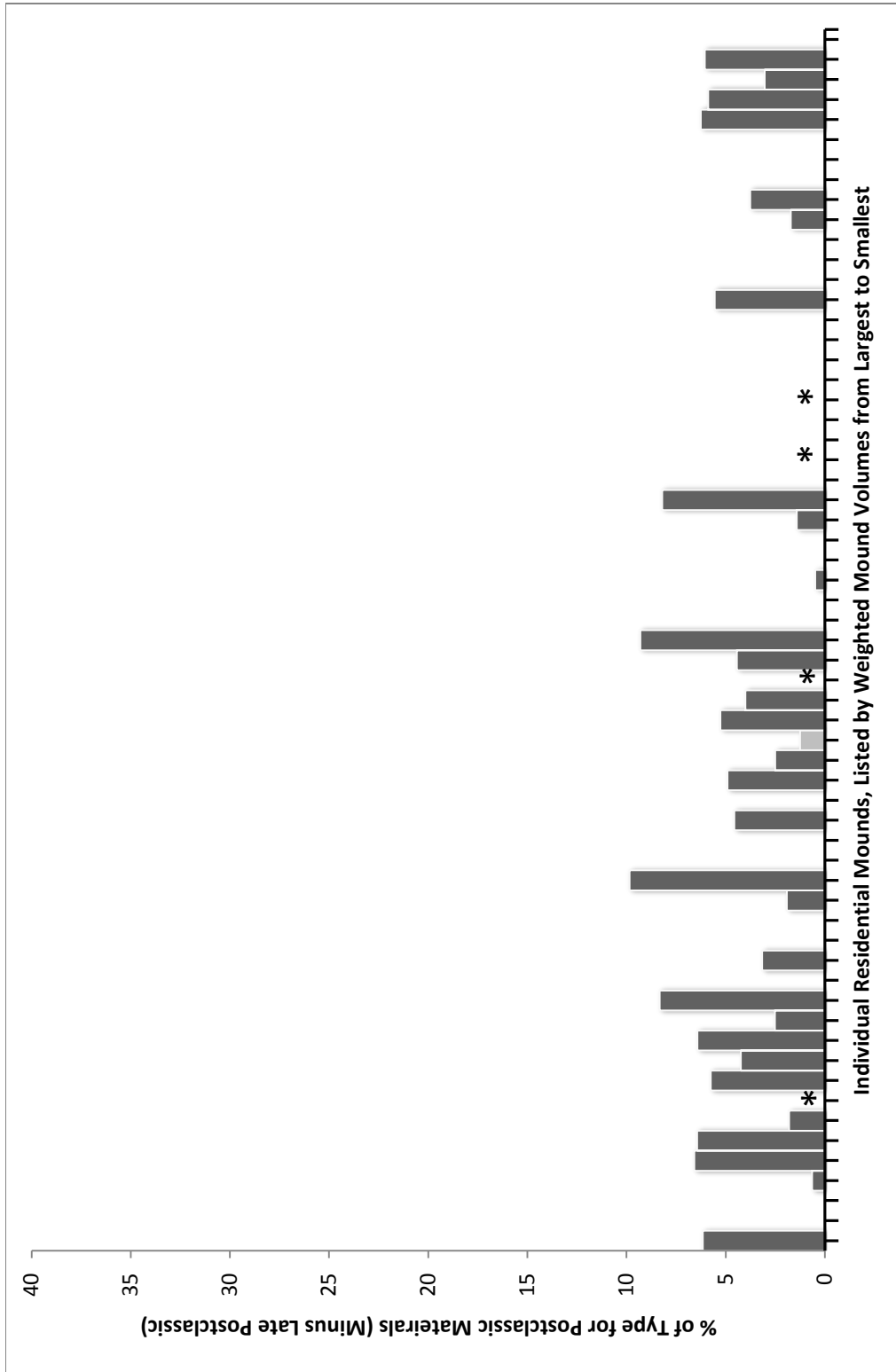
Figure 5.25 Black-on-Orange percents.
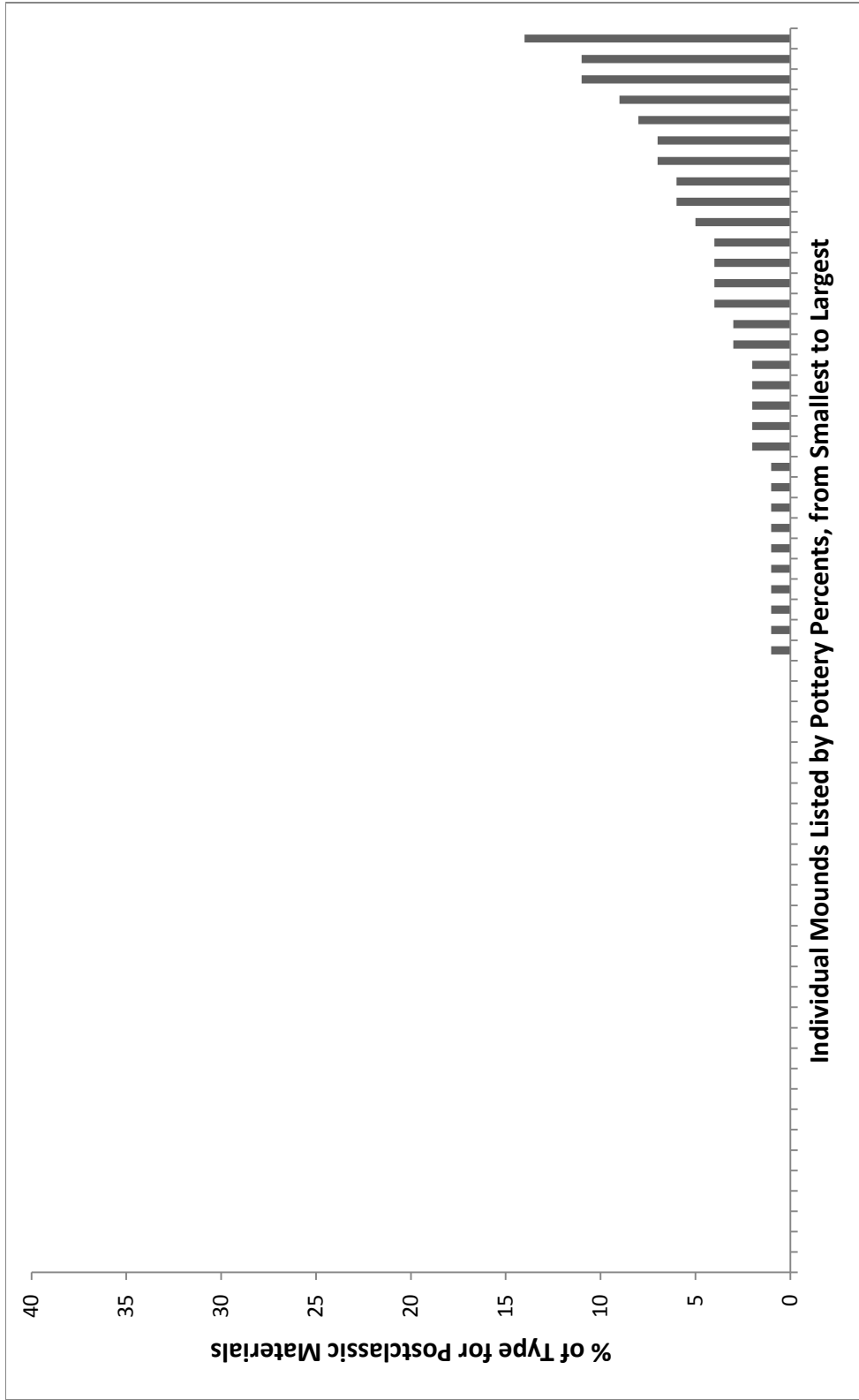
Figure 5.26 Black-on-Orange percents in order of amounts.

Network Simulation

I use a Bayesian inspired Monte Carlo simulation to generate probabilistic expectations for open access versus different forms of potentially restricted access in my dataset. Neither visual nor simulation distributional analyses alone provide a "yes or no" answer to the question of which methods of exchange were in operation in Sauce and its hinterland. Instead, my goal is to create a way of quantifying comparisons of different expectations for network exchange among the different pottery types without resorting to an arbitrarily chosen probability significance level to decide what kind of exchange was most likely. As Cowgill (1977: 367) suggests, statistical results cannot be directly converted into explanations. Instead, the statistical inferences are only part of series of related contextual data and connected reasoning about exchange networks. The purpose of applying a network simulation is to allow me to establish different probabilistic outcomes as a *relative* measure of exchange.

Bayesian statistics provide an alternative to the classical methods of statistics for hypothesis and confidence interval testing; they allow the user to affect statistical probabilistic outcomes by using information about the data distributions that were previously acquired (Iversen 1984: 70). Although I do not directly apply Bayes Theorem to my problem, I build the variations of different sample sizes of the separate residential mound collections into my model to handle uncertainty regarding the true proportions of the pottery types for each of

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the separate residential mound collections. This Bayesian inspired approach allows me to analytically separate potential sampling issues for each residential mound collection from the global totals of each pottery type whose network exchange is being tested. I begin by describing the statistical expectations for network exchange and methods of applying them to the simulation.

Definitions and Concepts of Statistical Expectations

I devised two statistically expressible methods for evaluating the expectations for open versus restricted network exchange that were outlined in Table 5.1. One method considers the population variance for an individual pottery type among all of the residential mound collections. The second measure considers the ratio of a pottery type's presence in residential mound collections compared to the set of all residential mound collections. Each method measures a distinctive aspect of the distributional approach that Hirth (1998) originally proposed, with some modifications given the practical constraints of the sample sizes for both individual units and the total number of residential mound collections. I discuss the utility of variance and pottery presence/residential collections ratios separately.

Variance is the measure of the amount of variation among all the values of a measured variable, in this case the amounts (expressed in row percentages) of a pottery type for each individual residential mound collection. Variance is calculated by taking the square of the deviation of each individual residential

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mound collection (x) from the mean (μ) (in percents), summing the result and dividing by the sample size minus one. The algebraic formula is: $Variance = \frac{\sum(x-\mu)^2}{n-1}$. Squaring the values of the deviations from the mean has the effect of magnifying the impact of outliers on the variance. The division of the squared deviations by the sample size (number of residential collections) minus one is an application of *Bessel's correction* to the variance calculation. The correction of N minus one, accounts for the fact that the true mean of a population of a pottery type is unknown because what we know is entirely derived from our sample.[1] The use of the number of cases minus one is an unbiased estimator of the variance of a population. Mathematical statisticians have proved that if one is not subtracted from the number of cases, the calculation will underestimate the magnitude of the population variance (Sokal and Rohlf 1987: 38). The obvious outcome of having the numerator divided by a smaller denominator is to make the resulting variance estimate a little larger due to our uncertainty about the accuracy of the mean. Importantly, the larger the sample size, the less difference there will be between division by N versus the correction of N minus one. I adopt the correction and use the formula for variance as the sum of the squared deviations from the mean divided by N (number of residential collection mounds) minus one. Next I consider how variance can be used to evaluate some aspects of network exchange.

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First, I describe and demonstrate the impact of the jumps in sample values on the value of variance in a distribution. According to my expectations based on Hirth's (1998) network exchange models, distributions of openly accessible products will show a lower variance than restricted products in general because of smaller differences between the percentages of a pottery type among residential mound collections. Abrupt changes in percentages of a pottery type among residential mound collections will produce higher variances if there are sufficiently high percentage collections. Additionally, the range of each individual pottery type among all the collections will have an impact. The fact that higher variances will result from abrupt changes in relative percentages of a pottery type follows from the definition of variance and has important implications for understanding the reasoning behind the statistical methods chosen for the network simulation.

Another important observation about variance concerns the impact of the sample range on the calculation of variance. The statistical range of a distribution is the full extent of its values from the highest to the lowest numbers. In comparing the variance of different distributions, range is important. If we go back and examine the variance equation again, we can see that this is because variance is most heavily influenced by the outliers or the far reaches of the range of values upon which it is calculated. This means that each pottery type's range will directly influence the empirical variance against which the simulated

variances will be measured. The greater the ranges, i.e., the larger the difference between the sample values, the greater the variance will be, while the smaller the range, the lower the variance will be.

Variance alone is not a perfect measure for considering smooth versus abrupt changes in percentages. For example, range may be a lot larger in pottery types that happen to be more numerous in raw counts, meaning that the abundant pottery types may simply have larger variances based on counts than the smaller ones due to differences in amounts. By using row percents instead of counts for the simulation, I can manage this issue by scaling everything to amounts between 0 and 100 percent. This helps standardize the values but still leaves us with the knowledge that pottery types in smaller amounts are more likely to have greater differences in range due to sampling vagaries being automatically larger once converted to percents. This makes direct comparisons among pottery type variances problematic. Based on these observations, I concluded that comparisons between a pottery type's individual empirical variance and the averaged variances of its simulation would help mitigate possibly misleading comparisons among pottery types of greatly different amounts. I also concluded that comparisons among pottery types of similar amounts (sample sizes) would help make the relative comparisons of their simulation results more compelling.

In addition to variance, I adopt a ratio of pottery presence to total residential collections to measure potential gaps in access to pottery types among

residential mounds. Such a ratio relies on good sample sizes, of course, in order to allow the researcher to assume that a pottery type is absent due to a factor other than sample size. This ratio method captures an aspect of Hirth's distributional approach that is not covered by the variance measure. Specifically, I am concerned with evaluating the absence of a pottery type based on the underlying empirical distributions. As with the variance measure, the outlier positive values will create larger ratio values than zero values. The zero values work to make the ratio smaller, by making the numerator of the ratio calculation smaller. However, zero values, if the sample size can be trusted, could be showing restricted access to pottery types that will not be captured by the variance measure. The variance measure will highlight abrupt changes in the value ranges, but do not allow one to distinguish a situation in which zero values are having an impact unless they are very numerous. For example, if a pottery type showed up in relatively even percentages in two thirds of the residential mound collections but is absent in the other one third, then a simulation that only used a variance measure might mislead one to highlight the evenness of the percents and diagnose the distribution as openly exchanged while ignoring the fact that one third of the residences did not have any of the pottery type. Employing a ratio of pottery presence/residential collections as a statistical measure in a simulation environment will allow me to consider whether those collections that have zero counts of a pottery type are the result of sample size or reflect restricted access. For the simulation, variance and

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ratio of pottery presence to total residential collections will be used to evaluate expectations for exchange.

Simulation Description and Implementation Details

Before I describe the simulation, I summarize some basic information about coding it. The simulation was written in the computer language Java because it is easily available and has free code writing platforms that work well in university environments. For the complete program text, including explanatory comments and pseudocode, see Appendix C. The basic structure of the program is outlined and the specific implementation choices explained so that following analysis can be described and interpreted.

The simulation had a set of conditions that were changeable to test different sampling levels. The simulation used only the collection units that had the minimum of 20 sherds because any lower sample size would not be sufficient to test the occurrence of the rarer decorated pottery types. The simulation was set to run for different levels of sherd thresholds in *increments* of 10 (starting at 20 sherds) up to 50 and above, matching the numbers of collections actually obtained for that value. Naturally, each incremental value produced lower numbers of residential mound collections that reached that sherd count sample level (Table 5.4). Therefore, the simulation dataset for each threshold required the input of a different dataset of residential mound collections. Each set of conditions was run separately for 1 million runs for each individual pottery type selected for testing.

Table 5.4 Number of Collections for Different Sherd Count Levels.

Sherd Count Levels	All Collections Counts	20 and Above	30 and Above	40 and Above	50 and Above
Number of Residential Mound Collections	65	55	49	40	37

The basic unit in the simulation was the residential domestic mound, a proxy for a real social unit that acquired domestic items such as cooking and serving vessels.[2] In the simulation, each residential mound acquired pottery counts of an individual pottery type per simulated run. These pottery counts were generated by populating mounds with a pottery type up to that pottery type's total known sherd count. In other words, for pottery types that had a total of 158 sherds, one run of the simulation would place sherds one at a time into residential mound units until all of the 158 sherds were placed (Figure 5.27). Sherd placement was based on a weighting system that was implemented using a random number generator provided by the Java language, as explained next.

The weighting system is worth explaining at length because it demonstrates how a Bayesian inspired estimation approach was implemented in the simulation. As stated earlier, I used the Postclassic pottery total count (sample size) of each residential mound collection to weight the random sorting of each pottery type's sherds into all of the residential mound collections.[3] Basically, I

am using my underlying population distribution of Postclassic sherds as my known distribution rather than using, for example, the binomial distribution. A Bayesian inspired approach makes sense because it means that the sample size of each residential mound collection will be taken into account in the simulation, with large sample collections attracting more sherds. Also, weighting the simulated residential mound collections with the known sample distribution may also capture some of the underlying socioeconomic variation among the collections themselves.

The weighting system was calculated as follows, first, each residential mound collection was converted into a percentage of the total counts overall. This percentage was then used to create individual mound collection weight numbers between 0 and 1 that were used to assign virtual pottery counts. The weight calculation was created as a table of residential mound collections, with probability "spaces" assigned to each individual mound collection by a weight number, the sum of which adds up to one. Table 5.5 shows several example rows of how this process of cumulative percentages works. The value between one row's weight number and the next row's weight number is the probability "space" that is used to assign randomly generated sherd counts within the simulation.

Each residential mound's weight numbers were used to assign the simulated individual pottery type sherds in a programming loop function that
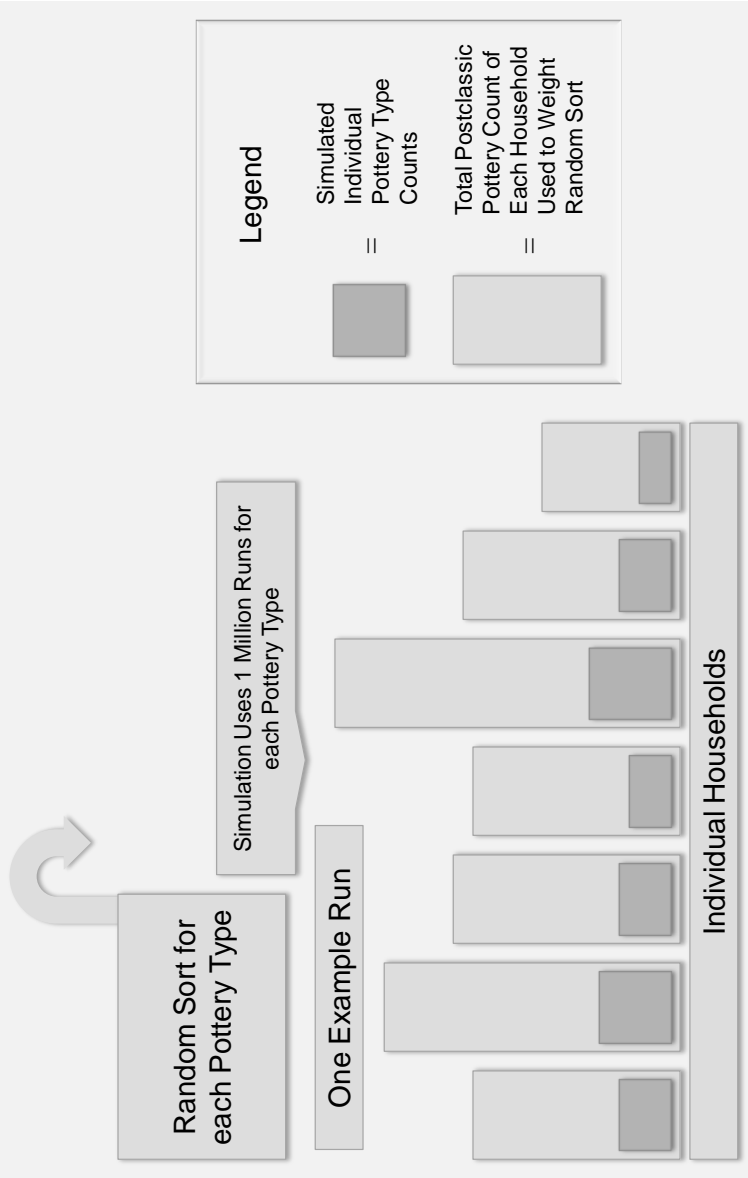
Figure 5.27 Network Simulation.

generates a random number between 0 and 1 and then assigns one pottery count to

a residential mound collection when that random number is less than the mound's

weight number. [4] How this loop function works may be better visualized if one

imagines that the probability "spaces" between sequential units' weight numbers

provide an area equal to the individual residential mound percentage in which the

random distribution will fall. Thus, if the random numbers generated were equal

to the total amount of Postclassic pottery, then the random distribution would

approximate the range of the empirical distribution based on the weighting

system. However, since the count of each pottery type is much smaller than the

totals, with many counts being only about 200 sherds, the use of the weighting

system to provide the underlying distribution provides the means to evaluate

whether the empirical distributions are due to much smaller sample sizes or

whether their distributions are actually different from that expectation and more

indicative of restrictions in exchange.

Table 5.5 Example set of residential mound collection weight numbers.

Mound Row #	Mound Pottery Count	Pottery Type %	Weight Numbers
1	65	0.014796	0.014796
2	97	0.022081	0.036877
3	102	0.023219	0.060096
4	155	0.035283	0.095379
5	106	0.024129	0.119508
6	62	0.014113	0.133622

In order to compare the empirical and simulation distributions, I used the simulation program to calculate row percents for each of the residential mound collections. Row percents are calculated by taking the counts of the randomly assigned sherds per residential mound collection and dividing them by the total of that individual residential mound's known collection total. Row percents are not free of sample size effects since they are generated on the assumption that each residential mound yielded a good sample, but they offer a way of standardizing comparisons that is better than using the raw counts. The row percents were calculated first for the empirical pottery type distribution and then for each of the runs of the simulated pottery type distribution. As stated earlier, the simulation was set to have a million runs.[5] One random run output was graphed with the Miscellaneous Polychrome (7w MISC) for the 20 and above sherd threshold to demonstrate what the program produces (Figure 5.28). It shows the distributions of actual (empirical) percentages compared to random (simulated).

The next step in the simulation calculates the two statistical tests for variance and presence/residential collections ratio and evaluates possible significance. Rather than apply probabilistic significance based on the empirical versus simulated distributions, the results are used as comparisons. I use the term probability loosely, only to indicate percentage of times out of a million runs that a particular statistical outcome was reached in the simulated data. I assume that if access to a particular pottery type is open, then the random distribution of many

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iterations of the pottery type in its known amount will not be much different from its observed distribution. However, if the empirical pottery type tends toward restriction, then the random distribution will differ from the empirical results. Variance and the ratio of pottery presence to total residential collections were handled in two different ways, which I describe next.

For assessing the population variance measure, if the simulation run variance was greater than or equal to the empirical variance of a pottery type, then it was stored in a field called "ProbNumerator" and after the million runs the simulation program generated a percentage of the number of iterations for which the random runs exhibited a variance greater than or equal to the empirical variance. This percentage gives me some idea of how easy it would be to obtain a variance as high as the empirical measure (and higher) from the random runs. If it happened very few times, then I could argue that the empirical variance was actually much higher than one would expect, given the underlying weighted distribution. I recognize that due to the differences in sample sizes among different collections, variances may always be higher than expected, but I expect the comparisons among the different pottery types to show me which of them are more likely to be restricted versus open in access.

To assess the presence/residential collections ratio, if the simulation run ratio was less than or equal to the empirical ratio of a pottery type, then it was stored in a field called "RatioNumerator"; after a million runs, the program

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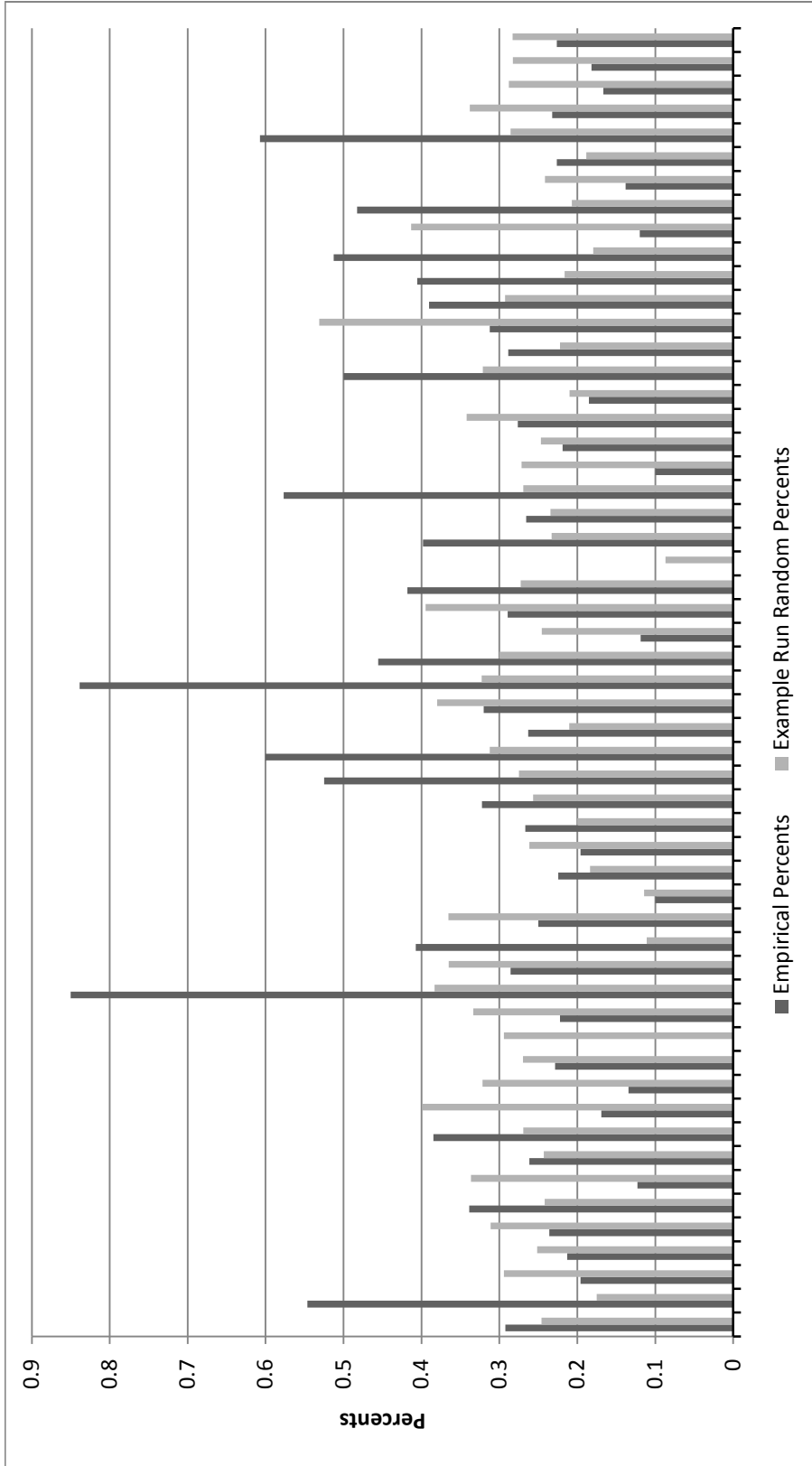
Figure 5.28 Example random run for Miscellaneous Polychrome.

generates a percentage of the number of iterations for which the random runs exhibited a presence/residential collection ratio less than or equal to the empirical presence/residential collection ratio. This percentage gives me some idea of how easy it would be to obtain a presence/residential collections ratio lower than or equal to the empirical ratio from the random runs. The reason the measure was set within the simulation to be lower than or equal to the empirical ratio is because a lower ratio of presence/residential collections indicates fewer collections that show a presence of a particular pottery type relative to the number of total residential mounds. If the simulated ratio of presence/residential collections was lower than or equal to the empirical result very few times, then the empirical presence/residential collections ratio is lower than one would expect, given the underlying weighted distribution. A lower ratio would mean that access could be restricted in that fewer than expected collections had a particular pottery type. Therefore, the ratio measure is an effective measure of access only in pottery types that are not present in every collection. As with variance, the empirical measure is a relative measure applied to consider restricted versus open exchange, as I explain below.

Lower empirical presence/residential collections ratios would be expected where there were large gaps in the pottery type presence among residential mound collections. However, for those abundant pottery types found in every single residential mound collection, the presence/residential collections ratio is

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automatically one and the simulated results will always be equal to or possibly slightly lower than that ratio (due to chance). This means that one cannot interpret the simulation percentage results without first considering the original pottery type presence within collections. In the abundant pottery types all mounds have access so the ratio measure won't show us anything, but for the scarcer pottery types, such as those pottery types that make up 2-4 percent of the total Postclassic pottery, the ratio measure can disclose if a rarer pottery type is distributed in as many collections as one might expect given the sample size, or if it shows up in far fewer collections than expected and is therefore probably restricted.

Network Simulation Analysis Results

Before summarizing the network simulation results, I introduce two axes of comparisons: sample size levels for the residential collections and overall sample size for the pottery types. First, the results of different levels of collection sizes were compared to see if larger sample sizes were having an effect on the relative comparisons of pottery type variances (as summarized in Table 5.4). This was done to ensure that for a pottery type with a low simulated variance percentage (i.e., the empirical variance was high) relative to other pottery types of a similar sample size, that type retained a similar relative position even when higher sample sizes for sherds were used. The second basis for comparison was overall sample sizes for pottery types. Specifically, I compare pottery types of

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similar sample sizes because of the potential effect of sample size on range (even when using percentages). Those types that share relative percentage amounts of total pottery will be considered together with their size groups for the network analysis comparisons. I divide them into two basic groups: the more abundant 29-35 Percent and the rarer 2-4 Percent Groups and consider their results separately.

29-35 Percent Types. The pottery types I considered first were the two types that dominate the Postclassic pottery, Black-on-Red (7a-f BLRD) and Miscellaneous Polychrome (7w MISC) each at about 35 to 29 percent. These two types made up such a large percentage of the Postclassic pottery that it was difficult to evaluate them using the simulation methods. In addition to being abundant categories, these two types also had many variants in the case of Black-on-Red while the Miscellaneous Polychrome was, as its name suggests, a category for polychromes that could not be safely assigned to other types. These two pottery types have the largest empirical variance values (see Figure 5.29). These high variance results may indicate the presence of several distinct polychrome types, so far unidentified (or unidentifiable given the erosion of some of the sherds) that may have had exchange patterns slightly different from each other for the residential mounds if they could be considered separately.

Given that these two abundant pottery types show a good deal of variance, and, in the case of the Miscellaneous Polychrome, show up in every single residential mound collection, what did the simulation results show us? The

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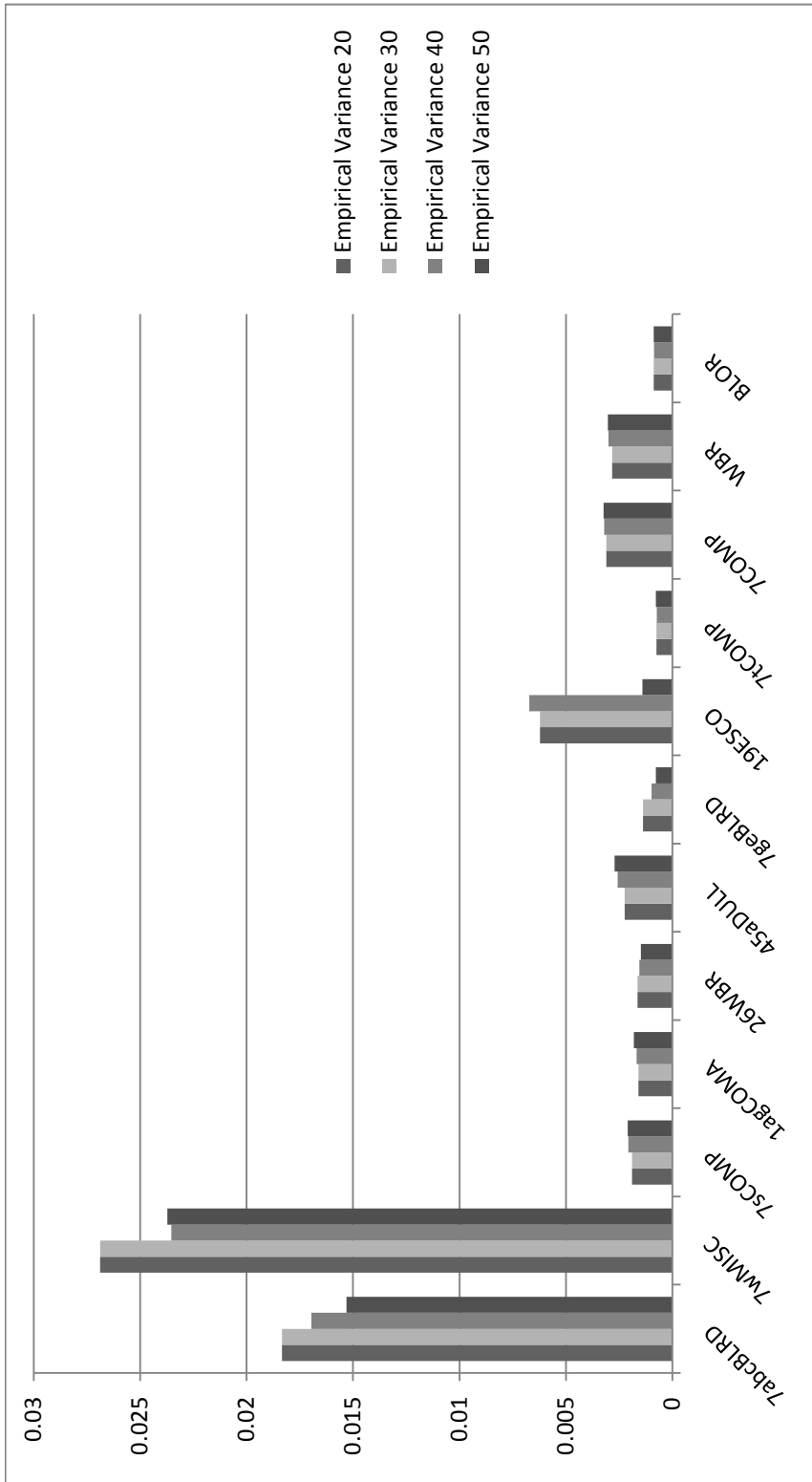
Figure 5.29 Empirical Variance for all Pottery Types.

simulated variance for both pottery types never reached a value greater than or equal to the empirical variance for both types at any sampling level (Table 5.6). There wasn't much difference between the results based on the sample size threshold levels (20, 30, 40, etc.). Given that the differences in the percentage distributions of these two abundant diverse types with each other probably stemmed from variants within the two types themselves, the simulated variance results are not surprising. These two types and at least some of their various potential sub-types are probably not restricted in access since they show up in almost every residential mound collection. However, some of the spikes in percentage values among collections that produce the higher variances for these two types may be due to some restrictions for some variants. What do these results mean for our network simulation approach for these two types?

The type variants within these two major pottery types may be the source of ambiguity that cannot currently be resolved given the analytical restraints on these two abundant and diverse pottery types. For example, for the Miscellaneous Polychrome, which has the highest empirical variance of all the pottery types, the simulation results for variance could be the result of sub-types within this category, but also sub-types that might be restricted and others that are not. For these two major pottery types, the ratio measure also was not particularly helpful for evaluating network exchange, which is what might be expected since most collections had Black-on-Red and Miscellaneous Polychrome.[6] These

results lead me to conclude that not all pottery types will lend themselves to a

distributional analysis of exchange. Future refinement of pottery typologies may

help identify separately exchanged variants, which could make them usable for

distributional methods. But in those cases for which a pottery type is broadly

defined due to constraints like surface erosion and/or has variants that are grouped

to obtain better sample sizes, it may not be useful to evaluate details of network

exchange. In those cases where pottery types and variants are grouped to gain

statistical power, the similarities of the underlying distributions and the likelihood

that they are similar or not, should be considered during any subsequent analyses.

Table 5.6 Simulation results for the 29-35 % group

Pottery Type	Black-on-Red (7abcBLRD)	Misc. Polychrome (7wMISC)
Empirical Variance 20	0.018341	0.026878
Empirical Variance 30	0.018341	0.026878
Empirical Variance 40	0.016961	0.023538
Empirical Variance 50	0.015308	0.023716
Probability Variance (%) 20	0	0
Probability Variance (%) 30	0	0
Probability Variance (%) 40	0	0
Probability Variance (%) 50	0	0
Empirical Ratio 20	0.979592	1
Empirical Ratio 30	0.979592	1
Empirical Ratio 40	1	1
Empirical Ratio 50	1	1
Probability Ratio (%) 20	0.0081	100
Probability Ratio (%) 30	0.0081	100
Probability Ratio (%) 40	100	100
Probability Ratio (%) 50	100	100

*Probability variance equaling zero means that simulated variances never

reached an amount greater than or equal to the empirical variance.

2-4 Percent Pottery Types. These pottery types each represent between 2 and 4 percent of the total Postclassic pottery and include Complicated Polychrome, Lacking White Underslip (7s COMP), Buff Comales (1a-g COMA), Splashy White-and-Black-on-Red Polychrome (26 WBR), Dull Buff Polychrome (45a DULL), Black-on-Red Incised (7ge BLRD), Escolleras Chalk (19 ESCO), and Complicated Polychrome with White Underslip (7t COMP). These pottery types were considered individually for the network analysis because of their comparable total sample size rather than what they had in common as pottery. Most of these pottery types share similar empirical variances with the exception of Escolleras Chalk (19 ESCO), which had much higher empirical variance levels than every other type (Figure 5.30). In considering the simulation variance probabilities, both Escolleras Chalk (19 ESCO) and Dull Buff Polychrome (45a DULL) have zero values, meaning that their empirical variance levels did not show up in amounts greater than or equal to their simulated variance. For most of the other pottery types, such as Complicated Polychrome Lacking White Underslip (7s COMP), Buff Comales (1a-g COMA), Splashy White-and-Black-on-Red Polychrome (26 WBR), and Black-on-Red Incised (7ge BLRD) the simulated variances were very low, but still above zero (Figure 5.30). For Complicated Polychrome with White Underslip (7t COMP) the simulated variances were very high for the first two sample group thresholds. What do these results suggest for these 2-4 percent pottery types?
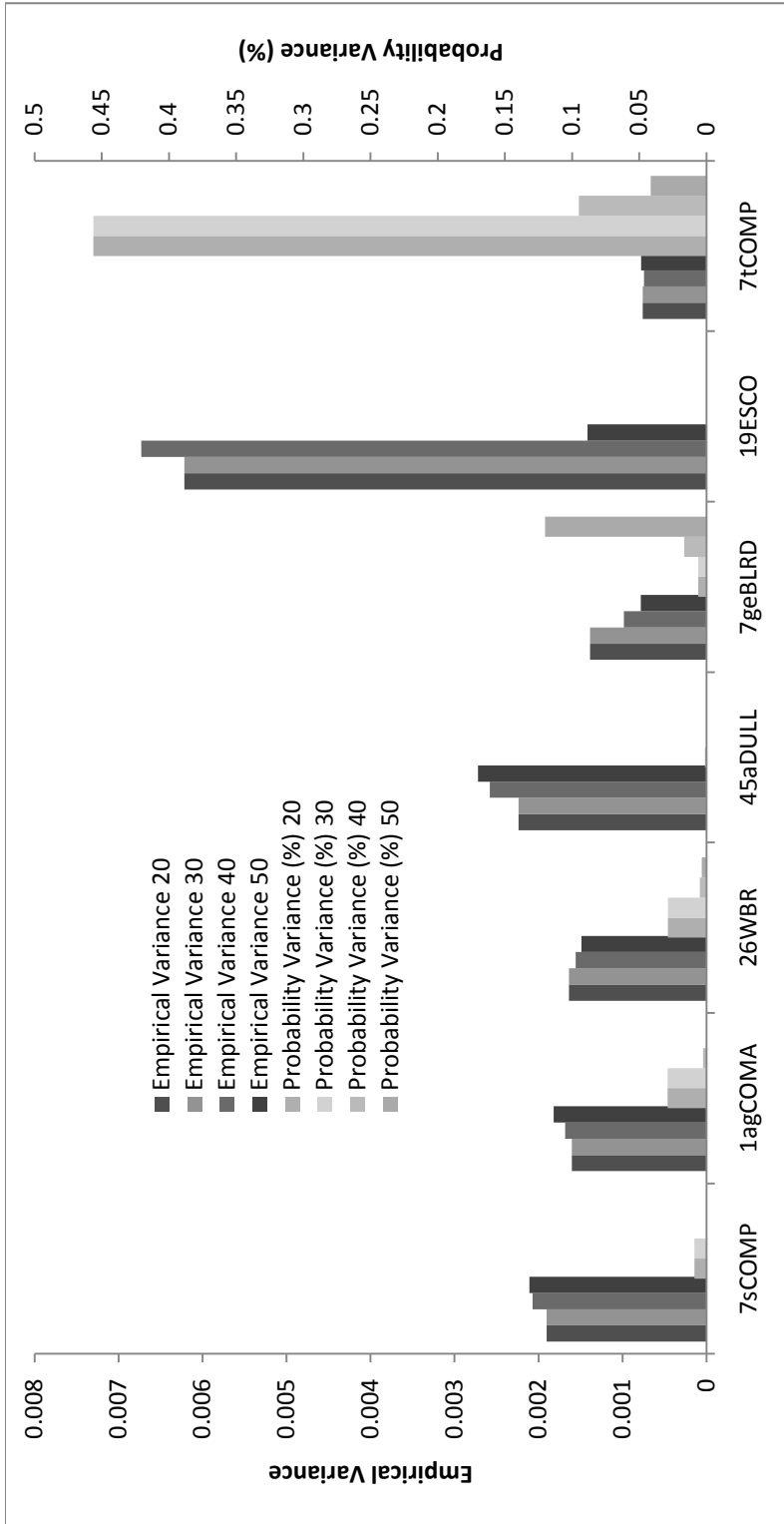
5.30 Empirical variance and probability % variance for pottery types between 2-4 % of Postclassic total.

For the Complicated Polychrome with White Underslip (7t COMP), the simulated variance is very large; especially in the two lower sample size thresholds (Figure 5.30). Obviously the Complicated Polychrome with White Underslip has the lowest empirical variance, and it also has a more regular distribution than the other types, despite its low counts (101 sherds). Its distribution was made less regular in the context of larger pottery counts (above 40 and 50 sherds) per collection. This is an interesting result for this pottery type, in that it suggests that despite its relative overall rarity, most of the residential mound collections had some small percentage of it, with the simulation matching the empirical patterning.

The other pottery types that had probability variances above zero including Complicated Polychrome, Lacking White Underslip (7s COMP), Buff Comals (1a-g COMA), Splashy White-and-Black-on-Red Polychrome (26 WBR), and Black-on-Red Incised (7ge BLRD), had larger empirical variances than might be expected given the overall Postclassic pottery distribution. The Buff comals, of which almost every residential mound collection had some quantity, had larger empirical variances than expected. Of course, very low probability variance for these pottery types isn't surprising given the probable variations due to the vagaries of sampling. Generally, the pottery types that had probabilities above zero probably had open rather than restricted access. Differences in sample

thresholds did not appear to make much difference for the probability variances for these types either.

For the variance measure, the types Escolleras Chalk and Dull Buff Polychrome appeared to be consistent with restricted access in the simulation. During the exploratory data analyses, both these types also appeared to have restricted access, based on viewing the spikes and gaps in the distribution of comparative percents among collections (Figure 5.31). However, there are differences between the simulation results for these two types. Dull Buff Polychrome is present in fewer collections than Escolleras Chalk. Escolleras Chalk is present in much higher percentages in one collection that may be heavily affecting the results. What happens when we remove this one collection (in which Escolleras Chalk makes up 50 percent of the Postclassic pottery)? In running the simulation without this collection, none of the probabilities change for Escolleras Chalk. The change merely puts the empirical variance for Escolleras Chalk into the same range as Dull Buff Polychrome, as observed in Figure 5.30. Sample size thresholds also do not appear to make any difference in the variance probabilities for either type.

Next, I consider the ratio of presence to total residential collections for the pottery types between 2-4 percent of the Postclassic totals. The results are complementary to the variance results but have some noteworthy exceptions. Thedifferent sample size thresholds (labeled 20, 30, etc.) did not show much

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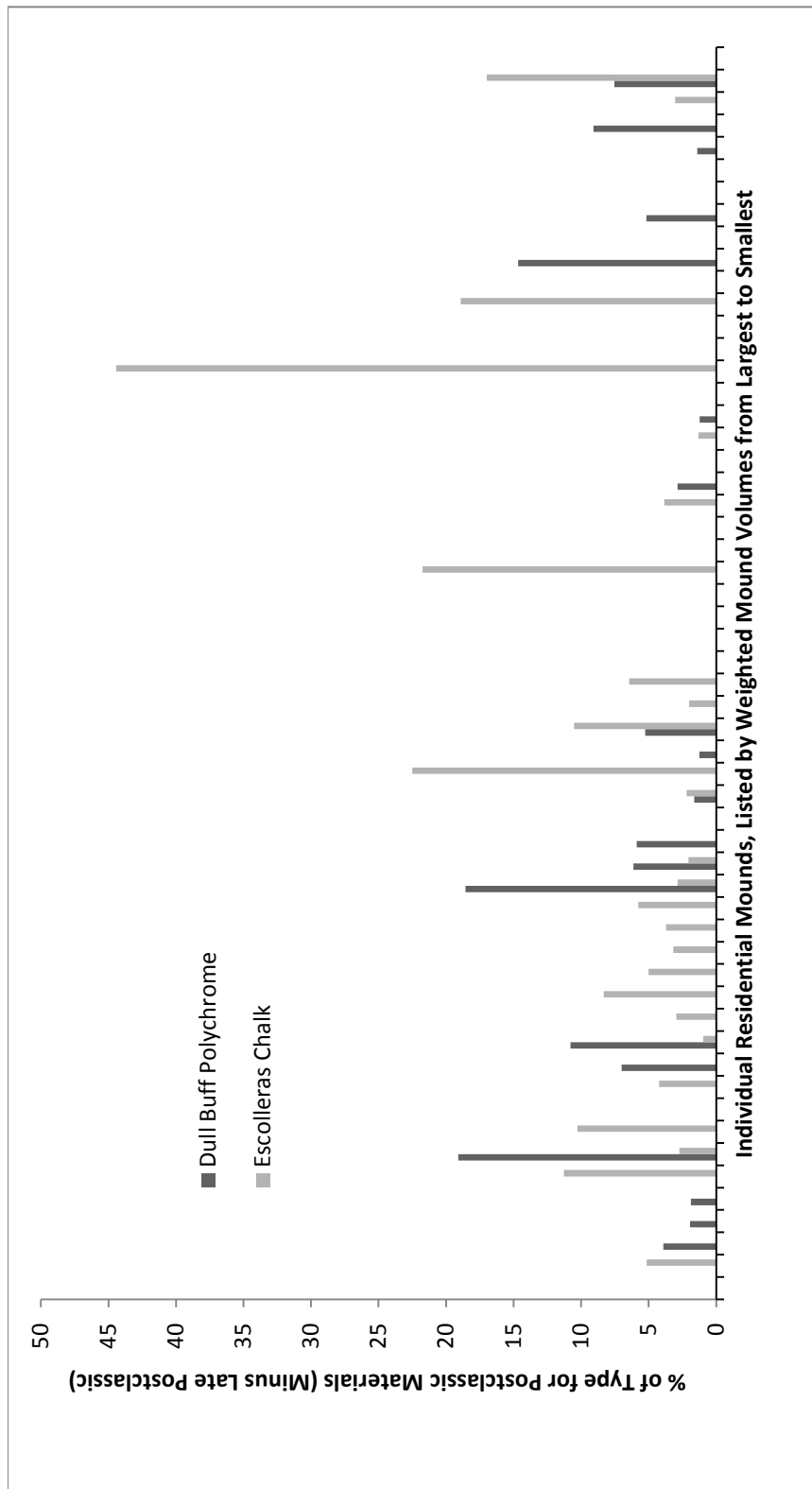
Figure 5.31 Dull Buff Polychrome and Escolleras Chalk for residential mound collections that had 20 and above sherds.
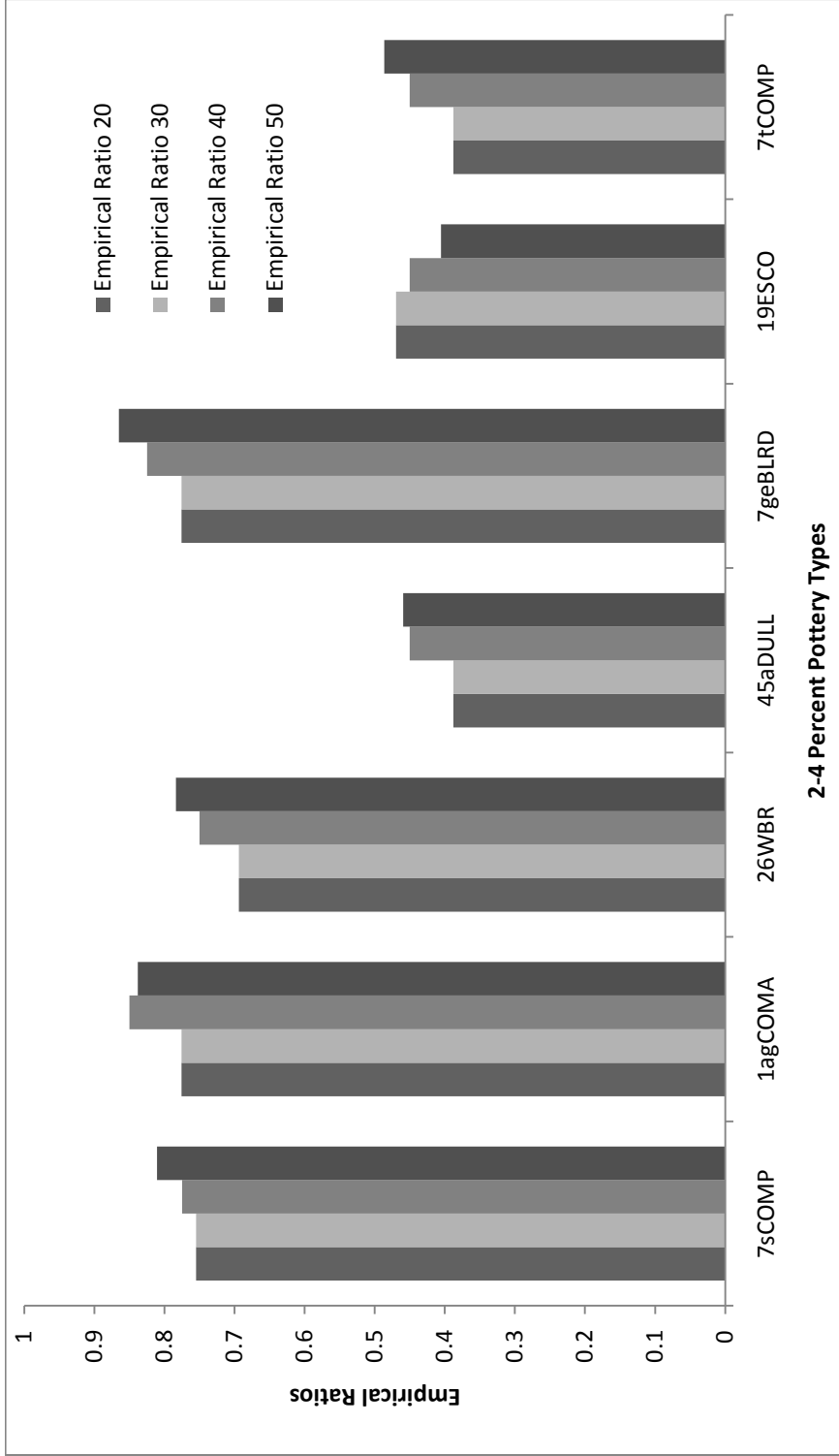
Figure 5.32 Empirical ratios for presence/residential collections for pottery types between 2-4 % of Postclassic total.

appreciable difference in the ratio of the amounts of residential mound collections that contained each pottery type (Figure 5.32). As one might expect, most of the empirical ratios were higher among those types that are probably open in access, including Complicated Polychrome Lacking White Underslip (7s COMP), Buff Comals (1ag COMA), Splashy White-and-Black-on-Red Polychrome (26 WBR), and Black-on-Red Incised (7ge BLRD). The two types that were probably restricted, Escolleras Chalk (19 ESCO) and Dull Buff Polychrome (45a DULL) had lower empirical ratios. The one exception to this rule was Complicated Polychrome with White Underslip (7t COMP), with an empirical ratio that was quite a bit lower than its other open counterparts. However, since Complicated Polychrome with White Underslip (7t COMP) also showed high probability variances, we can say that its relatively low empirical ratio matches its low overall sample size; I conclude it does not depart from the underlying overall pottery distribution by much, despite not being as evenly distributed as some of the other types that were open access. Possibly Complicated Polychrome with White Underslip (7t COMP) was restricted in access, but the network analysis is equivocal on this point. Spatial and contextual analyses will be added to these results to further evaluate this possibility.

Simulation probability was set up to require that the simulated ratios be lower than or equal to the empirical ratio for the percents of collections with these types. Most of the ratio probabilities are going to be zero for those cases in which

the empirical ratio of presence to total residential collections is less than half

(Table 5.7). There is one interesting result for Black-on-Red Incised (7ge BLRD)

for which the ratio probabilities appear in much greater amounts than any of the

other types. Given that Black-on-Red Incised had a high empirical ratio, the

results showing simulated runs with lower ratios in percentages ranging from 4 up

to 25 (given the different sample size thresholds), suggests that this type may be

more evenly distributed than one might expect given its overall sample size (112-

135 sherds for the different sample sizes). Basically, Black-on-Red was not only

openly accessible; it was perhaps highly desired as well.

Table 5.7 Simulation ratio presence/residential collections results for 2-4 % pottery types.

Pottery Type	7sCOMP	1agCOMA	26WBR	45aDULL	7geBLRD	19ESCO	7tCOMP
Empirical Ratio 20	0.755102	0.77551	0.693878	0.387755	0.77551	0.469388	0.387755
Empirical Ratio 30	0.755102	0.77551	0.693878	0.387755	0.77551	0.469388	0.387755
Empirical Ratio 40	0.775	0.85	0.75	0.45	0.825	0.45	0.45
Empirical Ratio 50	0.810811	0.837838	0.783784	0.459459	0.864865	0.405405	0.486486
Probability Ratio (%) 20	7.00E-04	0.0334	0	0	4.0278	0	0
Probability Ratio (%) 30	7.00E-04	0.0334	0	0	4.0278	0	0
Probability Ratio (%) 40	2.00E-04	0.3137	0	0	9.2469	0	0
Probability Ratio (%) 50	2.00E-03	0.0652	4.00E-04	0	25.841	0	0

Aggregated Variant Pottery Types. The aggregated variant pottery types were created to increase sample sizes and to allow the inclusion of some variants of types like the Black-on-Orange pottery that would otherwise be too low in overall sample size (well below 100 sherds in some cases), for a statistical analysis. These types and their groups were summarized previously in Table 5.3 and will be henceforth referred to by their aggregate variant pottery type names: 7 COMP, WBR, and BLOR. The different sample size thresholds did not make a difference in empirical variances. Also, the empirical variance values are much higher for the 7 COMP and WBR groups than for the BLOR group (Figure 5.33). For the simulation variance results, the BLOR group had a high probability variance, up to 45 percent for the first two sample sizes of 20+ and 30+ sherds (Figure 5.33). These results support the interpretation that for BLOR access was open. The drop-off in variance probability in the higher sample size thresholds is due to the fact that the BLOR group has such low percentages. In comparison, for both the 7COMP and WBR groups, the probability variances were zero or very close to zero. In the 7COMP and WBR groups, although the variants appear to have open access in the network simulation analysis when considered separately, they do not suggest open access when grouped together. This somewhat contradictory result may partly reflect that some of the pottery variants are associated spatially with one another, and adding larger amounts of a grouped

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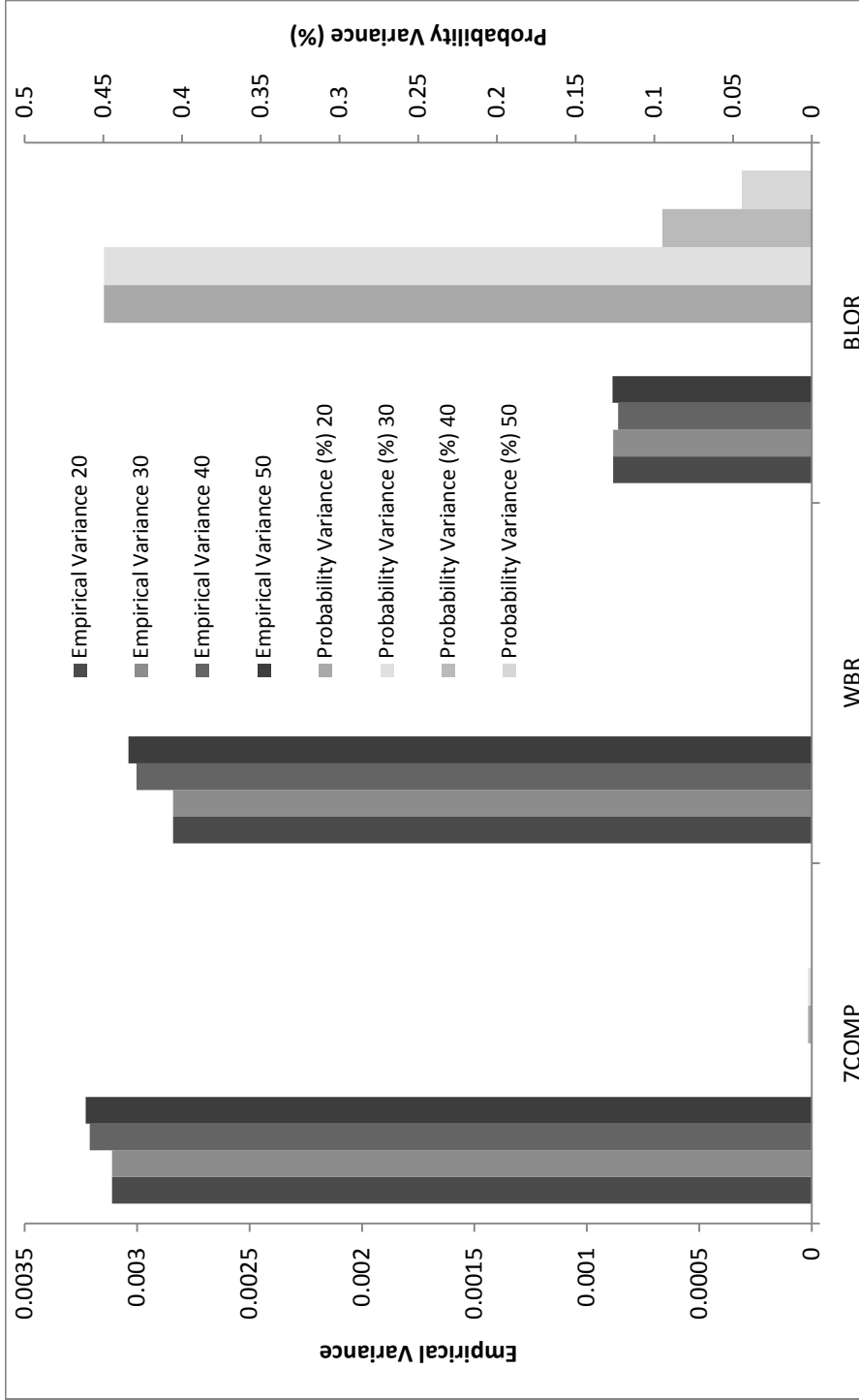
Figure 5.33 Empirical variance and probability % variance for aggregate variant pottery types.
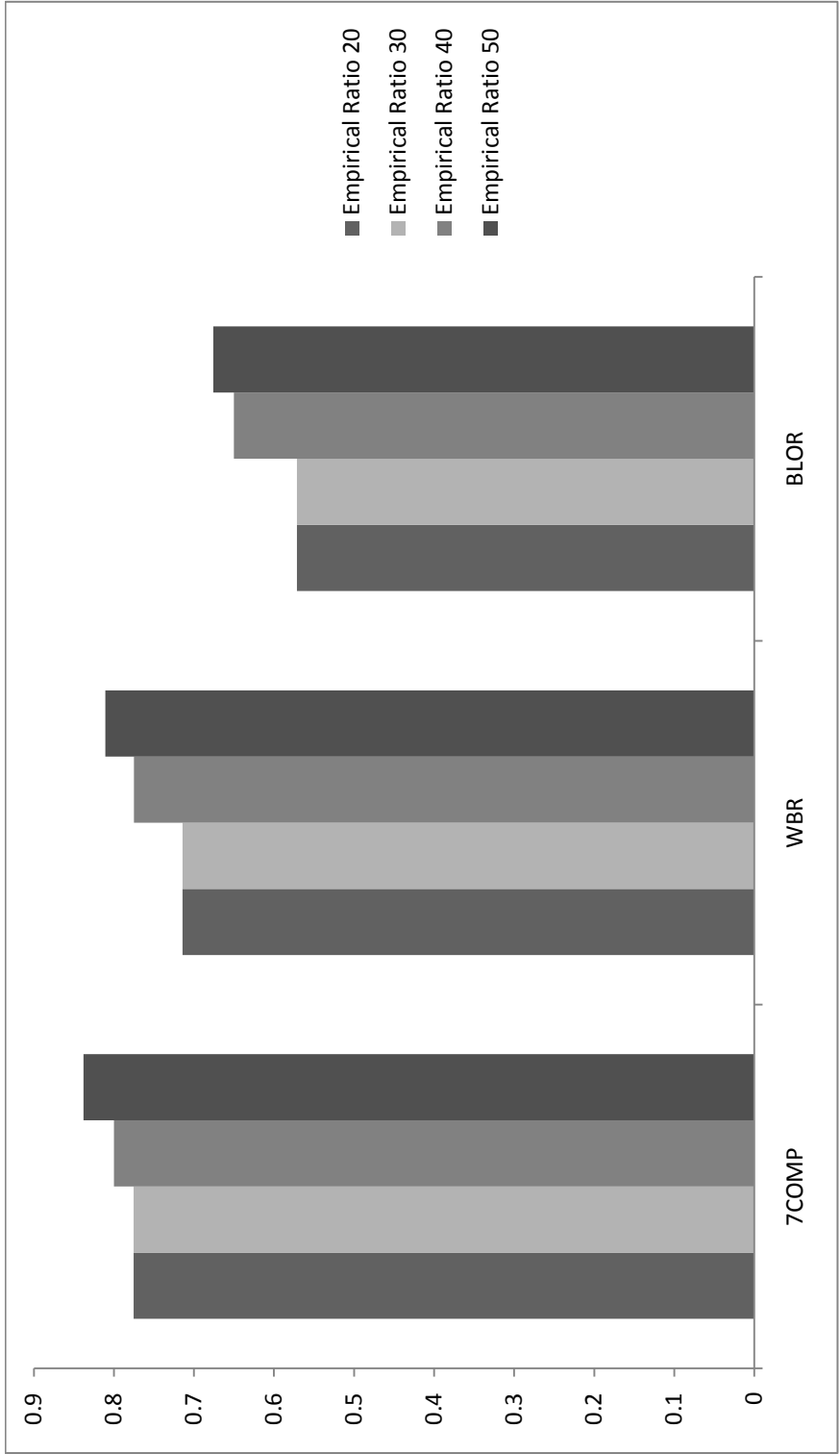
Figure 5.34 Empirical ratio of presence/residential collections for the aggregate variant pottery types.

pottery type to a few residential mound collections would then produce much

greater variances. For example, in the case of WBR, where only 30 sherds were

added by combining Framing White-and-Black-on-Red Polychrome, these added

sherds showed up in only a few collections that also had the Splashy White-and-

Black-on-Red Polychrome. The effect is that the group type WBR has much

greater variance than the Splashy type when considered alone (see Figures 5.13,

5.14 for comparisons).

For the aggregated variant pottery types, the empirical ratios of presence

to total residential collections for 7COMP and WBR were about the same and

fairly high, while BLOR was slightly lower (see Figure 5.34). The results do not

vary for the different sample size thresholds. The simulation results for all three

groups showed zero or very close to zero ratio probabilities (see Table 5.8).

These results were not surprising since all three groups had high empirical ratios.

In conclusion, although the higher ratios for these group types do not show open

access, they also do not suggest restricted access either.

Table 5.8 Simulation ratio presence/ residential collections results for aggregate variant pottery types.

Aggregate Variant Pottery Type	7COMP	WBR	BLOR
Empirical Ratio 20	0.77551	0.714286	0.571429
Empirical Ratio 30	0.77551	0.714286	0.571429
Empirical Ratio 40	0.8	0.775	0.65
Empirical Ratio 50	0.837838	0.810811	0.675676
Probability Ratio (%) 20	0	0	0
Probability Ratio (%) 30	0	0	0

Aggregate Variant Pottery Type	7COMP	WBR	BLOR
Probability Ratio (%) 40	0	0	1.00E-04
Probability Ratio (%) 50	0	1.00E-04	0.00E+00

Discussion of the Exchange Network Analysis

In this section, I summarize and synthesize the results for the network analysis for both the visual distributional and the network simulation methods regarding open versus restricted exchange. Table 5.9 shows that the visual and simulation distributional methods led to almost identical conclusions about whether a pottery type was open or restricted. However, each method added different insights about exchange. I discuss the specific evidence of open and restricted exchange networks separately and finally consider the effectiveness of the methods individually and in combination.

Table 5.9 Results for visual distributional and network simulation analyses.

	Visual Distributional		Network Simulation	
Pottery Type Name (Code)	Open	Restricted	Open	Restricted
Black-on-Red (7a-fBLRD)	X		X	
Miscellaneous Polychrome (7wMISC)	X		X	
Buff Comales (1a-gCOMA)	X		X	
Complicated Polychrome Lacking White Underslip (7sCOMP)	X		X	
Complicated Polychrome with White Underslip (7tCOMP)		X*	X	
Splashy White-and-Black-on-Red (26WBR)	X		X	
Dull Buff Polychrome (45aDULL)		X		X
Black-on-Red Incised (7geBLRD)	X		X	
Escolleras Chalk (19ESCO)		X		X
WBR	X		X	

7COMP	X	X
BLOR	X	X

*Results equivocal but more suggestive of restriction.

Open Exchange Network Evidence

The majority of pottery types considered for the economic network analysis appears to be openly exchanged based on the results of both methods (Table 5.9). These results are consistent with the interpretation that Sauce and its hinterland had a significant amount of market exchange. The spatial and contextual component to these likely market transactions will be addressed in the following chapter. For now, we only consider what each distributional method showed about the pottery types which were openly exchanged.

For the 29-35 percent types, which include Black-on-Red and Miscellaneous Polychrome, there are problems reflecting their inclusion of different typological variants, but exchange appears to be open. For the network simulation of these abundant and miscellaneous types, the methods did not prove to be very effective due to the skewing of the statistical tests by much larger sampling errors among the residential collections themselves. In contrast, for the 2-4 percent types, the network simulation was much more effective.

For the 2-4 percent types, the visual distributional method, because it could include the weighted mound volume proxy for socioeconomic rank, showed some interesting trends. Even for those types that were apparently openly

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exchanged, there appears to be a socioeconomic component in the distribution.
For example, the decorated types, excluding the Buff Comals, appear to be more
heavily represented in the large mounds. In the case of the Complicated
Polychrome types, the variant lacking a white underslip (7s COMP) shows higher
percents and presence within large mounds in the visual distributional analysis;
this tendency may reflect a socioeconomic component to the distribution (Figure
5.9) (after M. Smith 1999). However, the network simulation results supported
the interpretation that 7s COMP was not restricted in access based on both the
variance and ratio measures, even if it was more numerous in residences that may
be higher in socioeconomic rank. For Black-on-Red Incised, the visual
distributional analysis showed that collections from all weighted mound volumes
had access to this type. Furthermore, the network simulation demonstrated that
Black-on-Red Incised pottery was also more evenly distributed compared to the
other open access pottery types based on the ratio results (see Table 5.7).

For Complicated Polychrome, the variant with white underslip (7t COMP)
shows different results concerning open versus restricted exchange based on the
method. This polychrome showed higher percents and presence within large
mounds in the visual distributional analysis (Figure 5.11) and showed lots of gaps
and some very high amounts of percents when the percents were viewed in order
(Figure 5.12). Both of these visual methods suggested that access to this type was
restricted. However, for the simulation, the results supported open access. This

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was the only pottery type to have such divided results. 7t COMP showed a high probability variance in the network simulation, indicating that its distribution was fairly even among collections that had this pottery type, despite the fact that the ratio measure showed that it had many gaps in presence among collections. The ratio measure also indicated that these gaps could have been the result of sample size rather than restriction in access. In this case, reliance on the visual methods alone would have been misleading.

The aggregate variant pottery types were more equivocal in their results. Both WBR and the 7 COMP types showed some open access in the visual distributional analysis, but due to likely differences in spatial patterning or clustering, these types had high empirical variances in the network simulation. The Black-on-Orange group (BLOR) was the most useful aggregate group because all three of the Black-on-Orange pottery type variants were too small in total counts to be statistically reliable on their own. When lumped together they demonstrated open access in the visual distributional analysis although there were greater quantities in the larger mounds (Figures 5.25, 5.26). In the network simulation, BLOR's high probability variance also supported an open access interpretation.

Restricted Network Exchange

A few pottery types show restricted exchange (Table 5.9). Elite networks, kin networks, and local household sufficiency are often part of a region's

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economic organization and typically co-exist with other forms of exchange and provisioning like markets (Davenport 1986: 98-99). The spatial and contextual component to such restricted network transactions will be covered in the following chapter. For now, we can also consider what each distributional method showed about the pottery types which were restricted in exchange.

Dull Buff Polychrome (45a DULL) showed restricted exchange: some very high percentages in some collections and very low to none in other collections in the visual distributional analysis (Figures 5.17, 518). Interestingly, the higher percentages were not entirely from the larger mounds so there is likely a spatial and contextual component to the restriction that will be addressed later. The network simulation strongly backed up this visual impression to demonstrate that Dull Buff patterns were not due to small sample size alone. Escolleras Chalk (19 ESCO) also showed restriction in access, although the patterns in the visual distributional analysis are unusual, as I explain below. The figure (Figure 5.19) for the visual distributional analysis shows that consistency in access to this type appears correlated with the larger mounds which might suggest a socioeconomic component to the network. However, there are also quite a few isolated very high percentages of this type in collections scattered among the smaller mounds and these include four of the five chronologically ambiguous collections (Figures 5.19, 5.20). The network simulation also supported a restricted access interpretation based on both the variance and ratio measures.

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For Complicated Polychrome, the variant with white underslip (7t COMP) showed some indications of restricted access based on the visual distributional analysis. There are large gaps in access with fewer collections with this type among the smaller mounds (Figure 5.11). As stated earlier, these results didn't match those of the network simulation. The simulation indicated that this type was evenly distributed among the collections in which it was present and that its gaps in access are not that different from what one would expect due to sample size. Further contextual and spatial analyses may help evaluate whether there is a spatial component that could help explain the gaps among collections.

Summary of Methods

The application of two distinct methods to the problem of network exchange analysis has proven very useful in comparing and testing exchange results among pottery types. Each method allowed different aspects of Hirth's (1998) expectations to be explored within the SAP dataset. The results of the network analyses demonstrate that Sauce and its hinterland had a combination of open and restricted exchange networks. Now that the pottery types have been assessed as open or restricted in exchange access, with minor variations, this network dataset provides the building blocks upon which the spatial and contextual components of exchange can be explored in fruitful ways.

Broader Implications of Understanding Exchange Mechanisms

Hirth's key methodological contribution for identifying exchange mechanisms is that it allows for the analytical separation of the mechanism of exchange from spatial patterning expectations. This analytical separation allows one to consider some social and political aspects of consumption and distribution that would otherwise be subsumed within regional datasets. In developing explicit methods for network exchange, I can identify exchange mechanisms and add aspects such as socioeconomic rank and spatial patterns for further analyses.

For Sauce and its hinterland, most of the pottery is being exchanged openly, with some exceptions. The open exchange of most of the pottery is supportive of the interpretation that market exchange was an important feature of the local economy. The ways in which this open exchange may have been organized, by whom, and the socioeconomic components to consumption of the different pottery types, may now be dealt with in more detail, thanks to the network analysis. Specifically, I will be able to demonstrate whether the openly exchanged pottery types have similar spatial patterns or show regional variation. For example, pottery types that are openly exchanged but have different spatial patterns could indicate that they were distributed through more than one central place source. If most of the openly exchanged pottery types show the same spatial patterns, such as a decrease in densities from the center of Sauce, then I will be able to demonstrate that Sauce and its environs are the most likely location

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of a marketplace, which could indicate a political component to the encouragement if not direct support of market exchange.

For the restricted pottery types, such as Dull Buff Polychrome, if spatial analysis shows that it was mostly found near or within the Sauce center or only in association with the larger mounds, these results could indicate a political elite component to its consumption and distribution. Dull Buff Polychrome appears to be local, not found in other parts of Veracruz (Stark 1995:19). Therefore, Dull Buff and its restriction could be showing specific social and political relationships demonstrated by the use of a pottery that possibly came from sources that were distinct from the local Veracruz trade networks in which the other openly exchanged types such as the *guinda* complex and the Complicated Polychromes were found (Lira López 1990; Medellín Zenil 1960).

In conclusion, the network methods developed and presented here represent the important first steps in understanding the social, political, and economic components to exchange and consumption among a set of households from a small center and its hinterland in Veracruz, Mexico. Applying network methods that incorporate both community and household levels of analysis will help identify the variability and consistencies within local economies and put the social aspects of exchange and consumption back into the picture.

[1]Since we are measuring a behavior rather than a physical population when we address the creation and acquisition of decorated pottery, we may say that we are always dealing with a sample rather than a complete population under any circumstances.

[2]In building my network expectations, the residential mounds are obviously discrete from each other, so they can be considered separate units that acquire pottery even if each mound collection actually represents a group of buildings and/or possibly separate residences.

[3]I am using the total Postclassic pottery counts minus the Late Postclassic pottery per collection as the underlying sample distribution. This step maintains the chronological accuracy of the sample population as much as possible although I recognize that this does not eliminate all sampling errors.

[4]I used Java's math random function to generate a random number between 0 and 1. The Java math function uses a pseudo random generator to create the numbers, so it's not as good as the http://www.fourmilab.ch/hotbits/ website that uses radioactive decay to generate truly random numbers but it's good enough for a simple simulation.

[5] The network simulation Appendix shows that the number of runs is flexible for user input. I originally ran the simulation for many fewer runs, such as 1000, but the results seemed to stabilize with fewer variations due to rounding error once I used large numbers like 100,000 to 1,000,000.

[6]The empirical ratio is less than one (or a hundred percent) here due to rounding error which meant that the probabilities for a ratio less than or equal to the empirical results showed up very few times. This happens because the weighting system combined with the high numbers of Black-on-Red meant that this type showed up almost all the time as "present" in the simulation.

CHAPTER 6. SPATIAL AND CONTEXTUAL ANALYSIS OF POTTERY EXCHANGE

Networks of patronage, religious transactions, statecraft, and commercial exchange co-exist within economies (Granovetter 1985: 504-505). In this conceptual framework, all exchange systems are embedded within social and political institutions and the artifacts collected from household inventories are the result of a mix of social, political, cultural, and economic factors (Granovetter 1985, 2005). The spatial organization of exchange and the ideational context of the items being exchanged are both important in understanding exactly how exchange fits into local political and social institutions (Appadurai 1986; Smith 1976). For Sauce and its hinterland, I have established that a mix of exchange systems characterized its economic organization, including open (likely markets) and restricted exchange (see also Garraty 2009). In this chapter, I argue that the spatial dataset combined with the ideational content of the items being exchanged can be used to identify three key interrelated factors in understanding this mix of local exchange systems: spatial organization, political authority, and the degree of commercialization. Each of these factors will be defined and explained for Sauce and its hinterland.

Spatial patterns of artifact distributions are one of the staples for considering the political administration of exchange using settlement pattern data. Therefore, Renfrew's (1977) realization that spatial patterns suffered the problem of equifinality for identifying different kinds of exchange systems effectively

called into question the use of artifact distributions alone as reliable differentiators between certain types of exchange mechanisms. As described in Chapter 5, a solution can be obtained by using a network analysis suggested by Hirth's (1998) distributional approach to identify different kinds of exchange methods based on comparing the distribution of items among household inventories, as I have done in Chapter 5 for pottery. Next, the spatial patterning of pottery types combined with information about the social and political status of consumers via the residential mound data can be used to evaluate the intersection of political centers and exchange systems.

In dealing with a mix of exchange systems, multiple lines of evidence obtained from different scales, including households, regional, and interregional ones, are important to help identify how each type of exchange is organized (Feinman and Nicholas 2010; Stark and Garraty 2010:33-34). Stark and Garraty (2010) identify a method complementary to Hirth's (1998) distributional method, dubbed the regional production-distribution approach, to help recognize patterns in the organization of exchange at the regional scale. In Mesoamerica, this regional production-distribution approach has been applied with some success in several different areas even where household distributional data are lacking (Stark and Garraty 2010:64-65). For example, Fry (1980:495-500) used the spatial distribution of utilitarian and decorated ceramics in greater Tikal to conclude that the scale, distribution, and wide availability of decorated pottery were suggestive of a market system, albeit one in which localized production and consumption of utilitarian items were at a smaller scale. West (2002: 183-185) followed up on

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Fry's work by using both ceramic production and spatial data to pinpoint differences in the scales of elite administration of exchange among large centers, such as Palenque, Tikal, and Copan. I cannot use the regional production-distribution method for Sauce, because of the differences in scale. Sauce and its hinterland fit a polity rather than a regional scale. Therefore, for Sauce, where household distributional data are available, the spatial configuration of exchange systems can show how exchange systems were organized at a polity scale within the region, and help map potential political administration of exchange, and indicate the scale of each system within the polity (Stark 2007b: 109-110; West 2002:185).

I use the phrase the "spatial organization of exchange" to indicate how each item being exchanged is spatially distributed in relation to the Sauce center. The potential scale of the economic system being considered for Sauce and its hinterland extends about 12.5 km, which roughly fits the scale of what could be considered a market service area based on comparative studies of ancient markets (Blanton 1996a: 59). Sauce is plausible as a local central place for economic functions. However, one significant question is the spatial extent of the exchange systems shown through pottery types and whether they show a decrease in abundance away from the Sauce center that is associated with central place distribution (after C. Smith 1976). Also, it is currently unknown whether the openly exchanged pottery types are distributed through the same central place source or through more than one. If most of the openly exchanged pottery types show the same spatial patterns, for example, a decrease in densities from the

center of Sauce, then I will be able to demonstrate that Sauce is the most likely location of a marketplace for those types. Alternatively, spatial patterns could identify other potential central places for the distribution of pottery types.

I have some insights into the spatial extent and organization of marketplace exchange based on prior research undertaken using the PALM dataset by Garraty (2009). Although Garraty (2009) applied methods different than those employed for SAP, his insights are valuable starting points for the SAP spatial and contextual analyses[1]. Garraty (2009) found that there was a marked spatial drop-off in the similarity of pottery inventories among collections after about 9 km from Sauce (eastwards, where the settlement survey block extends) and that this drop-off may be due to the end of a market supply zone centered at Sauce or its immediate vicinity. For SAP, since most of the pottery types were probably distributed through market exchange, the question can be narrowed down to identifying the likely location and scale of exchange. For those pottery types that showed restricted access, the spatial organization and extent could help identify the political component to their restrictions. For example, if they are mostly found near or within the Sauce center or only in association with the higher ranked mounds, these results could indicate a political elite component to consumption and/or distribution.

Finally, I evaluate the degree of commercialization of exchange for Sauce and its hinterland. Commercialization involves the availability of an item or items for sale through markets. The degree of commercialization measures the amount of items within exchange systems that are openly available through

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markets versus those that are restricted. In anthropology, this availability is often discussed in terms of alienability. Items that are alienable are ones that can be more readily accessed by everyone, that can be turned into widely available goods (Appadurai 1986). Items that are inalienable are ones that are not available except through social position. The contextual nature of exchange means that local producers, consumers, and political elites decide which products are marketed and which are circulated through social networks (Appadurai 1986; Kopytoff 1986). Obviously, the ideational content of these items is important in characterizing how their exchange might be organized. Items of intrinsic great social value could be restricted in exchange, for example, while more utilitarian items circulate freely.

For Postclassic central Mexico, where market exchange is described, a large variety of products was available for sale with few restrictions on luxuries (Smith 2003b:117, 123). This great degree of commercialization, in which most items are readily available for sale in a market with limitations to access determined only by price, is considered a feature of Postclassic Mesoamerican trade, despite the apparent later development of sumptuary laws in the Aztec empire of the Late Postclassic period (Smith, M. 2003). The use of sumptuary laws is not an apparent contradiction, but a testament to the fluctuating nature of exchange itself, in which items can move in and out of open access through markets based on changing attitudes. The availability of differently valued products in Sauce is unknown and an important subject for study. Middle Postclassic Sauce may show market exchange in which specific types of products,

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such as basic necessities required for everyday activities (cookware and obsidian tools), were distributed in spatially distinct exchange systems from items which were more elaborate and fancy. Therefore, a significant component of understanding Sauce's economy is the social value of the products being exchanged.

In Chapter 5, the distinction between open versus restricted network exchange was established for all of the pottery types that had sufficient sample sizes for the statistical analysis. In this chapter, I analyze how the different pottery types were distributed within the region in combination with their associations with the weighted mound size groups (socioeconomic rankings) and how they may have been perceived socially. These two aspects: spatial and contextual, will be analyzed separately for pottery that was exchanged openly versus that which was restricted. In the first section, I establish the explicit methods by which pottery types were evaluated for establishing a measure of their potential social importance. In the second section, I establish the basic spatial patterns for the weighted mound size rank groups for the study area. In the third section, I apply the pottery type value and the mound ranking to my spatial and contextual analysis of pottery types. I summarize the two main methods I apply to analyzing the spatial and contextual dataset in Table 6.1.

Table 6.1 Summary of Methods.

Methods for Analyzing Spatial and Contextual Exchange
3. *Summary Visual Analysis* is exploratory data analysis that is a first step in analyzing spatial and contextual exchange.
d. Calculate the ratio of total Postclassic pottery (minus Late Postclassic) to the specific pottery type being analyzed for all 65 residential mound collections.

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e. Tally what percentage of collections per ring is above the median ratio of Postclassic ceramics for the specific pottery type.[1]
f. Create two-dimensional charts that show the percent of collections above the median ratio by ring.

4. *Detailed Visual Analysis* is an exploratory data analysis focused on individual pottery types and individual collections for spatial and contextual exchange analysis.
   e. Create bar charts for each pottery type depicting the counts and column percents of that pottery type for each residential mound collection ordered by ring zone, with collections depicted from ring 1 (Sauce) to ring 5 from left to right.
   f. Bar charts also include individual mound type information (scant versus robust sample) and weighted mound size rank groups as proxies for socioeconomic rank.
   g. Compare the individual collection bar chart results with maps of pottery type collections generated in MAPINFO (Corporation 1985-1997)when more detailed analysis is required.

Differentiating Product Values for Exchange Analyses

As stated in Chapter 4, the collections were analyzed using artifact typologies developed in PALM. For a detailed description of each of the pottery types, I refer to Stark's (1995) publication of Postclassic pottery types for the area (Appendix A). I apply a labor cost analysis to the ceramics based on the attributes of the dataset as outlined in the following sections.

Evaluating the Context of Exchange

Modern anthropological theory draws attention to the life-cycle of objects, both exchangeable goods and restricted valuables (Davenport 1986:95). Appadurai (1986:31) opines that consumption is a means of both sending and receiving social messages so that the exchange mechanisms by which products circulate are dependent upon how they are perceived. For example, decorated ceramic serving vessels could circulate differently than *incensarios* used in religious ceremonies due to variations in what these products meant (Fry 1980;

Kopytoff 1986:71). M. Smith (2003:122-123) differentiates five categories of

items in Postclassic Mesoamerica based on their social context: necessities,

widely used goods, regionally limited goods, goods with specialized utilitarian

uses, and luxuries. M. Smith (1994: 154-156; 2003b: 123) suggests the economy

was heavily commercialized because luxuries were available for purchase by all.

Some luxuries mentioned by M. Smith (2003:124-125), such as cacao, copper axe

money, feather-working, etc., are not likely to be obtained archaeologically in

south-central Veracruz. Therefore, I evaluated local artifact categories using a

combination of production labor inputs and product values to establish likely high

value products and identify whether this rural economy fits M. Smith's (2003)

description of commercialization.

In considering the relative value of products, I recognize that determining

the *emic* value of each type of product is not feasible. Furthermore, even with

historical records, there could be considerable biases in determining such socially

negotiated concepts as product values. However, the labor cost of artifact

production is one measure which may be used to determine a product's probable

value. Feinman et al. (1981) introduced the concept of the production step

measure to evaluate the comparative costs of various vessel types; the method

counts each step within the production process, such as painting with one versus

two colors, and quantifies the amount of "production complexity". For the

pottery types, I use surface treatment as a baseline for establishing a way of value-

coding labor costs; in my basic scheme each extra surface decoration such as the

number of paints, elaborateness of designs (to some extent), and incision would all add to the perceived "cost" of a pottery type.

In using production step groupings based on very general surface treatments (such as incision or not), I recognize that many other variables such as the fineness of paste, special vessel forms, and variations in polished finish could be equally important in establishing values of pottery. For at least one pottery type, Escolleras Chalk, the surface treatment is plain, but the fineness of paste and the relative quality of the observed vessels expressed in their regularity, smooth surfaces, and distinctive forms probably indicate that this type is more valuable than my simple value coding scheme would suggest. Therefore, although I will use the production value groupings as a general starting point, I will also consider variables other than surface treatment for identification of value. Below I outline the artifact variables and their product value assessments from south-central Veracruz that will be used as a guide for analyzing economic organization.

Relative Cost Groups for Pottery

I established relative values by comparing the elaborateness of decoration based on Postclassic type descriptions summarized in Stark (1995) and a few unslipped types that were identified as Middle Postclassic period pottery in later field seasons of PALM II (Stark 2008). The Middle Postclassic ceramic types include a few plain wares, but the majority are slipped and decorated. Pottery vessel types are divided into five groups in order of increasing labor: Unslipped/Plain, Unslipped/Incised, Bichrome/Simple Polychrome, Elaborate Bichrome/Incised, and Elaborate Polychrome (Table 6.2). The lower labor cost

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groups are good candidates for commercial market exchange. The more elaborate

ceramics, such as the Elaborate Polychrome group, which includes some possible

imports, are more likely to be part of elite gift-giving. However, I do not expect

labor costs to be the only criteria required to discriminate social networks versus

market exchange. For example, the lower cost Bichrome/Simple Polychrome

group includes types such as Black-on-Red that belong to the *guinda* complex (or

imitate it) that was the subject of far-reaching interregional trade during the

Postclassic (M. Smith 1990). I recognize that one cannot know, *a priori*, which

decorated ceramic type may have special regional significance for trade or

imitation or which ones might be socially restricted. As Hirth (1998:459-460)

observes, value is set by cultural norms which may or may not be influenced by

labor cost. I consider these groups to be trial categories for evaluating how higher

labor cost products and therefore how valuable products were exchanged.

Table 6.2 Production Cost Groups.

Category	Production Costs – Value Grouping
1. Comals 2. El Sauce Unslipped Types 3. Fine-paste Grey or Cream*	UNSLIPPED/PLAIN – 1
4. Incised Buff	UNSLIPPED/INCISED -2

5. Quiahuistlan*
6. Black-on-Orange (local style)
7. Interior-Banded Decorated Types:
    Red-on-Buff, Red-on-Orange,
    Red-on-White, & Polychromes
8. Black-on-Red
	BICHROME/SIMPLE POLYCHROME-3
	(includes *Guinda*)

9. Black-on-Red (elaborate variant) 10. Black-on-Orange (elaborate variant) 11. Frieze Motif: Orange, Red, and Polychrome	ELABORATE BICHROME/INCISED-4
12. Fondo Sellado* 13. Black and White on Red Polychrome 14. Complicated Polychrome 15. Dull Buff Polychrome	ELABORATE POLYCHROME-5

16. Misc. Decorated Types (some potential imports):
    Tres Picos, Cerro Montoso,
    Isla de Sacrificios, Totonac Polychrome

* Denotes type or category that fits the general Postclassic time type category.

(adapted from Garraty and Stark 2002: Table 1, for type descriptions, see Stark

1995 and Stark 2008; see also Appendix A for the complete list of pottery types

and associated pottery codes)

Settlement Patterns and the Spatial Organization of Weighted Mound Size Groups

      Prior to beginning spatial and contextual analysis of the SAP pottery, I

establish some basic spatial patterns for the settlement data. I will consider both

settlement patterns and how the weighted mound size groups are spatially

organized. As stated in previous chapters, the SAP collections were obtained

according to concentric rings, which extend from the Sauce center in 2.5 km

radial increments (see Figure 6.1). Also shown in Figure 6.1 are the centers of

Moral, Lobato, Sabaneta, Palmas Cuatas, and Villa Nueva because they had

collections on them that date to the Middle Postclassic period. Postclassic

materials do not make up the majority of the temporally diagnostic materials of

these centers. Therefore, they should not be considered to be Postclassic;

however, despite their relative paucity of Postclassic materials, it makes sense to

ask whether these monumental complexes may have been more attractive to

Postclassic settlement, particularly as locations for elite residences. The mound

size rank groups are based on mound volumes weighted by chronological material

percents, as discussed in Chapter 4. Therefore, the Classic period center

architecture that was re-occupied by some Middle Postclassic settlement was

dominated by Classic period materials, so their size is not captured by the mound

size rank measure. I will consider the intersection of Classic period center

architecture with Middle Postclassic settlement in addition to the mound size rank

groups in the spatial analyses.

The five weighted mound size groups established in Chapter 4 were

devised as a way of establishing a measure of socioeconomic rank that was

independent of the residential mound inventories. These five groups are ordinal

rankings from largest to smallest, one to five; Group five, which was the most

diverse and most numerous rank group, contained the smallest mound sizes. The

larger mound size categories appear to have associations with higher densities of

decorated ceramics, which supports the basic premise that larger mounds were

associated with more items, as one might expect to see within higher

socioeconomic ranks (see Chapter 4). Therefore, prior to beginning the

spatial/contextual analyses, I consider whether there are spatial associations of the

mound size rank groups with rings. Any potential associations will help guide the

spatial analyses of the pottery collections.

In considering the weighted mound size rank groups as summarized per

ring (Figure 6.2), it appears that most of the higher ranked mound groups are in

rings 1 and 4. These spatial associations may be the result of having some larger

mounds with possible elite residential locations at the center of Sauce. The

concentration in ring 4 suggests that elite residences may also be found there,

away from Sauce. Elite residences located away from the center are a pattern that

is consistent with other lowland agrarian based polities, such as Tikal, which had
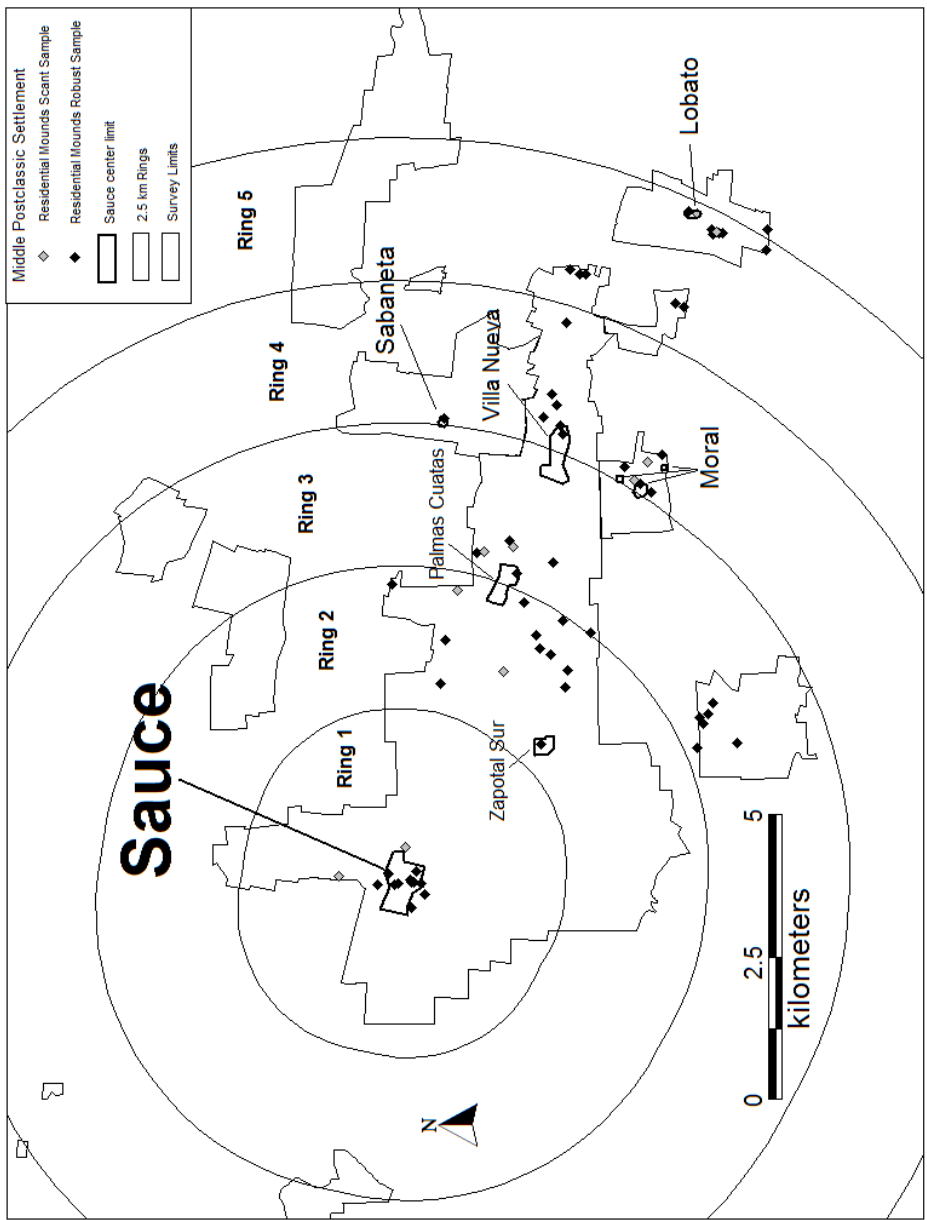
Figure 6.1 Map showing Sauce, SAP Collections, and Classic centers with Middle Postclassic settlements by rings.

elite residences and palatial plaza groups located away from the center (Taschek and Ball 2003).

Figure 6.3 depicts both the weighted mound volumes and their group ranking per individual mound; this chart shows that each of the rings has a few of the higher ranked mounds (mounds with larger weighted volumes). Even by considering the weighted mound volumes individually, no ring has noticeably greater mound volumes than any other (Figure 6.3). Although the summary and detailed mound volume data don't suggest very strong spatial associations, rings 1 and 4 have a slight edge in higher ranked mound groups (Figures 6.2, 6.3). The ring 1 associations are unsurprising; ring 1 includes the Sauce center and would therefore be expected to have higher ranked residences. Ring 4 is a more interesting case. Garraty and Stark (2002) identified an area of higher wealth concentration based on increased quantities of decorated pottery located about 8.5 km to the SE of Sauce. This distance matches up with ring 4. Therefore, this is an area that could have elite residences and higher quantities of decorated pottery for SAP collections as well.

Generally, the spatial and contextual data will be presented according to the rings, although individual spatial patterning will also be considered in addition to the summary data. I also consider each of the mound rank groups individually with their respective collections, rather than solely by rings.
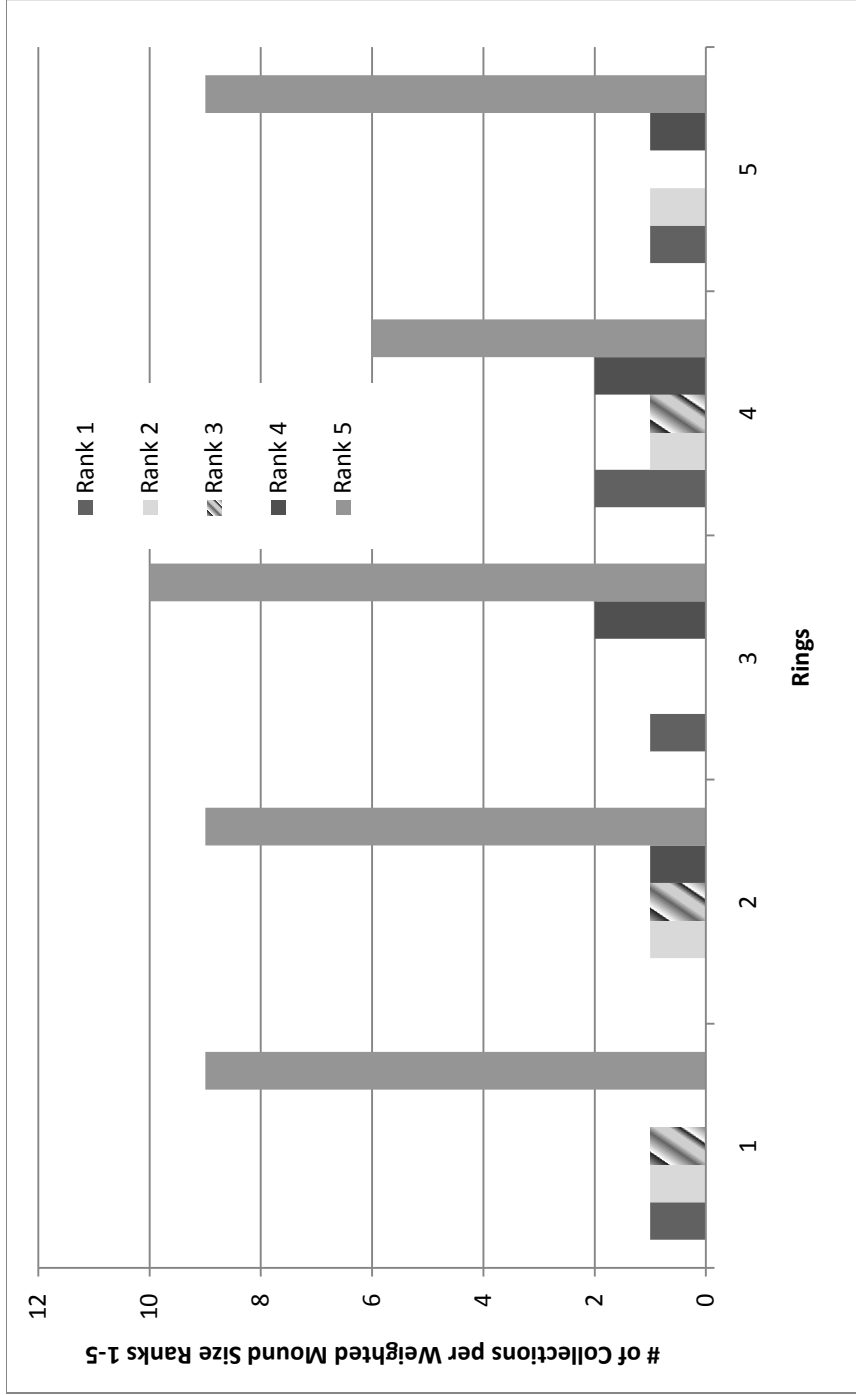
Figure 6.2 Number of mound size ranks per ring.
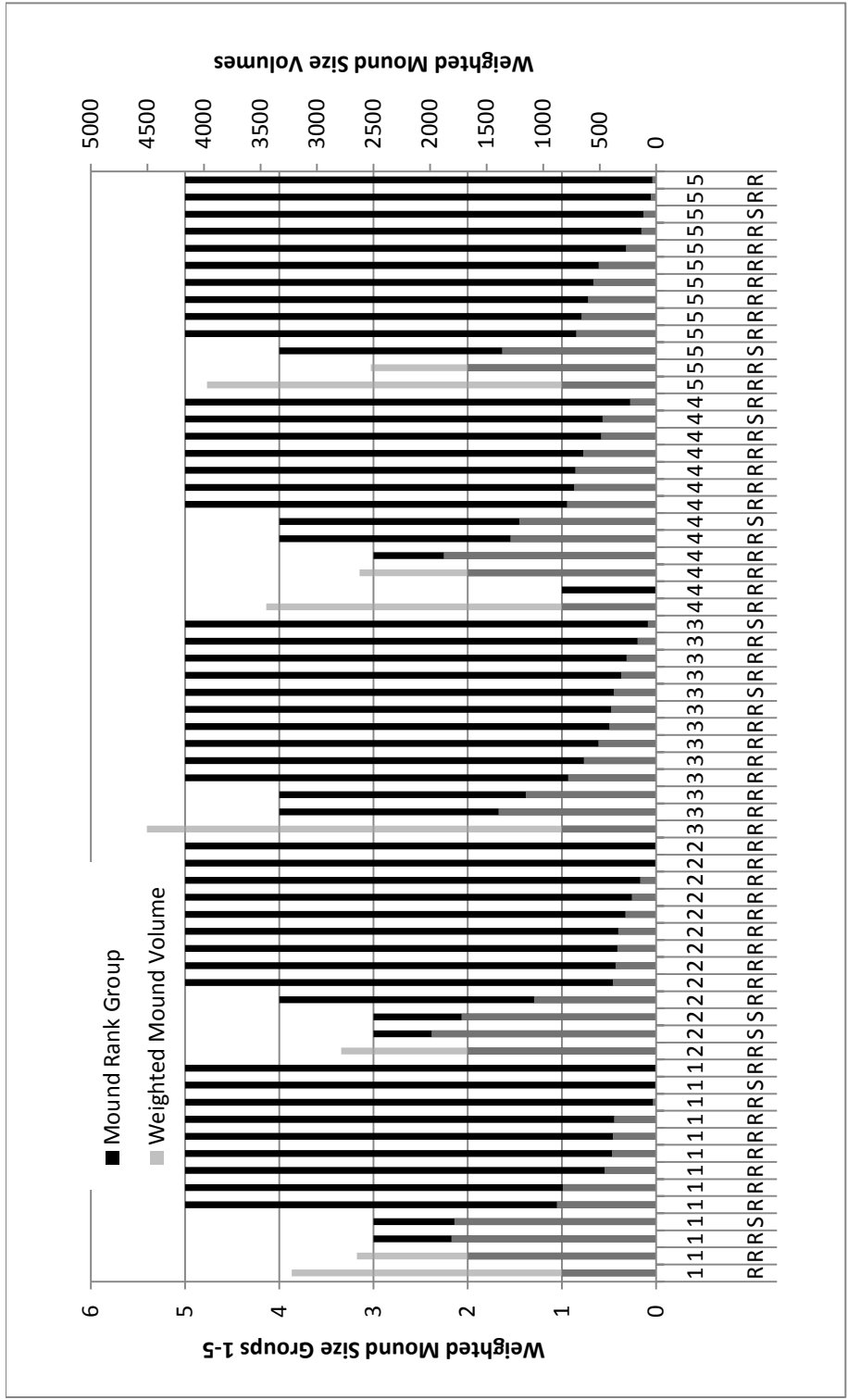
Figure 6.3 Weighted mound size ranks and volumes per residential mound collection listed by rings (1-5) and collection type R(obust) and S(cant).

Pottery and Markets

From the network exchange analysis in the previous chapter, most of the pottery types from SAP showed distributions consistent with being openly exchanged. Previous research on the region of Sauce and its hinterland is also supportive of market exchange based on a regional production-distribution approach, as described by Stark and Garraty (2010: 65). Several studies found that some products including decorated pottery and obsidian appeared to show widespread availability combined with a spatial drop-off in amounts from the center of Sauce in the Middle Postclassic period (Garraty 2009; Stark and Ossa 2010). Additionally, the results of a pilot study undertaken for SAP (described in Chapter 2) showed that comals and obsidian blades had spatial drop-offs as they got farther away from Sauce, consistent with a market centered at or near Sauce.

The drop-off results showed important variation. Garraty's (2009) study showed complications to a monotonic fall-off pattern from Sauce based on decorated ceramic densities. The area with a higher concentration of decorated ceramics that Garraty identified fits into SAP rings 4-5, an area with no identified Postclassic centers. The possibility that there might have been several elite hotspots on the landscape away from the only Middle Postclassic center of Sauce could show that there were some variations in political administration and/or elite land-use. The detailed information from SAP's collections should help identify whether these higher amounts of decorated ceramics are indicative of other central places on the landscape or represent concentrations of elite residences.

In sum, I do not expect to find a pattern for SAP collections radically different from what these previous research efforts uncovered. In later chapters I consider spatial patterns for other artifacts than pottery vessels for a more comprehensive approach than that of previous researchers. In this chapter, I expect to be able to answer questions about the scale and degree of economic integration, the role of local political administration, and the degree of commercialization for the more elaborately decorated pottery types. In the following few sections, I will consider spatial patterning and social contexts of the pottery types for the SAP collections. These sections will be divided by the production cost groups that were developed earlier in this chapter.

Unslipped and Plain – Group 1

The only plain ware identified as openly exchanged are the Buff Comals, found under the Unslipped and Plain Group 1 of the production cost table (Table 6.2). The fact that there was only one plain ware that could be evaluated for exchange is unsurprising, given that most of the plain and utilitarian wares from the PALM projects are not distinguished by time period. There are a few exceptions, such as Hard Buff, but this pottery type was so scarce in the SAP collections that it was not considered a reliable pottery type to analyze.

From Chapter 5, we know that at least some Buff comals were found in almost every residential mound that was collected. They can be considered an everyday cooking item used daily by most families (Nelson 1991). Lower comal amounts could be expected for residences located farther from the source due to transport costs. The pilot studies for SAP based on prior PALM collections

showed drop-offs in amounts of comals away from Sauce as described in Chapter 2. However, these pilot results were summarized by rings by using the ratio of decorated ceramic rims to comals and noting the percentage of individual collections with amounts above the median ratio. Although individual residential mounds were used as the base unit of analysis, the results for a drop-off were summarized by ring. For the SAP analysis I use both a ring summary and values for individual collections to examine the question of how comals were distributed.

I consider the summary data first. The summary methods described earlier allow me to handle the outlier effect of some collections with large amounts of comals possibly due to the known production locale in ring 2 (Curet 1993). In Figure 6.4 there is a drop-off from Sauce, despite the distortion in ring 2 related to comal production. These results also hold up for individual data from residential mounds (Figure 6.5). In the individualized analysis, we also see a drop-off in the number of collections with comals that is noticeable at ring 3.

Although the drop-off pattern is strong enough to suggest that Sauce or its vicinity were the source of Buff comals through some form of market exchange, we also see that there are a few collections (one notably in ring 4) that have much higher amounts of comals, despite the overall drop-off (Figure 6.5). How can we explain these localized higher amounts? In Nelson's (1991) ethnoarchaeological research on comal use in Mesoamerica, he found that the number of comals in use per household was not correlated with the household population. This result was different from those found by Longacre's (1985) ethnoarchaeological studies in the Philippines which were able to correlate vessel amounts and size with

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household populations. Cooking pots from the Philippines were associated with the total amount of food being processed per day, namely, cooked rice. In Nelson's (1991) study, a few comals could be used to produce few or many tortillas according to what a small or large household needed; thus the number of comals could not be directly correlated with household size.

Therefore, for SAP collections I did not initially expect comals to be present in markedly greater numbers in larger households based on Nelson's (1991) data on the numbers of comals that were currently "in-use". Instead, I surmised that the more abundant collections have more comals (see Figure 6.4, 6.5) because larger households probably wear out comals quicker than smaller households. As Nelson (1991:167) remarks, his study relied on informant reportage for vessel use wear and so may only have captured how long people *thought* their pots were lasting, not actually how long they really lasted. Because comals are typically subjected to direct heat while cooking tortillas, they are subject to higher rates of breakage; higher rates of use and thermal shock are associated with cooking vessels (Nelson 1991: 174; Rice 1987: 366). Therefore, although the ethnographic evidence suggests that larger households don't have more comals in use than smaller households at any given time, larger households wear comals out more quickly than smaller households because of their higher usage and breakage rate, which explains the higher amounts of comals in the abundant collections. Therefore, localized areas of higher amounts in some of the larger archaeological collections, even away from Sauce, do not change the over-
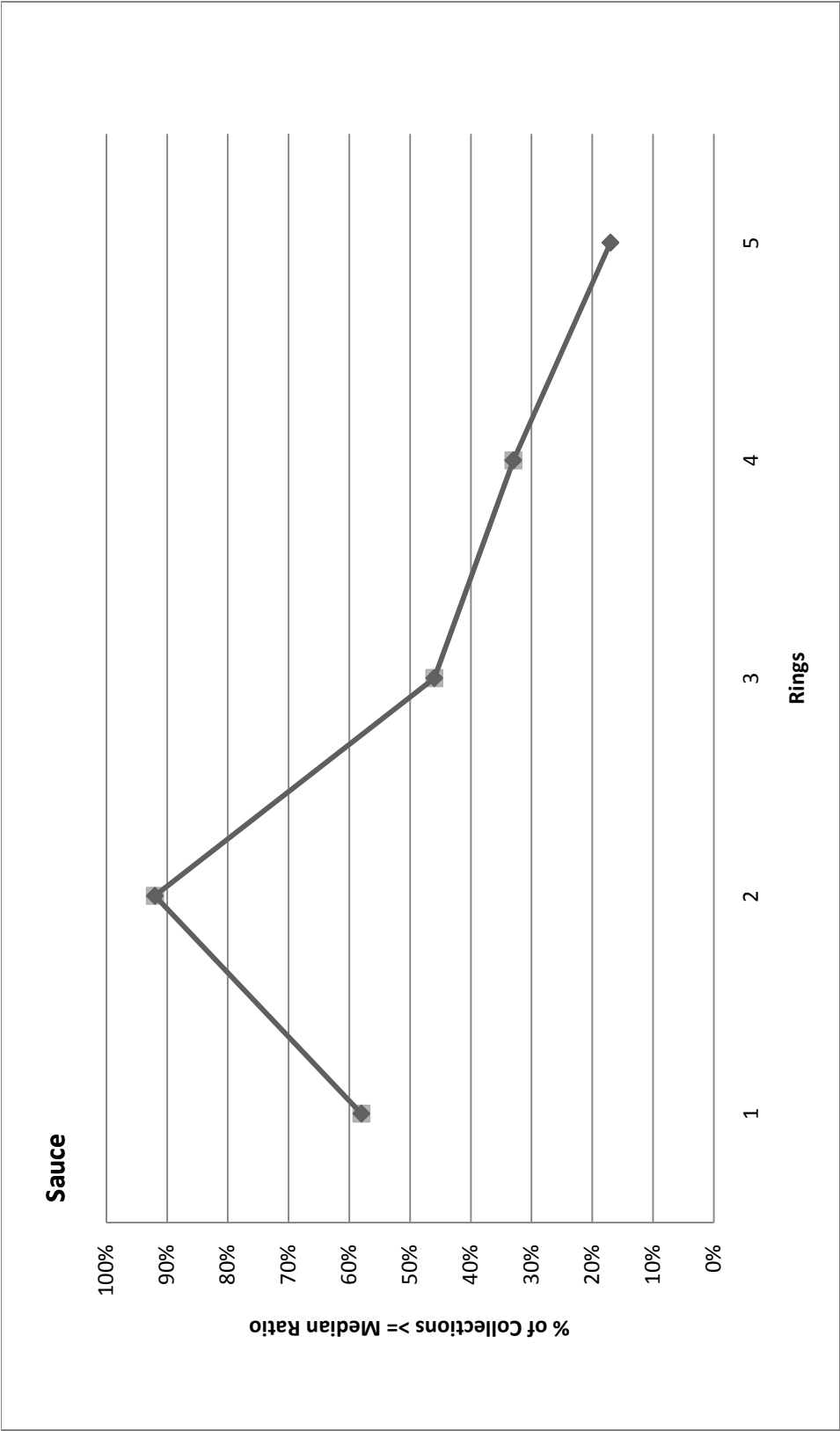
Figure 6.4 Results of Buff comals summary method for collections. Ring 2 is affected by comal production.

Figure 6.5 Buff Comals counts and percents per residential mound collection listed by collection type R(obust) and S(cant), then by rings (1-5) from left to right, and finally by weighted mound size ranks (1-5).

all spatial patterning that shows a clear drop-off in comals suggestive of market

access located at or near the Sauce center.

Bichrome/Simple Polychrome – Group 3 and Elaborate Bichrome and/or Incised
– Group 4

Both Group 3 and Group 4 of the production cost groups (see Table 6.2)

had to be combined for the analysis because both the Black-on-Orange and Black-

on-Red elaborate variants couldn't always be accurately separated during the

pottery analysis. In the case of Black-on-Red, only two differentiations of

variants could be made, the difference between a general Black-on-Red type and

the Black-on-Red Incised variant. However, the Black-on-Orange variants were

easier to identify and therefore were sufficiently numerous to be considered

separately. Therefore, for the spatial and contextual analysis I consider both the

aggregate group Black-on-Orange and each of its variants individually.

Black-on-Red. As stated earlier, this is one of the most widespread pottery

categories. This type is part of the *guinda* complex, which is one of the defining

pottery categories of Postclassic central Mexico and was probably quite important

in trade (M. Smith 1990). Due to the difficulties in separating out the decorative

variations within this pottery category, all of them had to be lumped together in

one group. Some differences in network exchange and spatial patterns might

exist among the variants of this group, but there is some utility in considering this

group for analysis. Although the Black-on-Red complex is found in many

different areas in Veracruz, it is apparently most abundant in the study area (Stark

1995:19-20). Therefore, spatial patterns for the Black-on-Red group could show some important patterns for the local exchange systems.

There is a sharper decrease in Black-on-Red from ring 4 than from ring 1 where Sauce is located (Figure 6.6). Instead, the Sauce ring ties with ring 3 for second highest amounts of collections above the median ratio of Postclassic pottery to Black-on-Red pottery. Black-on-Red may have had a different central place distribution located around or within ring 4. This would be about 8 km southeast of Sauce and at about the limit of what could be considered a market service area (Blanton 1996a: 59; Minc 2006: 99). Alternatively, the spatial pattern could indicate that there are elite residences in ring 4 that had higher amounts of decorated pottery such as Black-on-Red. It may also be a result of the statistical distribution of the Black-on-Red ceramics within the SAP collections. Black-on-Red is the most abundant decorated pottery found by SAP. Even residential mound collections that were quite scant had some of this pottery.   This could mean that even the more eroded collections from the outer rings of 4 and even 5 may be showing slightly inflated percents of this decorated pottery because it could be more easily identified than some other Postclassic pottery. Differential erosion may also be an issue with the other abundant pottery category, Miscellaneous Polychrome, which is discussed in a later subsection.

Using the individualized collection method, the general pattern of a drop-off from ring 4 is much harder to see (Figure 6.7). There are more collections with higher percents of Black-on-Red in the first 1-3 rings, but ring 4 has a cluster of very high amounts of Black-on-Red in four residential mound collections

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(Figure 6.7). We know from the sampling plan for ring 1 that most of the collections are located within the immediate vicinity of Sauce itself (see Chapter 3), but there is no spatial clustering for the mounds in ring 4. On a map those four abundant collections of Black-on-Red pottery in ring 4 do not cluster together (Figure 6.8). Interestingly, the weighted mound size rankings of these four collections involved ranks 1, 2, 3 and 5, so these were mostly residences of persons of higher socioeconomic rank (Figure 6.7). These results support the notion that while there are some collections that had much higher amounts of Black-on-Red within ring 4, there is a gradual decrease in Black-on-Red extending away from Sauce. Although there are some higher amounts in four collections of Black-on-Red pottery within ring 4, the overall patterning from both the summary and detailed methods do not favor a second source of Black-on-Red in this ring, although it cannot be entirely ruled out. Black-on-Red was a generally abundant pottery and higher amounts are associated with the more abundant collections.

Black-on-Red Incised. Black-on-Red Incised is a distinctive and more elaborate variation of Black-on-Red pottery and so may show similar patterning. The decorative technique consists of black designs painted on top of a red slip. The black paint generally forms a design which includes geometric forms such as spirals, circles, volutes and other more elaborate designs that are outlined by incision applied post-firing (Drucker 1943:51; Stark 2008). Drucker (1943:51) remarks that this particular pottery is found in the site of Cerro Montoso (also in Veracruz) and is similar to pottery from Aztec levels in the Valley of Mexico.

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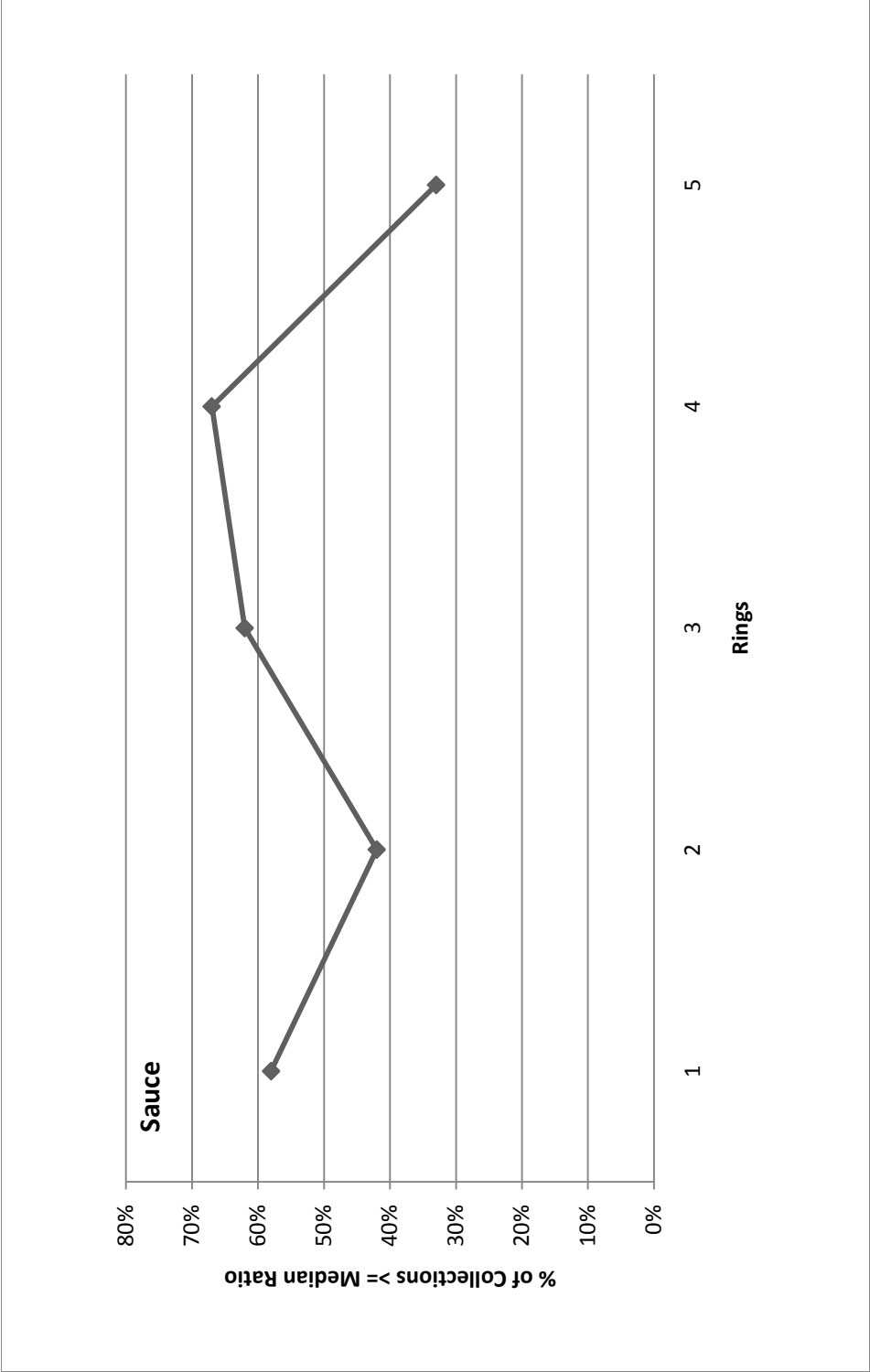
Figure 6.6 Results of Black-on-Red summary method for collections.
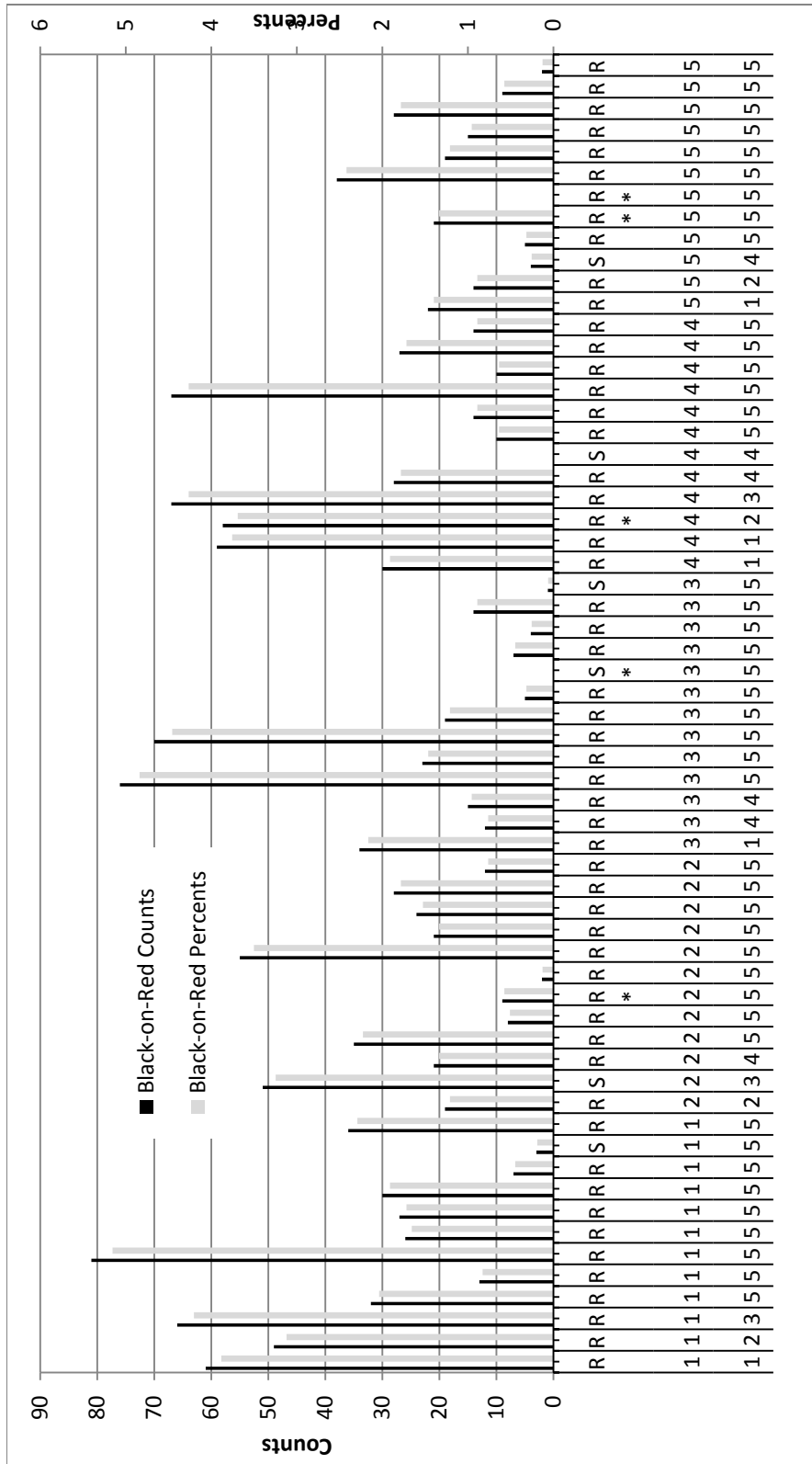
Figure 6.7 Black-on-Red pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

The results from the network analysis indicated this pottery type had a much more even distribution than one might expect, given its overall sample size. For the summary method (Figure 6.9), the Black-on-Red Incised pottery shows spatial patterns similar to the general Black-on-Red pottery type. In both cases, instead of a drop-off from Sauce, the amount of collections with a ratio greater than or equal to the median ratio of Postclassic pottery to both Black-on- Red and Black-on-Red Incised peak at ring 4. The ratios are similar for rings 1-3 with the only major drop-off in ring 5 (Fgure 6.9). However, the individualized collections method shows less equivocal results than the previous Black-on-Red pottery. For Black-on-Red Incised, the individual residential mound collections with the highest amounts are located within ring 1, with one particularly high amount in ring 2 (Figure 6.10). There are some high amounts in ring 4 as well, though not as high as in rings 1 and 2; interestingly, for ring 4, the highest amounts are associated with residential collections that also had high weighted mound size group ranks including two with rank 1 and one each with ranks 2 and 3 (Figure 6.10). Residential collections with higher amounts were not associated strongly with the high weighted mound size rankings in other rings except for ring 4. This could indicate a socioeconomic factor is affecting the higher amounts of Black-on-Red Incised within ring 4.

In the case of Black-on-Red Incised, the total amounts of sherds per collection vary, with quite low amounts in many cases (the median amount is one sherd) so it is difficult to believe too strongly in a drop-off pattern through the summary method, which shows an even spatial distribution of this type.

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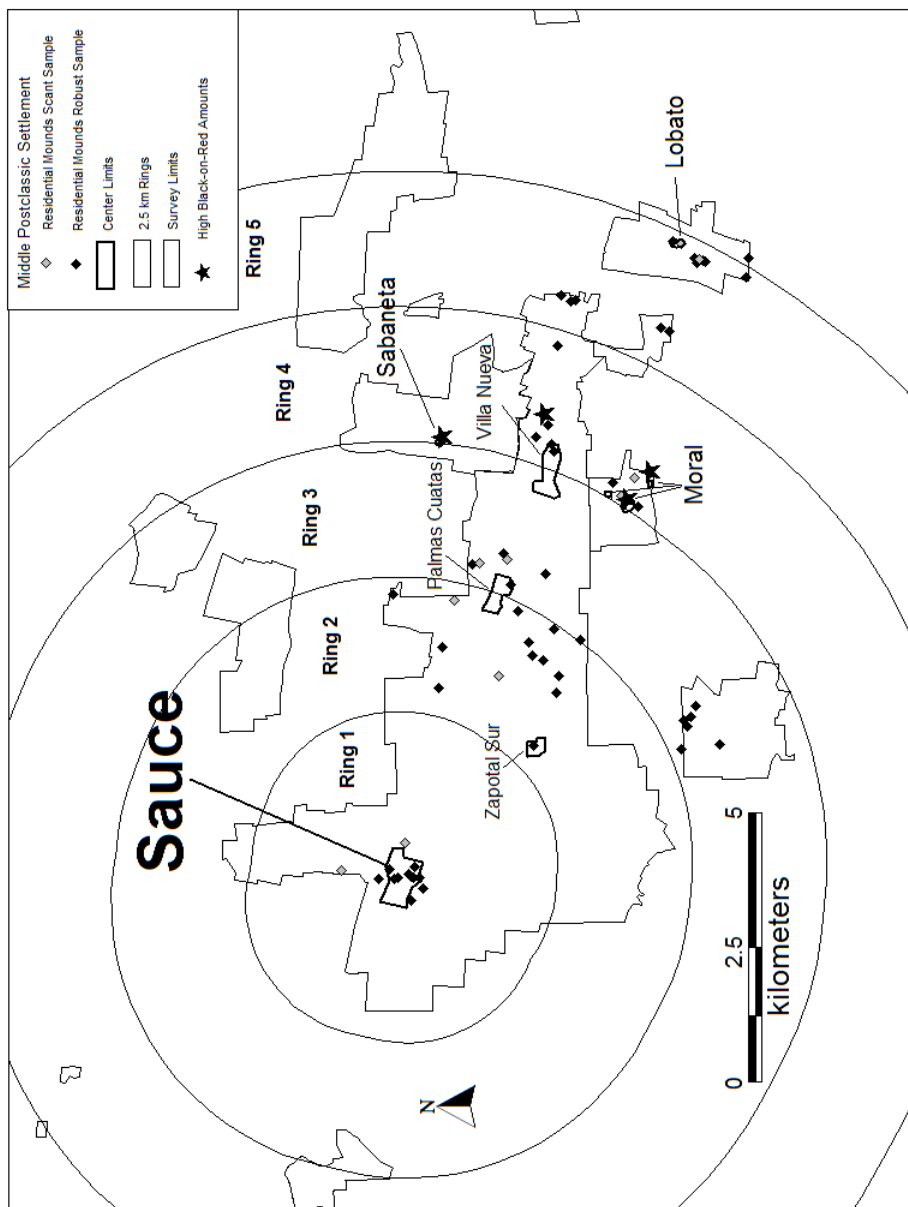
Figure 6.8 Map showing the 4 collections in ring 4 with high Black-on-Red amounts.

Black-on-Red Incised, while a rare pottery type, is actually more evenly spread than one might expect for its overall sample size, even though ring 1 has a slight edge in having the highest amount overall. One possibility to account for the relatively even spread of this pottery type among residential mounds is that these vessels were highly valued. If true, it could help explain why many residential collections have this type although the pottery category is relatively small in total sample size. There are some higher amounts within ring 1 and some collections with higher amounts in ring 4, but the usage for all residences was not great enough to produce significant discrepancies in amounts among all collections. Black-on-Red Incised may well have been marketed from the Sauce center; certainly the network analysis supports an open access hypothesis, but this information is not obvious from the spatial patterning alone.

Black-on-Orange. For Black-on-Orange I first consider the aggregate Black-on-Orange and then the three variants (codes 57a, b, and c) separately. The variants are worth describing for the purposes of analysis. Differences among the variants reflect additional painting: black rim bands (57a), black rim bands with horizontal bands on the sidewall (57b), and complex black designs below a rim band (57c). For SAP collections, which included body sherds, the most prevalent of the variants of Black-on-Orange was 57c (complex designs) but, at 85 sherds, it wasn't particularly numerous. This low amount is not surprising when one considers the PALM collection totals for Black-on-Orange (57c) were only 287 rims from survey and 199 non-rims. SAP had a lower amount of 57a (black rim
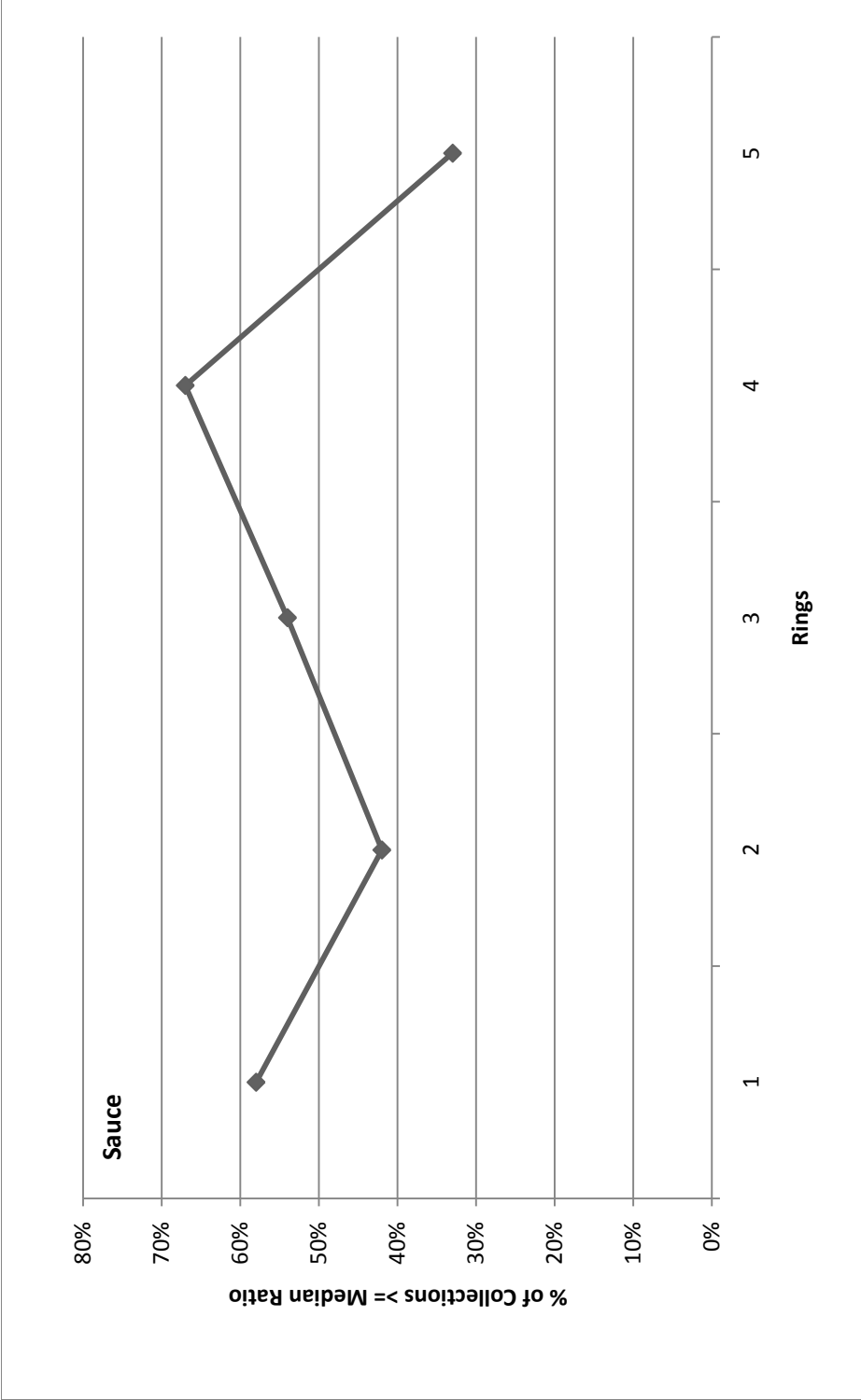
Figure 6.9 Results of Black-on-Red Incised summary method for collections.

Figure 6.10 Black-on-Red Incised pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

bands only) at only 32 sherds compared to PALM's 463 rims, 4 non-rims.

Interestingly, PALM collections had more Black--on-Orange "a" variant

compared to "c" variant while SAP had almost three times as much "c" variant

than "a" variant. This is a clear effect of a different collection strategy with SAP

collecting all sherds rather than just rims and decorated body sherds. The

sampling methods may well have increased the amounts of Black-on-Orange "c"

variant because body sherds may not have been as easily identified in the PALM

seasons if sherds were particularly eroded or dirty.

The Black-on-Orange pottery from the Middle Postclassic period (variants

a-c) is distinct compared to the Aztec style variant (57 m) that occurs later in the

chronological sequence (Stark 1995, 2008a). Therefore, the social significance of

the Black-on-Orange a-c variants cannot be based on possible relationships with

central Mexico. Due to the fragmentary and often eroded nature of the SAP

surface collections, I was unable to carry out any kind of quality analysis of the

sherds themselves beyond identifying their type and variant. However, there are

some interesting spatial patterns in this type and the variants that could be

identified.

In the summary methods (Figure 6.11), the Black-on-Orange aggregate

pottery type shows an overall drop-off from Sauce. It also shows a great decrease

in values in ring 2, picking up a little beyond that but largely continuing the drop-

off from ring 1 and the Sauce center. These results are also confirmed in the

individualized collection analysis method shown in Figure 6.12, which shows the

largest collections in ring 1, with hardly any collections in ring 2, and then quite a

few collections in rings 3 and 4. The drop-off does not appear so convincing in the detailed method because many collections have Black-on-Orange pottery despite the rather low over-all sample size of this type. Additionally, although two abundant collections in ring 4 have higher mound size ranks (1 and 3), the three other abundant collections outside of ring 1 fall into mound size rank 5. These results do not support clear associations of the Black-on-Orange aggregate pottery type with rank.

In considering the three variants of Black-on-Orange separately, 57a, 57b, and 57c respectively, I note that 57b, with 85 sherds, makes up most of the Black-on-Orange aggregate; 57a has 32 sherds and 57c merely 10 sherds. As stated previously, the SAP collections included body sherds as well as rim sherds for analysis, which may have made the identification of variants a and b impossible in some cases because they rely on rim band decorations for identification (Stark 2008). Due to their smaller sample size, they represent a very rough approximation of the overall aggregate group pattern. In viewing the summary results for variants 57a, b, and c, there is a severe drop-off from Sauce in ring 2 and then a slight increase for ring 4 (Figures 6.13, 6.14, and 6.15). The increase in amounts in ring 4 appears to be related to a few abundant collections.

The detailed method results for the three Black-on-Orange variants show a similar drop-off from Sauce with a few abundant collections in ring 4 (Figures 6.16, 6.17, and 6.18). Three collections (6636, 6507, and 6489) within ring 4 had higher amounts for each of the Black-on-Orange variants. In examining a
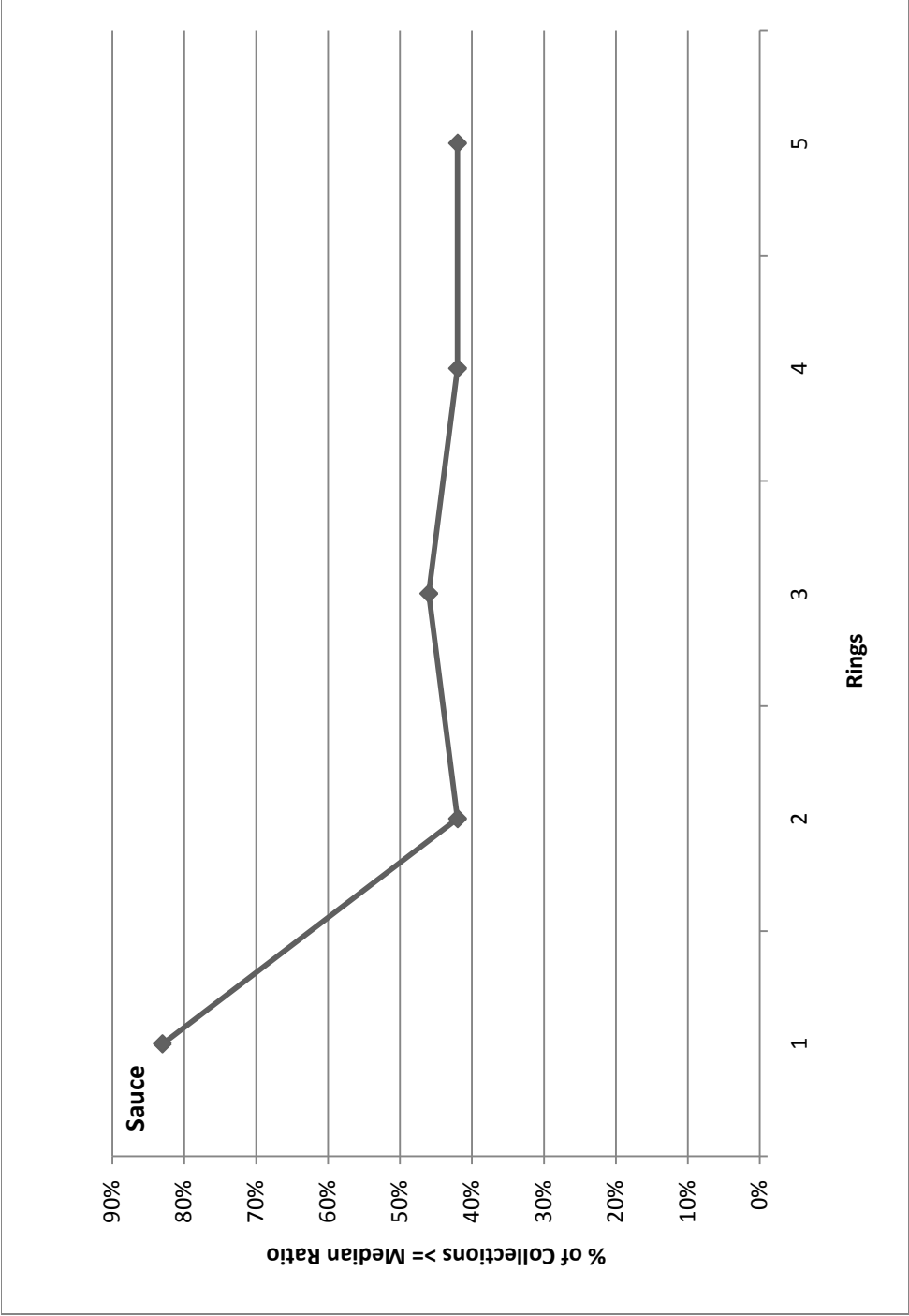
Figure 6.11 Results of Black-on-Orange summary method for collections.

Figure 6.12 Black-on-Orange Aggregate pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), then by rings (1-5) from left to right, and finally by weighted mound size ranks (1-5).
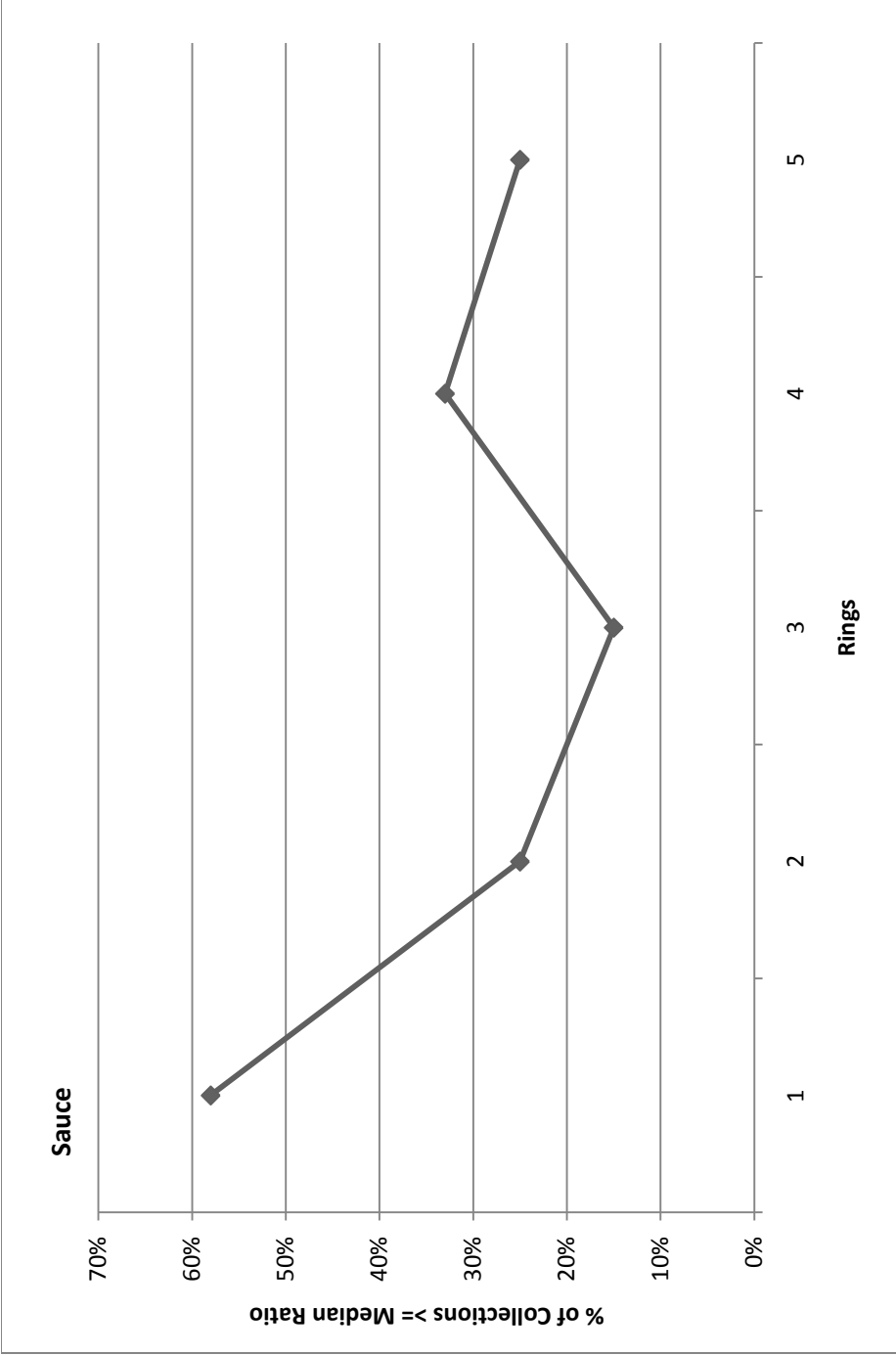
Figure 6.13 Results of Black-on-Orange 57a variant summary method for collections.
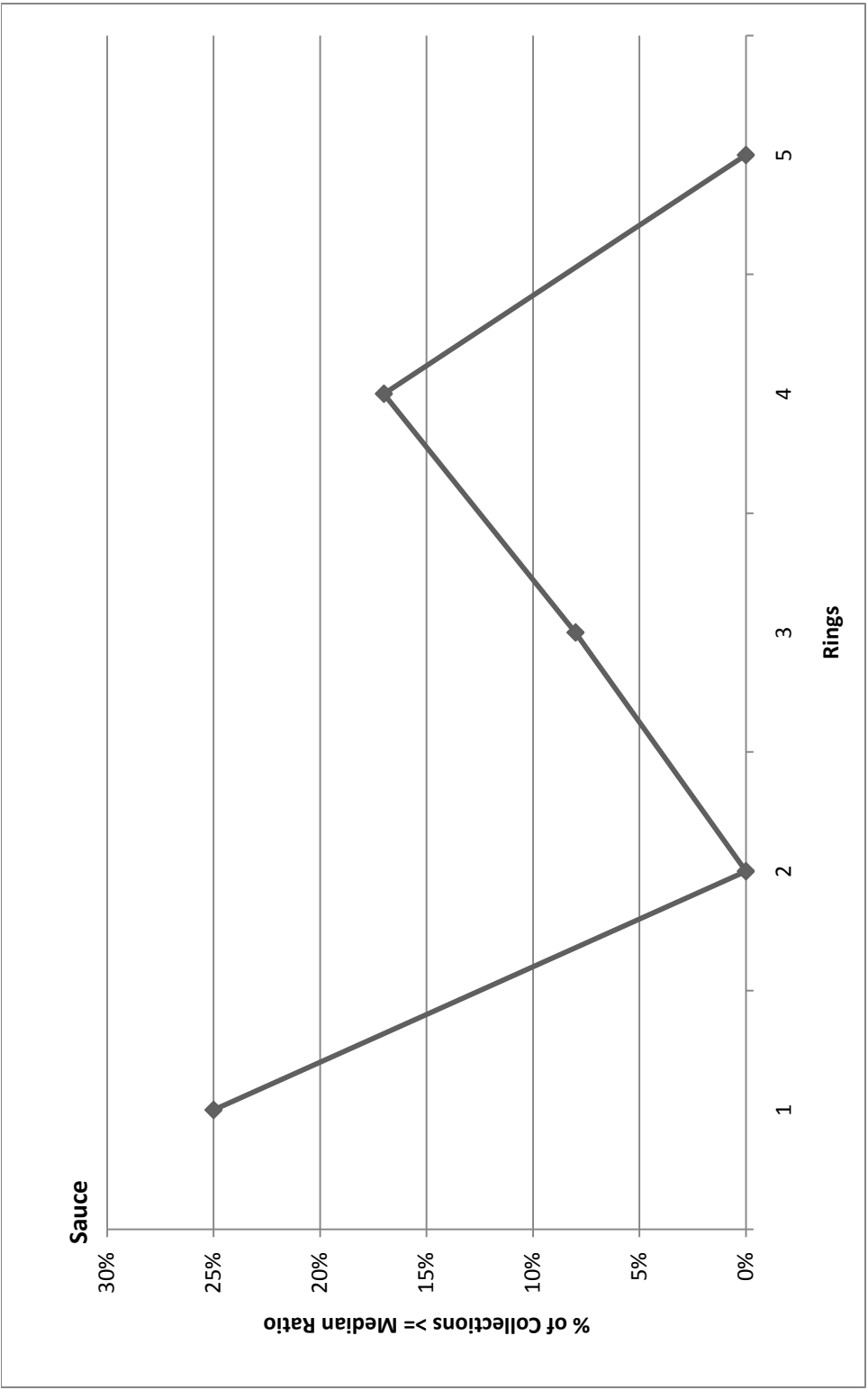
Figure 6.14 Results of Black-on-Orange 57b variant summary method for collections.
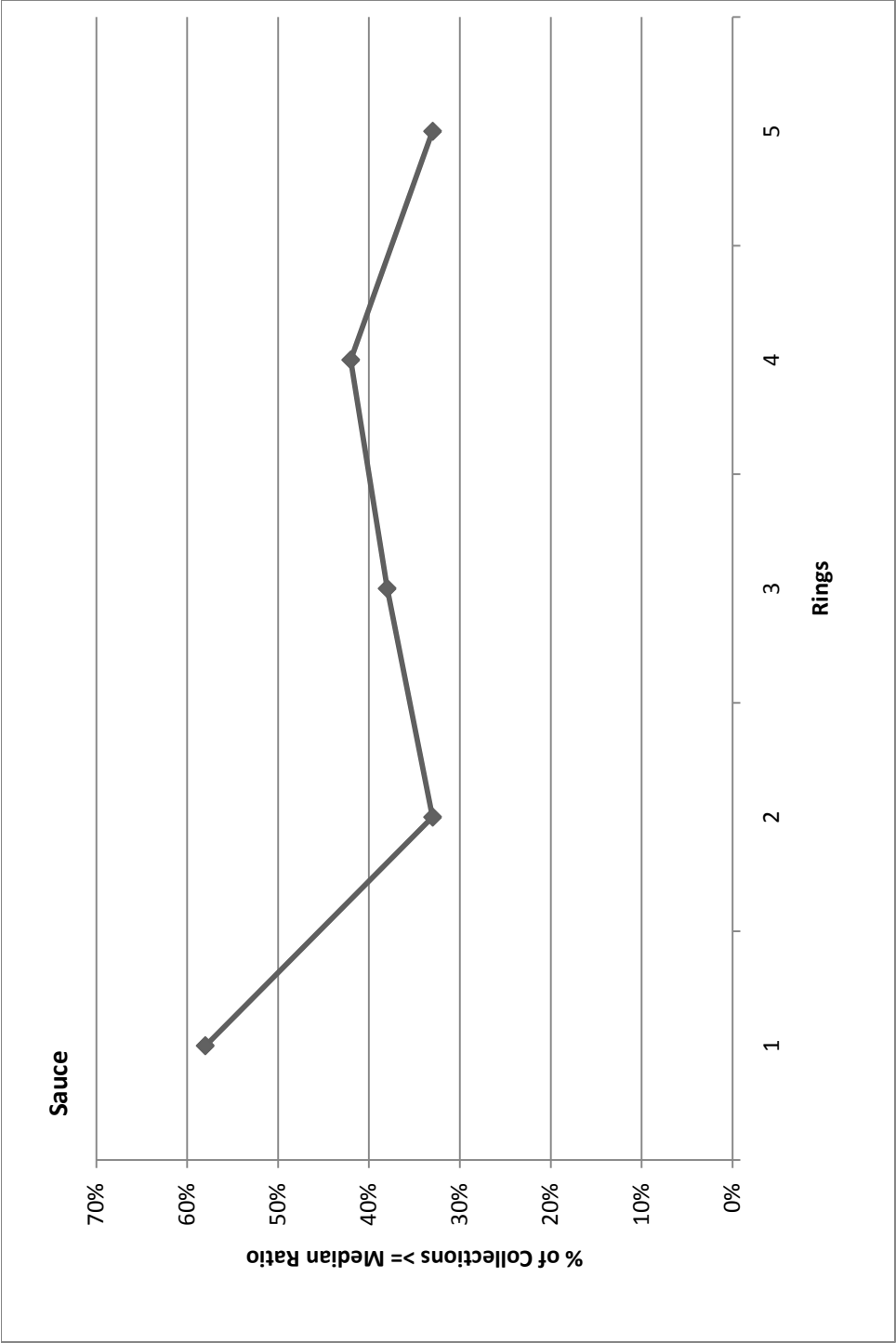
Figure 6.15 Results of Black-on-Orange 57c variant summary method for collections.

Figure 6.16 Black-on-Orange 57a pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).
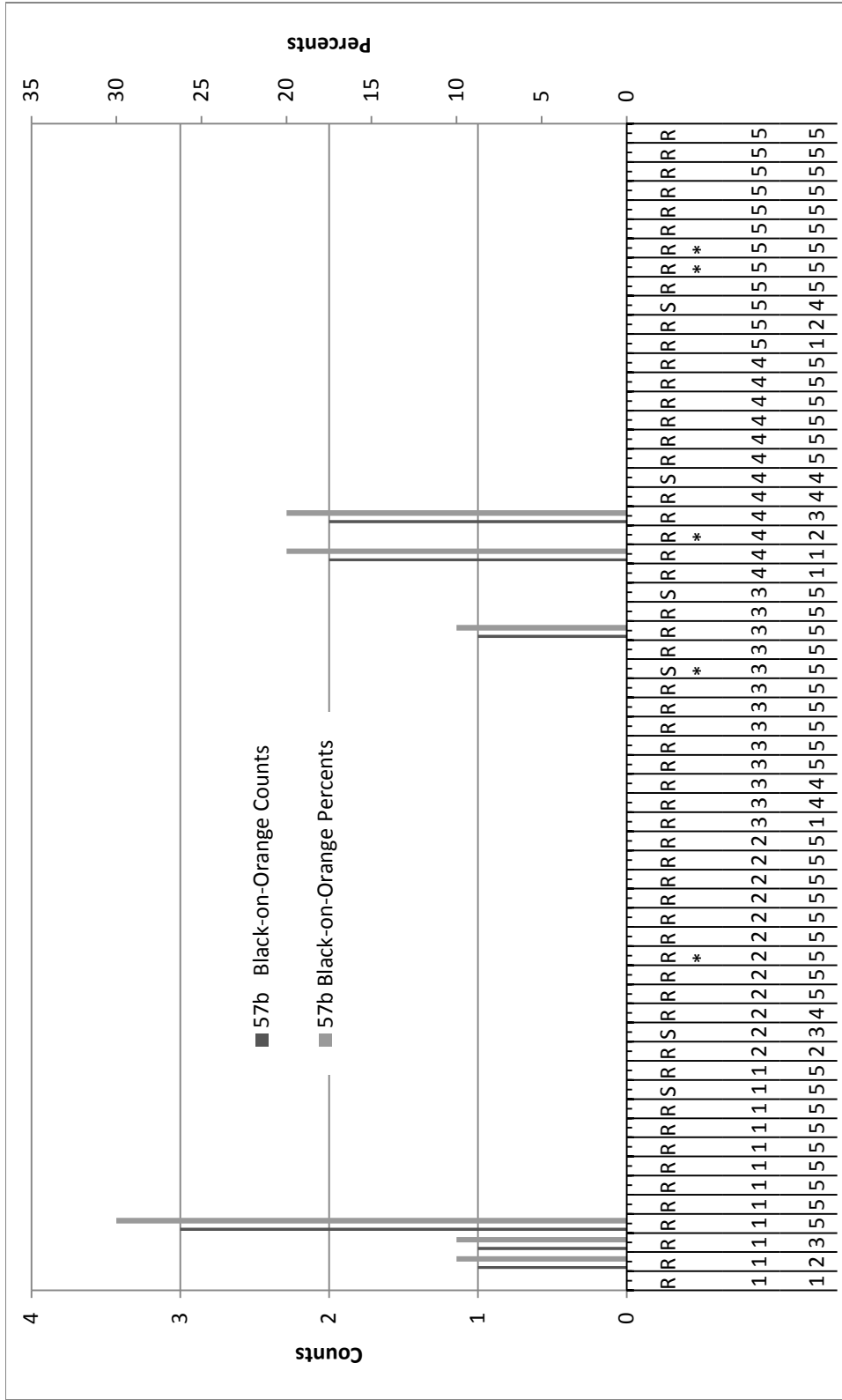
Figure 6.17 Black-on-Orange 57b pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

Figure 6.18 Black-on-Orange 57c pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).
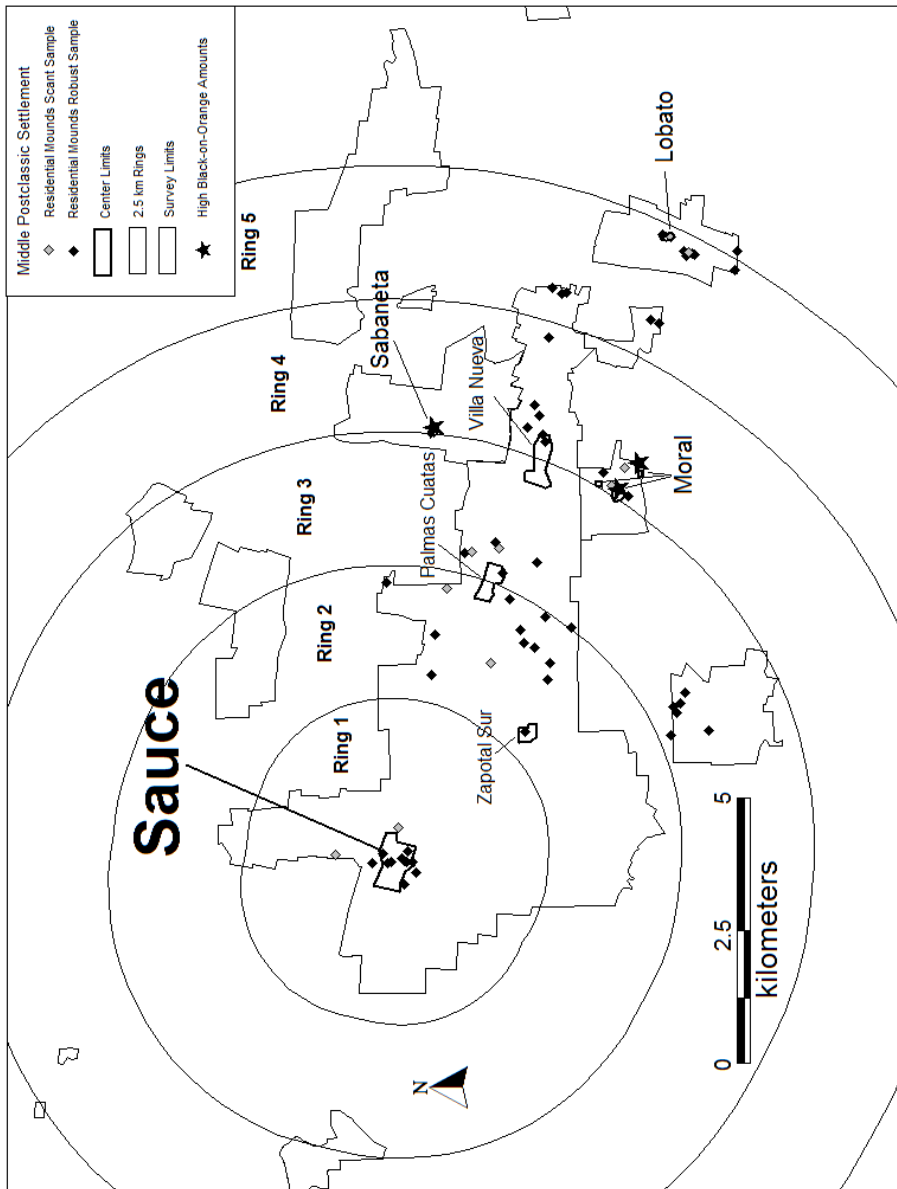
Figure 6.19 Map showing 3 collections with higher amounts of Black-on-Orange pottery.

map with these collections, two of the three are very near each other while the third is located north of them (Figure 6.19). Also, although the third northern residential mound collection has a weighted mound volume rank that is in the smallest size (5), it is located in one of the Classic period large plaza groups with large mounds that were identified earlier in this chapter (Sabaneta). All three of these residential mound collections were taken from fairly sizable mounds that were on or near some Classic period monumental architecture (Figure 6.19). It could be that with Black-on-Orange, as with the previously discussed decorated pottery, there is a socioeconomic component to higher densities, with potential elite residential re-use of monumental architecture linked to its distribution. Despite some higher amounts in ring 4, the detailed and summary methods support the existence of a market located somewhere in the vicinity of Sauce.

Quiahuistlan. Quiahuistlan pottery gets its name from the archaeological site located in the north of the modern state of Veracruz, approximately 400 km from Sauce away as the crow flies, which is known for its distinctive material culture and tomb tradition (Medellín Zenil 1960:153-154). The source of Quiahuistlan pottery is probably the site of Quiahuistlan itself or nearby, since it is found in greatest quantities associated with the cemeteries of the site (Lira López 1990: 124). Quiahuistlan pottery for PALM or SAP has not been analyzed using chemical or petrographic methods for comparison to the pottery found at Quiahuistlan. However, based on the paste, decoration, and vessel form, the locally identified versions of this type match the type description for Quiahuistlan

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pottery (Lira López 1990:176-185). Therefore it is likely that Quiahuistlan pottery was imported into the region.

In the PALM pottery type descriptions, Quiahuistlan mostly consists of very small convex bowls that sometimes have little nubbin supports (Stark 1995:30). The paste is very fine and typically eroded, making it difficult to discern the designs and the paint. Some sherds of this type have dark reddish brown paint around the rim and in one case an animal was painted in the interior of the bowl (Stark 2008: 125). Stark (2009) suggests that the rather small size of these bowls may suggest use as bowls for supported spinning of thread, but the characteristic wear was not observed. Due to the extreme rarity of this type in the SAP collections, with only 12 sherds found in total, I was unable to apply a reliable network analysis to the dataset. All of the SAP collections are statistically comparable and can be considered representative artifact densities, which allows some very cautious statements about the extremely rare types such as Quiahuistlan regarding the spatial patterns and associations with socioeconomic rank.

Due to the extremely low counts, the summary method for Quiahuistlan is not very useful. In Figure 6.20 most of the sherds found were in rings 1, 2, and 4. The individualized collection method in Figure 6.21 shows that most of the collections outside of ring 1 were from the weighted mound size group 5; two collections were also from the Scant sample that was originally aimed at finding lower socioeconomic residences, as described in Chapter 3. This fact is quite

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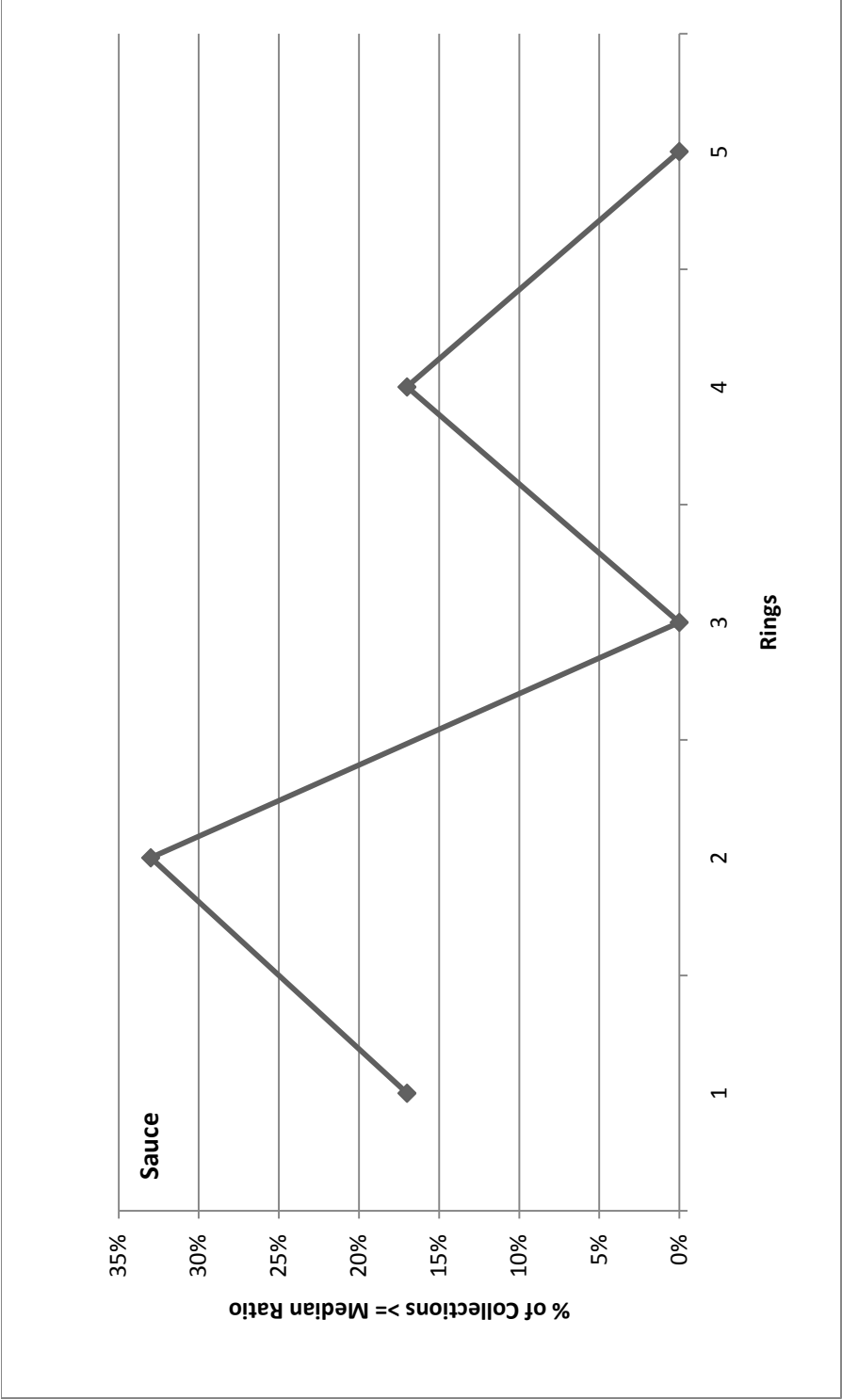
Figure 6.20 Results of Quiahuistlan summary method for collections.

Figure 6.21 Quiahuistlan pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).
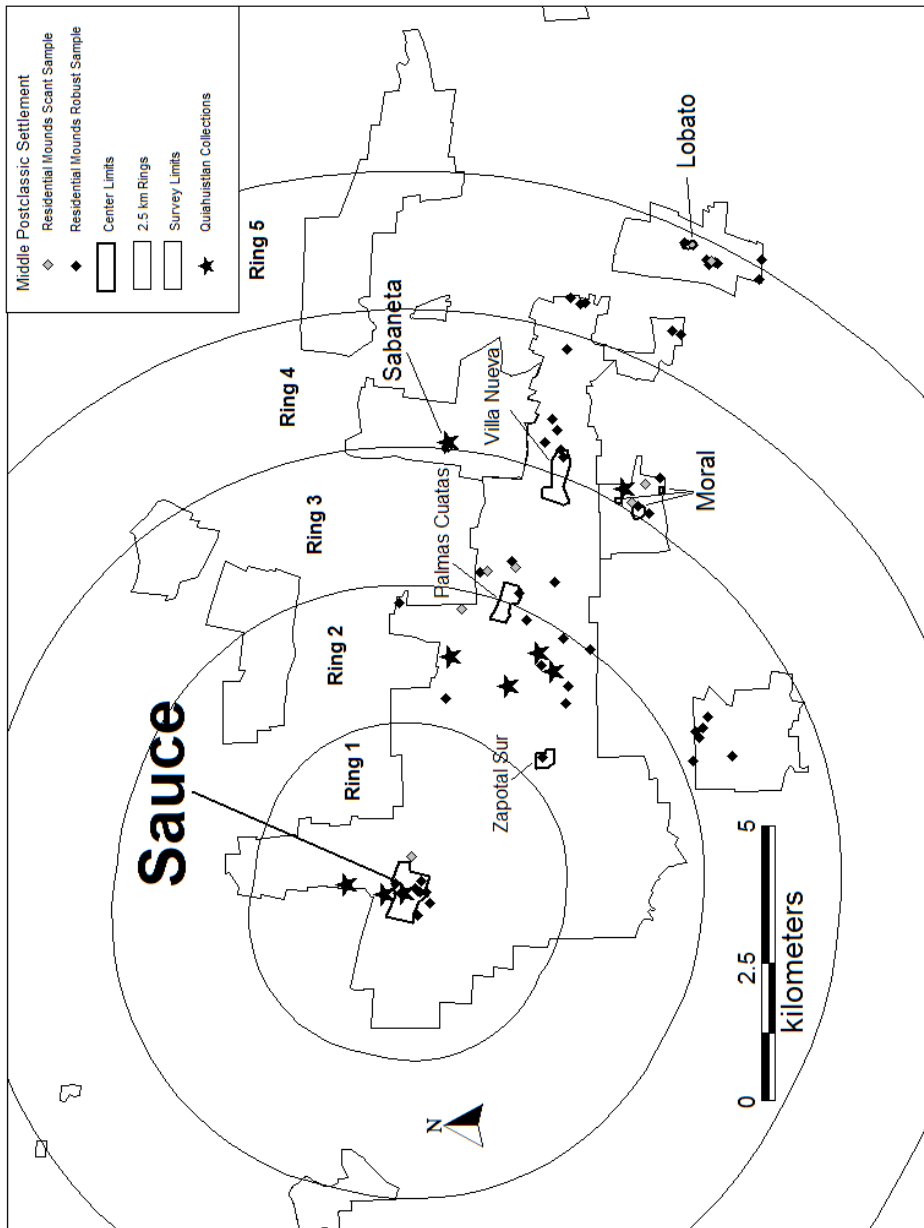
Figure 6.22 Map showing all collections with Quiahuistlan pottery.

striking as most of the other decorated ceramics with this low of a sample size have not been found in these Scant collections. The discovery of Quiahuistlan in Scant residential mound collections suggest open availability of and specialized use of this likely imported pottery.

Since there are so few collections with Quiahuistlan, we can view them in their entirety on a map (Figure 6.22). Collections in ring 2 appear to be close, almost adjacent to each other (Figure 6.22). This pattern is also true for ring 1, but I consider it likely due to sampling issues; the majority of the mounds in ring 1 are close to each other. Again, because this is such a rare type, it is not surprising that a few of the higher ranked mounds from ring 4 also have a sherd or two.

The collections in ring 2 are of particular interest because these mounds are not the higher ranked mounds associated with high amounts of decorated ceramics as in ring 4. In fact, these mounds are all low ranked mounds (in weighted mound size rank Group 5, Figure 6.21). Why might lower ranked mounds have enough of this rare type to show up in such a small sample? Lynette Heller (2008), a member of the original PALM survey crew, was present during SAP collections in ring 2 and noted that nearly whole vessel examples of Quiahuistlan had been found in a mound almost adjacent to the SAP collection during the PALM project (collection 1006). That mound had been destroyed by modern brick-making. Heller's observation might mean that these lower ranked mounds adjacent to each other in ring 2 could have been engaging in a local industry involving spinning. One of the mounds with Quiahuistlan pottery from

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ring 2, collection 1286, had four spindle whorls in its inventory. In fact, of the

nine residential collections that had Quiahuistlan pottery, seven of them had

spindle whorls, some in quite large amounts (two collections had four whorls

apiece). In particular, the two mounds adjacent to each other in ring 2 had two

and four spindle whorls. These spatial results and possible artifact associations

suggest that access to this pottery type was not restricted and furthermore that it

may well have been associated with spinning activities. Associations of this type

with spindle whorls will be considered in further detail in Chapter 8 where the

scarce artifact categories will be analyzed separately.

Elaborate Polychrome – Group 5

This final group of decorated ceramics that was openly exchanged

includes the most elaborate polychromes and some fancy, probably imported,

pottery types. I included the major pottery types that were considered in the

network analysis such as Miscellaneous Polychrome, the Complicated

Polychromes (with and without white underslip), and the White-and-Black-on-

Red polychrome variants. I also included those few assorted pottery types such as

Tres Picos Polychrome and Fondo Sellado that did not have large enough sample

sizes to do a statistical network analysis but which showed no obvious restrictions

based on associations with only Sauce or elite mounds.

Miscellaneous Polychrome. As with the Black-on-Red pottery group, this

pottery group is an abundant category and was found in almost all of the SAP

collections. Due to its likely internal variations (sub-types) and ubiquity, it

proved tricky to analyze in a network setting. Some real differences in network

exchange systems and spatial patterns might exist between the variants of this large and complex pottery group, but due to the analysis restrictions of surface collections, I am unable to differentiate all of them here.

In Figure 6.23, the patterns seem to be almost the exact opposite of all of the other decorated pottery types, with rings 1 and 4 showing the lowest amounts and ring 5 showing the largest. What could explain this result? Although all collections had Miscellaneous Polychromes, rings 3 and 4 in particular had smaller collections (which could inflate the ratio measure) and in rings 4 and 5 many collections were heavily eroded, making many of the identifications for Miscellaneous Polychrome in those zones more likely. The individualized collection results in Figure 6.24 show a similar pattern, with the higher amounts found within rings 4 and 5. Additionally, with the exception of one residential mound collection within ring 1, virtually all of the collections that had high amounts of Miscellaneous Polychrome were in the weighted mound size Group 5. However, given that Group 5 is the most abundant of the size groups (45 out of 65 of the residential mounds are in Group 5) the correlation of Scant mounds with Miscellaneous Polychrome is difficult to evaluate.

On a map showing SAP collections with 40 or more Miscellaneous Polychrome pottery sherds, most of the abundant collections are found in ring 5 (Figure 6.25). There are a few collections scattered among the other ring zones that also had very high amounts of Miscellaneous Polychrome, but for ring 1 these collections appeared to be much less eroded, so that small and harder to differentiate polychrome sherds might explain the high amount of sherds ending
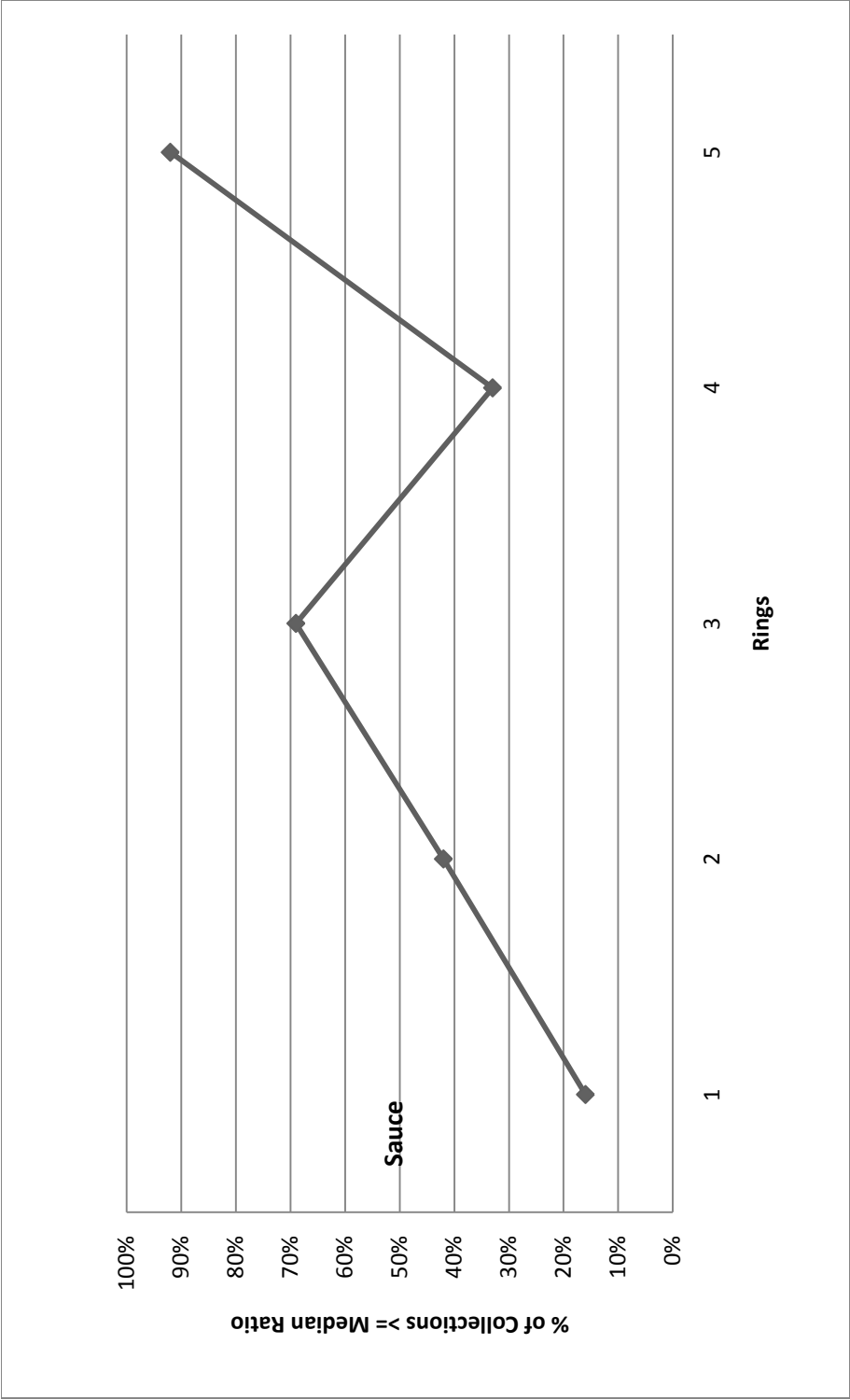
Figure 6.23 Results of Miscellaneous Polychrome summary method for collections.

Figure 6.24 Miscellaneous Polychrome pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

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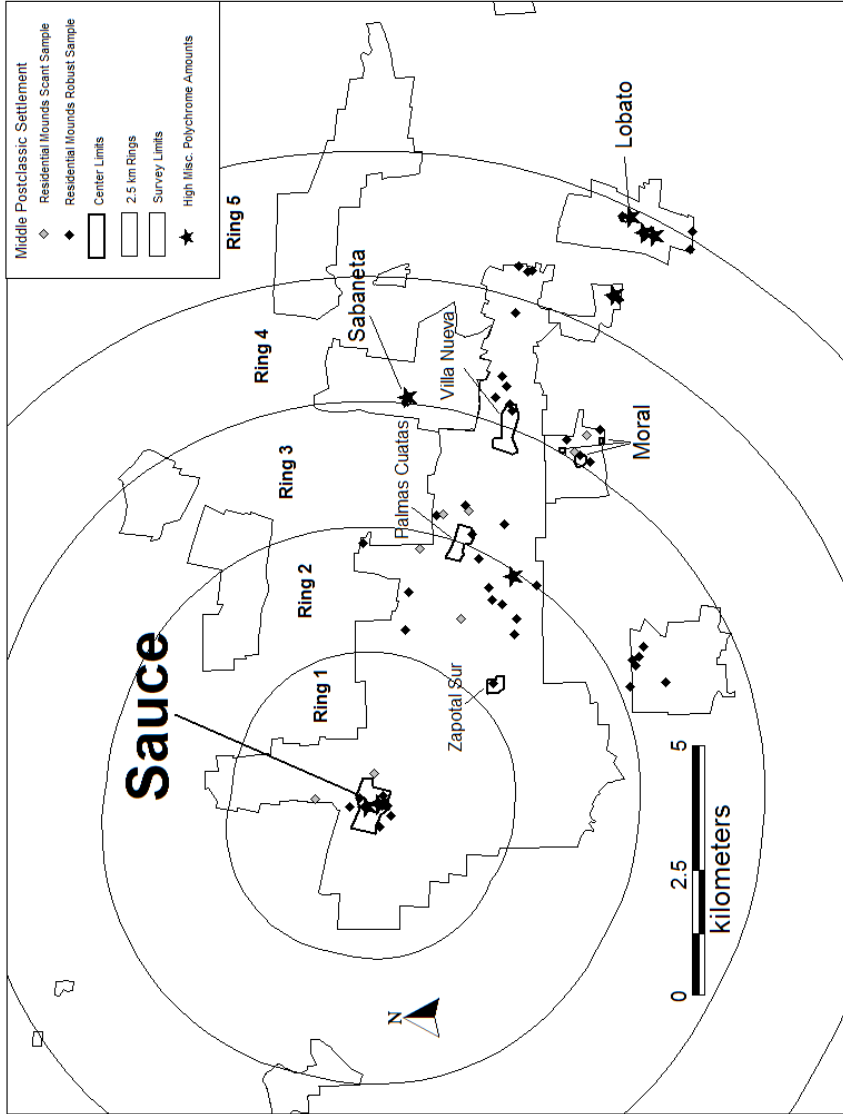
Figure 6.25 Map showing collections with 40 or more Miscellaneous Polychrome pottery sherds.

up in the Miscellaneous category for ring 5, where it was hard to differentiate different polychrome types from eroded materials. In summary, the spatial patterns for this pottery type group may be governed by the fact that many eroded sherds end up in this category rather than pinpointing specific economic or social activity.

Complicated Polychrome (with and without white Underslip). Complicated Polychrome is a candidate for an import due to its elaborate cholutecoid painted and incised designs, although its origin and production provenance have not been studied (Drucker 1943; Stark 1995). Complicated Polychrome is broken down into two variants, one with white underslip and one without. The variant without white underslip (7s COMP), was first defined by Drucker (1943:48). The variant with white underslip was rarer in PALM collections and also proved to be rare in SAP collections. Complicated Polychrome with White Underslip is a candidate for Noguera's (1954) polychrome "no firme" and also the "laca" variants but due to poor preservation of sherds, a solid identification was not possible (Drucker 1943: 48; Vásquez Zárate 1990: 126-127, cited in Stark 1995: 25). Both variants of Complicated Polychrome will be considered separately for the spatial and contextual analyses.

Complicated Polychrome without White Underslip had a total of 202 sherds in the SAP collections. For the summary results in Figure 6.26, the most abundant collections of this type are in ring 1. After that, a sharp decrease is followed by an increase in rings 4 and 5. Interestingly, the amounts increase in ring 5, which could lend support to the idea that there is another center here or

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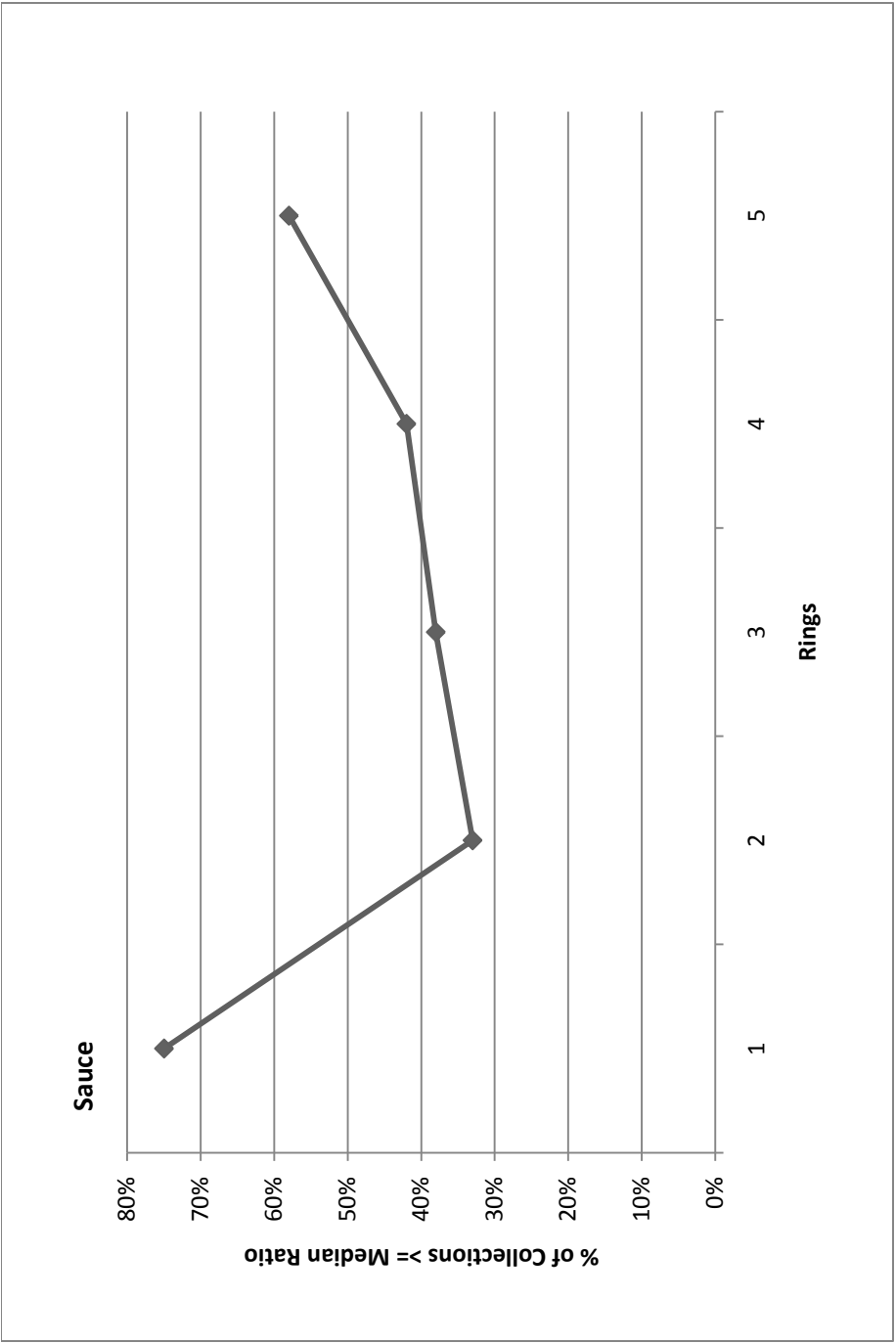
Figure 6.26 Results of Complicated Polychrome without White Underslip summary method for collections.

nearby that may have served as a distribution point. However, even the median

ratio method used in the summary results did not erase the impact of the smaller

quantities of materials recovered from the artifact collections in ring 5. This

means that for these collections, even very low amounts of a pottery type (such as

one sherd) might be enough to make it exceed the median ratio. The statistical

methods used here, although helpful, do not mitigate the effects of small samples

for ring 5.

In viewing the individual collection detailed method in Figure 6.27, the

small amounts starting in ring 5 prove to be misleading. The majority of high

amounts (above 8 sherds) are found within ring 1, with two collections in ring 2,

one collection in ring 3, and one collection in ring 4. There are no obvious

associations of Complicated Polychrome without White Underslip with the higher

weighted mound size ranks; instead, many of the higher amounts are found in

Group 5, the lowest rank group (Figure 6.27). The network analysis established

that this was not restricted access pottery, and the spatial analysis confirms that

each of the rings had some amount of this pottery type, albeit in lower amounts

than ring 1. It is likely that a market for this pottery type was located in or around

Sauce. Despite the higher ratios of this type to total collections in ring 5, it is not

convincing that higher amounts were associated strongly with ring 5.

Complicated Polychrome with White Underslip was less numerous than

its variant counterpart without White Underslip, having a total of 106 sherds in

the SAP collections. In Figure 6.28, the summary method shows an obvious

decrease in this pottery type from ring 1. These results are even more strongly

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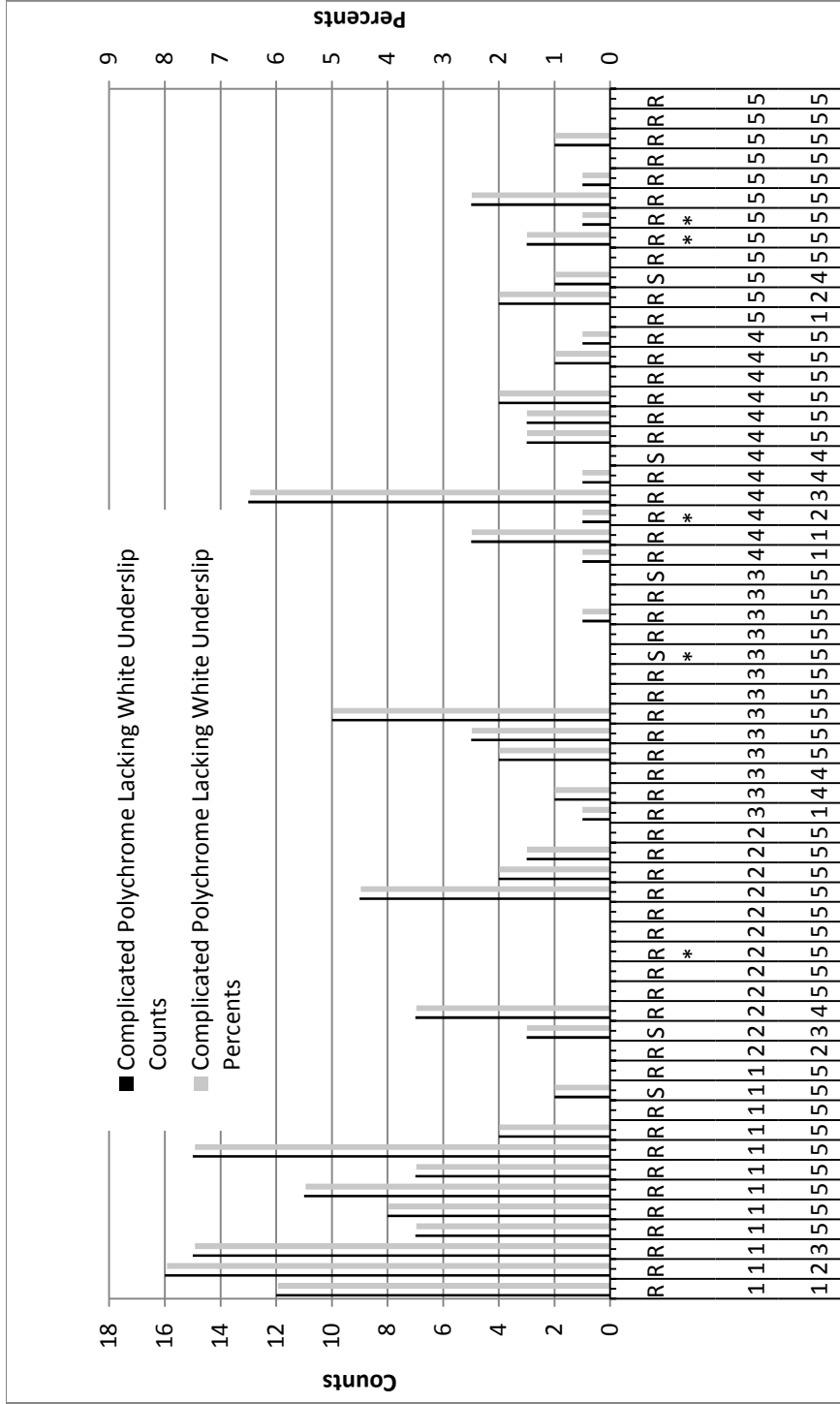
Figure 6.27 Complicated Polychrome without White Underslip pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).
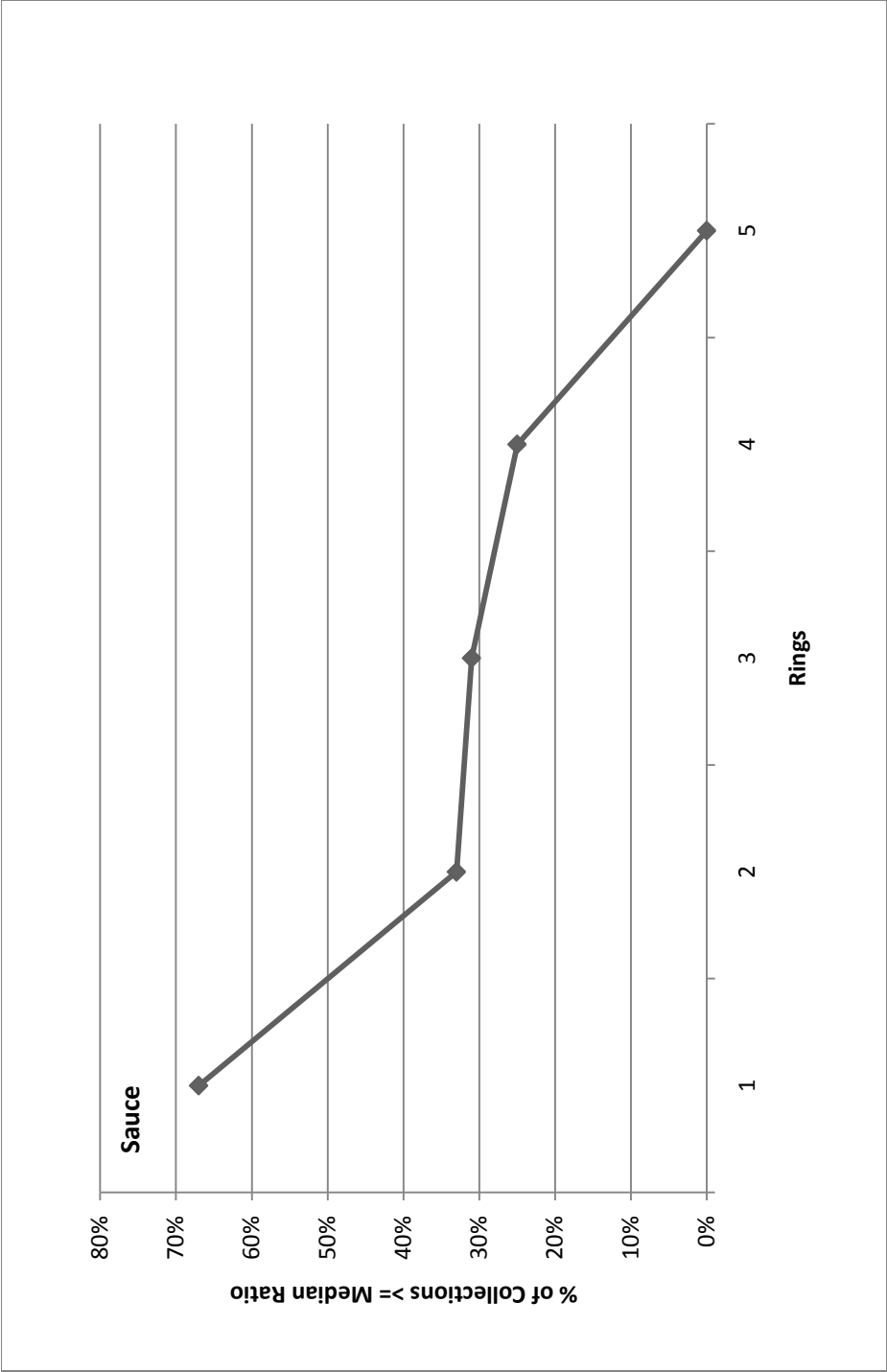
Figure 6.28 Results of Complicated Polychrome with White Underslip summary method for collections.

Figure 6.29 Complicated Polychrome without White Underslip pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

confirmed in the individualized collection method seen in Figure 6.29. The largest amounts are in ring 1, with a few higher ones in rings 2 and 4. As with the previous Complicated Polychrome variant, there is not an obvious association with the higher weighted mound size ranks. No spatial association is evident between the two abundant collections in ring 4 since they are not close to each other (Figure 6.30). In summary, the spatial and contextual data for Complicated Polychrome with White Underslip supports the idea that the local point of distribution was a market near Sauce in ring 1.

White-and-Black-on-Red Polychrome. Although this polychrome was considered in aggregate as pottery group WBR for the network analysis, I will consider the two variants: Splashy White-and-Black-on-Red Polychrome and Framing White-and-Black-on-Red Polychrome, separately for the spatial and contextual analysis. One interesting feature about these two polychrome variants is that the SAP collections have one variant, the Splashy White-and-Black-on-Red Polychrome, in much higher amounts in its 65 collections at 189 (rims and bodies) than the 2,233 PALM collections which had a total of 559 (rims and bodies). SAP had a more intensive collection method than PALM that included rims and bodies for all collections. Therefore, it wouldn't be surprising that the ratio of a pottery type to total collections would be higher for SAP. This might be a feature of the intensive SAP collection method indicating that at least one variant of this pottery type is more numerous than it originally appeared to be in PALM.

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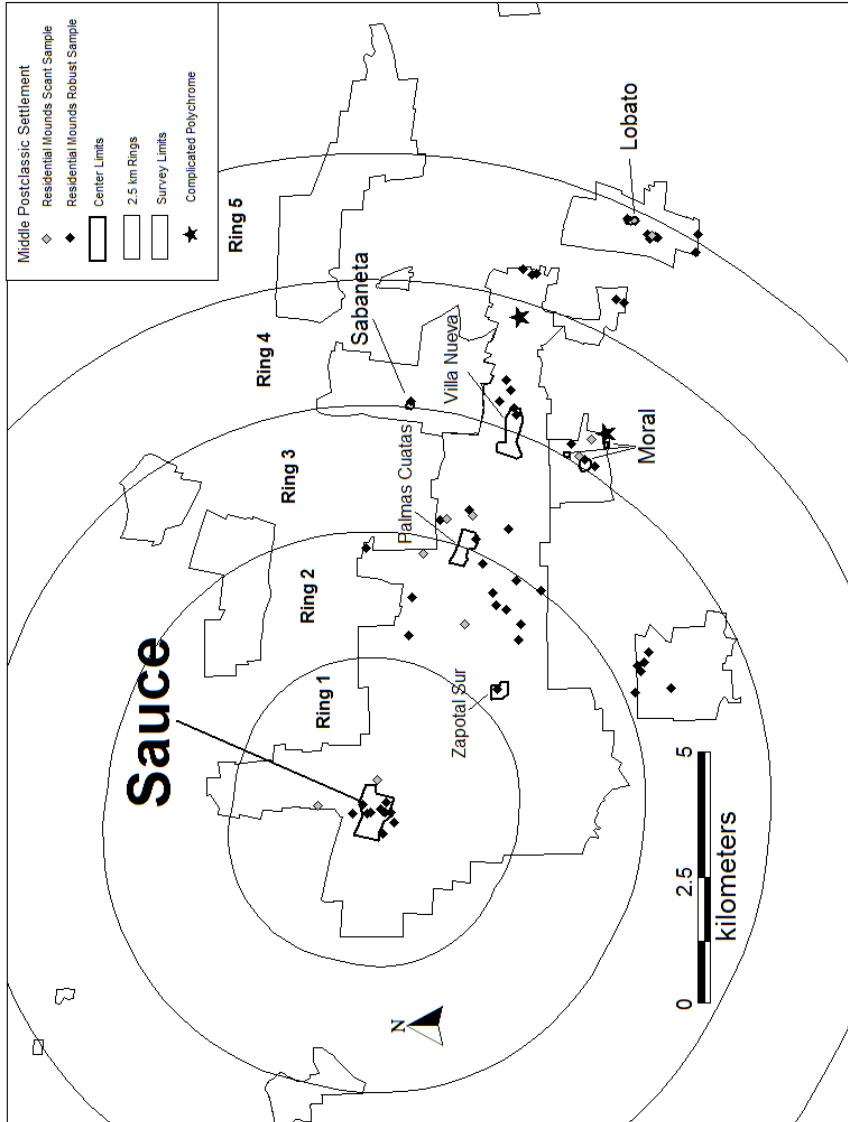
Figure 6.30 Map showing two collections in ring 4 with high amounts of Complicated Polychrome with White Underslip.
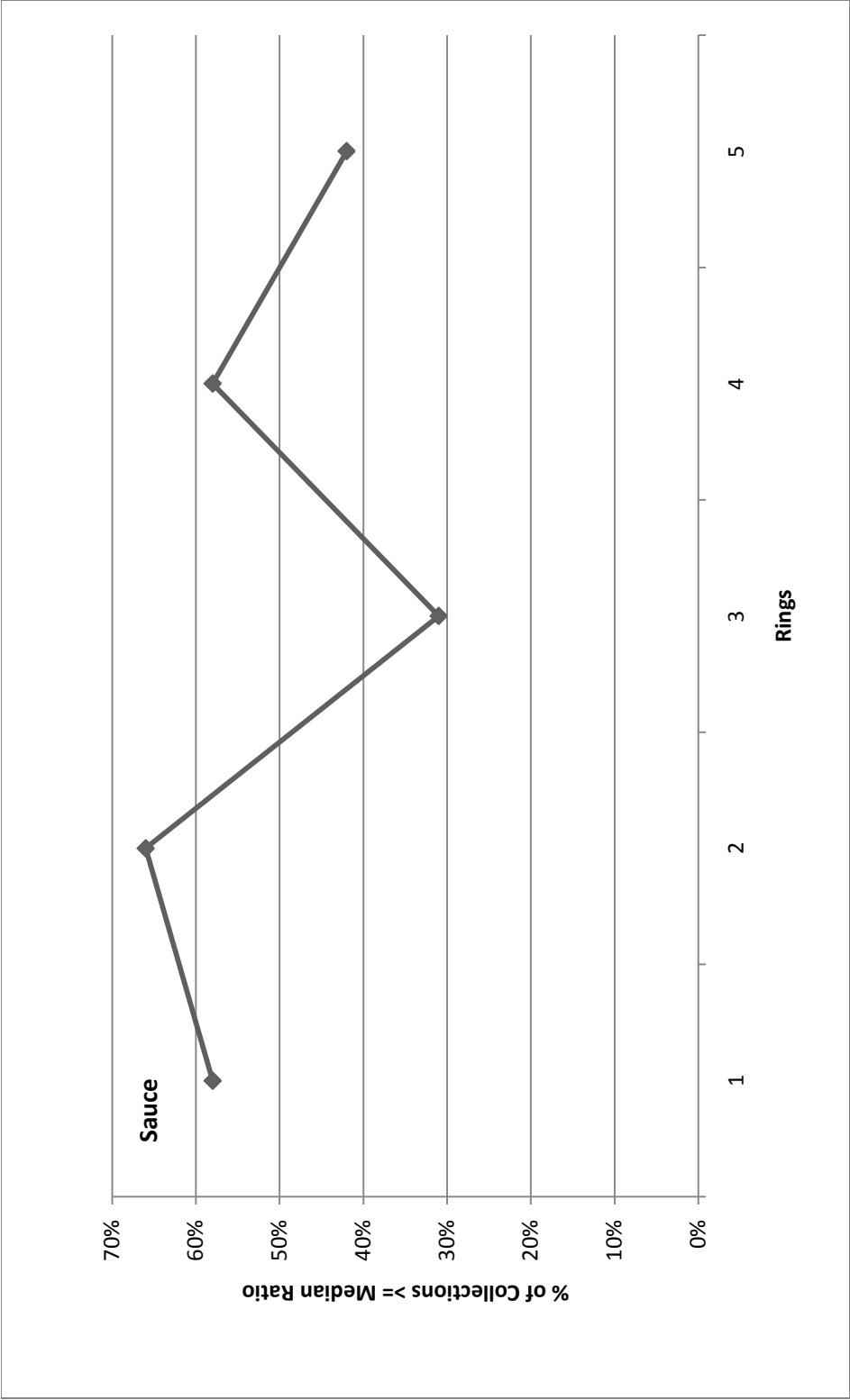
Figure 6.31 Results of Splashy White-and-Black-on-Red Polychrome summary method for collections.
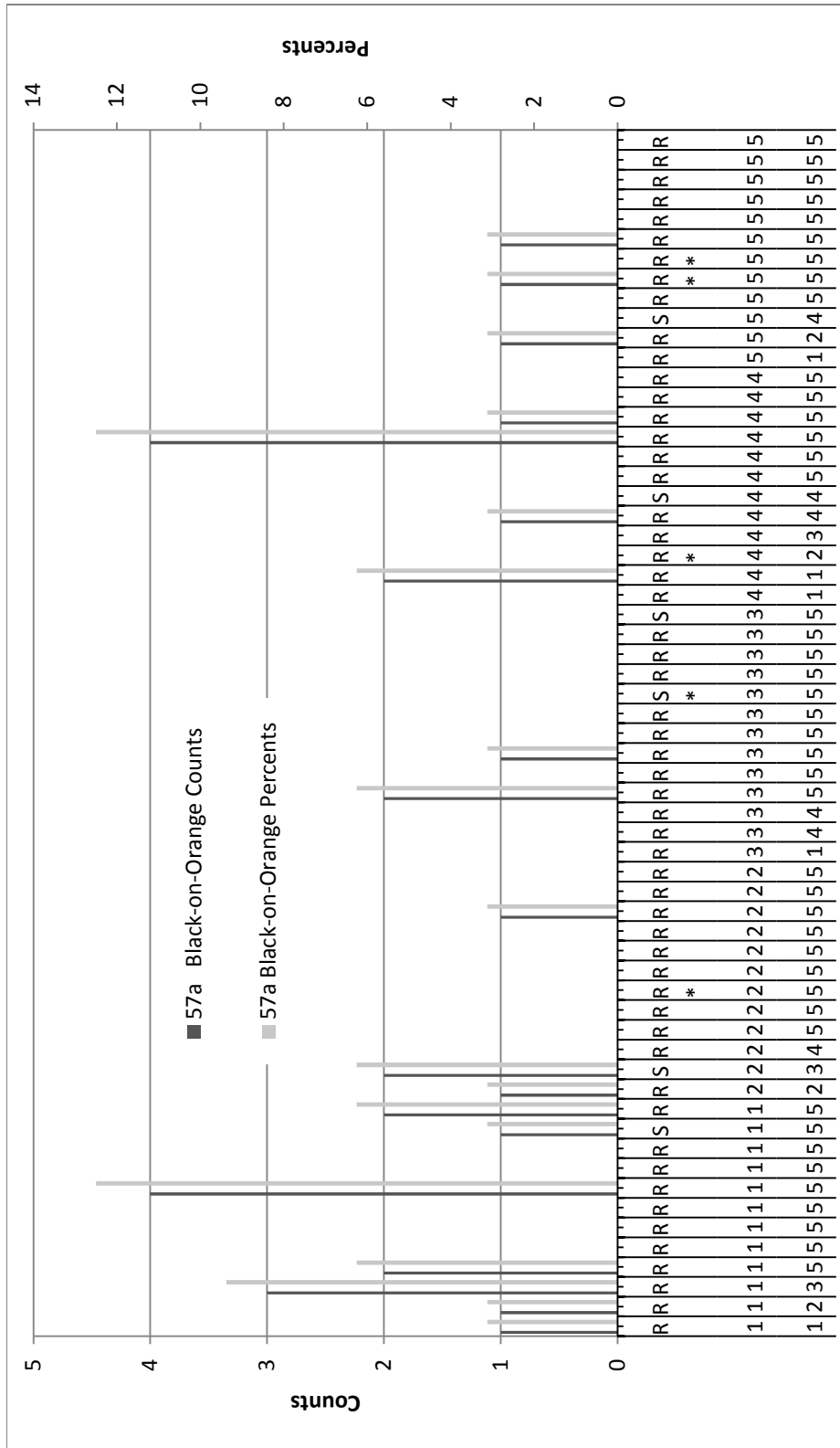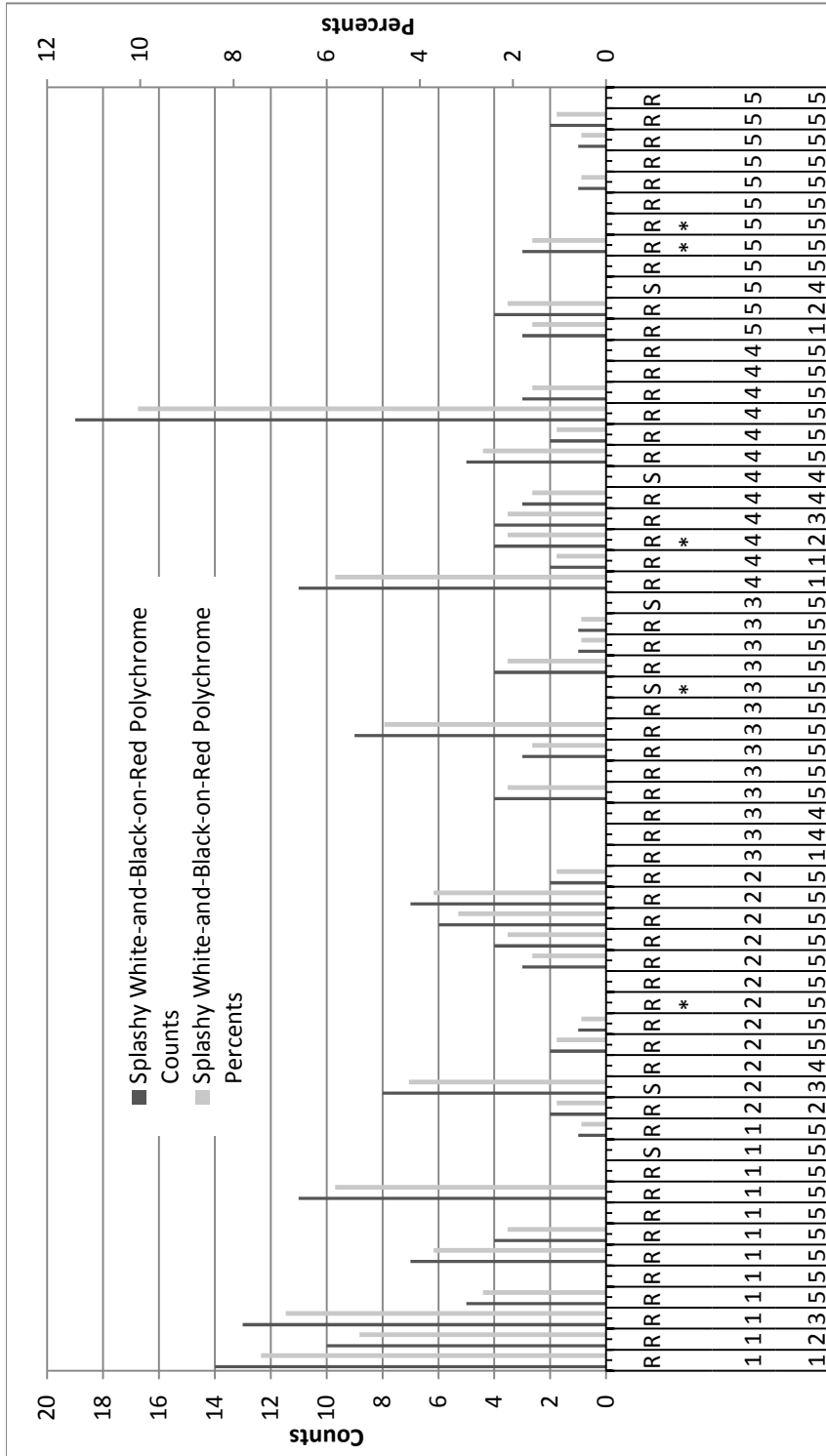
Figure 6.32 Splashy White-and-Black-on-Red polychrome pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

In Figure 6.31, there is no clear drop-off in collections from the summary method. The differences between rings 1 and 2, is one collection, and the same for the difference between rings 1 and 4. In Figure 6.32, the higher amounts are found in rings 1 and 2, with a few abundant collections in ring 4. Most of the collections are not within the highest weighted mound size rank, with theexception of ring 1 which has a few higher ranked mounds and ring 4, which has one highly ranked mound, collection 1306, which is in the weighted mound size rank 1. Collection 1306 also had higher densities of the Complicated Polychrome and rare items (a flute/whistle). The other collection from ring 4, collection 6636, also had higher amounts of elaborate polychrome pottery. In Figure 6.33, the three high collections outside of ring 1 (above 8 sherds) are not spatially associated with each other. One of them, collection 6636 is associated with one of the Classic period centers identified earlier in the chapter (Sabaneta, see Figure 6.1). Overall, although there isn't a clear drop-off from Sauce, the highest proportions of abundant collections are within ring 1, and with a few elite residences with higher amounts in ring 4.

Framing White-and-Black-on-Red Polychrome has only 20 sherds in the SAP collections. This pottery type was not considered separately for the network analysis because of its small sample size, although it was considered together with the Splashy White-and-Black-on-Red Polychrome as the aggregate group WBR. For the rare Framing variant, it is likely that only the most abundant collections will have this type. In Figure 6.34 summary results, there is a clear drop-off in this pottery type from ring 1. The detailed method in Figure 6.35 shows that the
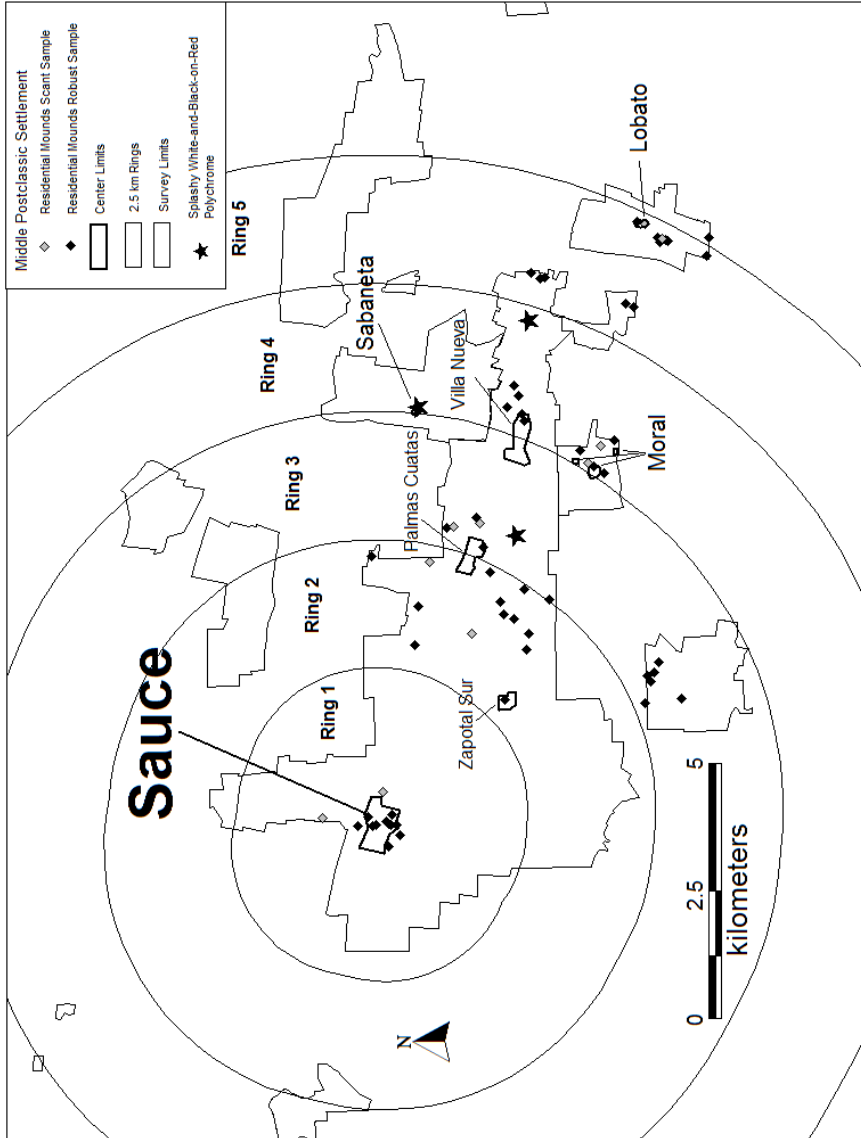
Figure 6.33 Map showing three collections outside ring 1 with high amounts (> 8 sherds) of Splashy White-and-Black-on-Red polychrome.
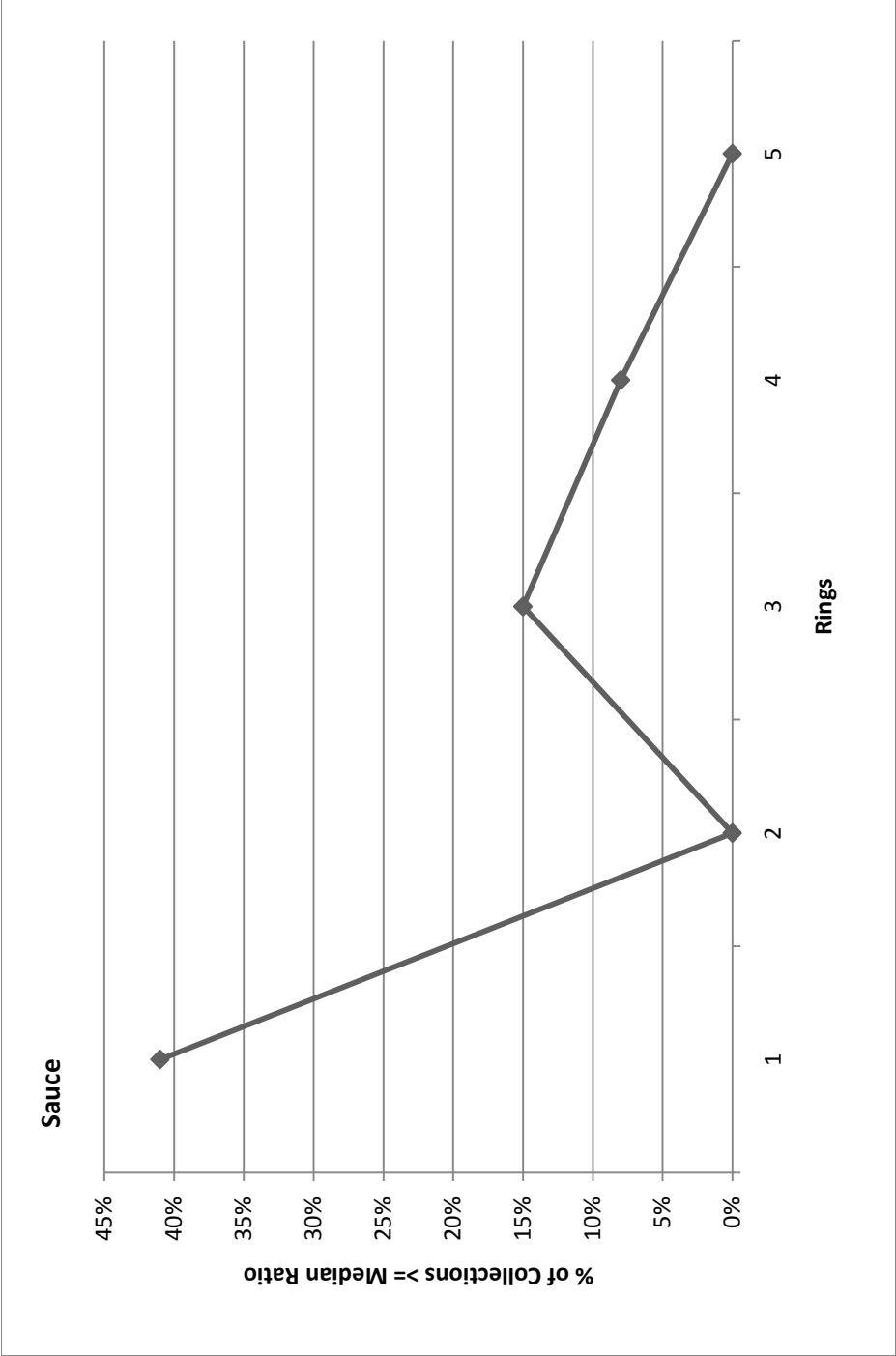
Figure 6.34 Results of Framing White-and-Black-on-Red Polychrome summary method for collections.

Figure 6.35 Framing White-and-Black-on-Red polychrome pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

highest collections are in rings 1, 3 and 4. There are too few collections to make much of the association or lack of association with different ranked mound size groups. However, the two collections, from rings 3 and 4 that were most abundant for this type (Framing variant), collections 1022 and 1306, also happen to be two of the three collections that were the most abundant for the Splashy variant. In other words, the Framing variant has similar spatial patterns and associations to its Splashy counterpart. Overall the pattern shows a drop-off from Sauce with a few abundant collections outside ring 1.

Fondo Sellado. This pottery type was not rare in PALM collections, but for the SAP collections it yielded 85 total sherds, which was not sufficiently numerous to consider statistically within the network analysis. Fondo Sellado, or stamped base pottery, has very distinctive decorative features (including the stamped base) that make it easy to identify. I include this pottery type in the spatial and contextual analysis because Fondo Sellado is recognized as a distinctive Postclassic type and because two possible Fondo Sellado molds were found by SAP, one located in ring 1 associated with the abundant collection 225 and the other in ring 2 (Figure 6.36). One mold is associated with the center of Sauce (collection 225) but the other is in ring 2, away from the center and associated with a residential mound collection within low rank (Group 5).

The location of a Fondo Sellado mold in the Sauce center is not surprising considering the noted association of craft production with centers for this area beginning in the Late Classic period through the Postclassic period (Stark 2008:106-108). However, the location of another mold in ring 2, away from the

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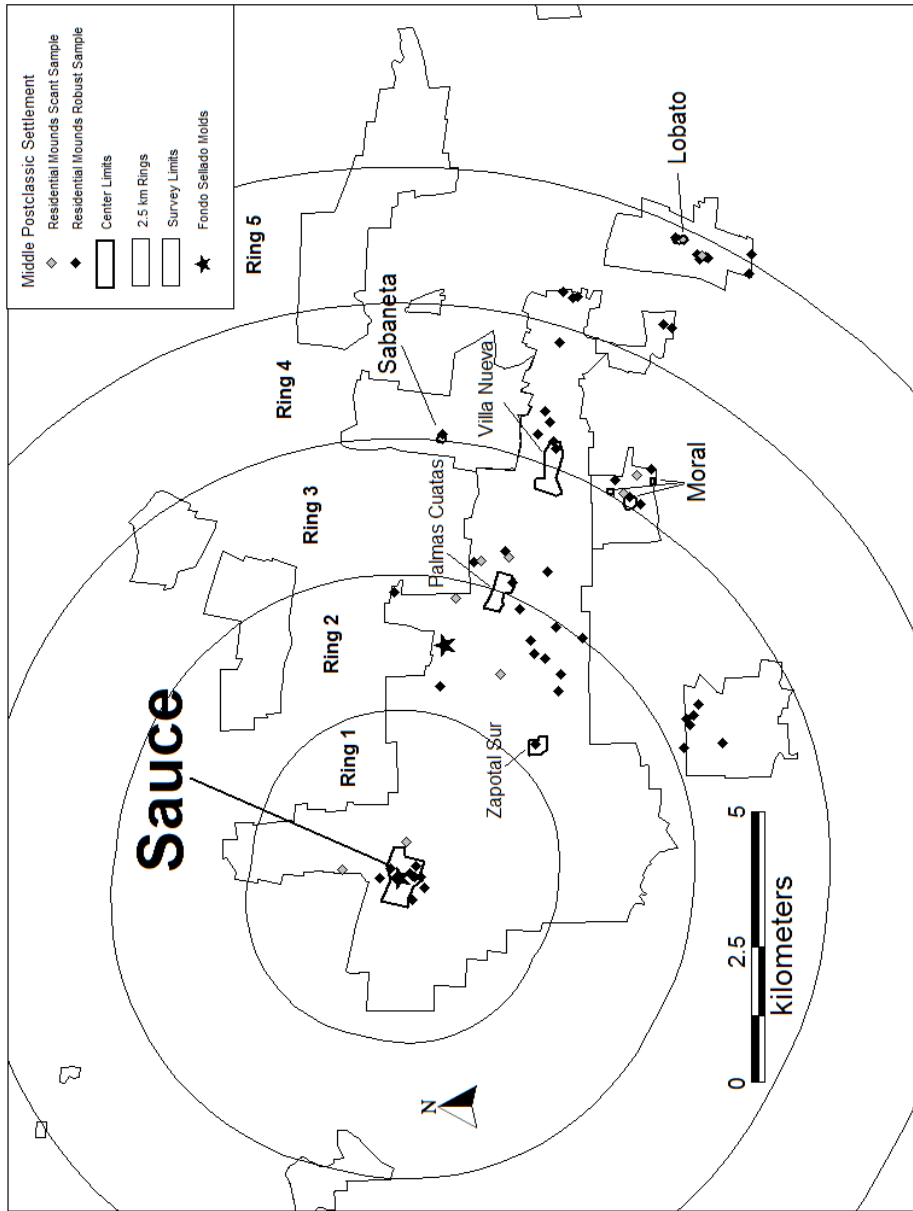
Figure 6.36 Map showing the two collections with Fondo Sellado molds.

center is also consistent with the type of household production that likely characterized a good deal of Sauce's economy. Feinman and Nicholas (2007: 112-114) found that for Classic period Oaxaca, most production was household based with considerable variations in both intensity and scale. For Sauce, the marketplace could be located near or within the center, but all pottery production need not have taken place there as well. Fondo Sellado production might also be reflected in higher amounts of this type reflected by the median ratio method (Figure 6.37). For Fondo Sellado, both rings 1 and 2 show higher percentages of collections, followed by a sharp drop-off in ring 3 and then leveling off in rings 4 and 5 (Figure 6.37).

In Figure 6.38, the individualized collection method shows a clear drop off in amounts of Fondo Sellado from Sauce outwards. The most abundant collections are located within ring 1. There are also many collections in ring 2 that have Fondo Sellado though in much smaller amounts although they are a larger proportion of ring 2 collections. Also, no mound size rank associations are evident with Fondo Sellado. Instead, Fondo Sellado appears in both the abundant collections identified in ring 4 (such as collections 6636 and 1306) and also in collections which were not abundant. In view of the spatial and contextual data Fondo Sellado was probably openly exchanged through markets. It was also produced both within Sauce and also in ring 2. The higher amounts of Fondo Sellado in rings 1 and 2, combined with the relative proximity of the two molds to Sauce suggest that Fondo Sellado was probably marketed out of or near the center, as with most of its decorated pottery.
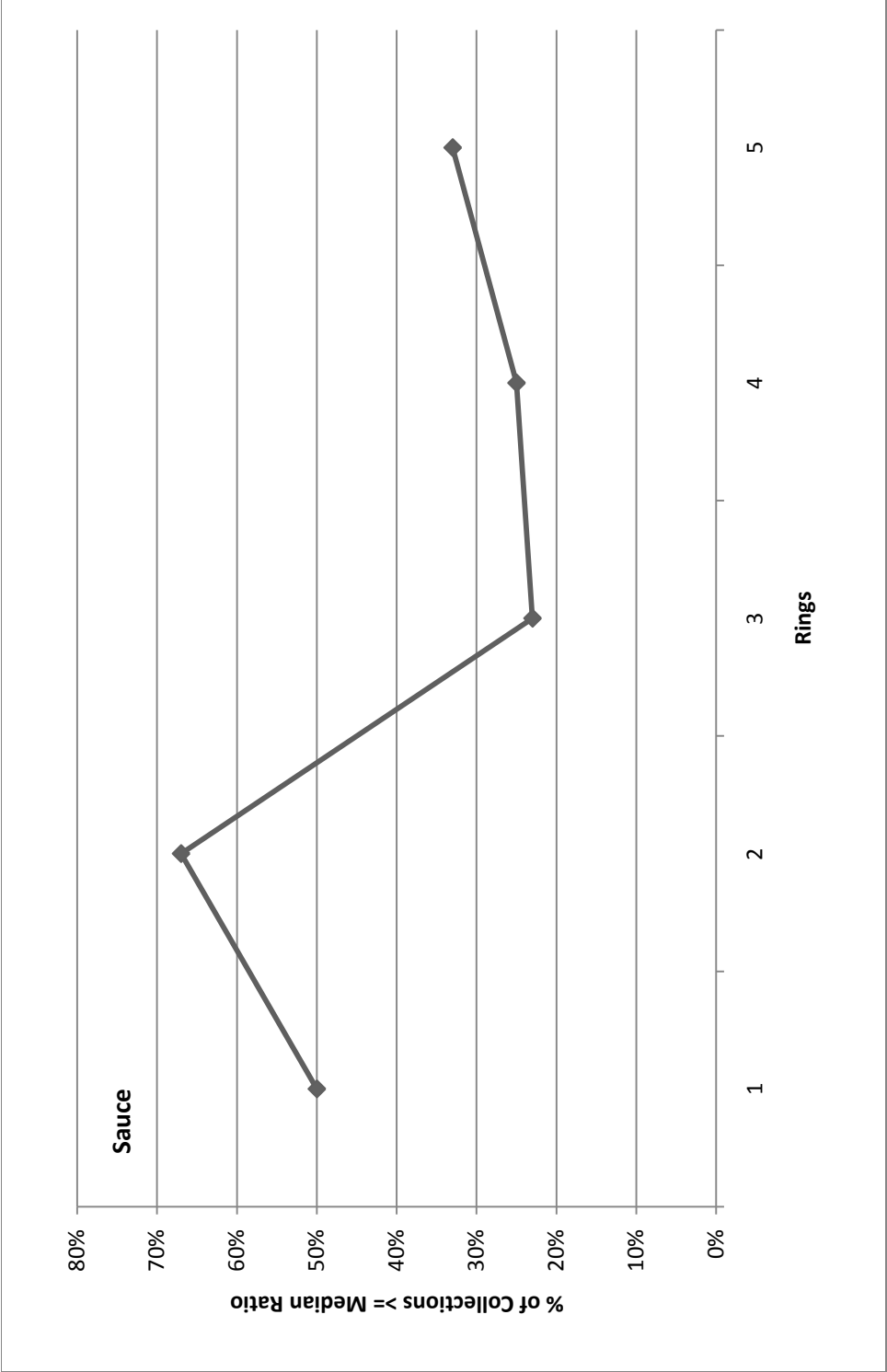
Figure 6.37 Results of Fondo Sellado summary method for collections.

Figure 6.38 Fondo Sellado pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

Tres Picos Polychrome. This pottery was quite rare for the SAP, a total of 35 sherds, as for PALM (63 rims and nonrims). Therefore, Tres Picos Polychrome was too scarce to be statistically viable for the network analysis. However, Tres Picos polychrome has a distinctive fine paste and decoration and is identified as a likely import that is also found in other major Veracruz centers such as Cempoalla, Quauhtochco, and Tajín (Lira López 1990:187-193; Stark 1995:19-20). For PALM, Tres Picos was associated with Middle Postclassic period occupation based on the seriations and the unmixing methods (Curet et al. 1994; Stark and Garraty 2002). Torres Guzmán (1999: 314-316) found Tres Picos Polychrome in his excavations at Zapotal (an important Late Classic period site in the WLPB). Based on the slip colors and incising patterns, he suggests that his Tres Picos dates to the Early Postclassic period with some features that were to characterize the Late Postclassic period variant of this polychrome (Torres Guzman 1999:314). Based on these associations, Tres Picos Polychrome could provide interesting spatial and contextual insights into exchange and in future research perhaps help identify an Early Postclassic period complex for the region.

In Figure 6.39, the summary method shows that Tres Picos Polychrome decreases after ring 1 and disappears completely by ring 5. In Figure 6.40 the detailed method shows a few abundant collections within rings 3 and especially 4. There is no association with higher ranked mound sizes or abundant collections outside of ring 1 for this type. For example, in ring 4 only one of the abundant collection mounds, collection 6636, had Tres Picos Polychrome and none of the collections with Tres Picos Polychrome in ring 4 were from the higher mound
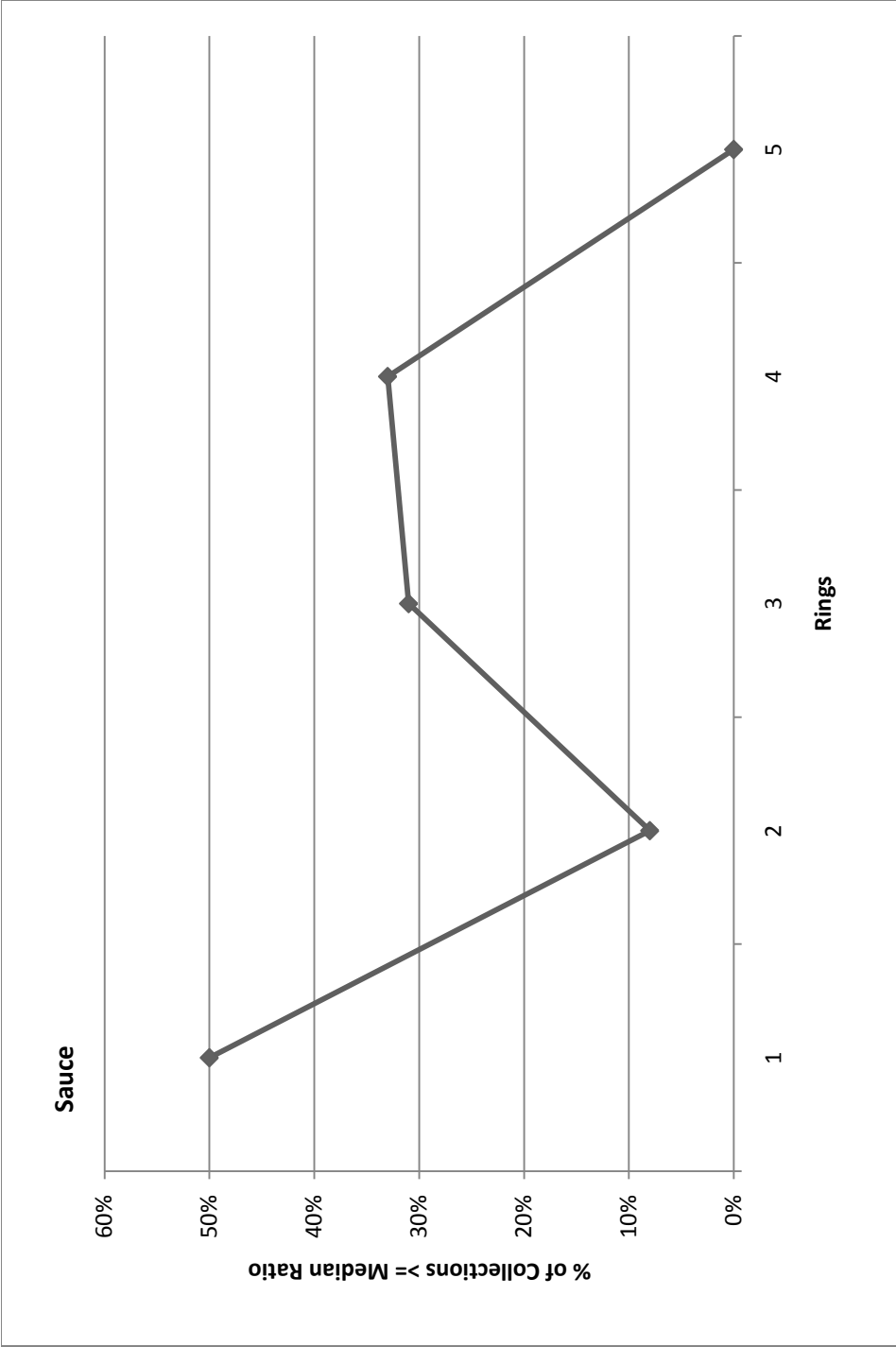
Figure 6.39 Results of Tres Picos Polychrome summary method for collections.

Figure 6.40 Tres Picos Polychrome pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).
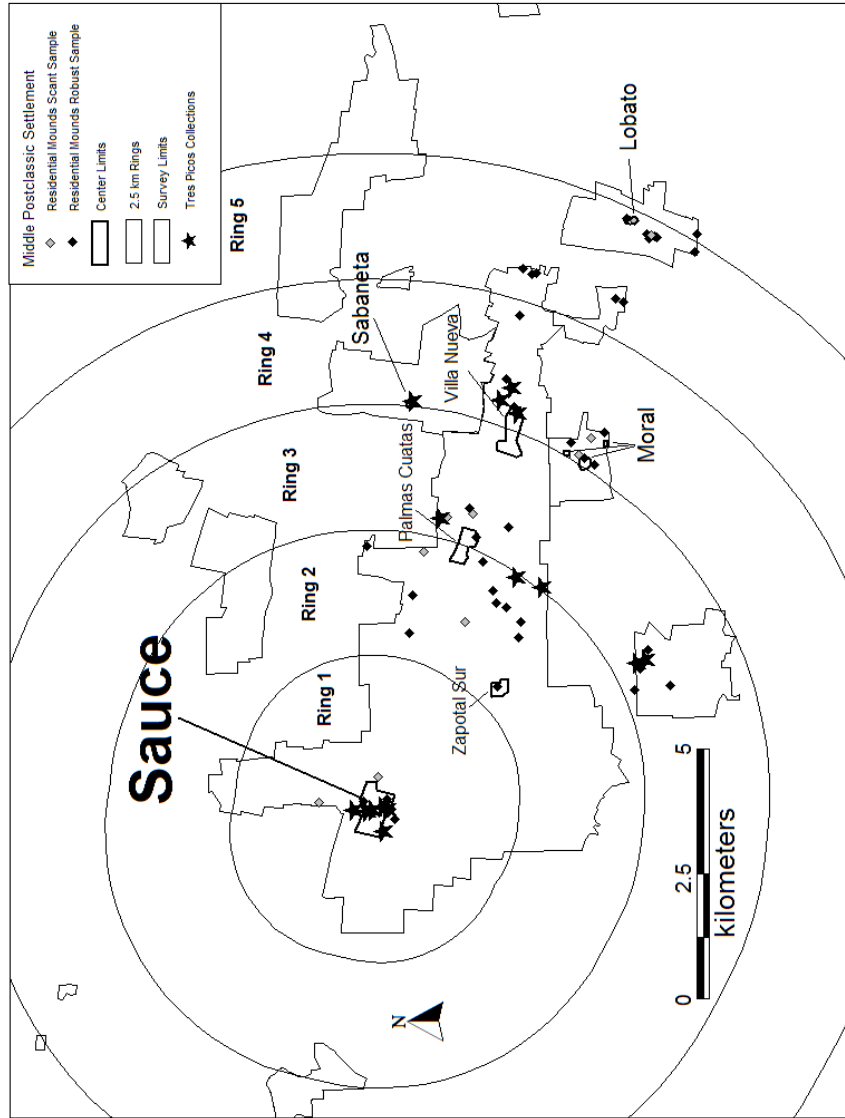
Figure 6.41 Map showing all collections with Tres Picos Polychrome.

size ranks (1-3) although collection 6636 is associated with one of the Classic period centers (Sabaneta). In a map that shows all collections with Tres Picos Polychrome, there are no obvious spatial clusters outside of ring 1 (see Figure 6.41). Based on the spatial and contextual data, Tres Picos Polychrome was not restricted in access despite its rarity. Sauce was probably the source of the distribution of this pottery through market exchange, although scarcity makes it difficult to say for certain.

Spatial Structure and Social Aspects of Market Exchange

The spatial and contextual patterns for the openly exchanged pottery dataset indicate that the majority of these types were probably marketed from or near the center of Sauce in ring 1. Most of the decorated pottery shows a sharp drop in amounts after Sauce and ring 1. However, the spatial evidence also shows some interesting variation; some of the types, including the Black-on- Orange variants and Complicated Polychrome variants, have some higher amounts within ring 4, although they never show amounts as high as Sauce and ring 1. The relatively higher amounts, located about 8 km east of the Sauce center, could indicate an overlapping market service area in the eastern portion of the delta survey blocks, directly adjacent to the one that was likely centered on Sauce in the western portion. In previous analyses of the PALM Middle Postclassic period dataset, the eastern edge of the Sauce hinterland showed increases in Black-on-Red and Black-on-Orange bowls and clear grey obsidian (Garraty 2009: 169-170; Stark and Garraty 2004: 139).

The inference of a potential overlapping market service region is complicated by several factors. Some, though not all, of the residential mound collections that showed higher amounts of pottery in ring 4 were probably elite residences, based on both their abundant collections, mound size ranks, and the location of at least a handful of them on Classic period monumental architecture. Ring 4 amounts were never quite as high as those found in ring 1, but they could represent elite estates rather than another market service zone. Additionally, if ring 4 is the western edge of a market zone, then ring 5, directly to the east should also show amounts that are at least as high as ring 4, perhaps a little higher as it should be closer to an alternative source. However, most pottery type amounts do not increase in ring 5; instead, they are typically lower. There are some pottery types, mostly from the *guinda* complex, that appear in consistently higher amounts in rings 3 and 4. To fully evaluate a potential overlapping market service zone versus elite residences with higher amounts of materials, these types are worth considering more closely.

The *guinda* complex, which includes the Black-on-Red Group, Black-on-Red Incised, and the Splashy and Framing variants of Black-and-White-on-Red polychromes have some exceptional spatial patterns compared to the other decorated types. The *guinda* variants all appear to have high amounts within the same few residential collections within rings 4 and occasionally 3, although they all also show high amounts in ring 1 (see Figures 6.7, 6.10, 6.32, 6.35). The summary method for the *guinda* variants had more diverse results. For Black-on-Red and Black-on-Red Incised, amounts appeared to drop off from ring 4 (see

Figures 6.6, 6.9), while for the Splashy and Framing Black-and-White-on-Red

polychromes there were high amounts in both rings 1 and 4 without a clear spatial

drop-off pattern from one or the other ring (see Figures 6.31, 6.34). Possibly the

higher amounts for rings 3-4 represent part of a system overlapping the one

centered on Sauce, but the data from ring 5 make it difficult to decide if ring 4

represents an edge of a different zone extending eastward. In summary, the

spatial patterns for the *guinda* complex provide little support for an overlapping

market service zone for these openly exchanged pottery groups. Instead, the

spatial patterns are more consistent with a group of elite residences, contra the

suggestion of Garraty and Stark (2002) that they represent another market service

zone. This observation is important because it reveals the utility of the suite of

methods employed here.

The exceptional spatial patterns for the Miscellaneous Polychrome group

may help demonstrate the interpretive spatial problems associated with ring 5.

Miscellaneous Polychrome has its highest amounts in ring 1, but it also has a

cluster of higher amounts in rings 4 and 5. Uniquely, it shows a drop off from

ring 5 in the summary method (see Figure 6.23). As discussed in Chapter 5,

Miscellaneous Polychrome really represents multiple pottery types that were not

sufficiently preserved to be identified securely. Due to the known problems with

eroded sherds in many of the collections of ring 5, it is likely that counts of

Miscellaneous Polychrome are inflated. Therefore, it is not possible to eliminate

the possibility that an eastern overlapping market service area exists based on the

ring 5 collection data, but there is no clear support for it either in view of sherd erosion and size.

In conclusion, the spatial and contextual dataset for the openly exchanged pottery types show strong support for Sauce as a central place in a market system. Generally, the higher amounts of different pottery types were not *exclusively* associated with mounds in the higher size ranks away from Sauce. Additionally, the scarcer pottery types that were originally excluded from the network analysis of the previous chapter due to small sample sizes, including Quiahuistlan, Fondo Sellado, and Tres Picos Polychrome, showed no obvious restrictions based on either mound size ranks or proximity to the Sauce center. These scarcer types also showed some drop-off in amounts outwards from the Sauce center. Therefore, despite small samples, it is likely that the scarcer types considered here were probably open in access, via a marketplace near Sauce.

Pottery and Social Networks

Restricted exchange is more difficult to model for specific scenarios than openly exchanged materials because it requires more contextual information (such as rank, kinship ties, etc.) in combination with the distributional household data. In the case of SAP, two particular types had network patterns consistent with restricted exchange: Escolleras Chalk and Dull Buff Polychrome. In addition to these two types, SAP had a few very rare types such as Isla de Sacrificios (with only two sherds) that may well have only been obtainable through social networks, but sample size makes them impossible to evaluate. For Escolleras Chalk and Dull Buff Polychrome, spatial and contextual patterns will be used in

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different combinations to infer what kind of social networks may have operated to distribute these two types, such as elite gift exchange, local kinship, and house-to-house exchange.

The expectations for different social network scenarios not only require contextual data but often their expectations can overlap with each other, so we can only make a reasonable case for one over another if a few conditions are met. In other words, we may be able to identify restricted exchange, but we may not be able to make a very strong case for exactly how it may have worked, as I explain below. For the SAP collections, my inferences reflect these limitations.

In the case of elite gift exchange, I expect that items within these networks may only be present in residential mound collections that are within the larger weighted mound size rankings (1-3) or that are particularly abundant collections such as collections 6636 or 225. This doesn't mean that elite gift exchange couldn't happen across differently ranked residential mound collections, I simply argue that if they are found *only* within highly ranked residences, than elite gifting is the most likely restricted exchange scenario. Another alternative for an elite component is a pottery type that only appears associated with the center of Sauce. In this elite scenario, we might hypothesize a political elite controlling access to the pottery type. Finally, I would also expect fancier pottery would be a more likely candidate for elite gift exchange or represent a pottery type restricted to political elites.

House-to-house exchange or local kin group production would be expected to have a spatial component not *necessarily* linked to weighted mound size rankings or the Sauce center. In other words, if a restricted pottery type was found in clusters of residential mounds adjacent to each other without being located within a center or at only elite residential mounds, then we might expect that the relationship between the exchange parties may have been localized production sharing and/or kin group sharing. For example, Sheets (2000: 218) found that people at the Classic period site of El Cerén produced products for internal consumption and also engaged in house-to-house or localized exchanges with neighbors or likely kin networks based on comparative household inventories. In the case of localized production or kin group sharing I also expect that pottery types that are less fancy, perhaps more utilitarian, would make better candidates for this type of exchange. In considering the two restricted pottery categories, I apply the same summary and detailed method to their analyses in addition to mapping where necessary in the following sections (Table 6.1).

Unslipped/Plain – Group 1

Escolleras Chalk is within the Plain Utilitarian group due to the fact that it is undecorated by paint or slip, despite having a very distinctive paste, thin walls, and delicate, graceful vessel forms. Escolleras Chalk demonstrates the inadequacies of applying the production cost method to different pottery types using only one measure of quality, surface treatment, as I have done. In this case, Escolleras Chalk probably belongs to a finer category of item than something like the Buff comals, for example. Escolleras Chalk pottery has a very distinctive

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lamellar, dense, and temperless paste that is typically dark grey, almost black, but also has cream to orange variants (Stark 1995; Stark 2008:112). The surface is very polished and silky to the touch and the lamellar structure shows up well with the use of a hand lens. Vessel forms included composite silhouette bowls, frequently with tall pedestal bases, vessels with elongated supports, possible composite silhouette bowls or vases, and a few outflaring forms (Stark 2008:112). Despite being considered a plain ware based on surface treatment alone, these vessels seem likely to have played special roles as serving ware and were therefore probably not a cooking or storage vessel.

In Figure 6.42, the summary method shows higher amounts of Escolleras Chalk for collections in both rings 2 and 4. In Chart 6.43, the detailed method shows the most abundant collections are located in rings 2, 4, and 5. Although there are insufficient data to associate this pottery type with the higher weighted mound size ranks, fully 6 of the 10 Scant sample collections had this type. Many of the Scant collections may have also had heavier components of other time periods included as well. There is a distinct possibility that there is some identification overlap between the Escolleras Chalk pottery type and some of the Classic period Fine Grey pottery (Stark 2008a: 65). In viewing a map showing the four residential mound collections that had the largest counts of Escolleras Chalk pottery, in this case, greater than or equal to nine sherds, there are no obvious spatial associations (Figure 6.44). In fact, most of the abundant collections of Escolleras Chalk do not appear to be associated with the largest total pottery collections of rings 1 or 4.

At 125 total sherds for SAP, Escolleras Chalk was not rare, but its distribution is odd compared to most other pottery, which is partly why it showed up as restricted in the network analysis. Since I observed neither spatial associations connected with possible specialized use or kin groups, or house-to-house exchange, nor associations with elite residences as one might for elite gifting, Escolleras Chalk may be a case of mistaken temporal identity. Interestingly, two of the abundant collections of this type (greater than 10 sherds) come from the five collections that were identified in Chapter 3 as being chronologically ambiguous for the Middle Postclassic period (marked with asterisks in Figure 6.43). At this point, I cannot rule out the possibility that some unknown amount of the Escolleras Chalk collections might belong in the Fine Grey category of the previous Classic period or to the Early Postclassic period, a time interval for which prior research has not successfully defined diagnostic archaeological materials in the region.

Elaborate Polychrome – Group 5

Dull Buff had elaborate decorations and a distinctive paste, putting it within the most elaborately decorated production cost Group 5 (see Table 6.2). Its decoration, paste, and forms appear to be completely new, unlike the openly exchanged pottery types like Complicated Polychrome, *guinda*, and Black-on-Orange variants which have some analogues in Postclassic period Puebla and the Valley of Mexico (Curet et al. 1994). The paste is light buff to brown in color, light in weight, and is tempered (Drucker 1943:45). The surface is possibly self slipped and only slightly polished with a light yellow-buff wash on which red,
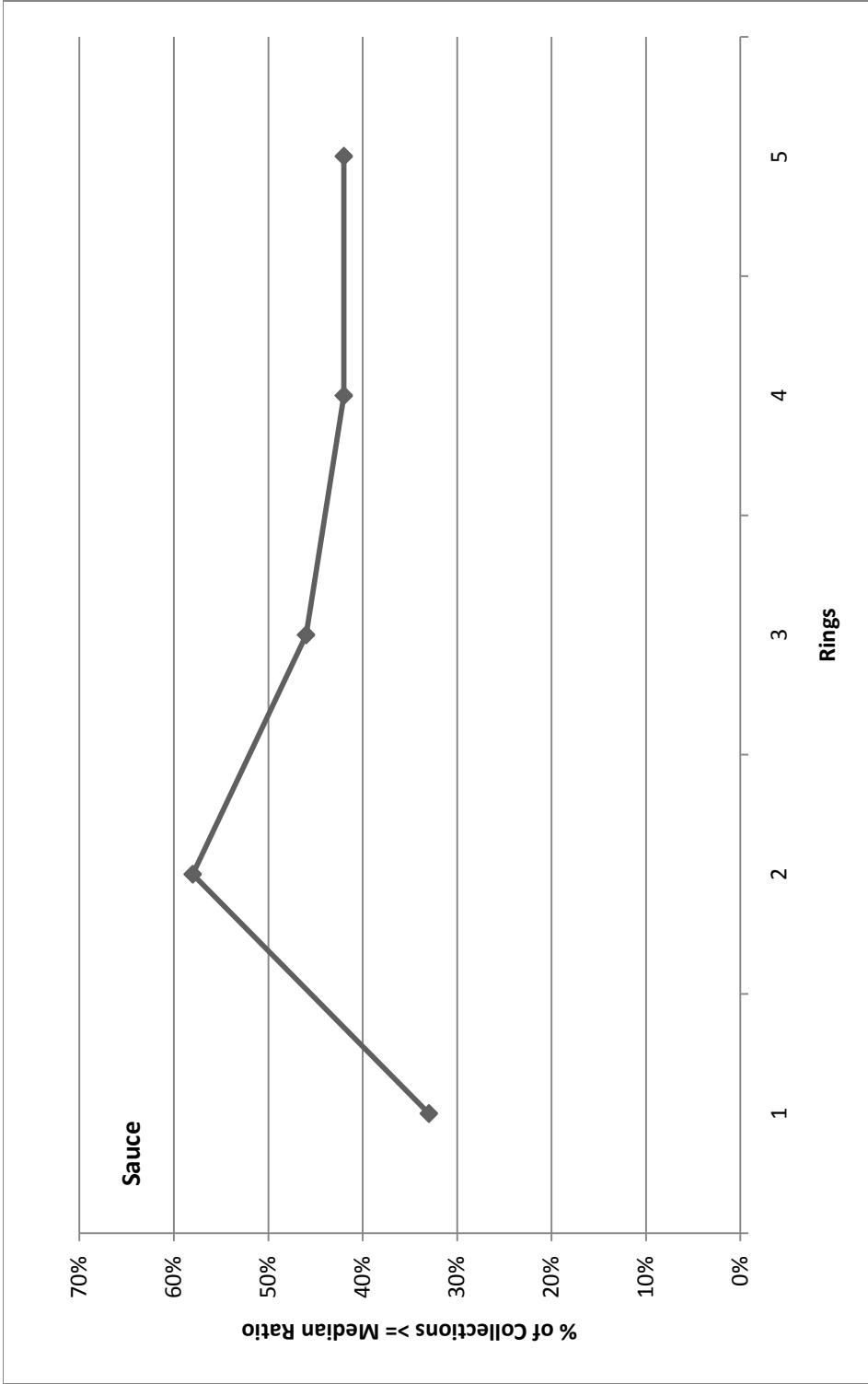
Figure 6.42 Results of Escolleras Chalk summary method for collections.

Figure 6.43 Escolleras Chalk pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).
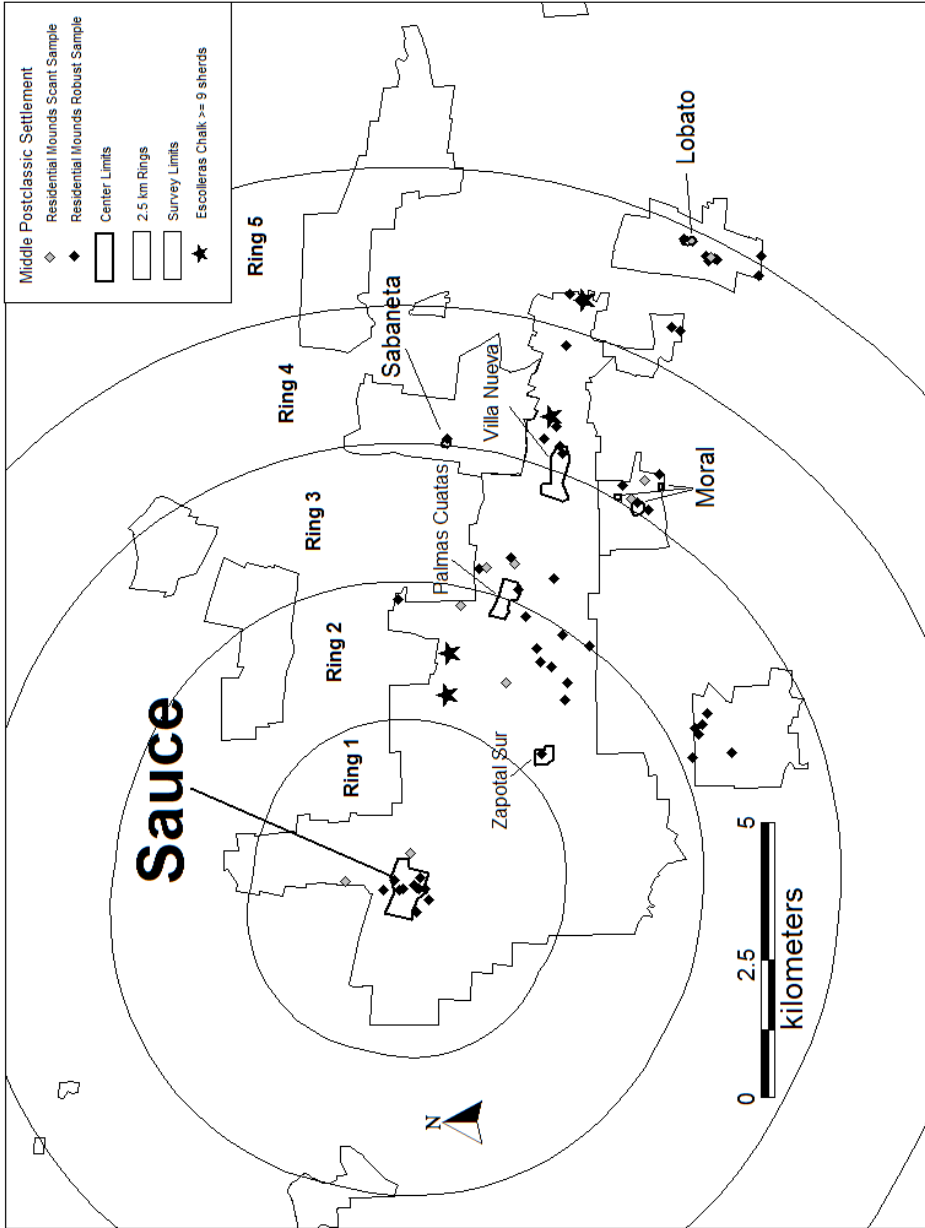
Figure 6.44 Map showing the four collections with greater than or equal to nine counts of Escolleras Chalk pottery.

black, and white designs are painted. Drucker (1943:47) suggests that the painted decoration of this polychrome appears to have a dull finish along with the buff wash, possibly due to the porosity of the paste. This dull finished appearance is what gives Dull Buff Polychrome its name and distinctive surface treatment, as Drucker (1943:47) remarks, "one is reminded of the flat lackluster appearance of a priming coat of common house paint on new wood". The decorative designs are mostly geometric. Rows of diagonal lines descending from the interior rim of bowls are a common theme. It is possible that some pottery type exists elsewhere that is similar to Dull Buff, but, if so, it has not yet been identified.

Dull Buff was a pottery type associated with the Sauce center itself (Garraty and Stark 2002: 13). Stark has hypothesized that the founding of the Sauce center was undertaken by a population that was new to the area, based on clear breaks in settlement and material culture with the earlier cultural tradition and political authorities (Stark 2008ab: 49). Stark (2008b:48-49) suggests that the Dull Buff Polychrome, in addition to other serving and storage vessels, may signify part of an intrusive population within Sauce and its hinterland. Stark (2008b:49,52) argues for an intrusive enclave based on a suite of evidence including new figurines, food preparation (buff comals), a center (Sauce), source for obsidian (clear grey), and serving and storage vessels including the Complicated Polychromes, the *guinda* complex, Fondo Sellado, Dull Buff Polychrome, and Black-on-Orange pottery.

If this hypothesis is valid, then it seems likely that Dull Buff's restricted exchange that was identified in Chapter 5 was limited to the political elites of this

new enclave. There may have been some special meaning attached to this pottery type, while other contemporary fancy pottery types such as Complicated Polychrome, the *guinda* complex, Fondo Sellado, and Black-on-Orange were openly exchanged. Dull Buff may represent more of a case of preference than restriction. Dull Buff may have been something akin to an identifier, like an ethnic marker, rather than simply the results of restricted gift exchange.

In viewing the summary method, the spatial patterning of Dull Buff shows high amounts in two locations (Figure 6.45). The first locale is in and around Sauce proper, in ring 1, and the second is farther away in ring 4 (Figure 6.45). These results indicate that high-ranking or political elite were also located in a place distant from the center of Sauce; my analyses earlier in this chapter have indicated that some higher ranked residences (identified by higher proportions of polychrome pottery) were located a few kilometers to the southeast of Sauce in ring 4 (Garraty and Stark 2002:13).

In Figure 6.46, the detailed method shows that only two collections (1817, 225) in ring 1 had large amounts of this pottery type, both above 30 sherds apiece. These two abundant collections belong to the higher mound size ranks (2, 3). The rank of these collections in addition to their location within Sauce supports the supposition that these represented elite residences. The other three collections having high amounts of Dull Buff pottery have only about ten sherds apiece and the other collections are quite sparse, with most below five sherds. There appears to be an association with the larger weighted mound size ranks (1-3) as well, but the pattern is complex.
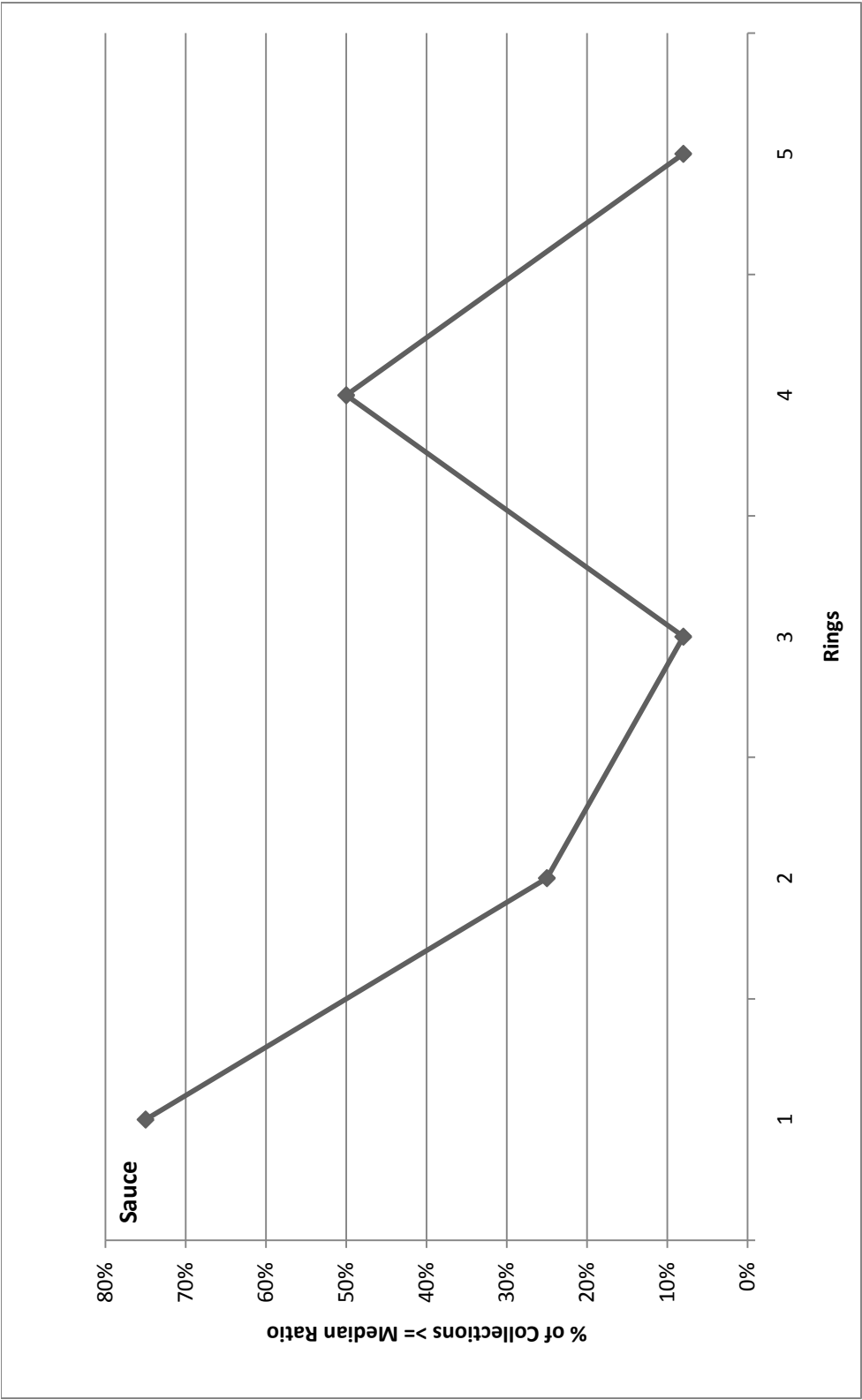
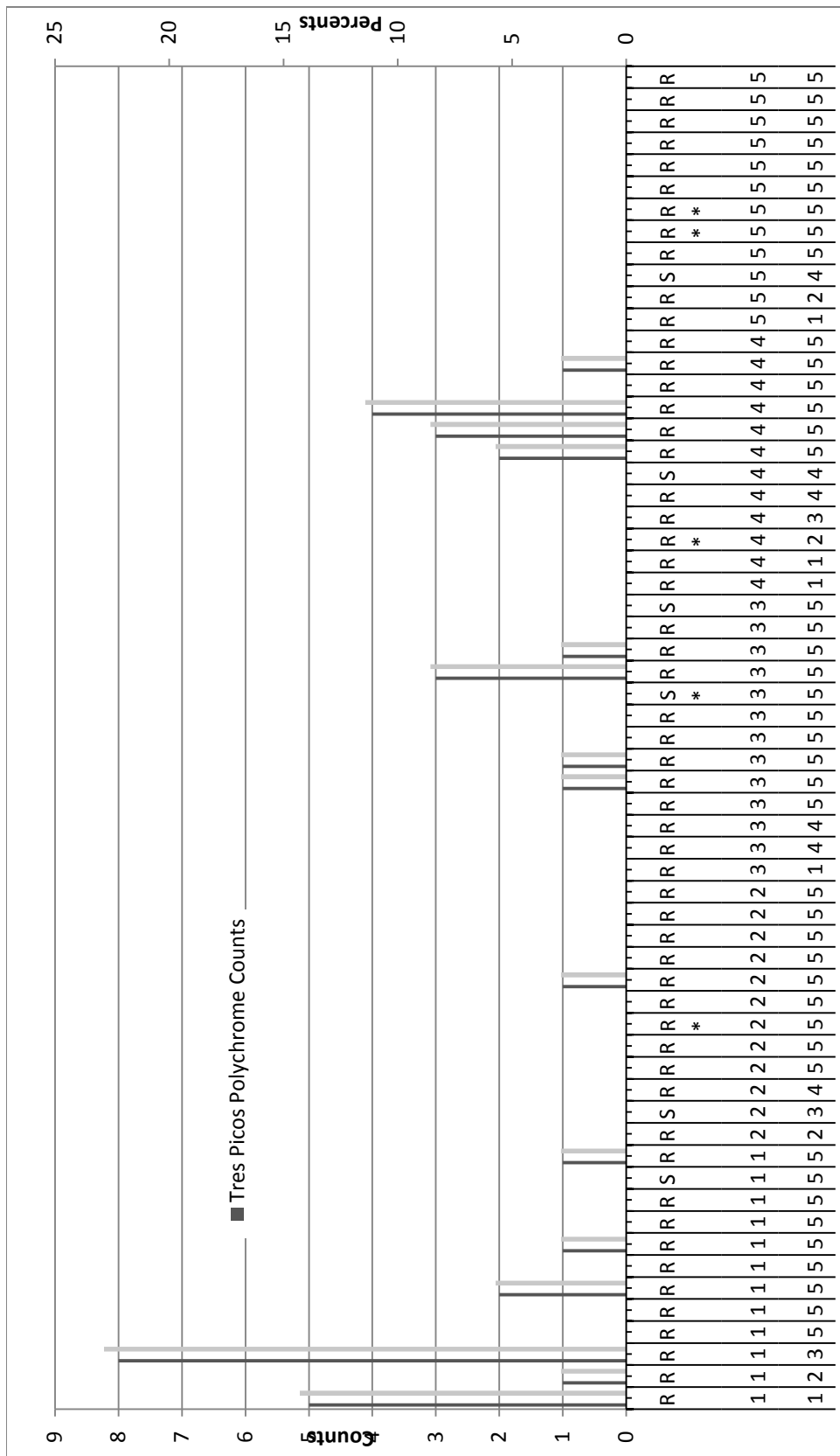**Figure 6.45 Results of Dull Buff Polychrome summary method for collections.**
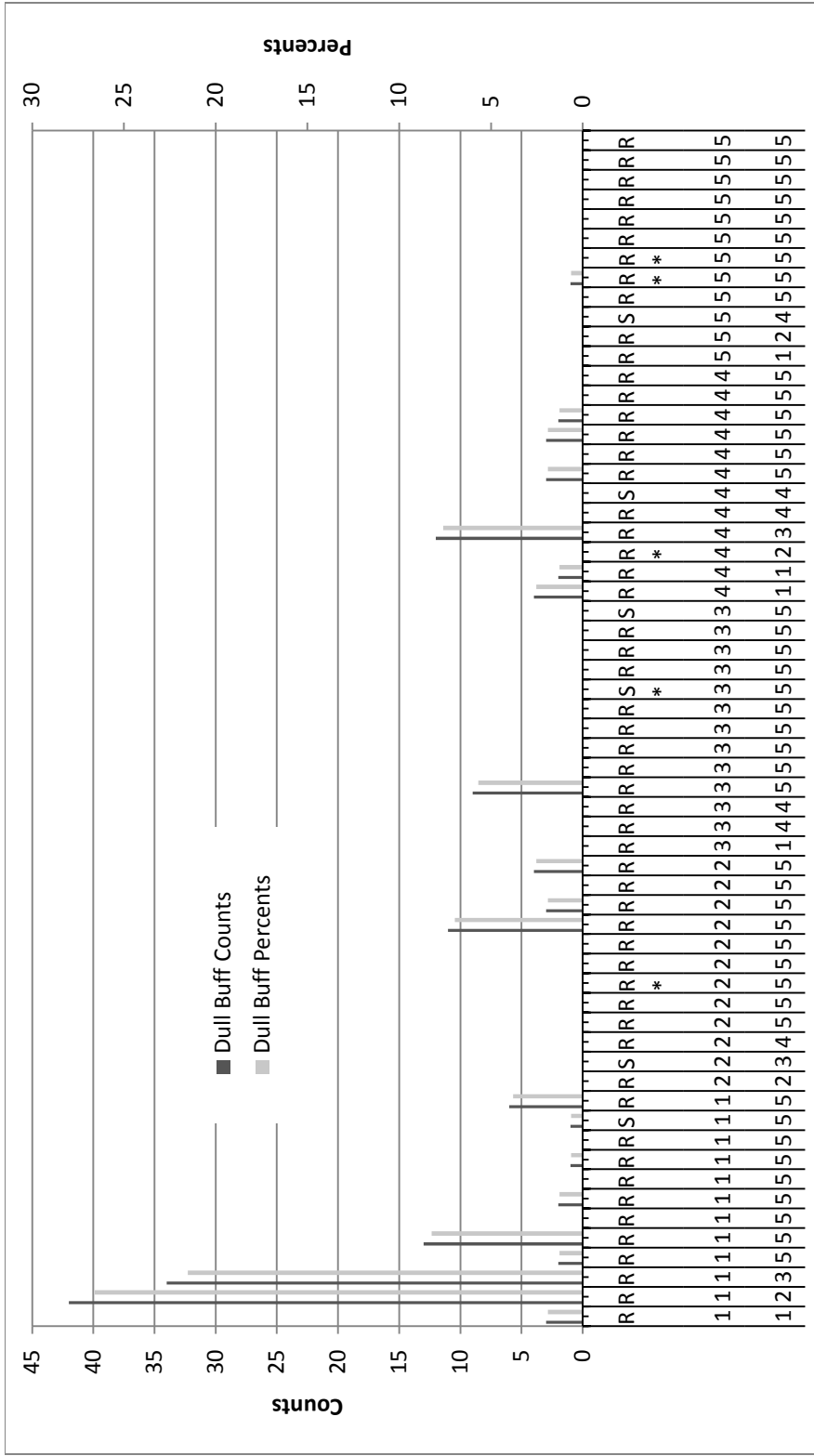
Figure 6.46 Dull Buff Polychrome pottery counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

For ring 1, Dull Buff Polychrome appears slightly associated with higher mound size ranks (1-3) while in ring 4 the association between Dull Buff Polychrome and higher mound size ranks is much stronger (Figure 6.46). One way of evaluating the association is to collapse the mounds into two size ranking categories, a "high" (mound size ranks Groups 1-3) and "low" (mound size ranks Groups 4-5), and to compare the ratios of high/low ranked mounds per ring to the ratio of high/low mounds with Dull Buff Polychrome. Due to the samples sizes involved, a contingency table analysis is unadvisable. However, the ratio comparisons are suggestive. If there was no association of high mound size ranks with Dull Buff Polychrome then we would expect the ratio of high/low mounds overall to closely match the ratio of high to low ranked mounds with Dull Buff Polychrome. For an overall comparison, the overall ratio of high to low mounds is 14 to 51 (.27) while the ratio of high to low ranked mounds with Dull Buff is 6 to 20 (.3). Therefore, overall the pattern shows no association. If we consider the same ratios individually, ring by ring, a pattern emerges. The ratios are not that different for rings 1-2, 3, or 5. For ring 4, the ratio of high (1-3) to low (4-5) mound size ranks for Dull Buff collections is 3 to 3 (1) which is higher than the overall ratio of high to low ranked mounds in the 13 collections ring 4 (4 to 9 [.44]). These rank associations suggest that for mounds farther away from Sauce, especially in ring 4, high mound size ranks were favored for having Dull Buff Polychrome. This pattern was not true for the few collections in rings 2-3, and both of those rings had fewer high mound size ranks among them.

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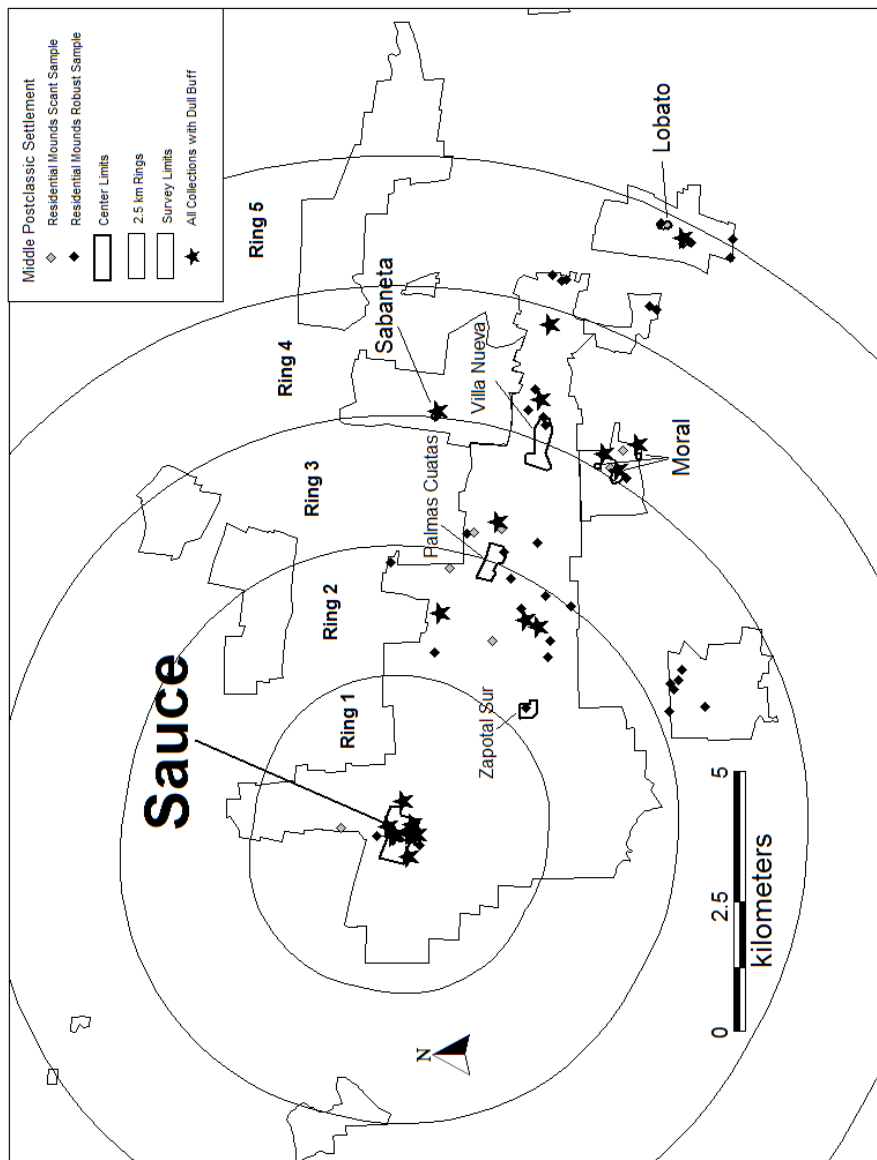
Figure 6.47 Map showing all SAP collections with Dull Buff Polychrome.
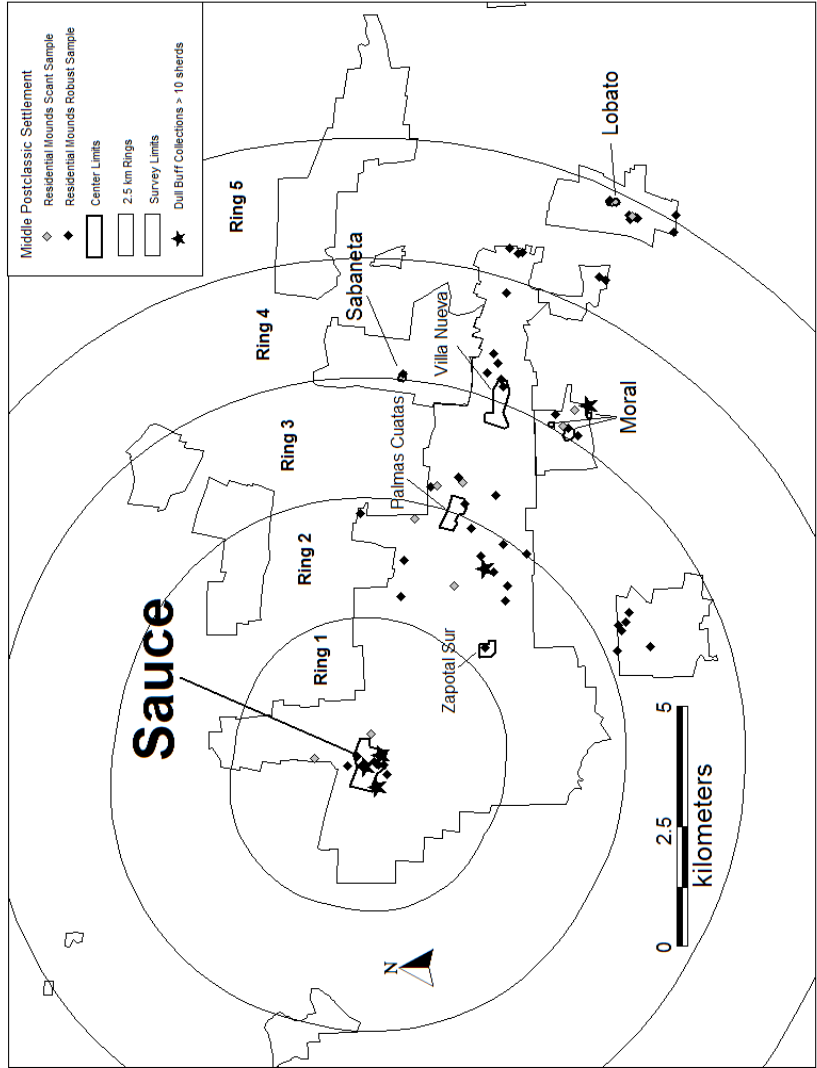
Figure 6.48 Map showing collections with Dull Buff Polychrome amounts greater than 10 sherds.

In viewing a map showing all 20 of the residential mound collections that had at least one sherd of Dull Buff Polychrome, they are associated with Sauce and with a few of the higher ranked mounds in ring 4 (Figure 6.47). In a map showing only those collections with greater than ten of Dull Buff Polychrome sherds, most are found in the Sauce center (Figure 6.48).

In view of the contextual and spatial data for Dull Buff Polychrome, this pottery was restricted to mostly political elites in Sauce or with higher status residences from the outer rings (such as 4). Although a few collections in ring 2 had some Dull Buff Polychrome, these were rather exceptional collections; one had one of the two Fondo Sellado molds while the other was near an area of possible higher/specialized production of comals and spinning based on other pottery types.

Spatial, Political, and Social Aspects of Restricted Exchanges

The pottery types for which the network analysis suggested restricted access exhibited both temporal and social features that helped explain the patterns. For the pottery type Escolleras Chalk, the spatial and contextual patterns do not indicate that it was associated with either the Sauce center or mounds with higher size ranks. From the geographical maps and individual collection method chart (Figures 6.43, 6.44), Escolleras Chalk did not show spatial clusters associated with either house-to-house exchanges or kin networks. Instead, it is likely that overlap between Escolleras Chalk and a Classic period Fine Grey pottery is causing the pattern, making the apparent restriction the result of temporal mixing rather than socially motivated.

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For Dull Buff Polychrome, the results offer strong support for a political and social elite component to its restricted access. The highest amounts of Dull Buff pottery are found within the immediate environs of the Sauce center and in ring 4. For Dull Buff in ring 4, there was a strong association with higher mound size ranks (1-3) (Figures 6.46, 6.47, 6.48). It is likely that Sauce's political and social elite had exclusive access to Dull Buff Polychrome, possibly obtained through social networks such as gift-giving. Although I cannot rule out the possibility that this exclusivity was simply preference rather than restriction, the fact that most of the residential mound residents had access and apparent interest in obtaining other fancy polychromes, makes it less likely that they would avoid Dull Buff unless that type was restricted in some way.

Pottery and the Economic Organization of Sauce and Its Hinterland

Sauce and its hinterland had a mix of open and restricted exchange systems. Exchange mechanisms probably included markets and social networks, but the details of how these intersected with local political and social organization are not clear on the basis of methods used in Chapter 5 alone. In this chapter, the spatial and contextual information about the social status of the pottery types and the residential mounds were used to evaluate spatial organization, political effects, and the degree of commercialization for pottery. I summarize the results below.

The Spatial Organization of Exchange

The spatial extent and organization of exchange was considered separately for each of the pottery types in order to identify potential differences. Most of the openly exchanged pottery types showed a clear drop-off from the Sauce center

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and ring 1. This matched expectations for Sauce as a central place for market exchange within the region. However, some pottery types, particularly those that included the *guinda* complex, showed an increase in ring 4. The spatial patterning is somewhat complicated by the fact that many collections in ring 5, directly east of ring 4, were heavily eroded, which could have affected the identification of many pottery types. Despite these issues, the spatial patterning is sufficiently strong for many of the pottery types to indicate the presence of a group of elite residences within ring 4 but not a separate market zone.

There are two sets of observations that support the presence of a group of elite residences within ring 4: the mound rank size groups and collection association with Classic period centers or large constructions. Each observation complements each other in identifying the presence of elite residences. The mound size rank groups were weighted in size by amounts of Postclassic materials, and in doing so hopefully captured a volumetric construction measure that dated to Postclassic period construction rather than re-use of Classic period structures. Although not all of the large identified Classic period mounds (Figure 6.1) were re-used by people who had access to abundant decorated pottery, a few were identified by the spatial analyses. For Black-on-Orange, Quiahuistlan, and much of the *guinda* complex, some of these elite residences with high amounts of pottery are associated with Classic period centers or large constructions that were identified in Figure 6.1. The higher mound rank size Groups (1-3) showed clear associations in ring 4 with higher amounts of Dull Buff Polychrome. These patterns support both the existence of a central place market at Sauce and also

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pinpoint a zone (within ring 4) where some elite residences had access to higher

amounts of decorated pottery than the other rings.   I examined whether there

might be another central place and market zone nearby, because studies from

other complex societies where small polities were found in association with

multiple exchange systems indicate that a simple central place model may not be

an adequate model to describe spatial patterns (Knapp 1993: 340). Different

types of trading activities can overlap or cross-cut one another. Therefore,

products moving through different mechanisms and locales could result in

complicated spatial patterns in which multiple areas show higher amounts of

products. Nevertheless, no conclusive case could be made for another market

service area overlapping the eastern study zone.

Political Implications of Spatial Associations for Market Exchange

The production of pottery or other specialized production such as cotton

spinning was not the focus of SAP; nevertheless, some interesting patterns were

uncovered in the analysis. Spatial patterns from SAP support household

production or specialized workshops in rings 1 and 2, where there was a

previously identified comal production area (Curet 1993). SAP collections in this

area showed more signs of spinning and suggest the Quiahuistlan bowls were

used as spindle supports, and also elevated levels of spindle whorls (to be

discussed in Chapter 8). The discovery of Fondo Sellado molds in rings 1 and 2

supports the inference that Sauce and its environs were locales for the production

and distribution of locally marketed items.

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Stark (2007b: 108-109) suggests that beginning in the Late Classic period prior to Sauce, the spatial proximity of more intensive craft specialists to centers suggest polity sponsorship of specialization and market exchange. Stark (2007) found that craft associations with centers began in the Late Classic period and continued through the Middle Postclassic period. Stark and Ossa (2010) extended this pattern to the Early Classic period (A.D. 300-600) for obsidian blades. As with the Late Classic period data for the region, some amount of craft specialization was also apparently associated with the Middle Postclassic period center of Sauce (Stark 2007: 109).

Sauce's spatial association with production, combined with a clear drop-off outwards from ring 1 for the majority of pottery types, suggest that the political elites of Sauce could have encouraged market exchange located at or near the center. As Stark suggests (2007), perhaps beginning in the Late Classic period, local elites and later newcomers at Sauce had incentives to seek out market exchange and associated administrative taxes as additional sources of revenue and prestige rather than the traditional land and labor combination. Despite probable support for markets, Sauce's political elite may not have had exclusive control of market exchange.

Degree of Commercialization

To test commercialization, I needed to know the availability of different pottery types for market exchange. In this case, I evaluated whether there was any distinction in how fancier vessels were being exchanged versus those that were plainer, based on numbers of paints used in decoration. The highly

decorated pottery types, such as the Complicated Polychromes, were almost certainly openly exchanged from a marketplace somewhere near or within the Sauce center in ring 1. Even rare fancy pottery such as Tres Picos polychrome also showed signs of being openly available, as it was not restricted to Sauce, abundant collections, or higher mound size ranks (1-3). There was at least one restriction among the fancy decorated pottery types, however, which will be considered below. Sauce and its hinterland had a fairly developed and unrestricted market for pottery, including elaborately decorated pottery, in other words a high degree of commercialization.[3]

In sum, the apparent wide distribution of products over the 55.41 sq km area of survey blocks containing collections from Sauce and its hinterland supports the view that most of the pottery being marketed fits a highly commercialized model of exchange. Elaborate ceramics, even rarer varieties, were apparently widely available to residential mound residents from all socioeconomic levels and locations within or away from centers. Although we can know nothing of the perishable luxuries for Sauce, the fact that the finest nonperishable pottery was widely available supports presence of a strong degree of commercialization in Sauce's economy.

Political and Social Aspects of Restricted Exchanges in Sauce

The spatial and contextual associations of Dull Buff Polychrome suggest that it was restricted to political elites within Sauce and to higher status residences in ring 4. The highest densities were located in Sauce, and there was an association between the higher mound size ranks (1-3) and this pottery type in

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ring 4. Dull Buff Polychrome suggests elite gift exchange, although, given the remarkably high densities in a very few residences, these vessels may also have been particularly curated and used (perhaps as serving vessels) by these households. Dull Buff Polychrome exceptionalism may have also been the result of its probable association with the land holdings of Sauce's political elite, located away from the center. One could imagine a situation where higher status residences located outside the center are elite estates or residences, such as those identified for greater Tikal (Taschek and Ball 2003). Four of the six residences that had Dull Buff Polychrome in ring 4 had collections with almost every decorated pottery type combined with high quantities of pottery overall. Of these four collections (6636, 1306, 777, 6507), three of them were located within or very near the Classic period centers and in some cases were on top of large structures (6636) (see Figure 6.48). Collection 6636 in particular was very rich in its diversity of pottery types. It was one of only two collections in ring 4 to have Quiahuistlan, and it also had Escolleras Chalk and Tres Picos Polychrome in addition to many of the main types such as Black-on-Orange. Also, although collection 6636 did not have a high mound size rank based on its relative percents of Postclassic period materials, it was a sizable mound from the Sabaneta group. It is likely that these collections represent elite residences, and that the mound size rank measure, while reasonable, will not capture all of the potential ranking information from structures.

Conclusions and Implications

The Middle Postclassic period Western Lower Papaloapan Basin saw the major Classic and Late Classic period centers replaced by the small center of Sauce. Sauce's role as a central place for market exchange in the local economy and association with production indicate the support and encouragement of its political elite. The widespread availability of most of the decorated pottery also indicates the participation of the local population in commercialized market exchange. The dynamics associated with smaller polities, including weak political centralizing tendencies or fluctuating political boundaries, could have encouraged the development of multiple competing market service zones (Hansen 2000). A process of increased market interactions could, in turn, have helped institutionalize the support of market activities by elites as a feature of economic development in Veracruz.

Finally, I conclude by stressing the analytical separation of network and spatial expectations for archaeological analyses. One interesting feature of this approach for SAP pottery is that it highlights the differences in how each individual pottery type was exchanged and consumed. Although most of Sauce's pottery was openly exchanged through market exchange, different pottery categories did not share the same distributional or spatial patterns among all collections. Some of the different pottery spatial distributions could be a result of sampling, but it could also be a reflection of different preferences or use. Smith (1999) expects some households to have greater densities of certain pottery types based on wealth, even with market exchange. Residences that apparently have

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larger amounts of some of the elaborate pottery types do not have larger amounts of all of the elaborate pottery types. These small variations in the different pottery distributions means that the application of an aggregate method that uses the relative percents of all pottery categories per household unit could be problematic for diagnosing market exchanges (Garraty 2009; Minc 2006). By considering each pottery category individually in Chapter 5, I was able to evaluate network expectations separately from the spatial variations among collections due to preferences or, in the case of *guinda*, the existence of an area of elite residences outside of the center.

The pottery network and spatial analyses have added the social and contextual dimensions to my understanding of exchange and economic organization in Sauce and its hinterland. In Chapter 7 I consider the case of chipped stone, which was an item to which almost every household had access. Based on this universal access and the necessity of importing the raw materials into the area, chipped stone, unlike most of the decorated pottery, is a good candidate to evaluate the potential for restricted exchange in the form of redistribution that was outlined in Chapters 1 and 2. The results of the pottery network and spatial and contextual analyses have indicated that Sauce's exchange systems for pottery were not administered. The following chapter may indicate that chipped stone exchange was administered, or it could show that chipped stone matches the pottery findings.

CHAPTER 6 NOTES

[1]Garraty (2009:165) used a homogeneity score to compare individual collections. The homogeneity index (h) is an aggregate measure which considered the overall similarities in relative percentages of Middle Postclassic pottery types among collections to generate a score per individual collection. Then, to identify potential market zones, Garraty (2009) looked at spatial drop-offs in pottery similarity scores away from Sauce by considering the median h score among collections per 1 km ring zones. SAP methods apply a summary by ring approach but do not use an aggregate index of all pottery types, rather, each individual pottery type is considered separately.

[2]The summary method standardizes each of the pottery type amounts per collection by the number of Postclassic ceramics for each collection, which means that the larger collections won't swamp the spatial data. Using the median value of ratios as the cut-off also allows me to get rid of the outlier effect of some collections.

[3]On a methodological note, SAP results suggest a somewhat mixed verdict for the utility of the production cost valuation method. Some categories, like the *guinda* complex had more in common with each other in terms of exchange patterns than with pottery with a similar number of paints or decorative techniques.

CHAPTER 7. CHIPPED STONE AND EXCHANGE

The purpose of this chapter is to evaluate exchange mechanisms and spatial patterns of chipped stone materials for the 65 residential mound collections. As discussed in the previous chapters, different networks of exchange typically co-exist within any economy and are often defined by having different sets of rules and exchange values attached to the items that are circulating within them (Kopytoff 1986: 71-72). Chipped stone artifacts have a different set of rules and exchange parameters than the pottery because of three major factors: the materials were all imported, almost everyone in this area had chipped stone tools, and functional variation could produce differential inventories unrelated to exchange mechanisms to a greater degree than pottery. All of these factors have important implications for the chipped stone that requires deviations from the exchange analyses from previous chapters.

Chipped stone artifacts are mostly obsidian with small quantities of chert (Heller and Stark 1998). As discussed in Chapter 3, the clear grey obsidian of the Middle Postclassic period is imported from mines near Pico de Orizaba, a source located approximately 125 km from Sauce (Lewenstein 2001: 173). Chert was also imported, but a source has not been identified. The importation of these materials could mean there was an opportunity for the political control of the material source. Political control might be identified by restricted access or by large amounts of obsidian in high status households. But, in this case, access to clear grey obsidian, which makes up the majority of the Middle Postclassic period

chipped stone dataset, was widespread among households, at least in the form of

blades and blade parts (Heller and Stark 1998:122-123). Therefore, despite the

fact that this item was imported, it is not possible to identify different exchange

mechanisms based on open versus restricted access because most households had

access to some form of chipped stone tools. Another factor is that high amounts

of chipped stone tools could indicate wealth or status, but could also pinpoint

special use in craft activities.

The Sauce center and its associated residences are connected with

economic activities, including blade production and use of chipped stone scrapers

for processing other items (Stark 2008a). For PALM, blade workshop debris was

identified at mound 1756 by production evidence (Heller 2000). Lewenstein

(2001:174-175) identified a concentration of clear grey scrapers near Sauce that

were used in processing woody plants. Based on PALM and SAP data, household

activities associated with craft production and plant processing, in addition to

market exchange, may have a significant effect on the distribution of stone tool

artifacts.

In summary, exchange mechanisms are not the only factor that impacts the

distribution of chipped stone tools; activities and special processing needs could

also be a factor in determining higher amounts of artifacts. Therefore, methods

that rely solely on greatly differing underlying distributions among households or

presence/absence to identify exchange mechanisms will not be effective. Any

exchange analysis must take into account the socioeconomic context of each

household and its potential activities using stone tools when evaluating

inventories.   The goal of this chapter is to develop explicit spatial and contextual models of exchange based on methods developed for chipped stone artifacts, which I explain below.

Models for Chipped Stone Exchange

Purely spatially based models for identifying exchange mechanisms are known to be flawed based on problems with equifinality, in which different forms of exchange such as centralized redistribution and central place markets result in the same spatial pattern (Renfrew 1977:88). Additionally, SAP chipped stone tools have further complications: singular geological source, universal access, and potential specialized activities. No single model will identify all of the competing influences on household obsidian inventories. However, the careful analytical separation of production and distribution in tandem with spatial and contextual data about the producers and the consumers can mitigate the overlapping expectations and influences on inventories to help identify the most likely exchange mechanisms. This technique, a modification of the regional production-distribution approach, was originally proposed by Stark and Garraty (2010:43-45) for distinguishing central redistribution and command economies versus market exchange in archaeological regional datasets where an item is known to have quotidian use, widespread availability, and specialized production and/or importation.

The regional production-distribution approach is based on the assumption that a quotidian item will show different spatial patterns of production and access based on how it is being managed in both production and exchange at the regional

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level. As Hirth (2010) proposes, mundane items are a good candidate for both market exchange and redistribution because they are items that will be acquired by the majority of households within a region. Obsidian blades have played the role of quotidian and mundane household items for many time periods and regions in Mesoamerica, making them a good candidate to evaluate using the regional production-distribution approach. Although I have polity scale rather than regional scale data, I can use both the household inventories and production evidence combined to evaluate how obsidian is being exchanged. Additionally, there are certain challenges to identifying exchange for obsidian that mean I cannot apply the same methods used on pottery.

Discerning the differences between market exchange and redistribution cannot apply the same network expectations used in the pottery analysis in Chapter 5 because most households are expected to have some quantities of a quotidian item. There are further complications that differentiate obsidian from pottery. Although pottery is also a quotidian item, not all of the pottery types can be compared on the basis of utility alone, with the exception of comals, which are a special use cooking item. The reason can be explained by considering the variations within pottery categories compared to the chipped stone corpus. Most households have assorted pottery for cooking, storage, and serving, but the variations among the pottery for these categories can be based on preference and potential restriction. For example, all households have some form of serving vessel; however, they don't necessarily need all categories of serving vessels so long as they had access to at least one, so restrictions and/or preferences could be

more easily reflected by comparing household inventories of different *varieties* of decorated serving vessels. For example, in Chapter 5 and 6, the analyses results demonstrated that most households had some decorated Black-on-Red serving vessels, but only a small fraction had Dull Buff Polychrome serving vessels. Therefore, an analytical method could be designed that tested the availability of each *kind* of serving vessel; blades cannot be divided into discrete categories in a similar manner.

Due to their technology, obsidian blades are generally far more similar to each other than different pottery types. Theoretically, a comparison could occur across different sources of obsidian. If contemporaneous, these sources could be assessed for different exchange mechanisms (see Clark 2003). For SAP, geological sources are not a good option for categorical divisions; only one primary source is identified for the Middle Postclassic period, the clear grey obsidian from Pico de Orizaba. This does not mean that blades cannot be evaluated; other measures such as blade size and quantity can be used to consider differential access. In other parts of Mesoamerica, blades can have variations based on dimensions such as width. A study by Aoyama (2006) found that greater blade width was associated with higher status residences. However, size is not completely free from other factors. Clark (2003) points out that blade size can also be impacted by local factors and expedient production by itinerant knappers rather than high status access; intended use could also play a factor in blade sizes.

For the study region, blade size and cutting edge have been analyzed for clear grey obsidian. Lewenstein (2001:173) applied a cutting edge/mass ratio analysis to all medial segments recovered from PALM I and found that the clear grey obsidian from Pico de Orizaba was used to create blades with the highest cutting edge/mass ratio that yielded up to two or three times more than obsidian from other sources and periods for the area. Heller (2000) suggested that these smaller blades (with greater cutting edges per unit of material weight) were partially the result of the smaller average size of the Pico de Orizaba blade cores compared to blade cores from other sources. This does not preclude elites having access to bigger blades; however, the variations in size are a continuum, in which categorical divisions cannot easily be made. This is particularly true in SAP's case, where the range for blade size is tied to the production of relatively small cores, a process that is possibly unrelated to elite restriction at the consumer end in Sauce. Since almost every household had access to at least some blades, the statistical methods adopted in the pottery analyses cannot be applied to evaluating the relative quantities of blades among households. Instead, blades can be evaluated by determining the relative quantities associated with socioeconomic ranks, to consider if exchange occurred via redistribution or central markets.

For chipped stone, the difference between market exchange and redistribution can be described as a special case of "open" versus "restricted" because almost all households have some quantity of obsidian blades. Because most households have some quantity of blades, it could appear that they have open access, even when this is not the case. In this case restricted access follows

social networks while open access is affected more by distance from a production and/or distribution point. Therefore, items obtained through restricted access may be available to everyone (through social or political means, or some combination of the two) but high ranked households would be expected to have control over this item which would result in enhanced chipped stone collections associated with control. Therefore, archaeological expectations can be based on differentiating between "open" and "restricted" exchange by comparing spatial and contextual patterns of access. In redistribution, I would expect to find spatial clustering of items within high ranked households, even outside the places where production and distribution were taking place (Stark and Garraty 2010:75). For open exchange such as markets, I would expect to find more dispersion of items across a region, with no obvious concentrations within higher ranked households, with gradual decreases in quantities away from the place where they were being produced and/or marketed. From my expectations for open versus restricted chipped stone exchange, it should be clear that to distinguish between the two forms one must rely on nuanced differences and contextual information to make a strong case.

For the Middle Postclassic period, Stark and Ossa (2010) apply a regional production-distribution approach to the PALM obsidian dataset. We analyze spatial patterns and access for individual residential mound collections by considering the ratio of obsidian blades to Postclassic pottery for individual collections using a spatial ring method similar to the sampling rings used in SAP (Stark and Ossa 2010). We suggest that pockets of higher densities of blades

scattered in spatial patches away from the center of Sauce, which could represent higher status residences, would provide support for a redistributive or restricted exchange economy rather than market exchange (Stark and Ossa 2010:156). Because we found no such spatial patterns, we argue that market exchange is the most likely explanation for the distribution of obsidian blades (Stark and Ossa 2010).

I apply a similar but smaller than region scaled production-distribution approach to evaluate the SAP obsidian inventories. SAP collections were more intensively sampled than PALM, and this fact, combined with less chronological mixing of materials, allow a detailed analysis of obsidian exchange focused on the Middle Postclassic period. I use recent research on obsidian production-exchange systems in Mesoamerica to establish where and how production of chipped stone artifacts was taking place (De León, et al. 2009; Hirth 2008, 2009a). Production circumstances and locale will be used to help evaluate the articulation of chipped stone exchange. Additionally, my analyses include a measure of socioeconomic rank for the residential mounds using the weighted mound size rank groups that were described in Chapter 4. A rank measure allows me to evaluate whether the higher density obsidian collections measured by both counts and ratios of chipped stone artifacts to Postclassic pottery are more associated with any subset of chipped stone artifacts[1]. For example, if a group of chipped stone items, such as formal tools, or blades, appear in much higher amounts *at high ranked mounds*, this lends support to restricted access, which would accord more with a redistributive model. However, groups of chipped stone items could also appear

in much higher amounts if they were used by households in specialized activities. Activity or multi-craft driven inventories with elevated chipped stone counts will be difficult to separate from expectations for redistribution unless the higher amounts are not consistently associated with higher ranked mounds. This is not a perfect measure to identify redistribution, as one can imagine situations in which elites are practicing multi-crafting activities or engaging in activities which require elevated amounts of chipped stone compared to the average householder. Despite these overlapping expectations, if elevated amounts are found in elite households or spatially clustered households along with evidence for the control of production, there is a stronger case for redistributive mechanisms.

Almost all of SAP's 65 collections had obsidian artifacts and will be used in the following analyses. Chert was found in much smaller quantities as formal tools (bifaces or projectile points). In contrast, most obsidian artifacts were prismatic blade fragments. For obsidian, I use three categories: formal tools, blade segments, and total prismatic blade parts. In this chapter, I analyze how the different chipped stone categories were distributed within the region spatially and whether high densities are associated with the mound rank groups (established in Chapter 4 as proxies for socioeconomic rankings). These two aspects, spatial and contextual, will be analyzed separately for formal tools, blade segments, all blade parts, and for chert for the inventories of the 65 residential mound collections (Table 7.1).

Table 7.1 Expectations and Methods for Evaluating Exchange.

General Expectations for Open versus Restricted Exchange

3. *Open Exchange* will produce graduated differences and spatial dispersion among residential inventories in the amounts of a quotidian good. If there is a singular source, open access will produce a relatively smooth and gradual drop-off in amounts from that source, although some exceptions based on specialized activities could occur.

4. *Restricted Exchange* will produce greater differences and spatial concentrations among residential inventories in the amounts of each quotidian good. If there is a singular source, restricted access may produce elevated amounts away from that source *based on social status*.

Methods for Analyzing Chipped Stone Exchange

5. *Summary Visual Analysis* is ring based exploratory data analysis.
    g. Calculate the ratio of chipped stone category totals to the total Postclassic pottery (minus Late Postclassic) for all 65 residential mound collections.
    h. Tally the percentage of collections per ring above the median ratio of chipped stone artifact category to the Postclassic ceramics.
    i. Create charts that show the percent of collections above the median ratio by ring.

6. *Detailed Visual Analysis* uses individual collection exploratory data analysis.
    h. Create bar charts for each chipped stone group depicting the counts and percents of that chipped stone inventory for each residential mound collection ordered by ring, with collections depicted from ring 1 (Sauce) to ring 5 from left to right.
    i. Bar charts also include mound sample information (scant versus robust sample) and weighted mound size rank groups as proxies for socioeconomic rank.
    j. Create bar charts for each chipped stone category, depicting the ratios of chipped stone category totals to the total Postclassic pottery (minus Late Postclassic) for each residential mound collection ordered by ring, with collections depicted from ring 1 (Sauce) to ring 5 from left to right.
    k. Compare bar chart results with maps of chipped stone data and Classic period center associations generated in MAPINFO (Corporation 1985-1997)where more detailed analysis is required.

In the first part of this chapter, I introduce the obsidian and its analysis categories. In the second part, I summarize prismatic production evidence and its implications for economic organization. For this chapter, the production analysis is a necessary step in identifying different exchange mechanisms for a staple artifact category such as chipped stone. In the third section, I consider the

exchange mechanisms and spatial and contextual components of the obsidian: formal tools, blade segments, and all blade parts. Finally, in the fourth section, I consider chert and its potential implications for Sauce's economic organization.

SAP Obsidian: Source Provenience, Chronology and Technological Classification

Before considering the exchange mechanisms directly, I introduce the SAP obsidian, discuss its defining characteristics, and consider their implications for the exchange analyses. Most of the SAP obsidian materials are prismatic blades, which are basic tools that were used by most households in Mesoamerica by 600 to 800 B.C. (Hirth 2003: 3). In Mesoamerica in general, and for SAP, prismatic cores and blades were traded over long distances (Cobean 2002: 197-203; Heller and Stark 1998). Although trade and specialized production of chipped stone preciosities such as obsidian eccentrics are documented elsewhere in Mesoamerica (Aoyama 2006), none were recovered by SAP.

Sources and Technological Chronology Associations

Obsidian at Sauce and its hinterland can be ascribed to periods on the basis of color and texture associations with geologic sources and blade technology, as described in Chapter 4 (Heller and Stark 1998:122). For the Middle Postclassic period, clear grey obsidian was ascribed to Pico de Orizaba, using Instrumental Neutron Activation Analysis (INAA) (Heller and Stark 1998:122). Additionally, the use of ground platforms on prismatic blade cores appears to be particularly associated with the Postclassic period prismatic technology in the Sauce region, although some recent discussion on this particular

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technology in other parts of Veracruz shows earlier associations (Heller 2000:

141; Santley and Barrett 2002). Therefore, I consider all of the clear grey

obsidian and those prismatic materials from a different obsidian source (dark grey

or black from Zaragoza-Oyameles, Puebla) with ground platforms.

Prismatic Core-Blade Technology

Within Mesoamerica, the obsidian industry is recognized as a major

economic force because obsidian was the main cutting tool for most households

and often, though not always, required specialists to produce prismatic core-blade

technology (Hirth 2008: 436). Prismatic core-blade technology in Mesoamerica

has been defined primarily from a few sites such as Teotihuacan and Ojo de

Agua, but there are spatial and temporal variations in the core-blade technology

across Mesoamerica that are not well understood (Hirth and Andrews 2002: 1).

Hirth and Andrews (2002:1-2) suggest that researchers tend to view the prismatic

core-blade technology as homogenous, but it is not. Instead, regional and

temporal variation is likely in both the production sequence and the production

stages at which cores and blanks are imported into regions. Furthermore, regional

and local provisioning and exchange systems vary. Differences in household

inventories and the evidence of different debris from production stages can be

used to evaluate how blades were being produced and traded within local regions

(De León et al. 2009:114-115). Therefore, the identification of production

sequences will be important in my analyses. I begin by describing the general

prismatic core-blade typology and the specific technological classifications

adopted for SAP.

The PALM obsidian typology, which was applied to SAP materials, was based on Mesoamerican obsidian technological studies with similar analytical goals (Heller 2000). PALM obsidian was analyzed using visual characteristics including color, texture, and transparency (Heller and Stark 1998: 121). For the technological classification, Heller applied a general prismatic core-blade reduction model similar to the one developed by Clark and Bryant (1997: 111-113). Heller adopted a typology that documented the technological process of prismatic blade production and included both the production sequence of pressure and percussion blade techniques and knapping errors (Heller 2000:142-143). As Clark and Bryant (1997: 131) suggest, the identification of production errors and the production sequence of artifacts in the analysis of obsidian artifacts can greatly aid in understanding provisioning and exchange systems.

All of the SAP obsidian was characterized by a combination of artifact categories that were based on flake and prismatic blade-core production sequences (blade, core, shatter, etc.) and color (Heller 2000, 2001; Heller and Stark 1998: 159). Heller (2000:140) describes the prismatic blade-core production sequence for Middle Postclassic period Sauce, based on a workshop assemblage from Mound 1756 near the center. Preformed obsidian cores were imported into the area, although some may have arrived in small, naturally blocky forms (Heller 2000:141). Grinding the platform of prismatic blade cores is a technological advance that is sometimes applied prior to core preparation. It allows for better purchase of a tool on the ground surface for pressure blade removal. It was adopted at varying times and places across Mesoamerica. Heller

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(2000) notes that ground platforms were identified in PALM excavation contexts associated with the Postclassic period, because they were found in the upper layers. Data from the obsidian workshop identified by Heller (2000) near the center of Sauce showed that the great majority of the clear grey prismatic cores and core proximal segments had ground platforms.

Obsidian cores with or without ground platforms are typically further prepared for blade removal by removing cortex (decortication flakes) and macroflakes to create platform surfaces (Hirth and Andrews 2002:3-4). The next step could include the removal of crested blades, ridged blades, and/or percussion blades to prepare the polyhedral core. However, the process will vary from place to place, and for the PALM Sauce assemblage, Heller (2000:142) found very few ridged blades, but instead found percussion blades and initial series blades. After the initial series of blades are removed, pressure prismatic blades are removed, and then a series of core-rejuvenation flake removal techniques can be applied so that more blades can be removed as the core is depleted. Included within these sequences are flakes and debitage that are related to errors that knappers had to handle by making corrections during core reduction.

SAP artifacts were grouped to capture information about obsidian use and production. In depicting the group categories, I use the divisions defined by Heller for PALM. For the SAP collections, the clear grey obsidian had the following categories that group more specific designations (see Table 7.2).

Table 7.2 SAP total for the categories of grouped artifacts for clear grey obsidian.

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Group Artifact Type	Counts	Weights (g)
Blades:		
Blade Related	67	15.3
Blade Tools	7	4.1
Flake or Blade Tools	2	24.4
Prismatic Blades	914	443.3
Production/Use:		
Debitage and Macrodebitage	23	39.4
Flake Tools or Polyhedral Core Reduction	6	2.5
Polyhedral Core Reduction	48	200

In the following section, I describe each group category and the individual artifact types included.   These brief summaries demonstrate what aspect of production or product each artifact group is supposed to describe. The table and descriptions below are not exhaustive for the entire PALM technological typology, but show those artifact types in SAP collections for clear grey obsidian. Not all listed categories are used in the exchange analyses of this chapter, but I include all of the SAP clear grey data for informational purposes. All clear grey individual artifact types are listed, showing counts and weights, in Table 7.3.

Table 7.3 SAP totals for the individual artifact type categories for clear grey obsidian.

Artifact Types	Counts	Weights (g)
Blade Related:		
Ribbon Blades: Very Small, Delicate	11	1.3
Blades: Shatter	56	14.6
Blade Tools:		
Blades or Flakes retouched to Points/Punches	4	2.5
Notched Blade	1	0.4
Projectile Points on Prismatic Blades	2	1.2
Flake or Blade Tools:		
Scrapers on Transverse Core Tab	1	9.2
Scraper on Longitudinal Core Fragment	1	15.2
Debitage and Macrodebitage:		
Percussion Flakes	20	17
Macro Flake: Whole	2	19.1

Artifact Types	Counts	Weights (g)
Macro Flake: Proximal	1	3.3
Flake Tools or Polyhedral Core Reduction:		
Unidentified Flakes without Platforms	6	2.5
Polyhedral Core Reduction:		
Prismatic Cores: Distal	2	6.5
Hinge Recovery Blades	1	0.5
Flake Fragments/Probable Platform Trimming Flakes	2	2
Distal Rejuvenation flake	1	19.2
Chunks	4	6.3
Platform Trimming/Faceting Flakes	2	2
Bipolar Flakes	1	1.8
Irregular Pressure Blades	3	2.1
Transverse Core Flake with Faceted Dorsal	1	11.7
Prismatic Cores: Shatter	3	4.1
Pressure Flakes	9	2.6
Transverse Core Flake with Non-Faceted Dorsal	3	8.7
Prismatic Core Face Flakes: Longitudinally Struck Off	4	20.2
Transverse Core Flake Fragment	1	1.6
Small Shatter	3	1.7
Probable Platform Trimming/Faceting Flakes	1	0.8
Prismatic Cores: Whole	2	48.9
Prismatic Cores: Proximal	3	52.3
Prismatic Cores: Medial	1	6.4
Unidentified Blades	1	0.8
Prismatic Blades:		
Percussion Blades: Medial	1	0.5
Prismatic Blades w/Platform Reversal Scars	1	1
Percussion Blades: Proximal	4	8.9
Prismatic Pressure Blades: Proximal	216	118.5
Prismatic Pressure Blades: Medial	590	270.3
Prismatic Pressure Blades: Distal	102	44.7

The blade related artifact types are byproducts of the blade industry that include very small ribbon blades and blade shatter. The categories of blade tools and flake or blade tools include blades reused and fashioned as tools such as projectile points, or tools that were created from blade core fragments. SAP did not find any tools created from flakes or any retouched flakes. The group

categories of debitage and microdebitage are broken down into individual categories of flakes over 2.5 cm wide and flakes under 2.5 cm wide. Given the predominance of the blade industry, they are probably related to the production of blades or tools rather than a flake industry (Heller 2000). The flake tools or polyhedral core reduction category applies to flakes that do not have an identifiable platform to categorize as percussion and to macroflakes; these artifacts could represent flake-based tools or could simply be part of the prismatic core reduction sequence, and cannot be categorized as flake tools or polyhedral core reduction. The polyhedral core reduction category includes prismatic blade cores, core rejuvenation flakes, platform trimming flakes, pressure flakes, etc.; basically all obsidian artifacts that can be directly linked to the reduction, rejuvenation, and reshaping of prismatic blade cores. Finally, prismatic blades include a handful of percussion blades, but the vast majorities are prismatic pressure blade parts. For SAP, platforms and/or the bulb of force were required to identify proximal sections of blades and the tip or tip curvature was required to identify distal sections of blades, an analytical method identical to the method used in PALM.

Summary of the Dataset and Implications for Exchange Analyses

Prismatic blade artifacts make up the great majority of the SAP obsidian (Tables7.2, 7.3). This is not surprising because most of the residential mound collections would be expected to represent household obsidian use rather than production. The relative homogeneity of the SAP obsidian means that the statistical methods of the network analyses applied to the pottery cannot be

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applied in this case.² Instead, models based on the articulation of production with the spatial distribution and contexts of blade related artifacts will be used to distinguish between redistribution and market exchange.

Obsidian Production Indicators, Provisioning, Spatial Patterns and Exchange

In prior research on Mesoamerican obsidian assemblages, production indicators showed how production was organized and aspects of the political economy behind it (Clark and Bryant 1997: 134; Hirth 2008). Therefore, production indicators found among the SAP inventories can provide important insights into the ways in which obsidian blades were being provisioned to households and where production took place. Previous research on the spatial patterning of obsidian production for the Middle Postclassic period found an association with Sauce. Obsidian artifact production at Sauce represents the continuation of craft production association with centers for the region that began by the Early Classic period for chipped stone (Stark and Ossa 2010) and by the Late Classic period for multiple crafts (Heller 2000; Stark 2007a).

Previous evidence for blade production at Sauce was based on the identification of large amounts of production-related debris in mound 1756 on the edge of the Sauce center. Few production indicators for prismatic blade technology were found in the 65 residential mound inventories collected for SAP. For example, Heller's (2000:145) study had 719 pieces of production indicators compared to SAP's entire collection of 50 pieces for all 65 collections, representing only about 5% of SAP's clear grey obsidian. To increase the sample

of Middle Postclassic period obsidian production, I also consider production

indicators from a selection of Middle Postclassic mounds from PALM.

PALM and SAP datasets were considered separately because they were

collected differently. SAP collections are density based measures in which

vegetation clearing was employed while the PALM collections did not involve

vegetation clearing and were variable in coverage based on the type of ground

vegetation cover (Stark and Garraty 2008). Due to different collection practices,

SAP and PALM data are not statistically comparable. For PALM data, I selected

only those collections that dated to the Middle Postclassic period. Therefore, I

tabulated obsidian production indicators from the 130 mounds originally selected

as having adequate amounts of Middle Postclassic materials as described in

Chapter 3 (the Robust sample mounds).

Production Insights about Provisioning

Recent approaches to the analysis of obsidian production indicators

proposed new methods for obtaining more detailed information about

provisioning and exchange (De León et al. 2009; Hirth 2008, 2009). De León et

al. (2009) employ a new way of defining production indicators and blade part

ratios to evaluate regional provisioning and exchange. They suggest that

different types of blade trade will have different archaeological signatures

represented by different suites of chipped stone artifacts (De León et al. 2009).

For the production analysis of SAP and PALM collections, I use their new

method of defining production indicators. This new method divides production

into categories that can pinpoint where blade production is taking place versus their reuse.

My analysis will also look at the spatial patterning of production indicators to evaluate where blades may have been produced. The presence of different types of production indicators can distinguish onsite blade production by local producers from provisioning by itinerant specialists, or the exchange of processed blades. I explain De León et al.'s (2009) approach below and discuss how it can be applied to SAP and PALM materials.

De León et al. (2009:115) divide prismatic core-blade production evidence into two categories, primary production evidence and secondary production evidence. Primary evidence is mostly core related and includes prismatic blade cores, exhausted cores, recycled cores, core fragments, and core rejuvenation flakes. Secondary evidence is related to by-products associated with core reduction and maintenance, production errors and corrections, including core-shaping flakes, macroblades, percussion blades, early series blades, plunging blades, blades with hinge fractures, crested blades, distal-orientation blades, and overhang removal flakes (after De León 2009:114-115, Table 1). De León et al. (2009) suggest that while primary production evidence is required to support an inference of local blade production, artifacts associated with secondary production are more equivocal as evidence of local production. De León et al. (2009:125-126) propose that secondary production evidence could represent the re-purposing of blade by-products and exhausted cores by itinerant knappers rather than local production.

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I divide the PALM production indicators into primary and secondary production indicators based on De León et al.'s (2009:115, Table 1) approach. The presence or absence of both sets of production indicators will be considered for both SAP and PALM collections based on the indicators in Table 7.4.

Table 7.4 Primary and secondary production indicators for SAP and PALM materials.

Primary Production	Secondary Production
Prismatic Cores: Whole, Proximal, Medial, Distal, and Shatter	Macro Percussion Blades: Proximal, Medial, Distal, Whole
Longitudinal Blade Core Fragments	Bipolar: Flakes, Shatter, Cores, Blades
Prismatic Core Rims	Transverse Core Flakes
Prismatic Core Face Flakes	Platform Trimming Flakes
Core Face Rejuvenation Flakes	Macro Flakes
	Flakes without Platforms
	Second and Initial Series Blades
	Irregular Pressure Blades
	Ridged, Secondary Ridged, Unidentified, and Plunging Blades
	Hinge Recovery Blades
	Small Pressure Flakes

PALM. For the PALM Middle Postclassic subset, production indicators totaled 85 artifacts, including 30 primary and 55 secondary. Both primary and secondary production indicators are listed in Tables 7.5 and 7.6 below. The tables only show the artifact types that had counts for the 130 Middle Postclassic period PALM collections. Also, due to differences in recording practices between the PALM I and II field and analysis seasons, it was not possible to include artifact weights. Artifact weights were recorded for all PALM materials; however, these weights were recorded in different grouped categories rather than by individual categories and so could not be resorted for use in this particular analysis.

Table 7.5 Primary production indicators for PALM Middle Postclassic collections.

Primary Production	Counts
Prismatic Cores: Whole, Proximal, Medial, Distal, and Shatter	27
Longitudinal Blade Core Fragments	2
Prismatic Core Rims	1
Totals	**30**

Table 7.6 Secondary production indicators for PALM Middle Postclassic collections.

Secondary Production	Counts
Bipolar: Flakes, Shatter, Cores, Blades	9
Transverse Core Flakes	13
Platform Trimming Flakes	3
Flakes without Platforms	1
Second and Initial Series Blades	3
Irregular Pressure Blades	24
Ridged, Secondary Ridged, Unidentified, and Plunging Blades	1
Small Pressure Flakes	1
Totals	**55**

SAP. For SAP, production indicators totaled 50 artifact counts, including 16 primary and 34 secondary. Both primary and secondary production indicators are listed in Tables 7.7 and 7.8 below. The tables only show the artifact types that had counts for SAP collections. SAP recording and analyzing practices by individual categories allowed artifact types to include both counts and weights (in grams) for the production indicators.

Table 7.7 Primary production indicators for SAP.

Primary Production	Counts	Weights (g)
Prismatic Cores: Whole, Proximal, Medial, Distal, and Shatter	11	118.2
Longitudinal Blade Core Fragments	4	20.2
Rejuvenation Flakes	1	19.2

Primary Production	Counts	Weights (g)
Totals	**16**	**157.6**

Table 7.8 Secondary production indicators for SAP.

Secondary Production	Counts	Weights (g)
Bipolar: Flakes, Shatter, Cores, Blades	1	1.8
Transverse Core Flakes	5	22
Platform Trimming Flakes	5	2.8
Macro Flakes	3	22.4
Flakes without Platforms	6	2.5
Irregular Pressure Blades	3	2.1
Ridged, Secondary Ridged, Unidentified, and Plunging Blades	1	0.8
Hinge Recovery Blades	1	0.5
Small Pressure Flakes	9	2.6
Totals	**34**	**57.5**

The presence of primary production indicators, although scant, supports Heller's (2000) identification of local production for obsidian blades during the Middle Postclassic period. Spatial information on where the primary production indicators were located versus where the secondary production indicators were located will allow conclusions about whether local blade production was associated with the Sauce center. In the following section, I summarize the spatial patterns for PALM and SAP.

Spatial Patterning

The production indicators support local prismatic blade production for Middle Postclassic period Sauce and its hinterland. However, the spatial associations of production are not yet established for the SAP dataset. Based on De León et al.'s (2009) logic, primary indicators would be located near the onsite production of obsidian blades while secondary indicators, if found without

primary indicators, probably represent itinerant knapping and reuse of obsidian

materials. The SAP and PALM production indicators recovered were analyzed to

see if the association of obsidian production with the Sauce center and its

environs is consistent. In my consideration of production indicators, primary and

secondary are considered separately for a spatial analysis based on the concentric

2.5 km rings established as part of the SAP sampling strategy (see Chapter 3).

PALM. PALM had 30 primary production indicators (see Table 7.5). The

spatial patterning of these primary indicators shows markedly higher amounts

within ring 1, near Sauce (Figure 7.1). However, primary production indicators

are not completely absent from the other rings, with a few pieces appearing in

rings 2-5. These data suggest that while most of the primary production appears

to be associated with the Sauce center and ring 1, it is also present in small

amounts within the rings 2-5.

PALM had 55 secondary production indicators (see Table 7.6). The

spatial patterning of these secondary indicators shows greater amounts in ring 1,

although the pattern is less strong than it was for the primary production

indicators (Figure 7.2). There are fewer secondary indicators farther away from

Sauce in ring 1, and the amounts drop to zero in ring 5, despite collections from

this ring having a few prismatic cores (primary indicators). These results are

consistent with some amounts of production and reuse throughout most of

Sauce's hinterland, with greater amounts near the center itself.
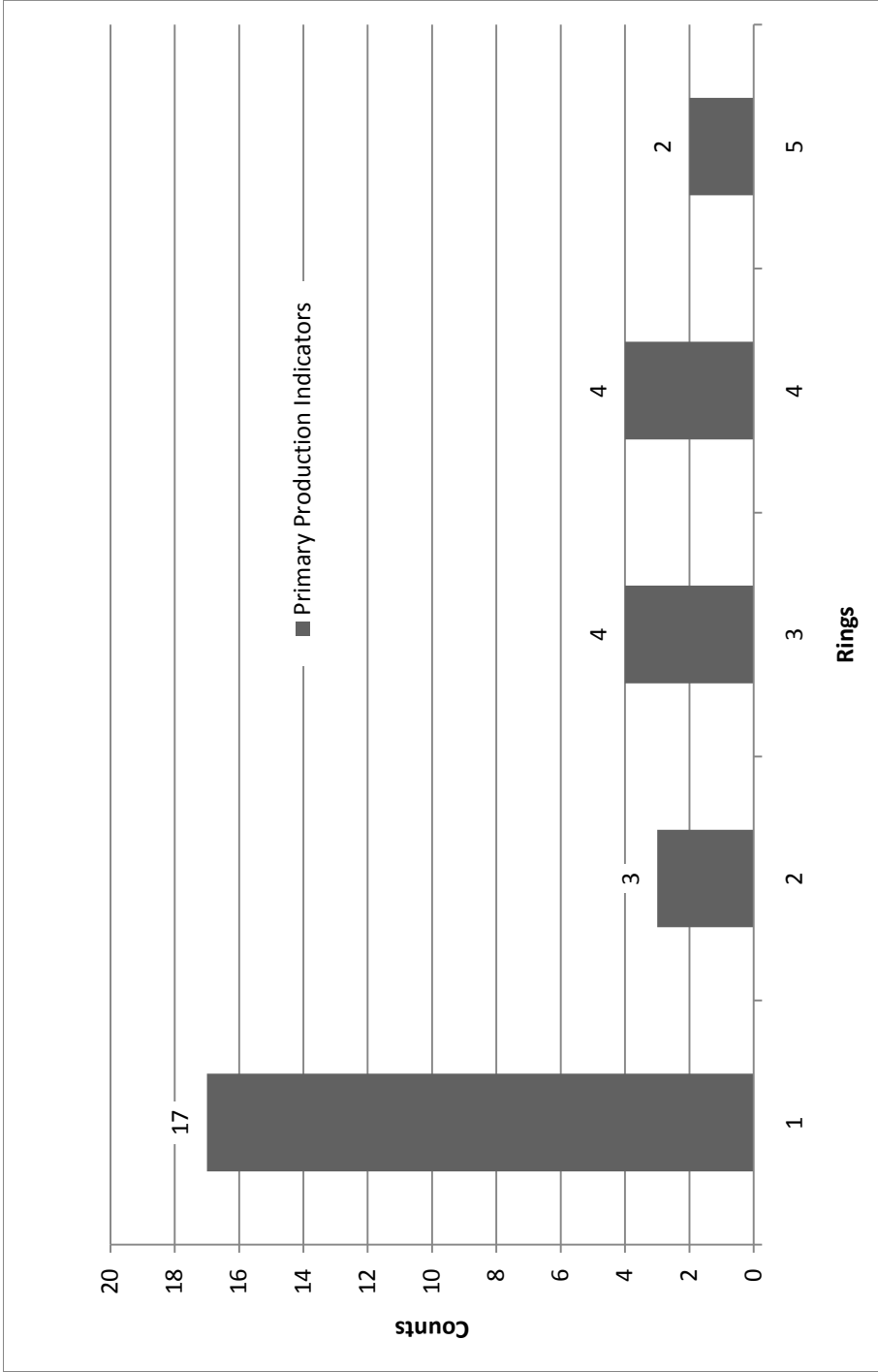
Figure 7.1 PALM Middle Postclassic robust collections showing primary production indicators by rings.
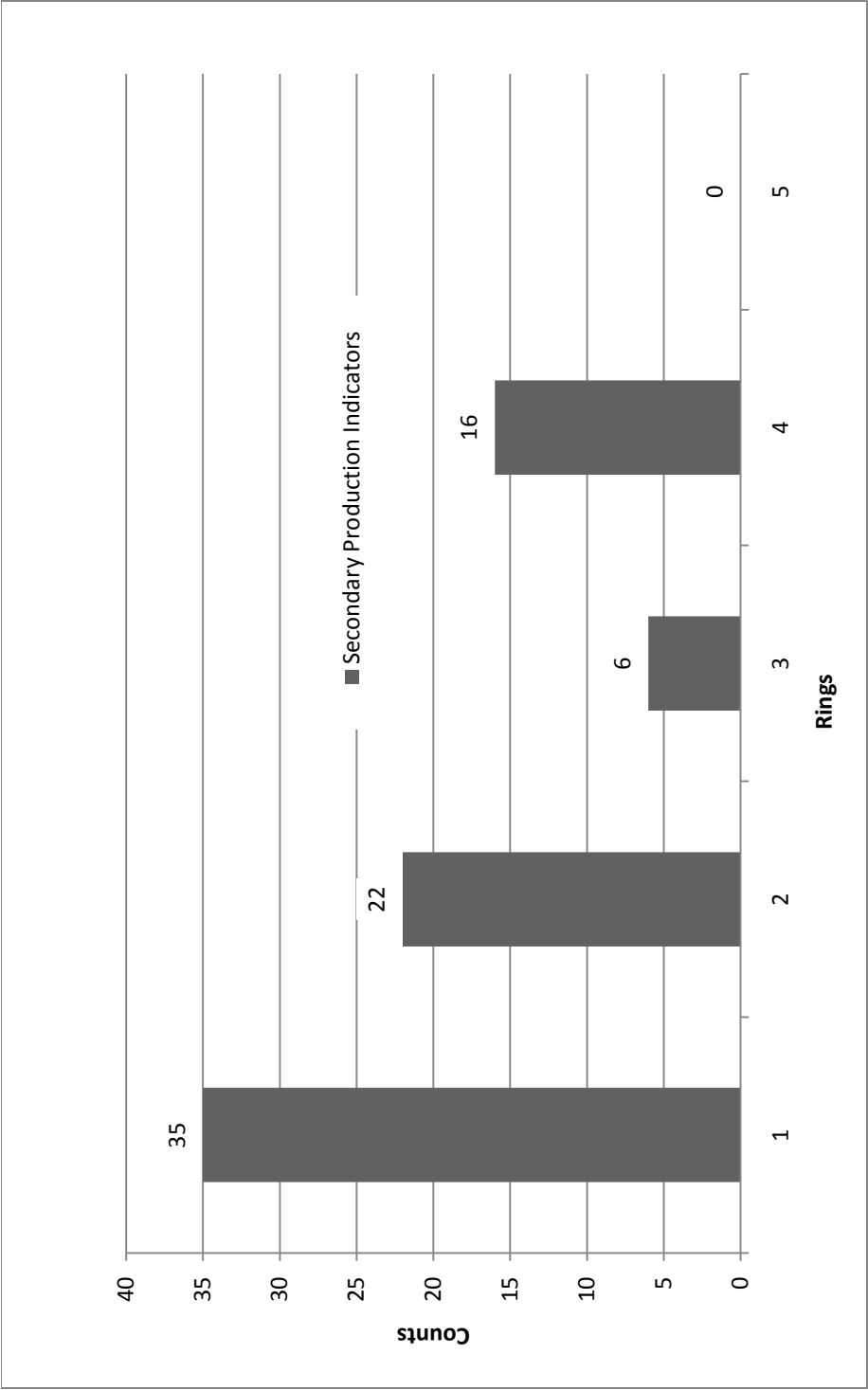
Figure 7.2 PALM Middle Postclassic collections showing secondary production indicators by rings.
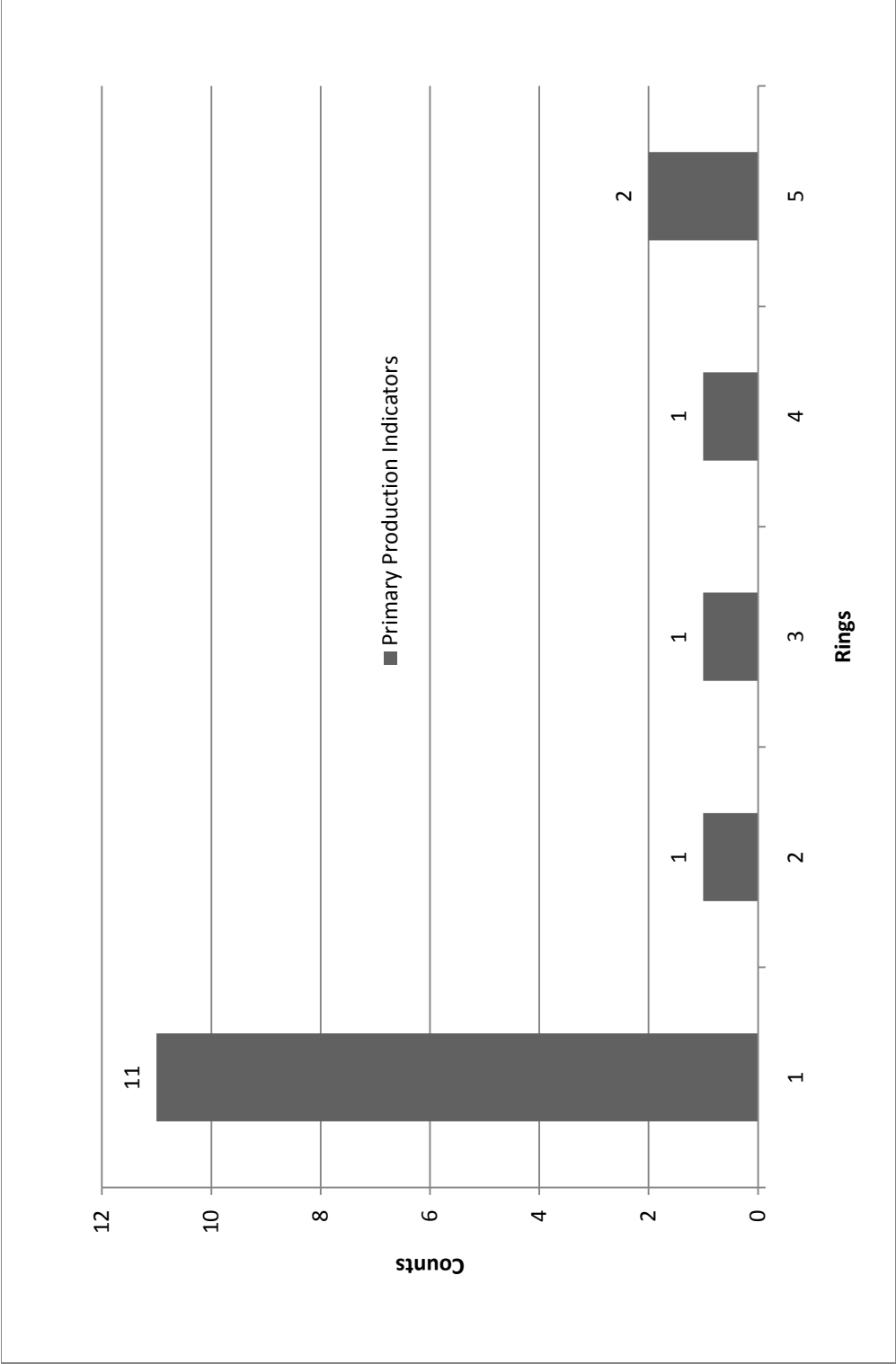
Figure 7.3 SAP primary production indicators by rings.

SAP. SAP has both counts and weights available for tabulation of primary

and secondary indicators (see Table 7.9). For SAP, I can also consider the

percent of production indicators per ring in proportion to the total obsidian

because all of the collections are densities and statistically comparable.

SAP had 16 primary production indicators (see Table 7.7). The spatial

patterning of these primary indicators shows a marked association with ring 1 and

the Sauce center (Figure 7.3). The differences between the amounts of primary

indicators in ring 1 compared to the other rings is slightly greater in the SAP

dataset than in the PALM dataset, but the general pattern remains similar.

Interestingly, when considering SAP primary production indicators as a percent of

the total obsidian, both rings 1 and 5 show slightly higher percents of primary

production indicators; however, the amounts are still quite low at about 2 percent

each (see Table 7.9). Overall, the evidence supports much higher amounts of

blade production near the Sauce center, with smaller amounts of production

occurring within all rings away from ring 1 and with some evidence of primary

production occurring within ring 5 in slightly higher amounts than rings 2-4 (see

Table 7.9).

Table 7.9 SAP clear grey production indicators by rings.

Rings	Primary Production		Secondary Production		Production Totals		Obsidian Totals	
	Counts (%)	Weights (g)	Counts (%)	Weights (g)	Counts (%)	Weights (g)	Counts	Weights (g)
1	11 (2.2 %)	140	17 (3.4%)	30.7	28 (5.6%)	170.7	500	417
2	1 (.7 %)	1.2	5 (3.6%)	2.9	6 (4.3%)	4.1	141	97.1
3	1 (.6%)	1	10 (5.9%)	25.1	11 (6.6%)	26.1	168	97.1
4	1 (.6%)	6.4	1 (.6%)	0.1	2 (1.2%)	6.5	173	80.3
5	2 (2.4%)	9	1 (1.2%)	0.7	3 (3.5%)	9.7	85	38.9
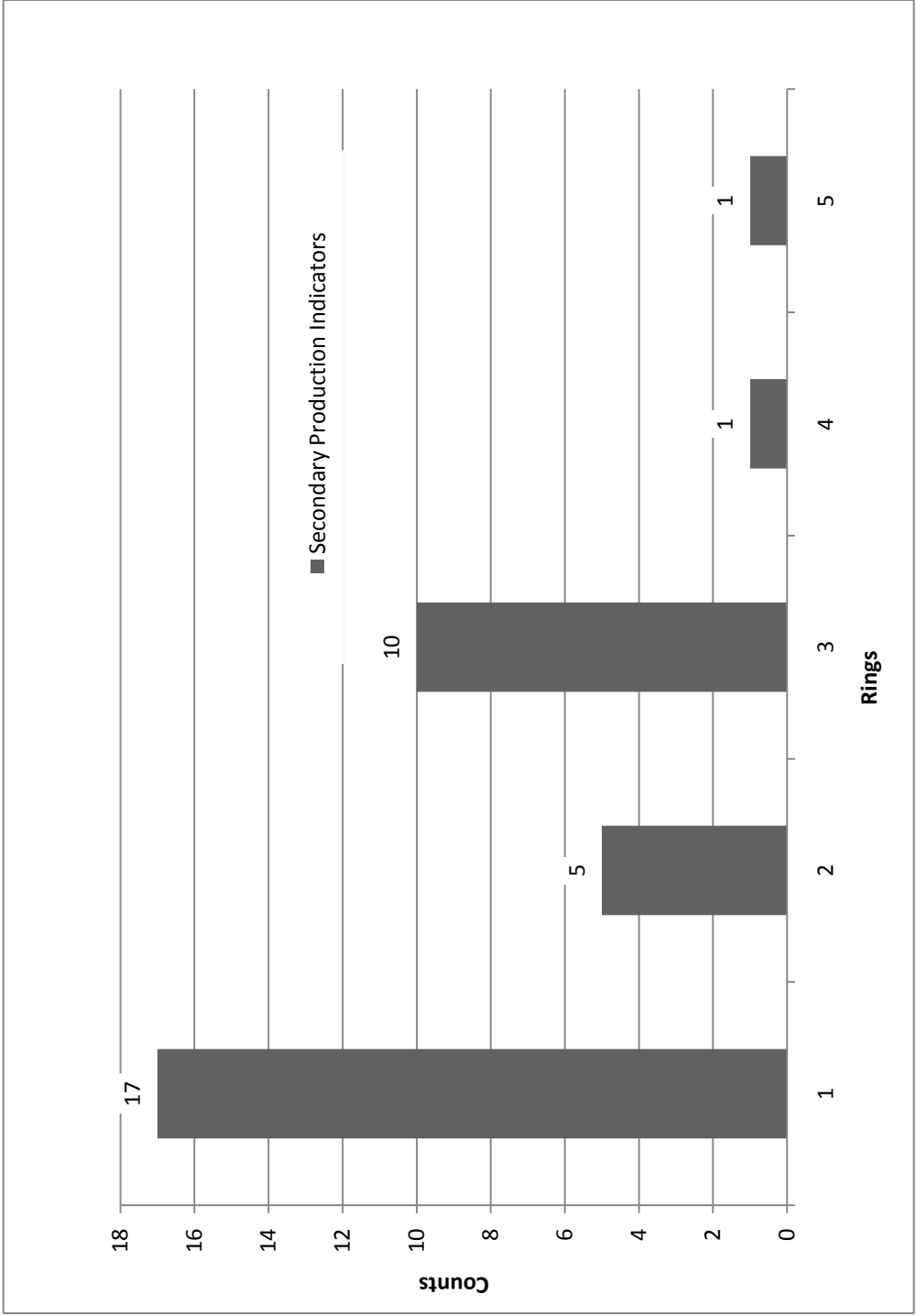
Figure 7.4 SAP secondary production indicators by rings.

SAP had 30 secondary production indicators (see Table 7.8). The spatial patterning for the secondary indicators has some similarities and differences with PALM. The highest concentration of secondary indicators is located in ring 1 near Sauce, as with PALM (Figure 7.4). However, the spatial patterns in rings 2-5 differ. For the SAP collections rings 2 and 4 have lower amounts of secondary production indicators while ring 3 has more (Figure 7.4, Table 7.9). The opposite appears to be true for PALM collections (Figure 7.2). However, PALM was obtained from the 130 Middle Postclassic mounds which varied in number per ring (see Chapter 3). This variation in amounts of collections per ring could be biasing spatial patterns within PALM. SAP's even number of mounds per ring collection strategy offers some insulation towards spatial biases. Therefore, SAP may offer a more accurate fine-grained spatial dataset for the production indicators compared to PALM collections. SAP's production evidence, while low in amounts, supports the presence of higher amounts of secondary production indicators than the PALM evidence.

Production Evidence Implications

Evidence from both SAP and PALM shows that local blade production was taking place both onsite near the Sauce center, and possibly in low level amounts scattered among the rings 2-5 away from the Sauce center. The presence of primary production supports the presence of local specialists producing blades near Sauce, although some very small amounts of primary evidence are found within every ring. The secondary production evidence is found in greater

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amounts near the Sauce center, and is also in rings 2-5, though in much lower amounts. These results support the interpretation of some itinerant knapping within rings 2-5 outside the Sauce center. In other words, it is possible that there are domestic-based workshops in the outer rings, but they have not been located yet. Finally, the results of production indicator analysis support the view that the majority of SAP households were being provisioned by blades made near Sauce and that blades were being distributed mostly from there, rather than being the result of itinerant craftsmen provisioning the entire region.

Chipped Stone Datasets for Exchange Analysis

In this section, I consider the evidence for how tools, blades, and blade parts being exchanged, based on the characteristics of their spatial distribution and associations with the mound rank groups. As summarized in Table 7.1, higher spatial concentrations associated with residential units with high socioeconomic rank would be an expected result for restricted exchanges such as redistribution rather than the spatial dispersion and fall-off curve away from the production source or distribution point (mainly Sauce) that would indicate open exchanges such as market exchange. Some potential complications in this pattern include the possibility that specialized use or activities involving chipped stone tools may elevate the inventories of some households, even if markets were the main mechanism of exchange. Therefore, special attention will be paid to the context of residential associations of rank and also the co-occurrence of other artifact classes that could support multi-crafting, such as spindle whorls (after Stark 2007).

Formal Tools

In a recent study in residential variation in chipped stone assemblages by Feinman et al. (2006: 168-171), they found that better access to formal tools (such as projectile points, bifaces, unifaces) was associated with higher status households. This finding motivates my analysis of SAP formal tools. Since specialized artifacts require more skill and labor, these items were probably of higher value. Formal tools are quite rare among PALM collections and proved equally elusive in the SAP intensive collections. For SAP collections, 9 tools were found. These included Notched Blades, Projectile Points on Prismatic Blades, Scrapers on Transverse Core Tabs, Scrapers on Longitudinal Core Fragments, and Blades or Flakes Retouched to Points or Punches.

Most of SAP's clear grey obsidian tools were constructed from prismatic blades modified into points; the skill required to produce these is not in the same category as the formal tools that Feinman et al. (2006) refer to in their work, such as bifaces, unifaces, or constructed larger projectile points. Therefore, these should be considered ad hoc tools. In other prismatic-core blade industries in Mesoamerica, blade and flake based tools are often found based on blade and flake recycling (Hirth and Andrews 2002). We could suppose that many households are capable of repurposing blades they acquired into things like points or punches after the edge of blades had been worn. Since the Postclassic period obsidian is dominated by prismatic blade technology, it is unsurprising that most of the tools recovered from SAP come from prismatic blades and flakes (see Table 7.10).

Table 7.10 Tools in SAP collections.

Ring s	Sample Population	Mound Rank Order	Counts	Weights (g)	Artifact Tool Type	Postclassic Pottery
1	Robust	3	1	0.4	Notched Blades	315
1	Robust	5	1	0.7	Projectile Points on Prismatic Blades	81
1	Robust	1	1	9.2	Scrapers on Transverse Core Tab	155
1	Robust	1	1	0.8	Blades/Flakes retouched to Points/Punches	155
1	Robust	5	1	0.7	Blades/Flakes retouched to Points/Punches	206
2	Robust	5	1	0.5	Projectile Points on Prismatic Blades	75
2	Robust	5	1	15.2	Scraper on Longitudinal Core Fragment	99
4	Scant	5	1	0.7	Blades/Flakes retouched to Points/Punches	23
5	Robust	5	1	0.3	Blades/Flakes retouched to Points/Punches	28

The majority of the flake or blade based tools are found within ring 1 (see Table 7.10). Although these tools are not very numerous and appear to be much more heavily associated with Sauce, they do not appear to be restricted only to collections with abundant ceramics, particularly in the outer rings 4 and 5. Based on this dataset, there is no evidence to suggest that tool access was restricted to ring 1 or to collections that have higher mound rank sizes or abundant ceramics. These results could fit a situation in which households are simply repurposing their old blades to create tools. If some of them are being exchanged rather than made, these results suggest that although formal tools were apparently a much rarer artifact type than blades, access to them was not restricted and their exchange was most likely through some form of market exchange. Based on their associations with ring 1, it seems more likely that these tools were created nearby,

perhaps in places like the workshop identified by Heller (2000) near the Sauce center.

Another intriguing possibility is that craft production taking place near the Sauce center helped inflate the amounts of chipped stone tools. For example, the PALM survey identified a mound associated with large amounts of scrapers that show wear patterns associated with processing woody plants near Sauce (Lewenstein 2001). Likewise reuse may have occurred, just as exhausted cores were processed for scrapers. Generally, the spatial association combined with no obvious abundance or association with higher ranked mounds lends support to the idea that these tools were created and exchanged in a market within or near Sauce, rather than being the product of itinerant craftsmen.

Blade Part Provisioning, Exchange Mechanisms, and Spatial Patterns

The main body of evidence concerning the exchange and provisioning of chipped stones is the obsidian blades and blade parts that were being produced in greatest quantities near the Sauce center. The production data from SAP and PALM support the presence of local blade production there. I use information about the ratio of blade parts to infer whether whole or processed (segmented) blades were exchanged (De León et al. 2009). No whole prismatic blades were recovered for SAP; therefore, to infer how blades were being exchanged, I use blade segments. The basic premise is this: if blades are traded as whole blades, processed blade segments, or through local blade production, each alternative blade form or production method will leave a signature in the ratios of different blade segment parts to each other (such as proximal to distal) within a set of

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households within a region (De León et al. 2009; Hirth 2008). Therefore, blade part statistics are the first step in evaluating obsidian exchange.

De León et al.'s (2009:119) blade trade models suggest, in the case of local blade production, that the proximal to distal ratio should be about even, since both parts would be expected to be present in similar amounts. Medial to distal ratio should be about 2 or 3 to 1 since medial segments would be more numerous due to breakage into multiple pieces either intentionally or unintentionally. For the SAP collections, I evaluate blade part ratios by rings, because primary production evidence for onsite production, while present in all rings, was most abundant in ring 1. Additionally, ring 5, although lower in obsidian counts, had a percentage of production indicators similar to ring 1 (see Table 7.9). Therefore, blade part ratios by rings could bolster the case for a distant production and distribution location in or near ring 5.

A summary table showing the prismatic blade part statistics for clear grey obsidian shows that medial segments make up more than twice the amount of the next largest blade part, proximal segments (see Table 7.11). Overall, the ratio of proximal to distal blade parts is 2.1 to 1 while the ratio of medial to distal parts is 6 to 1. The summary blade segment data shows that processed blade parts, particularly medial segments, were the main focus of exchange. However, the results are a little different when the data are viewed by rings.

Table 7.11 SAP prismatic blade part statistics for clear grey obsidian.

Prismatic Blades	Counts	Weights (g)
Pressure Blades:		

Prismatic Blades	Counts	Weights (g)
Proximal	216	118.4
Medial	590	270.2
Distal	102	44.3
w/Platform Reversal Scars	1	1
Percussion Blades:		
Proximal	4	8.9

In rings 1 and 5 the proximal to distal ratios are a little lower at 1.6 to 1 than the ratios in rings 2-4 at 3 to 1 (Table 7.12). Proximal to distal ratios are expected to be closer to 1 to 1 in cases where whole blades are being acquired. Distal segments are expected to be more fragile, so their numbers are not expected to be as reliable. Therefore, taking post depositional processes into account, the spatial patterns of proximal to distal ratios may indicate that rings 1 and 5 were places that had greater access to whole blades or more complete blades, possibly due to nearby blade production.

Table 7.12 SAP blade part segments and ratios by rings.

Rings	Proximal Counts	Medial Counts	Distal Counts	Proximal/Distal	Medial/Distal
1	90	260	54	2 to 1	4.8 to 1
2	30	87	11	3 to 1	8 to 1
3	34	89	10	3 to 1	9 to 1
4	43	106	15	3 to 1	7.1 to 1
5	19	48	12	1.6 to 1	4 to 1
Totals	**216**	**590**	**102**	**2.1 to 1**	**6 to 1**

Interestingly, the medial to distal ratios show a pattern similar to the proximal to distal ratios by ring. Medial to distal ratios for rings 1 and 5 are high, at about 4-4.8 to 1 but the ratios are even higher at 7.1 or 9 to 1 for rings 2-4 (see

Table 7.12). These results show that medial segments are far more prevalent compared to distal segments in rings 2-4, which one might expect if medial segments were preferentially exchanged or processed (breaking into more pieces) and if onsite production was making access to whole blades (and distal segments) more prevalent in rings 1 and 5. De León et al.'s (2009) original idea was that processed blade trade probably favored medial segments, which would produce medial to distal ratios that were high, approximately 6 to 1, for his data. Due to variations in core sizes and probably local use (different regions could plausibly prefer different sized medial segments based on use or local tradition), SAP's higher amounts of medial segments do not violate the logic of DeLeón et al.'s (2009) general expectation. For SAP, production was probably a combination of local producers with some itinerant knappers, with the highest amount of production in ring 1 and possibly some in ring 5 as well. Blades could be produced near Sauce and medial segments could be the main blade segments being exchanged. The results of blade segment ratios support the model of onsite production and local processed blade trade.

In summary, the spatial patterns of blade segment ratios suggest that although prismatic blades were being produced near Sauce, with some probably much smaller amount of itinerant or domestic production, blades and medial segments were the focus of exchange. The observed blade segment patterns may have been affected by the fragility of distal segments; however, the relative differences in amounts are too great for this factor to explain all of the variation. Blade segments could be exchanged rather than whole blades. Therefore, in order

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to examine exchange models for the SAP prismatic blades, I evaluated the spatial and contextual data for each blade part separately and then grouped.

Proximal Blade Segments. Proximal blade sections have the platform or bulbar end, depending on completeness. Proximal segments are expected where whole blades are being produced and exchanged. I include the few black or dark grey proximal blade segments with ground platforms.

For the clear grey obsidian, SAP collections had a total of 216 proximal blade segments with ground platforms, weighing 118.4 g. For black obsidian, SAP collections had 23 proximal blade segments, weighing 15.9 g. I will evaluate the clear grey and black obsidian proximal blade segments separately, since they might be obtained through different exchange networks due to having different geological sources.

Ring 1 has the highest percentage of collections that are greater than or equal to the median ratio of proximal blade segments to Postclassic pottery (Figure 7.5). After ring 1, there is a fairly substantial decrease in the percents of collections that are greater than the median ratio for rings 2-5. These results support the interpretation that proximal segments were created near the Sauce center. There are no obvious high ratios in the outer 2-5 rings.

In contrast, the spatial patterns of the black obsidian proximal segments appear to be the inverse of the clear grey obsidian, with percentages of collections in rings 5, 4, 3 and 2 being greater than or equal to the median ratio of proximal segments to Postclassic pottery (Figure 7.6). In the summary method for the

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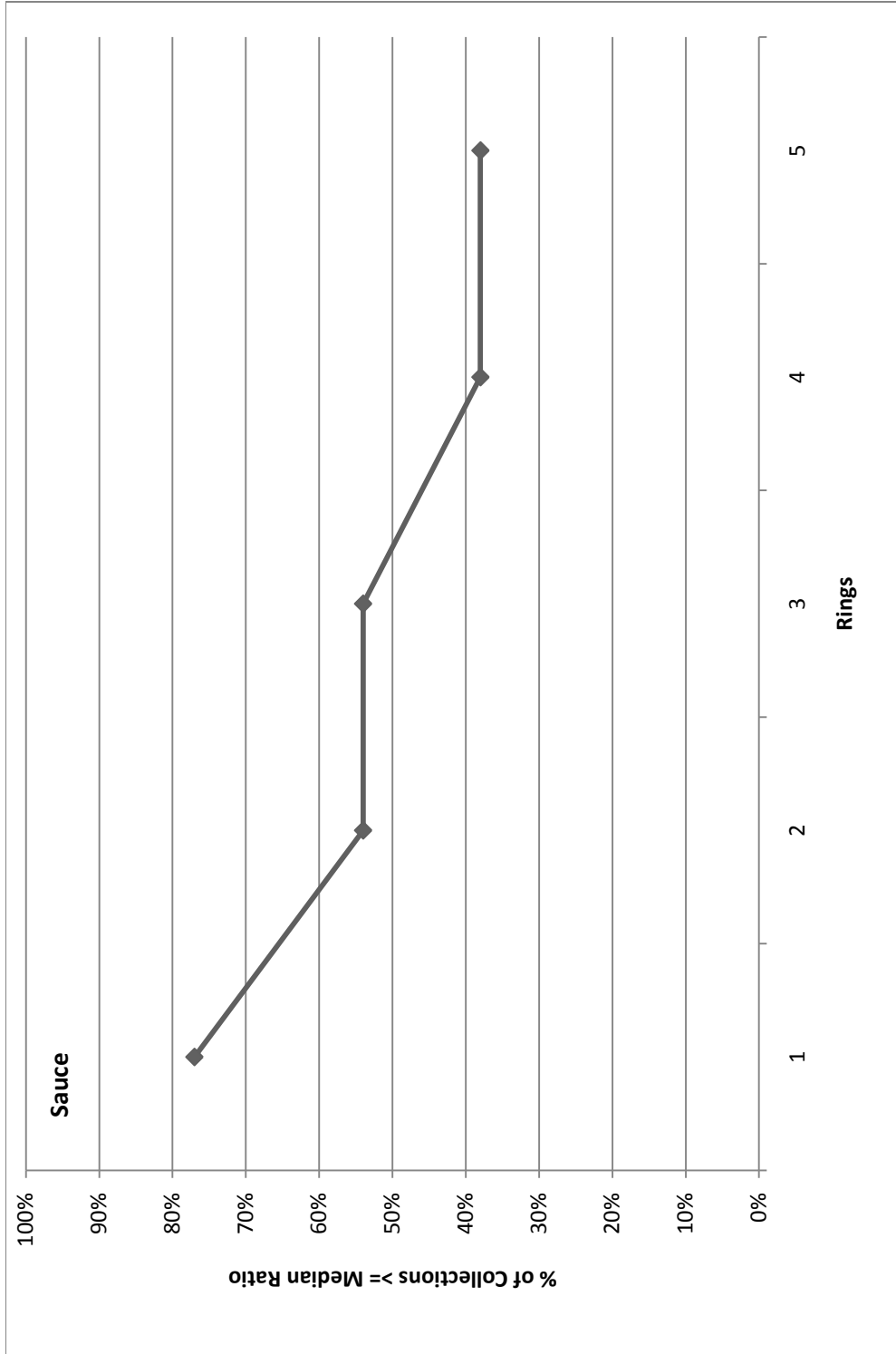
Figure 7.5 Results of summary method for clear grey proximal blade segments.

black obsidian proximal segments, ring 1 has zero collections that are greater than or equal to the median ratio of proximal segments to Postclassic pottery (Figure 7.6). Because the locale of production for black-dark grey obsidian prismatic blades during the Middle Postclassic period is unknown, and because the counts of proximal segments are so low overall (23 pieces), I cannot say for certain whether this pattern shows that black-dark grey blades may have had a different source than the clear grey for the same period. However, the current evidence points to a different source of production and exchange, possibly nearer to ring 5, based on the spatial patterns.

In considering the clear grey proximal segments using the individual collection method, the spatial patterns show results similar to the summary method (described in Table 7.1). Most of the abundant collections are found within ring 1, although there appear to be a few abundant collections in ring 4 as well (Figure 7.7). These results are consistent with the interpretation that the proximal blade segments are associated with the primary production of prismatic blades in ring 1. However, the individual collection method also shows that proximal blade segments may have a slight association with the higher ranked mound Groups 1-3 (Figure 7.7). The 3 collections that had over 10 proximal blade segments in ring 1 were in the mound rank Groups 1-3 while the single collection with over 10 proximal segments in ring 4 was in mound rank Group 3. Although the dataset is too small to support a strong statistical association, it does offer the intriguing possibility that higher ranked mounds may have had more access to proximal segments, which may be indicators of whole blades.
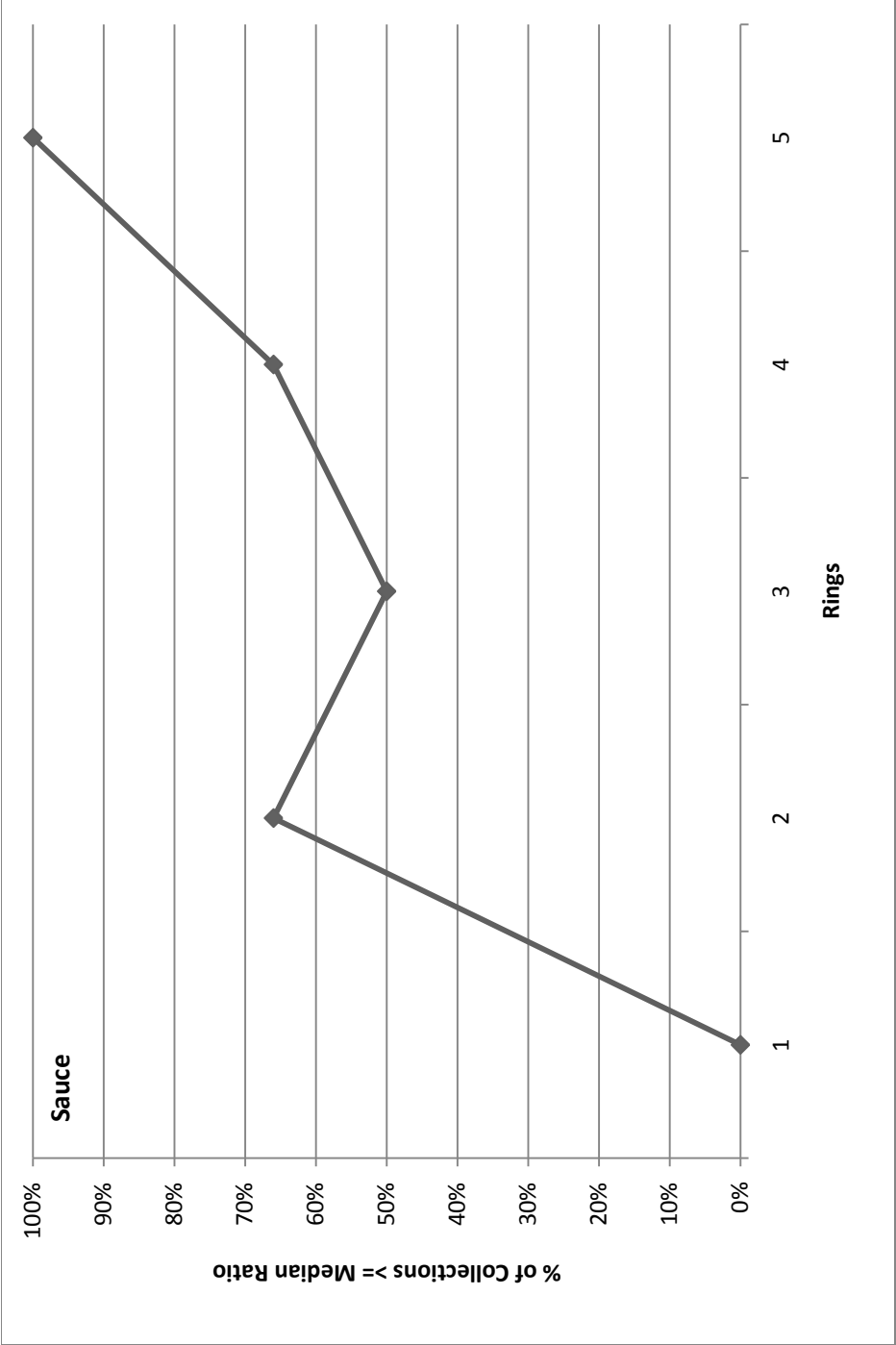
Figure 7.6 Results of summary method for black/dark grey blade segments.
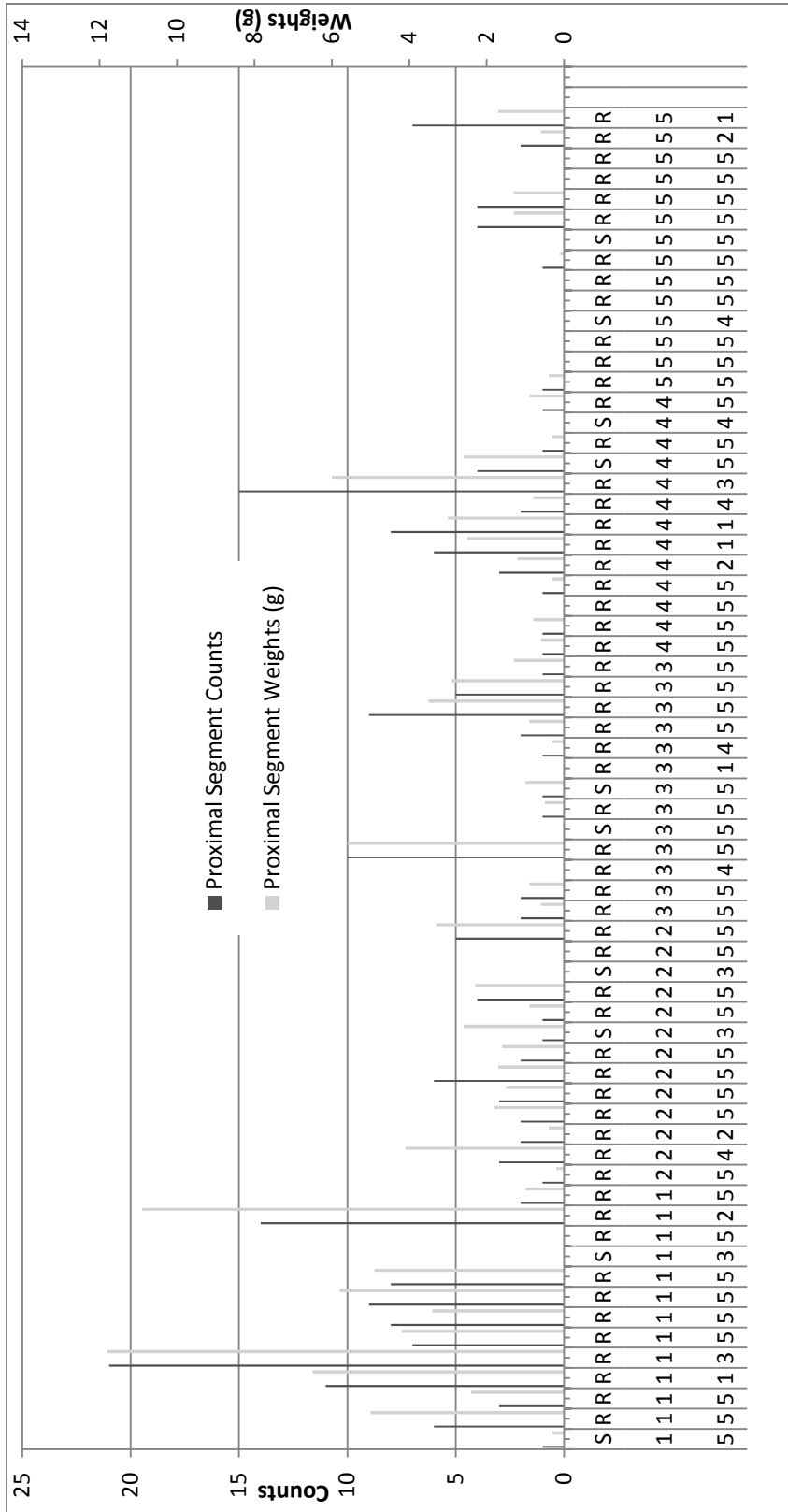
Figure 7.7 Clear grey proximal blade segments, counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

In viewing detailed results for the black-dark grey obsidian proximal
segments, the largest counts per collection are found within rings 1 and 2, with
one higher count (3) found in ring 3 (see Table 7.13). Most of the associated
mounds are in the lower mound rank Groups (4-5) so, unlike the clear grey
obsidian, having a high socioeconomic rank does not increase access to black
proximal blade segments. Higher counts within ring 1 lend support to the idea
that onsite production may have been taking place near Sauce, just as for the clear
grey obsidian blades.

Table 7.13 Black proximal blade segments by individual collections.

Coll #	Rings	Mound Rank Order	Sample Population	Weights (g)	Counts
1753	1	5	Robust	0.7	1
1817	1	2	Robust	5.4	5
1751	1	5	Robust	0.5	1
691	2	2	Robust	1.3	2
687	2	4	Robust	1.1	2
1617	2	5	Robust	1.5	1
1690	3	5	Robust	0.2	1
5260	3	4	Robust	0.4	1
1679	3	5	Robust	0.9	1
5282	3	5	Robust	0.6	1
790	4	5	Robust	0.4	1
778	4	5	Robust	1.5	3
6636	4	5	Robust	0.4	1
1511	5	5	Robust	0.8	1
5452	5	5	Robust	0.2	1
Totals				**15.9**	**23**

In summary, the evidence for the proximal blade segments for both clear
grey and black obsidian is more consistent with open distribution via market
exchange than restricted exchange like redistribution. Neither the clear grey nor

the black obsidian proximals showed clustering of high amounts either spatially or with higher ranked mounds that could pinpoint differential access with certainty although it is possible that clear grey whole blades (represented by proximal segments) were more available to high ranked residences in Sauce and ring 4. Additionally, both the summary and detailed methods indicated a decrease in amounts of proximal blade segments after ring 1, which is consistent with blade processing and exchange taking place near or at the Sauce center.

Medial Blade Segments. Medial blade segments might be expected to be generated from the regular lifetime use of longer blades which broke into parts over time, but they may also indicate re-use or the specific acquisition of middle sections as a desirable item for exchange. Medial segments could also have been deliberately broken at specific lengths for special use and/or hafting. Medial segments are likely to be the most desired parts of prismatic blades because they are the most flexible in use. Medial sections of blades would generally have greater flatness compared to the curving ends of either proximal or distal segments, making them easier to haft for use (De León et al. 2009:115). For PALM, the workshop evidence pointed to medial segment exchange. Heller (2000:142) found that for the obsidian workshop near the Sauce center, the percentage of medial blade segments was extremely low compared to the other Sauce obsidian collections. Heller (2000:142) suggests that more of the medial blade segments were removed and/or that the higher percentage of proximal blade segments could also suggest failed blade productions within a workshop setting[3].
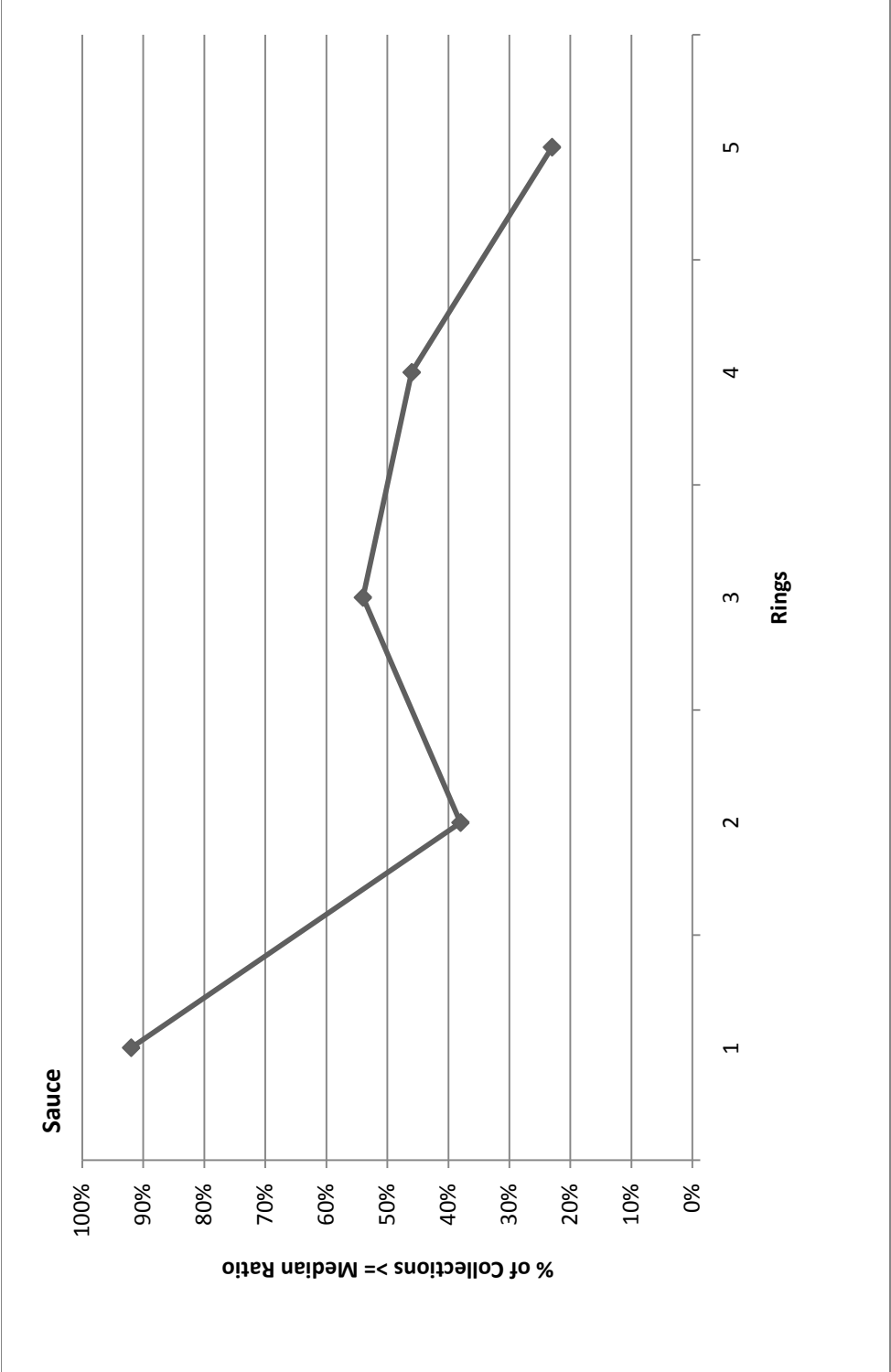
Figure 7.8 Results of summary method for clear grey medial blade segments.

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The SAP collections have a total of 590 medial blade segments weighing 270.2g. The summary results for the medial blade segments indicate a clear drop-off from Sauce and ring 1 (Figure 7.8). Interestingly, although some ratios increase after ring 2, with ring 3 showing a greater percentage of collections greater than or equal to the median ratio, there is a steady drop-off through ring 5. In this case, unlike the PALM dataset analysis summarized by Stark and Ossa (2010), there is *not* an apparent increase in medial blade segments in ring 5 (near the complex of Lobato). Although Stark and Ossa (2010) summarized all blade parts, not just medial segments, one would expect medial segments to have patterns similar to the overall grouped data, so the differences between the PALM analysis and SAP are probably real.

The results show that although there may have been a socioeconomic component to obtaining larger amounts of medial blade segments, it was not a strong trend in the SAP collections. The most abundant individual collections are found in ring 1 (Figure 7.9). Overall, there is a drop-off in medial blade segments in rings 1 through 5. There are two collections within ring 4 that show greater counts and weights as well. Additionally, these two abundant collections in ring 4 are from mounds that belong to the higher mound size ranks (1 – 3) (Figure 7.9). In viewing a map of the 7 residential mound collections that had greater than 20 medial blade segments, there are clear associations with the Sauce center (Figure 7.10). However, for the two collections in ring 4, only one collection, 1306, has abundant Postclassic pottery that offers additional support for higher socioeconomic status. Finally, the map of the abundant collections shows that

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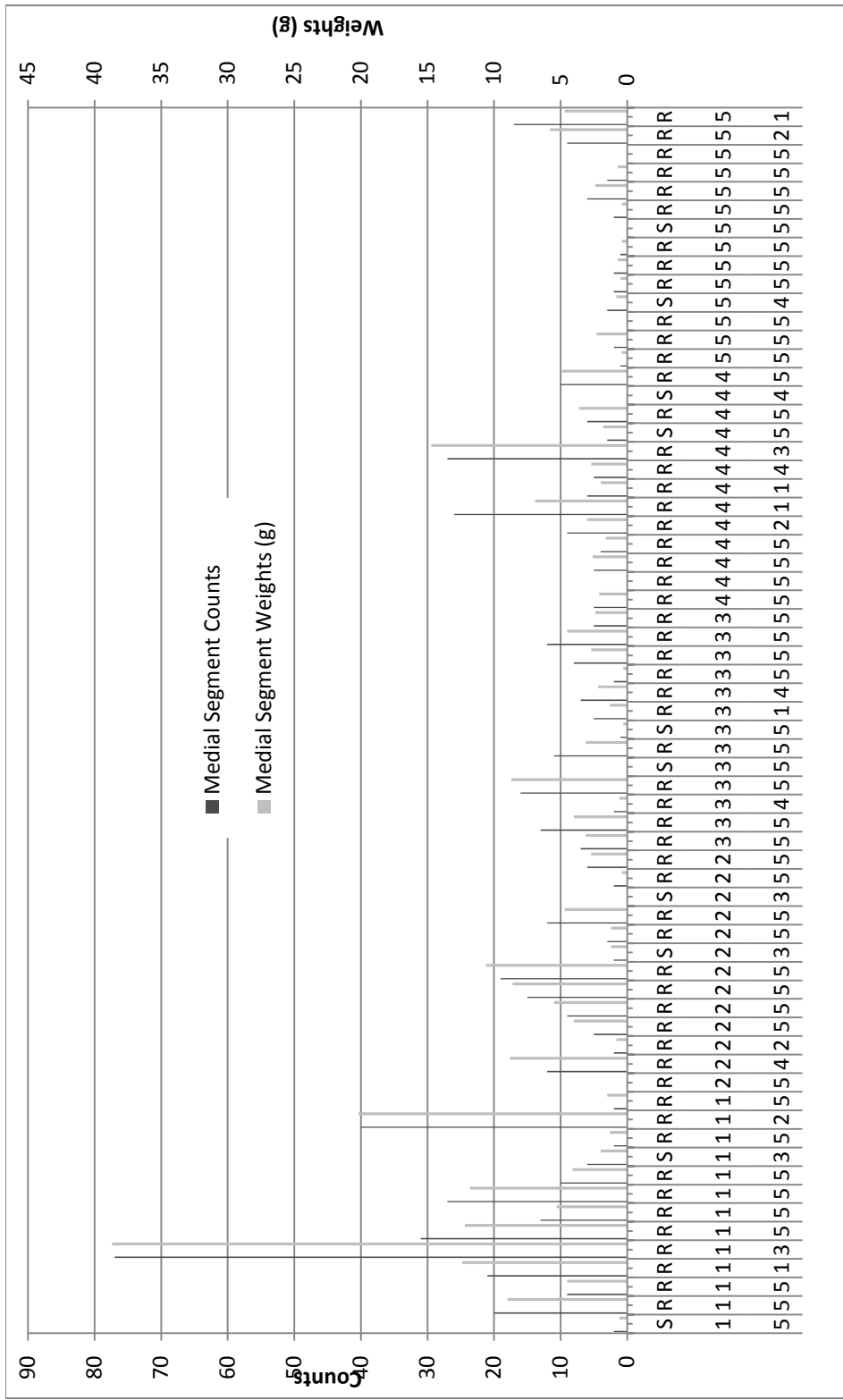
Figure 7.9 Clear grey medial blade segments, counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).
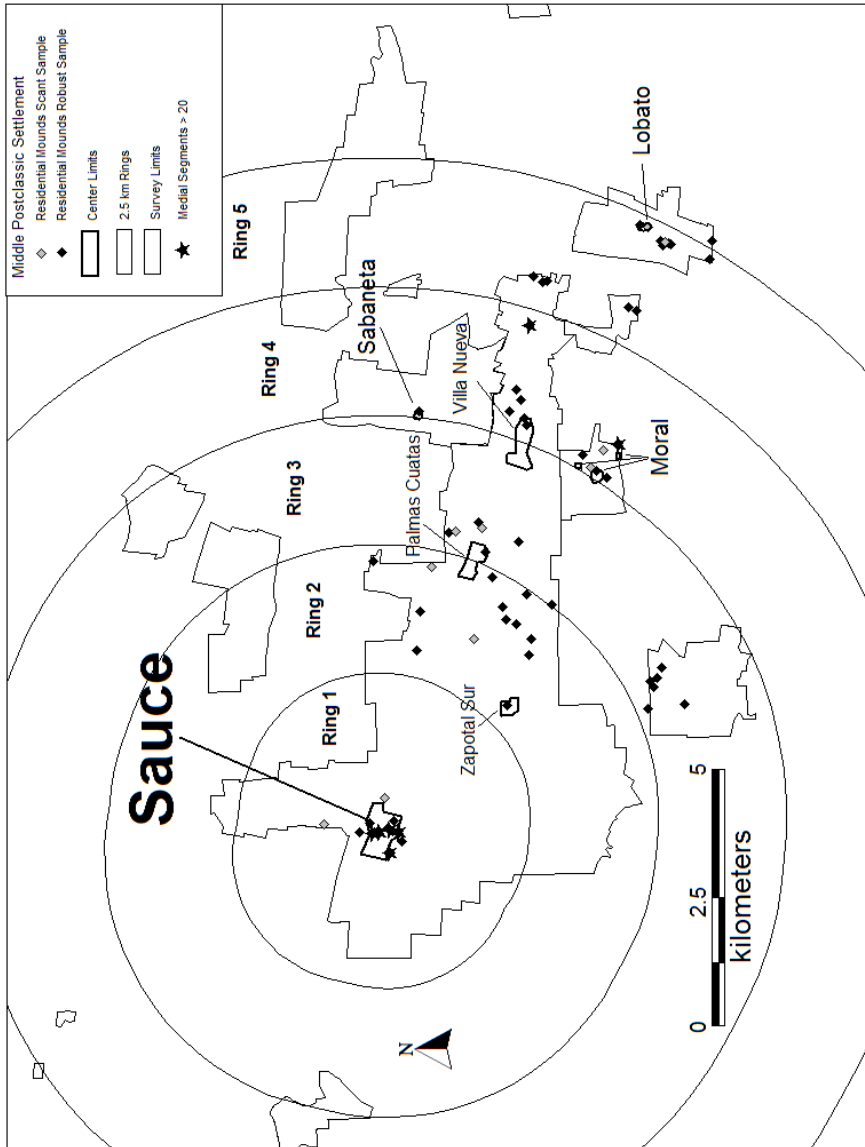
Figure 7.10 SAP collections with greater than 20 medial blade segments.

outside of ring 1, the two largest medial blade segment collections are not close to each other (see Figure 7.10).

The combined summary and individual collection methods do not show consistent clustering of large amounts of blade segments with mounds with high socioeconomic rank that would support redistributive exchange. Furthermore, the map of the largest medial blade segments collections does not show spatial clustering. The evidence is more consistent with open distribution via market exchange. Both the summary and detailed methods indicated a decrease in amounts of medial blade segments after ring 1, which is consistent with blade processing and exchange taking place near or at the Sauce center.

Distal Blade Segments. Distal blade segments are the most easily lost blade part because they are the fragile ends of blades and are often curved, which makes them more likely to break in transport (De León 2009:116). Like proximal blade segments, I expect to find distal blade segments nearer to places where blades were being produced and/or exchanged. Additionally, because distal segments are less useful than medial segments, I expect to find them associated with residential units whose occupants had access to whole blades, because the distal ends would probably not have been traded separately from a whole blade.

The SAP collections have a total of 102 distal blade segments weighing 44.3g. The summary results indicate a clear drop-off from Sauce and ring 1 (Figure 7.11). However, in ring 5, the percent of collections that is greater than or equal to the median ratio of distal blade segments to Postclassic pottery returns to

372
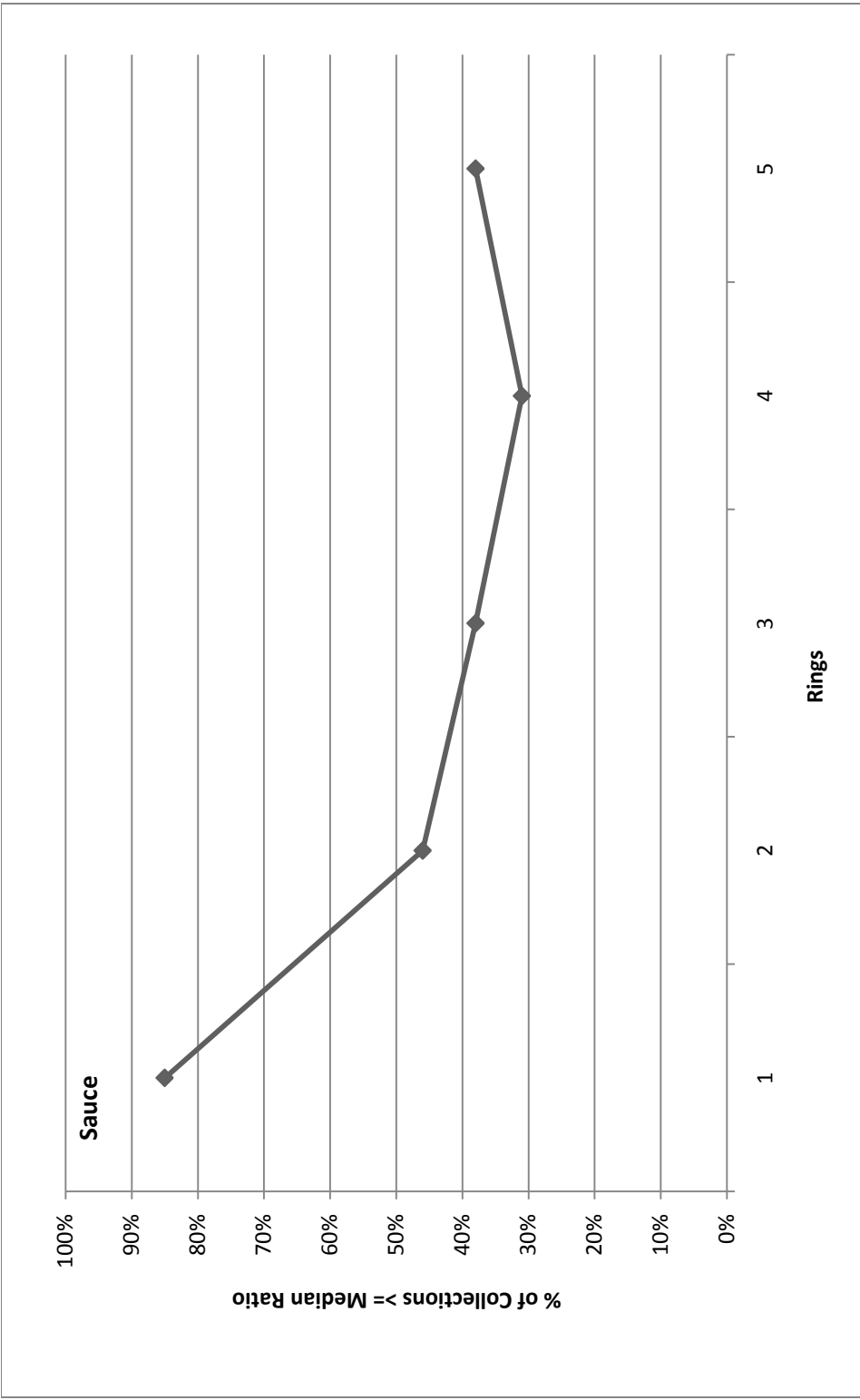
Figure 7.11 Results of summary method for distal blade segments.
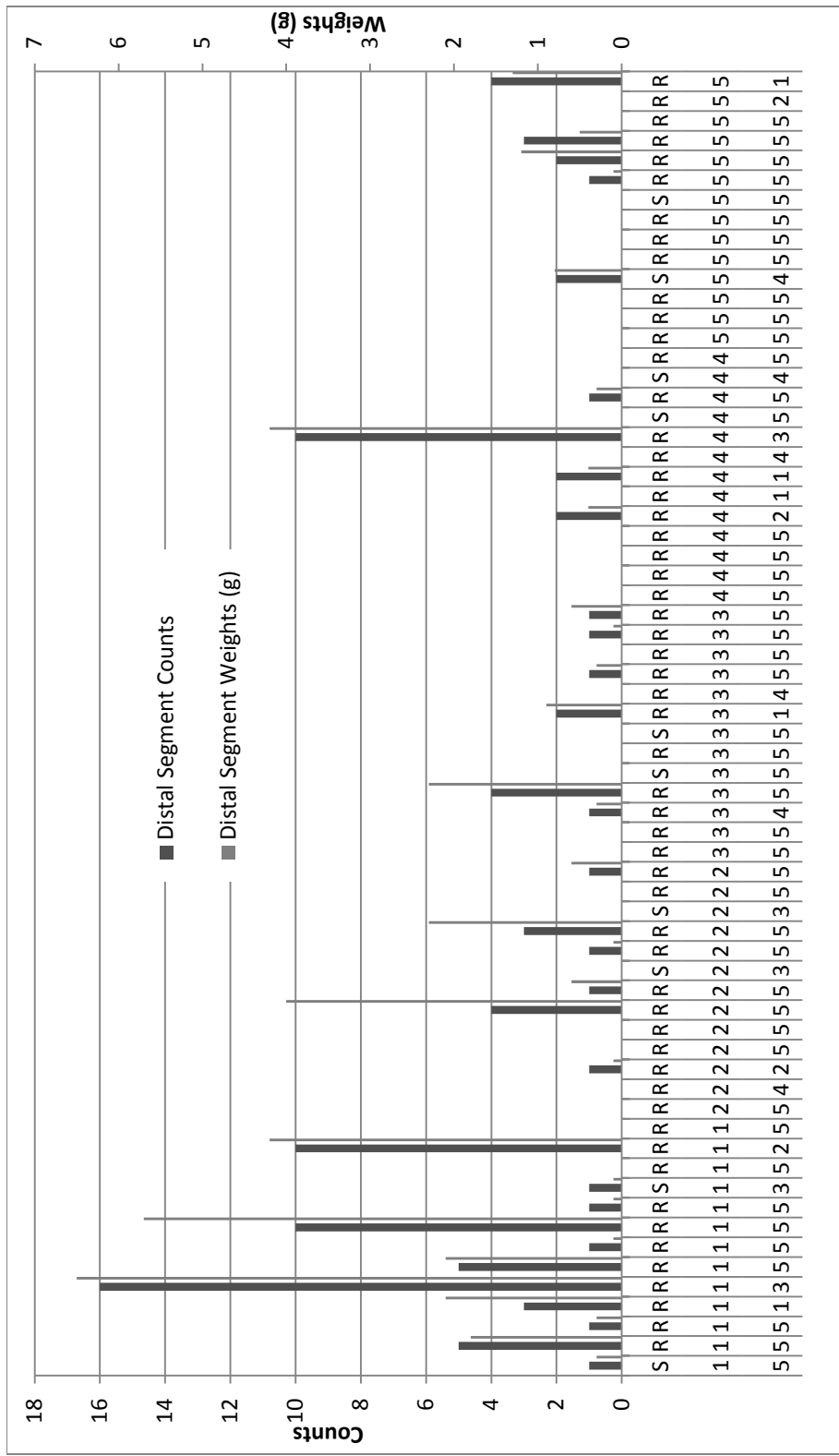
Figure 7.12 Clear grey distal blade segments, counts and percents per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

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amounts similar to those found in ring 3. This slight increase rather than decrease in ring 5 may indicate the presence of whole blades or blade processing nearby, which is consistent with the slightly elevated amounts of primary production indicators found in ring 5.

In viewing the detailed results for distal blade segments, there are higher amounts and more collections with distal segments in ring 1 (Figure 7.12). The one collection that has high amounts of distal segments in ring 4 also had high amounts of proximal segments, suggesting that this particular residence had access to whole blades. Since whole blades might be more difficult to transport all the way from the Sauce center to ring 4 (a distance of approximately 9 km) these could have been obtained nearby because primary production indicators were found in some concentrations in ring 5. Generally, distal segments are found in every ring, probably indicating low level production and whole blade exchange for almost every ring, although the highest concentration of production and access is found near the Sauce center in ring 1. The location of the concentration with production and the lack of large concentrations of distal segments outside of ring 1 support the idea that distal segments, perhaps as parts of whole blades, were being exchanged openly through market exchange.

Total Prismatic Blade Parts, Exchange Mechanisms and Spatial Patterns

Finally, I analyzed the total blade part quantities among all of the collections to evaluate exchange. These results were not expected to differ much from the previous analyses for each of the blade segments, but they provide an overview. Blade parts were compiled by adding the following group artifact

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categories together: Blade Related, Blade Tools, Flake or Blade Tools, and

Prismatic Blades (Table 7.2). SAP blade parts were compiled only for clear grey

obsidian (Heller and Stark 1998). [4] These artifact categories include many items

that would have been exchanged, such as blade tools, flake or blade tools, and

prismatic blades, but they also include artifact types like blade shatter which

could be related to blade use and production.

There were a total of 990 clear grey obsidian blade parts and blade related

artifacts, which I will henceforth refer to as "blades," although they do not include

any whole blades. The summary method in Figure 7.13 shows a drop-off in the

percent of collections greater than or equal to the median ratio of blades to

Postclassic pottery from ring 1 through 5, although there is a sharper decrease for

ring 2 with the percents of collections rising again in ring 3. The high percent of

collections above the median ratio is somewhat inflated in ring 3 by two

collections with large amounts of blade shatter, which could be related to use or

post-depositional processes, since one of these collections was taken from a

modern cattle corral.   Generally, the higher ratios in ring 3 are the result of this

extra shatter and medial blade segments, judging from a chart that shows the

summary results for all blade part segments and blades (Figure 7.14).

In the individual collection method results in Figure 7.15, the amounts of

blades decrease from Sauce and ring 1. There are a few scattered large

collections in rings 2 and 4, but the overall pattern shows that while almost every

collection had some blades, they dropped in amounts away from the Sauce center.

Some of the large collections in rings 4 and 5 also belong to the higher weighted
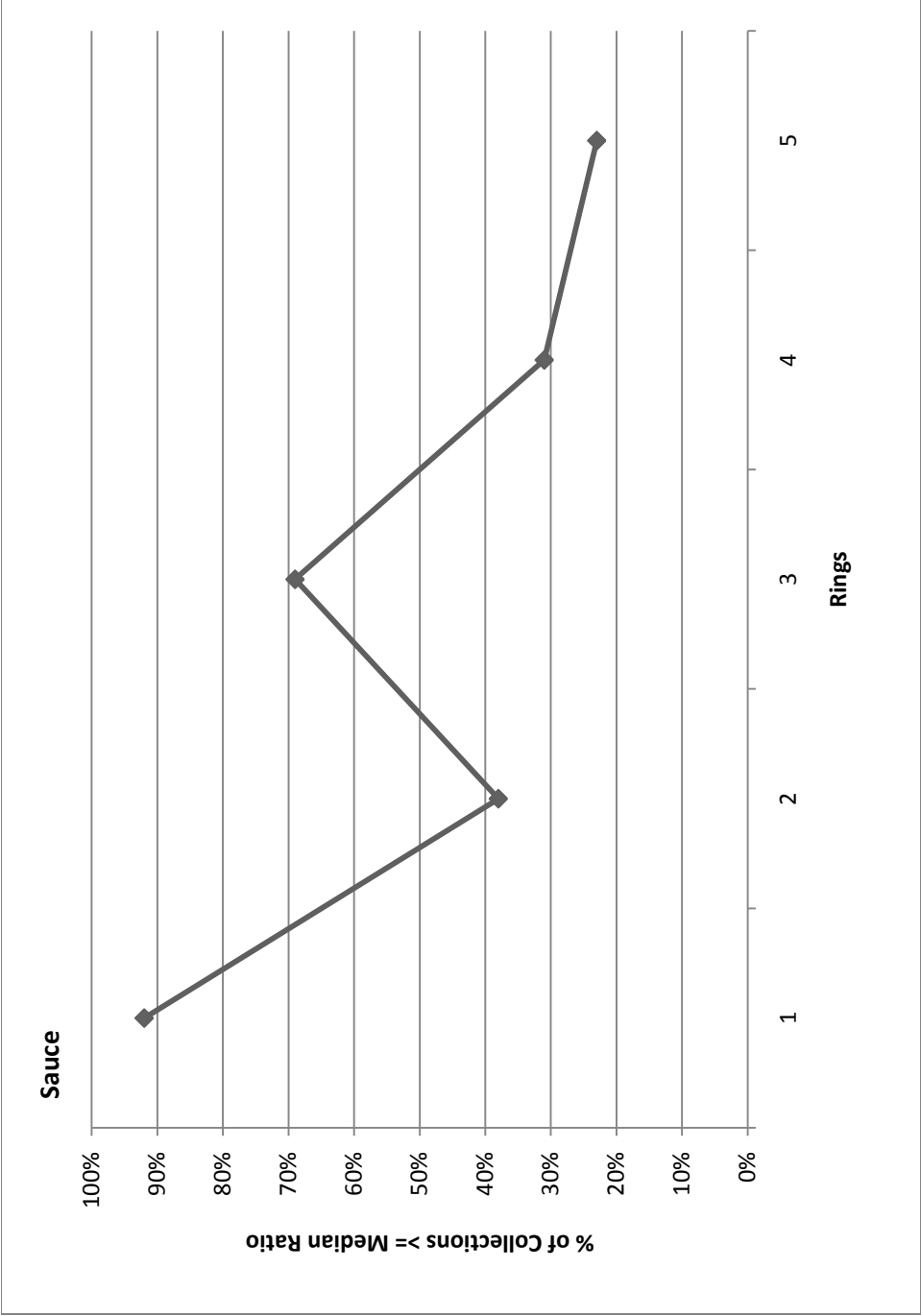
Figure 7.13 Results of clear grey blades summary method for SAP.
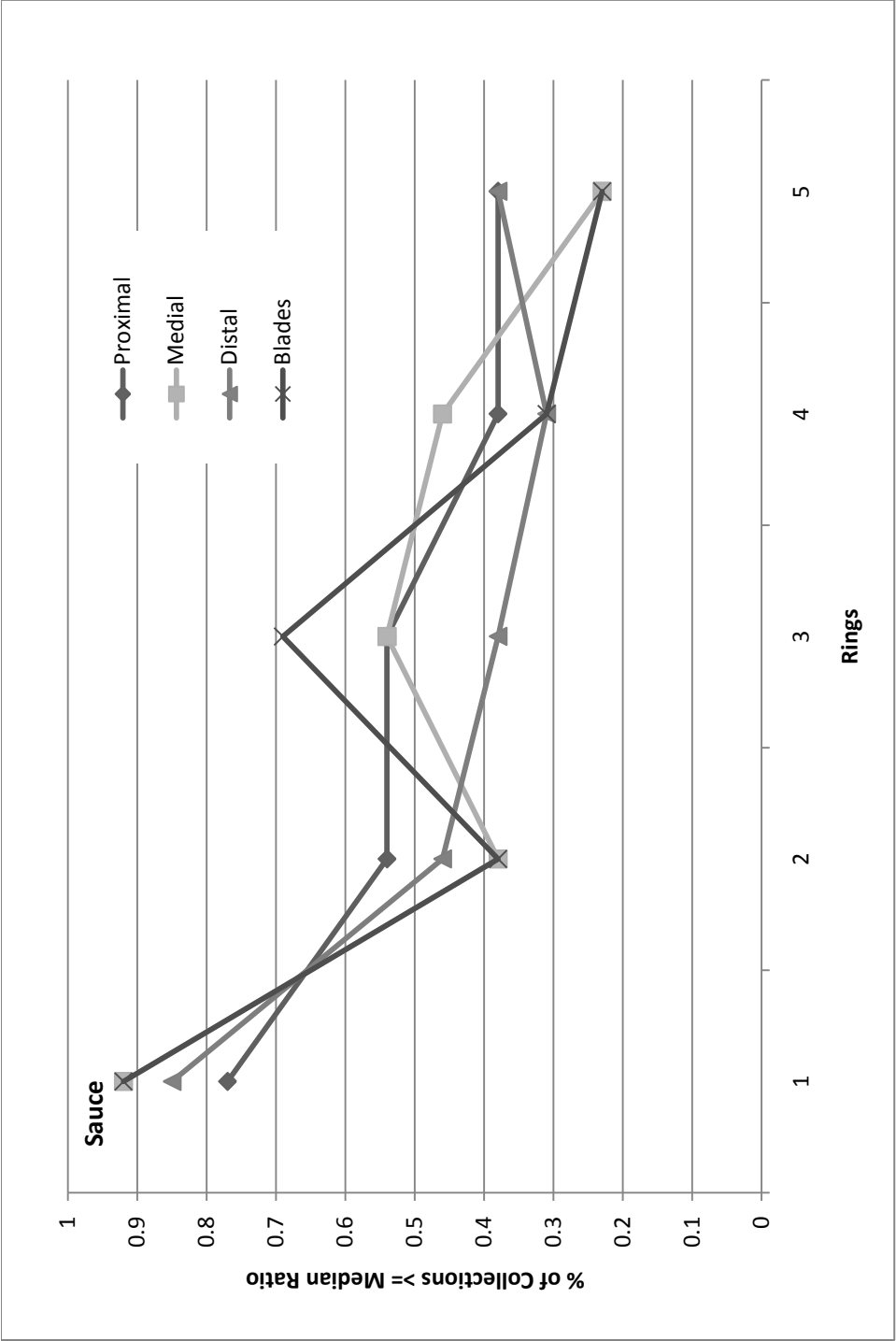
Figure 7.14 Results of total clear grey blade part segments summary method.

Figure 7.15 Clear grey blades counts and weights (g) per residential mound collection listed by collection type R(obust) and S(cant), rings (1-5) from left to right, and weighted mound size ranks (1-5).

mound size Groups (1-3). These few mounds with large amounts of blades had amounts of Postclassic pottery in even greater proportions relative to the blades, which is why rings 4 and 5 had so few collections greater than or equal to the median ratio of blades to Postclassic pottery (Figure 7.13). However, collections that had large amounts of decorated pottery did not always have large amounts of obsidian blades. Therefore, although there may be a socioeconomic component to having larger amounts of blades, some mound residents used more blades than others, regardless of rank or densities of other materials. Residences with larger amounts of blades may have had activities that required higher blade use.

A map showing every collection with 30 or more blades indicates that the great majority of them are found within the Sauce center in ring 1 (Figure 7.16). There are a few abundant collections in rings 3 and 4, but only one in ring 4. Overall, the spatial patterns do not show much clustering of collections with large amounts of blades outside of ring 1 and the Sauce center. These results are consistent with open rather than restricted access, which is unsurprising given that each of the blade segments supported market exchange rather than redistribution. The results also show that there is no particular district, outside Sauce and ring 1, where craft specialization or some other activity required more blade use.

Chipped Stone Dataset Summary

Both the summary and detailed methods for all blade segments and blades indicate a decrease in amounts of blade parts after ring 1, which is consistent with blade processing and exchange taking place near or at the Sauce center.
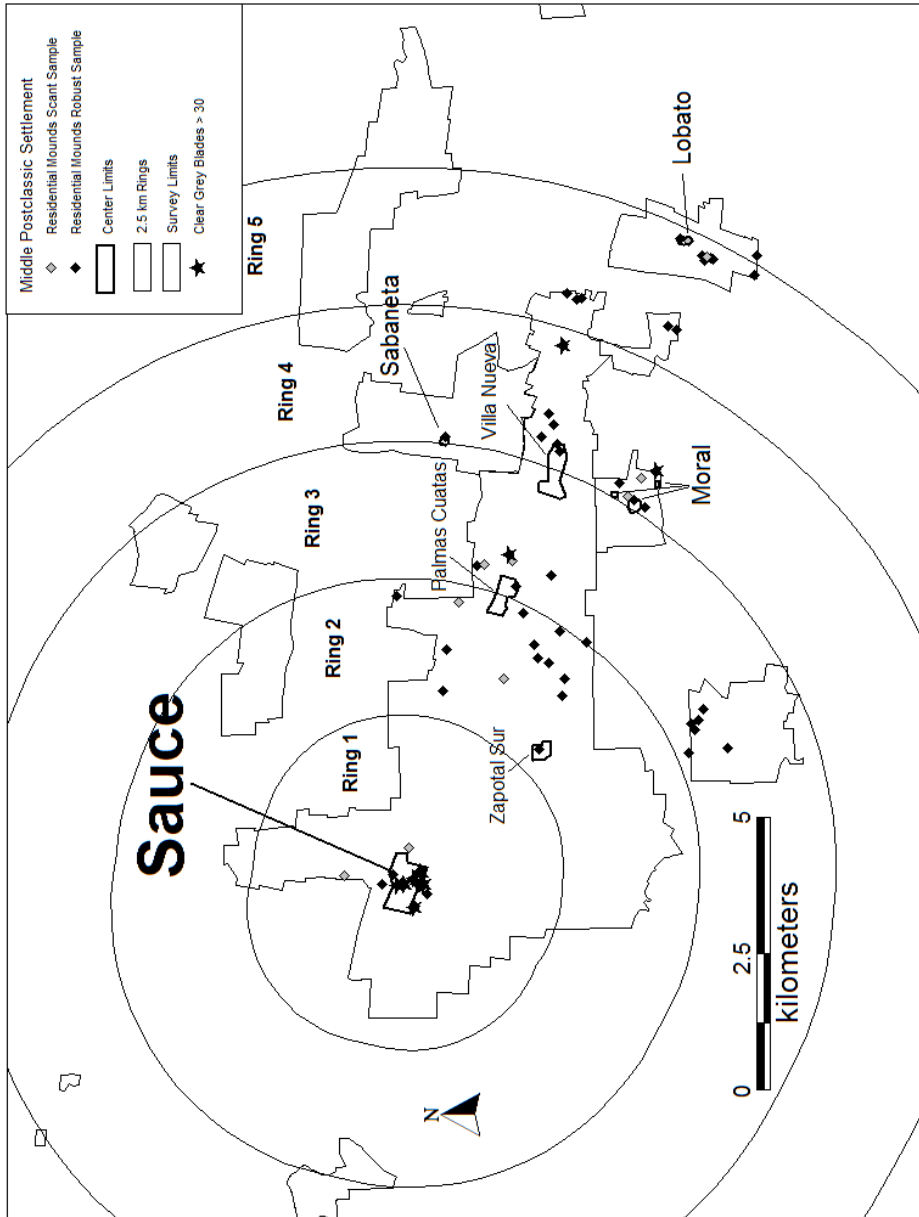
Figure 7.16 SAP collections with greater than 30 clear grey blade parts.

Furthermore, the distribution of blades and blade segments does not show clustering of large amounts of blade segments outside of ring 1 that would support redistributive exchange. Also, contrary to earlier findings based on the PALM collections, SAP collections did not show an increase in overall blade densities within ring 5 (Stark and Ossa 2010) although there was some evidence for whole blades being acquired for a few collections nearby based on slightly elevated counts of proximal and distal blade segments. These contrastive results may be due to the greater intensity of the SAP collections for the other rings and also due to the difficult field conditions of many of the collections in ring 5, which showed much more erosion and damage related to cattle ranching. Heavy cattle use resulted in densely packed earth surfaces, which were much more difficult to clear of vegetation and collect, resulting in much more scant collections in ring 5. Overall, the spatial and contextual evidence for the blades and blade parts is more consistent with open distribution via market exchange in which most residential mound occupants had access regardless of location and mound rank group.

Chert Exchange and Spatial Associations

Chert bifaces and projectile points are part of a body of evidence, including changes in figurines, food preparation, a new pottery complex, and settlement patterns that identify the settlement associated with Sauce as a population probably new to the region (Stark 2008a). Therefore, how the chert tools were being exchanged and the spatial patterns of their distribution are important for understanding the economic organization of Sauce and its hinterland. Chert was imported, like obsidian, although its source is unknown.

Based on PALM, chert was probably imported as finished bifaces. Unfortunately, chert was only found in low quantities (5 pieces) in SAP collections. Therefore, in order to evaluate Middle Postclassic period chert exchange, I will use chert from both the SAP collections and a selection of mounds from PALM.

As stated previously for the obsidian production indicators, PALM and SAP datasets will be considered separately because they were collected using different field methods, as described in Chapter 3. Due to these different collection practices, the SAP and PALM dataset are complementary, but not statistically comparable. Because chert was such a rare artifact type, I have to use a wider sampling approach for the PALM dataset than I did for the obsidian production indicators. I did not restrict my PALM sample to only those 130 mound collections that were originally selected as having significant amounts of Middle Postclassic materials for the SAP main sample. Instead, I selected the subset of all PALM mounds that had chert that were also found within SAP's rings. By selecting the PALM chert mounds found only within SAP's rings, I can limit my discussion of chert exchange to the area of Sauce and its hinterland.

PALM Chert

Within the selected PALM collections, chert was not a variety of chipped stone that was typically used prior to the Postclassic period (Stark 2008). Additionally, Vonarx (2004) found that PALM chert was primarily from mound collections that had a strong association with the Middle Postclassic (and the Postclassic in general). Chert from PALM was analyzed by Vonarx using basic descriptive categories based on biface, flake, and projectile point technology.

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Most of the pieces recovered were bifaces, biface pieces, or projectile points and projectile point fragments.

For PALM, 28 collections with chert were found within SAP's rings. These collections had a total of 29 pieces of chert, which were mostly bifaces and projectile points (and fragments of both types). Weight was not tabulated for the PALM dataset because weight information was not collected on partial pieces. In viewing the counts of chert artifacts per ring, the largest amounts of chert are found within ring 1, with the next largest amount found in ring 3 (Figure 7.17). Generally, these patterns are consistent with chert being most heavily associated with the Sauce center, although the quantities found in the other rings are not much smaller than the amounts in ring 1. Because the dataset is so small, it is difficult to generalize statistically about the findings; however, in viewing a map showing PALM collections with chert next to SAP collections, chert does appear to be associated with Middle Postclassic settlements (see Figure 7.18).

SAP Chert

SAP chert was analyzed according to a typology initially developed for PALM and expanded by Vonarx (2004). As with the PALM collections, SAP chert was mostly bifaces and projectile points (Table 7.14). For SAP, at least half of these items were found within the center of Sauce itself in ring 1. Collection 124 in particular had two obviously different pieces of projectile points/bifaces (they didn't refit and were not the same material). Generally, chert was rather rare in PALM collections; there were 93 pieces of chert in total, for roughly all 2000 PALM collections. SAP has almost twice as much chert for its
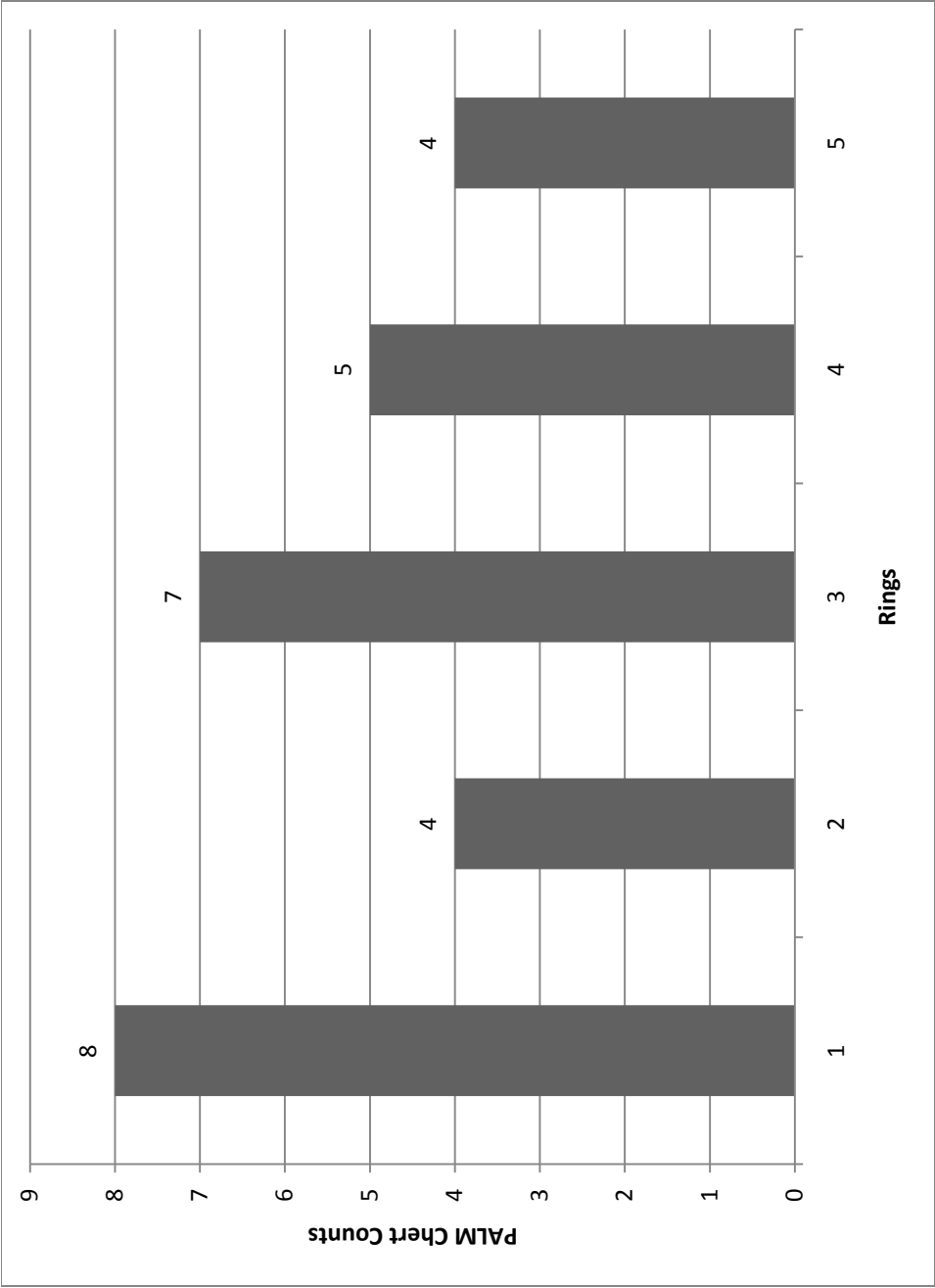
Figure 7.17 PALM chert counts by SAP rings.

collections as PALM does, with 6 pieces in 65 collections. This is not surprising, as SAP deliberately targeted Middle Postclassic period residences, whereas PALM included all time periods.

Table 7.14 SAP chert dataset.

Coll#	Ring Zone	Mound Ranked Order	Sample Population	Count	Artifact Type
225	1	3	Robust	1	Biface
124	1	5	Robust	1	Projectile Point/Biface
124	1	5	Robust	1	Projectile Point/Biface
1617	2	5	Robust	1	Projectile Point/Biface
1679	3	5	Robust	1	Projectile Point/Biface
6514	4	5	Robust	1	Angular Fragment

Among the projectile points and bifaces for SAP chert, there is an association with the inner rings 1 through 3 (Figure 7.19). Three chert points were found from the center of Sauce itself (one collection had two) and the other two were found in rings 2 and 3. No mound rank associations with chert are obvious, but given the size of the SAP dataset it is difficult to generalize on this point. The association with Sauce offers some support that chert points may have been an item that was acquired from a person who had access to the chert source who lived within or near Sauce, but the spatial and contextual evidence does not support the idea that it was restricted in access to either ring 1 or to higher ranked mound groups.

Chert Conclusions

Despite the addition of the PALM dataset, the chert dataset is very small, but some basic patterns can be discussed regarding its exchange. No production
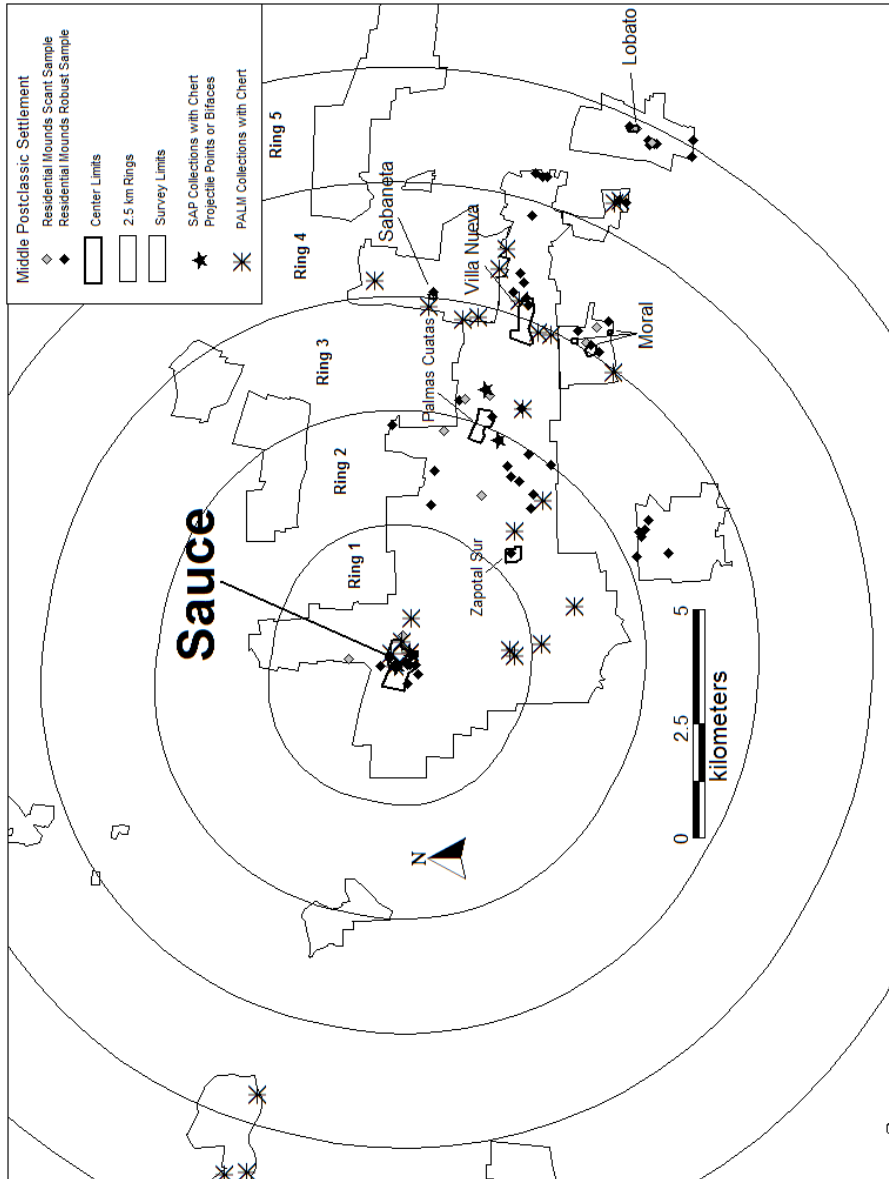
Figure 7.18 PALM collections with chert within SAP rings.
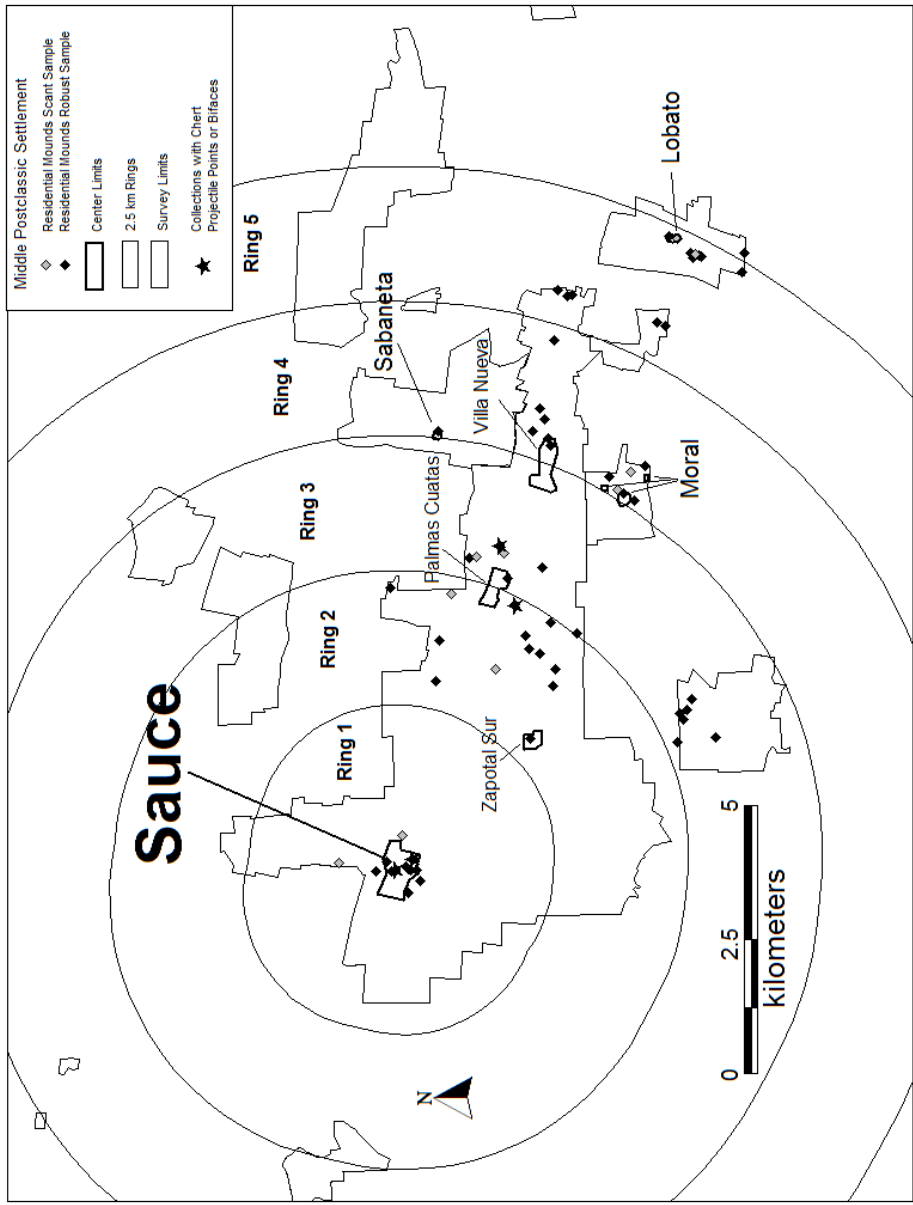
Figure 7.19 SAP projectile points and bifaces.

related evidence has been recovered for chert, only finished bifaces or projectile points. This probably means that these items were coming into the area as manufactured pieces. Therefore, it is possible that access to them could be more easily limited than it was for the obsidian because they are products that were finished elsewhere, much less abundant, and without local producers that can be detected from surface collections. Spatial patterns for such a rare artifact might be expected to show presence only in cases where the artifact densities were quite high, such as in ring 1. The spatial patterns show that there are slightly greater quantities of chert artifacts associated with the Sauce center and mounds near the Sauce center. However, chert artifacts are found within all of the five rings sampled by SAP. In summary, there is no evidence at present to support the restricted access of chert based on either an exclusive spatial association or association with the higher mound rank groups. Based on its evident dispersion, it could have been exchanged through markets, although we do not have large enough quantities to do a reliable analysis.

Chipped Stone Exchange Conclusions

Evidence for the production, exchange, and distribution of obsidian, which made up the majority of SAP's chipped stone, supports market exchange that was centered at or very near the center of Sauce. Primary production indicators from both the PALM and SAP datasets showed a strong association with the center of Sauce and ring 1, which supports previous researchers' conclusions about the

importance of that center and its political elite in managing some aspects of obsidian processing and the putative location of a marketplace nearby (Heller 2000; Stark and Ossa 2010). However, small amounts of primary indicators are found in all five of the rings, which suggest that there were some local itinerant knappers or household production. Additionally, based on the secondary production evidence found within all five rings, some itinerant or local knappers were also engaged in limited production or repurposing of cores and other artifacts among some of the residential mounds.

Evidence from some of the chipped stone, such as formal tools made from repurposed blades, was exceedingly rare, but none of these artifacts showed either an exclusive association with Sauce or with residential mound collections that belonged to the higher mound rank Groups (1-3). Blade part ratios showed that medial segments or processed blades may have been exchanged, although some collections showed that whole blades were also exchanged based on proximal and distal segments. Therefore, all blade segments were considered separately for exchange analyses. Both the summary and detailed methods for all blade segments and blades indicated a decrease in amounts of blade parts after ring 1, which is consistent with blade production, processing, and exchange taking place near or at the Sauce center. Also, contrary to earlier findings based on the PALM collections, SAP collections did not show an increase in overall blade amounts within ring 5, although there was some evidence for whole blades being acquired

for a few collections nearby, based on slightly elevated counts of proximal and distal blade segments (Stark and Ossa 2010). Overall, the spatial distribution of blades and blade segments does not show clustering of large amounts of blade segments outside of ring 1 that would support redistributive exchange. Additionally, the spatial patterns do not support the existence of a second distribution source located near ring 5.

The PALM and SAP chert was scarce, but the results did not show any evidence for restricted access in the form of exclusive spatial associations with the Sauce center or with the higher mound rank groups. Chert was found within every ring in some small quantity, further supporting the interpretation that access was open, although there are not enough data to suggest exactly how chert may have been exchanged.

In sum, the SAP dataset supports the notion that market exchange was the main mechanism that explains the distribution of chipped stone. Furthermore, the associations of the largest concentration of primary production indicators with Sauce and ring 1 along with the highest quantities of obsidian blade parts suggests that political elites played a role in supporting or encouraging the market exchange of chipped stone even if they did not direct its exchange. Additionally, the production evidence suggests that obsidian was provided to households by means other than just market exchange at Sauce. Specifically, the very low level of primary and secondary production indicators found within most of the rings

suggests that a combination of local producers along with itinerant producers was responsible for provisioning Sauce and its hinterland.

Finally, this dissertation goes further than previous studies that attempted similar spatial analyses of drop-off patterns to evaluate the exchange and provisioning of chipped stone artifacts to households (after Clark 2003:40). My focus on individual household inventories enables analysis of exchange mechanisms more directly. Additionally, my analysis of two aspects of chipped stone tool production (spatial associations) (after Stark and Garraty 2010) and stage of production indicators (primary versus secondary) (after De León et al. 2009) allowed me to analyze how producers may have acted to supply consumers. Finally, the innovative blade ratio analysis, designed by De León et al. (2009) to study the Formative period blade trade in Mesoamerica, provided a model for examining how blades and blade segments were being exchanged and used among consumers in Sauce and its hinterland. In the next chapter, I consider the scarce artifacts categories, which, in contrast to the pottery and chipped stone, are not found in many households. These include items such as spindle whorls, figurines, and incense burners that, despite their rarity as artifact categories, could have been used every day by households, and which will provide additional information about how households were provisioned.

CHAPTER 7 NOTES

[1]I use the ratio of chipped stone to Postclassic pottery to standardize the dataset. Pottery counts can be considered a decent measure of overall artifact counts because pottery is the most abundant artifact category.   Therefore, pottery counts can be seen as a good measure of sampling differences between residential units. Standardizing chipped stone relative to Postclassic pottery helps control for sampling vagaries.

[2]Since SAP obsidian is mainly clear grey blades, it is challenging to compare each artifact type against the distribution of overall chipped stone artifacts; the underlying distribution and the subset artifact distribution are almost identical. For archaeological cases where there are more identifiable subdivisions within the obsidian dataset such as different sources of obsidian or larger datasets of formal tools, etc., that can be compared against the whole distribution of chipped stone, a network simulation could prove to be very useful in evaluating exchange mechanisms for subsets of chipped stone. For the SAP dataset, a network simulation approach is not feasible.

[3]Higher amounts of proximal ends do not always suggest failed production. They could be indicative of access to whole blades. Heller's (2000) point is that in the specific setting of the workshop, where blade parts are being removed for distribution via market exchange or otherwise, higher amounts of proximal blade segments could indicate either blade failures or perhaps the processing of medial segments by snapping off the less usable parts of the blades (proximal and distal) prior to distribution.

[4] For the total blade segment analysis, the 23 black obsidian proximal blade segments with ground platforms were left out. These artifacts had already been considered separately in the blade parts analysis and since they obviously had a different source and were so few in number, it did not make sense to include them with the clear grey obsidian blades.

CHAPTER 8. SCARCE ARTIFACTS: EXCHANGE AND SPATIAL ASSOCIATIONS

My purpose here is to evaluate exchange mechanisms and spatial patterns for the scarce artifacts for the 65 residential mound collections. Previous chapters have noted the intersection of different and overlapping exchange networks and emphasized the importance of determining how these networks are socially and politically embedded (Granovetter 1985; Kopytoff 1986). The diverse scarce artifacts from the Sauce Archaeological Project were difficult to analyze in the same way as the bulk artifacts of pottery and chipped stone for two major reasons. First, PALM typologies for these items do not have enough chronological distinctions to be certain of a Middle Postclassic date. Second, the scarce artifacts are too few for statistical characterizations. Despite these statistical and chronological drawbacks, the scarce artifact categories include household items that probably played important social, economic, and ritual functions, including spindle whorls and other spinning tools, groundstone tools, incense burners, figurines, and molds for pottery. Therefore, the goal of this chapter is to describe the basic spatial and type associations based on current information about each artifact category.

In this chapter, I analyze how the scarce artifact datasets were distributed within the region spatially and whether they are associated with the mound size ranks (established in Chapter 4). These two aspects: spatial and contextual, will be analyzed separately for each of the scarce artifact categories listed for the inventories of the 65 residential mound collections (Table 8.1). SAP's intentional

sampling bias towards Middle Postclassic materials help reduce some of the

chronological mixing, although for some artifact categories, such as groundstone,

there will always be significant ambiguity. Also, the intensive collection methods

employed by SAP bolster the reliability of even scarce artifact samples.[1] Basic

inferences about exchange mechanisms will be made based on descriptive

statistics and contextual associations with the mound size ranks rather than the

more complex statistical analyses undertaken for the pottery and chipped stone.

Table 8.1 Scarce artifact category counts for SAP collections.

Scarce Artifact Categories	Counts
Spindle Whorls	57
Incense Burners	49
Figurines	246
Groundstone	46
Special Forms	40
Lapidary Items	1
Totals	**439**

In the first part of the chapter I consider the items that were more

frequently used and owned by most households, such as spindle whorls,

groundstone tools, etc. In the second section I consider special use items, such as

pottery molds, that were not used by every household, or only infrequently used

by all households. Many artifacts show information about production as well as

consumption, but I focus on exchange and use for my study. I consider the

frequency of use-based categories to be a helpful way of organizing the data for

the preliminary study undertaken here.

Frequently Used Items

Items that were used in frequent activities such as fiber processing (spinning), grinding corn, household rituals, etc. were probably artifacts that every household could have used. The purpose of my analysis is to identify likely exchange mechanisms based on access and describe the spatial organization and context for each artifact category. For SAP, these include spindle whorls and possible bone spinning or weaving tools, clay stamps, groundstone tools, incense burners, and figurines. I will consider each of these categories separately as each has distinct uses.

Spindle Whorls, Possible Bone Spinning Tools, and Clay Stamps

Cotton and cotton cloth have long been recognized as one of the most important items for trade and tribute, at least by the time of the Aztecs (Hall 1997; Hicks 1994). Therefore, the production and processing of cotton was probably economically and socially important in the region. Cotton is a product of the tropical lowlands, where it could be grown (Stark, et al. 1997). Given the available prehispanic technology, cotton cloth was impossible to make more efficiently with specialized intensified production, so it was probably produced by most households (Hicks 1994:103). Hicks (1994:94) observes that Mesoamerican ethnohistoric records describe spinning and weaving as an important gender-specific activity, with special cloth processing equipment given to girls in a ceremony establishing their social role and identity shortly after birth. Spinning activities were also likely an important industry in south-central Veracruz as early

as the Classic period, based on spindle whorls found in domestic contexts (Stark et al. 1998).

Ethnohistoric accounts describe the important role of weaving and spinning equipment for women (Hall 1997). Additionally, Hall (1997:133) observes that the advent of specialized spindle whorl production may signal cotton textiles' social importance rather than simply the advent of a better spinning technology. Therefore, spinning artifacts such as spindle whorls may have been specially produced and exchanged (Hall 1997). Probably many of the artifacts and tools associated with spinning were specially decorated, exchanged, and curated as part of the value attached to cotton itself. Due to the tropical climate and humidity of the lowlands, cloth and fibers rarely survive, and many of the tools for spinning and weaving are perishable, except for ceramic spindle whorls and bone tools associated with spinning and weaving such as needles, awls, and battens, and clay stamps associated with cloth decoration (Hall 1997:115).

First, I consider the temporal associations of spindle whorl types and spinning tools within PALM. Stark et al. (1998:19) note that at least by the Classic period (A.D. 300-900), local spindle whorls were being mold-formed and specially manufactured for spinning. Their relatively small size and weight supports their use in cotton spinning (Stark et al. 1998:17, 19). Increases in cotton production and spinning have also been documented for the Postclassic period in areas in central and northern Veracruz (Hall 1997:134-135; Stark et al. 1998).

Unfortunately, the circumstances in which ceramic spindle whorls were produced remain unknown. It is not known whether they were produced by and for households or whether they were made by more specialized producers, perhaps alongside other pottery products. The dearth of production data is partly because very few molds for whorls have been located by PALM and also because whorls were probably heavily curated over time (Stark 2001b: 226).

Stark et al. (1998) and Stark (2001) found spindle whorls with mold impressed decorations in contexts that suggested that these decorative techniques dated to the Postclassic period, a pattern that was also identified for other areas within Veracruz (Stark 2001:223).[2] In addition to mold impressed designs, Stark et al. (1998:21, 23) found that certain shapes typed as "conical" were also associated with Postclassic materials. Oralia Cabrera revised the PALM typology in 2000 and in the new system, the spindle whorl category for "conical" shapes was subdivided into three different types: cones, funnels, and spools. These stylistic techniques and whorl shapes can be used to identify those spindle whorls which were probably from the Postclassic period. Unfortunately, I cannot know if I am undercounting Postclassic period spindle whorls; earlier forms could still have been in use in late periods.

For the SAP collections, I first identified the whorl type most associated with the Postclassic period. Next, I used typological variations to consider spindle whorl associations with special pottery types like Quiahuistlan, which may have been used in spinning, and the few bone tools and clay stamp (listed under the general category of special forms along with other miscellany in Table

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8.1). I also considered the spatial patterns of spindle whorl typological variations

to see if there is a strong spatial clustering aspect to them that might indicate

localized production and distribution rather than market exchanges. The revised

form of the PALM typology created by Cabrera was applied to the SAP spindle

whorls. All 57 spindle whorls were analyzed according to whorl shape,

decorative motif, methods of construction, paste color, slip, size, and weight.

The Postclassic period traits for spindle whorls were shape and decorative

technique. SAP counts for each combination of major shape and decoration type

(see Table 8.2), show that the majority of the shape types are Subdomes, which

matches the pattern for the spindle whorls found for PALM (Stark 2001). Many

SAP whorls are mold impressed (see Table 8.2). Of the 57 spindle whorls, there

are only 36 that fit Postclassic period shapes and/or decorative techniques (see

Table 8.3).

Table 8.2 Shape and decorative technique counts for SAP spindle whorls.

Shapes and Decorative Technique	Counts
Cone, Undecorated	2
Dome, Red Slip and Chapopote	1
Dome, Undecorated	1
Funnel, Chapopote	6
Funnel, Mold Impressed	1
Funnel, Undecorated	1
Grooved Subdome, Chapopote	3
Grooved Subdome, Undecorated	1
Spool, Chapopote	1
Subdome, Chapopote	7
Subdome, Chapopote Design	1
Subdome, Incised	1
Subdome, Mold Impressed	10
Subdome, Mold Impressed; Chapopote	13
Subdome, Orange Slip and Chapopote	1

Shapes and Decorative Technique	Counts
Subdome, Red Slip and Chapopote	3
Subdome, White Slip and Chapopote	2
Zoological, Mold Impressed; Chapopote*	1
Zoological, Mold Impressed; Orange Slip*	1
Total:	**57**

*Zoological is a conical shape but was coded by Cabrera as "zoological" in shape, although the zoological element is part of the mold impressed design.

Table 8.3 Postclassic shape and decorative technique counts for SAP spindle whorls.

Postclassic Shapes and Decorative Techniques	Counts
Cone, Undecorated	2
Funnel ,Chapopote	6
Funnel, Mold Impressed	1
Funnel ,Undecorated	1
Spool, Chapopote	1
Subdome, Mold Impressed	10
Subdome, Mold Impressed; Chapopote	13
Zoological, Mold Impressed; Chapopote	1
Zoological, Mold Impressed; Orange Slip	1
Total:	**36**

In Chapter 4, I noted that the SAP collections have more Middle Postclassic materials than there are for any other period. However, the residential mounds are not single component collections and have a certain amount of mixing from other time periods. This is not a problem for the pottery or chipped stone materials which have well developed Middle Postclassic diagnostics that can be recognized and analyzed. For spindle whorls this time admixture poses problems for analyzing exchange. It is quite likely that some of the non- "conical" or mold impressed whorls also date to the Middle Postclassic period, but because I cannot be sure of their dates, I am omitting them from this analysis. For now, I limit the

discussion to the 36 probable Postclassic spindle whorls and the 24 residential

mound collections in which they were found.

The summary spatial patterns for all Postclassic spindle whorls match the

general patterns for the pottery analysis in Chapter 6 that showed a drop-off from

Sauce, with some interesting exceptions (Figure 8.1). Ring 2 shows higher total

whorl counts and has a larger number of residential mound collections with

whorls than any other ring. Ring 1 has the next highest amount, followed by rings

4, 5, and then 3. This is an interesting result because although ring 1 and Sauce

show higher densities of most materials, for spindle whorls, ring 2 shows higher

amounts. Are these spatial patterns the result of greater access to spindle whorls

or related to spinning activities? Associations with Quiahuistlan pottery may help

the evaluation.

The rare Quiahuistlan pottery type and its associations with spindle whorls

was considered because it is mostly small bowls that could have been used as

spindle supports. Also, preliminary analyses in Chapter 6 identified a potential

association with spindle whorls in ring 2. Out of the 12 sherds of Quiahuistlan

pottery, 6 were found in 5 collections with Postclassic spindle whorls. One sherd

was found in ring 1, 4 in ring 2, and 1 in ring 5 (Figure 8.2). The spatial patterns

could reflect cotton spinning patterns as well as information on exchange. Ring 2

shows more spinning activities than other rings, although counts are so small it is

difficult to know for certain. In Postclassic period central Mexico, Evans (1996)

found evidence for elite women involved in specialized textile production.

Therefore, it is possible that women, or larger households in general, possibly
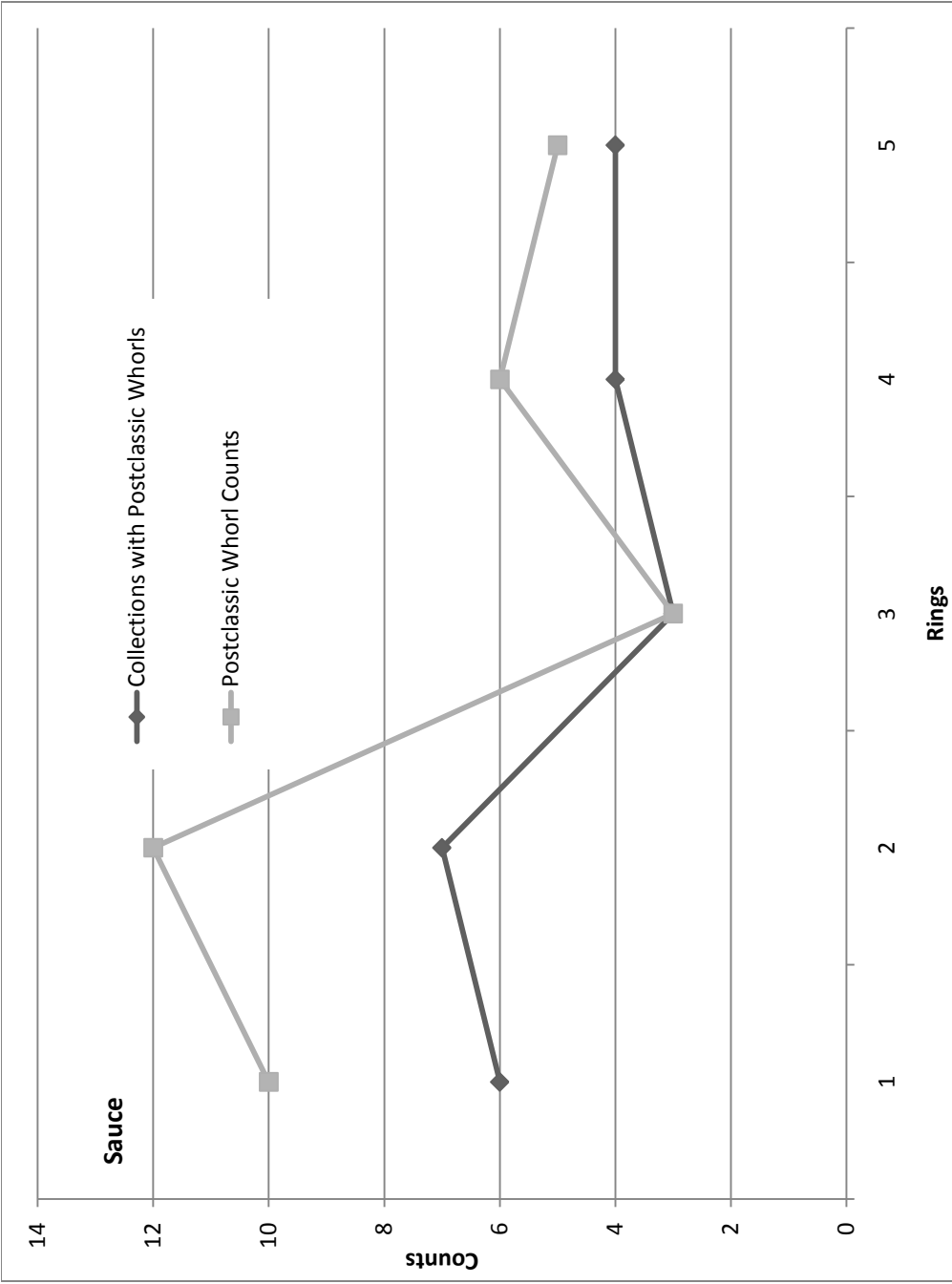
Figure 8.1 Postclassic spindle whorls counts and collections.
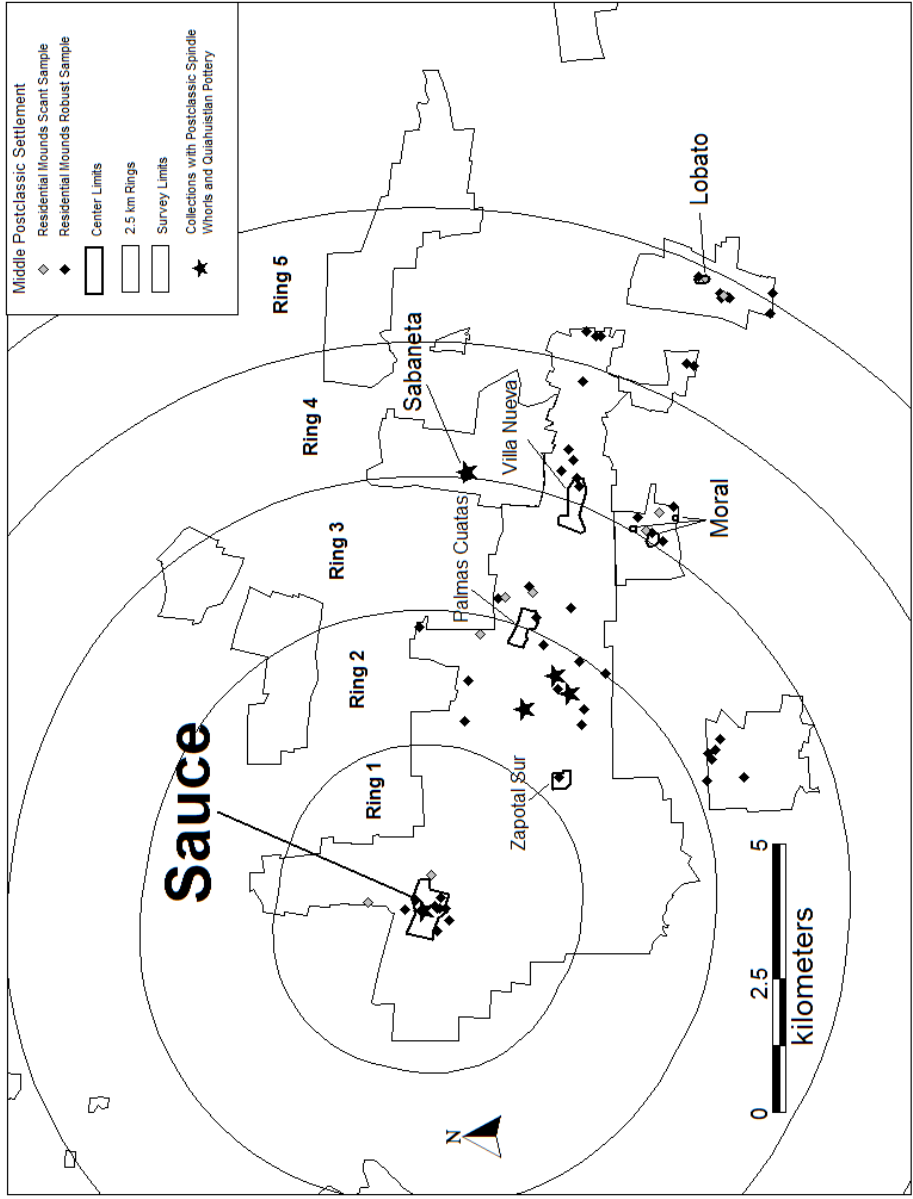
Figure 8.2 Map showing all collections with Postclassic spindle whorls and Quiahuistlan pottery.

associated with the Sauce center, had more spinning activities. Generally, the overall patterns of spindle whorls supports the idea that their source was probably centered in ring 1 or 2.

The next step in looking at spindle whorl exchange is to consider the different shape and decorative technique combinations. Unfortunately, the SAP spindle whorls include many eroded and partial whorls which made identifying the decorative motifs impossible. Therefore, I rely on the shape and decorative technique combinations to identify the Postclassic period whorls rather than decorative motifs. There are also variations in surface treatments including slip and chapopote that can be considered despite the small sample sizes for whorls within these subdivisions. In viewing the combinations of shape, decorative technique, and surface treatments in Table 8.4, most variations for spindle whorl types are found in rings 1 and 2. This is expected, given that these two rings have the most whorls. Overall, there is no strong spatial clustering pattern for whorl types, although the two zoological mold impressed whorls were found only within the Sauce center.

Table 8.4 Postclassic spindle whorls types by rings.

Ring	Cone Undecorated	Funnel Chapopote	Funnel Mold Impressed	Funnel Undecorated	Spool Chapopote	Subdome Mold Impressed	Subdome Mold Impressed; Chapopote	Zoological Mold Impressed; Chapopote	Zoological Mold Impressed; Orange Slip
1	1	2				3	2	1	1
2	1	3	1		1	3	3		
3		1				1	1		

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Ring	Cone Undecorated	Funnel Chapopote	Funnel Mold Impressed	Funnel Undecorated	Spool Chapopote	Subdome Mold Impressed	Subdome Mold Impressed; Chapopote	Zoological Mold Impressed; Chapopote	Zoological Mold Impressed; Orange Slip
4							2	4	
5				1			1	3	

Overall, the typological variations among the Postclassic shape and decorative technique whorls are not suggestive of restricted access, although due to low counts, some of the rarer types are only found in rings 1 and 2, which had the largest amounts. The SAP collections with Postclassic whorls are not exclusively associated with the center of Sauce (Figure 8.3). One of the three bone tools (an awl) and a flat clay stamp were found with a collection that also had Postclassic whorls (Figure 8.3). Although the count of spindle whorls is quite small, the current data supports openly available whorls that, due to their standardized production and relatively elaborate decorations, could have been produced or exchanged alongside pottery, perhaps near Sauce in ring 1 or 2.

Incense Burners

Incense burners are ritual items that were probably used in a variety of settings, some in households and some in more formal ritual contexts. For PALM, there are difficulties in differentiating among the different types of incense burners because some of their characteristics overlap with coarse utilitarian jars and tubing (Stark, et al. 2001: 114-115). Potential
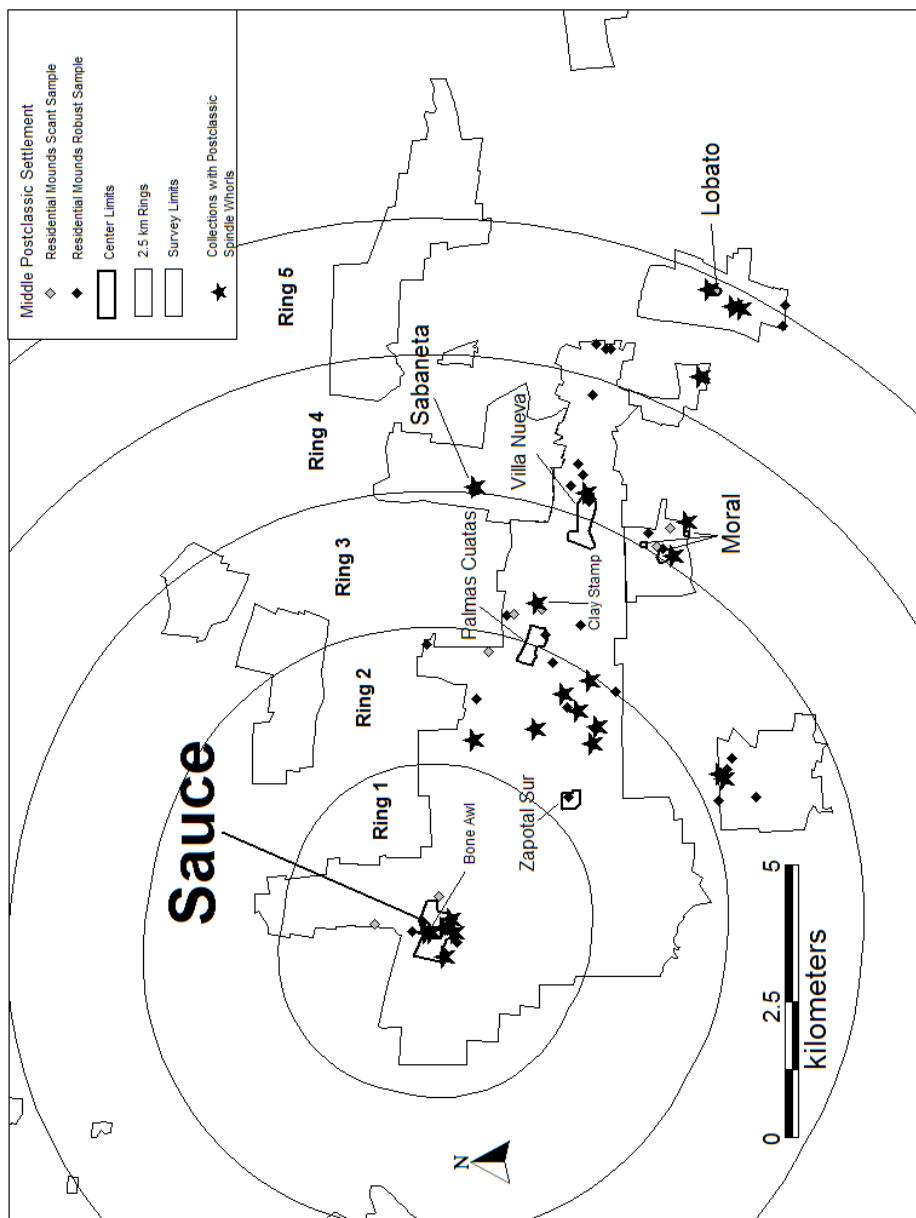
Figure 8.3 Map showing all SAP collections with Postclassic spindle whorls.

misidentifications of incense burners make this category problematic for analyses. There are also temporal problems to consider.

Incense burners were found in Classic period trash from the PALM excavations but they were not found in sufficient quantities to give much temporal information associated with different types (Stark, et al. 2001:115). In other parts of Mesoamerica there are chronological associations with particular incense burner forms. For example, cone appliqué (spiked) incense burners are associated with the early Postclassic period (A.D. 900-1150) and possibly early in the Late Classic period, depending upon the region (AD 600-900) (Cobean 1978: 254). However, most of the PALM incense burners are not assigned to any distinct chronological periods, except for "frying pan" incense burners, which have Late Postclassic associations in the area (Curet et al. 1994). Therefore, the analysis of SAP's incense burners can only be descriptive and tentative since there is likely some temporal mixing.

Many of the incense burners are large, elaborate specialty items that could have been restricted in exchange and/or only used by larger households. Information about their production and chronology is scanty, but I will consider these items for the exchange analysis.

All SAP incense burners were analyzed according to the PALM typology, which was based on forms and decorative techniques for each subdivision (Stark 2008b; Stark, et al. 2001: 114-115). For SAP, data were collected on the pottery type, vessel part, and weight for each individual sherd. Very few incense burners

were identified for SAP, only 49 sherds (see Table 8.5). Most of the incense

burners fell into the Appliqué bands and Cones category (see Table 8.5).

Table 8.5 SAP incense burner counts by category.

Type Code	Category Name	Counts
46a	General (Brushing)	3
46b	Incised	1
46c	Appliqué Bands or Cones	23
46d	Appliqué and Incision	5
46e	Conical Appliqué	7
46f	Flanges or Frying Pans	5
46h	White Stucco	5
	Totals:	**49**

Spatially, the incense burners show patterns similar to the pottery types in

Chapter 6, with the highest amounts found at Sauce in ring 1, with lower amounts

in all the other rings (Figure 8.4). However, the pattern is not a steady decrease

from Sauce outwards because incense burner amounts increase in ring 4. These

spatial patterns coincide with the decorated pottery, which also showed a steady

decrease in amounts from ring 1 through 5, with some types showing higher

amounts in ring 4, where a few abundant collections are located. For the pottery,

this is evidence for an area of elite residences. For the incense burners, potential

restrictions and mound size rank associations could support similar

interpretations.

Although most of the incense burners fit into one category, the spatial

variations with the incense burners can be analyzed for possible restrictions or

associations. In Table 8.6, the most varieties of categories of incense burners are

found in ring 1. This is expected because ring 1 has the greatest amounts of

incense burners. The variant (46f) that includes both flanges and frying pans, despite having very low counts, is found in rings 1, 4 and 5, while the equally rare white stucco variant is found in rings 1, 2, and 4 (Table 8.6). Based on the categories, there are no obvious restrictions, although the counts are so low it is difficult to say for certain.

Table 8.6 Incense burner types by rings.

Ring	Applique and Incision	Applique Bands or Cones	Conical Applique	Flanges, Frying Pans	General (Brushing)	Incised	White Stucco
1	4	8	7	3	3	1	2
2		5					2
3		3					
4		6		1			1
5	1	1		1			

A map showing all SAP collections with incense burners indicates an association with Sauce, although some are located within the outer rings (Figure 8.5). In the outer rings, incense burners show some association with mounds in the higher mound size ranks; this association is particularly strong in rings 4 and 5 (Table 8.7). Although the chronology and sample size for incense burners are problematic, the overall spatial patterns show a general pattern of higher densities at Sauce with a decrease through ring 5 which could be supportive of central place distribution at Sauce. However, the incense burner data from the outer rings 4 and 5 show associations with the higher mound ranks which could be suggestive
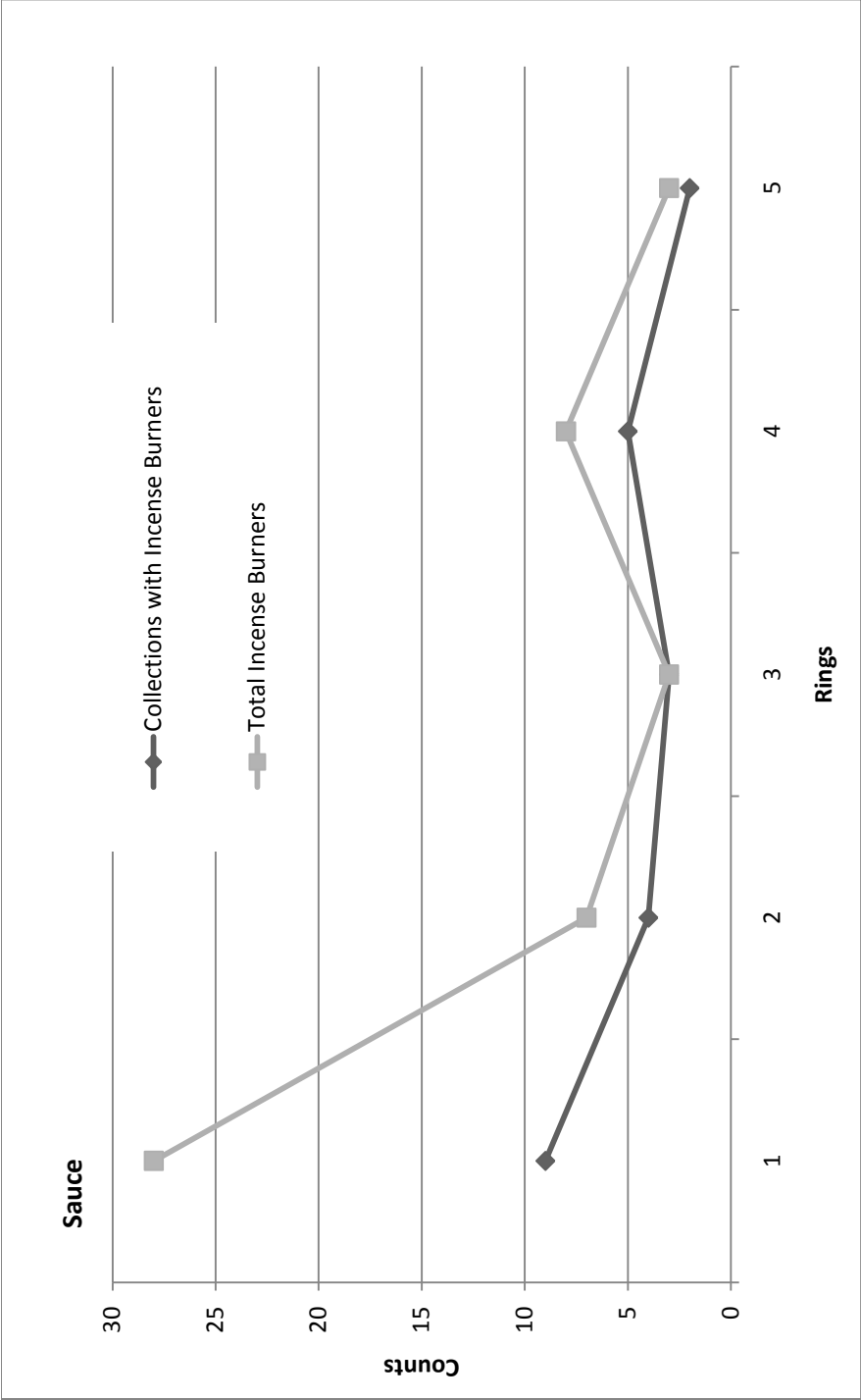
Figure 8.4 Incense burner spatial summary data.
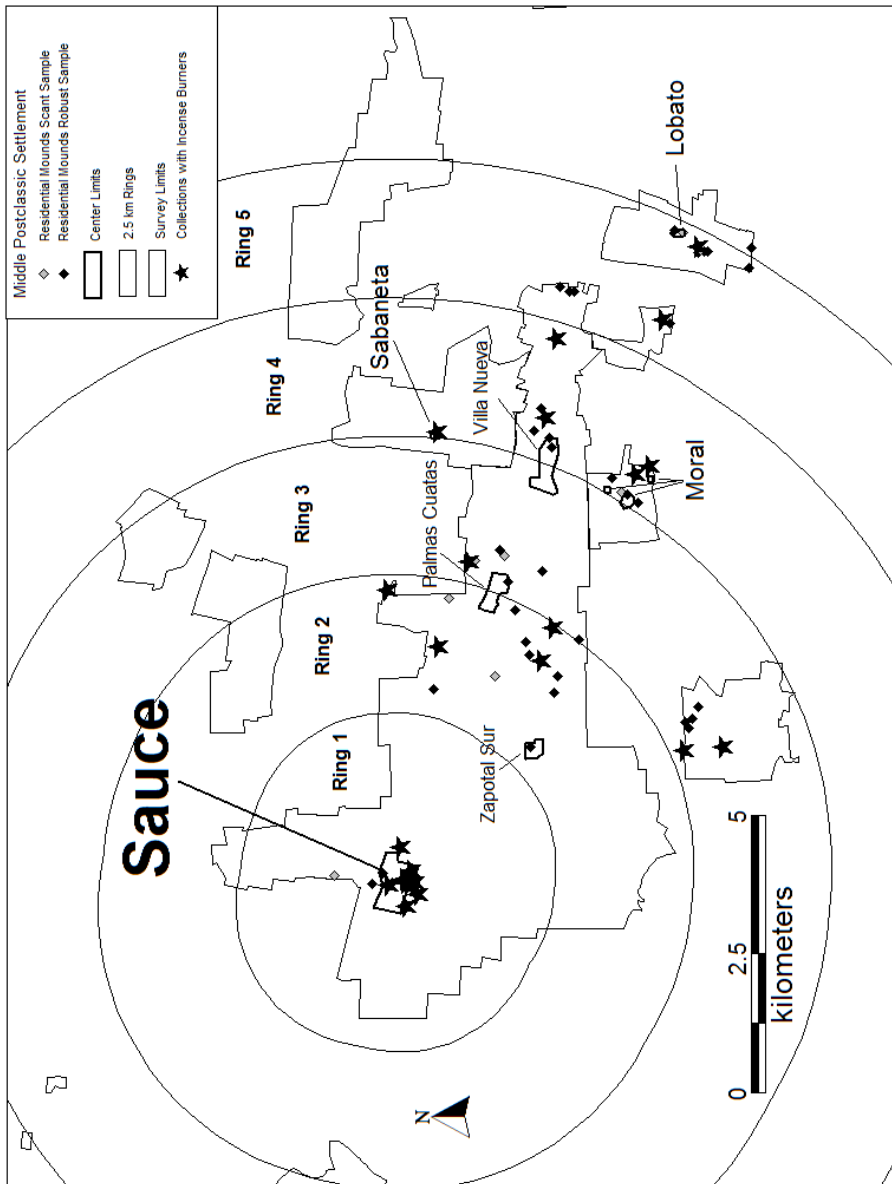
Figure 8.5 SAP Collections with incense burners.

of an elite socioeconomic component to ownership farther away from Sauce.

Interestingly, collections that had incense burners did not always have abundant

Postclassic pottery (see Table 8.7). In sum, the data are somewhat equivocal for

supporting either restriction or central place markets.

Table 8.7 SAP incense burner data.

Coll#	Mound Size Rank Order	Ring Zone	Sample Population	Total Incense Burners	Postclassic Pottery
1751	5	1	R	3	142
124	5	1	R	1	70
224	1	1	R	3	155
1152	5	1	R	10	206
1175	5	1	R	1	81
1817	2	1	R	3	220
1759	5	1	R	1	16
1753	5	1	R	5	66
114	5	1	S	1	17
1003	5	2	R	1	58
1013	5	2	R	2	123
1370	5	2	R	3	53
1466	5	2	R	1	28
5185	1	3	R	1	65
5260	4	3	R	1	36
1690	5	3	R	1	18
1306	1	4	R	1	102
6507	3	4	R	2	171
777	5	4	R	1	49
6510	5	4	S	1	23
6636	5	4	R	3	183
6818	1	5	R	2	97
5456	5	5	R	1	80

Figurines

Postclassic period figurines in Sauce and its hinterland are identified as

part of a new set of material culture for that time period (Curet et al. 1994; Stark

2008: 50). The new style of Postclassic figurines, dubbed "cookie-cutter,"

appears to be a complete break from previous local traditions in manufacturing

technique and style (Stark 2008: 50-51). These figurines are mold-made with one

flat side hence the name "cookie-cutter", with very different clothing and hairstyle

representations (Stark 2008: 51). Changes in these household level ritual items

have been interpreted as signs of a new ethnic group's intrusion into the region

(Stark 2008a). Therefore, figurine exchange networks could prove useful in

understanding how these household items may have been distributed and who had

access to them.

Unfortunately, the SAP figurine collections were fairly scanty and did not

have very many pieces that were chronologically diagnostic. Figurines were

analyzed according to the PALM typology and data were collected on the type,

part (head, body, etc.), paste, texture, and weight. SAP collections included

mostly items categorized under three miscellaneous non-diagnostic types,

although the next largest type was the Postclassic "cookie-cutter" group (Table

8.8). Some of the types pertain clearly to earlier periods (e.g., Laughing Face,

Remojadas Inferior).

Table 8.8 Figurine type counts for SAP collections.

Figurine Type	Counts
El Faisan Figurine	1
Hand Modeled Figurine	1
Large Idols or Figures	4
Laughing Face Figurines	1
Miscellaneous Figurine Part, Hand Modeled or Indeterminate	60
Miscellaneous Figurine, Incensario, Effigy Vessel, or Whistle part	79
Miscellaneous Molded Figurine	71
Movable Figurine Parts	1
Possible Aztec-style Head	1
Postclassic "cookie-c utter" Figurines	22
Remojadas Inferior Figurine	1

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Figurine Type	Counts
Remojadas Superior Figurine	4
Totals:	**246**

For SAP, I restrict my analysis to the 22 pieces of Postclassic figurines and the 9 collections in which they were found. Despite having a very low sample size, Postclassic "cookie-cutter" figurines were found in four out of the five rings (1-2, 4-5). In viewing Figure 8.6, the highest amounts of figurines and collections with figurines were found within ring 1, with the next highest amounts found in ring 4. Although the summary data shows results similar to the pottery, the sample size is small.

The Postclassic "cookie-cutter" figurines were classified by Drucker (1943:64) as Type II and III. The Type II is the "small" version and Type III is the "large" version, with the difference between them being an average of 2-3 inches in length. Stark (2008:50-51) notes that for PALM collections, the larger Type III figurines appear to be associated with Middle Postclassic occupation, while the Type II cases were found in both Middle and Late Postclassic occupations (see Miller 2006). The spatial patterns for these subtypes show that Type II, Type III, and unidentified "cookie-cutter" variants were present (Table 8.9), with no clearly identifiable spatial patterns for the subtypes. This result is not too surprising considering that the counts are so low.
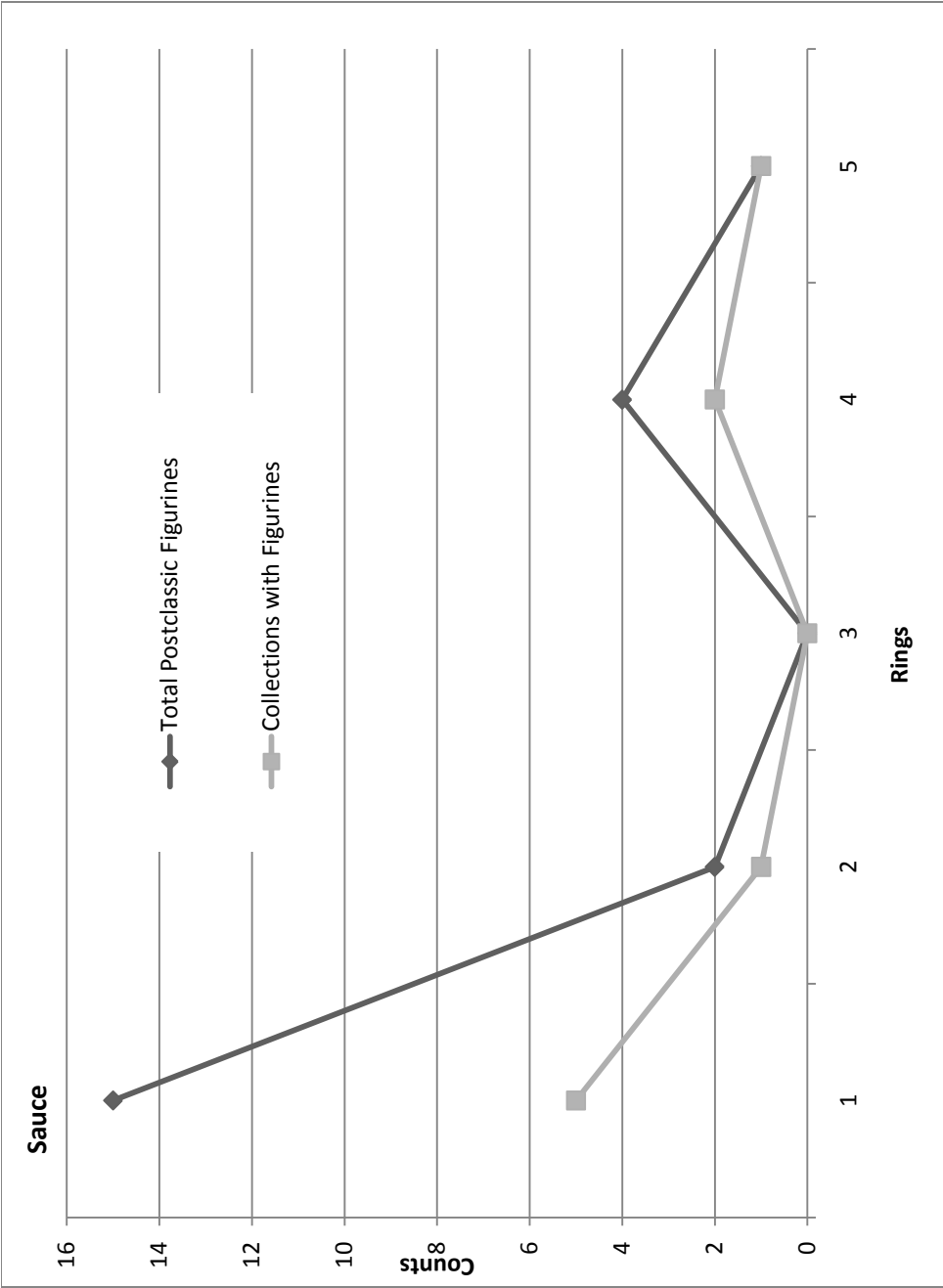
Figure 8.6 Postclassic figurine counts and collection counts by rings.

Table 8.9 Postclassic figurines by collections listed by collection type, rings, and weighted mound size ranks.

Mound Rank Order	Ring	Sample Population	Body: Drucker's Type II Bodies	Body: Drucker's Type II or III Bodies, Miscellaneous	Body: Drucker's Type III Bodies	Feet/legs	Head: Drucker's Type IIA Head	Head: Drucker's Type II Head, Miscellaneous	Head: Drucker's Type III Head	Possible Body Parts
2	1	Robust	1	1						
5	1	Robust								3
5	1	Robust				2	1	1		
1	1	Robust							1	
5	1	Robust						2		3
5	2	Robust								2
3	4	Robust							1	
2	4	Robust			1					2
1	5	Robust						1		

Five of the nine collections with "cookie-cutter" figurines were from the larger weighted mound size rank Groups (1-3). These higher ranked mounds are located within ring 1 and the Sauce center and in ring 4 and 5 (Table 8.9). A map of figurine collections shows that although five of the figurines are from Sauce, there are three collections from rings 4 and 5 that come from mounds that have the higher mound size ranks (1-3) (Figure 8.7).

With so few figurines, it is difficult to generalize about the results despite the seemingly strong associations with the Sauce center and with higher mound ranks in the outer rings. Collections with the highest artifact amounts tended to
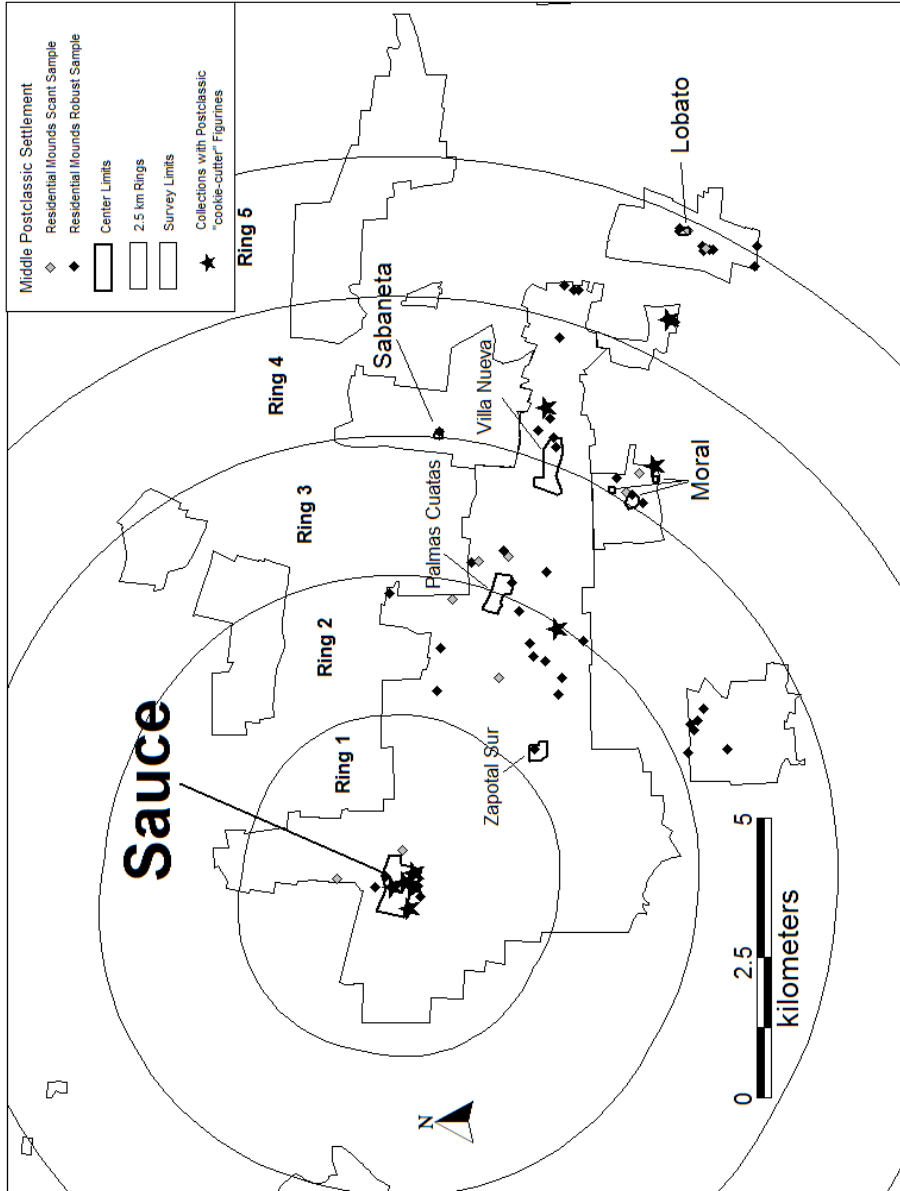
Figure 8.7 Map showing all SAP collections with Postclassic figurines.

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be within the larger weighted mound size rank groups so it is not surprising that these abundant collections are associated with rarer artifacts like figurines. However, given that the style and manufacturing technique of these figurines is new and intrusive into the area, they are candidates for items that may have been restricted or perhaps only preferentially consumed by this new population (Stark 2008a).

One way of testing restriction in access is to consider whether these figurines were associated with the Dull Buff Polychrome, which was established as a pottery type that was probably restricted in access or preferentially consumed (Chapters 5 and 6). In viewing Table 8.10, 5 of the 9 collections that had Postclassic figurines also had Dull Buff Polychrome (rows colored in grey). Although there are some associations, the highest quantities for both the figurines and Dull Buff Polychromes are in ring 1, which would create the appearance of association even if there is none. The results offer some evidence that these figurines could have been restricted in access or preferentially used by a subset of the Middle Postclassic period people, but fully testing this hypothesis would require additional data and excavations.

Table 8.10 SAP Postclassic figurine dataset and Dull Buff Polychrome counts.

Coll	Mound Size Ranks	Zone	Sample Population	Postclassic Figurines	Postclassic Pottery Counts	Dull Buff Counts
1817	2	1	Robust	2	220	42
1753	5	1	Robust	3	66	6
1152	5	1	Robust	4	206	0
224	1	1	Robust	1	155	3
124	5	1	Robust	5	70	13

Coll	Mound Size Ranks	Zone	Sample Population	Postclassic Figurines	Postclassic Pottery Counts	Dull Buff Counts
1013	5	2	Robust	2	123	0
6507	3	4	Robust	1	171	12
1099	2	4	Robust	3	107	0
6818	1	5	Robust	1	97	0

Groundstone

Groundstone artifacts for the PALM excavations and survey were relatively scarce and included a number of utilitarian items such as manos and metates, and also finer items, such as a fragment of a mirror mosaic and celts (Hall 2001: 175). Groundstone artifacts for PALM mostly fit under the utilitarian categories as either worked stone that had grinding surfaces for pigments, pebble polishers, or household tools such as hammerstones. Therefore, it was expected that SAP would have mostly utilitarian items whose distribution and exchange could be evaluated.

Groundstone items were collected and analyzed for the PALM excavations, but were not collected for the PALM regional survey, only counted in the field. Only special items, such as celts, were collected. Therefore, the SAP season represents the first time that the major and mostly utilitarian groundstone objects were systematically obtained from surface collections. As one might expect from surface collections, much of the groundstone collected was fragmentary and occasionally difficult to categorize. For the analysis, I limit my discussion to those pieces of groundstone that were positively identified as tools.

Only 46 pieces of groundstone tools were found associated with 23 of the 65 residential mounds. The SAP groundstone was analyzed using a basic typology of known Mesoamerican groundstone tools including: manos, metates, a possible mano/palette, and two other objects that were classified as "other" due to having grinding surfaces not recognizable as manos or metates. Data were collected on the tool type, color, material, size, and weight of each groundstone piece, but for the purposes of this analysis I will limit my discussion to the tool distribution.

In viewing the tool counts for SAP, it is clear that the majority are utilitarian tools such as manos and metates (see Table 8.11). Unfortunately, these tools are found throughout all periods within the region, meaning that SAP's collections probably include some groundstone objects from other periods. There are a few chronological patterns observed from PALM that are useful. Hall (2001:176) notes that there are possible decreases in the width of groundstone tools such as manos and metates over time, possibly due to increasing scarcity of the materials used to make them. However, due to the fragmentary state of these tools, obtaining reliable thickness measures for all of the SAP groundstone proved problematic. Hall (2001:176) also observes that the one footed metate from PALM's collections was recovered from a Late Classic period excavation. She notes that the feet may have been indicative of the tripod metate shape that is common for the Postclassic period Tehuacan valley. SAP has two footed metate fragments, too few for definitive chronological support for a Postclassic date. I

describe the overall distributional patterns of all groundstone tool types, with the understanding that I cannot control for the chronology of this artifact category.

Table 8.11 SAP groundstone tool category counts.

Tool Category	Counts
Mano	3
Mano Fragment	16
Footed Metate Fragment	2
Metate	4
Metate Fragment	18
worked stone	3
Totals:	**46**

Despite the shortcomings of the groundstone dataset, the distribution of tools can be considered as a first step in analyzing groundstone consumption and availability. A breakdown of groundstone tools by ring matches the general trends in the pottery data (Figure 8.8). There are many collections with groundstone in ring 1, with a slight increase in ring 2, followed by a decrease through ring 5. There is a spike in counts of groundstone tools in ring 3, but in Figure 8.9, which shows the weights of groundstone by rings, it seems likely that the higher counts may simply be a reflection of more fragmentary groundstone materials collected for that ring. There is a noticeable drop off in groundstone weight from ring 1 (Figure 8.9).

For groundstone tools, I used the counts rather than the weights because the weights varied so much it was almost impossible to compare them on a graph. In viewing the groundstone spatial patterns, the great majority of them are fragmented manos and metates which show no obvious spatial clustering (Table

8.12). The two identified footed metates were found in rings 1 and 2, but too few for a secure association. Most of the collections that had groundstone do not appear to be from within the higher mound size ranks (1-3); instead, most of them are from the lowest rank 5. One collection had more groundstone artifacts than any other, collection 1690 from ring 3, labeled in Table 8.12. The high groundstone counts in this collection are not the result of more fragmentary groundstone. Additionally, careful field collection notes were kept and collection 1690 was observed to have more groundstone tools than any other SAP collection. During field collection at collection 1690, two whole manos, a heavily worn metate, and many other fragments of groundstone tools were observed outside the collection square, although these are not included in the counts. Therefore, this collection accurately represents an exceptionally high presence of groundstone.

In summary, although the data are extremely fragmentary and probably chronologically mixed, the groundstone tools appear to be openly accessible and show no associations with higher mound size ranks. In general, there is a decrease in collections that have groundstone away from Sauce (and rings 1 and 2) through ring 5. This decrease in groundstone outwards from the Sauce center is consistent with a model of central place provisioning for groundstone, which had to be imported from outside the region.
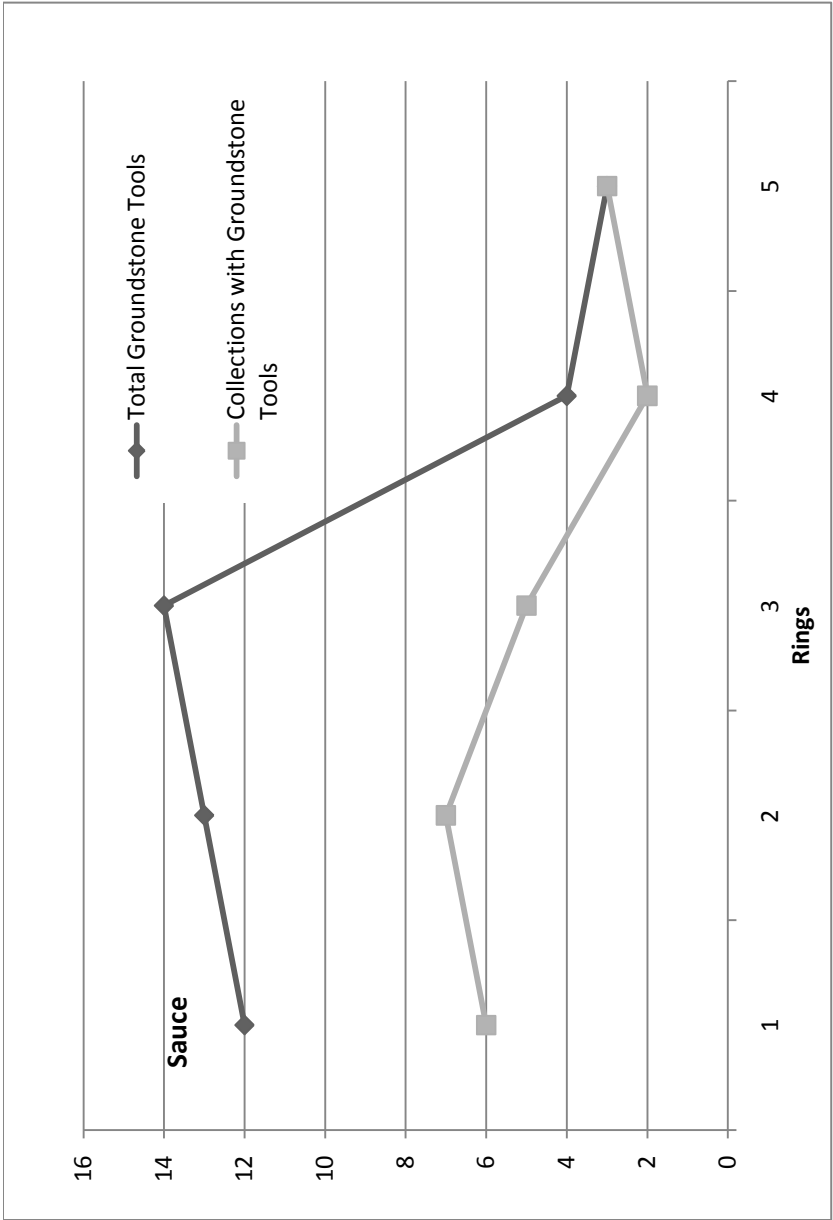
Figure 8.8 SAP groundstone counts and collection counts by rings.
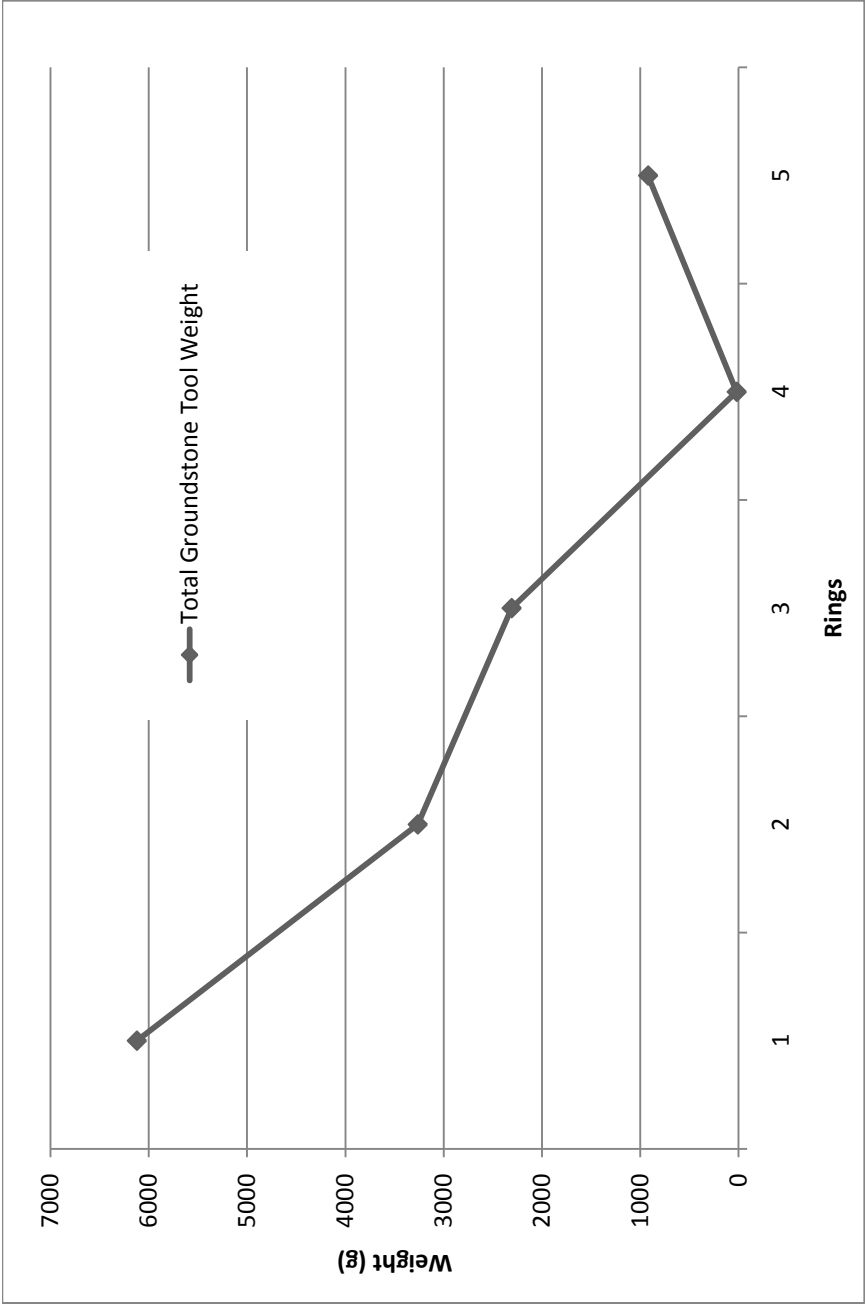
Figure 8.9 SAP groundstone weights by rings.

Table 8.12 SAP Groundstone tools by individual collections listed by collection type, rings, and weighted mound size ranks.

Coll	Mound Rank Order	Ring	Sample Population	Mano	Mano Fragment	Footed Metate Fragment	Metate	Metate Fragment	worked stone	Totals
1751	5	1	Robust		1			1		2
1152	5	1	Robust				1			1
114	5	1	Scant			1		2		3
225	3	1	Robust	1				2		3
224	1	1	Robust		1		1			2
124	5	1	Robust					1		1
395	5	2	Robust					1		1
1370	5	2	Robust	1		1		3		5
1003	5	2	Robust		1					1
1013	5	2	Robust				1			1
1286	5	2	Robust		1			1		2
1314	3	2	Scant						1	1
1341	5	2	Robust		2					2
5282	5	3	Robust		1			1		2
1690	5	3	Robust		8			1		9
1628	4	3	Robust					1		1
1022	5	3	Robust						1	1
1679	5	3	Robust	1						1
790	5	4	Robust				1			1
1306	1	4	Robust		1			2		3
1511	5	5	Robust						1	1
5457	5	5	Robust					1		1
5452	5	5	Robust					1		1
Totals:				3	16	2	4	18	3	46

Other Special Use and Rare Items

This section on scarce artifacts includes ones with special uses, such as molds for pottery and figurine production that might not have been practiced by every household. Other objects may have been fairly restricted in access, such as a greenstone bead or a flute. Items such as bone tools were probably common but, due to poor preservation, are now rare items archaeologically. I will consider each of these categories separately. Most of the special form categories have small samples and in many cases lack chronological associations, so my investigations are basically descriptive.

Special Forms

The following special form artifacts were analyzed for SAP according to the PALM typology (Table 8.13). Several of these artifact forms have already been mentioned in connection with spinning activities and pottery type analysis (molds). However, each of these objects will be considered again using spatial and contextual data from the collections. For SAP, only 23 collections had these special artifacts with a total of 40 items that are listed below (see Table 8.13).

Table 8.13 SAP special forms artifact type counts.

Special Form Types	Counts
lid	2
bead	1
bone awl tip	1
bone disk fragment	1
colander	4
figurine mold	2
flat clay stamp	1
flute fragment	1
fondo sellado mold	2

Special Form Types	Counts
mineral	1
net weight	1
pellet	17
whistle	2
worked bone fragment	1
worked sherd	3
Totals:	**40**

The special forms are grouped together by general use categories based on the PALM descriptions (Stark 2001b: 213-218). Pellets are small spherical ceramic objects somewhere between .9 and 1.8 cm in diameter (Stark 2001: 213), typically fired; Stark (2001: 213) suggests that they could have been used as rattles in hollow supports in ceramic vessels. For PALM, the pellets were rare, with 10 identified from the excavations. Approximately 17 pellets were found in SAP collections, which might be more than expected given PALM levels, but perhaps this was because of the intensive collection methods. Most of the pellets were recovered from ring 1 and also appear to come from relatively abundant collections (see Table 8.14). These results could indicate that more hollow support vessels were associated with Sauce, although it also possible that the more abundant collections turned up rarer artifacts such as pellets due to better samples. There is no observed association with higher mound size ranks.

Table 8.14 SAP pellets by individual collections.

Coll	Mound Size Rank Order	Ring	Sample Population	pellet	Postclassic Pottery Counts
224	1	1	R	1	155
225	3	1	R	3	315
1175	5	1	R	1	81
1817	2	1	R	2	220
1753	5	1	R	3	66

Coll	Mound Size Rank Order	Ring	Sample Population	pellet	Postclassic Pottery Counts
1751	5	1	R	2	142
124	5	1	R	2	70
1314	3	2	S	1	118
1370	5	2	R	2	53
			Totals:	**17**	

Other special pottery forms included colanders, lids, and beads. Many of these items were not found in ring 1, nor were they exclusively associated with the most abundant collections in all cases (see Table 8.15).

Table 8.15 Special pottery forms by individual collections.

Coll	Mound Size Rank Order	Ring	Sample Population	colander	lid	bead	Postclassic Pottery Counts
224	1	1	R	1			155
1013	5	2	R			1	123
1628	4	3	R		1		27
5260	4	3	R		1		36
6514	5	4	R	2			38
1517	5	5	R	1			13
			Totals:	**4**	**2**	**1**	

Collections 5282 and 691 have figurine molds and also have miscellaneous molded figurines (see types listed in Table 8.8) associated with them, but no Postclassic period figurines. The two Fondo Sellado molds were found in rings 1 and 2, and were associated with Fondo Sellado pottery. Most of the collections that had molds and worked sherds appear to have relatively abundant collections of Postclassic pottery (see Table 8.16)

Table 8.16 SAP pottery molds and worked sherds.

Coll	Mound Size Rank Order	Ring	Sample Population	Figurine Mold	Fondo Sellado Mold	Worked Sherd	Postclassic Pottery Counts
225	3	1	R		1		315
1751	5	1	R			1	142
691	2	2	R	1			62
1370	5	2	R		1		53
5282	5	3	R	1			118
6636	5	4	R			2	183
			Totals:	2	2	3	

Possible spinning and weaving artifacts included one bone awl, one bone disk (edges not worked, but it could have been a spinning weight), one smoothed worked bone piece, and one flat clay stamp. Only the clay stamp and bone awl were found in collections that also had Postclassic period spindle whorls, as described in an earlier section. There were no obvious associations with higher mound ranks or the Sauce center (see Table 8.17).

Table 8.17 Possible spinning and weaving related artifacts.

Coll	Mound Size Rank Order	Ring	Sample Population	bone awl tip	bone disk fragment	worked bone fragment	flat clay stamp	Postclassic Pottery Counts
225	3	1	R			1		315
1679	5	3	R				1	153
777	5	4	R	1				49
6514	5	4	R		1			38

Lapidary Items and Preciosities

The PALM regional survey recovered few lapidary items. Only five pieces of lapidary work were found in proximity to Nopiloa, a Late Classic period center (AD 600-900), and they do not appear in PALM collections from the

immediate vicinity of Sauce (Stark 2007a). This could mean that Middle Postclassic households did not have much access to this class of products (Stark 2007: 250). Hall (2001: 177) also notes decreasing quantities of ground stone celts by the Late Classic period, so it is possible that such items were rare during the Postclassic period. For SAP the only lapidary item recovered was one greenstone bead. This bead was an isolated find associated with a SAP collection in the Sauce center. Although the collection had mostly Middle Postclassic period materials, we cannot tell whether this bead dated to the same period.

Scarce Artifact Exchange and Distribution

Previous chapters have established that a mix of exchange systems including market exchange and social networks characterized the economic organization of Sauce and its hinterland. Based on the spatial patterns for the pottery and chipped stone, market exchange appears to be mostly centered on Sauce with the possibility of an area of elite residences with high amounts of material wealth located near ring 4 east of Sauce. The scarce artifact categories were analyzed separately from the pottery and chipped stone because the chronology and the sample sizes for the scarce artifacts are problematic. The statistical network evaluation could not be applied due to these issues. However, basic spatial and contextual information about the scarce artifacts allow for some inferences.

For the frequent use categories, only two had chronological distinctions that could be applied to their analysis, the spindle whorls and the figurines. Despite these issues, most of the artifact categories show spatial patterns similar

to those found for the pottery and chipped stone. However, there are some interesting exceptions. The amounts of Postclassic period spindle whorls decreased in amounts away from Sauce, and there are no obvious restrictions based on mound size ranks. Ring 2 had higher amounts of Postclassic spindle whorls. Although groundstone did not have chronological information, it showed patterns similar to the spindle whorls. The counts of groundstone tools were greater in rings 3 and 4 than in the other rings, but the number of collections with groundstone tools per ring was highest in rings 1 and 2, with a decrease east (after ring 2) from the Sauce center. There were no obvious associations between higher mound size ranks and groundstone tools.   Both spindle whorls and groundstone tools showed slightly higher amounts per collection in ring 2 than the pottery or the chipped stone. This spatial pattern could indicate more activities involving these artifacts in this area, although temporal ambiguity could be playing a role.

The Postclassic "cookie cutter" figurines showed a drop-off in amounts from Sauce, as with the other artifact categories. However, in the outer rings 4 and 5, they appeared to be associated with the higher mound size ranks (1-3). For the incense burners, despite a lack of temporal information about the different types, a similar pattern emerged with a drop-off in amounts from Sauce and apparent association with the higher mound size ranks in outer rings. Due to low counts for both artifact categories, it is difficult to fully evaluate the association with higher mound size ranks. Since not all of the high amounts of figurines and incense burners were associated with collections that had abundant Postclassic

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pottery, the socioeconomic component being measured by the higher mound size ranks could be separate from collection counts for scarce artifacts. There is a suggestion that the figurines and incense burners could be items that were more available to residences with higher mound size ranks or proximity to Sauce. The suggestion of overlap with Dull Buff Polychrome for the figurines could also indicate that these were both items that were associated with Sauce's political elite (Stark 2008a).

Most of the special forms that were probably less used by everyone, such as figurine and Fondo Sellado pottery molds, were not obviously associated with higher mound size ranks. In the case of the molds and possible spinning and weaving tools, there are spatial associations with related artifact types, such as Fondo Sellado pottery for the former (see Chapter 6) and spindle whorls for the latter. However, the rest of the sample sizes are too small to interpret exchange and household access.

In summary, the scarce artifacts offer some further support for market exchanges at a central place in or near the Sauce center. There are also some indications that restrictions or preferential consumption of some items, such as the Postclassic figurines and possibly the incense burners, were also part of Sauce's economic organization. There are some interesting patterns of larger amounts of groundstone and spindle whorls associated with ring 2 than for other artifact types. However, the dataset is not large enough to say for certain whether the spatial patterns that indicate more grinding and spinning activities associated with ring 2 (which also had an area of more abundant comals identified by PALM) are

accurate (Curet 1993). Future research that establishes more refined

chronological control and larger samples will be required to confirm most of these

patterns.

CHAPTER 8 NOTES

[1]Due to the chronological and sampling size issues attached to these artifact categories, PALM collections were not used to bolster the SAP analyses. The comparability of SAP's surface collections (with vegetation clearing) to PALM's density collections proved problematic. For the scarce artifact categories, some of the underlying population distributions between PALM and SAP were quite different, probably due to different collection practices.

[2]As a point of clarification, all ceramic spindle whorls were probably mold made by the Middle Classic period (A.D. 450-650) for a number of Gulf lowland sites, but mold impressed designs are a decorative technique in addition to the mold manufacture (Hall 1997:133).

CHAPTER 9. EXCHANGE SYSTEMS AND COMMERCE IN
POSTCLASSIC VERACRUZ

The development of commercial exchange for all levels of communities,

from big regional centers to smaller towns and villages, is an important topic for

understanding Postclassic period Mesoamerica (Smith and Berdan 2003a). This

topic informed my research on a small Postclassic town in Veracruz. Recent

views of economic organization recognize that all complex societies have

multiple forms of exchange; one form of exchange does not preclude the

existence of another (Blanton and Fargher 2010; Hirth 2010: 242; Smith 2004).

Guiding this research was the assumption that households are the significant units

engaging in exchange, consumption, and production. Household inventories

provide important information about exchange systems and insights into decision-

making concerning subsistence, specialized production, and social positioning.

My research fits well with new approaches and syntheses that emphasize the

complex role that co-existing exchange systems play in social and political

dynamics, and how these new perspectives should be deployed in anthropological

research (Blanton and Fargher 2010; Stark and Garraty 2010).

One persistent problem for understanding exchange has been the

projection of a false dualism into our conceptions of different kinds of systems,

such as between markets and redistribution (Blanton and Fargher 2010: 222).

Although I adopted the abstraction of a continuum in access from open to

restricted for my evaluation of exchange, I do not believe that the processes that

produced this continuum are similarly binary. Instead, as M. Smith (2004) indicates, the comparative study of ancient complex societies shows that exchange mechanisms, transfer actions, and institutional forms of exchange intersect in complicated ways that are challenging to model precisely in their entirety. I attempted to identify how these different exchange systems intersected with social and political aspects of Sauce's organization by adopting an analytical framework that differentiates aspects of exchange systems with separate household expectations archaeologically. I view this work as a first step in building more refined methods to advance the archaeological study of exchange systems and the processes behind economic development.

For my research, I used PALM data to select 65 residential domestic mounds for intensive collection occupying a 55.41 sq km area dating to the Middle Postclassic period. In this concluding chapter, I combine the results of three different sets of analyses from Chapters 3-8, which focused on identifying exchange mechanisms and mapping spatial patterns to describe economic organization. I organize the synthesis and conclusions of this research around significant elements of exchange identified in these chapters: exchange mechanisms, spatial organization of exchange, political and social aspects of exchange, socioeconomic residential associations, and the degree of commercialization. In the second section, I discuss the role that small polities, such as Sauce, may have played in economic development scenarios in comparative perspectives for Mesoamerica and other complex societies. Next, I discuss the methodological contributions of my study, with an emphasis on the

new concepts about identifying exchange systems and the network simulation application. Finally, I summarize the broader applications of this research for advancing our general understanding of ancient complex societies.

Modeling Multiple Exchange Mechanisms in Sauce

Although I realize that exchange mechanisms are highly variable within complex societies (Smith 2004), for the purposes of my study I adopted two sets of expectations for distinguishing between market exchanges and social networks, which included elite gift-giving, kin exchange, self-sufficiency, and house-to-house exchanges. These alternative models are simple, but they provide the starting point for our separate consideration of exchange processes from spatial and contextual information. This separation is the first step in describing the multidimensional social, political, and economic aspects of Sauce's economic organization.

As discussed in Chapter 5, open access was expected to correlate with market exchange and restricted access was expected to identify social networks. However, for dealing with items where every household had access to the same category, such as obsidian blades, I adopted a slightly different approach. For the chipped stone dataset in Chapter 7, restricted access was expected to correlate with social networks linked to redistribution (directed towards households with higher socioeconomic rank or proximity to Sauce) while open access was expected to correlate with market exchange. Due to different sets of expectations for each artifact type (such as pottery versus chipped stone), I describe my results for each artifact type separately.

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Pottery. Two methods were used to analyze the pottery, a visual distributional approach and a network simulation approach. Both methods led to almost identical conclusions about whether a pottery type was exchanged through market exchange or social networks, inspiring some confidence in the results. The majority of the pottery types that were analyzed in the network analysis of Chapter 5 were openly exchanged. However, there was one exception; Dull Buff Polychrome matched the expectations for restricted exchanges.

Chipped stone. The regional production-distribution method (after Stark and Garraty 2010) was modified for a smaller polity scale analysis using De León et al.'s (2009) blade trade inventory model to evaluate the likely exchange mechanisms for the chipped stone. The chipped stone included formal tools from repurposed blades, blades and blade parts, and chert. Generally, the exchange mechanism was open exchange, probably through a combination of market exchange via a central place and some itinerant or local knapping by specialists, as I describe below.

The evidence for formal tools was quite scarce; I found a handful of blades refashioned into tools. Yet none of these reused blade tools showed either a spatial association with Sauce or with residential mounds that belonged to the larger mound size ranks (1-3). Therefore, my interpretation is that these tools were not restricted in access and were instead the result of residential recycling or the result of open exchange as in markets. Data were too few to offer substantial distributional evidence.

For the obsidian prismatic blade industry, production indicators associated with primary production (after De León et al.'s model, 2009) were found in the strongest association with the Sauce center. However, some small quantities of primary indicators were also found in all five of the rings, indicating that production was not limited to Sauce's environs. Also, secondary production indicators, which I interpret as identifying the work of itinerant or local knappers, indicated limited production or repurposing of various artifacts (including cores) within all five rings. Therefore, although the association of blade production with the Sauce center is strong, it is not exclusive, indicating that Sauce's political elite may not have exercised tight control on the movement of obsidian within Sauce's likely hinterland. Instead, the very low level of primary and secondary production indicators found within all of Sauce's rings supports the interpretation that combinations of central, local, and itinerant producers provisioned Sauce and its hinterland residences.

The evidence from the blades and blade segments was considered separately on the basis of research that suggests that ratios of different blade parts within households can indicate the type of end product being exchanged (i.e., blade medials versus whole blades) (De León, et al. 2009). SAP blade part ratios offered some support for exchange of medial segments, although some residences showed access to whole blades based on the presence of distal and proximal blade segments that would be expected in whole blade trade. The spatial distribution of blades and blade segments did not show clustering of large amounts outside of ring 1 that would be expected if there was redistributive exchange. Nor were the

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highest quantities of blades or blade segments exclusively associated with the Sauce center or the higher mound size ranks. Furthermore, no blade concentrations pointed to use of blades in other specialized crafts.

Chert was identified in earlier studies (Stark 2008a; Vonarx 2004) as associated with Postclassic period collections and possibly with the Sauce center itself. For the chert analysis, I used both PALM and SAP data because of the rarity of chert. Despite the dataset being quite small, the results of the analysis did not indicate any restricted access in the form of either exclusive association with the Sauce center or with the higher mound size ranks. For now, chert appears to have been openly accessible.

Scarce Artifacts. The scarce artifacts were too low in amounts to apply the statistical methods used on the pottery and chipped stone in Chapters 5-7. Additionally, the artifact typologies in most cases lacked the chronological refinement necessary to identify items as Middle Postclassic. Only two of the scarce artifact types, spindle whorls and figurines, had types that could be identified as Postclassic. Two pottery molds for the Postclassic Fondo Sellado were also analyzed. The rest, including the groundstone tools, incense burners, and assorted special forms were not associated with a particular time period. The statistical network analysis could not be applied to this dataset because of these temporal and sample size issues. However, the basic spatial and contextual information about the scarce artifacts allowed me to evaluate the most likely exchange mechanisms. Specifically, if scarce artifacts showed an association with either the Sauce center or the higher mound size ranks, they could be

considered candidates for restricted exchange rather than open access through market exchange.

Some of the scarce artifacts indicated they could have been marketed, while others indicated potential restrictions. The Postclassic spindle whorls showed no obvious associations with Sauce or higher mound size ranks to indicate restriction. Groundstone tools, although no temporal types were assigned, also showed open access. However, the Postclassic "cookie cutter" figurines showed some associations with higher mound size ranks away from the Sauce center in ring 4. A similar pattern appeared for the incense burners, with apparent associations with the higher mound size ranks in the outer rings. Because the numbers were so low, it was statistically problematic to attempt a contingency table analysis to test the associations, although the comparisons of the ratios of expected to observed numbers of collections with high mound size ranks (1-3) versus low ranks (4-5) are at least suggestive.

In summary, the results indicated that a mix of market and social network exchanges characterized Sauce's economic organization. However, the majority of household materials were probably attained through market exchanges.

The Political Implications of Spatial Patterning for Market Exchange

The spatial patterning of exchange systems has long been recognized as an important variable in identifying the political administration of exchange (C. Smith 1976; Minc 2006). For Sauce and its hinterland, previous evidence of production and spatial drop-off patterns of artifacts, such as obsidian blades, had

suggested its role as a local solar market (Heller 2000; Stark and Ossa 2010).

Additionally, a pilot study on PALM data, described in Chapter 1, showed that

other artifacts such as comals also showed drop-offs from Sauce in support of its

potential role as a central place for market exchange. For solar market

expectations, Minc (2006:82-85) cites C. Smith (1976:179-181) in stating that

solar markets are characterized by exchange matching political boundaries, and

typically administered by a centralized political authority. These models were

originally formulated by Christaller (1966) for central place theory, which

predicted the regularized appearance of centers based on least-cost for transport in

economic networks. Other Mesoamerican researchers such as West (2002: 142)

have pointed out that these models were not originally meant to represent political

units, but were instead designed to predict economic relationships. The question

of whether monumental centers also served as economic central places is still

actively debated, and remains an issue that should be investigated using spatial

patterns of artifacts.

Prior to this study, it was unknown if the interpretation of solar market

exchange was an accurate representation of Sauce' economic organization, as

most of the artifact categories were not numerous enough within the collections to

be analyzed for separate households. Previous analyses had resorted to grouping

collections (and hence households) in order to generate large enough samples (see

Garraty 2009), and had not been able to examine the role of multiple goods

separately. Therefore, one of the goals of this research was to evaluate the most

likely role of the Sauce polity in exchange based on multiple goods from

individual households. In this discussion, I interpret the spatial organization of

market exchange, by combining the evidence of all of the openly exchanged

artifact types. Next, I consider the association of production with Sauce and also

with the other rings. Finally, I combine the two datasets, exchange and

production evidence, to consider the role of Sauce and its political elites in market

exchange.

Spatial Patterns

The recurrent spatial pattern showed a drop-off of amounts of products

from the Sauce center. Most of the artifact types, including the majority of the

pottery types, all of the chipped stone, and scarce artifacts, decreased in amounts

outwards from Sauce in rings 1 to 5. These spatial results, combined with the

indication that most of the exchange mechanisms involved market exchange, offer

strong support for Sauce's role as an economic central place within the survey

area. However, not all of the artifact types showed the same spatial patterns. A

few spatial patterns could indicate the presence of elite residences or an

overlapping market zone eastward of Sauce.

The pottery types that included the *guinda* complex showed an increase in

ring 4 that could indicate the beginning of another market zone or an area of

isolated concentration.   If it were the former, I would expect the increases to be

gradual (by ring 3) and continue through ring 5. If the latter, then the spatial

patterns would show an abrupt increase in amounts in ring 4, without gradual

increases in rings 3 and 5. The spatial pattern for this eastern zone is difficult to

fully assess because many of the collections obtained farther east in ring 5 were

heavily eroded. This erosion affected the identification of many pottery types within ring 5. However, the issues with ring 5 collections do not change the overall pattern of higher quantities within ring 4. Based on the current spatial data, the evidence supports a higher area of isolated concentration, which could be indicative of elite residences located outside the Sauce center. Other lowland centers were similarly configured, such as Tikal, which had elite residences located outside the central urban core (Taschek and Ball 2003). Currently, the contextual data for residences in ring 4 do not show obvious associations with the previous Classic period centers.

Production Associations

Although the production of pottery, chipped stone, or other specialized production activities such as cotton spinning were not the primary focus of SAP, residential collections also included production evidence. Pottery production occurred in rings 1 and 2, where Curet (1993) identified a potential comal production or use area. For SAP, Fondo Sellado molds were found in rings 1 and 2. In ring 2, there were indications of spinning and textile production, possibly associated with the Quiahuistlan pottery type and elevated amounts of spindle whorls with some associated bone tools and a clay stamp. The primary production indicators for prismatic blade production were associated strongly with the center of Sauce and ring 1. PALM researchers identified an obsidian workshop and a concentration of scrapers that were identified as being used in processing woody plants, both indicating craft related activities near the Sauce center (Heller and Stark 1998; Lewenstein 2001). These craft associations

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support the interpretation that Sauce was an important locale for the production

and distribution of locally marketed items. The location of a marketplace within

Sauce would support the increase of craft-related activities nearby, as producers

might want to be located nearby to lower the costs of moving their products to

market and benefit from a concentration of consumers. Marketplaces in the

modern world are similarly configured, with more permanent shops and craftsmen

found in association with marketplaces that sponsor periodic vendors and stalls as

well. Sauce's association with production in combination with a clear drop-off

outward from ring 1 for many of the openly exchanged artifacts suggest that

Sauce's political elites supported and possibly encouraged market exchange

located at the center or somewhere nearby.

The association of centers with craft production activities begins in the

Late Classic period, when Stark (2007a, b) suggests that spatial associations of

more intensive craft production with local centers could indicate polity

sponsorship of specialization and market exchange. Political processes beginning

with local elites in the Late Classic continued with possible newcomers at Sauce,

who may have been motivated to seek out markets and market taxes as alternative

sources of revenue and prestige in addition to or perhaps as an alternative to

traditional land and labor (Stark 2008a). Despite evidence for market exchange

centered at Sauce, the spatial dataset indicates that there are complications to

seeing Sauce as a sole central place. Sauce's political elite may not have had

exclusive control of market exchanges in the region, based on the concentration of

higher amounts of several different categories of materials in households in ring

4. Instead, the details that emerge from SAP indicate that there is considerable complexity in the exchange of different products that defies simplistic models. It is likely that as our methods for detecting and evaluating exchange mechanisms for individual products improve, the economic complexity of small centers will be recognized as commonplace, rather than the purview of major centers that have tended to attract more economic research, such as Teotihuacan.

Sauce as a Central Place

What was the precise nature of Sauce as a central place for market exchange? For solar market expectations (Smith 1974) administrative or political boundaries for Sauce would have determined the movement of goods and consumers. If Sauce was a simple solar market, then we might expect that the boundaries of fall-off patterns for different central places would intersect but not significantly overlap in the fall-off patterns of separate categories of goods. In other words, one solar market might produce Black-on-Orange pottery for the populations within its boundary, but these products would not be found in the nearby solar market zone (except perhaps in extremely low amounts). Abstract models for solar markets are useful for thinking about general spatial trends, but boundaries for products were probably never impermeable. The complexity of exchange systems and consumer choices will produce overlap in products in specific and often unexpected ways (i.e., we won't necessarily know a priori which products were attractive enough to inspire acquisition over larger distances).

For Sauce, many of the decorated pottery types show a steady decrease from Sauce outward through rings 4 and 5. Therefore, it seems likely that for some of the pottery types, Sauce was the central place source, while for others, such as the *guinda* complex, some other social and economic reason is required to explain the higher concentrations in ring 4. Because there is no clear gradual drop-off for the *guinda* complex from rings 3 and 5, as we find for the other artifact categories for the rings around Sauce, I do not think the evidence supports the existence of another competing central place. It is possible that the pottery spatial patterns could be the results of different chronology. It may be that some of the *guinda* complex dates to a later period than most of the other decorated pottery types within the Middle Postclassic period (A.D. 1200-1350). Detailed evidence from the chipped stone dataset lends support for the existence of a contemporaneous zone of higher acquisition in ring 4 and some amount of independent exchange within all rings.

All of the SAP rings had some amounts of primary and secondary production indicators for obsidian blades, although the highest amounts were in ring 1. This indicates some amount of blade processing and production away from the Sauce center in the form of local knappers or itinerant specialists. Additionally, based on the ratios of blade segments (after De León et al. 2009), there is some evidence that whole blades were being acquired in two places, rings 1 and 4. Given that most of the evidence for blade segments supports the interpretation that medial blade segments were being exported from the Sauce center (Heller 2000) and that most primary production evidence is found near

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Sauce, it makes sense that whole blades would be associated with ring 1 and Sauce. The finding that whole blades were also possibly being acquired by residents in ring 4 could suggest that they were elites, yet the residential collections in question are not associated with either higher mound size ranks or even with more abundant pottery. This may not preclude elite residences or that special activities were associated with residences in this area that required different chipped stone inventories. At this point, because there is no clear evidence for another competing central place (although I cannot entirely rule it out) the interpretations that best fit the current findings are that ring 4 residences had larger inventories based on social status, residential sizes, or special use needs (or a combination of all three factors).

In summary, it is likely that market exchange was encouraged by Sauce's political elites. Furthermore, the increase in craft production association with Sauce indicates that it was the primary location of market exchange and probably had an associated marketplace. Sauce is associated with several different kinds of craft production and craft activities, rather than simply one (such as chipped stone). Other centers in Postclassic central Mexico, such as Otumba, demonstrated that multiple craft specialization was ;located within the urban center, which housed an urban marketplace (Nichols 1994: 185). Other Postclassic towns, such as Huexotla and Xaltocan, focused more intensively on community-wide specialization such as agricultural production and lapidary work, respectively; Huexotla's and Xaltocan's economic specialization indicate that the scale of market exchange was large enough to foster interdependence among

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towns. At this time, it is not clear that the same level of community specialization

was taking place in Sauce (Brumfiel 1980; Charlton 1994, 1991). The size of the

Sauce polity is unknown and the western half of the center is occupied by the

modern town of Sauce, making size estimates challenging. Based on the

monumental architecture left in Otumba, for example (Charlton 1994), the

differences could be related to scale. Sauce appears to have been smaller than the

towns I've compared it to in central Mexico. For now, Sauce's local craft

production and exchange suggest that the scale and intensity of local market

exchange and economic integration was less here than for towns in central

Mexico.

Social Dimensions of Market Exchange

Some enigmatic patterns were identified by the network and spatial

analyses. The statistical methods used in identifying differences between the

empirical network distributions and the network simulations were designed to

identify departures from the underlying pottery distribution. Most of these

departures were expected to indicate pottery that was more restricted. However,

the methods also indicated that one particular type of pottery, Black-on-Red

Incised, showed a more even distribution among residential collections than one

would expect based on the total pottery distribution.

Every residential mound collection appeared to have a little of this pottery

type, despite its overall counts being low (only 138 sherds). There are some

higher quantities within ring 1, and within ring 4 some probable elites identified

by higher mound size ranks had higher amounts of Black-on-Red Incised.

Generally, however, abundant residential collections didn't have more Black-on-Red Incised. Also, there was no obvious association with mounds from the higher or lower mound size ranks among all rings. What could explain this pattern? Given the counts, the even spread could be a statistical accident, but the network simulation offers support for this degree of evenness occurring very rarely due to chance. Black-on-Red Incised was something that every residence had, but in small amounts.

One possibility to account for the relatively even spread is that these vessels were more highly valued for special occasions or for activities not correlated with household size. If that were true, it could help explain why this type, although relatively small in counts, is present in many residential collections. Black-on-Red Incised is one of the more elaborate and distinctive members of the *guinda* complex, with incised lines outlining, on top of, or very near the black paint, with a lot of variation among the motifs. Due to the fragmentary nature of the pottery, it is impossible at this point to evaluate the iconography of the designs found on Black-on-Red Incised. Future studies that included whole or partial vessels from excavated contexts could help explain why these vessels were apparently important. The potential social importance of this pottery type based on the evenness of its distribution was identified as a result of the network simulation.

The Political Implications of Spatial Patterning for Restricted Exchange

Restricted exchanges were expected to be the result of social network exchange, which could include processes like elite gift exchange, elite patronage

networks, kin exchanges, and house-to-house exchange. Only a few artifact types were identified as restricted in access. These included Dull Buff Polychrome and some scarce artifact categories, specifically, figurines and incense burners. Dull Buff Polychrome showed restricted access based on the results of the network simulation. However, the scarce artifacts were identified as being restricted only by their association with collections from larger residential mounds (1-3) in the outer rings (4-5). Therefore, both spatial and contextual information are required to help decide which social networks could account for the observed restrictions.

The spatial and contextual associations of the Dull Buff Polychrome suggest that it was restricted to political elites within the Sauce center and to higher status residences in ring 4. The Postclassic "cookie cutter" figurines were scarce, but they too showed an association with the Sauce center and with higher status residences in ring 4. The incense burners, although not temporally diagnostic, also show higher densities in central Sauce and association with higher status residences in ring 4. Finally, the figurines show some overlapping association with Dull Buff Polychrome, though this may simply be the result of their association with ring 1, since 5 of the 9 figurine pieces were found in the Sauce center.

What social and political configuration could explain the spatial patterns and socioeconomic associations of these artifacts? The associations of these artifacts with residences in ring 4 may be the result of a higher concentration of elite residences. The residences from ring 4 show a combination of higher amounts of items obtained through market exchange and items that were

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restricted. At this time, I cannot be certain that the observed restriction for figurines and incense burners reflects anything other than low counts. However, the Dull Buff distribution is sufficiently unusual to support its restriction or preferential access.

Dull Buff Polychrome is found within all rings, but its relative amounts among collections are disparate enough for its empirical distribution to never match the network simulation results. Also, high densities of Dull Buff are found in some collections that did not have abundant Postclassic pottery but did have higher mound size ranks, possibly indicating that the rank category captures a component of socioeconomic status separate from collection abundance. Dull Buff Polychrome could have been exchanged through elite gift exchange, but given the remarkably high densities of this type in a handful of residences it seems likely that these vessels could also have been particularly curated and used by occupants of these residences rather than circulated.

Commercialization in Sauce from a Mesoamerican Perspective

For the purposes of my study, I defined commercialization as the availability of an item or items for sale through market exchange. Items can move in and out of commercial availability, meaning that local producers, consumers, and political elites help decide which products are openly available through market exchange and which are circulated through social networks or banned from trade altogether, for instance through sumptuary laws (Appadurai 1986; Kopytoff 1986). Therefore, the commercialization of an economy is more a matter of scale, based on how many of these products are openly available for

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sale. As M. Smith (2004) describes it, the concept of the degree of commercialization measures the proportion of items within exchange systems that are openly available through markets versus those that are restricted.

A high degree of commercialization was noted as an important aspect of Postclassic Mesoamerican political economies described by Smith and Berdan (2003). As explained in Chapter 2, the specific circumstances leading to this high degree of commercialization are not precisely known, although there are several important theories. Blanton et al. (1993) argue that the increase in commoditization of many different artifacts, including luxuries that are not archaeologically visible (Smith 2003b), was the result of market development in the absence of state control. However, Garraty (2006) makes a compelling case that markets and state development evolved together in Postclassic period central Mexico, based on evidence from the expansion and contraction of plainware pottery production and market exchange. In this newer interpretation, elites may not have been the sole impetus for the market forces, but markets were something that they could and apparently did opportunistically exploit (Garraty 2006:241-243). This model of economic development as a result of both governmental and social forces may not be unique for Mesoamerica. More recent studies on economic development have demonstrated that both social values and state practice are an integral part of economic development processes, not contrary to them. Hudson (2010: 17) suggests that private and public commercial enterprise developed through the governance of the temple institution in Mesopotamia. Hudson (2010) posits that this growth was the result of a system of religious

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values embodied in a central authority (the temple) that supported and sustained the long term growth of commerce.

For Veracruz, Stark (2007b) proposed that the association of craft production with centers beginning in the Late Classic period was probably the result of political strategies that supported and possibly even sponsored market exchanges as a way of promoting prestige and power outside of traditional land-holding and labor control. There is a cultural break between the Late Classic and Middle Postclassic period for the area (Stark 2008a), so we cannot say that there is continuation of an established local tradition and consumer interest in the products that were being produced. However, a process similar to the one described in the Late Classic period (Stark 1999a, 2007c) could have occurred in the Postclassic where prestige items, such as decorated ceramics, escape elite control precisely because they attract social interest, leading to general consumption.

By the Middle Postclassic period, the highly decorated pottery types of great value, based on labor production costs, were being openly exchanged through markets associated with Sauce. The apparently wide distribution of pottery, chipped stone, and some of the scarce artifacts over the 55.41 sq km study area suggests open commercialization. Elaborate pottery, even the rarer varieties such as Tres Picos Polychrome, were apparently available to residences from all socioeconomic levels and at locations away from the center. Although pottery is not the most luxurious item that was available in Postclassic period Mesoamerica, these decorated bowls demonstrate that some of the nicer

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nonperishable items were commercialized. In the following section, I discuss

evidence for the specific set of political and social circumstances that probably

contributed to the development of a high degree of commercialization for Sauce.

Small Polity Dynamics and Exchange Systems

In most parts of the world, the concentrated interests of dense urban

populations are probably what created the initial framework for market exchanges

(Blanton and Fargher 2010). For Mesoamerica, a combination of state policies

and political situations helped support market systems. By the Late Postclassic

period, an active market system that further developed the fungibility (or mutual

substitution) of products was actively encouraged by the policies of the Aztec

state. For example, Cummins (1995) describes how a local community recounted

that they were expected to sell slaves to purchase the specific tribute requirements

for the Aztec state. Slaves were therefore substituted for the luxury goods, such

as gold, featherworking, etc. that were the specific tribute requirements for that

community. Tribute demands and taxes by the Aztec state encouraged and

exploited community craft specialization and regional specialization (such as the

requirements for cotton from areas where it could be grown) but they also fully

exploited and encouraged the use of the market system to obtain wealth

commodities from subjects through processes of mutual substitution (Berdan

1985).

Aztec state policies were not the only source of support for market

exchange. The interaction and demands of the small polities (in comparison to

previous periods) of some areas of Postclassic Mesoamerica helped encourage

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market development. Small polities and city-state dynamics are directly related to the growth of commercial exchange (Hansen 2000); the same is true for Postclassic central Mexico as well (Smith 2003c: 37). During the Mediterranean Bronze Age, small polities (and some regional states) engaged in complex interregional trade systems in which consumer and supplier demands existed alongside elite gift exchange and the elite interest in prestige goods acquisition (Knapp 1993: 340-341). Centers on a scale similar to Sauce were the local context in which Postclassic period commercialization could have occurred in northern Veracruz (Gutierrez 2003; Ossa 2000; Zaragoza Ocana 1999), and in southern Veracruz both in the Tuxtlas and the Catemaco valley (Venter 2008). Small polity dynamics, which include competition, decentralized political regional control (or multiple centers), and often the sharing of a common set of symbols could provide a good fit for understanding Sauce's case (Hansen 2000).

Political Competition. The combination of the investment of local and possibly newcomer elites in trade and local exchange networks in Sauce was probably important in local market exchanges in south-central Veracruz. As Stark (2008) suggests, if the Sauce political elites were newcomers to the region, they would have had incentives to support markets as a means to prestige and income in competition with other older political elites in adjacent territories. Another center may have been located nearby (though, as stated earlier, it was not detected in the area despite some reconnaissance on the part of both PALM and SAP crew members), and could have been competing with Sauce's political elites for control over market revenue. Elsewhere, many of the wars among the city-states of

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Renaissance Italy were over the determination of trade routes and many of these city-states directly competed with each other's urban markets (Hay and Law 1989). Alternatively, independent market centers could have been founded earlier with administrative control exerted by political elites in the Postclassic period, as was the case for the Aztec empire (Garraty 2006). Although the current data are preliminary, it is likely that competitive and opportunistic policies on the part of Sauce's political elite played some role in commercialized market development, even if they were not directly administering exchange or responsible for founding it.

Local Commoditization as a Social Process

Most anthropological researchers recognize that exchange systems have their own cosmologies, or overarching systems of socially imbued value and meaning (Sahlins 1994). Unfortunately, this conceptual framework has been associated with the substantivist side of the substantivist/formalist debate and not considered within the context of market exchanges. In considering the valuation process, Sherratt (2004) describes a situation in which the social value of particular goods is institutionalized through increased investment in their production until they take the form of commodities for the Near East, Europe and the Mediterranean. For example, Sherratt and Sherratt (1991) trace the cycling of bronze material objects from luxuries to commodities in the Mediterranean Bronze age trade. Sherratt's (2004) conception of commodities as materialities of social values offers an intriguing way of considering how and why commoner households and elites support specialization and increased exchange.

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We have well-documented examples of this process from the Maya region. Freidel et al. (2002) describe the associations of rulership with spondylus shell for millennia, supporting the subsequent development of shell beads as currencies that were used in increasing amounts in Postclassic period Yucatan. The process Sherratt (2004) describes is not necessarily one way; items can move out of the category of commodities and are often contested as such even in societies with very developed and commercialized economies. Such was the case of the Triple Alliance Empire in which some specially endowed materials were prohibited from all but high noble use (Umberger 2010). Here, I am suggesting that the commoditization of fine ceramics in Veracruz provided incentives for elites and regular householders in the form of a social resource. Fancy decorated pottery (at least to some degree) could have represented a form of materialized social resource that appealed to elites (for the finest objects) and was also present in less fancy decorated vessels, and its acquisition encouraged less powerful and wealthy household participation in its production and exchange. The feedback cycle of production and increasing exchanges is a key part of the cycle that led to market development.

There is a good deal of complexity in these cycles of market development. Conflicts are likely among people acquiring socially important items, resulting in the creation of imitations or cheaper versions, such as the creation of cheap knock-offs of prestige items in the modern world. In greater Tikal, Fry (2003) used a careful attribute analysis of pottery serving vessels to identify a range of quality characteristics identified for Ik complex vessels. Furthermore, higher

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quality Ik complex vessels were found in much higher frequencies in the large

architectural groups associated with elites within central Tikal and also in a minor

center that may have had special relations with elites from central Tikal (Fry

2003). In this case, it appears that consumers could and did have access to

differential quality vessels within the same complex (Fry 2003). Competition

probably went further than the differential acquisition of quality goods. There is

often a conflict between open market exchange and controlled access which takes

place between the creation of commodities and the creation of inalienable goods.

In systems in which commoditization is taking place, we might expect resistance

on the part of elites who attempt to restrict access to particular items or classes of

goods. In this case, the restriction of Dull Buff Polychrome may not be part of a

previous exchange system but part of an ongoing commercialization process in

which elites resist open access of all items. A huge part of how we might

identify these tensions requires more contextual information about how items

were displayed, used, and acquired. Although we lack this kind of detailed

information for south-central Veracruz, we have some information about the

social context of local exchange systems.

As described in Chapter 2, the local social context of exchange systems

probably played an important role in how economic organization took shape.

Sauce's postulated population of newcomers probably did not come into the area

with an entirely new set of exchange practices. The evidence suggests that

elaborate pottery local to Veracruz were already established as items of value and

importance. For the Postclassic pottery complex, there are material

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interpretations (and pottery imports) that allude to the traditions of other regions

(such as the Cholultecoid polychromes like the Complicated Polychrome

variants), but the appetite for finely crafted ceramics pre-dates the marketing of

these types. It could be that an independent and enthusiastic set of consumers

existed among the local populations already, not all of whom were identified by

their residences as either political elites or having high socioeconomic status.

Wide distribution of decorated ceramics was identified in the Classic period for

the WLPB (Stark 1999), offering support for the interest of the local population.

It was through consumers similar to those Classic period populations that the

existence of multiple markets that were at least partly independent of political

control by either Sauce or other local polities came into being. A similar situation

has been described for market development in central Mexico, where a system of

regional markets was established prior to the formation of the Triple Alliance

Empire (Blanton 1996; Hodge and Minc 1990; Nichols et al. 2002). In this case,

the development of markets and commercialization was at the instigation of

ordinary households; based on the current data, Sauce's political elite did not

direct local development.

Methodological Contributions to the Archaeological Study of Exchange Systems

Exchange systems are socially, culturally, and politically embedded

(Granovetter 1985). This basic observation perfectly encapsulates the difficulties

involved in identifying key elements of distribution, consumption, and

production. One important methodological contribution of Hirth's (1998)

distributional approach for identifying exchange systems is that it points towards a way of analytically separating the mechanism of exchange from spatial patterning. Expectations in the distributional method rely on differential distributions of goods among a network of households based on whether an item is restricted or not. As described in Chapters 1 and 2, these network expectations allowed me to consider the social and political aspects of consumption and distribution that would otherwise be difficult to distinguish in the regional datasets. By developing specific expectations and methods for network exchange, I was able to identify exchange mechanisms and add aspects such as spatial patterns and the socioeconomic rank of residences as separate steps for a more complete analysis.

In this section, I describe two specific methodological contributions that were developed in this study. The first is a method for analytically separating exchange mechanism from spatial patterning with separate considerations for each artifact type. The second is a statistical approach to modeling exchange mechanism differences. The implications of these two major contributions for advancing the archaeological study of exchange systems will be discussed and described below.

Analytical Contribution

The first major contribution is my explicit separation of spatial expectations from network expectations and the formulation of a means to evaluate artifact categories and items individually (e.g., individual pottery types). This separation is based on Hirth's (1998) insight that distributional differences

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are the key to identifying different exchange mechanisms. Hirth's innovation did not require the analyst to ignore spatial data; Hirth's (1998) original configuration incorporated spatial elements in his analysis and comparison of residential inventories in Xochicalco. However, the conflation of spatial and distributional data during analysis could result in confusing separate distributional networks with spatial patterns. An example of why this happens can be demonstrated through a brief description of previous approaches that employed spatial and aggregate statistical methods to identify markets.

Several applications of Hirth's ideas employed statistical methods that were explicitly spatial (Garraty 2009; Minc 2006). These approaches also applied aggregate statistical methods in which the characteristics of *groups* of artifact types were compared among analytical units. These analytical units ranged from individual households to concentric rings or archaeological sites. Using an aggregate index based on the relative percents of artifact types that make up all the decorated pottery for each individual unit's inventory means that differences in *spatial* distributions among artifact types will be inextricably linked to consumption, production, and exchange mechanism that the index also measures. This conflation of spatial and distributional patterns could be useful if one expected very similar consumption and wealth for all units (as if they were all buying the same proportions of things at the same store). However, as Hirth (2010) and many others point out, even in cases where goods are being acquired via market exchange, there are differences in consumption among consumers based on wealth and preference. Although the aggregate measures are generally

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useful for identifying overall homogeneity over a wide spatial region, they are not as useful for identifying and separating social and political aspects of exchange from an exchange dataset at the scale of just one polity. Simply put, homogeneity is not the expectation for a market economy; although it might be the expectation for a state run economy that successfully rationed per capita, such as soldiers' quarters, but only under very specific sets of circumstances.

In considering each artifact type (insofar as it could be identified) separately, I was able to identify differences in how the individual pottery types were exchanged and consumed. Although most of Sauce's pottery types were openly exchange through markets, they did not share the same spatial distribution among all of the residential collections. Some of this pattern could be the result of sampling, but it could also show differential preferences or use. M. Smith (1999) expects some households to have greater amounts of certain pottery types based on wealth, even with market exchange. Also, one might expect that households closer to a marketplace to show greater heterogeneity based on their greater access to a variety of artifacts not necessarily based on wealth and social status.

My results indicate that Sauce had complicated exchange systems, because those residences that had larger percentages of elaborate pottery types did not have large percentages of *all* of the elaborate pottery types, nor did all of these residences have higher socioeconomic rank. Small scale variations in the different pottery type distributions suggest that the application of an aggregate method using an index of the relative percents of all pottery types per household

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unit could be problematic for diagnosing market exchanges. By considering all the residential collections on a per category basis, I was able to evaluate network expectations for the type of exchange mechanism separately from the spatial micro-variations among collections due to preferences, or, in the case of the *guinda* complex, the existence of a group of elite residences in ring 4.

Network Simulation Approach to Identifying Exchange Mechanisms

Hirth's insights on how commodity flows could be identified using consumer inventories led me to devise a statistical method to define different kinds of exchange beyond the spatially based ideas that have been the staple of economic geography. The network simulation approach for considering alternative exchange mechanisms was developed to quantify and compare different expectations for network exchange among the different pottery types without resorting to an arbitrarily chosen probability significance level to decide what kind of exchange was most likely. I designed a Bayesian-inspired Monte Carlo simulation to evaluate network exchange alternatives introduced in Chapters 1-2, in order to generate probabilistic expectations for open access versus different forms of potentially restricted access in my dataset. The network analysis allowed me to establish different probabilistic outcomes as a *relative* measure of exchange.

Generally, Bayesian statistics provide an alternative to the classical methods of statistics for hypothesis and confidence interval testing by allowing the user to affect statistical probabilistic outcomes by using information about the

data distributions that were previously acquired (Iversen 1984:70). For my Bayesian-inspired network simulation, I did not apply Bayes's theorem directly. Instead, I built the variations of different sample sizes of the separate residential mound collections into a model using the underlying Postclassic pottery distribution to handle uncertainty regarding the true proportions of the pottery types for each of the separate residential mound collections. I used the Postclassic pottery sample size of each residential mound collection to weight the random sorting of each pottery type's sherds into all of the residential mound collections. I used the underlying population distribution of Postclassic sherds as the network simulation's known distribution. This tactic separated sampling issues for each residential mound collection from the global totals of each pottery type whose network exchange was being tested.

I devised two methods for evaluating the expectations for open versus restricted network exchange that were outlined in Chapter 5. One method measured the population variance for an individual pottery type among all of the residential mound collections. The second measure considered the ratio of a pottery type's presence in residential mound collections compared to the set of all collections. Each method captured a distinctive aspect of the distributional approach that Hirth (1998) originally proposed. In the network simulation, variance and the pottery presence to total residential collections ratio were used to evaluate network exchange expectations for the SAP dataset. The interpretation was straightforward; I assumed that if access to a particular pottery type is open, then the random population of many iterations of the pottery type in its known

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amount would not be much different from its empirical population. However, if the empirical pottery type tended toward restriction, then the random distribution would differ from the empirical results.

In summary, the network simulation results matched the visual distributional method that I adopted as exploratory analysis. The advantage of using a network simulation is that it allowed me to fully test my visual hunches on the basis of probabilistic reasoning and defend the results using methods of statistical modeling.

Conclusions and implications for future research

The models described here are very simple, but the underlying framework of the simulation allows one to factor in the sample size of the residential collections and to try different levels of sample cutoff rates for different subsets of residential collections. Although I may not have identified the best mathematical methods for modeling the underlying exchange systems, by attempting to abstract and quantifying the expectations, I have provided a conceptual framework for others to modify and improve. Future attempts could include many more refinements and additions to consider ways of quantifying expectations for different kinds of exchange systems. Even though mathematical modeling will not replace descriptive efforts at understanding the immense complexities of exchange, the results of this study have shown that some aspects of exchange expectations can be quantified and give interpretively consistent and valuable results.

Implications for the Study of Exchange Systems in Complex Societies

Trade and exchange systems have been recognized as important factors in sociopolitical and economic development in complex societies for a long time. By the 1970s, active interest in trade research was advanced by much new thinking about how to study trade archaeologically (Sabloff and Lamberg-Karlovsky 1975), while recognizing the complexity of social, political, and economic factors involved (Adams 1975; Renfrew 1975). Scholars have emphasized the role of elites in demanding the production and acquisition of goods that had special social status attached to them (Sherratt 2004) and the role of a prestige goods economy in developing economies and increasing political complexity (Schortman and Urban 1992). For example, in the Bronze Age Mediterranean, prestige goods could become commodities and vice versa, and the circulation of materials (even gifts) tended to advance commercial exchange as the scale of trade and mediums of transfer increased across political boundaries (Knapp 1993:339). However, advances in economic development rarely seem to have been the result of a coherent strategy either on the part of managing or consuming elites or on the part of the average consumer. Instead, more recent syntheses of the ancient Old World economy (Manning and Morris 2005) support the view that a combination of strategies and overlapping exchange systems provided the context, rather than any one simple explanation, for how commercial market exchange developed.

New descriptions of the conflicting motivations, differential consumption, and subsistence strategies of the different players in creating these ancient

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exchange systems (Manning and Morris 2005) are based in part on new research focused on multiple categories of goods and the identification of local consumers within different sites (Knapp 1993:341). For example, Liverani (2005: 54-54) describes the co-existence of administered trade via state control of exotic products and free market trade in luxuries by independent merchants in the Near Eastern Bronze Age. In the Bronze Age Mediterranean, trading strategies combined entrepreneurial impulses, politics, and social status for merchants, rulers, and market consumers in different times and places, depending upon historical contingencies (Knapp 1993). The potential for theoretical advance based on describing more specific circumstances of exchange complexity is great. As Bernard Knapp (1993:341) remarks, trade and exchange systems predate the strongly centralized polities, and are probably the result of socioeconomic and political processes at a much smaller scale than the Weberian models of "political economies."

Multiple scales of analyses, both domestic and regional, are therefore required to understand exchange and economic organization. There are good examples of this approach from the Old world. For example, Ian Morris's (2005: 107) work on economic growth in the Aegean uses evidence of large increases in Greek household inventories dating from 800 to 300 B.C. to identify sustained economic growth. Morris's analysis takes into account possibilities of changing attitudes about consumption of luxury goods and depositional (and post-depositional) processes before reaching his conclusions. Morris's (2005) focus on

household roles in larger regional economic processes provides a good model for advancing theoretical research on the intersection of the two.

Recent approaches to household production in Mesoamerica (Brumfiel and Nichols 2009; Hirth 2009b) represent attempts to locate the impetus for socioeconomic changes and innovations in the household. In particular, Mesoamerican research has a strong focus on households and domestic residences, as well as site level research, which has made regional and local studies to identify economic, social, and political networks feasible (De León et al. 2009; Feinman and Nicholas 2004, Fry 1980; Hirth 1998, 2008; Minc 2006; Santley and Hirth 1993; M. Smith 2003, 2010; Stark and Ossa 2010; West 2002). This dissertation follows in this tradition to apply new concepts and develop new methods for identifying different exchange mechanisms.

One of the major methodological findings of this dissertation is that the separation of network expectations for exchange mechanisms from spatial distribution and contextual information, such as socioeconomic rank, allowed for greater precision in determining how exchange systems were organized. This analytical separation allowed me to develop and consider nuanced political and social aspects of how the exchange systems were organized. The details that have emerged from the Sauce study show that a considerable amount of variation and diversity existed for local exchange, even for a relatively small center away from the large urban zones of central Mexico. It is likely that future research will identify similar variation as our methods for modeling exchange systems advances. My results indicate the periods and regions with small polities are an

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active ingredient in economic changes advancing market exchange. Furthermore, the further refinement of methods that analyze this variation will allow researchers to make theoretical contributions to the study of economic organization by helping them identify different developmental circumstances in complex societies.

More recently, researchers have gone beyond the old debates to describe the immense complexity of exchange within the states and empires of the ancient world, eschewing generalized explanations for economic development. Studies on ancient economies in complex societies have to contend with often conflicting historical records on economic transactions and their social context (Stark and Garraty 2010). For example, there is an identified bias against describing state administration of trade in the Aegean Bronze Age, where Grecian records do not discuss the impact of likely state policies and administration, instead focusing on merchant activities (Morris 2005:91-92). Relatively advanced market exchanges and complex exchange institutions have been identified within Augustan Rome (Storey 2004; Temin 2006), overthrowing old models that held Rome's economy as static and lacking major financial institutions and risk management (Garnsey and Saller 1987). Dietler's (1990, 1997) archaeologically based studies of Roman Gaul have refined and in some cases refuted previous views of the one-sided nature of Roman trade in goods for slaves with its provinces. For the city-states of 13th to 14th century Italy, the old bias towards urban zones has shifted to include settlement patterns to show how the land tenure systems in the countryside overlapped with social and political processes in economic

development (Hay and Law 1989; Spufford 2002). All of these studies emphasize the potential of more comparative archaeological studies that rely on local models of economic organization to identify development trends.

Directions for future research

In this thesis, I present some new methodological approaches that promise the future development of more ways of modeling the intersection of political, economic, and social actions and how these can be studied via household inventories (Garraty and Stark 2010; Hirth 2010). Similar approaches could be developed for tackling exchanges that are more difficult to identify archaeologically such as tribute, taxes, theft and plunder, among many others (M. Smith 2004:84). The new analytical ideas and methods developed in this dissertation in combination with the brief review of recent work from the Old World point to important conceptual breakthroughs to identify different components of these complex exchange systems by examining units smaller than amorphous political economies or elites alone. These innovations will allow researchers to get closer to modeling the real decision-making actors behind economic organization and to evaluate the mix of competing factors and often unintended consequences of exchange, trade, and production. Archaeologists can use the new arsenal of quantitative methods in combination with humanistic and qualitative interpretation to understand how exchange systems might appear archaeologically and develop new theoretical insights based on comparative datasets.

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APPENDIX A
PALM POTTERY CHRONOLOGY AND POSTCLASSIC TYPE

DESCRIPTIONS

PALM Time Associations by Pottery Type

The PALM pottery associations for all periods are listed in the following tables (A.1- A.7). The chronological relationships were based on pottery seriation using data from both residential excavations and systematic surface collections from the PALM projects. These lists were further refined using a statistical unmixing method applied by Garraty and Stark (2002) to the PALM dataset. The results of the cumulative research projects and these statistical methods were used to tabulate groups of pottery types associated with the following general periods.

Table A.1 General Preclassic Pottery Types.

Ceramic Code	Description
2a,b,d DIBW	Differential black-white
2c DIBW	Differential black-white enhanced
3a,b DIBO	Differential black-orange
3m,n DIBO	Differential black-orange, orange slipped
4 DIBR	Differential black-red
60d, m-p RBL	Red-on-black

Table A.2 Middle Classic Pottery Types.

Ceramic Code	Description
5a STRK	Streaky, blotchy, or brown-fired
5d STRK	Streaky, blotchy, or brown-fired, with plastic decoration
6a BLAK	Fine-medium textured black
6d BLAK	Fine-medium textured black, with plastic decoration
6e MAPO	Streaky-black: Matte and polished areas
9l,m RBU	Exterior banded or multi-banded red-on-buff, medium textured
11o,t ROR	Red-on-orange, fine-medium texture, exterior banded or multi-banded
15 ARAR	Armas Unpainted, Armas variant
36a,b,c,d,f NEG	Red slip, orange slip, double slip, or bi-slip, negative resist
36e NEG	White slipped negative resist
40a SLSL	Orange-over-white double slip

Table A.3 Late Classic Pottery Types.

Ceramic Code	Description
20 HPUN	Heavy coarse punched
33a NTP	Estrella Orange
38a,b,c,d,e,f FGRY	Fine grey
43 (and 34e) MOUN	Mojarra Orange-grey
44 CHIN	Blanco White
45b,l TUXT	Tuxtlas Plychrome

Table A.4 General Classic Pottery Types.

Ceramic Code	Description
10m RORS	Medium textured red and orange bislips
16b PARO	Red-orange, pattern burnish
17a ACMO	Acula Red-orange, Monochrome Variant
17b ACMP	Acula Red-orange, plastic decoration
37i WHTS	White slip, medium textured orange-to-buff paste, glossy slip
55b LACA	Orange-over-white double slip with incision not bounding
54m WR	White-on-red combed
9k,p RBU	Rim band or misc, red-on-buff, medium textured
9a,b RBU	Coarse textured red-on-buff
60c TEMP	Unusual temper
11a-c ROR	Coarse tempered, red paint on orange slip
11m,n ROR	Red-on-orange, red rim band or miscellaneous, fine-medium texture
13 PRBU	Polished red-on-buff
16a PARO	Patarata Coarse, Red-orange variant, no decoration
16c PARP	Red-orange, plastic decoration
17c ACMO	Acula Red-orange, highly polished
22b CAOB	Caoba, very fine to ultrafine texture
22m CAOB	Caoba, medium to coarse texture
8m,n ORBU	Medium textured orange-on-buff
8a,b ORBU	Coarse textured orange-on-buff
56a BLWH	Black-on-white
54h FNEG	Red bands on varied slips, possible false negative
40f SLSL	Orange-over-white double slips and red bi-slip
40d SLSL	Red-over-orange double slip
23p,q RWH	Red-on-white, fine-textured, rim band or misc
28a ORWH	Orange paint on white slip
30a RED	Medium to coarse textured, red slip

Ceramic Code	Description
30b REDP	Medium to coarse textured, red slip with plastic decoration
30m RED	Fine to medium textured, red slip
30n REDP	Fine to medium textured, red slip with plastic decoration
30s PRED	Polished red
34c FINW	White Paste
37s WHTS	White slip, fine textured

Table A.5 Middle Postclassic Pottery Types.

Ceramic Code	Description
7g, some e BLRD	Black-on-red Incised
9n,o RBU	Interior multi-banded red-on-buff
10n RORS	Interior multi-banded red-on-orange, with red bi-slip
18b ACEN	Acula Red-on-orange, incised frieze motif
23n RWH	Red-on-white, multi-banded both sides
24 WBR	White framing black-on-red polychrome
26 WBR	Splashy black and white-on-red
30o RFRI	Polished red incised with frieze motif
41a BUFF	Hard buff
45a DULL	Dull Buff Polychrome
45d TPIC	Tres Picos Polychrome
45f MONT	Cerro Montoso Polychrome
45h,i BAND	Banded Polychrome
45j FRIS	Frieze Polychrome
45k ISLA	Isla de Sacrificios Polychrome
57b BLOR	Fugitive black-on-orange rim band and interior horizontal bands
57c BLOR	Fugitive black-on-orange, complex designs
58 HARD	Hard Plain
60f PINC	Incised Buff

Table A.6 Late Postclassic Pottery Types.

Ceramic Code	Description
9v RBU	Interior crossed bands
42x PLBR	Coarse plain with brushed exterior
42y PLBR	Medium to fine textured plain with brushed exterior
53a TEXM	Texcoco Molded
57m BLOR	Aztec III style black-on-orange
61a TEFI	Texcoco Fabric Impressed

Table A.7 General Postclassic Pottery Types.

Ceramic Code	Description
1a-g COMA	Buff comal
7m-o LPOLY	Coarse polychrome
7s COMP	Complicated Polychrome, lacking white underslip
7t COMP	Complicated Polychrome, with white underslip
7w MISC	Miscellaneous for Complicated Polychrome, Black-on-red or Black-and-white-on-red, or Sellado with laca band
19 ESCO	Cream to black Escolleras Chalk
21a,b,c,m,o,p SELL	Fondo Sellado
35e,f QUIA	Quiahuistlan
38m FGRY	Fine grey with Postclassic forms or finish
45c MPOL	Miscellaneous Polychromes
57a BLOR	Black-on-orange rim band only
7a,b,c,d,f, some 7e BLRD	Black-on-red
11p,u ROR	Interior multi-banded red-on-orange

Postclassic Pottery Type Descriptions

The Postclassic pottery type descriptions included in this Appendix were written by Dr. Stark and are included in Stark's (2008) codebook, which includes descriptions of all types and variants. The descriptions I include here have very minor annotations based on SAP collection observations. As noted in Chapter 5, the PALM pottery typology is generally based on a type-variety approach. Therefore, with some exceptions, the types are classification devices aimed at answering specific questions and not "emic" types (Stark 1995:17). Generally, the PALM pottery types are based on contrasting manufacturing steps, and the variants within each type are based on different decorative elements within surface treatments and painting designs. Stark (1995) remarks that the attributes within the PALM typology were aimed at capturing production steps that would

offer insights into the place and date of manufacture. The full description of these attributes was written by Stark (1995; 2008). I enclose only the annotated versions of the Middle Postclassic and general Postclassic types listed below in the same order as Tables A.5 and A.7. These annotated versions do not include all of the associated letter variants for each type.

Middle Postclassic Pottery Types

7g, some 7e. Black-on-Red Incised (BLRD)

Paste. Sand tempered, very fine texture. Paste near the surface is light colored, buff to orange-buff. The grey core is usually pale.

Surface Treatment. Red slip, but rarely there may be only red paint instead of a red slip. One sherd may have a metallic wash over the red slip, possibly indicating a rare case of continuation of a Classic period technique.

Decoration. Incised lines outlining, on top of, or near black paint. Predominantly decoration is on the exterior. There is great diversity in the motifs, suggesting rather complex designs. Design subsets could not be readily discerned and the different individual elements co-occur in a variety of ways: (a) jagged line, made in an area bounded by another line; (b) volute, inside a bounded area formed by other line(s); (c) "scales", inside an area bounded by an incision; hatched lines, bounded by an incised line; (d) a loop with a central element (may occur in a series), may have added central line, often these motifs are subrectangular and in a series in a row; (e) concentric circles, sometimes occurring as a series in a banded area; (f) fringed volute; (g) frieze-like band; (h)

little bits of background area hatched or scratched out; (i) interior horizontal bands, plus decoration on the exterior, some are 2 or 3 lines at least, not very wide; (j) fringed lobes; (k) double-line incising, i. e., instead of one bounding incision line, there are two. Some sherds show a banded or register-like design layout. Others seem to have large, free-standing somewhat curvilinear or flowing forms. Generally the latter have parts or segments which have some detailing of extra lines or added elements.

Form. Straight convex forms are the most common for PALM (38 rims), with straight to outflaring sidewalls less common (25 rims), and a few others: 5 restricted convex, 3 open convex, and 2 large outflaring necked jars. Two solid half-and-half handles were noted, with one set definitely parallel to the rim, not placed vertically. On one necked jar the incised black area occurs on the body of the vessel. Several sherds are relatively thick and have little curvature, possibly from fairly large vessels, although often such sherds have an interior slip, which would not be expected for jars. The high ratio of nonrims to rims plus the tendency toward a rather stout sidewall and low curvature on some sherds suggests rather large vessel forms, with a considerable decorated area. SAP showed a general similar pattern of form frequencies although many sherds could not be categorized by vessel form since they were non rims.

Figure A.1 SAP Black-on-Red Incised.
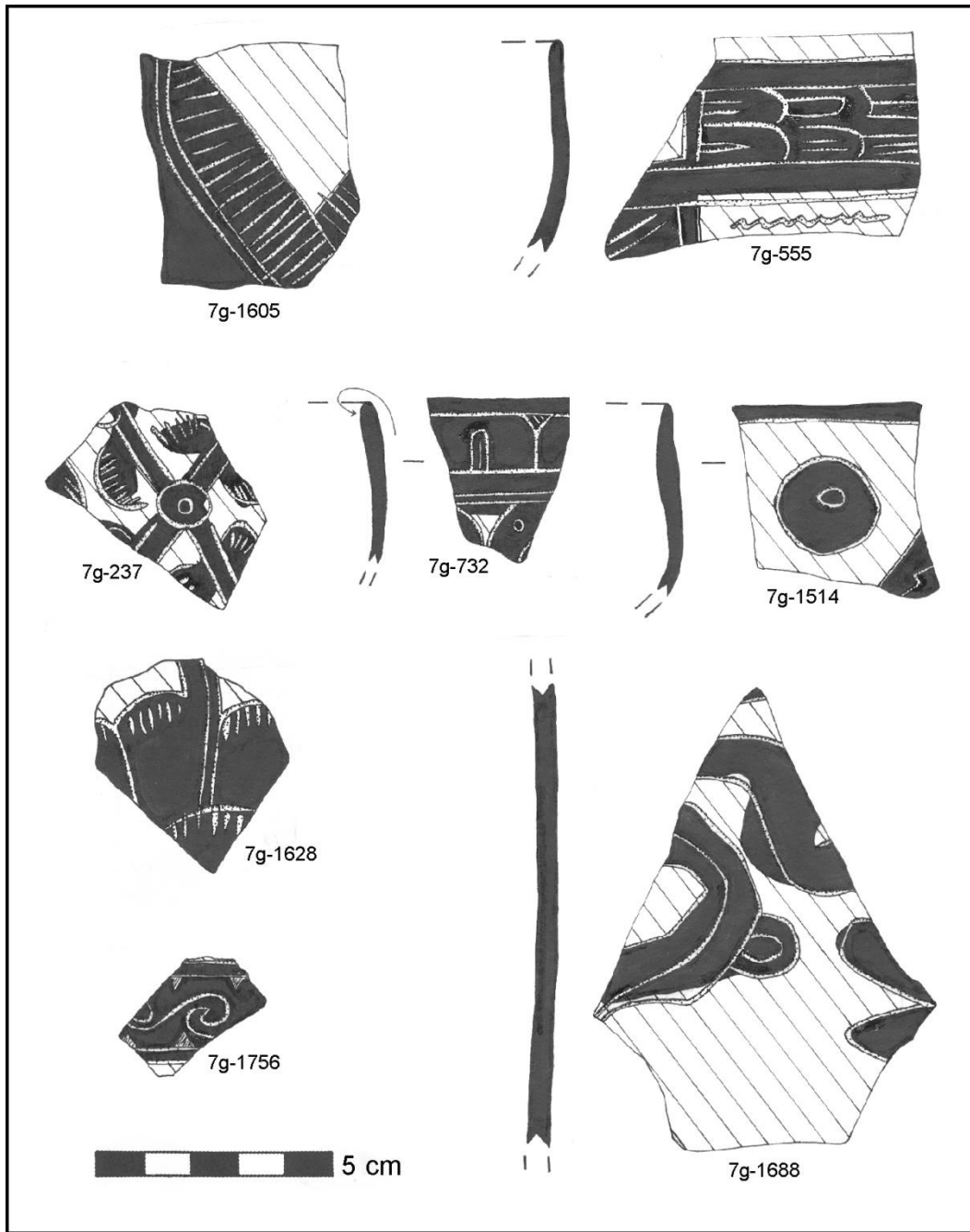
Figure A.2 PALM Image Archive Drawings of Black-on-Red Incised.

9n, o. Interior Multi-banded Red-on-buff (RBU)

Paste. Paste is orange-buff, compact but coarse to medium textured, fired hard. These paste attributes likely reflect a Postclassic period date.

Surface Treatment. Poor surface finish.

Decoration. Two or more parallel red bands on interior (includes red rim band). Always horizontal when sherd can be oriented.

Form. Vessels tend to be straight convex to open convex forms. There are also several straight to outflaring sherds. PALM found one small outflaring necked jar. The vessels have relatively thin walls. .

10n. Red-on-Orange (RORS)

Paste. Medium textured tempered paste.

Surface Treatment. Sherds tend to be well smoothed. Orange slip on the interior, red slip on the exterior.

Decoration. Horizontal red bands on the orange slip. All are interior bands except one dubious sherd.

Form. There were six straight to outflaring forms but two were straight convex forms.

18b. Acula Red-on-orange, Incised Frieze Motif (ACEN)

Paste. Fine-medium textured tempered paste.

Surface Treatment. Orange to red-orange slip on one or both sides. Well smoothed. Degree of polish is a basis for subdivision.

Decoration. Fine incision-engraving occurs on the exterior red area, usually clearly a wide red band at rim with the repeating frieze motif clearly represented. Lines may delimit the painted area. The interior has multiple red horizontal bands (if the sherd is small the interior may have only one red band showing). Sometimes the exterior has one (or more?) thin red horizontal bands below the band which has incision. There are several cases on larger sherds and this composition may have been fairly common. In two cases the added band was outlined by incised lines. Several sherds are classified here because they have interior banding and a fragment of exterior incising with red-on-orange, and no other category is likely. Three elements comprise the frieze. (1) A stepped or zig zag line occurs, and in two cases double zigzag lines are present. (2) pendant and vertical triangles are arranged like "stalactites and stalagmites". In one case the triangles alternate. Most sherds are small and only onr triangle is evident. (3) A scroll or "s" shape is scratched as a stylized, simplified volute. There are a small number of sherds which might display variants of the frieze or else more highly stylized versions.

Form. Open convex and straight convex forms predominate, with the former slightly more common.
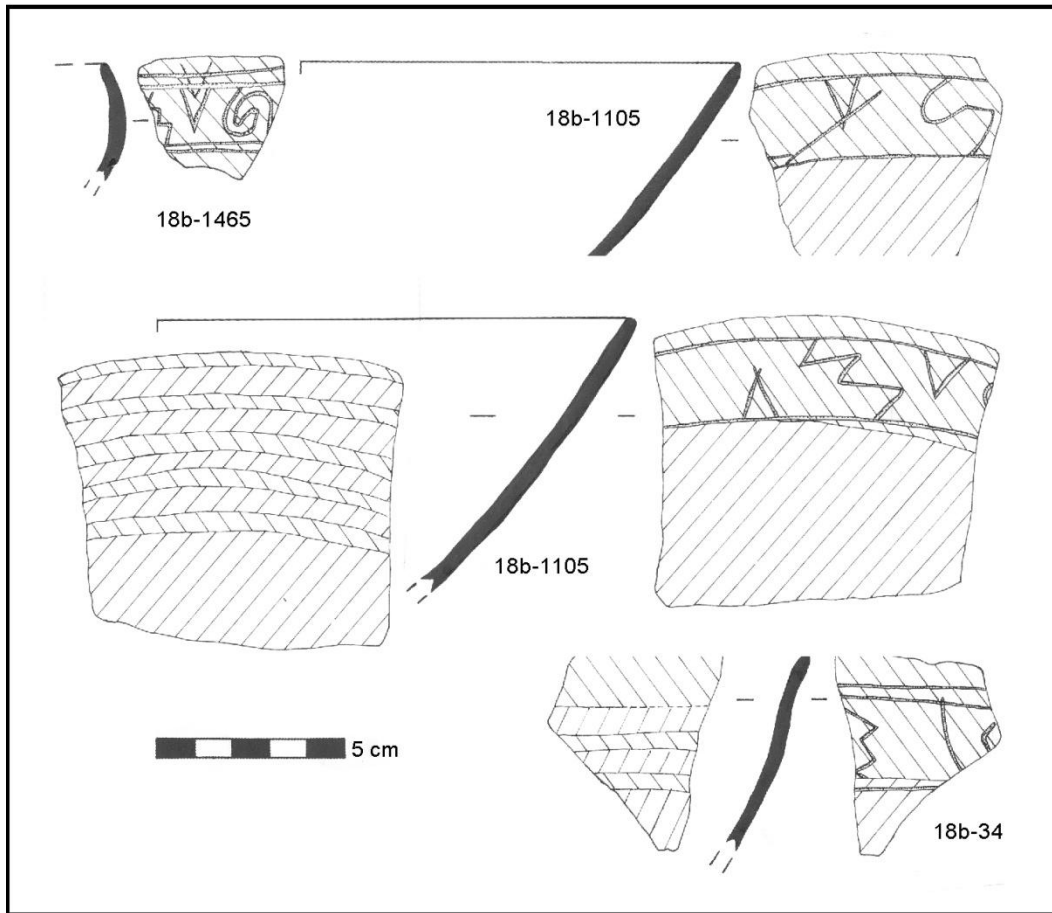
Figure A.3 PALM Image Archive Drawing of Acula Red-on-orange, Incised Frieze Motif, code 18b. Exterior views to right, interiors to left.

23n. Red-on-white (RWH)

Paste. Medium to fine textured paste. Although rather coarse temper particles are common, they are not very abundant. Among PALM sherds examined more closely **for** paste: 1 has sparse, fine-medium sand temper, 2 have medium sand, and 2 have medium-coarse sand. One has a relatively even, regular break, while 4 have an irregular, rough break. The texture was slightly gritty and fine in one

case, but moderately gritty, medium in 4 cases. Two had cores greater than 2/3 of the section, 2 had 1/3 to 2/3. Cores were dark black in 1 case, with 3 dark brown.

Surface Treatment. The white slip, applied to both sides in almost all cases, was rather thin and streaky. It barely whitens the sherds from the orange-buff paste surface color. Rarely white slip is missing on one side. Smoothing was poor. Both sides were usually unpolished but occasionally had slight polish.

Decoration. Multiple horizontal red bands on both sides. Only two sherds definitely have four interior red bands (in addition to the rim top band). Two display three interior bands (plus rim top). Generally if the sherd is big enough there are two or three bands (plus rim top). The rim top red band appears to be universal. The exterior seems to have more widely spaced bands than the interior and therefore likely fewer, though this could be confirmed only in two or three cases due to the size of sherds. There are one or two cases also where there may not be any difference in spacing. Where there was a difference in spacing, the exterior had one fewer band. There is at least one case in which the exterior white slip only goes down halfway on the side and is then bounded by a red band; the remainder of the vessel exterior is smoothed and slightly polished buff. There are one or two other possible cases of the same pattern. In only one case was there definitely a design beyond the horizontal bands: a slanting stripe running from the bands toward or across the base. Two other cases have bulges on their horiztonal bands, likely sloppy overstrokes where the two ends of the band did not match up well. Mainly the bands range between 2 - 8 mm, but one body sherd has three tiny lines only 1 mm across. One sherd appears never to have had a

white interior slip, but has the same triplet of red bands on the smoothed orange-buff paste, while the exterior has the white slip and red bands. The quality of the painting of the lines is rapid and slap-dash, with inconsistent band width, variable spacing, and careless initiation and termination of lines, leading to trailing or deviant slops of paint.

Form. Exclusively small convex bowls, with three form variants: (1) a small straight to open convex bowl, (2) the same form, but tending to thicken slightly at the lip, which is rounded, and (3) similar to the first form but tending to straighten toward the lip or to slightly evert at the lip. These variants are present in about equal numbers. Lips are predominantly regular, but may thicken slightly and symmetrically in a rounded fashion. Rare lips include one interior bevel, three top bevels, and two that thin very slightly toward the lip.
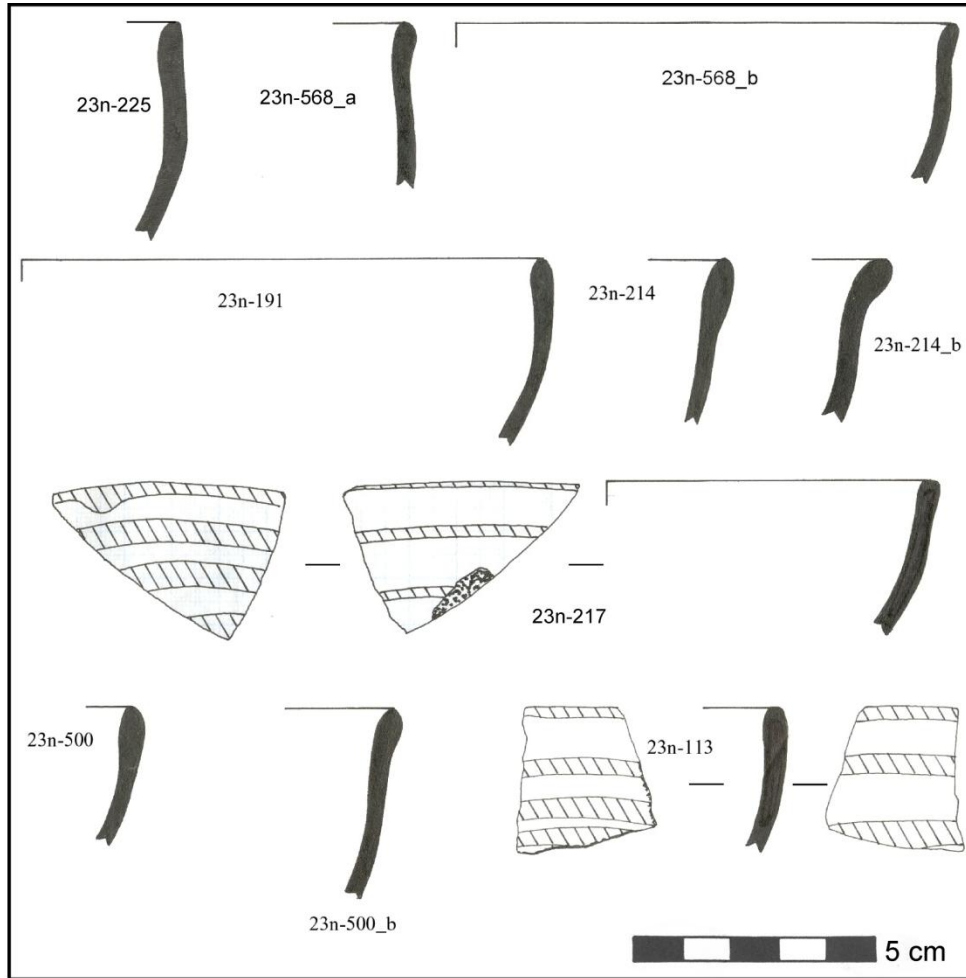
Figure A.4 PALM Image Archive drawing of red-on-white multi-banded on exterior and interior, code 23n. Interiors views to left, exteriors to right.

24. White Framing Black-on-Red Polychrome (WBR)

Paste. Sand tempered, very fine, smooth feeling, like code 7a-f. Paste is light colored on the surface, buff to orange buff. The gray core is usually pale.

Surface Treatment. Most are slipped a dark, polished red inside and out, sometimes specular. A few have a polished pink, orange, or white interior slip. The interior may have a black rim band, but usually just the slip. Proportions of

slips recorded for bowls of medium to small size and from those rim sherds with better preservation of design: 4 white interior slip, 36 red slip both sides, 14 interior orange slip. Ten sherds have unslipped interiors and may be from large jars.

Decoration. Black painted decoration is outlined by a thin line of white to grey paint; almost always on the exterior. Rarely a small area is filled in white in addition. One case lacks red slip, but has a wide red band on the exterior, with an orange slip on both sides. Decoration on its red band is the same as on red slips. Only four rims had some interior design. Out of all the body sherds 5 had interior designs. Only two sherds show designs on part of the base exterior.

Form. Thin walled. Most common were straight convex forms, or straight convex with a slight straightening or flaring out at the rim. Rare are three out-flaring forms, one shallow convex vessel, one shallow convex straight vessel, and ten possible large jars. Four sherds likely present a flat, continuous curve base with an unslipped base exterior.

Figure A.5 Framing White-on-Black-on-Red Polychrome.
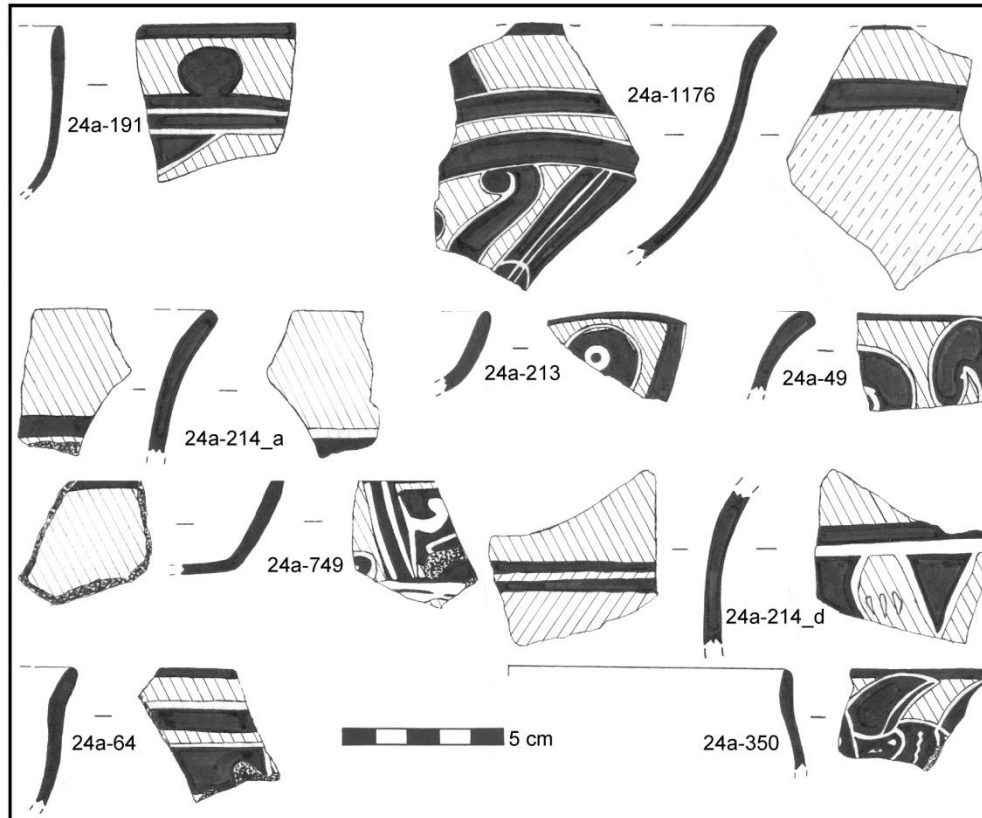
Figure A.6 PALM Image Archive drawing of White framing Black-on-red Polychrome. Exterior views to right, interiors to left.

26. "Splashy" Black-and-White-on-Red (WBR)

Paste. Sand tempered, very fine textured, smooth on the surface. Paste is light colored on the surface, buff to orange buff in color. The gray core is usually pale.

Surface Treatment. Polychrome with red slip on both sides in most cases and generally polished. Sometimes an orange slip occurs on one side.

Decoration. Black paint on the side with a red slip, with thick white applied apparently in wide lines or filling areas. White paint is often patchily preserved. Similar to code 24 except no fine lines---white is thicker, and applied generously.

Form. The forms present are very similar to code 26a: 77 straight convex, 19 straight to outflaring, 10 restricted convex, 4 open convex, and one large outflaring necked jar.

30o. Polished Red Incised Frieze (RFRI)

Paste. Paste is fine textured, tempered, like codes 30s and 7. Paste is usually fired buff toward the surface.

Surface Treatment. Red slip on the exterior; the interior may be red slipped or have red horizontal bands on buff or light brown paste. Sherds tend to have traces of polish but only a couple are as polished now as code 30s.

Decoration. Fine line incised frieze on yhe exterior. Very thin incision, although the band bearing motifs itself may be up to 2-3 cm wide; elements of the frieze may be incised in simplified, hasty "shorthand." See code 18b for a description of the frieze motifs.

Form. Vessel walls are relatively thin. Forms include straight to outflaring (7), restricted convex (3), and straight convex (1).

41a. Hard Buff (BUFF)

Paste. Hard fired, compact, pale orange to buff, like Mojarra Orange-grey in color of paste. Fine sand temper.

Surface Treatment. Hard, very smooth on the exterior, sometimes with polished and smoothing tracks visible, such as those found on comales (code 1a-g) and hard ware (code 58).

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Decoration. Thin-line designs incised when the clay was moist. The designs occupied a very large field on the exteriors. The designs are open, with looping lines, but, despite some large sherds, it is impossible to get a clear idea of the designs.

Form. Small jars, slightly turned out lips that also form the short neck. Some have small "pushed up" clay ridges under the neck from manufacture. The curvature and thickness of several of the body sherds suggest jar forms. There are few rims, and they may be from large open jars or big bowls.

45a. Dull Buff Polychrome (DULL)

Paste. The paste is fired a buff or light orange tone toward the surface, usually with a thick medium gray core. The paste is compact with sand temper, with a medium to fine texture.

Surface Treatment. Buff surface well smoothed. Occasionally there is an orange slip instead of buff surface.

Decoration. White, black, and red painted geometric forms. White is used quite a bit in the designs, neatly applied, unlike code 26.

Form. Predominant forms found in PALM are almost exclusively bowls, almost all open convex forms (122), with 11 straight convex, 1 restricted convex, and 13 straight to outflaring forms recorded. A few turn out slightly at the lip. Forms, where they could be identified for SAP conformed to this general pattern.

Figure A.7 SAP Dull Buff Polychrome.
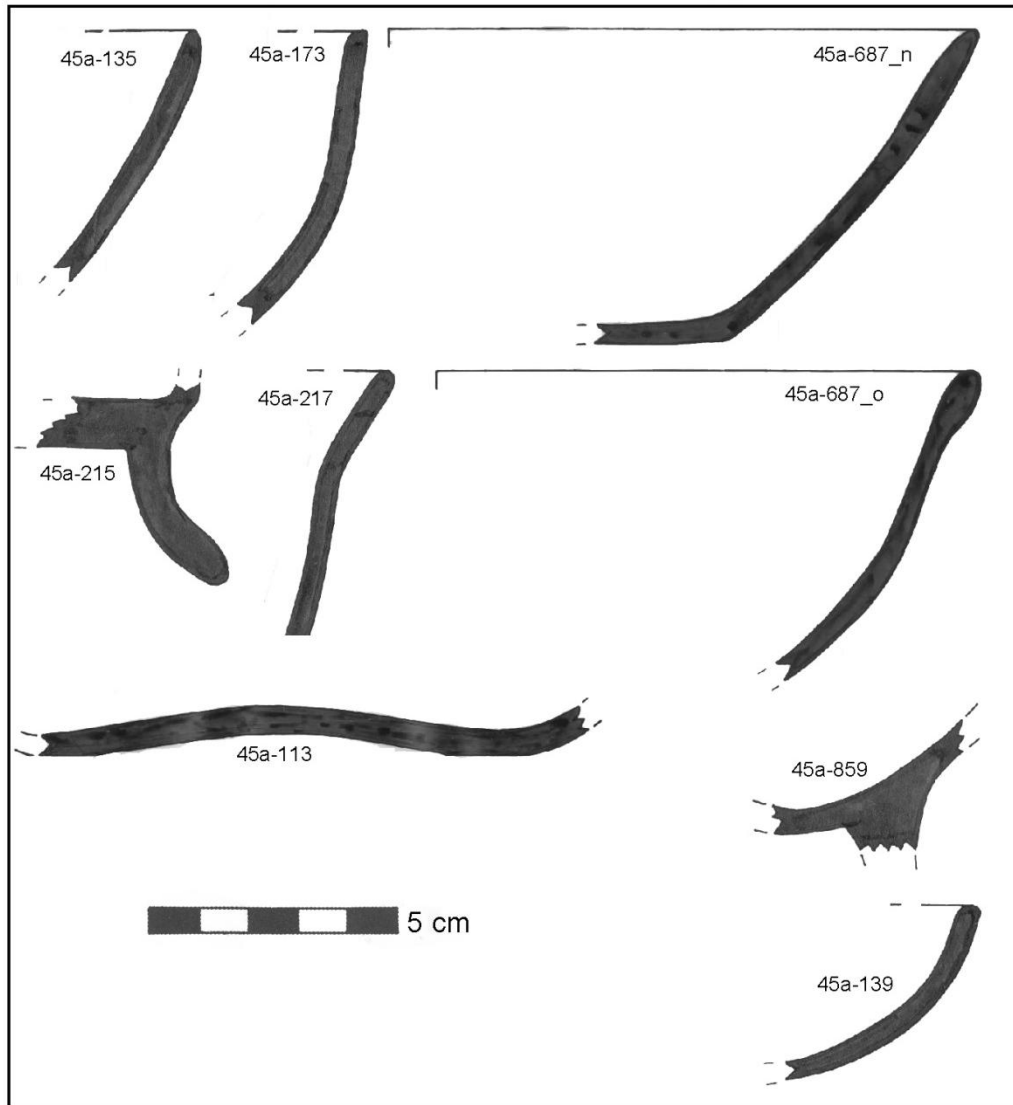
Figure A.8 PALM Image Archive Profiles of Dull Buff Polychrome.

45d. Tres Picos Polychrome (TPIC)

Paste. Fine tempered paste. Paste is fired cream or pale orange.

Decoration. Exhibits dark reddish-brown matte paint or slip (caoba). May also have very dark grey to black paint. Orange paint occurs, usually in bands, with sharp edges. May have fine incised lines.

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Form.   Mainly open convex forms were observed (16), with 1 straight convex, 1 restricted convex, and 1 straight to outflaring. A single "D" lip was recorded, a form more characteristic in several Classic period bowl categories.
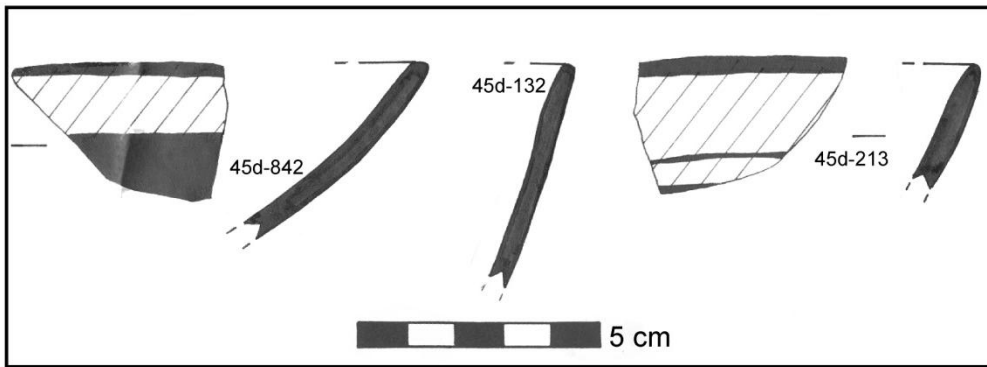
Figure A.9 PALM Image Archive Drawing.

Figure A.10 SAP Tres Picos Polychrome

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45f. Cerro Montoso Polychrome (MONT)

Paste. Fine textured, with very fine temper particles. The paste is fired orange throughout on some sherds, but others have a thick medium gray core and are fired a light orange-buff at the surface.

Surface Treatment. Sherds are very well smoothed. The few examples include an exterior shite slip or paint.

Decoration. Painted designs are on the exterior. The available example are small sherds. One includes a series of white volutes on an orange painted or slipped area with a line of small dark red dots placed on top of the volutes. Another example includes an orange circular form outlined by a dark red line and a row of red dots.

Form. Sidewalls are thin, 3-4 mm. One straight to outflaring form was recorded.

45h,i. Banded Polychrome (BAND)

Paste. Fine to medium textured tempered paste.

Surface Treatment. White slip or orange slip depending on variant.

Decoration. Polychrome with multiple horizontal bands on the interior. Exterior painted designs are variable. In the case of orange slipped variants, the exterior may have a red band and black band. For orange slip the interior has multiple horizontal bands, usually just red but sometimes alternating with black.

Form. Mainly convex bowls occur, with straight convex, open convex, and restricted convex (rare); some outflaring forms were recorded.

45j. Frieze Polychrome (FRIS)

Paste. Fine to medium textured tempered paste.

Surface Treatment. Well smoothed.

Decoration. Miscellaneous poychrome with incised or painted frieze motifs on the exterior. A band around the lip contains repetitive motifs of a stepped line, pendant triangles, and "s" lines. This is a diverse group of sherds, with the frieze as the main characteristic in common.

Form. Only convex bowls occur, with 16 straight convex, nine open convex, and four restricted convex.
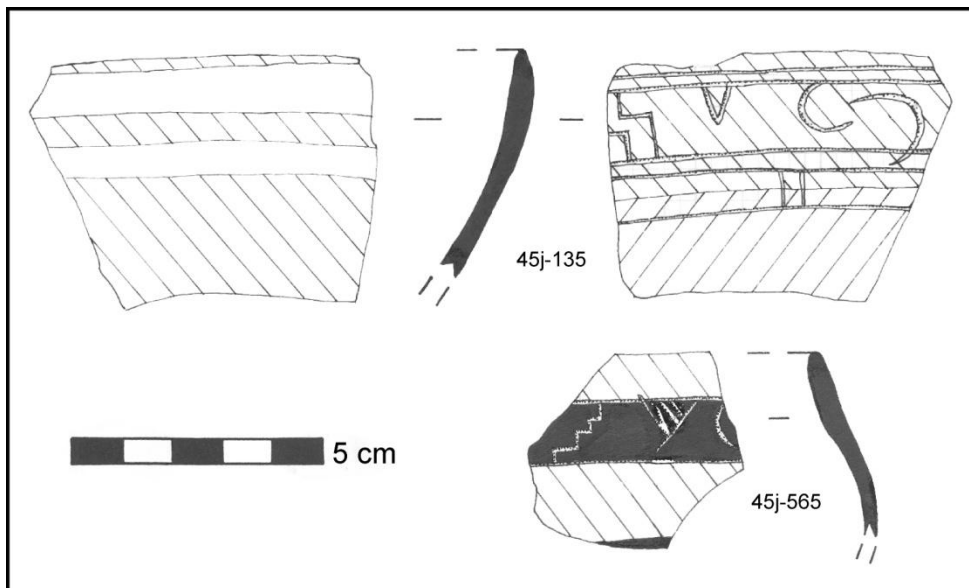
Figure A.11 PALM Image Archive drawing of Frieze Polychrome.

45k. Isla de Sacrificios Polychrome (ISLA)

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Paste. Paste is ultrafine textured, orange or buff in color.

Surface Treatment. Impossible to say based on fragmentary samples.

Decoration. Thick, matte white fills areas formed by matte black lines. Forms of designs are blocky, with subrectangular edges. Designs may occur on the exterior or interior. Bands also occur (i.e., white delimited by dark line but dark paint applied first).

Form. Impossible to say based on fragmentary samples.
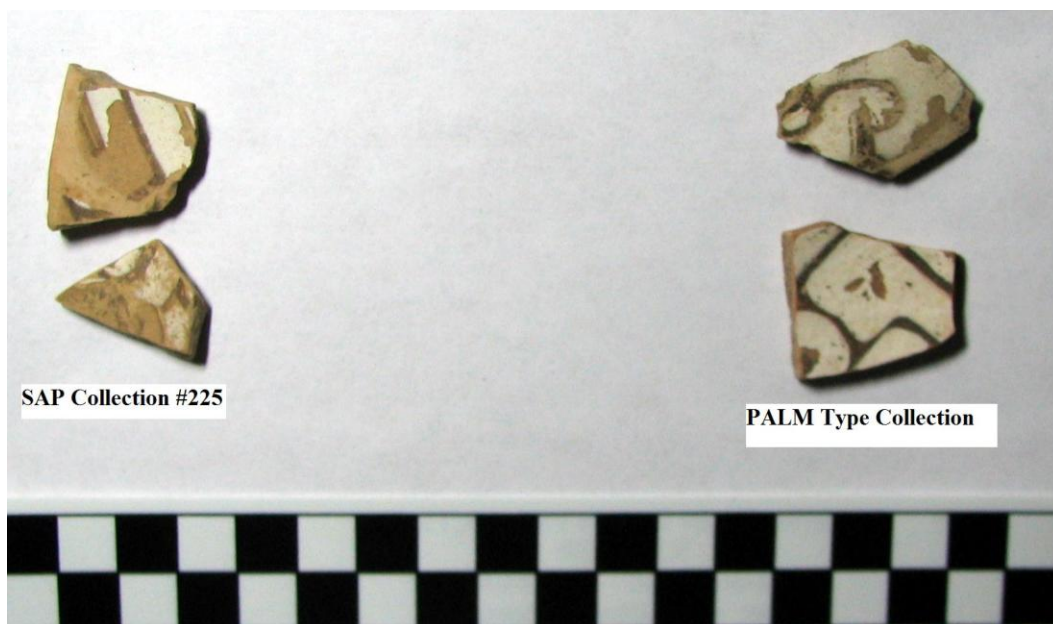
Figure A.12 Isla de Sacrificios Pottery.

57b. Fugitive Black-on-orange, Rim and and Interior Horizontal Bands (BLOR)

Paste. Fine-medium textured, sand tempered paste.

Surface Treatment. Thin, rather pale orange slip. Orange slip may occur on both sides or only one.

Decoration. Black paint, often poorly preserved. Black paint is applied in relatively broad lines and bold designs. Black rim band plus one or more interior horizontal bands. Only rarely with exterior horizontal bands.

Form. Generally forms are outflaring or open convex. No supports were detected.
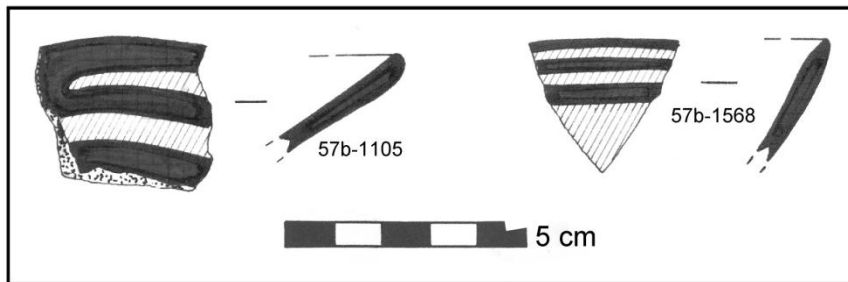
Figure A.13 PALM Image Archive drawing of Fugitive Black-on-orange with interior views.

57c. Fugitive Black-on-orange, Complex Designs (BLOR)

Paste. Fine-medium textured, sand tempered paste.

Surface Treatment. Thin, rather pale orange slip. Orange slip may occur on both sides or only one.

Decoration. Black paint in complex or other designs than just horizontal bands; designs may occur on the interior or exterior. This category applies to designs with any paint besides just a rim band or a rim band plus some horizontal bands. For PALM twelve rims (exterior design) have vertical or slanting short lines

always from the rim band to the first horizontal band. In the case of one rim, there is a single interior horizontal wiggly line, with horizontal parallel lines, and the exterior has one horizontal line. Two sherds have crosshatched lines (one rim interior, one nonrim exterior). Two nonrim exteriors have tiny dots in delimited areas. Two rim exteriors have a band of opposed slanted lines. Two rim exteriors have pendant triangles, in one case within a horizontal space banded by horizontal bands, reminiscent of the frieze band in other codes (see code 45j, Frieze Polychrome).

Form. Generally the 57c forms are more convex than in 57m, often straight convex, seldom open convex. Almost all cases are exterior designs. (Only 6 interior design sherds were noted in Palm 1). One sherd had both.
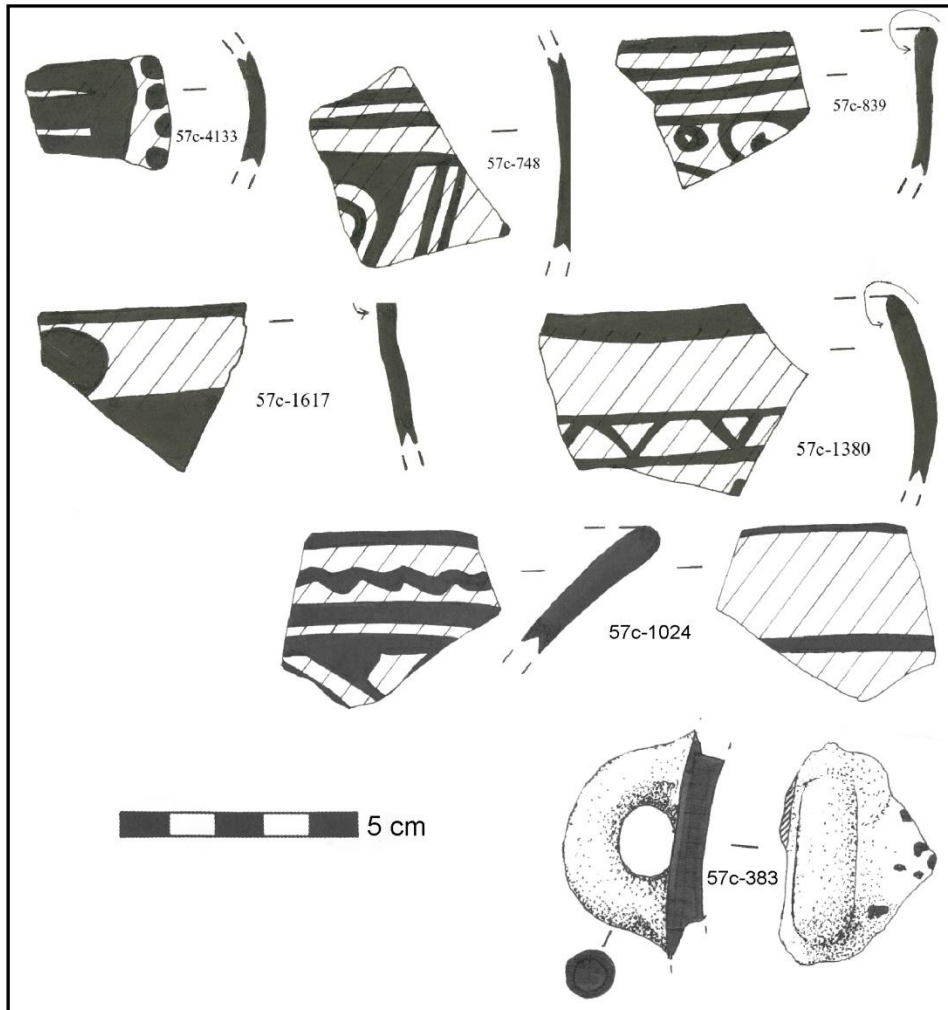
Figure A.14 PALM Image Archive drawing of Fugitive Black-on-orange, complex designs with exterior views on left (except lower right sherd), interior views on right.

58. Hard Plain (HARD)

Paste. Has "Postclassic" paste attributes (see "Comment" section in code 16). Code 58 is fired harder than code 16 utility vessels. Often sherds are hard to break with pliers. Code 58 tends to have very jagged breaks because the hard paste holds the coarse temper better, and it does not pop out as readily. These sherds tend to have well compacted surfaces. Firing is more oxidized, with lack of a core, often buff-brown or orangey tone, but sometimes brick red. The dark

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temper shows up well in the lighter section. The self slip tends to look like faded orange as a consequence of the firing atmosphere. Consistently light buff color for 58a, m. It is not yet clear if the coarse vs. medium-fine paste texture distinction between variants 58a and 58m is reliable or useful. 58p has distinct paste.

Surface Treatment. Smoothly finished, almost silky surface. Many closely related sherds have been placed in code 16m because of the orange slip and streaky polish-induced coloration. The remainder, left under the 58 number, have shiny polish lines (narrow, as on comales), and hard surfaces. Many sherds have self-slip or a layer of finer clay on the surface from smoothing and polishing. Others look more like an orange slip is present.

Decoration. None**.**

Form. About equal numbers of large and small outflaring necked jars ocurr.

60f. Incised Buff (PINC)

Paste. Paste is sand tempered with moderately large particles but they are not very abundant. They are not quite as large as code 32, Mojarra Orange-grey, Coarse variant, particles, nor as dispersed, but there is some similarity in texture. In all the 1502 collection and in about half the other cases, white sand temper particles predominate. Otherwise, they may be rare, with darker sand particles predominating. Overall paste texture falls generally between fine and medium. Cores are usually relatively thick and dark grey. Surface paste is generally fired to a buff or light brown color.

Surface Treatment. Surfaces are well-smoothed and generally slightly to moderately polished. Although occasionally there are tinges of orange on the surface, only one or two really clear cases of orange slip were observed (note in comments on coding form). The occurrences of orange tinges is probably a firing effect on a self-slip or on the finer particles brought to the surface through polishing.

Decoration. Incision execution is quite deep, fairly bold, but generally made when paste was still quite plastic. Three design categories were noted:

(1) pendant ticked rim loops bounded below by incised horizontal lines (27 rims, 1 nonrim). On larger sherds, vertical lines and curving elements occur. This is the most commonly observed design.

(2) Reversed (i.e., croquet hoop) scallops below rim, which also may be bounded by horizontal line(s). In most cases the reversed loops are not ticked (7 rims, 3 nonrims). One has ticks like decoration 1.

(3) other (for sherds lower down on vessel, especially): vertical lines and/or looped, looped and ticked, or curving incised elements.

Form. Convex bowls predominate, mainly straight convex.
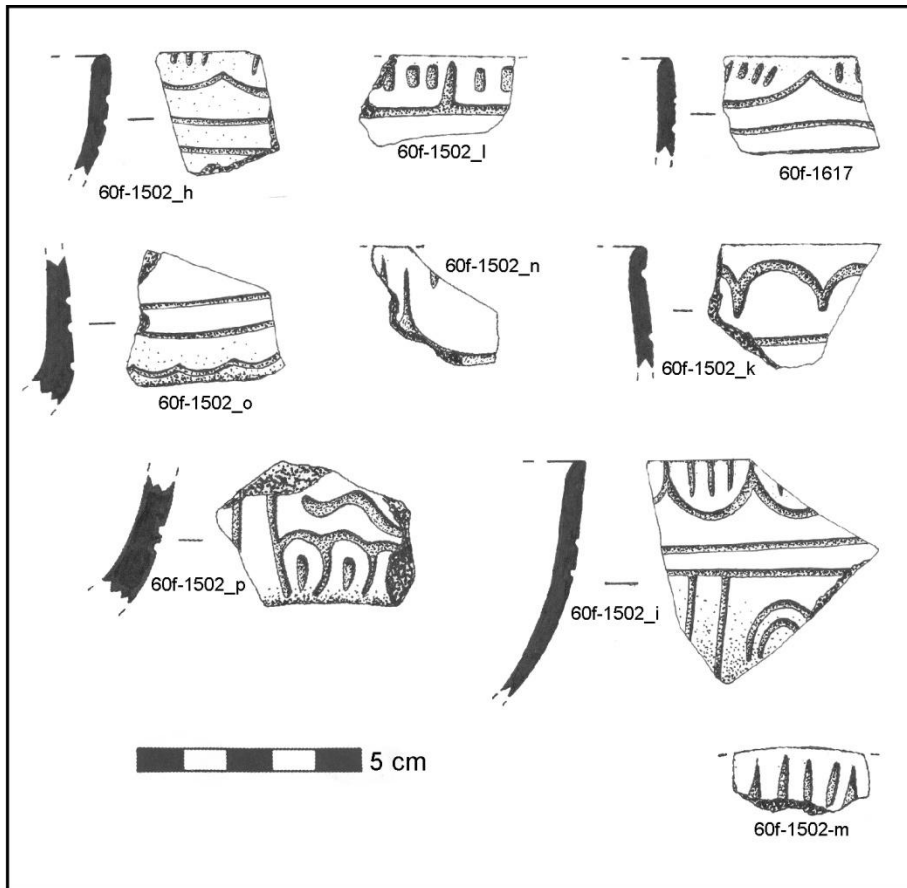
Figure A.15 PALM Image Archive drawing of Incised Buff, exterior views.

General Postclassic Pottery Types

1a-g. Buff Comal (COMA)

Paste. Paste is medium textured and sand tempered, usually fired buff to orange-buff.

Surface Treatment. The interior surface is smoothed and very compacted, with a faint polish.

Decoration. Some variants have distinct polish lines (pattern burnish) that probably were decorative. Some appeared to have an interior incised line, but the scarcity of incision suggests that these lines represented wipe marks. Small

tabular lugs are present for some Palm 1 subdivisions and are treated as decoration because they are small, but they may have been useful to some extent as handles.

Form. This comal is a flat griddle with the lip area slightly inclined upward, often with a slight ridge at the outer perimeter of the base. Relatively thin base and sidewalls are characteristic.
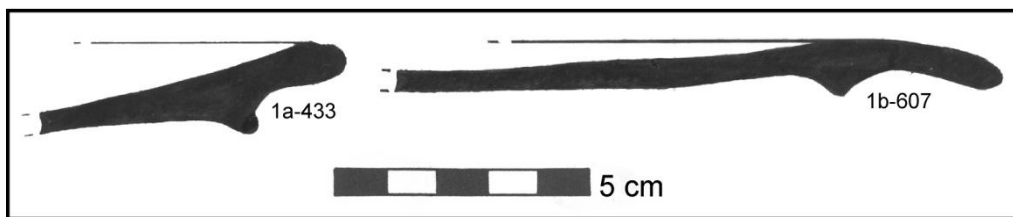
Figure A.16 PALM Image Archive drawing of Buff Comal profiles.
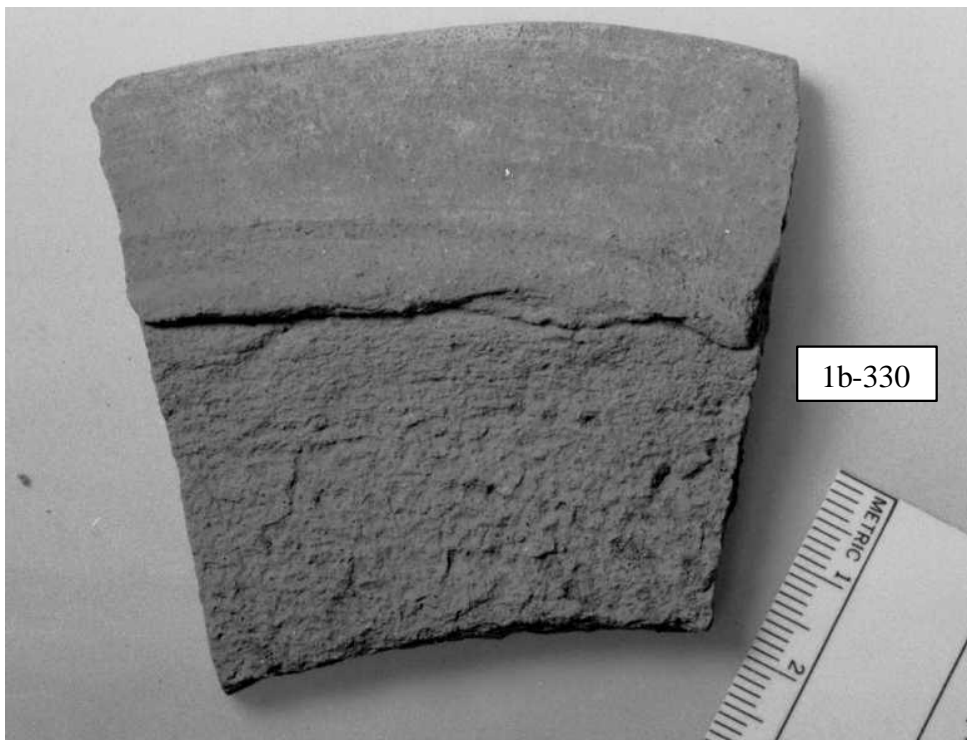
 Figure A.17 PALM Image Archive photo showing Buff Comal base exterior.

7m-o Coarse Polychrome (LPOLY)

Paste. Medium to coarse textured paste.

Decoration. Polychrome painting applied as described below; designs on only one side, generally the exterior. Paint on buff paste. Red, black, orange, or white may occur, but this category does not include black-and-white-on-red slip. Designs are relatively large in scale, so sherds usually present only part of motifs. Paint typically is poorly preserved.

Form. Some rims definitely derive from jars, with some straight to outflaring jars, a large straight necked jar, and some small outflaring necked jars.

7s. Complicated Polychrome, Lacking White Underslip (COMP)

Paste. Fine textured tempered paste.

Surface Treatment. Red or orange slip on the interior, sometimes well finished or polished buff surface. The exterior may be slipped also. When decoration is only on the exterior, usually the interior has a red slip. Slipped and painted surfaces are sometimes well polished.

Decoration. Exterior exhibits complicated designs in black, red, white and orange paint; both interior and exterior surfaces may be decorated, but mainly decoration occurs on the exterior. Sherds are highly variable in appearance because they are part of complex designs. Rarely naturalistic motifs appear among geometric designs.

Form. Straight convex forms are by far the most common for PALM (382 rims), with 62 straight to outflaring rims, 50 open convex, 27 restricted convex, one

tecomate, one composite silhouette, 1 plate, 2 large outflaring necked jars, and one small outflaring necked jar. A single "D" lip was observed, as were 2 hollow supports of unknown form and a solid loop handle. The "D" lip is a characteristic Late Classic form, perhaps therefore indicating a very minimal continuity in pottery technology.

7t. Complicated Polychrome, with White Underslip (COMP)

Paste. Fine textured tempered paste.

Surface Treatment. Sherds have a white underslip, overslipped with red or orange. This category includes both examples with firmly adhering white underslip and others that flaked off easily and often were almost gone. Interiors have a red or orange slip. When the design is on the exterior, often the interior has a red slip. Designs are similar to code 7s. The poorly adhering slip and paint generally seems to have been highly polished, but some firmly adhering cases are too.

Decoration. Exterior exhibits complicated designs in black, red, white and orange paint; both interior and exterior surfaces may be decorated, but mainly decoration occurs on the exterior. Sherds are highly variable in appearance because they are part of complex designs. Rarely naturalistic motifs appear among geometric designs.

Form. Most common in PALM were straight to outflaring forms (35 rims), with 24 straight convex, 21 open convex, 6 restricted convex, and 2 composite silhouettes. Notice that the proportions of forms contrast with code 7s, with its

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emphasis on straight convex forms. Two "D" lips and one serpent support occurred. As noted above, the "D" lips may indicate an extremely scant continuity with Late Classic forms. Among the examples with firmly adhering underslip, there was one nonrim with a mend hole, and one hollow support fragment. Flaky underslip sherds included two outsloping slab supports (not enough present to determine if they were stepped [*almenado*]), one stepped support was present and one outsloping hollow support, a ring base, 8 pedestal ring bases, and a horizontal flat strap handle.

7w. Miscellaneous Polychrome (MISC)

Paste. Fine textured tempered paste.

Surface Treatment. Eroded or fragmentary, likely either Complicated Polychrome or Black-on-red or Black-and-white-on-red; may also include eroded sherds from a fondo sellado sherd with a laca band (21o). . A fragment from this band, heavily eroded, could appear similar to an eroded Complicated Polychorme sherd.

Decoration. Eroded or fragmentary.

Form. No form observations provided for this category.

19. Escolleras Chalk (ESCO)

Paste. Distinctive lamellar, dense, temperless paste. Fired dark grey generally, verging on black, but cream to orange firing variants exist also. Both grey-black

and cream pastes were subdivided by presence and abundance of reddish-brown temper particles, not otherwise identified.

Surface Finish. Polished, silky surface, in many cases with well-preserved surfaces. Sherds generally have an exceptionally smooth feel.

Decoration. Rarely, fine incision and grooving occurred, with one case of red pigment filling.

Form. Composite silhouette bowl and tall annular pedestal bases (23) are common forms, as are vessels with elongated, pinched, vaguely serpentine supports (13). The elongated, piched supports are rather carelessly formed, resulting in a lumpy effect. Eleven ring supports were recorded, also. Composite silhouettes are common (102), as are straight to outflaring walled sherds (72), perhaps the upper part of composite vases.

21 a, b, c, m, o, p. Fondo Sellado (SELL)

Paste. Tempered paste of medium texture, fired orange-buff.

Surface Treatment. Exteriors are unslipped and buff colored. Interiors may be slipped, but slip is applied only to sidewall, not to impressed base.

Decoration. Some variation with painted decorations. Some show horizontal rim band below the rim. In others, a red rim band placed on the interior, then one or two black horizontal bands on the orange slip below (rarely on the red band). Very rarely, vertical black bands descend, or slanting black bands; in the space framed by the two sets of bands, a black spiral or volute may appear.

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Form. Large bold designs molded onto base interior. Curved and "ray" motifs occur. Medium to thick sherds. The main forms are open convex (204) or straight to outflaring (241), likely representing the same basic shape, as convexity is primarily apparent in the lower part of the sidewall, with the upper part relatively straight.

Figure A.18 Fondo Sellado Pottery.

35e, f Quiahuistlan (QUIA)

Paste. Temperless and very fine textured paste, buff or cream in color, rarely with more orange tones. The paste is soft, almost always rather eroded. Consequently, the majority of sherds are so eroded that that the occurrence of paint is uncertain.

Surface Treatment. One case of brownish-red paint over white-to-buff slip on the exterior, but otherwise the sherds are unslipped. Well smoothed.

Decoration. Dark reddish-brown paint, unless eroded.

Form. Very small convex bowls almost exclusively, about evenly divided between straight and open convex. Eleven composite silhouettes are present. Nine supports are small tapered nubbins, with three of them attached to flat bases that join the sidewall in a curving angle.
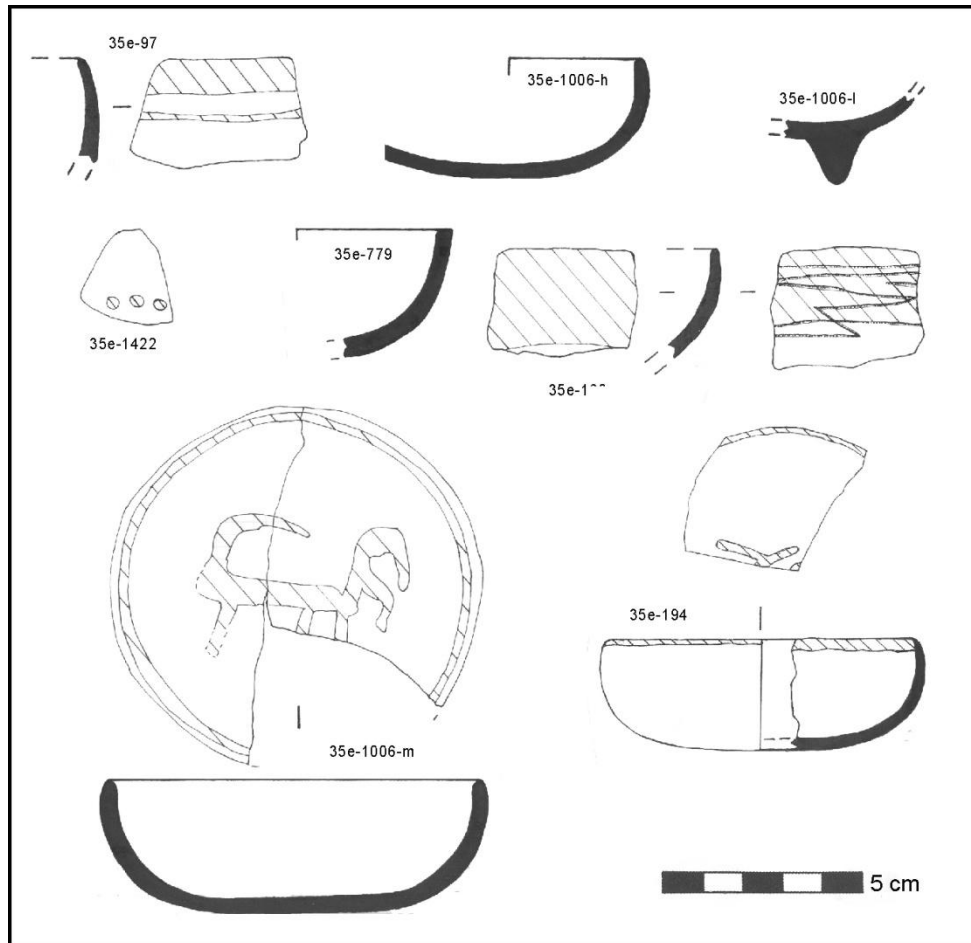
Figure A.19 PALM Image Archive drawing of Quiahuistlan.

38m. Fine Grey with Postclassic Forms or Finish (FGRY)

Paste. Like Prieto Grey-black in paste and texture. Somewhat variable firing and hardness. Some are fired whitish grey, others, black-grey. Some are chalky in paste texture, but some are hard and smooth. A light, "bright" grey color is characteristic. Like the Classic period grey, except usually not the brighter grey color. May also be fired cream colored, with a brown slip or design. Sherds are usually dark grey and lack a definite llamelar structure that would qualify the sherd for code 19 Escolleras Chalk.

Surface Treatment. Polished, resembling code 19 in texture.

Form. Any definitely Postclassic form, such as a serpent support, pinched serpent support, or tall pedestal vase. Sherds usually are relatively thin.

45c. Miscellaneous Polychromes (MPOL)

Paste.   Finely tempered paste, fired orange to buff; several sherds have a gray core.

 Surface Treatment. Polychrome or likely polychrome sherds that do not conform to other categories. White, red, and orange slips occur.

Decoration. Miscellaneous or one of a kind polychromes have red, black, or white paint. In most cases the painted designs are on the exterior, but a few occur on the interior.

Form. Forms are diverse, with 1 tecomate, 2 straight to outflaring, 3 restricted convex, 2 straight convex, and 4 open convex. A single "droopy D" lip was recorded, a form associated with Late Classic Tuxtlas Polychrome.

57a. Black-on-orange, Rim Band Only (BLOR)

Paste. Fine-medium textured, sand tempered paste.

Surface Treatment. Thin, rather pale orange slip. Orange slip may occur on both sides or only one.

Decoration. Black rim band only.

Form. Forms predominantly are shallow bowls, mainly straight convex to open convex. Also present are slightly convex, bag-like convex and slightly outflaring

forms, but in much lower proportions. No slab supports. One pinched nub handle is present on a small convex vessel, see photo.

7a, b, c, d, f, some 7e. Black-on-red (BLRD)

Paste. Sand tempered, very fine texture. Paste near the surface is llight colored, buff to orange-buff. The grey core is usually pale.

Surface Treatment. Well smoothed, with a polished red slip applied to one or both sides.

Decoration. Variable black paint, decorations, sometimes on both sides, often on just one side. Some decorations are limited to rim bands, others are more elaborate designs.

Form. Straight to outflaring forms are most common, some open convex forms and some indications of supports and variable open forms.

Figure A.20 Black-on-Red Pottery.

11p, u. Interior Multi-banded Red-on-orange (ROR)

Paste. Fine to medium textured tempered paste.

Decoration. Orange slip usually on both sides. Two or more interior horizontal bands, including rim band. The other side may have one band or none. One case has exterior orange slip limited to a broad rim band. One variant has bands on both sides. Rarely the orange slip may be lacking on the interior side with multiple bands. One instance of a groove was observed.

Form. Open convex are very numerous, straight to outflaring forms are nearly equal in frequency, with fewer straight convex or restricted convex. One tecomate form recovered.

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APPENDIX B

GAINES MOUND VOLUME PROGRAM

Description of Gaines Mound Volume Program

Appendix B includes the BASIC code for the calculation of mound volume that was originally written by Warren Gaines for PALM. The subsequent re-write into BASIC was undertaken by Tony Stratton and Alanna Ossa to rerun the new mound data from PALM II. This program is made up of one function, called "CalculateMound" which generates mound volumes for each set of dimensional mound data that is entered. These include basic information that was recorded during fieldwork, such as length, width, and height. To calculate an accurate mound volume, the surface curve of the mound is required in addition to length, width, and height. To assist in that goal, separate profiles for different mound curves were developed as separate "mound types" that were selected by researchers during fieldwork based on what they observed. These different profiles are best described as stacked conic sections that approximate different curves, such as a steep profile compared to a very gentle slope (Figure B.1). For this program, each mound is assigned a separate profile attached to the "mound type" and the volume is calculated using this information.
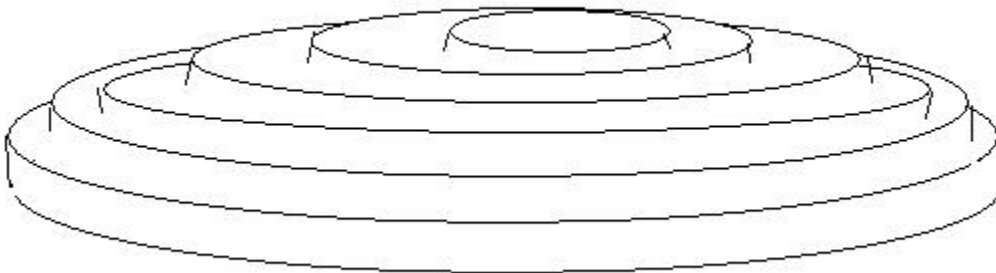
Figure B.1 Example Mound Profile.

BASIC PROGRAM:

Option Compare Database

 Public Sub CalculateMound(ByVal length As Double, ByVal width As Double, ByVal height As Double, ByVal moundType As Integer, ByRef outputArea As Double, ByRef outputVolume As Double)
    '
    ' Input
    '   Length, Width, Height in meters.
    '   moundType is an integer between 1 and 8, cooresponding to the shaped defined in this function
    '
    ' Output
    '   outputSurfaceArea in meters squared.
    '   outputVolume in meters cubed.
    '
    'Dim SWT3 As Boolean = False
    Dim Prof1 As Double(,) = New Double(,) { _
    {1, 15.0, 15.0, 0.0, 1.0, 1.0, 0.0, 0.0}, _
    {2, 12.0, 12.0, 0.3, 0.8, 0.8, 0.6, 0.6}, _
    {3, 6.0, 6.0, 0.5, 0.4, 0.4, 1.0, 0.4} _
    }
    Dim Prof2 As Double(,) = New Double(,) { _
    {1, 20.0, 20.0, 0.0, 1.0, 1.0, 0.0, 0.0}, _
    {2, 15.3, 15.3, 0.8, 0.77, 0.77, 0.4, 0.4}, _
    {3, 11.3, 11.3, 1.3, 0.57, 0.57, 0.65, 0.25}, _
    {4, 7.0, 7.0, 2.0, 0.35, 0.35, 1.0, 0.35} _
    }
    Dim Prof3 As Double(,) = New Double(,) { _
    {1, 25.0, 25.0, 0.0, 1.0, 1.0, 0.0, 0.0}, _
    {2, 22.1, 22.1, 0.4, 0.88, 0.88, 0.1, 0.1}, _
    {3, 15.0, 15.0, 2.1, 0.6, 0.6, 0.53, 0.43}, _
    {4, 8.2, 8.2, 3.6, 0.33, 0.33, 0.9, 0.38}, _
    {5, 4.9, 4.9, 4.0, 0.2, 0.2, 1.0, 0.1} _
    }
    Dim Prof4 As Double(,) = New Double(,) { _
    {1, 25.0, 25.0, 0.0, 1.0, 1.0, 0.0, 0.0}, _
    {2, 20.6, 20.6, 1.4, 0.82, 0.82, 0.2, 0.2}, _
    {3, 12.6, 12.6, 4.9, 0.5, 0.5, 0.7, 0.5}, _
    {4, 9.1, 9.1, 6.2, 0.36, 0.36, 0.89, 0.19}, _
    {5, 7.0, 7.0, 6.7, 0.28, 0.28, 0.96, 0.07}, _
    {6, 4.2, 4.2, 7.0, 0.17, 0.17, 1.0, 0.04} _
    }
    Dim Prof5 As Double(,) = New Double(,) { _
    {1, 25.0, 25.0, 0.0, 1.0, 1.0, 0.0, 0.0}, _

```
    {2, 22.3, 22.3, 1.4, 0.89, 0.89, 0.11, 0.11}, _
    {3, 17.7, 17.7, 4.4, 0.71, 0.71, 0.34, 0.23}, _
    {4, 10.1, 10.1, 10.4, 0.4, 0.4, 0.8, 0.46}, _
    {5, 8.5, 8.5, 11.3, 0.34, 0.34, 0.87, 0.07}, _
    {6, 6.1, 6.1, 12.2, 0.24, 0.24, 0.94, 0.07}, _
    {7, 4.0, 4.0, 12.6, 0.16, 0.16, 0.97, 0.03}, _
    {8, 1.3, 1.3, 13.0, 0.05, 0.05, 1.0, 0.03} _
    }
Dim Prof6 As Double(,) = New Double(,) { _
    {1, 35.0, 35.0, 0.0, 1.0, 1.0, 0.0, 0.0}, _
    {2, 29.0, 29.0, 2.5, 0.83, 0.83, 0.14, 0.14}, _
    {3, 24.8, 24.8, 4.8, 0.71, 0.71, 0.27, 0.13}, _
    {4, 20.0, 20.0, 8.5, 0.57, 0.57, 0.47, 0.21}, _
    {5, 14.0, 14.0, 13.5, 0.4, 0.4, 0.75, 0.28}, _
    {6, 8.1, 8.1, 16.9, 0.23, 0.23, 0.94, 0.19}, _
    {7, 6.3, 6.3, 17.5, 0.18, 0.18, 0.97, 0.03}, _
    {8, 3.5, 3.5, 18.0, 0.1, 0.1, 1.0, 0.03} _
    }
Dim Prof7 As Double(,) = New Double(,) { _
    {1, 15.0, 15.0, 0.0, 1.0, 1.0, 0.0, 0.0}, _
    {2, 13.2, 13.2, 2.0, 0.88, 0.88, 0.5, 0.5}, _
    {3, 12.0, 12.0, 3.0, 0.8, 0.8, 0.75, 0.25}, _
    {4, 11.0, 11.0, 3.5, 0.73, 0.73, 0.88, 0.12}, _
    {5, 10.0, 10.0, 3.8, 0.67, 0.67, 0.95, 0.07}, _
    {6, 9.0, 9.0, 4.0, 0.6, 0.6, 1.0, 0.05} _
    }
Dim Prof8 As Double(,) = New Double(,) { _
    {1, 24.0, 24.0, 0.0, 0.0, 0.0, 0.0, 0.0}, _
    {2, 21.0, 21.0, 3.0, 0.0, 0.0, 0.0, 0.0}, _
    {3, 19.0, 19.0, 5.0, 0.0, 0.0, 0.0, 0.0}, _
    {4, 17.0, 17.0, 6.6, 0.0, 0.0, 0.0, 0.0}, _
    {5, 15.0, 15.0, 7.5, 0.0, 0.0, 0.0, 0.0}, _
    {6, 13.0, 13.0, 8.0, 0.0, 0.0, 0.0, 0.0} _
    }
Dim profiles As Double(,) = Prof1
Select Case moundType
    Case 1
        profiles = Prof1
    Case 2
        profiles = Prof2
    Case 3
        profiles = Prof3
    Case 4
        profiles = Prof4
    Case 5
        profiles = Prof5
```

```
    Case 6
        profiles = Prof6
    Case 7
        profiles = Prof7
    Case 8
        profiles = Prof8
End Select
'
' These are column numbers for the Prof# arrays defined above.
'
'Dim NP As Integer = 0
'Dim LP As Integer = 1
'Dim WP As Integer = 2
'Dim HP As Integer = 3
Dim FL As Integer
FL = 4
Dim FW As Integer
FW = 5
Dim FDH As Integer
FDH = 7


'Dim FL As Integer = 4
'Dim FW As Integer = 5
'Dim FH As Integer = 6 NOT USED IN PROGRAM
'Dim FDH As Integer = 7
'Dim k1 As Double = Math.PI * length * width * height / 12
Dim k1 As Double
k1 = (3.14 * length * width * height) / 12

'Dim k2 As Double = Math.PI / 32
Dim k2 As Double
k2 = 3.14 / 32

outputVolume = 0#
outputArea = 0#
'Dim FAN As Double = profiles(0, FL)
Dim FAN As Double
FAN = profiles(0, FL)

'Dim FBN As Double = profiles(0, FW)
Dim FBN As Double
FBN = profiles(0, FW)

'Dim FAN1 As Double = profiles(0, FL)
Dim FAN1 As Double
```

```
FAN1 = profiles(0, FL)

'Dim FBN1 As Double = profiles(0, FW)
Dim FBN1 As Double
FBN1 = profiles(0, FW)
For rowNum As Integer = 0 To profiles.Rank
    '
    ' Start loop
    '
    FAN1 = profiles(rowNum, FL)
    FBN1 = profiles(rowNum, FW)
    Dim FDHN1 As Double = profiles(rowNum, FDH)
    Dim FAB As Double = FAN * FBN
    Dim FAB1 As Double = FAN1 * FBN1
    'Dim MCSA As Double = 0.0
    'If SWT3 = True Then
    'MCSA = MCSA + MH * FDH * (MB * FN + MB * FN1) / 2
    'End If
    '
    ' Lamda values used to approximate the perimeter
    '
    Dim ML As Double = Math.Pow((((length * FAN - width * FBN) / (2 *
(length * FAN + width * FBN))), 2)
    '
    ' perimeters for the lower elipse
    '
    Dim MPN As Double = (length * FAN + width * FBN) * (3 * (1 + ML) +
1 / (1 - ML))
    '
    ' upper elipse
    '
    Dim ML1 As Double = 0
    Dim MPN1 As Double = 0
    If FAN1 > 0# Or FBN1 > 0# Then
        ML1 = Math.Pow((((length * FAN1 - width * FBN1) / (2 * (length *
FAN1 + width * FBN1))), 2)
        MPN1 = (length * FAN1 + width * FBN1) * (3 * (1 + ML1) + 1 / (1 -
ML1))
    Else
        MPN1 = 0
    End If
    '
    ' length of slope of A and B profiles
    '
    Dim SAN As Double = Math.Sqrt(Math.Pow((height * FDHN1), 2) +
Math.Pow(length * (FAN - FAN1) / 2, 2))
```

```vbnet
        Dim SBN As Double = Math.Sqrt(Math.Pow((height * FDHN1), 2) +
Math.Pow(width * (FAN - FBN1) / 2, 2))
        '
        ' Volume of segment
        '
        Dim DV As Double = k1 * FDHN1 * (FAB + FAB1 + Math.Sqrt(FAB *
FAB1))
        outputVolume = outputVolume + DV "&& Sum to get total volume
        '
        ' Area of segment perimeter
        '
        Dim DA As Double = k2 * (MPN + MPN1) * (SAN + SBN)
        outputArea = outputArea + DA "&& Sum to get total area
        FAN = FAN1
        FBN = FBN1
    Next
    '
    ' Correct for flat top
    '
    If FAN1 > 0# And FBN1 > 0# Then
        outputArea = outputArea + (Math.PI * FAN1 * length * FBN1 * width /
4)
    End If
    '
    ' Never called.
    '
    'If SWT3 Then
    'MAREA = MAREA / 2
    'MVOL += MVOL / 2 ' ???Maybe
    'End If
  End Sub
End Module
```

APPENDIX C

NETWORK SIMULATION

Network Simulation Description

Appendix C includes the java code for the network simulation program that written by Alanna Ossa for the pottery network analysis. Two other java programs (called "classes" in java code terminology) were used to run the simulation, one by Walter Savitch who provided free java code with the multimedia for his textbook. The other was written by Keith Kintigh to read data files using Java and distributed for free for seminar use during the Simulations course at SHESC-ASU. I do not enclose those two java programs here, although they are required to run the simulation, because they were written by others. Explanatory comments are marked in this program after the double slashes "//" and provide brief descriptions of what each part of the program does.

The java language is written in functions that are called "classes", which are encapsulated within parentheses { }. Within those parentheses, basic functions or loop structures are used to perform tasks. These functions could include calculating the variance of a set of values. Prior to performing the function, one must set the variables of the function (such as $x = 5$) for each item that will be used in the function call. An example class format is provided here:

Public class EXAMPLE

{

Set variable types to double (number);

FUNCTION

}

import java.io.*;

import java.util.*;

```
/***************************
 * Alanna Ossa
 * Network Simulation
 * 7/23/2009
 ***************************/
//The public class NetworkSimulation simply pulls in all the values for each of the
required fields such as number of household units, pottery type counts, etc. and
then calls all of the functions written later on in the program to calculate variance
and the ratio of pottery presence to total collections.

public class NetworkSimulation
{
        public static int HOUSEHOLDCOUNT = 53;//you have to change this
category depending on how many rows you want by hand...

        //number of households/units

        public static double [] HouseholdUnits = new
double[HOUSEHOLDCOUNT];
        public static double [] HouseholdCounts = new
double[HOUSEHOLDCOUNT];
        public static double [] RowTotal = new double[HOUSEHOLDCOUNT];

        public static int HouseholdCount;
        public static double [] RunVariance;

        //number of ceramic types (raw counts)
```

```
        public static int MaterialTypeAmount;
        public static double [] MaterialCounts = new
double[HOUSEHOLDCOUNT];
        public static double MaterialVariance = 0.0;

        //probability variables
        public static double ProbNumerator = 0.0;

        public static double TargetRatio = 0.0;

        public static double RatioNumerator = 0.0;

        //number of runs of simulation (range will be no less than 100).
        public static int Runs;

        public static void main (String[] args)
        {

                //DATA INPUT
                readData();//reads the data file of household unit weights, percents,
etc.

                readTypeData();
                convertToRowPercent(MaterialCounts, HOUSEHOLDCOUNT);
                MaterialVariance = calculateMaterialVariance();

                Runs = KWK.readInt("How many runs? (possible range 100 to
1000000) ", 100, 1000000, "1000000");
                RunVariance = new double[Runs];

                for (int i = 0 ; i < Runs ; i++)
                {
                        placeArtifacts();
                        //every 10000 runs, print out a period.
                        if (i % 10000 == 0)
                        {
                                System.out.print(".");
                        }
                        convertToRowPercent(HouseholdCounts,
HOUSEHOLDCOUNT);
                        double currentVariance = calculateVariance();
                        double currentRatio = calculateRatio();
```

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```
                        RunVariance[i] = currentVariance;
                        if (currentVariance >= MaterialVariance)
                        {
                                ProbNumerator++;
                        }
                        if (currentRatio <= TargetRatio)
                        {
                                RatioNumerator++;
                        }
                }
                System.out.println("Probabilities are variance based.  The results
are tabulated as follows,");
                System.out.println("the percentage of runs that the artifact type
category reaches a variance greater");
                System.out.println("than or equal to the empirical variance is the
probability that the artifact type category");
                System.out.println("is due to chance.  For this simulation the
phrase, due to chance, signifies open/market-like access.");
                System.out.println("The probability that your artifact type category
is due to chance:");

                System.out.println("Last Run:");

                for (int count = 0; count < HouseholdCount; count++)
                {
                        System.out.println("Household " + (count+1) + ", " +
HouseholdCounts[count]);
                }

//              System.out.println("Run Variances:");

//              for (int i = 0 ; i < Runs ; i++)
//              {
//                      System.out.println("Run " + (i+1) + ", " + RunVariance[i]);
//              }

                double varianceOfVariances = calculateRunVariance();
                double meanOfVariances = calculateRunMean();

                double probability = (ProbNumerator / (double)Runs) * 100.0;
                double ratioProbability = (RatioNumerator / (double)Runs) *
100.0;
```

```java
        System.out.println("Probability, " + probability);
        System.out.println("Material Variance," + MaterialVariance);
        System.out.println("Last Run Variance, " + RunVariance[Runs-1]);
            System.out.println("Mean of Variances, " + meanOfVariances);
            System.out.println("Variance of Variances, " +
varianceOfVariances);
            System.out.println("StdDev of Variances, " +
Math.sqrt(varianceOfVariances));
            System.out.println("TargetRatio, " + TargetRatio);
            System.out.println("RatioProbability, " + ratioProbability);


    }
//Calculates row percents for each pottery type

    public static void convertToRowPercent(double[] array, int size)
    {
            for (int i = 0 ; i < size ; i++)
            {
                    array[i]= array[i] / RowTotal[i];
            }
    }
//Calculates ratio of pottery type to total collections

    public static double calculateRatio()
    {

            int runNonZeroCount = 0;

            for (int unit = 0; unit < HouseholdCount; unit++)
            {
                    if (HouseholdCounts[unit] > 0)
                    {
                            runNonZeroCount++;
                    }
            }

            double runRatio = (double)runNonZeroCount /
(double)HOUSEHOLDCOUNT;

            return runRatio;
    }
```

//Calculates variance, the variance equation is translated into java code. I tested to make sure this code calculated the correct population variance by running my data in excel first and then checking that I got the same values in this program.

```java
public static double calculateVariance()
{
        long n = 0;
        double mean = 0;
        double s = 0.0;

        for (int unit = 0; unit < HouseholdCount; unit++)
        {
                double x = HouseholdCounts[unit];
                n++;
                double delta = x - mean;
                mean += delta / n;
                s += delta * (x - mean);
        }

        return (s / (n-1));
}
// Calculates the variance of each run of the simulation.

public static double calculateRunVariance()
{
        long n = 0;
        double mean = 0;
        double s = 0.0;

        for (int run = 0; run < Runs; run++)
        {
                double x = RunVariance[run];
                n++;
                double delta = x - mean;
                mean += delta / n;
                s += delta * (x - mean);
        }

        return (s / (n-1));
}

public static double calculateRunMean()
```

```
                {
                        long n = 0;
                        double mean = 0;
                        double s = 0.0;

                        for (int run = 0; run < Runs; run++)
                        {
                                double x = RunVariance[run];
                                n++;
                                double delta = x - mean;
                                mean += delta / n;
                                s += delta * (x - mean);
                        }

                        return mean;
                }

        //Calculates empirical variance of each pottery type.

                public static double calculateMaterialVariance()
                {
                        long n = 0;
                        double mean = 0;
                        double s = 0.0;

                        for (int unit = 0; unit < HouseholdCount; unit++)
                        {
                                double x = MaterialCounts[unit];
                                n++;
                                double delta = x - mean;
                                mean += delta / n;
                                s += delta * (x - mean);
                        }

                        return (s / (n-1));
                }

                public static void placeArtifacts()
                {
                        // Clear the counts
                        for (int count = 0; count < HouseholdCount; count++)
                        {
```

```java
                HouseholdCounts[count] = 0;
            }

            for (int artifact = 0; artifact < MaterialTypeAmount ; artifact++ )
            {
                double unitWeightNumber = Math.random();

                int candidateUnit = 0;
                while (HouseholdUnits[candidateUnit] <
unitWeightNumber)
                {
                    candidateUnit++;
                }

                HouseholdCounts[candidateUnit]++;
            }
        }

// 	user interface handler...
        public static boolean notDone(String message)
        {
            boolean retVal;
            char answer;

            System.out.println(message);
            do
            {
                System.out.println("Enter y for yes and n for no.");
                answer = SavitchIn.readLineNonwhiteChar();
                if ((answer == 'y') || (answer == 'Y'))
                {
                    retVal = true;
                }
                else
                {
                    retVal = false;
                }
            }while ((answer != 'y') && (answer != 'Y') && (answer != 'n') &&
(answer != 'N'));
            return retVal;
        }
```

```java
//        public static void getMaterialAmount()
//        {
//                System.out.println("Your network exchange simulation calls for
comparing separate material categories to the total distribution of artifacts among
households/units.");
//                System.out.println("In order to run your simulation, please enter a
new material type amount below.");
//                MaterialTypeAmount = KWK.readInt("What is the value of your
material type amount (possible range is 1 to 500000) ",0,500000, "135");
//        }


        public static void readTypeData()
        {
                int rowCount;

                MaterialTypeAmount = 0;

                BufferedReader streamIn=null;
                streamIn=KWK.readFile("Input File",
"C:\\PhdProject\\Data\\NetworkAnalysis\\Simu20Above\\1agCOMA.txt");
                //you have to enter in the input file by hand, it will ask you if its
the right one first but still...hand entry.
                int RatioNumerator = 0;
                int materialRowCount = KWK.getInt(streamIn);
                for (int count = 0; count < materialRowCount; count++)
                {
                        rowCount = KWK.getInt(streamIn);
                        MaterialTypeAmount += rowCount;
                        MaterialCounts[count] = rowCount;
                        if (rowCount > 0)
                        {
                                RatioNumerator++;
                        }
                }


                TargetRatio = (double)RatioNumerator /
(double)HOUSEHOLDCOUNT;

                KWK.closeBufferedReader(streamIn);
        }
```

```
        public static void readData()//a lot of this function is never used, the first
int variables listed are mostly defunct and read lower down or calculated
elsewhere...
        {
                int HouseholdsUnits;
                int vars;
                int MoundNum;
                int MoundCounts;
                double MoundPercents;
                double MoundWeights;
                int HouseholdUnitCount = 0;
                int MoundCollNumbers;


                BufferedReader streamIn=null;
                streamIn=KWK.readFile("Input File",
"C:\\PhdProject\\Data\\NetworkAnalysis\\Simu20Above\\HouseholdUnits20Abov
e.txt");
                //streamIn=KWK.readFile("Input File",
"C:\\PhdProject\\Data\\NetworkAnalysis\\Simu20Above\\TestingEvenBuckets.txt
");
        //again you have to enter in the right file by hand here for your data files for
each set of collections you are testing.  These are your "households".
                HouseholdCount=KWK.getInt(streamIn);
                vars=KWK.getInt(streamIn);
                for (int count = 0; count < HouseholdCount; count++)
                {
                        MoundNum=KWK.getInt(streamIn);
                        MoundCounts=KWK.getInt(streamIn);
                        MoundPercents=KWK.getDouble(streamIn);
                        MoundWeights=KWK.getDouble(streamIn);
                        MoundCollNumbers=KWK.getInt(streamIn);

                        HouseholdUnits[count] = MoundWeights;
                        HouseholdCounts[count] = 0;
                        RowTotal[count] = (double)MoundCounts;

                }


                KWK.closeBufferedReader(streamIn);
        }
```

}