CERAMICS AND THE POLITICAL ECONOMY OF MOUNDVILLE:

A COMPOSITIONAL STUDY USING NEUTRON

ACTIVATION ANALYSIS

by

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ABSTRACT

Neutron Activation Analysis (NAA) is used to determine the chemical composition of 80 stylistically local and nonlocal ceramics recovered from the Mississippian civic-ceremonial center of Moundville in west-central Alabama. The chemical data derived from NAA is compared to a previously analyzed ceramic chemical database produced for the Mississippian Southeast in order to: (i) independently confirm if pottery specimens are locally made or imports; (ii) evaluate the accuracy of traditional sourcing of pottery by style techniques as compared to NAA sourcing; and (iii) identify the sources of pottery, allowing for the mapping of the spatial extent of Moundville's trade and interaction network. These results are then used to critique our current model of Moundville's political economy, especially as it relates to the use of prestige goods as an ideological source of elite authority.

The analysis demonstrates that NAA can successfully differentiate between locally produced and nonlocal pottery. NAA generally confirms the accuracy of stylistic analyses in identifying the foreign nature of archaeological ceramics, but the results also indicate the need for chemical compositional analysis in order to fully and accurately map the distribution and production sources of prehistoric ceramics at Moundville. Confirmation of nonlocal trade in ceramics leads to the conclusion that elites at Moundville maintained links with distant populations, providing some evidence to support the efficacy of the prestige goods model in describing the establishment and legitimization of chiefly power in the Mississippian world.

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CHAPTER 1:
CHIEFLY POWER AND ELITE TRADE

A recurring theme in the archaeological study of chiefdom-level society concerns the rise of hereditary elites and the ways by which they were able to establish and legitimize their authority (e.g., Carniero 1981; Earle 1997; Pauketat 2007; Peebles 1987). This is certainly true of the hierarchically organized Mississippian societies that emerged across the late prehistoric American Southeast. In the case of the civic-ceremonial center of Moundville in west-central Alabama, some scholars have suggested that participation in an interregional prestige goods economy may have provided elites with access to nonlocal symbolic objects conveying an "international style" that allowed them to express and manipulate the ideological underpinnings of their authority (Blitz 1993; Steponaitis 1991; Welch 1991).

Although evidence for long-distance interaction and trade at Moundville can be derived to some extent from the presence of copper, stone, and shell foreign to the site (Emerson 2003; Gall and Steponaitis 2001; Steponaitis and Dockery 2011; Welch 1991), Mississippian scholars have traditionally identified nonlocal pottery based on stylistic criteria (Blitz 1993:166; Steponaitis 1983:49). Put simply, archaeologists often identify vessels and sherds as nonlocal when they exhibit many unusual distinctive features relative to the majority of pottery found in a region, especially features known to occur commonly in other regions (Steponaitis 1983:49). This thesis seeks to test such arguments based on stylistic sourcing of ceramics by undertaking a chemical provenience study comparing stylistically local and nonlocal pottery using Neutron Activation Analysis (NAA). This project will consist of three main empirical objectives: (i) to independently confirm if pottery specimens are locally made or imports; (ii) to evaluate the accuracy of traditional sourcing of pottery by style techniques as compared to NAA sourcing; and (iii) to identify the sources of pottery, allowing for the mapping of the spatial extent of Moundville's interaction and trade network. From a theoretical perspective, the presence of highly crafted nonlocal goods, including fineware ceramics, can be interpreted as reflecting elite strategies towards economically and ideologically reproducing their authority.

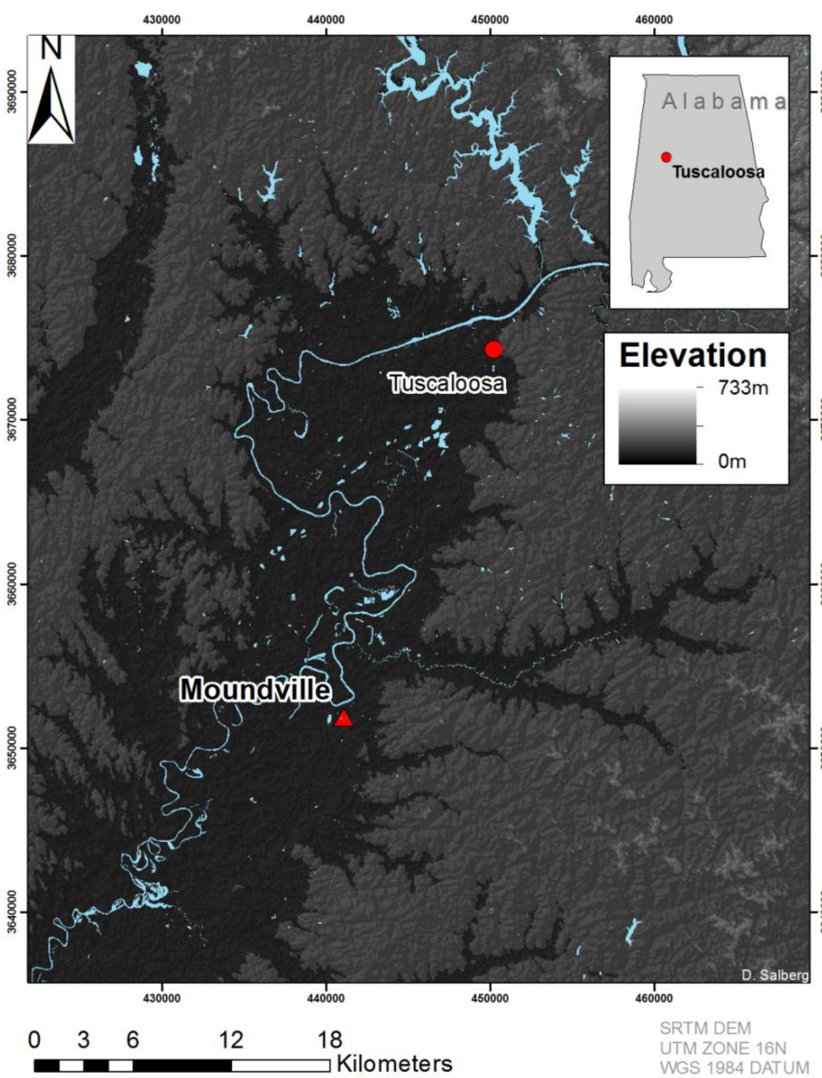

Figure 1. Map of the Black Warrior River valley.

Mississippian Chiefdoms

Mississippian culture thrived across the American Southeast from approximately A.D. 1000 until A.D 1600. Although a number of definitions of Mississippian culture have been proposed over the years, most focus on the shared cultural traits, including maize horticulture, fortified communities with large earthen mounds, social ranking, and a set of rituals and symbols known as the Southeastern Ceremonial Complex that characterized this period.

Mississippian societies are considered to be at the chiefdom level of sociopolitical organization in the seminal social evolutionary sequence of Service (1962). The chiefdom concept as a societal type was abstracted from ethnohistorical accounts of South American and Circum-Caribbean societies (Steward 1948), but the term itself was not coined until several years later by Kalervo Oberg (1955). The chiefdom was initially defined on the basis of sociopolitical organization (Oberg 1955; Service 1962). Carniero (1981:45) states that, "such societies consist of an autonomous political unit comprising a number of villages or communities under the permanent control of a paramount chief." Early descriptions of chiefdoms often emphasized the importance that the redistribution of foodstuffs and other goods by the chief played in the competition for prestige and the maintenance of the political status quo (e.g., Sahlins 1958:xi; Service 1962:144). This is distinct from the concept of "rank society" as developed by Fried (1967). A rank society is defined on the basis of social relations, wherein social groups have equal access to economic resources but unequal access to status positions. Before long the term was increasingly applied to the apparent emergence of centralized polities with notable social stratification across the prehistoric Southeast (e.g., Peebles and Kus 1977; Steponaitis 1978; Carniero 1981).

In Mississippian archaeology, the chiefdom concept is a commonly used but often controversial term. It serves an important purpose as a heuristic concept, yet it also essentializes the nature of what is fundamentally an ethnohistorical and archaeological abstraction, thereby masking cultural variation. Most often objections focus on the term's social evolutionary connotations (Pauketat 2007; Yoffee 1993) and imprecision (Feinman and Neitzel 1984). Rather than providing a reason for discard, however, the term's intellectual baggage and negative connotations necessitate that each author explicitly define the term for his or her own work. While early discussion of the chiefdom concept focused on the chiefdom as a paradigmatic evolutionary type (e.g., Oberg 1955; Service 1962), today Southeastern archaeologists use it to specify the scale of political complexity in Mississippian societies because it highlights material aspects of communities as they are identifiable as archaeological sites, as well as the territory of polities as they are identifiable as settlement patterns (Blitz and Lorenz 2006:4). It is in this descriptive sense that the term is used here: as a form of sociopolitical organization with a superordinate group of ascribed elite and a sovereign political territory that can be identified by a site-size hierarchy consisting of at least two tiers.

Despite the widespread use of the chiefdom concept, however, it is clear that Mississippian polities were extremely variable in size and social organization. They ranged along a continuum from small, politically decentralized societies lacking strong leadership, to polities with large populations and social stratification based on non-kinship principles, and finally to societies, typified by Cahokia, with overt evidence for a centralized political authority. This variation suggests localized differences in elites' abilities to exert control over groups of people by monopolizing economic resources. Therefore, rather than assume that the rise of hereditary elites and centralized leadership is linked to their ability to monopolize economic resources, it is essential to investigate the nature and structure of Mississippian political economies on a case by case basis.

Chiefly Power and the Prestige Goods Economy

Much recent scholarship has focused on how nascent elites or "chiefs" were able to integrate communities socially while at the same time reinforcing their superior status within their respective societies. Timothy Earle (1997) has suggested that chiefs in emergent complex societies had several principal sources of power available to them: social (kinship), economic, military, and ideological power – a position borne out in the literature (e.g., Blitz 1993; Carniero 1981; Pauketat 2007; Peebles 1977; Blitz and Lorenz 2006; Welch 1991). For instance, Carniero (1981:64-67) contends that the initial emergence of chiefdom-level society in many cases was related to environmental or social conscription that led to violence between groups competing for land and resources. Success in battle led to the subjugation of neighboring communities and territorial expansion that conferred a military advantage while also allowing chiefs access to surplus resources that they could syphon off and redistribute to loyal subjects. Pauketat (2007), meanwhile, argues that the rise of diverse complex societies throughout the Mississippian Southeast was characterized by the mitigation of cultural diversity through the formation of a unified people from different places – from the creation of monumentality and a shared experiential landscape. In this sense Mississippianization, which he considers the dissemination of Cahokian ideas, was a particular history of politicizing maize production and domesticizing ideologies of power first idealized at Cahokia. This latter process, which involved social groups and aggrandizing elites adapting external ideologies, practices, and relationships to fit with their indigenous cultural logic, led to the emergence of a unique but variable brand of complex society across the Southeast. Blitz and Lorenz (2006) have argued that the pan-regional symbols acquired through inter-regional polity trade networks reinforced alliances, potentially reduced warfare, legitimized elite status, and in effect integrated distant communities socially and politically.

Current interpretations of Mississippian chiefly power reflect a large amount of work to theorize the role of nonlocal prestige goods in the rise of sociopolitical complexity and the reproduction of elite ideology (e.g., Blitz 1993, Blitz and Lorenz 2006; Blomster 2004; Earle 1997; Helms 1987; Spielmann 2002; Steponaitis 1991). Earle (1997) argues that manipulation of the prestige goods economy was one way by which chiefs were able to materialize and strategically produce the ideological foundation of their power. He notes, for instance, how Thy chieftains in Neolithic Denmark utilized well-crafted weaponry to create an ideology connected unambiguously to warrior might and prowess (Early 1997:207).

The prestige goods economy model, however, was originally formulated as an economic, rather than primarily ideological, theoretical construct to explain social reproduction. Extrapolating from a case study focusing on the Iron Age chiefdoms associated with the Hallstatt culture (ca. 650-300 B.C.), Frankenstein and Rowlands (1978:76-78) argued that prestige goods were items that were used in a ceaseless cycle of status competition. Status competitions, which were evident even in fairly egalitarian societies, generally led to hierarchical economic, social, and political structures as emergent elite descent groups invested food surpluses in socially valued goods that were used to acquire more wives and dependents for the group. According to the authors, increasing the demographic strength of the local group was a crucial strategy for gaining status in this system. They describe the system thusly:

> The specific economic characteristics of a prestige goods system are dominated by the political advantage gained through exercising control over access to resources that can only be obtained through external trade . . . emphasis is placed on controlling the acquisition of wealth objects needed in social transactions, and the payment of social debts [Frankenstein and Rowlands 1978:76].

In sum, access to exotic prestige goods allowed nascent elites to compete more effectively for prestige within the community and thus expand their political power. A steady and tightly controlled supply of prestige goods allowed elite groups to maintain political and social dominance. On the other hand, a disruption in the supply of prestige goods or loss of control over production led to a loss of authority as elites were no longer able to meet their ritual and social obligations.

Chiefly Power and Prestige Goods as Ideology

Later constructions of the prestige goods model provided a more elaborate discussion regarding the ideological dimension of prestige goods that extended beyond their basic economic value, that is, as goods that could be traded for subsistence products, used to repay social debts, or rewarded to loyal followers (DeMarrais et al. 1996:15; Earle 1997; Helms 1987). These authors suggested that exotic items, obtained through long-distance trade, held value in a society because of a shared worldview that equated geographical distance with cosmological distance and far-off places with great sources of esoteric knowledge. They established that prestige goods could be used ideologically for social reproduction or legitimization. Once established, ideological power could be used to structure and legitimize other power relationships both within and outside the community, including rights and obligations to an economic and military order.

From this perspective the exchange of prestige goods among elites in different regions could entail the circulation of a shared system of symbolism and iconography that, although it may have had little impact on most aspects of local material culture, could also symbolize the kind of sacred knowledge or leadership role in community rituals that served as an important noneconomic powerbase (e.g., Blitz and Lorenz 2006; Blomster 2004; Helms 1987). In an analysis of the rise of sociopolitical complexity at the Mixtec site of Etlatongo, Jeffrey Blomster (2004) argues that access to prestige goods carrying a distinct Olmec iconography may have been important in stimulating an already emerging social complexity at the center, as individuals vied to solidify their social status through access to symbolic objects from distant locations. Mary Helms (1987:80) similarly notes how in the protohistoric Circum-Caribbean region, polished black wood formed: “extensions of eliteness that expressed the concept of high rank in general, was employed in individual elite efforts and activities, and was identified with the essential essence of eliteness – that is, sacred wisdom and esoteric knowledge.” In their analysis of political and social integration of Mississippian chiefdoms along the Chattahoochee River valley of Alabama and Georgia, Blitz and Lorenz (2006:114-6) identify a prestige interaction sphere extending along most of the valley and involving the exchange of a distinctive style of incised bottles and beakers. They interpret the distribution of the bottle-beaker fine wares across typical utilitarian ceramic style-zone frontiers as an example of the materialization of an elite ideology.

From a style as communication perspective, material objects, including pottery, can communicate important social and ideological messages. Weisnner (1983) distinguishes between two types of style, emblematic and assertive. She defined emblematic style as formal variation in material culture that transmits a message to a distinct target population about conscious affiliation or identity. Emblematic style has a distinct referent that usually consists of a social group and the norms, values, goals, or property associated with this group, thereby carrying information about the existence of groups and sociopolitical boundaries. In contrast, assertive style is formal variation in material culture that is personally based and carries information supporting individual identity. Individuals interested in creating a positive self-image or achieving social recognition would therefore utilize assertive style to do so. However, these two types of stylistic messages are not mutually exclusive and might serve both purposes simultaneously depending on the audience. For example, the incised beakers and bottles exchanged in the elite interaction sphere of the Chattahoochee River valley (Blitz and Lorenz 2006) might symbolize a shared set of elite values when viewed by other high-ranking individuals, yet serve to distinguish that same individual as a superordinate member of society when viewed by non-elites.

Summary and Organization of Thesis

In summary, much archaeological research has demonstrated the economic and ideological importance of highly crafted nonlocal goods in structuring and reproducing elite authority in complex societies (Blitz 1993; Blitz and Lorenz 2006; Blomster 2005; Earle 1997; Helms 1987; Livingood 2010). On one hand, such goods can be used ideologically to assert one's connections to locations or fonts of sacred knowledge or power, demonstrating a higher status relative to other individuals. On the other hand, certain highly crafted goods can also be used to signal to other elite individuals a shared status and set of culture norms (Wiessner 1983). Highly crafted goods are also important economically as items that can be distributed to retainers, supporters, and possible allies in order to assure their loyalty. Certain scholars have argued that elites at Moundville used highly crafted nonlocal goods to economically and ideologically structure their power as well (e.g., Steponaitis 1991; Welch 1991).

While evidence for long-distance trade in such nonlocal goods at Moundville can be derived to some extent from the presence of copper, stone, and shell foreign to the site, Mississippian scholars have traditionally identified nonlocal pottery based on stylistic criteria. This thesis seeks to test the accuracy of stylistic sourcing of ceramics by undertaking a chemical provenience study comparing stylistically local and nonlocal pottery using Neutron Activation Analysis (NAA). Chapter 2 reviews the culture-history of the Moundville chiefdom and the relationship there between fluctuating levels of nonlocal goods and major sociopolitical transformations at the site.

Chapter 3 provides an overview of the research design and methods used in this project. Neutron Activation Analysis (NAA) is described, as are prior NAA studies conducted in the Southeast and their relevance to my dataset and research questions. My sampling strategy is also described.

Chapter 4 provides a description of the statistical techniques used to analyze the chemical data obtained through NAA. The results of this analysis are also presented, including the substructure of ceramic compositional groups recognized.

Chapter 5 discusses the chemical results in regard to the principal aims of my thesis. This project consists of three main empirical objectives: (i) to independently confirm if pottery specimens are locally made or imports; (ii) to evaluate the accuracy of traditional sourcing of pottery by style techniques as compared to NAA sourcing; and (iii) to identify the sources of pottery, allowing for the mapping of the spatial extent of Moundville's trade network. The results will show that NAA is successful in confirming if pottery specimens are locally made or imports, and that the chemical analysis generally parallels stylistic sourcing in its results. However, NAA also provides an independent and complementary line of evidence that is capable of identifying more anomalous instances of ceramic production and trade, such as in the case of imported utilitarian wares that resemble locally made products or locally made pots that imitate foreign styles. Aside from the ability to differentiate between probable local and nonlocal ceramic products, NAA is able to determine the actual source of pottery in some instances, and the results indicate that individuals at Moundville interacted most heavily with communities to the west, but particularly those living along the Mississippi River valley. Following a protracted evaluation of each principal aim, the implications of this research toward an understanding of Moundville's political economy, and particularly the prestige goods economy model outlined in the next chapter, are presented.

CHAPTER 2:
PRESTIGE GOODS AND POLITICAL TRANSFORMATION AT MOUNDVILLE

The Moundville polity, located along the Black Warrior River in west-central Alabama, is one of the largest and most intensively studied of the Mississippian chiefdoms and therefore presents one of the best opportunities to understand the interplay between long-distance trade, elite ideology, and authority. From about A.D. 1200–1500, Moundville was the political and ritual capital of a regionally organized Mississippian chiefdom, extending across 75 hectares and consisting of 29 earthen mounds surrounding a large plaza. Investigations at the site have portrayed a highly complex chiefdom epitomized by substantial organizational differences between mound and off-mound residential contexts as well as across the broader community and regional polity (Blitz 2008; Knight 2010; Knight and Steponaitis, eds. 1998; Peebles and Kus 1977; Scarry 1995; Welch 1991; Wilson 2008).

The boundaries of the Moundville chiefdom are the Fall Line, near Tuscaloosa, Alabama, to the north and the confluence of the Black Warrior River and the Tombigbee River to the south. The site itself is located along the eastern side of the Black Warrior River, 24 km south of the Fall Line - an ancient coastline that marks the boundary between the Gulf Coastal Plain and the Cumberland Plateau. The site sits atop a high, flat terrace rising 17 m above the river and beyond the 100-year flood level, yet the river is easily accessible.

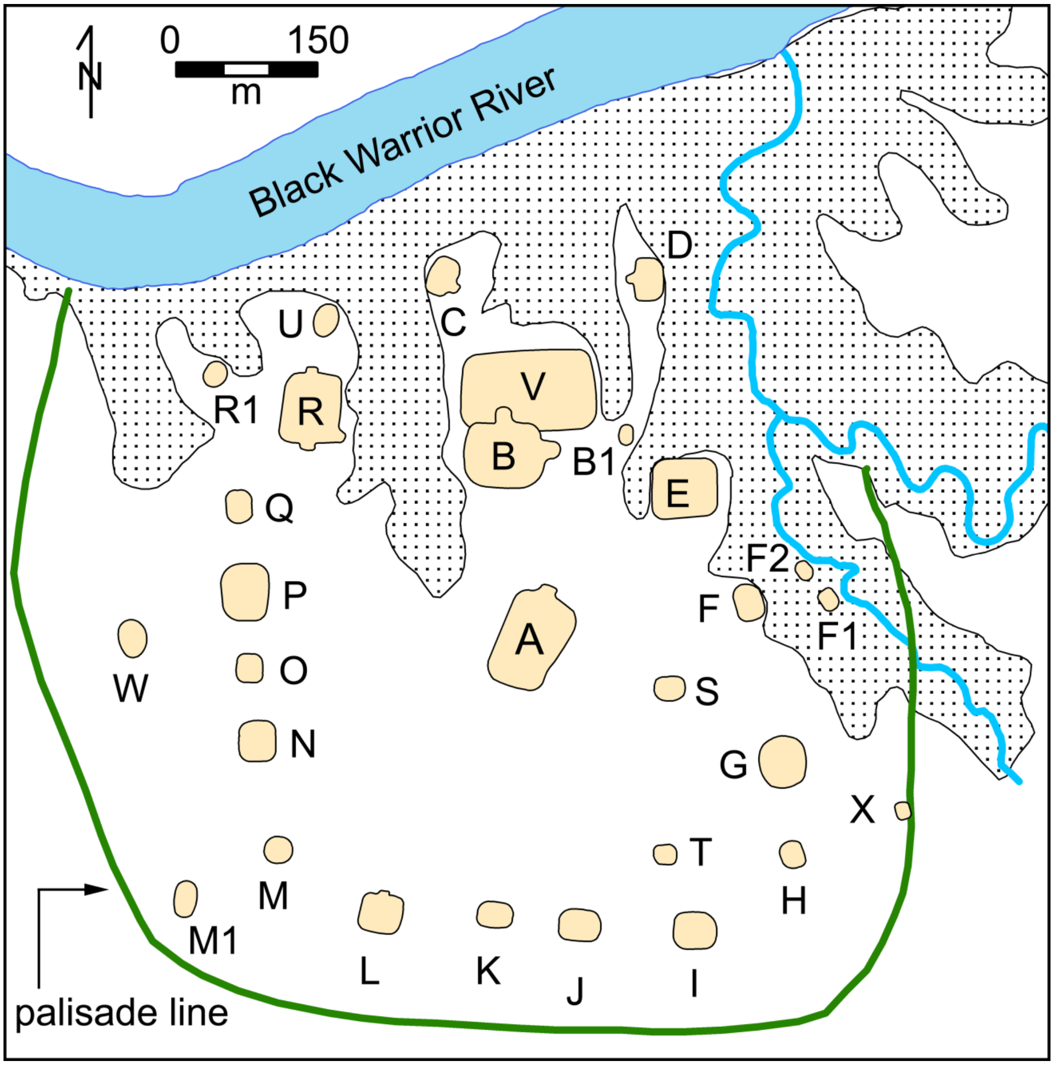

Figure 2. Schematic map of the Moundville site (Copyright 2009, John H. Blitz, used by permission)

At least three distinct environments predominate in the lower Black Warrior River valley where Moundville is found. In the poorly drained, low-lying portions of the floodplain, water tolerant tree species dominate. The more well-drained portions of the floodplain yield an assortment of evergreen and deciduous hardwoods. The higher, well-drained terrace supports mostly oak, pine, and hickory. Finally, mixed hardwoods and pine dominate in the Fall Line Hills beyond the alluvial valley margins. Many of the trees found in the Lower Black Warrior River valley produce edible nuts or fruit that would have served as a supplemental source to agricultural products throughout the Mississippian period. In addition, the residents of Moundville also hunted white-tailed deer, turkey, smaller mammals such as squirrel and rabbit, and a variety of aquatic species (Meyer 2002:14-17; Knight and Steponaitis 1998).

Moundville and the Prestige Goods Economy

Analysis of Moundville's economic organization and the distribution of nonlocal goods across the polity has led some scholars to suggest that the consolidation of the region surrounding Moundville into a single, paramount chiefdom during the mid-thirteenth century seems to have been fueled initially by intensified local production and later by the development of a more specialized "prestige goods economy" that depended on the acquisition and distribution of craft items made from nonlocal materials (Peebles and Kus 1977; Peebles 1987; Steponaitis 1991; Welch 1991). Over thirty years ago Peebles and Kus (1977) argued for elite sponsored production of prestige goods at Moundville. Their research identified manufacturing loci for greenstone celts, mica artifacts, and shell beads at the center and established Moundville as a prototypical example of elite control over prestige goods production in prehistoric chiefdoms.

However, Paul Welch (1991) was probably the first to explicitly evaluate the prestige goods economy model against other political economy models as it applied to Moundville. He concluded that the patterns among material remains at Moundville, as well as those at the single-mound White site, conformed to the tributary (mobilization) model developed by Steponaitis (1978). On the other hand, certain other economic practices, such as the importation of finished items, the manufacture of items that required some specialization of production, and the importation of foreign raw materials, conformed to the prestige goods model. Settlement pattern and catchment analyses demonstrated that elites at the paramount center of Moundville mobilized agricultural foodstuffs from secondary settlements within the polity in order to support themselves and their retainers. Catchment analysis also indicated that the single-mound sites of the Moundville chiefdom were in very similar locations and would have had direct access to the same set of wild food resources, indicating that subsistence goods were likely not redistributed to secondary and tertiary centers by the elites at Moundville (Welch 1991:132-133). Meanwhile, the movement of subsistence goods to the center was balanced by the outward distribution of local and select nonlocal craft items from Moundville. The prestige goods available to the nobility at the single-mound sites, however, constituted only a fraction of the range of prestige goods available to elites at Moundville. Welch notes, for instance, that exotic pottery is extremely rare to nonexistent at local centers in Moundville's hinterland, perhaps because only the regional center engaged in long-distance interactions and trade (Welch 1991:171-172). He interprets this as evidence that the distribution of nonlocally manufactured items depended on their function and social valuation rather than strictly their nonlocal origin (Welch 1991:175-177). He goes on to argue that the pattern of craft production and distribution at Moundville was one of centralized control of the production of, and access to, the majority of nonutilitarian goods, findings consistent with the prestige goods model of craft production and exchange (Welch 1991:179-181). One important distinction between the Moundville economic pattern and the prestige goods model was that no evidence was found for craft specialization outside of the paramount center of Moundville (Welch 1991:181-182).

The observed fluctuations in long-distance trade at Moundville correlate strongly with political developments at the center, providing evidence that the rise and decline in sociopolitical complexity may have been related to elite access to and control over certain prestige goods (Steponaitis 1991:209). The terminal Woodland period that preceded the Moundville culture in the Black Warrior River valley is known as the West Jefferson phase. This period was characterized by a few relatively large villages in the valley inhabited by people who subsisted primarily on wild foods, especially tree nuts, but increasingly took up food production. Evidence points to a sudden jump in the importation and manufacture of marine shell jewelry and greenstone that took place in the years leading up to A.D. 1000. Shell pendants and beads occur in burials of this period in various parts of the Southeast in contexts that suggest they may have constituted a standard of wealth (Knight and Steponaitis 1998:10-11). Knight and Steponaitis (1998:11) posit that wealth in the form of shell beads was being manipulated by community leaders at this time in a strategy to attract followers that foreshadows later competitive efforts.

The initial centralization of the Black Warrior River valley, beginning in about A.D. 1050, marked the appearance of many of the material hallmarks of Mississippian culture: platform mounds, quadrilateral wall trench architecture, increased dependence on maize agriculture, and shell-tempered pottery (Steponaitis and Knight 1998:12). Although most of the population of the Black Warrior River valley was apparently living in small farming settlements at this time, we see the first examples of platform-mound architecture in the immediate vicinity of Moundville. The occupants of these mounds were presumably leaders of a small-scale ranked society, and residents at the Asphalt Plant mound were adept at acquiring nonlocal raw materials such as chert, greenstone, and galena (Knight and Steponaitis 1998:13; Michals 1998). Lauren Michals (1998:180-182) found comparable abundances of utilitarian materials at both the Oliver farmstead and the Asphalt Plant mound during this period, yet there were differences in nonlocal goods and materials between the two sites that appear to confirm assumptions regarding socioeconomic differences between mound and off-mound sites. This led Michals to suggest that there was a connection between control of outside resources and sociopolitical power during the emergent Mississippian period in the Black Warrior River valley.

As Moundville emerged as the paramount center of a large polity after A.D. 1200, foreign materials continued to increase in abundance (Steponaitis 1991:208-209). From A.D. 1200 and lasting until A.D. 1300, the region surrounding Moundville was consolidated into a single polity with a primary center at the site and several second-order administrative centers. During this period construction of all the major mounds and surrounding palisade began, and socioeconomic complexity at the site increased (Knight and Steponaitis 1998; Knight 2010:361). Steponaitis (1998) estimates that the resident population during this period of regional consolidation probably never much exceeded 1,000, though most of the sheet midden around the plaza dates to this time. Indications of emerging social stratification can be seen in the regional settlement hierarchy, house size distinctions (Wilson 2008), mobilization of preferential foodstuffs from the hinterlands to the center (Welch 1991:132-133) mobilization of labor (to construct public architecture), and differential access to highly crafted local and nonlocal burial goods (Peebles and Kus 1977). In addition, nonlocal pottery reached its maximum frequency during this period, perhaps suggesting that nonlocal vessels (or the trade networks they reflected) had greater social value early in the chronology rather than later, when copper, shell, and other materials may have become the exclusive tokens of social status (Steponaitis 1991:209). Steponaitis, for instance, has identified vessels and sherds originating in the Lower Mississippi River valley, Cumberland Plateau, and Alabama Gulf Coast at Moundville based on stylistic similarity to local ceramic traditions there (Steponaitis 1983:327-341).

Subsequent to Moundville's emergence to regional dominance, the center saw exotics reach their maximum frequency in burials for the next century or so. It is only in the period following Moundville's political consolidation, during what Knight and Steponaitis (1998:17) refer to as the "entrenched paramountcy," that a chiefly cult symbolism became elaborated. During this period we find certain individuals buried with luxury goods and costumery bearing this symbolism. This "superordinate dimension" of burials most commonly included marine shell beads, copper gorgets, copper ear spools, notched stone paint palettes, mineral-based pigments, and galena crystals. The apex of the burial hierarchy possessed copper-bladed axes and other pieces of elaborate copper jewelry (Peebles and Kus 1977). This apparent symbolic and economic distancing of Moundville's rulers from the general populace was accompanied by a relatively rapid vacating of the center. As early as A.D. 1260, residential groups around the plaza were replaced by corporate cemeteries used by people who lived elsewhere in the Moundville domain but who may have sought to claim ancestral ties to specific spaces within the center's landscape (Wilson 2008). Although the apparently highest-ranked family groups that resided on or near the largest mounds in the northern portion of the site remained, Moundville had turned into what Knight and Steponaitis (1998:19) refer to as a "necropolis." Elites living on mound summits increasingly made up the majority of Moundville's inhabitants. However, excavations of mound-flank middens during this period indicates that they continued to be provisioned in the meat component of their diet by select portions of venison, male turkeys, fish, and a variety of other game (Knight 2010:362-363).

At about the middle of the fifteenth century mound building appears to have ceased abruptly at the center and several large mounds were abandoned, though some may have witnessed continued occupation into later decades (Steponaitis 1991:209; Knight 2010:364). Fewer burials were being placed in the off-mound cemeteries. This was accompanied by a drastic decline in long-distance trade after A.D. 1500 as the center's regional preeminence deteriorated and the site was eventually abandoned sometime in the sixteenth century. Welch (1991) asserts that the political collapse of the Moundville chiefdom may be related to a loss of external trade. He suggests that, "If the symbols that legitimize the status and authority of the elite became unavailable, the legitimacy of the elite would be undermined" (Welch 1991:194).

In addition to the importation of foreign goods into Moundville, residents at the center also engaged in the local production and circulation of a limited number of non-utilitarian goods. A recent analysis of the Hemphill style at Moundville by Knight and Steponaitis (2011) led them to identify a number of likely exports, including painted and incised pottery, copper, stone, and shell. Hemphill art emerged in the middle of the Moundville sequence, ca. A.D. 1300, and continued in various forms into the fifteenth century. Defined on the basis of a large corpus of engraved pottery at Moundville with representational imagery, Hemphill art is primarily characterized by zoomorphic, trophy, and center-symbols-and-bands themes (Knight and Steponaitis 2011:207-208). They note two circular copper pendants at Etowah that appear to be part of the Hemphill corpus, and a third that is somewhat atypical yet still demonstrates a Hemphill influence (Knight and Steponaitis 2011:230).

Interregional trade in tabular stone pendants and Pottsville sandstone palettes represent some of the more indisputable examples of Moundville exports (Marcoux 2007:240; Knight and Steponaitis 2011:230). Tabular red claystone pendants in the Hemphill-style have been recovered outside Moundville in two instances. First, TVA excavations at the Seven Mile Island site in the Tennessee River valley of northwest Alabama yielded a fragment of an engraved oblong tabular stone pendant that is identical in style and composition to specimens from Moundville. Second, a fragment of an engraved oblong stone pendant was recovered from excavations at the Halbert Camp site in the Tombigbee River valley. On the other hand, the known distribution of formal notched and engraved Pottsville sandstone palettes is considerably more far-reaching and includes seven occurrences, four of which were found in the lower Mississippi River valley over 250 km from Moundville.

In addition, a number of possible ceramic exports from Moundville have been identified, both *var. Hemphill* and others. Knight and Steponaitis (2011:219) identified at least two Hemphill-style ceramic vessels, one recovered from the Middle Mississippi River valley and another from the Lower Mississippi River valley. Welch (1991:186-187) identified several Moundville-style pottery vessels from north Alabama. These include vessels of Moundville Engraved, *var. Hemphill*, Moundville engraved, *var. Tuscaloosa*, and Bell Plain, *var. Hale*. Sherds from vessels possibly originating at Moundville have also been identified at Lubbub along the central Tombigbee River (Welch 1991:186-186; but see Blitz 1993:166-167).

Welch (1991:190) found a rough geographic symmetry between Moundville exports and imports of manufactured nonlocal goods. The origin of the majority of known imports came from the north and west, whereas he majority of known exports are found to the north and west as well. Welch also observes that this conclusion is limited until compositional analysis can be conducted on presumably nonlocal ceramics, the most ubiquitous foreign item found at Moundville.

A limited number of case studies comparing the sociopolitical trajectory of Moundville and neighboring polities have further examined the correlation between changing levels of political centralization and prestige goods at several sites in the Gulf Coastal Plain (Blitz 1993; Steponaitis 1991). Blitz and Steponaitis both found that prior to about A.D. 1200 the presence of nonlocal goods in burial contexts at the Lubbub Creek and Pocahontas sites was roughly equivalent compared to Moundville. However, from A.D. 1200 to 1300, as the Black Warrior

River valley experienced a period of regional consolidation in which the entire region was integrated into a single polity centered at Moundville and several second-order administrative centers, social complexity and the acquisition of nonlocal goods and raw materials increased at the Moundville center even as the smaller regional sites experienced a reduction in nonlocal artifacts per burial (Knight and Steponaitis 1998). These findings raise questions regarding the ability of large polities to negotiate control of prestige goods trade, as well as the importance of such trade in the rise of hereditary elites and sociopolitical complexity at different centers.

Prestige Goods as Ideology at Moundville

Despite suggestive evidence for the importance of prestige goods in the reproduction of elite authority at Moundville, some scholars have increasingly challenged the efficacy of the prestige goods economy model in explaining the political economy of the civic-ceremonial center (Marcoux 2007; Thompson 2011). Marcoux's (2007) work led him to tentatively reject the prestige goods economy model as it is typically applied to Moundville, and he questioned the use of the term "prestige goods" altogether. Although he found that the distribution of highly crafted nonlocal goods was entirely concentrated among elite contexts at the Moundville site during the height of its political ascendancy (ca. A.D. 1300–1450), the overall paucity of highly crafted nonlocal goods relative to highly crafted local goods did not fit with the expectations regarding the importance of nonlocal goods if they indeed functioned in a Moundville prestige goods economy as defined by Welch (1996; see also Frankenstein and Rowlands 1978). He interpreted evidence for production as a low-intensity activity, though largely restricted to elite mound-top structures. In addition, he found a complete lack of highly crafted goods in non-elite contexts. This finding contrasts with the expectations of the classic prestige goods economy model, since if highly crafted goods were used as an economic or ideological resource to reward loyal followers, then one would expect to find such goods in both elite and non-elite contexts. From these findings Marcoux (2007:242) concluded that highly crafted nonlocal goods were uniquely elite phenomena, but they were probably not prevalent enough to comprise "*a primary fund of power*," nor did they suggest the existence of a pervasive system of competitive gift exchange. He ultimately rejected the term "prestige goods" to describe highly crafted local and nonlocal goods found at Moundville owing to its connotations with the prestige goods model, instead proposing the introduction of the term "display goods" (Marcoux 2007:243).

More recently, Claire Thompson (2011:225-226) found that despite variation in locally available goods recovered in excavations of residential areas located away from mounds, consumption of nonlocal goods exhibited a pattern of redundancy through time and across space. Her study suggested that access to most crafted goods at Moundville, including items of both local and nonlocal materials, was more open and accessible than is accounted for in either the political economy model of Welch or the display goods model of Marcoux. Thompson found that residential deposits dating to the Moundville II and III time periods (A.D. 1260–1520) had discarded fragments of some of the same highly crafted goods as found in presumably elite contexts on the mounds. In fact, one of the few materials that appeared to be entirely restricted to elite contexts was copper, which was not present in any of the excavated residential middens. Thompson's data led her to suggest a model for Moundville's residential economy based on redundancy, ritual, and reciprocity, and not on the highly exclusive and competitive exchange of prestige goods as suggested by Welch (1991) and others (e.g., Peebles and Kus 1977).

Although the prestige goods economy model provides an important perspective for understanding the rise of sociopolitical complexity at Moundville, more data are needed to understand patterns of trade. Spielmann (2002:202) argues that in order to understand the relationship between elite ideology and economic production, it is essential to understand the raw material sources, qualities, production, and distribution of these "socially valued goods." Specifically problematic for Southeastern archaeologists are limitations in our ability to determine the source of highly crafted nonlocal goods, thereby hindering the possibility of directly mapping interactional networks across regions. For instance, archaeologists at Moundville now know a good deal about where craft goods were consumed or deposited (Marcoux 2007; Knight 2010; Welch 1991; Wilson 2008), but less about where craft production occurred (Peebles and Kus 1977; Knight 2010; Welch 1991), and even less about the specific source of raw materials or how nonlocal goods that entered into the Moundville chiefdom (but see Emerson 2003; Gall and Steponaitis 2001; Neff 1992; Neff and Stryker 1991; Steponaitis and Dockery 2011; Steponaitis et al. 1996).

Pottery and Regional Interaction at Moundville

Because the "value" of goods is a function of their geographic and social distance, it is essential to accurately identify these sources. For instance, the geographic remoteness of copper sources relative to the Moundville polity is likely related to not only its scarcity, but also its ceremonial significance. While direct evidence for regional interaction at Moundville can be derived to some extent from the presence of copper, stone and shell foreign to west-central Alabama, these materials are exceedingly rare and often found only in mortuary contexts (Peebles and Kus 1977). Owing to pottery's ubiquity archaeologically, exotic-looking ceramics have traditionally been used as a correlate of long-distance trade and interaction. While the vast majority of pottery at Moundville consists of plain, shell-tempered utilitarian ware attributed to production by local household labor, a minority of pottery at Moundville, usually highly decorated, has been identified as products of foreign production and importation based on stylistic criteria (e.g., Steponaitis 1983; Knight 2010). Chemical analysis of ceramics offers one of the more promising, albeit underutilized, avenues with which to objectively measure regional interaction in the Southeast.

This project will examine the chemical composition of stylistically local and nonlocal ceramics at Moundville through the application of Neutron Activation Analysis (NAA) in order to identify long-distance trade links between Moundville and other Mississippian polities during the "entrenched paramountcy" period at Moundville from A.D. 1300–1450 (Knight and Steponaitis 1998). NAA is one way in which archaeologists can chemically source artifacts such as ceramics and therefore elucidate trade networks and spheres of social interaction. The project consists of three major objectives: (i) to confirm if pottery specimens are locally made or imports; (ii) to evaluate the accuracy of traditional sourcing of pottery by subjective style techniques as compared to the more objective NAA sourcing; and (iii) to identify the sources of pottery, allowing for the mapping of the spatial extent of Moundville's trade network. The confirmation of nonlocal trade in pottery implies a sustained link with distant populations and will provide a better understanding of the strength and spatial extent of social relations at Moundville. On the other hand, if a pot was made locally in a nonlocal style, this implies knowledge of foreign ideas by a local potter, perhaps directly through social relations such as immigration or marriage, or at the very least, that foreign styles were sufficiently highly valued to motivate local copying of an import. NAA of ceramics from Moundville will be used to supplement and evaluate other published evidence of nonlocal trade, allowing us to better reconstruct Moundville's interactional networks, as well as the efficacy of the prestige goods economy model in describing the rise of hereditary elites and the foundations of their emergent authority.

Summary

In summary, many Moundville scholars have noted striking correspondences between changing frequencies of nonlocal imports at the center and sociopolitical transformations both internally and in smaller adjacent polities such as Lubbub Creek and Pocahontas (Blitz 1993: Knight 2010; Knight and Steponaitis 1998; Steponaitis 1991; see also Livingood 2010). However, some recent scholarship (e.g., Marcoux 2007; Thompson 2011) has argued that the distribution of highly crafted nonlocal goods at Moundville does not conform to the prestige goods economy model as proposed by Frankenstein and Rowlands (1978) and modified by Welch (1991). It is proposed that the chemical sourcing of stylistically nonlocal fineware ceramics is important if archaeologists are to understand the role of highly crafted goods in Moundville's political economy. The next chapter will provide an overview of the technical aspects of NAA as well as a survey of its use to address archaeological research questions in the prehistoric Southeast.

CHAPTER 3:
RESEARCH DESIGN AND METHODS

An Introduction to Neutron Activation Analysis

Neutron Activation Analysis is a technique that is capable of measuring the elemental composition of virtually any material. First developed by E.V. Sayre and colleagues at Brookhaven National Laboratory in 1954, by the late 1950s it was being utilized in provenience investigations of assorted archaeological materials, including pottery and coins (e.g., Emeleus 1958, 1960). Early work was hampered by the poor resolution of available detection systems, but advances in technology and statistical methodology over the last five decades has made NAA arguably the most successful chemical characterization technique available to archaeologists (Neff 2000:81-82). Modern applications of NAA are able to measure the chemical concentration of 30-35 elements to a high degree of precision (parts per million or billion).

During NAA, target materials are subjected to radiation from a nuclear reactor. During irradiation, neutrons bombard the nucleus of constituent elements, creating radioactive isotopes. As these isotopes decay they emit gamma rays with discrete energies specific to each element that can be measured. The University of Missouri Research Reactor, where the analytical sample utilized in this project was sent, measures a total of 33 elements. Sample preparation and irradiation procedures have been discussed at length elsewhere (e.g., Glascock 1992; Neff 2000; Neff 2008). In short, pottery specimens are subjected to two instances of irradiation: a short irradiation of five seconds duration and an extended long irradiation lasting 24 hours. Because the radioactive isotopes produced by neutron activation undergo radioactive decay at different rates (i.e., they exhibit distinctive half-lives), these irradiations are followed by three gamma counts conducted using a high-resolution, high-purity germanium detector (HPGe). A “short” count measures the short-halflife elements Al, Ba, Ca, Dy, K, Mn, Na, Ti and V. A “middle” count measures the medium-halflife elements As, La, Lu, Nd, Sm, U and Yb. Finally, a “long” count measures the long-halflife elements Ce, Co, Cr, Cs, Eu, Fe, Hf, Ni, Rb, Sb, Sc, Sr, Ta, Tb, Th, Zn and Zr.

Once the elemental composition of materials is determined, quantitative analysis of the chemical data is conducted. The goal of quantitative analysis of the chemical data is to recognize compositionally homogenous groups within the analytical database that can be linked to geographically restricted sources or source zones. Compositional groups are assumed to represent geographically restricted sources or source zones, reflecting the “provenance postulate” (Neff 2000:107; Neff 2008). The provenance (or provenience) postulate states that artifact raw material sources can be determined by chemical characterization as long as between-source chemical differences exceed within-source variation. The postulate is not an observation about conditions in the natural world, but rather a statement of conditions that must be met in order for provenience determination to be successful. One important thing to remember is that ceramics are not as “well-behaved” as natural, homogenous materials, such obsidian, that undergo fewer potential chemically transformative processes. A range of chemical variability is therefore expected within a sample of pottery vessels manufactured using a single clay source, though in most cases this variability is less than that found between sources (Neff 2000:114-116). The location of sources or source zones may be inferred by comparing the unknown groups to groups with known raw material sources, or arguments based on geological and sedimentological characteristics (e.g., Steponaitis et al. 1996), or by indirect means such as the “criterion of abundance," which assumes that a ceramic type was likely produced at the location in which it is found most abundantly. In sum, if local and distant source zones for the sample ceramics are confirmed, it becomes possible to differentiate between locally made and imported pottery, which in turn becomes the means to identify trade networks and social interaction.

NAA and Ceramic Styles

NAA studies can demonstrate the importance of chemical sourcing studies as an independent check on hypotheses regarding the origin of pottery derived from stylistic attributes. For example, a much publicized study by Blomster et al. (2005) determined through NAA of Olmec-style pottery that not only did the Olmec produce and export a wide variety of pottery depicting Olmec-style iconography across Mesoamerica, but local production of Olmec-style motifs also occurred in all regions involved in this interaction. Their findings ultimately contradicted the model that regional exports could be identified simply by style in assemblages of Olmec-style pottery (cf. Flannery et al. 2005). Similarly, at Pinson Mounds, a large Middle Woodland ceremonial center in western Tennessee, NAA analysis of 154 stylistically local and nonlocal (i.e., Swift Creek Complicated Stamped, McCleod Simple Stamped) sherds yielded a single compositional group, leading the authors to reject the hypothesis that the stylistically nonlocal ceramics were imported to the site (Mainfort et al. 1997).

NAA of Mississippian Ceramics

Although NAA has been used minimally in pottery studies in the Southeast as compared to other regions (e.g., the Southwestern United States and Mesoamerica), there are some notable exceptions (e.g., Mainfort et al. 1997; Lynott et al. 2000; O'Brien et al. 1995; Steponaitis et al. 1996; Wallis et al. 2010). Neff (2008) offers a broad overview of ceramic compositional studies in the Southeast, focusing especially on the Middle and Lower Mississippi River valley. He notes that although long stretches of the geology of the Mississippi River valley exhibit compositional similarity, making archaeological sourcing studies difficult, the prospects are more promising for identifying east-west movement of ceramics. For instance, O'Brien et al. (1995) showed that in southeast Missouri modern alluvium along the western edge of the Mississippi River valley is chemically distinct from sediments deposited by western tributaries. Similarly, Lynott et al. (2000) found that compositional analysis could confidently distinguish between Eastern Ozark and Middle Mississippi River valley ceramics and clays. They suggested that the distinction was based on the chemical difference between the Ozark Highland limestone and dolomite vs. the geological source material of diverse origin derived from the quaternary alluvial deposits of the Mississippi River alluvial valley.

Most relevant to provenience analysis at Moundville is the work of Steponaitis et al. (1996), in which the authors analyzed 186 sherds from 21 sites across the Southeast, including at Moundville, in order to create a baseline of ceramic compositional variability for the region. The results demonstrated that the analyzed pottery falls into four distinct compositional groups, each of which corresponds to broad geographic regions and their associated alluvial systems. One such group is associated with sites along the Mississippi River and its western tributaries; a second group is associated with sites on the Appalachian Rim in Tennessee; a third group is associated with sites on the Piedmont and associated drainages; and a fourth group is associated with sites in Alabama. The authors suggest that the compositional patterns revealed by the archaeological ceramics reflect the underlying variation in the proportions of clay minerals present in the sediments of the various regions.

This study underscores the potential to identify nonlocal ceramics at Moundville. Among the Moundville sherds analyzed were a small group that stylistically appeared to be imports from the Lower Mississippi River valley Plaquemine culture. These sherds were chemically shown to be nonlocal to Moundville and to come from at least two different sources originating in the Mississippi River valley (Steponaitis et al. 1996:568). Further, the authors suggest that the large, clay-mineral provinces identified in the study can be recognized as sources in future studies of long-distance trade in the Southeast.

Other studies have demonstrated the utility of NAA in providing an independent check on the use of stylistic criteria to identify long-distance pottery trade at archaeological sites. In collaboration with Vincas Steponaitis and Paul Welch, Neff (1992) and Neff and Stryker (1991) analyzed 102 sherd specimens from the vicinity of Moundville, which at the time constituted the largest analyzed collection from a single Mississippian site. This research remains unpublished, but it suffices to say that the authors identified two reference groups centered on Moundville, one made up mainly of specimens originally thought to be local and one made up largely of stylistically nonlocal engraved wares possibly imported from the west. Numerous other stylistically nonlocal sherds were also determined to be locally produced at Moundville. These findings led Steponaitis (1983:xxv) to revise some of his original interpretations of provenience. For instance, he now asserts that certain vessels originally classified as “Caddoan” were locally made, as were some vessels attributed to the Gulf Coast or the Tennessee-Cumberland region. This research concluded that some of the ceramic types often assumed to be nonlocal to Moundville based on stylistic attributes appear to be locally produced based on chemical composition.

Sampling for NAA

In June 2012, I visited the Office of Archaeological Research at Moundville Archaeological Park, Alabama, for the purpose of selecting a sample of pottery from the

Moundville site for NAA analysis. Eighty sherds recovered from archaeological excavations at the Moundville site were selected and sent to the University of Missouri Research Reactor Archaeometry Laboratory (MURR) for NAA analysis. Descriptive and provenience information for the sample can be found in Appendix C. The results of the chemical analysis are provided in full in Appendix D. The sample consisted of 38 stylistically local ceramic sherds and 42 stylistically nonlocal sherds. Vessels and sherds designated local are generally those having nuances of shape, decoration, and paste that occur commonly in the Black Warrior region. In contrast, vessels and sherds identified as nonlocal are those that exhibit many unusual distinctive features, especially features known to occur commonly in other regions. In most cases, style comparisons have been used to identify likely source areas for the imported wares (Steponaitis 1983:49, 327-341)

In their earlier analysis of Moundville ceramics, Neff and Stryker (1991) produced a chemical database of local ceramic production during the early Mississippian period in the Black Warrior River valley. Since the primary purpose of this study was to determine the extent of nonlocal trade in pottery at Moundville, a major focus was placed on analyzing as many stylistically nonlocal and stylistically ambiguous specimens as possible rather than on dramatically expanding this database. Although the focus of the initial study was on an earlier period of Moundville's history (ca. A.D. 1200–1300), it is a reasonable assumption that the chemical compositions of raw material sources utilized in ceramic manufacture at Moundville did not change considerably during the course of the town's history, as mineralogical studies suggest that people were probably obtaining their pottery clays from small tributaries of the Black Warrior River throughout the site's history (Steponaitis 1983:18-20).

To increase the probability of identifying multiple trade links with foreign communities, a variety of decorative styles were sampled. The sample was primarily limited to ceramics recovered from contexts dating to roughly A.D. 1300–1450. However, since the frequency of stylistically nonlocal ceramics is relatively low at Moundville (Welch 1991:172), particularly when whole vessels are not included in the analysis, some temporal exceptions were made in regard to the sampling of nonlocal specimens.

The stylistically local sample of 38 sherds consists of Mississippi Plain, Bell Plain, Bell Plain painted wares, and one sherd of Alabama River Incised. Mississippi Plain is a stylistically local utility ware and Bell Plain is a stylistically local serving ware. Both wares are shell-tempered, with Bell Plain exhibiting finer temper inclusions and a surface burnish. It is often black filmed. Knight (2010:21-23, 43-46) suggests that the Bell Plain painted service ware (e.g., Bell Plain, white on red) is locally manufactured, yet the wares are restricted mainly to elite contexts in the Moundville chiefdom and, relative to other local finewares (i.e., Moundville Engraved), are exceedingly rare. Although distinct from other serving and finewares at Moundville, these painted wares were designated Bell Plain because Steponaitis treated painting as a crosscutting decorative mode, meaning that red, white, and polychrome painted sherds that are burnished and shell tempered are classified as Bell Plain (Knight 2010:22; Steponaitis 1983:63-64). Alabama River Incised is a protohistoric shell-tempered type that is typically burnished but not filmed and decorated with incised lines (Knight 2010:20).

Of this sample, eight were collected during the 1978 and 1979 field seasons under the direction of Margaret Scarry. The excavations consisted of two 2-x-2 m units, designated 6N2W and 8N2E respectively, located north of Mound R. Sherds were typed by Steponaitis (1983) as part of his dissertation research. The remaining thirty sherds were acquired separately during two instances of mound excavations: older curated collections were recovered in 1937 by the Alabama Museum of Natural History when test trenches were placed into the flanks of certain eroded mounds (H, I, J, K), and a more recent mound excavation program conducted by Vernon J. Knight from 1989-1998 recovered assemblages from Mounds Q, R, E, F, and G (Knight 2010). Both the curated collection and the more recently recovered collection were analyzed by undergraduate students at the University of Alabama under the direction of Knight.

The 42 stylistically nonlocal sherds were selected with the intent of sampling as wide a variety of potential nonlocal sources as possible. Forty of the specimens were recovered from the aforementioned mound contexts. The remaining two sherds were recovered by Claire Thompson (2011) as part of her dissertation research with the Early Moundville Archaeological Project. Both sherds were recovered from a single 2-x-2 m unit south of Mound R. The vast majority of the stylistically nonlocal sherds selected in the sample are styles common to the Middle Mississippi River valley (i.e., Pouncey Pinched, *var. Pouncey*, Parkin Punctated, *var. Parkin*, Barton Incised, *var. Barton*, Barton Incised, *var. Barton*), south-central Alabama (i.e., Lake Jackson Plain), the lower Ohio River area and in southeast Missouri (i.e., Angel Negative Painted, *var. unspecified*, Matthews Incised, *var. Beckwith*) or are of indeterminate origin. This latter category primarily consists of “residual” types. The “residual” types fell outside the familiar range of variation in paste, temper, surface finish, and type of decoration seen in the Moundville type collections, and are therefore tentatively assumed to be of nonlocal origin despite the fact that they could not be confidently linked to specific cultural traditions through style (Knight 2010:42). The remainder of the ceramic sample consisted of sherds likely derived from the lower Ohio River area, the Lower Mississippi River valley, and the northern Gulf Coast.

Sherds were sorted by paste color and temper and these variables recorded. The sample was selected with an aim to represent as much variation as possible in terms of these variables, particularly in regard to Mississippi Plain and Bell Plain. This should provide additional information on the sherds themselves that may prove useful in interpreting differences in chemical composition as suggested by Rice (1987:321-324). Further, by including sherds exhibiting a wide variety of paste colors and inclusions, it may be possible to better approximate the degree of paste variation in local ceramic production at Moundville beyond the work already produced by Neff (1992) and Neff and Stryker (1991).

Summary

In summary, NAA is a bulk-elemental chemical compositional technique that can be used to link archaeological materials with raw material sources or places of manufacture. It has long been used successfully by archaeologists in collaboration with chemical and physical scientists in order to investigate trade and migratory patterns of prehistoric peoples. Previous research in the Southeast has produced a limited chemical database of Mississippian ceramic production covering much of the region and Moundville that is relevant to the study of trade and political economy at the center (Neff 1992; Neff and Stryker 1991; Steponaitis 1996). This comparative database will allow a more robust chemical analysis to determine if stylistically local and nonlocal ceramics recovered from Moundville were produced within the Black Warrior River valley or nonlocally. The next chapter describes the pattern-recognition techniques used in identifying and evaluating potential ceramic compositional groups, summarizes the results of the statistical analysis of the chemical data, and describes the substructure of the compositional groups that were recognized.

CHAPTER 4:
ANALYSIS AND RESULTS

In the previous chapter I presented the methodology of Neutron Activation Analysis (NAA) and research steps used to select samples for this analysis. A sample of eighty ceramic specimens from Moundville, Alabama, was sent to the University of Missouri Research Reactor (MURR) for NAA. In this chapter, I describe the quantitative analysis of the sample and present the results of the NAA. Recognized compositional groups are described and the probability that the pottery specimens represent local manufacture or non-local imports is assessed.

Quantitative Analysis of Chemical Data

The goal of quantitative analysis of an NAA sample is to group chemically similar specimens together through a variety of multivariate statistical techniques and analysis of bivariate scatter plots. The goal of statistical group recognition is to isolate distinct production groups that are associated with either particular geographic areas or different "recipes" for the mixture and processing of raw materials. The three primary steps in the quantitative analysis of the NAA sample, data processing, group construction, and group verification, are briefly discussed below. More detailed considerations of this discussion are presented by Glascock (1992) and Neff (2000, 2002). The GAUSS statistical package used at MURR can accomplish most of these statistical procedures.

NAA data are first subjected to several basic processing procedures. The raw elemental concentrations are transformed to base 10 log concentrations. This transformation minimizes the influence of elements with high concentrations, such as Fe and Al, during later statistical analyses. Analysts at MURR have also found that the data appear to be more normally distributed when treated as logarithms of the measured concentrations (Glascock 1992:16). In addition, missing values in the data are replaced by using a “best-fit” criterion based on Mahalanobis distance, a multivariate analog of a z-score (Sayre 1975). When many specimens are analyzed for a large range of elements, it is almost certain that a few element concentrations will be missed for some of the specimens. Missing values generally occur when the concentration of an element falls below the detector limits. Rather than eliminating the specimens or the element from consideration, substitute values minimize the Mahalanobis distance of that sample to the centroid of the data set as a whole. On the other hand, when a large subset of specimens exhibit concentrations of a certain element that is below the detection limit this element will be removed from consideration for statistical analysis. Researchers working with MURR data usually eliminate Ni from analyses entirely, as the concentration of this element in pottery generally falls below detection limits.

After basic data processing, potential groups of compositional specimens are identified. The determination of compositional subgroups that are archaeologically meaningful entails successive formulation and testing of working hypotheses regarding the number and make-up of subgroups in the compositional data set. Such hypotheses can be derived from a preliminary analysis of a ceramic collection, which may suggest potential groups that constitute a starting point for statistical analysis. These analytical groups can also derive from provenience information or from pattern-recognition techniques, such as hierarchical cluster analysis.

Whether evaluating a potential compositional group formulated through archaeological information or attempting to identify groups based on quantitative analysis and pattern recognition, decisions about whether to assign a specimen to a particular compositional group are based on the overall probability that the measured concentrations for the specimen could have been obtained from that group. Since the datasets derived from NAA often contain hundreds of samples, each with more than thirty variables, a common step during group identification and evaluation is to use a data reduction technique such as principal components analysis to reduce the dimensionality of the data. The principal components analysis (PCA) technique is the most commonly used reduction technique at MURR (Glascock 1992:17-18). PCAs create a new set of reference axes based on the original elemental variables and arranged in decreasing order of variance assumed. Thus, for pottery, the first several PCAs often describe 70% or more of the total variance in a sample population. PCA and other reduction techniques have the benefit of highlighting the largest dimensions of variability and potentially eliminating some of the "noise" in the data, making patterns more clear (Glascock 1992:18).

One particular strength of PCA discussed by Neff (2002) is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed specimens) displayed on the same set of principal component reference axes. A biplot using the first two principal components as axes is usually the best possible two-dimensional representation of the correlation or variance-covariance structure within the dataset, and therefore presents an excellent method for both identifying and evaluating potential compositional groups as well as elemental associations. Displaying both objects and variables on the same plot also makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Small angles between the vectors from the origin to variable coordinates indicate strong positive correlation; angles at 90 degrees indicate no correlation; and angles close to 180 degrees indicate strong negative correlation.

At the same time, reducing variability can make the identification of subtle distinctions in the data more difficult. Some dimensions of variability may be eliminated or masked by analytical reduction techniques. Owing to this, perhaps the best practice is to utilize multiple methods, both with and without the use of data reduction techniques (Schachner 2007:96). Visual inspection of bivariate scatter plots of elemental concentrations is a complementary approach to visual inspection of PC biplots. The visual inspection of bivariate plots of elemental concentrations, also referred to here as elemental scatterplots, is comparatively simple. Individual analyzed specimens are projected onto a scatter plot based on the concentrations of two elements in each specimen, which serve as the reference axes. Like the elemental vectors that characterize biplots, elemental scatterplots allow the analyst to identify the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Since the data are not statistically reduced, this type of inspection can lead to the recognition of subtle differences between potential compositional groups that might be otherwise missed. Groups of specimens that remain consistent despite the statistical method used are considered the most statistically robust.

The next step in quantitative analysis is to verify the distinctiveness of potential groupings identified in step two. Groups can be discriminated using both visual inspections in two dimensions, as discussed above, or statistically in multiple dimensions. Researchers working with MURR data often use a combination of Mahalanobis distance and Hotelling's T^2 probability measures to calculate the probability that data points are likely to be members of the same group and not another group (Glascock 1992:18-19; Schachner 2007:97). Mahalanobis distance, like Euclidean distance, makes it possible to mathematically describe the separation between groups or between individual specimens and groups on multiple dimensions, while Hotelling's T^2 is a way of expressing this distance as a probability of group membership (Glascock 1992 provides details of calculation).

Two important points should be noted regarding Mahalanobis distance-based membership calculations. First, Mahalanobis distance is considered a relatively conservative statistical measure (Schachner 2007:98). Because of this, fairly low probability thresholds for group membership are often used when assigning specimens to compositional groups. The decision about what constitutes “high” or even “adequate” probability of membership is somewhat arbitrary, but generally reflects concerns regarding what constitutes an acceptable probability of misclassification. I took a “soft” approach to membership assignments based on Mahalanobis distance. In other words, I generally used a threshold of greater than 2% probability of membership in a group combined with less than 0.5% probability in any other, or a probability of 10% or more in one group coupled with less than half that in any other group. Exceptions were made for several specimens that possessed high membership probabilities in both the Main Moundville group and Moundville 2, as well as several unassigned specimens that would have skewed group distinctions if included in specific compositional groups.

Second, calculation of Mahalanobis distances requires that compositional groups have a number of group members that exceeds the number of elements under consideration by at least one (Glascock 1992:19). Ideally, the number of group members will be several times greater than the number of elements. Since 33 elements are measured at MURR and many ceramic compositional groups do not exceed 30 member specimens, this is often an impossible requirement to meet. Fortunately, one means of circumventing a small specimen-to-element ratio is to base the Mahalanobis distance calculations on PCs calculated over the total dataset rather than use the original elemental concentrations. As mentioned above, the PCs are arranged in the order of decreasing variance explained. This method therefore provides a non-arbitrary criterion for reducing the dimensionality before calculating Mahalanobis distances. When membership probabilities are calculated using both elemental data and the PCA, both calculations can be used to assess group membership.

Mahalanobis membership calculations can be used in two primary ways. First, they can be used to calculate membership probability of specimens tentatively assigned to a group. During these calculations the sample is jackknifed, meaning that distance measures are calculated assuming the specimen in question is *not* a member of the group to which it is being compared. Multiple group-membership probabilities are often produced for each specimen, and normally probabilities of membership are highest for the group to which a specimen was assigned during the explanatory analyses in the previous step. If a specimen has a higher probability of membership in a group to which it was not originally assigned it is reassigned. Similarly, specimens with low probabilities of membership in each group for which membership probabilities are calculated might be removed from a group and left unassigned. Second, membership calculations can be used to calculate whether an unassigned specimen, or specific group members of a newly identified compositional group, might be members of a previously recognized group. Since Mahalanobis distance calculations have certain requirements regarding minimum group size, it can also be used to identify whether members of smaller groups might be better reassigned into a larger group. When group membership is altered, probabilities of membership are then recalculated for each specimen based on the newly defined groups, with the process repeated iteratively until a point in which the researcher is comfortable with the group assignments and the associated membership probabilities.

Analysis of the Moundville Sample

The present ceramic sample was compared with two datasets previously analyzed at the National Institute of Science and Technology (NIST) and MURR and reported by Neff and Stryker (1991), Neff (1992), and Steponaitis et al. (1996). The results of this analysis demonstrate that compositional characterization by NAA can successfully differentiate between local and imported ceramic specimens from Moundville. For this analysis, specimens were placed into one of seven recognized compositional groups or were left unassigned. Two of these compositional groups are assumed to reflect local ceramic production while the other five likely represent imports to the site. Table 1 displays a list of the previously identified compositional groups referenced in the text.

Table 1. Descriptive table of previously analyzed compositional groups referenced in the text.

Chem. Group	Analyst	Year	Material	Description	Suggested Provenience	No.
East Region	Steponaitis et al.	1996	Pottery	Mississippian	Piedmont and associated drainages	23
North Region	Steponaitis et al.	1996	Pottery	Mississippian	Appalachian Rim in Tennessee	36
South Region	Steponaitis et al.	1996	Pottery	Mississippian	Eastern Mississippi and Alabama	15
West Region	Steponaitis et al.	1996	Pottery	Mississippian	Mississippi River valley and western tributaries	56
General Moundville[1]	Neff and Stryker	1991	Pottery	Mississippian	Black Warrior River valley	46
Moundville 2[2]	Neff and Stryker	1991	Pottery	Mississippian	Black Warrior River valley	15

[1] This number refers to group membership as recognized by Neff and Stryker (1991) and does not include specimens assigned during the present study.
[2] Same as above.

In addition to the pre-analysis data processing steps described above, prior to comparative analysis a calcium correction routine was used in order to remove the effects of calcium dilution caused by shell-tempered pottery. Steponaitis et al. (1996:558-559) have previously noted the possible dilution effects of shell temper in Mississippian ceramics. As the amount of temper increases, the concentrations of elements associated with shell are enhanced while the concentrations of elements associated with principally with the clay paste are diluted. They argue that these differences generally reflect function rather than geographical origin, and thus must be controlled. In their analysis of sherds from across the Mississippian Southeast, Steponaitis and his colleagues implemented a mathematical correction routine to simulate the removal of the shell. Elements believed to be most associated with shell temper (i.e., Ca and Sr) were dropped from the data set, while concentrations of the remaining elements were recalculated to remove the effects of shell dilution. They suggest that for grog-tempered sherds, such correction is unnecessary because the grog itself is made of clay, presumably the same clay that comprises the rest of the paste. Although grit- and sand-tempered sherds are subject to dilution effects analogous to those that occur with shell, the elements that comprise quartz are not detected by neutron activation. This leaves us with no data on which to base a correction. They found that despite these potential problems, the uncorrected sherds behaved no differently in their analyses than the corrected, shell-tempered specimens. In other words, the shell-tempered sherds and quartz-tempered sherds generally clustered together by region, suggesting that the distortions caused by quartz temper were not great enough to obscure the broad geographical patterns in composition, at least for that sample.

Compared to the data obtained for their report, few of the shell-tempered ceramics analyzed here exhibited calcium concentrations in excess of 15 percent, but in the interest of maintaining analytical consistency I have chosen to follow their approach. For comparative purposes, I performed a calcium dilution correction on all shell-tempered ceramics from my dataset. Included in the correction were sherds where shell was either the primary or secondary temper. In total, I conducted the calcium correction of 64 sherds. However, a biplot of the first two principal components (as derived from my 80 sample dataset) displays the high loading caused by Ca and Sr on the first and second PCs in much of the shell-tempered pottery (Figure 3).

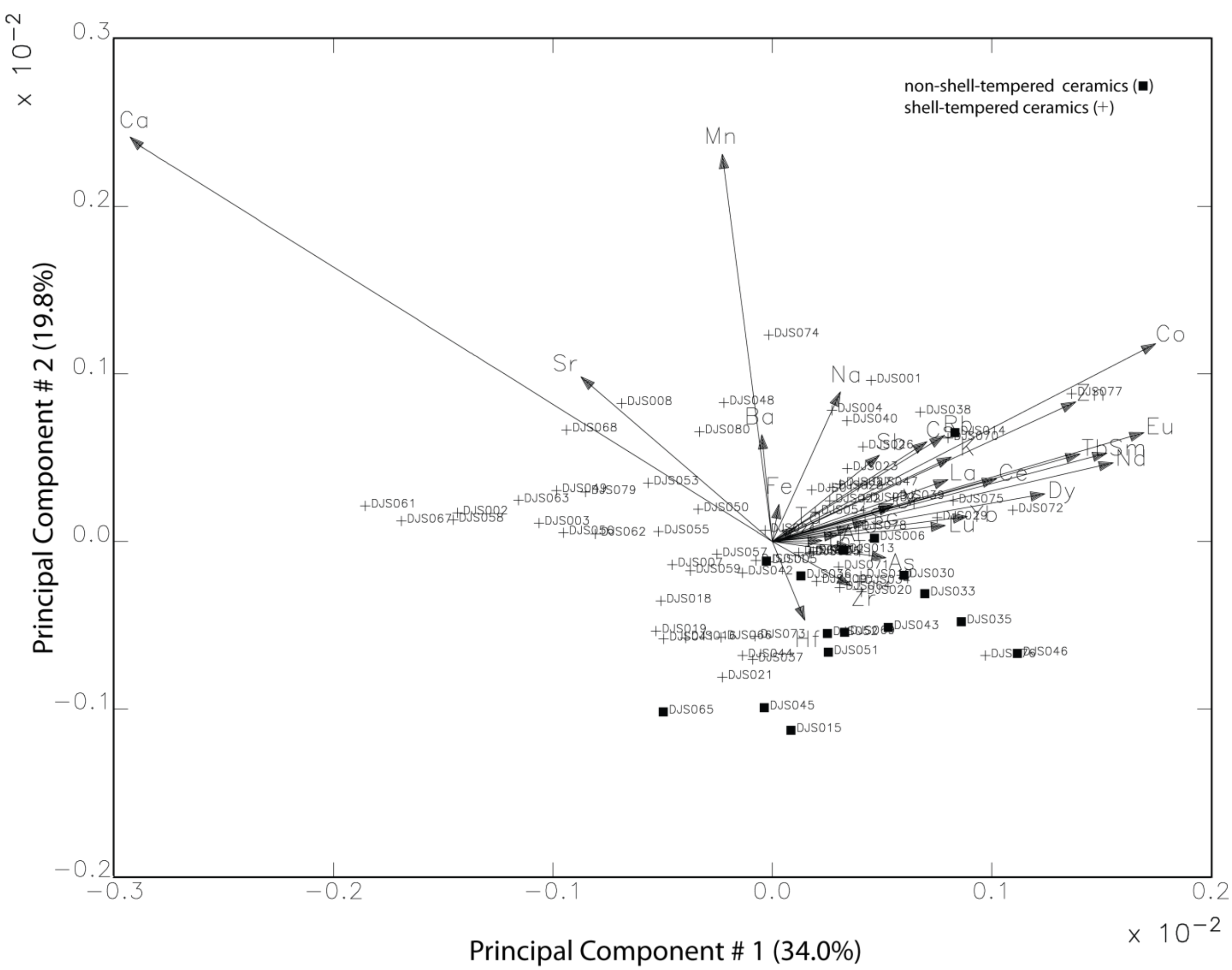

Figure 3. Principal component biplot of the 80 specimen dataset from Moundville. Elemental loading vectors are shown and labeled. Ellipses are drawn at the 90% confidence interval for membership in the group.

For this analysis it was hypothesized that distinctions in visual and paste characteristics (following the type-variety system developed by Steponaitis 1983 and augmented by Knight 2010) would be reflected in differential chemical compositions of the ceramics. In other words, I began with the assumption that stylistically local ceramics (i.e., Bell Plain and Mississippi Plain) would be affiliated with the chemical profile of local Moundville ceramic manufacture as determined by Neff and Stryker (1991) and Neff (1992). On the other hand, stylistically nonlocal ceramics were hypothesized to have been manufactured using raw materials derived from the geographical composition group (Steponaitis et al. 1996) subsuming its stylistic place of origin .

Neff and Stryker (1991) previously identified two reference groups centered on Moundville, one made up mainly of specimens originally thought to be local and one consisting largely of specimens that were initially assumed to have been imported from west of the Mississippi River but were more similar to the main Moundville group than to the West Region compositional group recognized by Steponaitis et al. (1996). These groups were augmented in a later analysis (Neff 1992). Despite the analysis of several clay sources from the Moundville vicinity, neither pottery group could be related directly to locally available clay (Neff 1992). However, considering the prior archaeological evaluation of most member specimens as locally manufactured based on style, the main group was assumed to consist of locally produced sherds.

With Neff and Stryker's main Moundville group as a starting point, the first step in data analysis was to create an expanded, yet still cohesive, compositional group that roughly profiled ceramic production at the site. Many specimens had missing values of Mn and Ni and therefore these elements were removed from the analysis. Stylistically local specimens (i.e., Mississippi Plain and Bell Plain) from my sample were added to Neff and Stryker's main Moundville group and evaluated for membership using Mahalanobis distance-based membership probability calculations derived from 29 of the 33 elements analyzed at MURR (Appendix B). Membership probabilities in the group were recalculated and refined iteratively until the group was considered stable. Specimens of unknown and presumably nonlocal origin were also tested for membership in the main group using the Mahalanobis test statistic. The group was further refined through visual inspection of elemental scatterplots.

Once a robust compositional group had been isolated, it was thus possible to evaluate which heretofore unassigned specimens were likely imports and which were more likely produced within the vicinity of Moundville, yet chemically marginal to either of the local reference groups. Bivariate plots of elemental concentrations led to the isolation of four distinct compositional groups in addition to the two local Moundville groups already described (Figures 4 and 5). These were groups West 1-4, all of which, as their name suggests, are comprised primarily of sherds that were recognized as imports from west of Moundville, and specifically the Middle Mississippi River valley, based on style. With the exception of group West 1, all groups contain only three specimens each. It should be noted here that groups this small should be considered tentative since it is impossible to conduct robust statistical tests to evaluate them. None of the specimens in these groups has a high membership probability in the main Moundville group, indicating that they were likely imported to Moundville. In the process of evaluating these tentative groups on elemental scatterplots, an additional reference group was isolated. This group, which is referred to as Lake Jackson Plain, consists of four sherds of the eponymous type-variety.

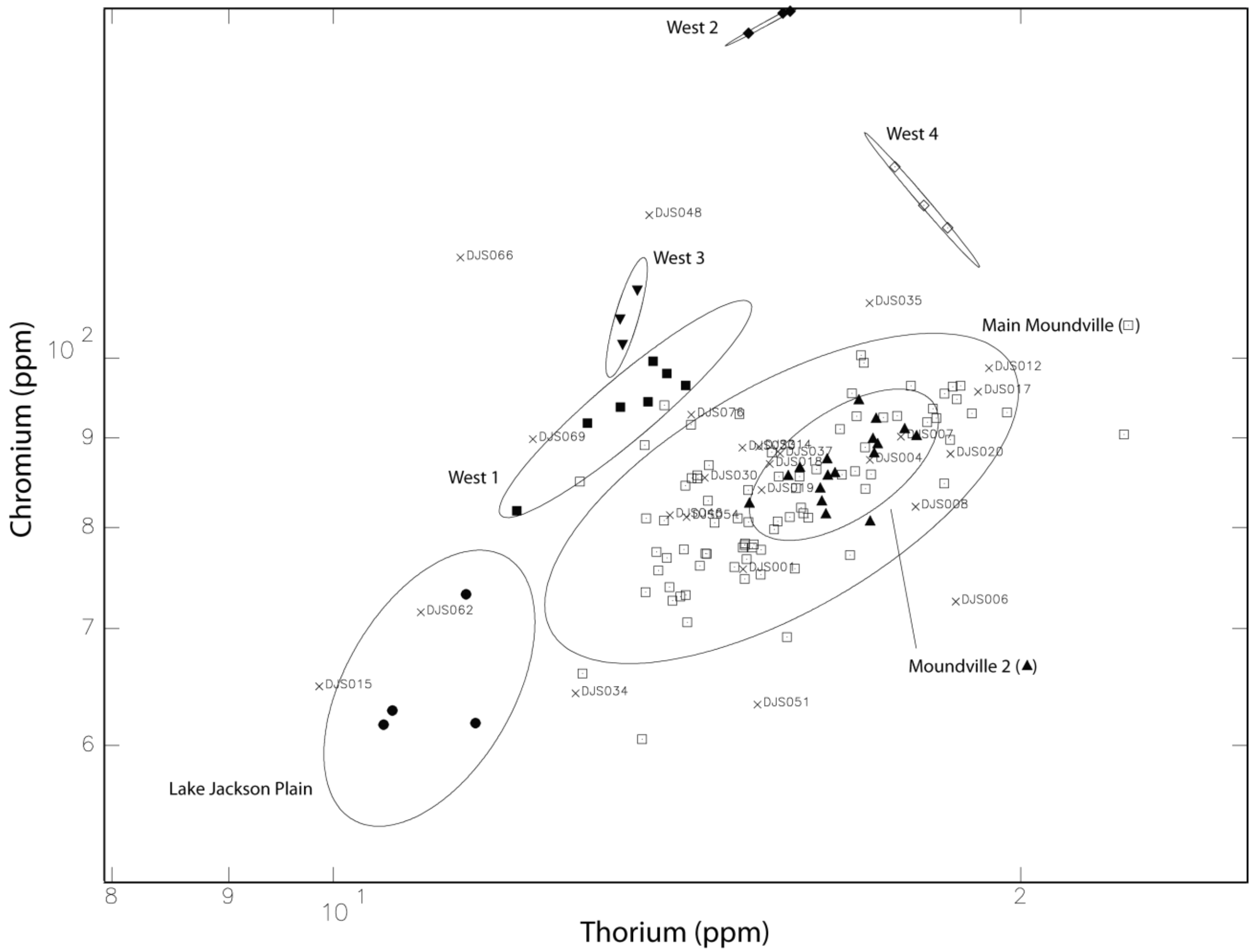

Figure 4. Bivariate log-log plot of Th and Zr concentrations showing the entire 80 specimen dataset and ceramic compositional groups. Ellipses are drawn at the 90% confidence interval for membership in the group.

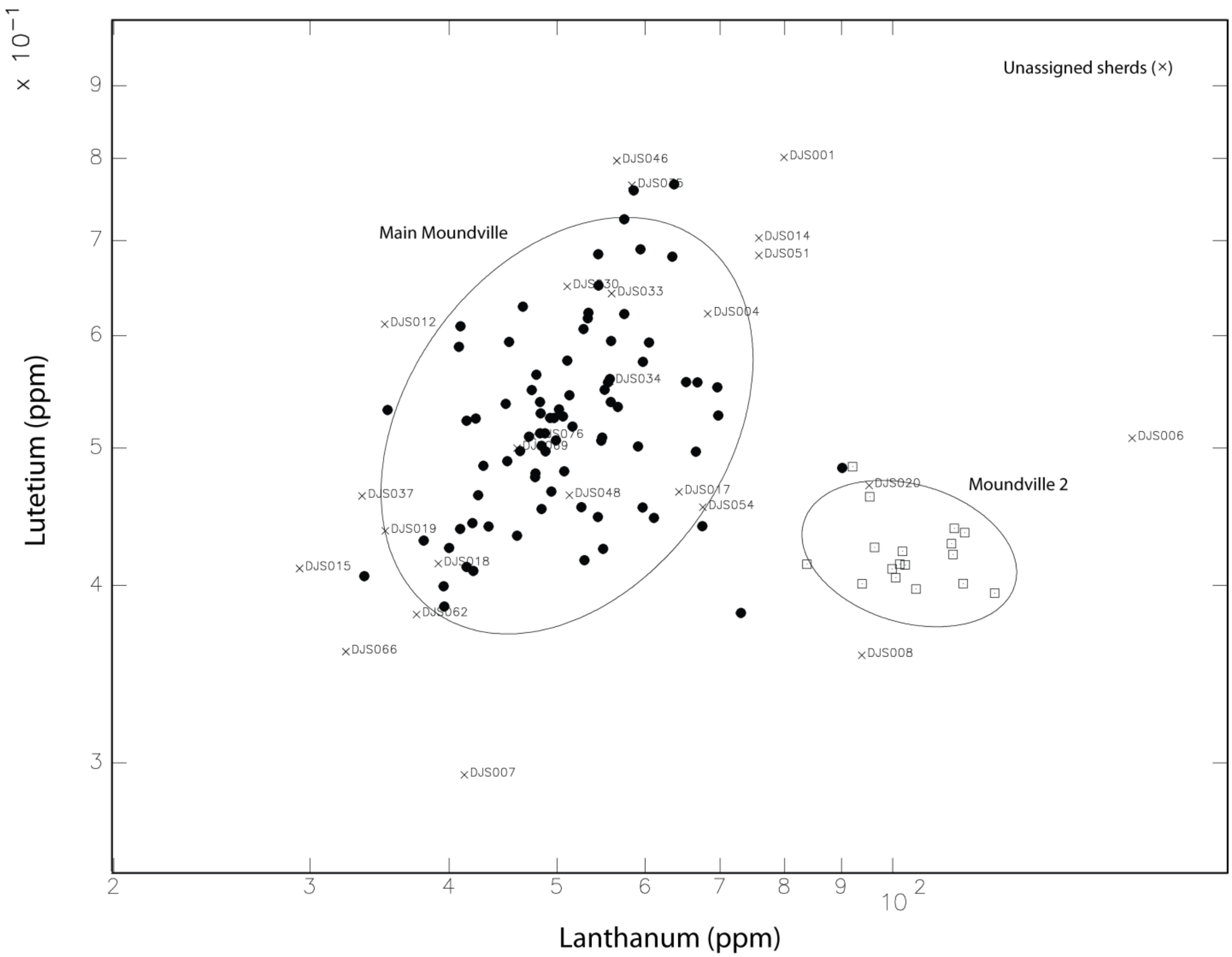

Figure 5. Bivariate log-log plot of La and Lu concentrations. Ellipses are drawn at the 90% confidence interval for memership in the group.

After compositional groups from the Moundville sample were determined internally, they were compared to the baseline of geological variability and ceramic production already available for the American Southeast and Moundville and documented in Steponaitis et al. 1996. This involved the comparison of the potential compositional groups to the major compositional groups identified in previous investigations (i.e., East Region, North Region, South Region, West Region) through visual inspection of elemental and principal component scatter plots (Figures 5-8). At this step, a principal components analysis (PCA) was conducted separately on the entire dataset (N=368 specimens) of Mississippian ceramics (Steponaitis et al. 1996; Neff and Stryker 1991). Zircon (Zr) and Nd were not included in the PCA owing to a high number of missing values in the Southeastern database (Steponaitis et al. 1996). Twenty-seven elements were utilized and greater than 90% of the cumulative variance was explained by the first nine principal components (PCs) in both instances. Probability membership in the major compositional groups (i.e., Main Moundville, Moundville 2, East Region, North Region, South Region, and West Region) were also calculated iteratively using Mahalanobis distance-based calculations based on the first nine principal components of the dataset (Appendix B). Further discussion below will make it clear that many sherds from the sample were probably imported to Moundville, but it appears that the chemical database of Southeastern ceramics currently available is not yet sufficiently large enough to serve as a definitive profile and comparative database for ceramic production across the Southeast.

Compositional Groups

Quantitative analysis led to the recognition of seven compositional groups in the present study. Two of these compositional groups, the Main Moundville group and the Moundville 2 group, are believed to represent local production at Moundville, whereas the remaining compositional groups likely reflect nonlocal imports. The Main Moundville group consists of 33 specimens from the present sample and 81 in total. The Moundville 2 group consists of two specimens from the present sample and 17 specimens total. The remaining five compositional groups and their respective sizes are as follows: Lake Jackson Plain (N=4), West 1 (N=7), West 2 (N=3), West 3 (N=3), West 4 (N=3). All group members for these five groups are derived from the present dataset. In addition to the identified compositional groups, 25 specimens were left ungrouped. The chemical and archaeological structure of each group is described in detail below. Selected descriptive data for each specimen sorted by group can be found in Appendix A.

Main Moundville: This group is an expansion of the General Moundville group recognized by Neff and Stryker (1991) and augmented by Neff (1992) in previous analyses of ceramics from Moundville. It is notably distinct from any of the major regional reference groups (Figure 6). The original group consisted primarily of Moundville Incised and Moundville Engraved sherds from early in the Moundville sequence. About a third of the group is comprised of sherds that were originally classified as nonlocal based on stylistic criteria. The majority of the newly assigned sherds are Bell Plain, Bell Plain painted, and Mississippi Plain (N=23). A number of the group members are somewhat more unexpected, and this includes residual sherds as well as five stylistically nonlocal diagnostics that exhibit a high membership probability in the group. Of these five, two are examples of the Middle Mississippian style Parkin Punctated, *var. Parkin,* two are examples of the Lower Ohio River area style Angel Negative Painted, and the final sherd is an example of the Middle Mississippian style Barton Incised, *var. Barton*. Although these sherds were identified as nonlocal based on stylistic criteria, their assignment to the Main Moundville group indicates that they were more likely produced locally.

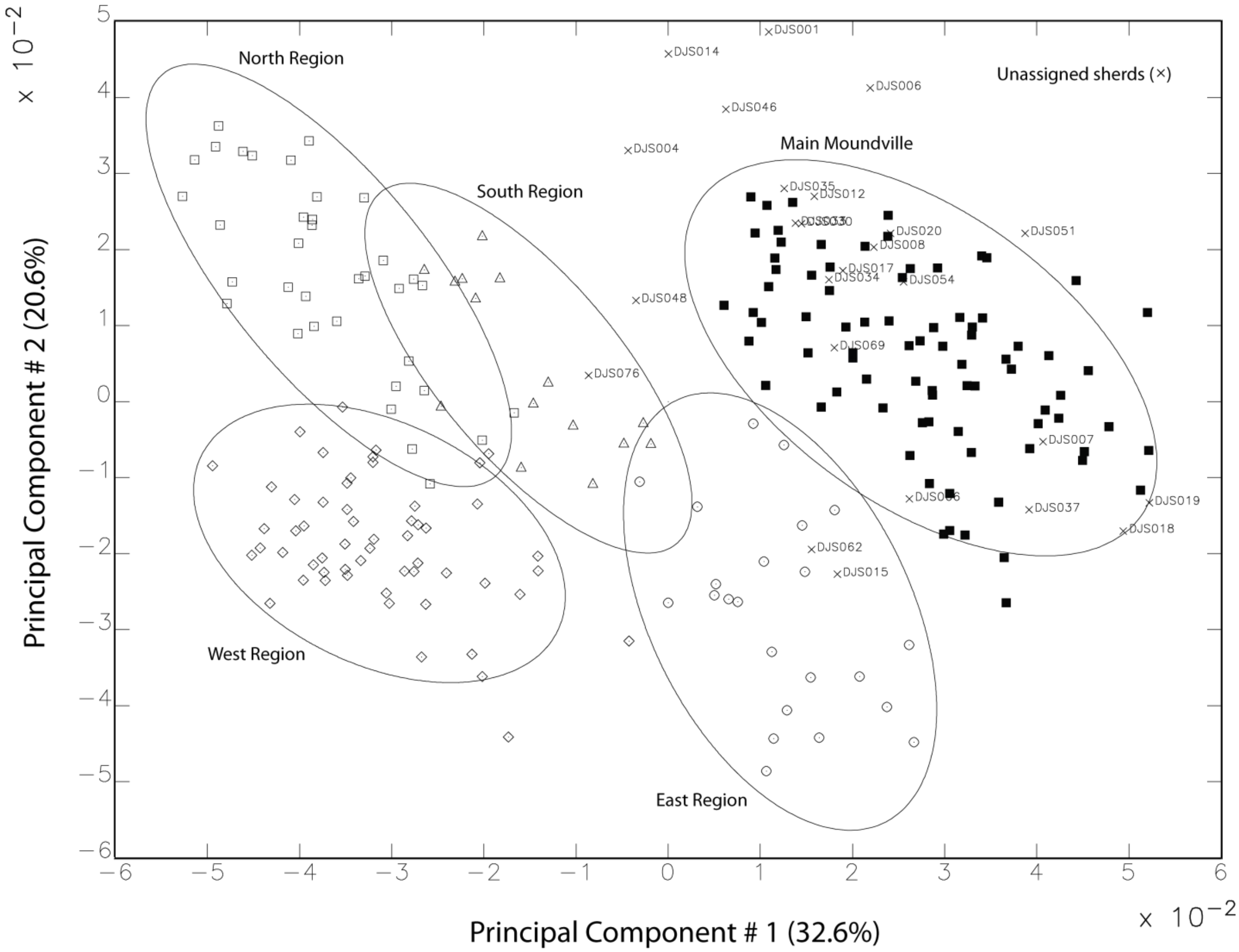

Figure 6. Bivariate plot of the first two principal components derived from the entire comparative database (N=368). Ellipses are drawn at the 90% confidence interval for membership in the group.

Moundville 2: This group was also initially recognized by Neff and Stryker (1991) and augmented by Neff (1992). The group consists primarily of engraved sherds originally thought to have derived from west of the Mississippi River based on stylistic criteria, along with some presumably locally made Moundville specimens and several specimens thought to have been imported from various non-Caddoan regions. Two sherds of Bell Plain from the present study were added to this compositional group. Most member specimens in Moundville 2 show a low membership probability in the main Moundville group, yet on scatter plots of the first two principal components Moundville 2 is contained entirely within the larger group (Figures 4 and 7). These statistical and chemical observations, combined with the lack of correspondence between Moundville 2 and the West Region, led to the conclusion that this group was locally made using raw material sources distinct from most other Moundville ceramics (Neff and Stryker 1991). Neff (1992) posited that the differences between the two Moundville groups reflects the presence of two distinct rare earth patterns in sediments within the vicinity of Moundville in west-central Alabama and eastern Mississippi. The two local groups are most clearly distinguished on elemental scatterplots of Ce, Eu, La, and Lu.

Lake Jackson Plain: This group consists entirely of sherds of Lake Jackson Plain, a ceramic type thought to be derived from the lower Chattahoochee River Valley of Alabama and Georgia (Knight 2010:42). All members of this group show a very low membership probability in the Moundville group. The specimens in this group do not form a particularly cohesive cluster, but they do separate themselves well on a number of elements, including Cr, Th, and Al (Figures 4 and 8).

West 1: This is the largest nonlocal group isolated in this analysis and consists of seven specimens. Four of these are sherds of Pouncey Pinched, *var. Pouncey*, two are sherds of Bell Plain painted wares, and the last is a sherd of Fortune Noded, *var. Fortune*. Both Pouncey Pinched and Fortune Noded are stylistically related to Middle Mississippi River valley cultures, and the chemical profile of this group bares that out. First, all seven specimens exhibit negligent probability of membership in Main Moundville. Second, on the first several PCs derived from the entire dataset (N=368) this group is shown to be chemically similar to the West Region compositional group (Figures 7 and 8). Several of these sherds also exhibit a meaningful membership probability in the West Region group.

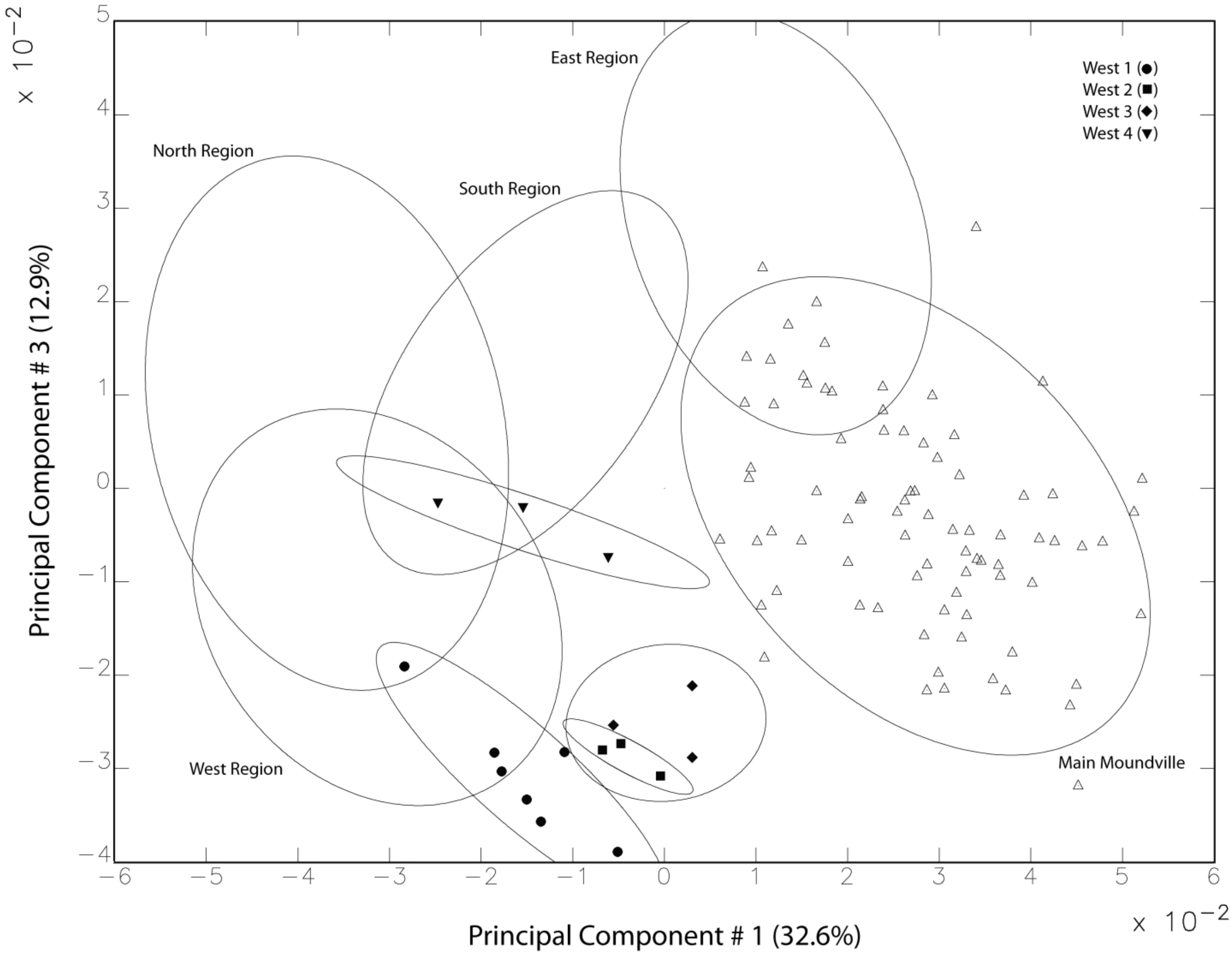

Figure 7. Bivariate plot of the first and third principal components, derived from the entire database (N=368). Ellipses are drawn at 90% confidence interval for membership in the group.

West 2: This group consists of three sherds that stylistically appear to be derived from the cultures in the Middle Mississippi River valley. Two sherds are Barton Incised, *var. Togo*, while the third is an example of Pouncey Pinched. All three sherds have very low membership probabilities in Main Moundville. On a scatterplot of the first and third principal components this group separates itself entirely from the main Moundville group (Figure 7). Although apparently nonlocal to Moundville, these sherds do not bear a strong chemical association to any of the five major compositional groups (Figures 8 and 9). It is very possible that they come from in or around the Mississippi River valley but were manufactured using raw material sources or paste recipes distinct from any ceramics previously analyzed at MURR.

West 3: This group is very similar to West 2; it consists of three members, two of which are specimens of Pouncey Pinched, *var. Pouncey* and the third of which is a specimen of Barton Incised, *var. Togo*. Like West 2, this group is distinct from the major compositional groups on a number of elemental scatter plots (Figures 8 and 9). They have corresponding low membership probabilities in any of the major compositional groups and separate themselves well on a scatterplot of the first and third principal components (Figure 7).

West 4: This group is comprised of three sherds of Barton Incised, *var. Barton*. The group is very cohesive chemically, and may actually consist of several sherds from the same vessel. Regardless, all three sherds have very low membership probabilities in the Main Moundville or Moundville 2 group, indicating that they are most likely nonlocal. Although they cannot be confidently associated with any non-Moundville compositional group, like West 2 and West 3 this group separates itself on scatterplots of the first several PCs (Figure 7) and on elemental scatterplots (Figures 8 and 9).

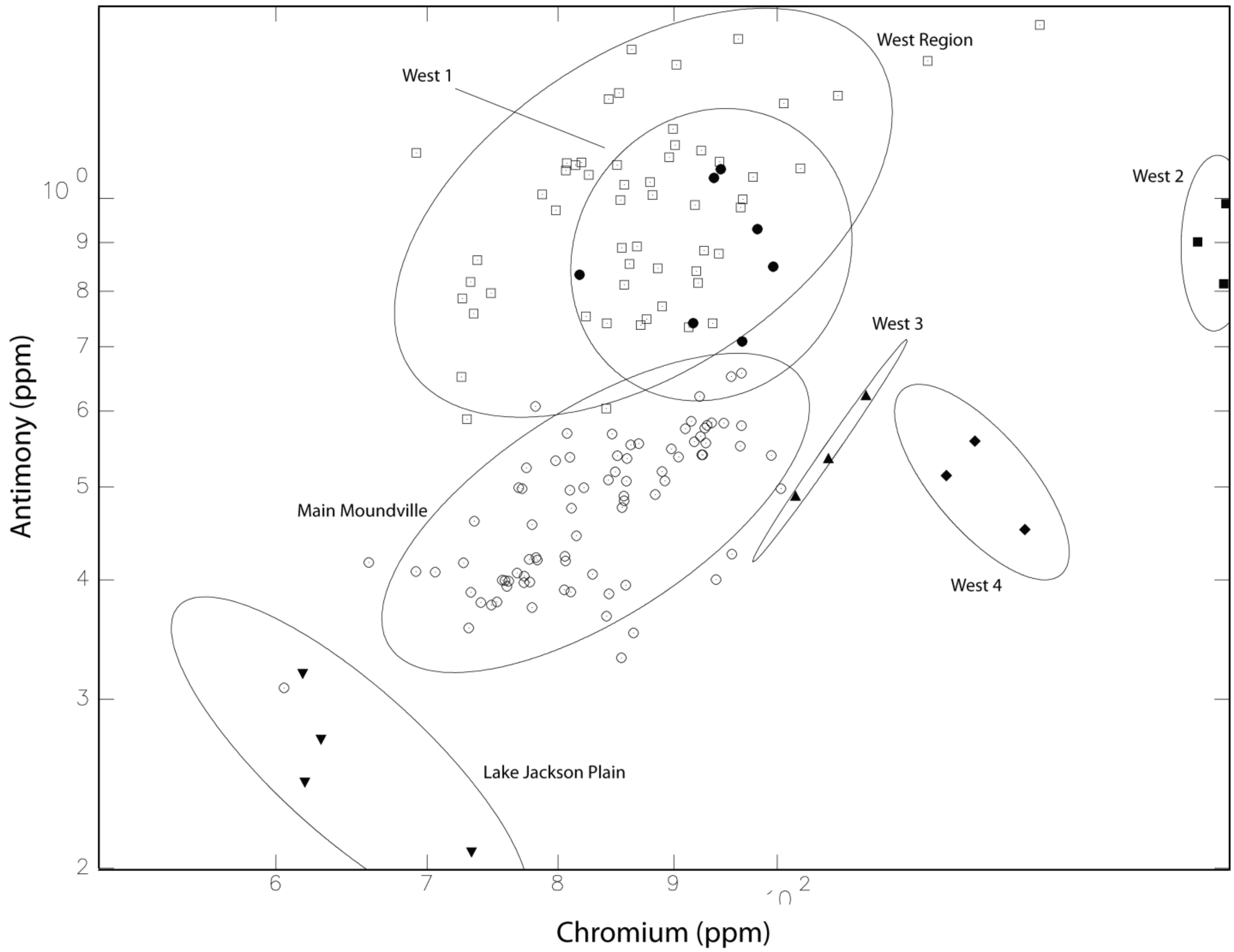

Figure 8. Bivariate log-log plot of Sb and Cr concentrations. Ellipses are drawn at the 90% confidence interval for group membership.

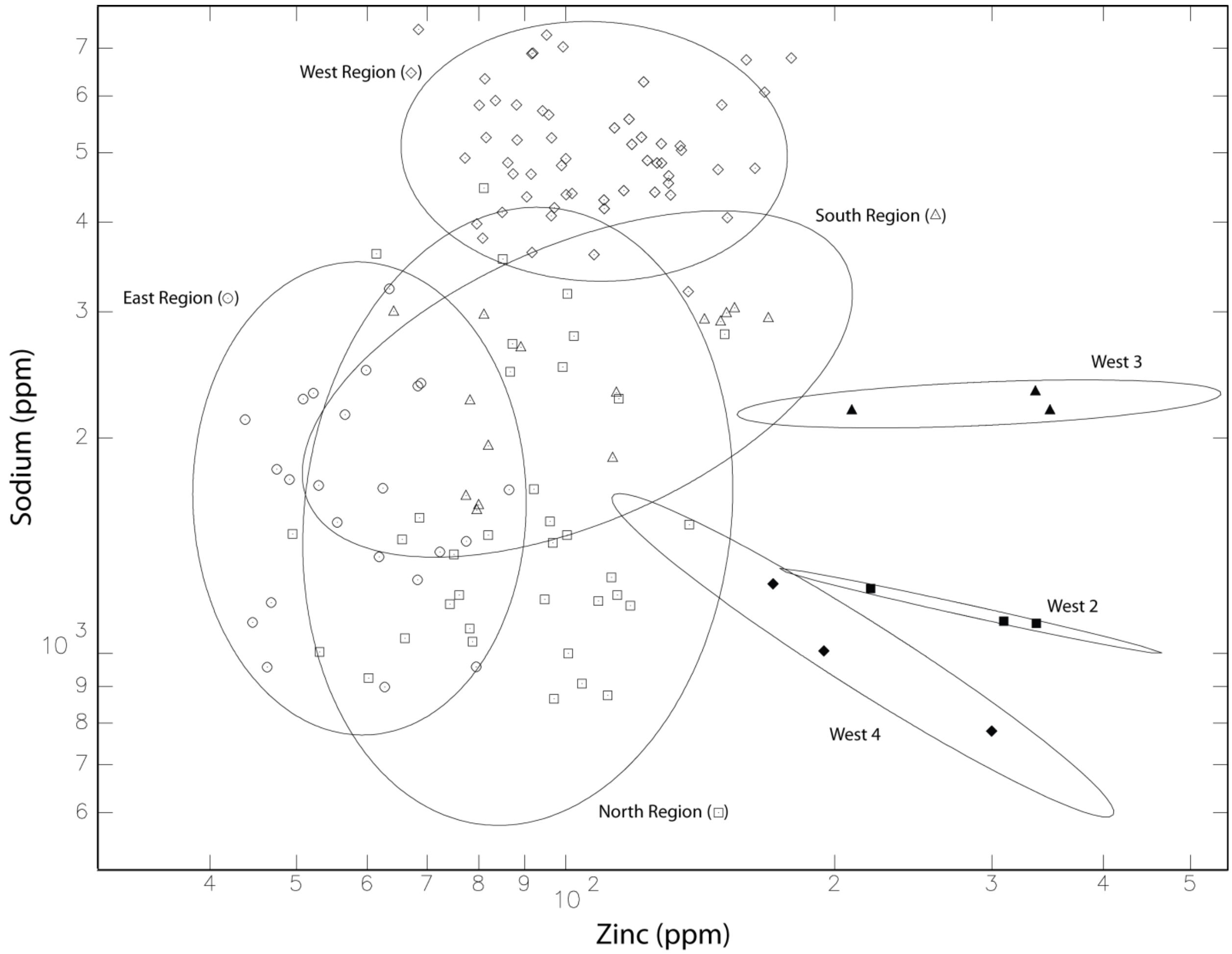

Figure 9. Bivariate log-log plot of Zn and Na concentrations. Ellipses are drawn at 90% confidence interval for membership in the group.

Unassigned: Of the 80 sample dataset, 25 sherds (31.25%) were left unassigned. Considering that a slight majority of the sherds selected for this project were stylistically nonlocal (N=42) and specific type-varieties were sampled in very low frequencies, this is not surprising. These specimens were left ungrouped because they had very low membership probabilities in the Main Moundville compositional group and in Moundville 2 or because they would have greatly skewed group distinctions if included in any of the internally recognized compositional groups. I did not iteratively assign specimens to any of the major compositional groups identified in previous analyses at MURR (i.e., the East Region, North Region, South

Region, or West Region), though a few yielded Mahalanobis membership probabilities high enough to warrant assignment.

A number of Mississippi Plain and Bell Plain sherds from the present study (N=9) were left ungrouped. These specimens had low membership probabilities in the Main Moundville group, but some are clearly chemically marginal to the local group based on visual inspection of scatterplots. Three explanations seem most likely in explaining the lack of fit of these stylistically local sherds with the Main Moundville group. First, these sherds may have been locally produced, perhaps utilizing seldom-exploited clay sources or slight variations in paste recipes. I believe that this is the most parsimonious explanation. The high frequency of unassigned Mississippi Plain sherds (N=8) in particular may be due to the coarse nature of the tempering found in these sherds as compared to much of the Main Moundville group. Figure 3 shows the compositional variability of shell-tempered ceramics compared to non-shell-tempered ceramics on a biplot of the first two principal components. The elemental vectors indicate that Ca and Sr, two elements most closely associated with shell temper, account for a great deal of this variation. Second, it is possible that an occasional nonlocal utility vessel could be brought to Moundville as a container carrying something more valuable than the pot itself. Without residue analysis of the contents of each vessel or a more refined understanding of local clay sources throughout the vicinity of the Black Warrior River valley and beyond, it is impossible to say for sure. A third scenario is that grog temper made from broken nonlocal vessels was present in these particular specimens, skewing their chemical composition relative to the Main Moundville group. However, I did not identify any grog temper in these particular sherds through macroscopic analysis. It is unlikely that NAA would be able to accurately assign these sherds to a local reference group if this were the case.

Some of the ungrouped sherds are tentatively designated “probably local.” The criteria for this designation are based on the quantitative analysis of the chemical data rather than style characteristics. Of the stylistically local ungrouped sherds (i.e., Bell Plain and Mississippi Plain), DJS007, DJS019, and DJS020, all specimens of Mississippi Plain, have the highest probability of being local products based on membership probabilities. In addition to these three specimens, DJS034 and DJS069 are also considered possible local products. DJS034 is a sherd of Moundville Place Incised, *var. McMillan* and DJS069 is a sherd of residual non-tempered incised. Both sherds exhibit a low, but non-negligible, probability of membership in the Main Moundville group.

There are perhaps 14 ungrouped specimens that may have been imported to Moundville. This determination is made based on their low probabilities of membership in the Main Moundville group and Moundville 2, as well as the presence of fabric or decorative characteristics that fall outside the range of typical Moundville variation (DJS014, DJS015, DJS030, DJS033, DJS035, DJS037, DJS046, DJS048, DJS051, DJS054, DJS066, and DJS069). In other words, these sherds are the residual wares identified by Knight (2010:42-43) and several stylistically nonlocal wares that could not be linked to a particular compositional group. In addition to these stylistically ambiguous and nonlocal specimens, DJS004, a sherd of stylistically local Bell Plain, and DJS076, a sherd of stylistically local Alabama River Incised, both exhibit non-negligible membership probabilities in the South Region. They are therefore interpreted as likely imports from some part of eastern Mississippi or western Alabama that possesses geological variability distinct from the Black Warrior River valley (Steponaitis et al. 1996).

Summary

In this chapter the pattern-recognition techniques used in identifying and evaluating potential ceramic compositional groups were described, the substructure of internal compositional group were presented, and potential source zones were assessed. Compositional analysis of the ceramic sample from Moundville successfully revealed subgroup structures based on bulk chemistry. For the most part these groups adhered well to our expectations based on archaeological data. Most specimens were isolated into one of seven compositional groups. Two of these are assumed to reflect local ceramic production at Moundville because they consist mainly of types that are abundant at the site (i.e., Mississippi Plain, Bell Plain, Moundville Engraved, Moundville Incised). Five are assumed to consist of ceramic imports because they exhibit noticeable chemical distinctness from both of the local Moundville groups on bivariate plots of the chemical data and exhibited a low probability of membership in either group based on Mahalanobis-based distance calculations. In the next chapter the empirical objectives of this project are reiterated and evaluated. Following this, the theoretical implications of the chemical analysis of Moundville ceramics are discussed.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

A common theme in archaeological reconstructions of ancient political economies is the role highly crafted nonlocal goods played in economically and ideologically structuring elite authority (Blitz 1993; Blitz and Lorenz 2006; Blomster 2005; Earle 1997; Helms 1987; Livingood 2010). At the Moundville chiefdom in west-central Alabama, the relationship between social hierarchy and highly crafted goods has been argued for on the basis of correspondences between changing frequencies of nonlocal imports at the center and sociopolitical transformations both internally and in smaller adjacent polities (Blitz 1993; Steponaitis 1991; Welch 1991; Livingood 2010). Yet, several recent analyses have cast doubt on the explanatory power of this apparent correlation (e.g., Marcoux 2007; Thompson 2011).

The goal of this research was to chemically analyze a sample of stylistically local and nonlocal ceramics at Moundville in order to gain insights regarding the participation of elites at Moundville in a prestige goods economy and the potential role of prestige goods, particularly fineware ceramics, in the ideological reproduction of their authority (Blitz 1993; Steponaitis 1991; Welch 1991). On a more technical level, this study had three main empirical objectives: (i) to independently confirm if pottery specimens are locally made or imports; (ii) to evaluate the accuracy of traditional sourcing of pottery by style techniques as compared to NAA sourcing; and (iii) to identify the sources of pottery, allowing for the mapping of the spatial extent of Moundville's trade network. Each of these analytical issues will be addressed in turn, followed by a discussion of the implications of this study for an understanding of Moundville's political economy.

(i) Independently confirm if pottery specimens are locally made or imports.

Quantitative analysis of the chemical data suggests that NAA is capable of distinguishing between local and nonlocal ceramics at Moundville. In addition to the 38 stylistically local ceramics analyzed for this study, 41 stylistically local ceramics were analyzed by Neff and Stryker (1991), allowing for the recognition of a compositional group that presumably reflects a relatively substantial degree of the ceramic paste variability in the Black Warrior River valley during Mississippian times. Whether the raw material sources were "local" is not a simple task to determine directly. It is widely recognized that ceramic materials are the heterogeneous byproducts of a pottery manufacturing process that generally alters the raw materials (Rice 1987). There is thus little chance of finding a "perfect" match between a specific clay's chemical and mineralogical profiles and ceramic specimens from vessels manufactured using the same clay, although ethnoarchaeological applications of NAA have demonstrated that a close match is possible (e.g., Arnold et al. 1991). Though the local Main Moundville and Moundville 2 groups identified in this study have not been linked directly to local production at Moundville through chemical analysis of raw clay sources or byproducts of pottery production, the abundance of stylistically local sherds in the context of a non-market economy provides good evidence that these compositional groups reflect ceramic production in the local vicinity and not elsewhere.

At the same time, we currently have no way of knowing how large an area might be represented by any "local Moundville" group defined by these analyses. If the analyzed "local" pottery derives from a large portion of western Alabama and eastern Mississippi, the fact that we have identified specimens of presumed Gulf Coast, Lower Ohio River area, and Mississippi

River valley origin as matching the “local Moundville” group is not necessarily surprising. It is possible that the Black Warrior River valley and a vast swath of this geographic region possess geological clay sources that are chemically indistinguishable from each other. Ultimately this question must be addressed with further compositional and petrographic work aimed at determining patterning in local ceramic production.

While these are issues for further resolution, a subset of sherds is extremely distinct from the local Moundville group based on both principal components and elemental-based analysis. In interpreting the origin of these sherds, we are faced with two alternative explanations: either they were produced nonlocally using geological sediments distinct from those occurring around the vicinity of Moundville, or they represent local production using distinct raw materials or unique paste recipes. The former is likely the most parsimonious explanation, especially considering the majority of the sherds that are chemically nonlocal are also stylistically nonlocal. However, it is also important to keep in mind that geological clay sources do not represent discrete sources of raw materials in the same way that a material such as obsidian does. Without additional ceramic compositional sampling that successfully links specific ceramic type-varieties back to production activities (e.g., through comparative chemical analysis of kiln furniture, wasters, or raw materials found at a manufacturing location), chemical compositional analysis provides only an indirect, albeit powerful, line of evidence that stylistically nonlocal ceramics are actual imports and not simply imitations.

(ii) Evaluate the accuracy of traditional sourcing of pottery by style techniques as compared to NAA sourcing.

Broadly speaking, the current analytical sample consisted of four degrees of hypothetical provenience: (1) wares of nearly certain local origin (i.e., Bell Plain and Mississippi Plain recovered from Moundville), (2) wares of probable local origin (i.e., Bell Plain painted), (3) wares of probable nonlocal origin (e.g., Pouncey Pinched, *var. Pouncey* and Barton Incised, *var. Barton*), and (4) wares of possible nonlocal origin (i.e., residual wares) that were outside the normal range of paste and stylistic variation at Moundville. Tables 2 and 3 display the associations between the stylistic provenience of ceramic sherds and their compositional provenience.

The tables suggest that there is some discrepancy between sourcing techniques based on stylistic criteria and provenience studies based on chemical compositional data, but that overall stylistic analysis is generally successful in differentiating local from nonlocally produced ceramics at Moundville. Overall, however, it would appear that in order to do an effective job of mapping the distribution and provenience of ceramic production in the Mississippian Southeast, some combination of stylistic and chemical analysis is needed. Roughly 64 percent of the sherds that were determined to be produced at Moundville based on stylistic criteria could be confidently identified as a local product based on chemical composition. Another 11 percent are likely local products based on chemical composition. The Bell Plain painted wares, which were hypothesized to be *probably* local, were chemically identified as local in 70 percent of cases. Similarly, 64 percent of sherds identified as stylistically nonlocal were confidently identified as chemically nonlocal. Twenty percent of the stylistically nonlocal sherds were confidently identified as local products based on chemical analysis. The residual wares, which like the stylistically nonlocal type-varieties fall outside the normal range of fabric variation of local Moundville ceramics based on macroscopic analysis (Knight 2010), present an interesting case. About 36 percent of these specimens were confidently identified as local, yet another 57 percent could not be reliably placed as either local or nonlocal. This is not surprising, and in fact

Table 2. Comparison of regional provenience by stylistic criteria and compositional analysis[3]

	Chemical Group								
Stylistic Region	Main Moundville	Moundville 2	Lake Jackson Plain	West1	West2	West3	West4	Unassigned	**Total**
Black Warrior Valley	16	2	0	0	0	0	0	10	28
Black Warrior Valley?	7	0	0	2	0	0	0	1	10
South-central Alabama	0	0	4	0	0	0	0	1	5
Middle Mississippi Valley	3	0	0	5	3	3	3	1	18
Lower Mississippi Valley	0	0	0	0	0	0	0	1	1
Lower Ohio Valley	2	0	0	0	0	0	0	0	2
Northern Gulf Coast	0	0	0	0	0	0	0	2	2
Unknown, Nonlocal?	5	0	0	0	0	0	0	9	14
Total	33	2	4	7	3	3	3	25	80

Table 3. Gross comparison of provenience as determined by stylistic and compositional criteria[4] [5]

	Compositional Provenience				
Stylistic Provenience	Local	Probably Local	Nonlocal	Unknown	**Total**
Local	18 (.64)	3 (.11)	2 (.07)	5 (.18)	28
Probably Local	7 (.7)	0	2 (.2)	1 (.1)	10
Nonlocal	5 (.18)	1 (.04)	18 (.64)	4 (.14)	28
Unknown	5 (.36)	1(.07)	0	8 (.57)	14
Total	35	5	22	19	80

[3] Note that *Black Warrior Valley?* refers to Bell Plain painted wares, which are generally assumed to be local to Moundville based on decorative characteristics and vessel form, but are nonetheless extremely rare and restricted to elite contexts (Knight 2010:21-23, 43-45).
[4] *Probably Local* also refers to Bell Plain painted wares.
[5] See Table 1 for the suggested chemical origin of each specimen.

independently confirms that there is something about these sherds that is unusual compared to the majority of sherds, both stylistically local and nonlocal, that are found at Moundville. Until pottery is more systematically sampled and chemically characterized from sites across the Mississippian Southeast, it is impossible to definitely say if these “residual” wares were produced locally or nonlocally.

(iii) To identify the sources of pottery, allowing for the mapping of the spatial extent of Moundville’s trade network.

Although the analysis was able to differentiate between ceramics locally produced at Moundville and likely imports, it is difficult to trace these potential imports back to a place of origin in most instances. One exception is the group West 1, which is chemically similar to the West Region compositional group in terms of many elemental concentrations as well as on biplots of the first several PCs. Despite the inability to demonstrate a chemical link between West 2-4 and the West Region or other Mississippi River valley wares, it is premature to dismiss this region as their likely source of origin. Although multiple compositional groups of ceramics cannot be assumed to necessarily represent different clay sources (Neff 2000:120), the archaeological stylistic assignment of these sherds as nonlocal, as well as their lack of chemical affinity with either local Moundville compositional groups, provides two indirect lines of evidence that they were most likely imported to Moundville. It is assumed that a larger sample from the region in question would likely contribute to an expansion of these chemical reference groups. I imagine, in particular, that a much larger sample of ceramics from the Mississippi River valley would allow for the expansion of the West Region compositional reference group to the extent that it would subsume the chemical variation found in the groups West 1-4. For the same reasons, the chemical analysis of the Lake Jackson Plain sherds provides little reason to doubt that they are foreign to Moundville and were possibly manufactured in the lower Chattahoochee River valley region of south-central Alabama. Finally, two sherds that were assumed to be local, one a specimen of Bell Plain and the other Alabama River Incised, also were chemically similar to the South Region and may be imports.

In regard to ceramics of more ambiguous origins, this analysis has revealed some interesting insights. Chemical analysis of Bell Plain painted ware suggests that much of it was indeed made at Moundville, but that people from across the Southeast may have been producing similar painted serving ware that can be difficult to differentiate based on visual stylistic criteria alone. Two sherds were confidently identified as nonlocal (DJS026 and DJS080) and a third was left ungrouped (DJS012). Residual wares that were assumed to be nonlocal because they exhibited fabrics outside the normal range of variation at Moundville appear to present a complicated picture as well. While some are undoubtedly nonlocal, none could be attributed to a nonlocal reference group. These and other unassigned pottery specimens are likely the result of different ceramic manufacturers or distinctly different paste recipes that would each comprise a compositional group if there were more specimens analyzed from across the Southeast and specifically their region of origin.

Implications for Moundville's Political Economy

A review of the archaeological literature of Moundville's political economy highlighted two notable contradictions. On one hand, there appears to be temporal correlations between evidence for long-distance trade at the center and major sociopolitical events. Regional consolidation of the center and the entrenching of the chiefly elite are both reflected in an increase in nonlocal items per burial, while the decline of the center in the late fifteenth and early sixteenth centuries parallels a similarly drastic decline in the importation of nonlocal goods

(Peebles and Kus 1977; Knight and Steponaitis 1998; Steponaitis 1991). Similarly, there is some evidence to suggest that control of prestige goods trade at large sites like Moundville compromised the political fortunes of smaller polities such as Pocahontas and Lubbub Creek (Blitz 1993:175; Livingood 2010; Steponaitis 1991). On the other hand, some recent studies have questioned whether the political economy model fails to account for the variability seen at Moundville regarding non-elite access to subsistence and prestige goods (Thompson 2011). Thompson, for instance, found that some categories of local and nonlocal craft goods were more evenly distributed at Moundville than either the traditional prestige goods economy model (Frankenstein and Rowlands 1978) or Welch's (1991) political economy model allowed. Her excavations indicated that residential deposits dating to the Moundville II and III time periods (A.D. 1260–1520) had discarded fragments of some of the same highly crafted goods as found in presumably elite contexts on the mounds. Although Marcoux's (2007) survey of the distribution and production evidence for highly crafted local and nonlocal goods failed to find evidence for heterarchical access to such items, he argued that the paucity of nonlocal display goods relative to local display goods, as well as the low frequency of display goods in general, suggested that such items did not serve as a primary fund of elite power.

Paralleling Marcoux's (2007) analysis, the results of this study provide evidence for the importance of nonlocal ceramics in the production of elite identity, if not their role in a prestige goods economy as described by Frankenstein and Rowlands (1978). Much of what we thought was stylistically nonlocal was confirmed by chemical analysis to be distinct from local ceramic production. Some of these specimens were successfully linked back to regions of probable manufacture as well. At the same time, though, eighteen percent of stylistically nonlocal sherds (5 of 28) are chemically indistinguishable from the chemical profile of Moundville ceramics.

Thirty-six percent of the residual wares (5 of 14), which also fall outside the normal range of variation of Moundville ceramics, turned out to be local. Neff and Stryker (1991) found a similar pattern of stylistically nonlocal pottery that was chemically indistinguishable from local pottery production.

Both the stylistically nonlocal and residual wares identified as compositionally local were possibly made by foreign migrants to Moundville in their native style. This pottery could also reflect imitation of foreign styles by Moundville natives. The strongest evidence for this interpretation is a stylistically nonlocal sherd of Barton Incised, *var. Barton* that was identified as locally produced. Of the four sherds of Barton Incised, *var. Barton* analyzed in this study, the remaining three were identified as chemically nonlocal. This suggests that this variety was produced outside of Moundville and imported to the site, but that some individuals also had an interest in imitating this style locally. From a style as communication perspective (Weisnner 1983), the imitation of foreign styles can be interpreted as an attempt by individuals at either asserting their elite identity or demonstrating their affiliation with a particular stratum of Moundville society.

The two sherds of stylistically nonlocal Angel Negative Painted that were identified as local are also notable, and provide additional evidence that immigrants to Moundville were continuing to make pottery in their native style. Previous chemical characterization studies of Moundville sherds have confirmed that some negative-painted ware is indeed local, while some is not (Knight 2010:45-46; Neff and Stryker 1991) Angel Negative Painted and Nashville Negative Painted sherds (Steponaitis 1983:336-337) feature black resist decoration over a highly distinctive burnished red-orange or white slipped background, a relatively sophisticated technique compared to more common decorative modes such as incising (Knight 2010:45-46;

Steponaitis 1983:28). Most competent potters who were already used to incising – a ubiquitous decorative technique at Moundville – could likely copy an unfamiliar foreign incised style or even a foreign shape with the training and experience they already had in the Moundville potting tradition. However, the resist technique would likely require an additional knowledge that cannot be produced just by copying; somebody has to show the potter. Thus, it is perhaps more likely that such vessels were produced by foreign potters living at Moundville and working in their native tradition rather than by Moundville natives imitating a foreign style.

Having chemically established the presence of nonlocal ceramics at Moundville as well as the potential for artistic imitations of foreign styles, it is possible to also consider how frequent nonlocal ceramics actually were at the site, as well as where these ceramics may have been coming from. Owing to the difficulty of identifying nonlocal styles from ceramic sherds, this is by necessity a rough evaluation. Although only five percent of sherds were identified as stylistically nonlocal during an analysis of the roadway sherd collections (Welch 1991:172), Steponaitis (1983:49) identified 15 percent (N=176) of the 954 whole burial vessels he classified from Moundville as nonlocal. In sum, the actual percentage of nonlocal pottery present at Moundville is probably somewhere between five and 15 percent of the total number of ceramics. Many of these ceramics were apparently coming from west of Moundville, and in particular the Mississippi River valley. As noted in Chapter 2, Paul Welch (1991:190) found a rough geographic symmetry between Moundville exports and imports of manufactured nonlocal goods. Stylistically at least, the origin of the majority of known imports came from the north and west, whereas the majority of known exports are found to the north and west as well. Over 45 percent (19 of 42) of stylistically nonlocal or residual pottery analyzed in this study was hypothesized to have been produced by cultural groups living around the Mississippi River valley to the west of

Moundville. Chemical analysis clearly indicated that the sherds sampled from most of these styles were foreign to Moundville, providing evidence for some sort of sustained link with populations to the west. Although the sample size for this analysis is too small to draw robust statistical conclusions from, it does suggest that a non-negligible percentage of pottery consumed at Moundville was being produced in this particular region. On one hand, perhaps there was something symbolically important about distant geographic locations to the west. On the other hand, the frequency of western styles relative to other nonlocal varieties of pottery may simply reflect proximity to certain trade routes. One interesting possibility to consider is that Moundville elite were intermarrying with populations from the Mississippi River valley, who in turn brought some of their pottery with them when they moved to the Black Warrior River valley. In every case where the sex of the burial associated with a nonlocal vessel is known at Moundville, the buried individual was female (Welch 1991:172).

Summary

In conclusion, NAA is successful at distinguishing between local and nonlocal pottery recovered at the Mississippian civic-ceremonial site of Moundville. Confirmation of nonlocal trade in ceramics during this study implies that elites at Moundville maintained a sustained link with distant populations, providing some evidence to support the efficacy of the prestige goods model in describing the establishment and legitimization of chiefly power in the Mississippian world. However, recent studies have suggested that the frequency of nonlocal goods is not high enough to serve as a primary economic and ideological source of power for Moundville's elite. Clearly though, these ceramics had social and symbolic value or importance for residents at Moundville, as there is evidence for imitation of nonlocal styles by local producers. Though the chemical analysis indicates that sourcing pottery using stylistic criteria is generally quite accurate, in order to do an effective job of mapping the distribution and provenience of ceramic production in the Mississippian Southeast, some combination of stylistic and chemical analysis is needed.

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APPENDIX A:
Ceramic Specimens Sorted by Compositional Group

Specimens sorted by compositional group for the present dataset. Selected descriptive information is included.

Main Moundville

ANID	Type/variety	Temper	Minor Temper	Stylistic Origin	Chemical Origin	Citation
DJS002	Mississippi Plain	shell	none	Moundville	Local	Steponaitis 1983
DJS003	Mississippi Plain	shell	none	Moundville	Local	Steponaitis 1983
DJS005	residual fine grog, sand-tempered plain	grog	sand	Unknown	Local	Steponaitis 1983
DJS009	Bell Plain	Shell	none	Moundville	Local	Steponaitis 1983
DJS010	Bell Plain	Shell	none	Moundville	Local	Steponaitis 1983
DJS011	Bell Plain (white on red)	Shell	none	Moundville?	Local	Knight 2010
DJS016	Mississippi Plain	shell	none	Moundville	Local	Knight 2010
DJS021	Bell Plain	shell	none	Moundville	Local	Knight 2010
DJS022	Bell Plain	shell	none	Moundville	Local	Knight 2010
DJS023	Bell Plain	shell	none	Moundville	Local	Knight 2010
DJS024	Bell Plain	shell	none	Moundville	Local	Knight 2010
DJS025	Bell Plain	shell	none	Moundville	Local	Knight 2010
DJS031	residual fine grog, shell-tempered engraved	grog	shell	Unknown	Local	Knight 2010
DJS036	residual fine grog tempered plain	grog	none	Unknown	Local	Knight 2010
DJS041	Parkin Punctated, var. Parkin	shell	none	Mid. Miss.	Local	Knight 2010
DJS042	Bell Plain Polychrome (black and red on white)	shell	none	Moundville?	Local	Knight 2010
DJS043	Residual Fine Grog Tempered engraved	grog	none	Unknown	Local	Knight 2010
DJS044	Barton Incised var. Barton	shell	grog	Mid. Miss.	Local	Knight 2010
DJS049	Bell Plain (red on white)	shell	none	Moundville?	Local	Knight 2010
DJS050	Bell Plain (red on white)	shell	none	Moundville?	Local	Knight 2010
DJS053	Bell Plain (white on red)	shell	none	Moundville?	Local	Knight 2010
DJS055	Bell Plain	shell	grog	Moundville	Local	Knight 2010
DJS056	Mississippi Plain	shell	none	Moundville	Local	Knight 2010
DJS057	Mississippi Plain	shell	none	Moundville	Local	Knight 2010
DJS058	Bell Plain (white)	shell	none	Moundville?	Local	Knight 2010
DJS059	Bell Plain	shell	none	Moundville	Local	Knight 2010
DJS061	Mississippi Plain	shell	none	Moundville	Local	Knight 2010
DJS063	Mississippi Plain	shell	none	Moundville	Local	Knight 2010
DJS067	Angel Negative Painted (black on orange)	shell	none	Lower Ohio River	Local	Knight 2010
DJS068	Parkin Punctated var. Parkin	shell	none	Mid. Miss.	Local	Knight 2010

Main Moundville continued

ANID	Type/variety	Temper	Minor Temper	Stylistic Origin	Chemical Origin	Citation
DJS071	Residual fine sand, shell tempered incised	sand	shell	Unknown	Local	Knight 2010
DJS073	Bell Plain (red)	shell	grog?	Moundville?	Local	Knight 2010
DJS079	Angel Negative Painted (black on white)	shell	none	Lower Ohio River	Local	Thompson 2011

Moundville 2

ANID	Type/variety	Temper	Minor Temper	Suggested Origin	Chemical Origin	Citation
DJS060	Bell Plain	shell	grog	Moundville	Local	Knight 2010
DJS064	Bell Plain	shell	grog?	Moundville	Local	Knight 2010

Lake Jackson Plain

ANID	Type/variety	Temper	Minor Temper	Suggested Origin	Chemical Origin	Citation
DJS013	Lake Jackson Plain	grit	none	SC Alabama	Nonlocal	Knight 2010
DJS045	Lake Jackson Plain	grit	none	SC Alabama	Nonlocal	Knight 2010
DJS052	Lake Jackson Plain	grit	none	SC Alabama	Nonlocal	Knight 2010
DJS065	Lake Jackson Plain	grit	grog	SC Alabama	Nonlocal	Knight 2010

West 1

ANID	Type/variety	Temper	Minor Temper	Suggested Origin	Chemical Origin	Citation
DJS026	Bell Plain (red on white)	shell	none	Moundville?	Nonlocal	Knight 2010
DJS027	Pouncey Pinched, var. Pouncey	Shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS028	Pouncey Pinched, var. Pouncey	Shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS039	Pouncey Pinched, var. Pouncey	shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS047	Fortuned Noded, var. Fortune	shell?	none	Mid. Miss.	Nonlocal	Knight 2010
DJS078	Pouncey Pinched, var. Pouncey	shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS080	Bell Plain polychrome (black and red on white)	shell	none	Moundville?	Nonlocal	Thompson 2011

West 2

ANID	Type/variety	Temper	Minor Temper	Suggested Origin	Chemical Origin	Citation
DJS038	Barton Incised, var. Togo	shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS070	Pouncey Pinched, var. Pouncey	shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS075	Barton Incised var. Togo	shell	none	Mid. Miss.	Nonlocal	Knight 2010

West 3

ANID	Type/variety	Temper	Minor Temper	Suggested Origin		Citation
DJS029	Pouncey Pinched, var. Pouncey	shell	grog	Mid. Miss.	Nonlocal	Knight 2010
DJS032	Barton Incised, var. Togo	shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS040	Pouncey Pinched, var. Pouncey	shell	none?	Mid. Miss.	Nonlocal	Knight 2010

West 4

ANID	Type/variety	Temper	Minor Temper	Suggested Origin	Chemical Origin	Citation
DJS072	Barton Incised var. Barton	shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS074	Barton Incised var. Barton	shell	none	Mid. Miss.	Nonlocal	Knight 2010
DJS077	Barton Incised var. Barton	shell	none	Mid. Miss.	Nonlocal	Knight 2010

Ungrouped Specimens

ANID	Type/variety	Temper	Minor Temper	Suggested Origin	Chemical Origin	Citation
DJS001	Mississippi Plain	shell	none	Moundville	Unknown	Steponaitis 1983
DJS004	Bell Plain	shell	none	Moundville	Nonlocal	Steponaitis 1983
DJS006	residual grog-tempered engraved	grog	none	Unknown	Unknown	Steponaitis 1983
DJS007	Mississippi Plain	shell	none	Moundville	Probably Local	Steponaitis 1983
DJS008	Mississippi Plain	shell	none	Moundville	Unknown	Steponaitis 1983
DJS012	Bell Plain (black on white/neg. painted)	Shell	none	Moundville?	Unknown	Knight 2010
DJS014	residual non-temp punctated	grog or grit	none	Unknown	Unknown	Knight 2010
DJS015	Lake Jackson Plain	grit	none	SC Alabama	Unknown	Knight 2010
DJS017	Mississippi Plain	shell	none	Moundville	Unknown	Knight 2010
DJS018	Mississippi Plain	shell	none	Moundville	Unknown	Knight 2010
DJS019	Mississippi Plain	shell	none	Moundville	Probably Local	Knight 2010

Ungrouped Specimens continued

ANID	Type/variety	Temper	Minor Temper	Style Origin	Chemical Origin	Citation
ANID	**Type/variety**	**Temper**	**Minor Temper**	**Style Origin**	**Chemical Origin**	**Citation**
DJS020	Mississippi Plain	shell	none	Moundville	Probably Local	Knight 2010
DJS030	residual non-temp engraved	none	none	Unknown	Unknown	Knight 2010
DJS033	residual non-temp engraved	none	none	Unknown	Unknown	Knight 2010
DJS034	Mound Place Incised var. McMillan	shell	none	N. Gulf Coast	Probably Local	Knight 2010
DJS035	residual fine grog tempered plain	grog	none	Unknown	Unknown	Knight 2010
DJS037	Matthew Incised var. Beckwith	shell	none	Mid. Miss.	Unknown	Knight 2010
DJS046	residual non-temp engraved	none	none	Unknown	Unknown	Knight 2010
DJS048	Salt Creek Impressed	shell	none	N. Gulf Coast	Unknown	Knight 2010
DJS051	residual non-temp engraved	none	none	Unknown	Unknown	Knight 2010
DJS054	residual Fine grog, shell-temp incised	grog	shell	Unknown	Unknown	Knight 2010
DJS062	Mississippi Plain	shell	none	Moundville	Unknown	Knight 2010
DJS066	Carter Engraved	grog	shell	Lower Miss.	Unknown	Knight 2010
DJS069	residual non-tempered incised	none	none	Unknown	Probably Local	Knight 2010
DJS076	Alabama River Incised var. unspecified	shell	none	Moundville	Nonlocal	Knight 2010

APPENDIX B:
Group Membership Probabilities

Membership probabilities for ceramic specimens in each ceramic compositional group.

Main Moundville								
	Elements[6]	*Principal Components Analysis*[7]						
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS002	33.12	54.04	0.02	0.19	0.00	0.04	0.00
DJS003	12.23	9.52	0.04	0.56	0.00	0.52	0.00
DJS005	84.31	66.72	0.12	0.14	0.00	0.05	0.00
DJS009	86.78	23.72	0.50	0.02	0.00	0.12	0.00
DJS010	62.22	44.15	0.40	0.09	0.00	0.07	0.00
DJS011	89.91	86.98	0.10	2.41	0.00	0.08	0.00
DJS016	1.85	16.30	0.11	0.02	0.00	0.05	0.00
DJS021	16.75	55.78	0.12	0.05	0.00	0.04	0.00
DJS022	17.45	52.86	0.13	13.23	0.00	0.50	0.00
DJS023	2.81	3.63	0.01	0.11	0.00	0.02	0.00
DJS024	2.21	16.79	0.29	0.37	0.00	0.40	0.00
DJS025	5.95	30.66	0.03	0.03	0.00	0.02	0.00
DJS031	49.14	42.62	0.11	0.01	0.00	0.02	0.00
DJS036	12.07	2.84	0.00	0.60	0.00	0.09	0.00
DJS041	93.38	29.06	0.04	0.02	0.00	0.04	0.00
DJS042	28.63	94.11	0.04	0.23	0.00	0.03	0.00
DJS043	31.30	39.51	0.25	4.05	0.00	0.37	0.00
DJS044	40.88	17.67	0.00	0.10	0.00	0.01	0.00
DJS049	53.33	2.97	0.01	0.01	0.00	0.01	0.00
DJS050	28.45	87.15	0.03	0.47	0.00	0.04	0.00
DJS053	55.45	36.43	0.21	0.47	0.00	0.09	0.00

[6] Element probabilities are based on 29 elements (As, La, Lu, Nd, Sm, U, Yb, Ce, Co, Cr, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Ta, Tb, Th, Zn, Zr, Al, Ba, Ca, Dy, K, Mn, Na, Ti, and V) determined at MURR. Specimens were removed from reference groups before calculating their own probabilities of membership.

[7] Principal component probabilities are based on the first nine principal components of the dataset for this project, the dataset of Moundville sherds analyzed by Neff and Stryker (1991), and the Southeastern dataset described in Steponaitis et al. (1996) (N=368), which subsume 91.3% of the total variance in the dataset. Specimens were removed from reference groups before calculating their own probabilities of membership.

Main Moundville continued

	Elements			*Principal Components Analysis*			
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS055	99.58	60.32	0.43	1.85	0.00	1.27	0.00
DJS056	2.16	84.54	0.45	0.32	0.00	0.13	0.00
DJS057	4.83	91.59	0.28	0.44	0.00	0.32	0.00
DJS058	19.44	83.45	1.30	0.51	0.00	0.11	0.00
DJS059	90.28	43.23	0.86	0.02	0.00	0.03	0.00
DJS061	92.63	50.86	0.00	0.09	0.00	0.01	0.00
DJS063	7.06	40.04	0.00	0.06	0.00	0.01	0.00
DJS067	31.07	25.04	0.01	0.02	0.00	0.01	0.00
DJS068	8.91	17.17	0.02	0.28	0.00	0.15	0.00
DJS071	9.80	2.54	0.41	0.19	0.00	0.06	0.00
DJS073	8.27	78.63	0.05	0.15	0.00	0.03	0.00
DJS079	22.12	36.79	0.67	0.06	0.00	0.33	0.00
VSR001	31.91	31.58	0.04	0.14	0.00	0.05	0.00
VSR002	35.55	17.05	0.78	1.30	0.00	0.68	0.00
VSR003	73.86	45.11	0.05	2.81	0.00	0.91	0.00
VSR006	43.44	45.97	0.03	1.31	0.00	0.20	0.00
VSR007	33.86	61.23	0.55	4.67	0.00	0.37	0.00
VSR010	76.20	93.44	0.59	0.82	0.00	0.31	0.00
VSR011	27.83	47.23	0.79	8.32	0.00	0.76	0.00
VSR012	65.13	64.25	0.16	7.10	0.00	0.23	0.00
VSR014	21.37	9.17	0.05	2.29	0.00	0.06	0.00
VSR017	42.66	57.94	0.11	5.70	0.00	0.42	0.00
VSR019	37.00	87.71	0.02	1.24	0.00	0.05	0.00
VSR020	2.22	20.38	0.01	0.50	0.00	0.05	0.00
VSR031	7.56	81.43	0.22	1.00	0.00	0.15	0.00
VSR032	54.02	91.27	0.17	0.17	0.00	0.19	0.00
VSR033	37.71	47.86	0.09	0.20	0.00	0.06	0.00
VSR034	34.88	3.60	0.01	0.03	0.00	0.05	0.00

Main Moundville continued

	Elements	*Principal Components Analysis*					
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
VSR035	98.81	72.32	0.01	0.12	0.00	0.07	0.00
VSR036	82.13	21.64	0.00	0.48	0.00	0.28	0.00
VSR037	99.61	88.53	0.13	0.20	0.00	0.06	0.00
VSR038	96.77	51.69	0.05	0.20	0.00	0.07	0.00
VSR039	67.26	37.66	0.02	2.94	0.00	1.48	0.00
VSR040	94.96	27.77	0.40	1.36	0.00	0.28	0.00
VSR041	26.01	17.29	0.15	8.02	0.00	11.44	0.00
VSR042	75.47	43.46	0.00	0.38	0.00	0.10	0.00
VSR043	78.24	94.48	5.88	1.82	0.00	0.41	0.00
VSR045	68.61	22.90	0.25	6.71	0.00	0.36	0.00
VSR047	9.04	66.42	0.01	1.05	0.00	0.02	0.00
VSR051	82.05	45.63	0.02	0.12	0.00	0.07	0.00
VSR052	58.86	62.47	0.56	9.91	0.00	0.43	0.00
VSR076	9.33	6.41	5.93	0.70	0.00	0.84	0.00
VSR081	99.98	99.30	0.36	0.32	0.00	0.13	0.00
VSR085	98.08	93.13	0.89	1.17	0.00	0.12	0.00
VSR086	99.80	97.55	0.39	0.24	0.00	0.08	0.00
VSR087	99.99	99.01	0.50	0.95	0.00	0.18	0.00
VSR093	8.28	51.90	0.05	4.33	0.00	0.77	0.00
VSR096	0.61	35.31	0.08	0.02	0.00	0.01	0.00
VSR106	34.34	2.06	0.02	0.08	0.00	0.04	0.00
VSR111	65.05	48.67	0.48	0.87	0.00	0.29	0.00
VSR121	99.14	67.39	0.31	1.31	0.00	0.12	0.00
VSR122	85.14	30.42	2.12	17.66	0.00	1.30	0.00
VSR125	5.90	61.00	0.09	0.05	0.00	0.10	0.00
VSR129	91.53	63.95	0.08	2.20	0.00	0.23	0.00
VSR141	96.25	82.43	0.04	4.18	0.00	1.01	0.00
VSR142	36.08	80.39	0.56	5.96	0.00	0.14	0.00

Main Moundville Continued

	Elements			*Principal Component Analysis*			
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
VSR145	92.54	34.18	0.02	1.27	0.00	0.45	0.00
VSR151	6.65	98.98	1.43	0.26	0.00	0.10	0.00
VSR152	79.62	77.80	0.05	1.70	0.00	2.11	0.00
VSR161	38.93	8.50	0.01	0.15	0.00	0.03	0.00

Moundville 2

	Elements			*Principal Components Analysis*			
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS060	40.54	2.70	41.90	0.14	0.00	0.12	0.00
DJS064	8.59	0.76	12.50	0.13	0.00	0.10	0.00
VSR005	0.33	0.08	76.60	0.06	0.00	0.08	0.00
VSR061	0.14	0.00	38.78	0.08	0.00	0.04	0.00
VSR062	0.51	0.13	67.14	0.09	0.00	0.21	0.00
VSR063	0.05	0.00	37.72	0.01	0.00	0.08	0.00
VSR064	7.09	0.18	21.40	0.09	0.00	0.14	0.00
VSR065	2.24	0.25	55.03	0.07	0.00	0.16	0.00
VSR066	0.95	0.03	74.11	0.12	0.00	0.14	0.00
VSR067	0.01	0.04	69.68	0.12	0.00	0.11	0.00
VSR068	0.78	0.01	46.33	0.13	0.00	0.07	0.00
VSR071	3.67	0.00	84.93	0.26	0.00	0.07	0.00
VSR072	0.12	0.01	88.25	0.23	0.00	0.08	0.00
VSR073	1.92	0.00	66.66	0.28	0.00	0.07	0.00
VSR074	27.70	0.84	43.73	0.72	0.00	0.21	0.00
VSR082	0.50	0.06	16.67	0.13	0.00	0.15	0.00
VSR110	1.58	0.06	18.54	0.25	0.00	0.13	0.00

Lake Jackson Plain

	Elements	*Principal Components Analysis*					
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS013	0.00	0.02	0.01	0.30	0.00	**3.04**	0.00
DJS045	0.00	0.05	0.01	0.06	0.00	1.12	0.00
DJS052	0.00	0.00	0.00	0.34	0.00	0.78	0.00
DJS065	0.00	0.00	0.03	0.00	0.00	0.05	0.00

West 1

	Elements	*Principal Components Analysis*					
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS026	0.01	0.00	0.00	0.01	0.05	0.05	0.08
DJS027	0.00	0.00	0.00	0.01	0.39	0.07	0.25
DJS028	0.00	0.00	0.00	0.01	1.61	0.04	0.05
DJS039	0.00	0.00	0.00	0.00	0.02	0.05	0.08
DJS047	0.00	0.00	0.00	0.05	1.85	0.33	**83.01**
DJS078	0.00	0.00	0.00	0.01	1.41	0.21	3.90
DJS080	0.00	0.00	0.00	0.02	0.03	0.05	**3.17**

West 2

	Elements	*Principal Components Analysis*					
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS038	0.00	0.00	0.00	0.00	0.00	0.01	0.00
DJS070	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DJS075	0.00	0.00	0.00	0.00	0.00	0.01	0.00

West 3

	Elements	*Principal Components Analysis*					
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS029	0.00	0.00	0.00	0.00	0.00	0.04	0.00
DJS032	0.89	2.04	0.00	0.04	0.00	0.09	0.00
DJS040	0.00	0.01	0.00	0.00	0.00	0.02	0.00

West 4

	Elements	*Principal Components Analysis*					
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS072	0.01	0.24	0.04	0.09	0.00	0.06	0.00
DJS074	0.00	0.00	0.00	0.14	0.02	0.31	0.00
DJS077	0.00	0.00	0.00	0.00	0.00	0.01	0.00

Ungrouped Specimens[8]

	Elements	*Principal Components Analysis*					
ANID	**Main MDV**	**Main MDV**	**MDV 2**	**East**	**North**	**South**	**West**
DJS001	0.00	0.01	0.02	0.01	0.00	0.00	0.00
DJS004	0.01	0.00	0.00	0.16	0.00	**13.62**	0.00
DJS006	0.00	0.00	0.28	0.03	0.00	0.02	0.00
DJS007	0.00	1.36	0.01	0.00	0.00	0.05	0.00
DJS008	0.00	0.03	0.03	0.01	0.00	0.08	0.00
DJS012	0.00	0.03	0.01	0.00	0.00	0.00	0.00
DJS014	1.10	0.28	0.00	0.00	0.00	0.01	0.00
DJS015	0.00	0.00	0.00	0.00	0.00	0.24	0.00
DJS017	0.00	0.02	0.00	0.00	0.00	0.03	0.00
DJS018	0.00	0.06	0.00	0.00	0.00	0.01	0.00
DJS019	1.23	**2.02**	0.00	0.01	0.00	0.02	0.00
DJS020	0.58	**2.72**	1.86	0.24	0.00	0.05	0.00

[8] Bolded membership probabilities are non-negligible and suggest chemical affiliation with a reference group. However, these sherds were left ungrouped because they would have skewed group distinction if included.

Ungrouped Specimens continued

	Elements		*Principal Components Analysis*				
ANID	**ANID**	**ANID**	**ANID**	**ANID**	**ANID**	**ANID**	**ANID**
DJS030	0.12	0.06	0.00	0.01	0.00	0.02	0.00
DJS033	0.12	0.00	0.00	0.04	0.00	0.03	0.00
DJS034	0.31	**2.88**	0.08	0.01	0.00	0.16	0.00
DJS035	0.00	0.00	0.00	0.01	0.00	0.00	0.00
DJS037	0.00	0.00	0.00	0.01	0.00	0.03	0.00
DJS046	**5.49**	**2.10**	0.01	0.00	0.00	0.02	0.00
DJS048	0.06	0.24	0.00	0.15	0.09	0.06	0.00
DJS051	0.63	1.30	0.02	0.06	0.00	0.04	0.00
DJS054	**2.32**	0.18	0.03	0.02	0.00	0.20	0.00
DJS062	0.00	0.00	0.00	1.36	0.01	2.06	0.00
DJS066	0.00	0.00	0.01	0.01	0.00	0.19	0.00
DJS069	0.13	**8.91**	0.02	0.11	0.00	0.37	0.00
DJS076	0.12	0.00	0.00	0.08	0.00	**2.99**	0.00

APPENDIX C:
Archaeological Descriptions of Ceramic Specimens

Archaeological descriptions of ceramic specimens

ANID	Alternate ID	Type	Paste Color	Munsell	Primary Temper	Minor Temper
DJS001	1978.1.1742	Mississippi Plain	dark grey	N3	Shell	none
DJS002	1978.1.1742	Mississippi Plain	moderate reddish orange	10R 6/6	Shell	none
DJS003	1978.1.1742	Mississippi Plain	light red	5R 6/6	Shell	none
DJS004	1978.1.1742	Bell Plain	medium dark gray	N4	Shell	none
DJS005	1978.1.1742	residual fine grog, sand-tempered plain	pale reddish brown	10R 5/4	grog	sand?
DJS006	1978.1.1742	residual grog-tempered engraved	moderate reddish orange	10R 6/6	Grog	none
DJS007	1978.1.1739	Mississippi Plain	moderate red	5R 4/6	Shell	none
DJS008	1978.1.1739	Mississippi Plain	light gray	N7	shell (very fine tempered)	none
DJS009	1978.1.1739	Bell Plain	moderate brown	5YR 4/4	Shell	none
DJS010	1978.1.1739	Bell Plain	medium dark gray	N4	Shell	none
DJS011	1993.41.992.1	Bell Plain (white on red)	moderate reddish orange	10R 6/6	Shell	none
DJS012	1993.41.992.2	Bell Plain (black on white/neg. painted)	light red	5R 6/6	Shell	none
DJS013	1993.41.1006.3	Lake Jackson Plain	yellowish grey	5Y 7/2	grit	none
DJS014	1993.41.1006.4	residual non-temp punctated	grayish black	N2	grog or grit	none
DJS015	1993.41.976.1	Lake Jackson Plain	black	N1	grit	none
DJS016	1993.41.4025	Mississippi Plain	moderate reddish orange	10R 6/6	shell	none
DJS017	1993.41.4025	Mississippi Plain	moderate red	5R 4/6	shell	none
DJS018	1993.41.4025	Mississippi Plain	medium dark grey	N4	shell	none
DJS019	1993.41.4025	Mississippi Plain	medium grey	N5	shell	none
DJS020	1993.41.4025	Mississippi Plain	yellowish gray	5YR 8/1	shell	none
DJS021	1993.41.4025.2	Bell Plain	yellowish gray	5YR 8/1	shell	none
DJS022	1993.41.4025.3	Bell Plain	yellowish gray	5YR 8/1	shell	none
DJS023	1993.41.4025.4	Bell Plain	very pale orange	10YR 8/2	shell	none
DJS024	1993.41.4025	Bell Plain	yellowish gray	5YR 8/1	shell	none
DJS025	1993.41.4025	Bell Plain	moderate reddish orange	10R 6/6	shell	none
DJS026	1993.41.4025	Bell Plain (red on white)	light brownish gray	5YR 6/1	shell	none
DJS027	1993.41.4025.1	Pouncey Pinched, var. Pouncey	medium dark grey	N4	Shell	none
DJS028	1993.41.4010.1	Pouncey Pinched, var. Pouncey	dark gray	N3	Shell	none
DJS029	1993.41.4012.1	Pouncey Pinched, var. Pouncey	pale reddish brown	10R 5/4	shell	grog
DJS030	1993.41.4013.5	residual non-temp engraved	dark gray	N3	none	none
DJS031	1993.41.4043.1	residual fine grog, shell-tempered engraved	light brown	5YR 5/6	grog	shell
DJS032	1993.41.4043.2	Barton Incised, var. Togo	pale reddish brown	10R 5/4	shell	none

ANID	Stylistic Origin	Context	Provenience	Date	Reference
DJS001	Moundville	L.5	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS002	Moundville	L.5	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS003	Moundville	L.5	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS004	Moundville	L.5	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS005	Unknown	L.5	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS006	Unknown	L.5	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS007	Moundville	L.3	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS008	Moundville	L.3	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS009	Moundville	L.3	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS010	Moundville	L.3	North of Mound R, 6N2W	A.D. 1400-1475	Steponaitis 1983
DJS011	Unknown	Cut 3	Mound G, 58R33	A.D. 1330-1400	Knight 2010
DJS012	Unknown	Cut 3	Mound G, 58R33	A.D. 1330-1400	Knight 2010
DJS013	South-central Alabama	Cut 1	Mound G, 60R33	A.D. 1400-1475	Knight 2010
DJS014	Unknown	Cut 1	Mound G, 60R33	A.D. 1400-1475	Knight 2010
DJS015	South-central Alabama	P.H. 16	Mound G	unknown	Knight 2010
DJS016	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS017	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS018	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS019	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS020	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS021	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS022	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS023	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS024	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS025	Moundville	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS026	Unknown	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS027	Middle Mississippi Valley	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS028	Middle Mississippi Valley	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS029	Middle Mississippi Valley	Cut 2	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS030	Unknown	Cut 2	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS031	Unknown	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010:5.35k
DJS032	Middle Mississippi Valley	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010:5.35d

ANID	Alternate ID	Type	Paste Color	Munsell	Primary Temper	Minor Temper
DJS033	1993.41.4030.2	residual non-temp engraved	black	N1	none	none
DJS034	1993.41.4071.1	Mound Place Incised, var. McMillan	grayish black	N2	shell	none
DJS035	1993.41.4071.2	residual fine grog tempered plain	grayish red	10R 4/2	grog	none
DJS036	1993.41.3995.4	residual fine grog tempered plain	pale reddish brown	10R 5/4	grog	none
DJS037	1993.41.3980.1	Matthew Incised, var. Beckwith	pale reddish brown	10R 5/4	shell	none
DJS038	1993.41.4035.4	Barton Incised, var. Togo	pale reddish brown	10R 5/4	shell	none
DJS039	1993.41.4071.1	Pouncey Pinched, var. Pouncey	grayish black	N2	shell	none
DJS040	1993.41.4071.2	Pouncey Pinched, var. Pouncey	moderate reddish brown	10R 4/6	shell	none
DJS041	1989.40.32.4	Parkin Punctated, var. Parkin	light red	5R 6/6	shell	none
DJS042	1993.41.460.4	Bell Plain Polychrome	yellowish gray	5Y 7/2	shell	none
DJS043	1993.41.462.12	Residual Fine Grog Tempered engraved	moderate reddish orange	10R 6/6	grog	none
DJS044	1993.41.462.20	Barton Incised var. Barton	pale reddish brown	10R 5/4	shell	grog
DJS045	1993.41.462.22	Lake Jackson Plain	black	N1	grit or sand	none
DJS046	1993.41.462.23	residual non-temp engraved	grayish black	N2	none	none
DJS047	1989.40.361.1	Fortuned Noded, var. Fortune	medium light gray	N6	shell?	none
DJS048	1993.41.620.7	Salt Creek Impressed	medium dark gray	N4	shell	none
DJS049	1993.41.629.2	Bell Plain (red on white)	dark gray	N3	shell	none
DJS050	1993.41.613.2	Bell Plain (red on white)	moderate reddish ornage	10R 6/6	shell	none
DJS051	1993.41.639.11	residual non-temp engraved	moderate reddish brown	10R 4/6	none	none
DJS052	1993.41.627.11	Lake Jackson Plain	grayish black	N2	grit or sand	none
DJS053	1993.627.7	Bell Plain (white on red)	moderate reddish orange	10R 6/6	shell	none
DJS054	1993.627.12	Residual Fine grog, shell-temp incised	moderate reddish brown	10R 4/6	grog	shell
DJS055	1993.41.627	Bell Plain	dark gray	N3	shell	grog
DJS056	1993.41.627	Mississippi Plain	moderate reddish brown	10R 6/6	shell	none
DJS057	1993.41.627	Mississippi Plain	moderate reddish orange	10R 6/6	shell	none
DJS058	1993.41.631.7	Bell Plain (white)	greyish yellow	5Y 8/4	shell	none
DJS059	1993.41.631	Bell Plain	medium dark gray	N4	shell	none
DJS060	1993.41.631	Bell Plain	moderate brown	5YR 4/4	shell	grog
DJS061	1993.41.631	Mississippi Plain	light brown	5YR 6/4	shell	none
DJS062	1993.41.631	Mississippi Plain	grayish black	N2	shell	none
DJS063	1993.41.631	Mississippi Plain	light red	5R 6/6	shell	none
DJS064	1993.41.626	Bell Plain	moderate brown	5YR 4/4	shell	grog
DJS065	1993.41.994.4	Lake Jackson Plain	pale reddish brown	10R 5/4	grit	grog
DJS066	1993.41.994.5	Carter Engraved	black	N1	grog	shell

ANID	Stylistic Origin	Context	Provenience	Date	Reference
DJS033	Unknown	Cut 2	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS034	Northern Gulf Coast	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010:5.35j
DJS035	Unknown	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS036	Unknown	Cut 2	Mound E, 22R49	A.D. 1400-1475	Knight 2010
DJS037	south-central Alabama	Cut 4	Mound E, 20R49	A.D. 1400-1475	Knight 2010:5.35a
DJS038	Middle Mississippi Valley	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010:5.35c
DJS039	Middle Mississippi Valley	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS040	Middle Mississippi Valley	Cut 3	Mound E, 20R49	A.D. 1400-1475	Knight 2010
DJS041	Middle Mississippi Valley	Cut 5	Mound F, 26R8	A.D. 1190-1260	Knight 2010
DJS042	Unknown	Cut 1	Mound G, 60R33	A.D. 1400-1475	Knight 2010:6.43K
DJS043	Unknown	Cut 2	Mound F, 26R10	A.D. 1330-1400	Knight 2010
DJS044	Middle Mississippi Valley	Cut 2	Mound F, 26R10	A.D. 1330-1400	Knight 2010
DJS045	South-central Alabama	Cut 2	Mound F, 26R10	A.D. 1330-1400	Knight 2010
DJS046	Unknown	Cut 2	Mound F, 26R10	A.D. 1330-1400	Knight 2010
DJS047	Middle Mississippi Valley	Cut 1	Mound Q, 43R23	unknown	Knight 2010
DJS048	Northern Gulf Coast	Cut 4	Mound G, 58R33	A.D. 1330-1400	Knight 2010:6.42n
DJS049	Unknown	Cut 3	Mound G, 58R31	A.D. 1330-1475	Knight 2010:Fig. 644l
DJS050	Unknown	Cut 2	Mound G, 58R33	A.D. 1400-1475	Knight 2010
DJS051	Unknown	Cut 4	Mound G, 60R33	A.D. 1330-1400	Knight 2010
DJS052	South-central Alabama	Cut 1	Mound G, 60R33	A.D. 1400-1475	Knight 2010
DJS053	Unknown	Cut 1	Mound G, 60R33	A.D. 1400-1475	Knight 2010:6.43j
DJS054	Unknown	Cut 1	Mound G, 60R33	A.D. 1400-1475	Knight 2010
DJS055	Moundville	Cut 1	Mound G, 60R33	A.D. 1400-1475	Knight 2010
DJS056	Moundville	Cut1	Mound G, 60R33	A.D. 1400-1475	Knight 2010
DJS057	Moundville	Cut1	Mound G, 60R33	A.D. 1400-1475	Knight 2010
DJS058	Unknown	Cut3	Mound G, 60R33	A.D. 1330-1400	Knight 2010
DJS059	Moundville	Cut3	Mound G, 60R33	A.D. 1330-1400	Knight 2010
DJS060	Moundville	Cut3	Mound G, 60R33	A.D. 1330-1400	Knight 2010
DJS061	Moundville	Cut3	Mound G, 60R33	A.D. 1330-1400	Knight 2010
DJS062	Moundville	Cut3	Mound G, 60R33	A.D. 1330-1400	Knight 2010
DJS063	Moundville	Cut3	Mound G, 60R33	A.D. 1330-1400	Knight 2010
DJS064	Moundville	Cut 1	Mound G, 60R33	A.D. 1400-1475	Knight 2010
DJS065	South-central Alabama	Cut 3	Mound G, 58R33	A.D. 1330-1400	Knight 2010
DJS066	Lower Mississippi Valley	Cut 3	Mound G, 58R33	A.D. 1330-1400	Knight 2010:645k

ANID	Alternate ID	Type	Paste Color	Munsell	Primary Temper	Minor Temper
DJS067	1993.41.1002.4	Angel Negative Painted (black on orange)	moderate orange pink	10R 7/4	shell	none
DJS068	1993.41.1001.5	Parkin Punctated, var. Parkin	greyish yellow	5Y 8/4	shell	none
DJS069	1993.41.1243.1	Residual non-tempered incised	black	N1	none	none
DJS070	1993.41.1243.2	Pouncey Pinched, var. Pouncey	greyish yellow	5Y 8/4	shell	none
DJS071	1993.41.611.1	Residual fine sand, shell tempered incised	medium light gray	N6	sand	shell
DJS072	1993.41.2551.1	Barton Incised var. Barton	grayish orange	10YR 7/4	shell	none
DJS073	1993.41.2558.1	Bell Plain (red)	light gray	N7	shell	grog?
DJS074	1993.41.1236	Barton Incised var. Barton	light brown	5YR 6/4	shell	none
DJS075	1993.41.3444.1	Barton Incised var. Togo	moderate red	5R 4/6	shell	none
DJS076	1993;41;3179.1	Alabama River Incised var. unspecified	pale reddish brown	10R 5/4	shell	none
DJS077	1993.41.3179.3	Barton Incised var. Barton	dark gray	N3	shell	none
DJS078	1993.41.3179.3	Pouncey Pinched, var. Pouncey	dark gray	N3	shell	none
DJS079	none	Angel Negative Painted (black on white)	greyish yellow	5Y 8/4	shell	none
DJS080	none	Bell Plain polychrome	medium gray	N5	shell	none

ANID	Stylistic Origin	Context	Proveience	Date	Reference
DJS067	Lower Ohio River area	Cut 7	Mound G, 58R33	A.D. 1260-1330	Knight 2010:6.44m
DJS068	Middle Mississippi Valley	Cut 7	Mound G, 58R33	A.D. 1260-1330	Knight 2010
DJS069	Unknown	Cut 3	Mound E, 20R56	A.D. 1400-1475	Knight 2010: 5.35l.
DJS070	Middle Mississippi Valley	Cut 3	Mound E, 20R56	A.D. 1400-1475	Knight 2010
DJS071	Unknown	Cut 1	Mound G, 58R33	A.D. 1400-1475	Knight 2010
DJS072	Middle Mississippi Valley	Cut 3	Mound E, 42R51	A.D. 1400-1475	Knight 2010:5.38
DJS073	Unknown	Cut 3	Mound E, 42R61	A.D. 1400-1475	Knight 2010
DJS074	Middle Mississippi Valley	Cut 3	Mound E, 18R56	A.D. 1400-1475	Knight 2010:5.35b
DJS075	Middle Mississippi Valley	Feature 74	Mound E, 20R55	A.D. 1330-1400	Knight 2010
DJS076	Moundville	Cut 1	Mound E, 17R58	A.D. 1520-1650	Knight 2010,: 5.36f
DJS077	Middle Mississippi Valley	Cut 1	Mound E, 17R58	A.D. 1520-1650	Knight 2010
DJS078	Middle Mississippi Valley	Cut 1	Mound E, 17R58	A.D. 1520-1650	Knight 2010
DJS079	Lower Ohio River area	Lot 1	N2120 E758	A.D. 1330-1475	Thompson 2011
DJS080	Unknown	Lot 2	N2120 E758		Thompson 2011

APPENDIX D:
Elemental Concentrations of Ceramic Specimens

Elemental concentrations of ceramic specimens

ANID	As	La	Lu	Nd	Sm	U	Yb	Ce	Co	Cr
DJS001	3.3223	74.2886	0.7450	90.6188	17.7710	4.8873	5.2470	188.5380	6.3221	70.4038
DJS002	3.4967	43.3507	0.3298	20.4099	2.9662	2.5233	2.3240	71.7119	5.6670	55.2633
DJS003	3.8507	36.3039	0.3536	21.9445	2.9327	4.1558	2.1077	56.7151	4.0626	76.7871
DJS004	1.3456	61.7966	0.5627	55.1690	9.8189	2.9995	4.0424	123.2712	18.5851	79.1623
DJS005	3.7667	64.5792	0.4819	50.4033	5.4878	3.7096	3.2048	124.3841	7.0212	73.6249
DJS006	4.1984	158.5940	0.4911	109.9313	12.5277	2.9957	3.6599	356.1790	6.2098	70.1217
DJS007	5.0027	40.0958	0.2859	18.1910	3.5411	3.7746	2.5628	59.5231	3.3649	87.6197
DJS008	3.6542	75.6276	0.2880	32.3399	6.3478	2.7119	2.3399	149.2858	5.4164	66.2744
DJS009	3.3577	50.1235	0.5323	37.7938	7.4932	3.1204	3.8833	95.3453	4.6030	75.5074
DJS010	3.8705	54.8507	0.5836	53.4410	8.9046	3.3886	4.3237	112.4960	4.1266	75.8368
DJS011	4.3847	53.4153	0.4934	26.7290	5.5772	5.1546	3.1780	86.9015	5.9196	90.6733
DJS012	12.7475	33.5368	0.5855	41.1876	9.7248	4.6007	4.1620	77.4110	6.2393	94.5475
DJS013	2.0096	48.4314	0.4850	47.5595	8.4516	3.2916	3.2651	100.7933	8.0644	60.8400
DJS014	7.6756	73.7910	0.6838	62.4407	12.6994	4.6454	5.1107	141.2075	20.9816	86.5668
DJS015	16.5025	29.1273	0.4080	26.4409	5.2424	3.2733	2.6932	68.8324	8.3313	64.3290
DJS016	2.8034	34.4596	0.5201	36.7946	4.3932	3.5065	3.3621	58.8241	3.5066	75.0592
DJS017	5.8404	62.4182	0.4519	37.6878	6.0605	4.3981	3.4695	91.0696	7.6372	92.8814
DJS018	3.5946	38.1821	0.4046	25.5176	3.4480	3.8717	2.4169	57.8752	3.4452	84.8999
DJS019	3.2978	34.2361	0.4268	24.9582	3.4868	3.6330	2.9228	52.7239	3.2953	82.0531
DJS020	5.8930	93.5931	0.4625	49.4134	7.8825	3.4160	3.7904	189.8401	5.4222	86.5989
DJS021	3.9774	40.6901	0.5128	33.5454	4.3878	3.1661	3.0421	67.2468	3.1590	86.6665
DJS022	2.9941	57.0963	0.4844	52.3730	9.0762	3.8125	3.7475	115.8261	6.5682	81.6661
DJS023	3.4846	58.3110	0.5722	53.3640	9.4200	3.5160	4.3102	119.0287	6.4198	83.7714
DJS024	3.4684	66.8452	0.5050	37.2272	6.3800	3.8720	3.0994	138.9321	7.0915	86.0541
DJS025	4.2483	68.1790	0.5405	46.7353	5.7180	3.3503	3.7702	127.1233	5.7695	79.8638
DJS026	7.5034	43.1027	0.4666	42.5414	7.4109	4.3482	2.9644	83.6757	12.1629	93.7354
DJS027	7.2153	36.3342	0.3907	30.1140	5.4852	3.7978	2.4418	68.3443	14.0695	96.0242
DJS028	7.5875	38.4430	0.3799	40.1457	5.6269	3.6325	2.5882	69.3007	12.4619	97.7682
DJS029	8.0383	54.2950	0.5782	49.6122	8.8755	5.5325	3.8068	92.9278	8.7422	107.5578
DJS030	3.5971	50.2062	0.6390	46.4968	8.1076	4.3413	4.5232	97.7076	22.4760	83.9802
DJS031	4.7163	45.5344	0.6146	41.3172	6.7948	2.8993	4.1538	86.8849	6.2116	79.1186
DJS032	4.9788	51.0369	0.5406	40.6532	8.4921	4.5151	3.8340	96.0718	8.7587	98.9189

ANID	Cs	Eu	Fe	Hf	Ni	Rb	Sb	Sc	Sr	Ta
DJS001	2.4226	3.5019	38463.6	9.6297	43.72	52.58	0.4555	12.8110	367.53	1.9393
DJS002	2.1093	0.4786	23947.4	7.2076	0.00	43.59	0.2897	11.4104	396.13	1.7312
DJS003	4.4507	0.4712	38815.1	5.9597	24.00	78.51	0.4481	14.5959	323.47	1.8429
DJS004	4.7937	1.8014	35693.5	6.9365	44.91	147.86	0.2559	15.9978	281.19	1.8975
DJS005	3.1609	0.9099	37620.3	9.0942	0.00	60.63	0.3817	14.3845	288.03	2.0839
DJS006	3.5086	2.0254	33217.7	8.8756	0.00	85.26	0.4476	15.2463	505.31	2.2244
DJS007	4.0176	0.6125	45760.1	6.2514	0.00	66.05	0.5368	17.1994	272.09	2.0365
DJS008	2.8685	1.1224	30406.4	5.4351	0.00	71.10	0.4187	15.6618	557.82	1.9041
DJS009	3.7854	1.4228	29176.7	9.1999	0.00	75.94	0.3882	14.9172	163.46	1.6826
DJS010	3.2846	1.6948	30065.6	10.0335	0.00	73.29	0.3961	15.0776	155.54	1.7256
DJS011	3.7109	0.9036	45236.1	9.2172	0.00	66.66	0.5418	17.5623	187.28	2.6225
DJS012	3.7733	1.8972	72739.9	7.2151	57.02	71.41	0.6351	16.9375	285.54	1.7618
DJS013	2.9133	1.6207	21101.9	6.0000	40.92	71.19	0.2424	13.4644	147.53	1.5306
DJS014	4.2624	2.5863	20192.5	8.2137	64.49	93.38	0.3580	17.4246	331.59	1.8916
DJS015	1.7984	0.8881	47871.7	7.7038	30.22	48.38	0.2344	9.9047	60.57	1.1263
DJS016	2.6700	0.7119	33850.5	9.7065	0.00	41.44	0.3976	14.4705	245.91	1.9078
DJS017	5.1931	0.9884	64671.6	5.8254	0.00	92.07	0.4982	19.6925	282.27	2.2017
DJS018	3.3568	0.5819	32493.4	7.6843	0.00	45.06	0.5030	16.1511	274.85	2.0486
DJS019	2.5239	0.6081	31737.9	8.6566	0.00	38.80	0.5025	15.7104	297.10	1.9813
DJS020	3.3877	1.1763	42495.8	9.0726	0.00	67.80	0.5413	17.5774	202.22	2.4508
DJS021	3.1156	0.7640	32635.4	8.7994	0.00	45.75	0.4819	16.1650	190.02	2.0499
DJS022	3.9361	1.7348	20523.7	6.9499	0.00	70.87	0.5486	16.5808	175.79	1.8139
DJS023	3.6735	1.8131	20695.5	7.1641	31.12	61.37	0.5353	16.7238	268.55	1.7483
DJS024	3.6384	1.1073	34415.6	8.6391	0.00	77.21	0.5249	18.5140	287.11	2.9754
DJS025	2.8727	1.0241	39441.7	10.0031	0.00	60.42	0.4358	14.7633	354.82	2.1884
DJS026	5.6741	1.4616	44335.9	4.8341	32.32	99.69	0.6890	16.3699	339.16	1.1533
DJS027	7.0830	1.0847	51430.8	4.9370	0.00	114.49	0.9104	16.4362	126.93	1.1904
DJS028	5.7762	1.0653	51150.4	4.8466	0.00	100.40	0.8333	16.2872	217.01	1.0840
DJS029	6.1171	1.6729	39392.3	6.8623	0.00	109.07	0.6111	18.4711	186.22	1.5976
DJS030	4.2377	1.4971	11705.2	9.0079	38.58	86.68	0.3642	16.4470	302.96	1.6826
DJS031	2.8595	1.2760	42721.4	8.4723	0.00	54.12	0.4848	14.4709	270.89	1.7611
DJS032	5.6587	1.5965	36341.7	6.7092	49.27	97.33	0.4742	17.2918	223.56	1.4917

ANID	Tb	Th	Zn	Zr	Al	Ba	Ca	Dy	K
DJS001	2.2056	14.0583	264.58	278.47	73470.4	3942.0	27937.2	8.3521	8361.3
DJS002	0.4072	10.5125	62.72	157.01	75771.5	3303.4	109341.8	3.0675	7252.9
DJS003	0.4156	14.7602	70.03	162.88	96359.5	2931.2	54578.5	3.0528	12329.6
DJS004	1.4974	15.5498	146.40	204.05	99200.4	4297.5	37873.4	7.6921	27011.5
DJS005	0.7068	14.5260	117.00	218.62	90398.7	5093.2	12147.7	4.8927	10508.6
DJS006	1.1197	18.1049	88.52	249.44	95821.2	4872.9	13294.1	6.3119	11642.6
DJS007	0.6953	17.2177	165.77	166.48	105044.1	5147.8	11369.6	3.5840	11334.2
DJS008	0.5825	14.4993	210.55	164.14	89450.6	5802.0	77530.2	2.8116	14270.0
DJS009	1.0197	14.2411	144.76	215.73	92255.9	4395.5	9019.8	6.1034	13647.4
DJS010	1.2124	14.2811	123.06	230.23	86566.4	4455.3	7457.2	8.0817	12316.1
DJS011	0.7182	18.5656	85.31	245.40	107010.1	4035.5	9894.9	4.3026	9117.7
DJS012	1.2647	18.5549	100.19	158.59	94482.4	5598.0	16756.0	7.5169	7881.7
DJS013	1.0879	11.3639	95.81	145.33	84957.1	3230.2	6131.3	6.2631	16434.0
DJS014	1.6839	14.9454	179.79	232.28	101268.2	5287.7	10828.2	10.0570	15158.4
DJS015	0.6579	9.7818	65.69	190.30	64836.5	1034.6	3172.8	3.7683	11279.2
DJS016	0.5557	14.8363	77.29	243.48	90543.7	3776.3	8678.5	3.7458	9736.0
DJS017	0.6073	18.5953	338.02	140.65	112189.6	7359.0	11724.4	4.7289	13255.2
DJS018	0.3746	15.1558	191.83	201.26	104405.5	4799.0	9530.9	3.0955	5801.3
DJS019	0.4748	15.0383	124.70	208.13	100043.1	3977.4	9404.9	3.1906	9341.1
DJS020	0.9716	18.3101	145.68	229.35	102448.1	3643.8	6904.1	4.6748	11287.4
DJS021	0.5468	15.2662	89.65	222.80	106699.6	3550.4	7428.6	4.4007	8819.4
DJS022	1.2351	13.7822	87.36	170.90	98777.8	3539.0	13435.6	7.4533	13145.4
DJS023	1.1438	14.0866	168.15	235.27	107037.2	5972.0	14103.0	7.8574	12845.9
DJS024	0.6761	17.8522	107.49	212.85	122547.8	2395.0	16616.0	4.3476	10465.8
DJS025	1.0496	15.7407	165.25	264.44	90656.4	4868.2	8029.6	5.1388	9172.8
DJS026	1.0139	13.8578	206.36	138.49	96635.9	6289.6	11386.6	5.6917	23090.4
DJS027	0.5683	13.7149	206.07	122.24	93303.9	2980.6	8098.7	3.7271	22198.8
DJS028	0.5837	13.5510	165.96	106.41	92744.1	5652.2	7270.0	3.7800	20948.1
DJS029	1.2560	13.3494	329.56	242.68	100623.3	4188.3	7022.3	6.6111	12084.5
DJS030	1.0392	14.2970	140.37	279.07	104718.1	5178.6	6689.0	6.5541	15008.4
DJS031	1.2253	13.3996	128.65	243.83	92740.4	4760.9	9029.9	6.6421	11561.8
DJS032	0.9178	12.9969	202.95	249.42	105916.4	5346.2	11624.2	6.2054	14283.2

ANID	As	La	Lu	Nd	Sm	U	Yb	Ce	Co	Cr
DJS033	2.5222	55.1152	0.6325	52.5271	8.2380	4.1501	4.1748	102.5765	31.6040	87.5225
DJS034	3.5287	54.8149	0.5480	46.0290	8.8845	2.9458	3.8454	100.9997	5.0148	63.1882
DJS035	5.3346	57.6990	0.7569	53.4357	11.4094	3.9392	5.2178	127.4852	10.5645	106.3434
DJS036	6.6324	48.0957	0.5126	42.7408	5.7115	3.7751	3.4246	81.8251	9.5960	91.3280
DJS037	3.4514	33.0392	0.4573	21.9768	4.2058	3.3807	3.0743	56.4693	3.6095	87.1631
DJS038	8.5746	65.9328	0.5854	66.5818	10.7247	3.9107	3.9187	106.4002	13.6115	151.3209
DJS039	7.1053	39.9124	0.4195	37.9132	6.9637	2.9527	3.2054	76.4136	14.7006	90.1535
DJS040	5.6576	55.0375	0.5076	39.3542	8.3721	4.7153	3.6048	88.3709	8.8971	101.0847
DJS041	6.9554	36.8549	0.4178	20.9537	3.6648	3.6125	2.6238	59.7819	2.9787	83.3389
DJS042	4.4931	47.4048	0.4830	34.5126	5.0887	3.8664	3.4922	78.9089	5.0942	82.3688
DJS043	5.3751	65.7916	0.5478	52.1159	9.5606	4.1062	3.8955	146.0430	4.8308	84.1149
DJS044	6.4654	53.8665	0.4993	23.4357	4.5106	3.7106	3.2438	91.6824	6.0772	79.1379
DJS045	6.4878	32.9046	0.3471	28.0807	5.3118	3.3625	2.2988	61.2174	4.8169	62.0940
DJS046	2.7706	56.0372	0.7893	52.2781	12.2823	3.3221	5.8824	119.1657	14.4647	80.5461
DJS047	6.7115	40.2016	0.4332	32.4727	6.9083	3.1342	2.7584	78.8269	14.2446	91.4724
DJS048	3.7604	43.3414	0.3916	45.5865	7.0197	3.9756	2.9220	86.9847	12.2719	102.1196
DJS049	4.3136	37.0360	0.4019	20.5085	4.0179	3.9040	2.7814	60.5393	4.4715	76.1225
DJS050	2.9174	46.1532	0.4848	24.1230	5.3165	3.6242	3.2910	81.0107	7.7916	81.5451
DJS051	2.2318	74.7065	0.6729	50.1135	7.8281	4.5844	4.4200	159.0060	4.7022	62.3704
DJS052	3.0445	61.9334	0.4038	30.2486	6.6076	3.2748	2.9582	100.3558	12.0438	60.9681
DJS053	2.8855	46.2966	0.4644	24.6873	4.7881	5.1400	2.9537	77.1226	4.8132	86.5146
DJS054	3.1076	66.1810	0.4449	44.8502	5.8694	3.9630	3.0846	110.2006	7.0806	79.4513
DJS055	5.3145	50.1933	0.3878	26.1098	4.7668	3.9259	2.6475	81.2095	5.1157	91.6958
DJS056	2.6574	45.5625	0.3590	24.2901	4.2524	3.5154	2.3349	75.5375	3.4295	77.8892
DJS057	4.0484	41.2622	0.4668	27.6557	4.9581	3.7288	3.0635	83.6671	5.7484	78.9275
DJS058	3.0509	30.3805	0.4386	16.2583	2.7851	2.8720	2.9701	53.1560	3.6575	52.5543
DJS059	5.7148	47.1809	0.4449	27.0983	5.1212	3.5197	3.1528	82.4851	4.2997	80.2609
DJS060	3.2590	88.8478	0.4680	56.0216	7.5076	3.7222	3.0666	179.5442	6.1603	81.2536
DJS061	4.4813	27.0950	0.2553	12.9184	2.8975	2.1624	1.7534	44.0997	3.4211	56.7894
DJS062	2.8234	33.1905	0.3387	25.7255	5.1793	2.3462	2.2985	63.8101	5.4653	63.4697
DJS063	4.2233	35.9446	0.3853	10.9369	3.2031	4.0107	2.2472	54.8618	3.7870	84.6248
DJS064	4.3727	93.4810	0.4527	61.7074	7.2290	3.2582	3.1327	197.2118	5.3345	83.9375
DJS065	7.2322	24.6249	0.2935	18.2491	4.5978	3.7608	2.0439	50.3976	3.5288	72.1619
DJS066	5.4777	31.6173	0.3515	22.2671	5.0676	3.7717	2.3204	52.0099	5.5482	111.7049

ANID	Cs	Eu	Fe	Hf	Ni	Rb	Sb	Sc	Sr	Ta
DJS033	4.5642	1.5200	10715.6	8.9149	0.00	84.38	0.3685	18.1858	229.57	1.8184
DJS034	3.8114	1.7698	23858.9	9.6757	0.00	79.49	0.3269	12.9938	264.89	1.4574
DJS035	3.1116	2.2729	24724.8	5.9151	52.79	30.12	0.5407	20.3929	85.58	1.5646
DJS036	4.8017	1.0232	50445.8	5.9597	0.00	66.67	0.5696	17.6252	206.56	2.2795
DJS037	3.1107	0.7510	34475.1	9.6915	43.41	43.97	0.4946	16.6711	128.31	2.1186
DJS038	5.6184	2.1404	57759.4	7.7622	0.00	87.41	0.9460	20.0395	397.17	2.1111
DJS039	6.0153	1.4083	41194.7	5.1056	61.73	87.99	0.7276	14.8866	181.93	1.0687
DJS040	5.9944	1.5977	36729.8	6.8410	0.00	110.32	0.5127	16.9750	393.42	1.5147
DJS041	3.7128	0.6485	53713.4	8.5904	0.00	55.25	0.5199	15.6219	238.02	1.9915
DJS042	3.1756	0.8221	37025.1	9.6657	0.00	53.44	0.5037	16.1002	251.02	2.2223
DJS043	4.9246	1.7216	30607.3	8.2789	0.00	78.00	0.4689	17.1723	249.45	1.7769
DJS044	2.2865	0.7937	49052.3	11.7842	0.00	36.06	0.4110	14.6796	203.55	2.2148
DJS045	3.2192	0.9793	25269.8	6.2844	0.00	68.05	0.2699	12.4133	133.45	1.4561
DJS046	3.6433	2.5232	11716.7	10.4944	43.42	86.20	0.3558	16.2404	131.74	1.8904
DJS047	7.9932	1.4036	43619.8	5.3778	42.12	123.68	1.0255	15.4585	131.11	1.1703
DJS048	4.4067	1.4212	36302.9	6.6151	0.00	71.35	0.4399	14.8493	387.31	1.2994
DJS049	3.7806	0.7216	32602.1	6.6525	36.89	59.64	0.4436	14.7919	363.98	2.1404
DJS050	3.7611	0.9579	38994.5	8.8271	0.00	64.87	0.5236	15.9269	284.43	2.3139
DJS051	2.1566	1.3627	42580.6	16.5450	0.00	54.43	0.3074	13.7032	246.62	2.0450
DJS052	3.6511	1.2573	25433.4	4.5921	0.00	73.21	0.3162	12.2516	157.61	1.2794
DJS053	3.6919	0.8636	43500.0	8.1312	37.70	66.50	0.5198	16.9880	221.96	2.5746
DJS054	4.1455	1.0279	55061.2	8.1549	0.00	95.85	0.4187	15.7580	299.53	2.2175
DJS055	4.4468	0.8599	45334.6	6.6675	36.30	74.85	0.4548	17.7284	174.39	2.0689
DJS056	3.5678	0.6361	33420.9	6.9128	0.00	55.43	0.4629	15.0943	197.85	1.9284
DJS057	4.0949	0.8656	31195.7	9.4246	0.00	72.54	0.4798	14.8495	213.79	1.6045
DJS058	1.8241	0.4997	27530.5	9.7090	0.00	43.70	0.3033	10.0811	295.43	1.5967
DJS059	3.8935	0.8839	29146.1	8.2928	0.00	68.02	0.3500	15.1503	311.29	1.6849
DJS060	4.3414	1.2928	32122.8	7.8480	0.00	81.45	0.4617	17.1585	355.36	2.3335
DJS061	2.2098	0.5254	31459.0	4.1858	0.00	33.81	0.3869	11.3864	369.60	1.5314
DJS062	3.8115	0.9643	40683.9	7.6994	40.55	72.99	0.2415	11.1783	293.19	1.2234
DJS063	3.8308	0.5488	45227.8	6.0367	0.00	53.62	0.4847	16.7829	442.75	1.9412
DJS064	3.8719	1.2953	44968.1	8.2813	57.18	79.38	0.4722	17.7476	248.77	2.5016
DJS065	2.0752	0.8555	31159.1	6.5246	0.00	40.10	0.2052	13.7421	257.03	1.1047
DJS066	3.2990	0.8449	32556.7	7.5333	0.00	80.68	0.2102	15.8089	330.19	1.2629

ANID	Tb	Th	Zn	Zr	Al	Ba	Ca	Dy	K
DJS033	0.9928	14.8787	107.74	256.69	102321.5	5509.6	6052.1	7.0958	15557.9
DJS034	1.2341	12.5523	170.54	256.06	71098.2	4101.6	6638.8	6.9216	12758.9
DJS035	1.4451	16.9745	157.06	193.85	126354.4	2405.9	4489.3	9.5346	6231.9
DJS036	0.7337	17.8713	112.39	162.02	107141.8	2364.3	9456.2	4.6346	7770.6
DJS037	0.5511	15.5094	239.67	238.33	105010.2	1959.6	4567.9	3.8516	6223.5
DJS038	1.5353	15.1792	296.06	222.62	107722.2	5106.3	16932.7	7.4352	13713.9
DJS039	0.8430	12.6864	258.23	174.96	95194.2	4037.5	7173.7	5.1711	22725.8
DJS040	1.1169	12.8098	334.11	215.93	99100.8	7062.0	16205.9	6.8252	11161.4
DJS041	0.5155	16.7057	102.53	208.09	95697.3	4193.3	11477.2	3.6701	8246.9
DJS042	0.8713	17.9884	103.30	276.42	96897.5	4229.7	11359.7	4.4758	9407.0
DJS043	0.9955	14.1382	100.83	218.59	102027.8	3397.0	5880.9	7.2619	12280.0
DJS044	0.7035	15.3662	86.78	271.67	95975.3	4415.5	7275.9	5.0862	5669.6
DJS045	0.7120	10.4936	57.23	139.93	74595.8	2790.6	4541.3	5.9352	12477.9
DJS046	1.8990	13.9100	176.22	250.70	88974.5	3487.4	3665.8	11.3046	19019.1
DJS047	0.8989	13.0332	141.27	121.33	89417.8	1671.9	9734.5	4.9277	23495.8
DJS048	1.1796	11.6268	145.82	164.66	82890.7	4951.4	61789.0	5.4801	13539.6
DJS049	0.6692	14.4980	85.24	162.47	84727.6	8387.3	71458.3	4.0665	7792.1
DJS050	0.7988	16.0188	88.50	205.37	89372.0	5667.6	21357.4	4.5966	9770.1
DJS051	1.0754	15.1034	64.54	351.80	73906.6	2925.7	6044.2	6.2285	11923.3
DJS052	0.8809	10.4009	87.97	118.53	67850.2	1655.3	4493.6	5.0073	14382.7
DJS053	0.6901	16.8865	96.56	190.53	97159.3	4305.5	41078.1	4.7058	11266.3
DJS054	0.9247	13.9895	230.16	167.42	90555.8	3443.5	8088.2	4.4520	12132.1
DJS055	0.5590	15.5474	83.75	151.66	110334.0	2517.6	34632.5	3.7785	11703.7
DJS056	0.5503	19.1156	71.52	147.56	94174.8	3471.9	55449.7	3.7138	7193.6
DJS057	0.6916	15.4041	87.90	194.92	98796.5	3879.2	15543.5	4.2482	14391.4
DJS058	0.6330	10.6373	47.65	212.99	64644.7	2857.2	102147.3	3.6526	8276.6
DJS059	0.6525	14.5093	81.09	193.56	95435.6	7679.9	17961.0	4.8132	11001.2
DJS060	0.8050	15.7668	88.91	179.56	104211.4	6229.5	13996.7	5.3442	13514.7
DJS061	0.4079	10.5403	58.00	94.98	71428.9	3088.5	164458.0	2.4194	4439.5
DJS062	0.7149	9.6939	55.60	184.96	62084.2	1922.2	45013.5	3.8193	10179.6
DJS063	0.4736	16.4084	74.35	129.46	107408.3	8143.0	48482.4	3.2335	6980.9
DJS064	0.7699	16.1345	100.09	187.46	110647.1	3492.3	8019.0	5.4623	12672.0
DJS065	0.6217	11.2645	64.60	132.69	86451.7	3949.4	5894.0	3.2668	8690.8
DJS066	0.6539	11.1224	108.54	166.18	98060.3	4307.7	8643.2	3.7595	14124.0

ANID	Mn	Na	Ti	V
DJS033	143.34	802.9	7451.6	91.6
DJS034	324.16	1524.4	6753.5	93.6
DJS035	270.65	816.4	6070.4	135.0
DJS036	438.07	647.0	6444.9	136.9
DJS037	505.39	1083.9	6448.7	99.6
DJS038	1052.38	1125.5	7264.9	178.2
DJS039	593.94	4795.4	6862.0	150.9
DJS040	1362.25	2156.6	7993.2	132.0
DJS041	281.02	674.8	6863.6	115.4
DJS042	620.15	815.7	7576.1	126.3
DJS043	114.62	1656.7	6665.6	109.8
DJS044	268.98	702.8	7679.1	103.4
DJS045	119.17	1545.8	5271.9	87.0
DJS046	71.56	797.8	7831.9	94.2
DJS047	835.75	4389.5	4890.9	164.4
DJS048	687.48	2896.2	6009.3	125.9
DJS049	627.21	650.2	5632.0	100.3
DJS050	869.36	921.6	6256.4	80.8
DJS051	221.39	618.4	7079.6	79.5
DJS052	347.14	510.0	4457.1	74.7
DJS053	1099.50	969.2	7476.8	108.9
DJS054	1381.50	656.4	5997.0	107.3
DJS055	521.09	981.1	5738.5	124.0
DJS056	520.16	1046.9	5053.4	103.4
DJS057	635.02	881.6	6966.4	114.6
DJS058	784.90	1263.2	5961.6	63.9
DJS059	344.12	902.5	6528.1	111.6
DJS060	233.01	931.7	6237.6	99.6
DJS061	664.18	973.3	4094.4	77.2
DJS062	367.34	2629.3	5625.8	81.0
DJS063	879.79	1257.6	6971.0	109.4
DJS064	301.06	708.2	8048.9	104.5
DJS065	144.72	1080.3	4926.0	100.6
DJS066	147.40	1637.9	6957.6	120.8

ANID	As	La	Lu	Nd	Sm	U	Yb	Ce	Co	Cr
DJS067	3.0770	40.2813	0.2944	15.0500	2.9036	2.8173	1.8065	67.3028	3.5243	50.8739
DJS068	4.9493	39.5765	0.3944	33.2914	6.1886	3.2701	2.5379	78.6076	3.8942	64.0203
DJS069	2.2937	45.2064	0.4913	42.1274	8.2088	3.2961	3.4171	93.1921	4.6968	88.3161
DJS070	8.1657	71.7111	0.5941	61.0682	11.1164	3.9124	4.2721	118.7090	17.3196	152.5163
DJS071	3.0979	88.4921	0.4754	45.2971	8.1168	3.4409	3.3250	168.4082	6.3326	74.4023
DJS072	8.0844	75.9181	0.7380	58.5695	12.2455	4.7423	5.1425	143.5053	10.4010	127.1889
DJS073	5.8941	50.0182	0.4747	24.7448	4.6196	3.7910	3.5430	84.5033	4.3593	79.9088
DJS074	3.2502	64.6705	0.6285	50.5167	9.9745	3.5660	4.3122	125.3984	27.5998	85.2039
DJS075	9.9202	63.0530	0.5570	59.6212	10.2233	4.1572	3.8791	104.2352	12.9250	149.6925
DJS076	6.2467	47.2335	0.5068	38.5614	7.7656	4.2619	3.4938	94.9226	6.9194	92.3245
DJS077	4.8538	88.7607	0.8261	73.0591	13.6688	5.1379	6.0292	184.4075	76.2349	116.3105
DJS078	10.0097	35.5854	0.3748	27.4549	5.4840	3.7651	2.8218	69.3905	12.2190	92.9396
DJS079	2.2741	38.7691	0.4489	23.9755	5.2009	3.2420	2.9651	74.4004	3.9179	63.5234
DJS080	5.4520	34.1661	0.3866	27.2888	5.8674	2.6886	2.8433	67.8422	9.6743	73.1726

ANID	Cs	Eu	Fe	Hf	Ni	Rb	Sb	Sc	Sr	Ta
DJS067	2.2168	0.4777	23430.4	6.2837	0.00	39.23	0.3286	10.7543	644.76	1.8101
DJS068	3.4174	1.1481	18780.7	5.2483	49.25	59.61	0.3643	12.6636	551.93	1.1854
DJS069	4.0168	1.5340	19109.7	12.3178	24.60	82.15	0.3437	12.9498	172.54	1.3538
DJS070	4.1704	2.2980	60913.3	7.4337	0.00	73.21	0.7885	19.3079	328.05	2.1466
DJS071	2.2260	1.4338	29473.7	12.4150	36.60	53.36	0.3922	14.7013	187.38	2.4857
DJS072	4.5220	2.4209	47211.1	6.5115	59.63	96.74	0.4460	24.2181	170.80	2.3911
DJS073	2.2024	0.7950	35698.6	8.8241	0.00	48.29	0.3831	15.2338	173.91	2.4270
DJS074	4.9051	2.0254	28412.1	4.7560	63.85	107.75	0.3889	15.7165	350.63	2.8348
DJS075	5.9529	2.0145	56948.6	6.9870	96.69	95.13	0.8786	19.1562	146.99	2.0982
DJS076	6.1818	1.4700	37162.1	7.1054	0.00	102.01	0.6928	17.9309	60.34	1.5751
DJS077	5.6210	2.8327	37333.2	6.5261	100.32	100.66	0.5029	21.5367	228.69	3.8306
DJS078	6.6040	1.0316	53061.1	4.8597	0.00	105.98	1.0559	15.8641	90.17	1.1133
DJS079	2.7930	0.9628	28230.5	7.7127	0.00	62.50	0.3252	12.5457	263.04	1.5463
DJS080	5.0182	1.1779	34438.6	6.1321	54.19	88.94	0.7452	11.5748	271.23	0.9687

ANID	Tb	Th	Zn	Zr	Al	Ba	Ca	Dy	K
DJS067	0.4352	11.1057	66.43	151.33	71549.9	4619.9	136118.0	2.8860	5937.8
DJS068	0.8235	9.8256	70.35	138.64	71864.0	4644.1	112835.0	4.4269	13657.1
DJS069	1.1348	12.0168	110.68	282.54	72736.3	5003.0	6954.0	7.2926	15560.2
DJS070	1.5428	15.2249	325.36	229.77	118508.8	8788.7	12953.3	8.4078	11649.0
DJS071	1.0112	15.6358	111.36	280.74	95673.7	2925.9	7212.0	6.0303	10430.2
DJS072	1.7985	17.4059	192.24	159.69	110975.1	3020.3	4743.2	9.9005	18148.0
DJS073	0.7030	15.9216	98.20	201.49	101138.5	3415.5	5504.3	4.4805	7878.6
DJS074	1.4603	12.6317	118.82	118.82	86660.8	2249.6	121358.8	7.9289	19425.8
DJS075	1.5469	14.8224	214.06	183.61	110054.8	5100.8	9887.2	7.6167	10756.2
DJS076	1.2945	14.2704	259.18	149.61	101817.1	1343.1	2139.0	5.8679	13537.4
DJS077	2.1618	18.1850	293.46	179.12	119387.1	4725.8	8373.7	11.2631	13262.8
DJS078	0.5672	13.5211	171.01	114.98	96696.3	1844.9	6229.9	4.2745	22134.6
DJS079	0.7871	11.6389	101.21	189.07	77979.5	3684.8	73047.4	4.4277	13392.0
DJS080	0.6265	10.7682	170.44	170.89	71917.8	3950.2	42006.1	4.3266	17589.2

ANID	Mn	Na	Ti	V
DJS067	386.15	759.5	4744.4	65.3
DJS068	777.38	1842.3	5549.5	91.6
DJS069	114.99	2555.1	6024.4	93.5
DJS070	700.37	1114.9	7138.5	169.9
DJS071	804.73	1105.5	7497.0	79.3
DJS072	891.17	1014.6	7622.1	153.6
DJS073	563.92	964.7	7533.7	97.6
DJS074	954.95	1323.1	5407.2	98.3
DJS075	425.52	1238.8	8213.9	180.7
DJS076	213.72	2104.4	6652.9	132.0
DJS077	1524.17	794.5	7464.3	124.3
DJS078	964.77	3155.3	5381.7	171.0
DJS079	593.24	1192.8	6157.9	63.6
DJS080	745.36	5204.1	4475.8	105.9