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Axe-Heads and Mississippian Political Economy: A St. Francois Provenance Study

Rosanna Yvonne Crow
Southern Illinois University Carbondale, rycrow@siu.edu

AXE-HEADS AND MISSISSIPPIAN POLITICAL ECONOMY:
A ST. FRANCOIS PROVENANCE STUDY

by

Rosanna Crow

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A Thesis
Submitted in Partial Fulfillment of the Requirements for the
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Approved by:

Dr. Paul Welch, Chair

Dr. Mark Wagner

Dr. Justin Filiberto

Graduate School
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ROSANNA CROW, for the Master of Arts degree in ANTHROPOLOGY, presented on 5 MAY 2014, at Southern Illinois University Carbondale.

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Axe-heads made of a distinctive raw material are found at Mississippian sites across southern Illinois and the Ohio-Mississippi confluence region, yet little research has been done to determine their geological provenance. In this thesis, I use geochemical methods to analyze ground stone tools and debitage from across the Confluence Region in order to prove their origins in the St. Francois Mountains of Missouri. I also compare patterns of axe-head production, consumption, and deposition to Charles Cobb's (2000) model of Mill Creek chert hoes, so as to gain a greater understanding of the political economy of these objects.

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CHAPTER I

INTRODUCTION

This research attempts to identify the geological source of a very distinctive raw material used to make ground stone tools found at Mississippian sites across southern Illinois and the Ohio-Mississippi confluence region. Recently, American Bottom researchers have begun to focus on Mississippian era axe-heads shaped from stone that may have geologic origins in the St. Francois Mountains of southern Missouri. These researchers (A. Butler 2011; Kelly 2010; Koldehoff and Wilson 2010; Pauketat and Alt 2004) have an American-Bottom perspective and focus on why Mississippian residents of the Cahokia region chose rock from the St. Francois to make ground stone axe-heads (also called celts). Many of these studies focus on the importance of these axes in community-building and ritual but little work has focused on the political economy of these objects outside the American Bottom. Using Charles Cobb's (2000) Mill Creek chert study as a model, I attempt to document the political economy of axe-heads with St. Francois origins that are found at Confluence Region sites away from the American Bottom.

I use both a geochemical (Shackley 2008) and visual (Andrefsky 1998:40-41; Odell 2004:28-32) approach to lithic analysis in order to make conclusions about the political economy of axe-heads in the Confluence Region. I use portable X-Ray

Diffraction (pXRF), supplemented by a preliminary Scanning Electron Microscope with Energy-dispersive X-ray spectroscopy (SEM-EDS) study, to source ground stone tools found in southern Illinois to specific mafic igneous rock outcrops in the St. Francois. In particular, I test a hypothesis that many of these axe-heads can be sourced back to visually distinctive Skrainka diabase outcrops-- a medium- to fine- grained diabase that is greenish or dark-bluish grey in color and contains large feldspar phenocryst inclusions (Tolman and Robertson 1969). In conjunction with geochemical and archaeological data, I use Cobb's model to examine where axe-heads were being produced, the extent of trade of these tools, and the level of autonomy of the Mississippians quarrying in the St. Francois region.

Sourcing Mafic Rock

Recent work in the American Bottom has led researchers to suspect that Mississippian axe-heads in this region have geologic origins in the St. Francois Mountains (A. Butler 2011; Kelly 2006, 2010; Koldehoff and Wilson 2010; Pauketat 1994, 1998; Pauketat and Alt 2004;). Based on visual characteristics, these axe-heads were likely made of mafic igneous rocks (basalt, diabase, and gabbro) from a variety of different rock outcrops in the St. Francois region. Recently, this hypothesis has been proven to be true (A. Butler 2011) via a study using portable X-Ray Fluorescence (pXRF) on an array of American Bottom axe-heads. Based on visual inspection I suspect that the Skrainka diabase outcrops in particular may have been heavily utilized as a source for lithic raw material. I attempt to verify this identification of the Skrainka source using pXRF.

Portable XRF sourcing methods have proven to be a valid technique in studies conducted on igneous mafic materials across the world. Latham et al. (1992) developed a technique specifically for the use of pXRF on weathered basalts; prior to this study the analysis of porous, vesicular basalts was troublesome (Odell 2000:276). Mills et al. (2010) used pXRF to source Hawaiian basalt tools and prove an island wide distributive economy. Reimer's (2011) impressive dissertation used ethnographic classifications of obsidian, dacite, andesite, and basalt artifacts. He found that the data provided by pXRF could produce the same groupings of lithic types as observed by the Sḵwx̱wú7mesh of southwestern British Columbia, Canada.

In this study, I attempt to test the limits of pXRF to see if this technology is capable of distinguishing between the geologic outcrops of the St. Francois Mountains. I aim to add to the knowledge of the distribution of axe-heads from the St. Francois, by focusing my sample on axe-heads and axe-head fragments from southern Illinois and the St. Francois region of Missouri.

Confluence Region

For this study, the Confluence Region is loosely defined as the area surrounding the confluence of the Mississippi, Missouri, and Ohio rivers. I have divided this region into archaeological study areas based on natural geographic units (Schroeder et. al 1987) and cultural boundaries (Figure 1). These regions include the St. Francois

Mountains and Big River Valley of eastern Missouri, the American Bottom of Illinois, the Upland Shawnee Hills, and Black Bottom of southern Illinois.

Research Design

Charles Cobb (2000) studied the political economy of Mill Creek chert hoes and created a model of production and exchange that challenged the popular theory that the Mill Creek quarry area was under the political control of Cahokia. Due to the fact that geography of the St. Francois region is similar to the Mill Creek chert locale in southern Illinois, it will be interesting to compare patterns of production and distribution of ground stone axes to Cobb's model. I use his model of the production and distribution of Mill Creek chert hoes, in order to determine if Confluence Region ground stone axes were produced and distributed in a similar manner. Cobb concluded that producers in the Mill Creek area were part-time specialists and autonomous traders. Once the hoes were traded outside of the Mill Creek area, the redistribution of chipped stone hoes was controlled on a chiefly level at major mound sites. At this time there is no published alternative economic model specifically designed to explain the distribution of ground stone objects from the St. Francois region. Cobb's study provides a solid testable model for examining the political economy of ground stone tool production and consumption.

This project has two components: First, this thesis provides a literature review, examining alternate theories of ground stone tool production in the American Bottom, the archaeology of the St. Francois region, and the potential for ground stone tool production in this region and at non-local sites where Skrainka diabase material is found in archaeological contexts. Next, I conduct an elemental analysis of geologic St. Francois rock samples and archaeological ground stone artifacts from across the Confluence Region. This will be done in order to determine whether Mississippian axe-heads, fragments, and debitage are coming from the St. Francois Mountains, and whether this material is coming specifically from Skrainka diabase outcroppings.

These data will then be analyzed in the context of Cobb's political economy model of Mill Creek chert hoe production, in order to determine if Cobb's model can explain the political economy of ground stone tool production of St. Francois region igneous rocks. Specifically, this study will examine where ground stone axe-head production is taking place and how objects are moving from producers to consumers.

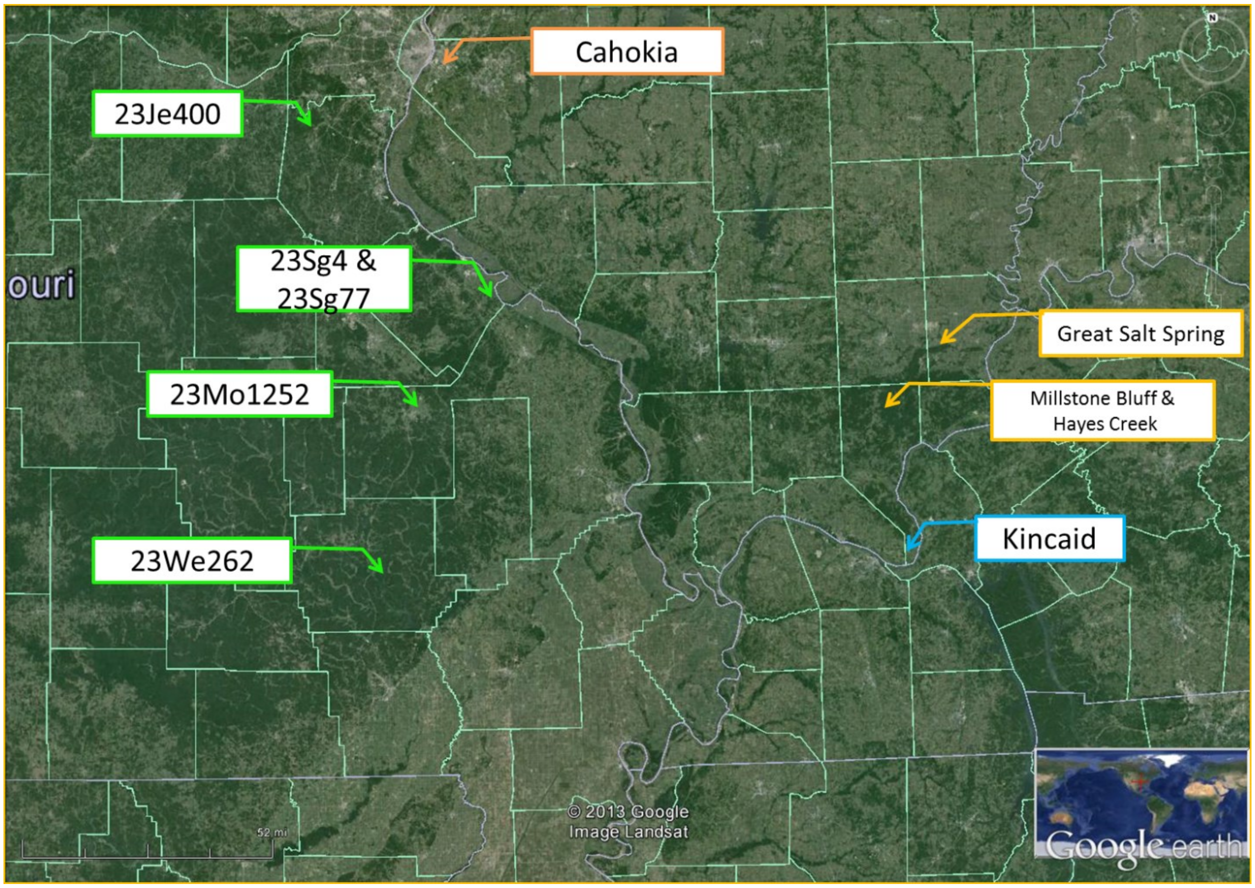

Figure 1- Some of the Confluence Region Mississippian sites discussed throughout this study. Archaeological study areas are designated by colored labels: the Shawnee Hills sites are designated by yellow, the Black Bottom is designated in blue, the American Bottom is orange and St. Francois area sites are in green.

CHAPTER II

THEORY

This research focuses on Charles Cobb's (2000) model of the movement of Mill Creek chert stone hoes. These chipped stone tools moved from quarries in southern Illinois to major mound centers and farmsteads throughout Confluence Region, a situation that may mirror the movement of ground stone axe-heads made of material from the St. Francois Mountains. Currently, there is no political economic theory regarding the movement of ground stone tools in the Confluence Region. There are, however, theories that specifically address the use of use of raw material from the St. Francois for making axe-heads; these theories utilize a framework of community-building (Pauketat and Alt 2004), animist theory (A. Butler 2011), or religious pilgrimage (Kelly 2006, 2010). These theories are discussed here, after an overview of Mississippian political economy and a detailed discussion of Cobb's Mill Creek hoe model.

Political Economy in Mississippian Archaeology

In this study, the production and exchange of ground stone tools in the Confluence Region is interpreted under the political economy paradigm. The term political economy has a variety of meanings, dependent upon both diachronic and academic contexts (Brumfiel and Earle 1987; Cobb 1993, 1996, 2000; Earle 1997; Feinman 2004; Hirth 1996; Litschi 2012; Mintz 1985; Muller 1997; Santley and Alexander 1992; Wolf 1982). When used in an anthropological framework, political economy can be used as both a descriptive term and as a theoretical approach. When used as a descriptor, political economy refers to the sectors of an economy that are controlled by political institutions and used to maintain that entity (Feinman 2004). As a theoretical perspective, political economy is a dynamic, historical approach with a strong concern with the nature of power on a scalar level and how power is related to material aspects of a society (Cobb 2000:6). Theoretically, political economy has been used in multiple analyses of the Mississippian sphere, often in conjunction with other theoretical perspectives (Cobb 2000; Muller 1997; Pauketat 1994; Saitta 1994).

Cobb's Political Economy Model of Mill Creek Chert Hoes

Cobb's (2000) political economy model focuses specifically upon the manufacture, trade, and consumption of Mill Creek chert hoes. Mill Creek chert was exploited by Native Americans in very small quantities in the Middle Woodland period. The intensification of maize agriculture in the emergent Mississippian period correlates with an explosion in the production and exchange of Mill Creek chert hoes (Cobb 2000:65). Mill Creek chert hoes were distributed across the Mississippian sphere, and are found in connection with almost all social strata. Mill Creek chert was the predominant material used to make stone hoes until the late Mississippian period when

Dover chert began to infringe on this monopoly, although not to the same scale of consumption (Cobb 2000:67).

The Mill Creek chert source is concentrated in the Shawnee Hills area of southwestern Illinois (Cobb 2000:110); this is an area geographically different from the ecological regions typically favored for Mississippian towns, namely agriculturally rich bottomland settings (Cobb 2000:99). The Mill Creek quarry area has two small associated mound sites, the Linn and Hale sites (Cobb 2000:113), as well as several mortuary and village/workshop sites within its proximity. The nearest major Mississippian centers, Kincaid and Cahokia, are approximately 60 km and 250 km away, respectively.

Cobb theorizes that villagers living in the small sites associated with the Mill Creek quarry were autonomous peoples, possibly under the influence of local elites. Archaeological surveying in the Mill Creek locale and excavation at Dillow's Ridge indicates that all hoe production took place at workshops near the quarry sites. Hoe producers were not specialists; hoe production was probably done within the daily sphere of chores of Mississippian men, who Cobb considers part-time specialists (2000:190).

As a result of the geographic network of intermittent waterways within the Shawnee Hills, fully formed hoes from each village were probably traded in different directions to individual external village and mound sites. From here, hoes were probably both consumed and redistributed following a network of overland trails and waterways. The consequence of this is that not all hoes produced in the Shawnee Hills region went to one major center for redistribution. Since there was no centralization of production or redistribution, villages were able to trade as autonomous entities (Cobb 2000:190).

Multiple lines of evidence from the archaeological record of the Mill Creek locale indicates that elites (if present here) and flintknappers probably had weak or no control of power or privilege. This is especially true when compared to elites and flintknappers living at major mound sites. The Mill Creek area has an absence of elite or ritualized flintknapper burials that can be found at many other Mississippian sites (Cobb 2000:193).

The small scale of the earthworks at the Linn and Hale sites supports the idea that leaders in this region had limited control over a sparse population (Cobb 2000:194). This idea is also supported by the limited amount of exotic and prestige goods in the Mill Creek quarry area, an indicator that leaders here were not participating in "far-flung" Mississippian trade networks. Cobb theorizes that these factors are an indication that "the impetus for the mobilization of surplus likely welled up from within the social or kinship group, rather than at the behest of elites" (Cobb 2000:193).

Once the hoes left the Mill Creek quarry area and reached major mound centers, the political aspect of hoe exchange was altered. The abundance of evidence of chipped stone hoe caches at mound sites alludes to the idea that elites were in control of accumulating hoes, which outside of the quarry region, would probably have been considered an exotic good. Caching of these tools indicates that elites probably controlled the distribution of hoes to agricultural producers in the hinterlands (Cobb 2000:199).

Cobb theorizes that the greater social demand for Mill Creek chert hoes in the emergent Mississippian period was largely based upon qualities inherent in the chert itself: it is a consistent material that makes durable tools with consistent retouch properties. In later Mississippian periods, the desire and demand for Mill Creek chert may have been more closely tied to ideas of social relation and identity than physical material properties (Cobb 2000:201).

In summary, Cobb theorizes that Mississippian's living in the Mill Creek locale were autonomous producers, free from the control of local or distant chiefs. The hoes were probably produced by men who handled hoe production within the scope of daily life; there was no specialization of labor. If there were elites living in the Mill Creek locale, they had limited power and probably no control over exchange. All elite mobilized labor, for example mound-building at the Linn site, was done on influence alone. Producers in this area were free to trade chipped stone hoes with anyone they desired, there was no monopolization of exchange. Once the stone hoes reached major mound centers, they were accumulated and redistributed by elites to commoners living in the hinterlands.

Tim Pauketat and Susan Alt's Model of a Cahokian Controlled Axe Economy

Pauketat and Alt (2004) conducted a technological study on the Grossman cache, a cache of 70 ground stone axe heads found in a village site in the American Bottom. From this study, they developed a theory about axe-head caching in the

American Bottom that encompasses constructed social memory, cultural identity, and landscape. Pauketat and Alt determine that the Grossman cache was part of a “series of production and distribution practices and commemorative rituals [that] embodied a ‘coming together’ process” (Pauketat and Alt 2004:779). They theorize these practices and rituals helped to create a more centralized Cahokian polity.

Pauketat and Alt theorize that an industry of axe-head production existed in the American Bottom in the late eleventh century (see Koldehoff 1990). At this time, axes were not valued as prestige symbols and are not found among mortuary goods in the elite tomb mounds of Cahokia. Pauketat and Alt speculate that it is unlikely the Grossman cache was an abandoned or forgotten domestic store because of the patterned deposition of axe-heads, the presence of axe-heads of an unfinished quality, and the infrequent discovery of buried functional axe-heads in domestic contexts.

Pauketat and Alt used a technological analysis (noting axe-head morphology, degree of production completion, use-wear, and descriptors of raw material type) to discriminate twelve different styles of axes. They conclude that the axe-heads were purposefully deposited as distinct groups in the pit by different axe-head producers or communities of producers. They suggest that either the axes were buried by people who recognized patterns in the axe-heads; or that the axes were buried by the individual producers themselves in a community ceremony. They hypothesize that the different “axe-head styles signify specific individuals, collective bodies, or cultural identities” (2004:790).

Pauketat and Alt suspect

> that the Grossman cache is one of a series of meaningful commemoration rituals that brought together both local and Cahokian products, if not people, and (re-)defined place and cultural identity as a part of a much larger and rapidly changing regional landscape. [Pauketat and Alt 2004:792]

These inferred temple rituals may have occurred periodically during the Lohmann through the early Sterling phase, and the researcher's suspect that, prior to deposition, some of these buried axes may have been used to clear land for Grossman settlement.

The Grossman axe-head deposit may be evidence for

> A rare, highly ritualized practice intimately linked with the construction of a new region-wide Cahokian cultural order, perhaps marking the special cultural or political status of the Grossman site or its people…Burying axe-heads at key points around Cahokia was part and parcel of the creation of a new, ordered, agricultural landscape… *and* a unified cultural landscape, with farmers newly resettled in the region setting aside potential enmities as part of Cahokia's late eleventh century political consolidation. [Pauketat and Alt 2004:792]

Pauketat and Alt theorize the raw material to make these axes was coming from the St. Francois Mountains in an unworked or roughly shaped form. They posit that Cahokian elites managed and distributed this raw material for the production of axe-heads to be made at and around Cahokia. It may be that some axe-heads were centrally made prior to distribution to farmsteads. At other times, raw, unworked or roughly shaped material was given to farmsteads where they produced their own axes. Therefore, the "Grossman cache suggests both the centralized and decentralized production of axe-head making material that was derived from a restricted source accessed, if not controlled, by Cahokia" (Pauketat and Alt 2004:793).

Overall, Pauketat and Alt see the caching of axes as part of a chain of creative practices wherein the acquisition, manufacture, distribution, and deposition of ground stone axes is controlled by Cahokia.

Amanda Butler's Landscape Study

Amanda Butler's (2011) study conclusively proved the connection between St. Francois sources and ground stone tools found in cache deposits in the American Bottom as was suspected by Pauketat and Alt (2004). She interpreted these geochemical results using landscape studies and animist theory. Following Pauketat and Alt (2004), Butler hypothesizes that the use of St. Francois rocks in place of locally available glacial tills in early Mississippian ground stone tool production was part of a larger community-building process. Use of the St. Francois raw material helped to create "deep meaningful and sociopolitical relationships with place and landscape" (A. Butler 2011:9).

During the Mississippian period various materials were imported from the Ozarks into the American Bottom. These resources were often brought in as raw material and then transformed into a finished form. Butler sees these transformations as being both spatial and meaningful. Using Bradley's (1990) theory, she interprets these items as "transformed from symbols of place to symbols of power" (A. Butler 2011:6). This, she conjectures, creates a deeper connection to place.

She sees these cached celts as embodying a deep connection to and reminder of place, therefore the Grossman celts are active participants in the creation of community (A. Butler 2011:8).

> The celts have a previously established network of powerful relationships with place i.e. the St. Francois Mountains…. [the Grossman celts] can be seen as being active participants in the creation of identity and community, by harkening back to the power of place. [A. Butler 2011:8]

John Kelly's Theory of the Religious Movement of Sacred Stone

John Kelly (2010) examined the evidence of axe-head manufacturing in both the American Bottom and the St. Francois region. He structures his perspective using a religious framework and bases many of his arguments on archaeological data and ethnographic work gathered from the Osage.

Kelly hypothesizes that Early Mississippians viewed both Cahokia and the St. Francois Mountains as sacred landscapes. The fact that axe-heads made of St. Francois igneous rock were manufactured in the American Bottom forms a clear and strong link between these two sacred landscapes. Kelly argues that due to its material association with the sacred landscape of the St. Francois Mountains, Mississippians viewed raw lithic axe-head material as imbued with power. This connection to a sacred landscape was what transformed mundane, utilitarian axe-heads into a source of sacred power (Kelly 2010: 208-209). Kelly states that in some instances these potent objects were used to “attack and kill” sacred trees of the Ozarks, which were then transported back to Cahokia to be integrated into a constructed scared landscape (Kelly 2010:210).

Kelly postulates that axe-heads moved into the American Bottom via people on religious journeys that traverse sacred landscapes. He questions who was actually moving the raw lithic material during these sacred journeys. Kelly hypothesizes that either a) stone for axe-head production was being brought back by people from Cahokia who are going on sacred vision quests to the St. Francois Mountains, or b) people living in the St. Francois region brought local stone along with them when they underwent pilgrimage to the man-made representation of the cosmos at Cahokia (Kelly 2010:206).

Regardless of which group is doing the movement, Kelly argues that the production of ritual objects may have been completed in different stages by different groups of people, “similar to the processes employed by the Osage at the end of the nineteenth century, when members from different clans had the necessary knowledge that contributed to the final product” (Kelly 2010:210).

Kelly also calls into question the link between axe-head production sites in the St. Francois region and the axes found in the American Bottom. Kelly notes that there is a plethora of axe-head production material found at Cahokia and surrounding American Bottom sites. Conversely, evidence for ground stone axe-head production has only been found at two sites in the St. Francois region. Other than a similarity of ceramic style, Kelly sees no evidence to link these St. Francois production sites to the actual ground stone axes found at Cahokia (2010:209).

In conclusion, Kelly believes that the raw material for axe-heads was being moved from the St. Francois to the American Bottom for religious, and not economic, purposes. These axe-heads may serve as a symbolic link to the spiritual importance of the St. Francois region. The proximity to sacred places (as well as rich mineral and biological resources) within the Ozarks may have contributed to the sacredness of Cahokia's constructed landscape.

Discussion

The theoretical perspectives utilized by these four researchers will aid me in answering my main questions. First, can tools made of St. Francois igneous rock be found at sites throughout the Confluence Region, and if so, can these tools be sourced to a specific outcropping? Amanda Butler (2011) proved the presence of ground stone tools of St. Francois origins in the American Bottom and central Illinois. Her ideas surrounding the importance of place and the processes of material acquisition/transformation can help guide my study, as we are both looking at tools sourced to the same (probably sacred) locale. Pauketat and Alt (2004) discuss the importance of American Bottom community-building when choosing this source. This study proves that axe-heads found outside this region share the same source. Their theory emphasizes local social ties and could prove useful in determining why consumers chose St. Francois stone over locally available materials.

My next question surrounds the political economy of these tools. Cobb (2000) provides a model for discussing the transformation from raw materials to finished products and the mechanisms which may have moved these tools across the region. His model will also be helpful in comparing Mississippian settlement patterns and the nature of political control in the St. Francois. Kelly (2010) also focuses on who may have been moving these objects between the St. Francois and Cahokia, and why these tools have a multi-step production sequence. His theories may prove helpful in teasing out the nature of habitation in the St. Francois and why American Bottom producers chose to employ a dual region axe-head manufacturing process.

CHAPTER III

ARCHAEOLOGICAL BACKGROUND

This study focuses on artifacts from Mississippian sites across the Confluence Region. Discussed here are the hallmarks of Mississippian culture and an elaboration of the regional cultural histories relevant to this study. I also provide a summary of Mississippian axe-head manufacture and use. Lastly, I summarize relevant research on Mississippian ground stone tool sources pertinent to the Confluence Region.

Mississippian Culture History

Archaeologically, the term Mississippian can be used to signify either a period of time or a cultural tradition. The Mississippian period is the chronological stage, while Mississippian culture is referred to as the cultural similarities that characterize this society. The Mississippian period in North America ranged from approximately 800 to 1500 AD and was characterized by a mound-building Native American culture that flourished through the Midwest, East, and Southeastern U.S. The Mississippian culture has certain socio-political and material characteristics that help to discriminate it from preceding and following cultural periods. Politically, Mississippian culture was structured around a chiefdom level of social complexity, which in some areas included institutionalized social inequality and the centralization of regional political and religious power. The Mississippians showed the beginnings of a settlement hierarchy, in which one major center has a clear influence or control over a number of lesser surrounding communities (Bense 2009:190-195).

Mississippians often constructed large truncated earthen mounds. They often supported their chiefdom level social system through the adoption of maize-based agriculture, and in riverine areas corn became their primary dietary staple. However, Mississippians living in coastal regions often limited agriculture and focused on marine and terrestrial wild foods (Bense 2009:184-191). Mississippian peoples adopted the use of riverine shells as tempering agents in pottery.

Mississippian culture is often associated with paraphernalia categorized as the Southeastern Ceremonial Complex, a set of symbols and religious ideas that extended throughout the Mississippian sphere (Bense 2009:195-198). However, Knight (2006) has argued that this concept is outdated. Knight states that these sets of images are not ceremonial or exclusive to the Southeast, nor are the sets of symbols consistent throughout the regions in which they are found. Nonetheless, it can be argued that Mississippian images, along with other exotic items, were exchanged through widespread trade networks extending as far west as the Rockies, north to the Great Lakes, south to the Gulf of Mexico, and east to the Atlantic Ocean. What is clear is that during the Mississippian period there was “a remarkable climax in skilled crafting in certain artistic media” (Knight 2006:3) with interconnected themes that were pervasive throughout the Mississippian world. However, these themes and images varied regionally, even within locally integrated areas such as the Confluence Region.

Mississippians in the Confluence Region

The Confluence Region is the area of Illinois and Missouri that surround the confluence to the Mississippi, Missouri, and Ohio Rivers. Here, I provide a literature review of material that is relevant to the political economy of ground stone tools in the Confluence Region.

Previous Studies on Exchange in the Confluence Region

The subject of trade and exchange has had some examination in the Confluence Region. These studies have usually taken an American Bottom-centric perspective; almost all studies have focused on what are considered to have been prestige goods. Some exotic goods found in the American Bottom, such as chert, quartz, hematite, galena, flint clay, igneous rock, wood, and salt, are known to have come from the Missouri Ozarks (A. Butler 2011; Emerson and Hughes 2000; Kelly 1991; Koldehoff 1987; Koldehoff and Wilson 2010; Walthall 1981). Other goods, such as Gulf Coast conch shell, Lake Superior copper, and Tennessee Valley chert and ceramic vessels, indicate much larger and far-flung trade networks (Kelly 1991:64).

In opposition to the diversity of foreign materials found at Cahokia, there is limited evidence of exotic goods or direct trade between polities at Confluence Region sites outside of the American Bottom area. At the Kincaid Site, evidence of non-local exchange can be seen via the presence of copper bead bracelets, a Gulf Coast conch shell (Cole 1951), galena fragments, and a small axe-head that may be made of greenstone (from the Hillabee schist source). This greenstone axe head would prove at least an indirect connection with the Moundville polity in Alabama, but further testing is necessary to support this.

It is interesting to note that, with rare exception, most exotic items found at sites in the Black Bottom and the Shawnee Hills come from sources that are within an approximate 200 km radius (Boles 2012, B. Butler 2010). At Kincaid there is some evidence of the exchange of large amounts of chert (B. Butler 2010) from the Mill Creek and Dover quarries. Surprisingly, the Kincaid site has more Dover Chert (which originates approximately 250 km south-east in Stewart County, Tennessee) than Mill Creek chert (which originates approximately 60 km north-east from Kincaid). This, in combination with the fact that there is far more Dover Chert found at the Kincaid site than in its surrounding hinterlands, suggests that the people of Kincaid controlled the distribution of Dover chert to people along the lower Ohio River (B. Butler 2010:11).

Boles (2012) found that Kincaid has yielded a very large number of fluorite artifacts, which probably came from outcrops near the Ohio River around Rosiclaire, Illinois, about 40 river miles upstream. Fluorite is also found in relatively high amounts at Hayes Creek, and in small quantities at Millstone Bluff. It is of note that fluorite is practically absent at Cahokia outside of the small quarry areas in this region, although the Mississippian people living here had an affinity for quartz (Boles 2012:87-88).

Larger Archaeological Mound Sites in the Confluence Region

Cahokia is located in the American Bottom, a low lying floodplain along the Mississippi River that extends 161 km north-south and 18 km wide. This region has exceptional environmental diversity and provided a wide array of resources for the native people who lived in this region (Pauketat 1994:43-46). Sedentary villages existed in the American Bottom as early as AD 600. In this region, the Woodland Period is thought to have ended around AD 750, marking the beginning of the proto-Mississippian period (Pauketat 1994:47).

In the decades surrounding AD 1050, abrupt changes in settlement patterns began to form throughout the American Bottom, nucleating around Cahokia and several other smaller administrative centers. Cahokia, the largest known Mississippian mound center in the United States, was a complex, planned, and designed urban center with a large residential population, intensive farming, and artisan production of refined crafts and goods (Emerson 1997:44-47). The Cahokia site spanned almost four square miles at its peak (Fowler 1997; Milner 1998; Pauketat 1998), and Cahokia's location near the confluence of three major rivers helped it to become a major player in a large regional trading network reaching to the Great Lakes and the Gulf Coast.

The estimated population of Cahokia ranges from 3,000 to 16,000 at its peak (Milner 1998; Pauketat and Lopinot 1997); regardless of the difficulties of population estimates, it is known that Cahokia was the largest city north of modern-day Mexico (Milner 1990). The city went into decline after AD 1300 and was abandoned before AD 1400. This abandonment may have been due to ecological reasons, such as deforestation and overhunting by the population (Lopinot and Woods 1993). While Cahokia's population and borders were growing and shrinking, so were those of a smaller mound site to its south- the Kincaid Site of the Black Bottom (see table 1 for a comparison of regional phases).

The Kincaid site is found in the Black Bottom, a floodplain region bounded to the south by the Ohio River and to the north by the Brownfield Terrace (Alexander and Prior 1971). It is 5 km in width and 16 km in length, with ridge and swale topography created by the movement of the Ohio River (Brown 1997, Butler 1977, Muller 1978). The Mississippi period in the Black Bottom dates from ca. AD 1050-1450 (Butler 1991). The archaeological site that is best known from this area is Kincaid Mounds. Kincaid is surrounded by a plethora of smaller sites that dot the Black Bottom; these sites peaked in the AD 1200’s (Butler 1977; Cobb and Butler 2002:627).

Surface surveys (Butler 1977, Muller 1978) have identified over 100 Mississippian sites in the Black Bottom. These surveys identified different types of sites based on size: small sites less than 0.01 hectares (ha) that are temporary camps or extractive stations, residential sites approximately 0.3 ha in size, larger residential sites ranging from 0.9 to 1.0 ha in size, and the Kincaid Mounds site spanning over 60 ha.

Muller theorizes that there is a basic “building block” system to settlement patterns. The basic unit is small farmsteads of one to three structures, when these farmsteads are found in clusters they comprise a hamlet of eight to fifteen structures (Muller 1978:280). Muller hypothesizes that farmsteads are settled year-round and are economically self-sufficient. Hamlets have the same political economic pattern as farmsteads and have no evidence for the specialization of labor or unequal distribution of wealth (Muller 1978:285). It is unclear how the Kincaid site fits into this schematic due to its size, monumental architecture, and unique (for the Black Bottom) patterns of domestic occupation.

The Kincaid site is located approximately less than one kilometer from the Ohio River in the Black Bottom (Figure 2), straddling Massac and Pope County. Kincaid emerged as a mound center around AD 1000 and reached its zenith in the AD 1200's, with all major mound-building ending in the AD 1300's (Cobb and Butler 2002:627). The site has an organized layout consisting of a central plaza ringed by five major mounds and several smaller mounds, with additional mounds to the east and west of the central group. The mounds and habitation areas were surrounded to the south by Avery Lake and, by the 1200's, to the north by a large palisade that enclosed at least 60 ha (Cobb and Butler 2002:627; Welch et al. 2007). Kincaid was part of a larger Mississippian sphere- this can be evidenced by the presence of stylized cultural patterns and imported foreign goods (Cole 1951). However, not all Mississippian sites are grandiose mound centers. A large portion of the Mississippian world lived in smaller groups outside of localized centers. Some of the smaller sites relevant to this study are discussed in the next section.

Smaller Archaeological Sites in the Confluence Region

Here, I introduce some of the relevant smaller sites throughout the Confluence Region, based on archaeological region.

American Bottom Region Sites. As discussed previously in the summary of Pauketat and Alt's 2004 article, a large axe-head cache was found at the Grossman site, an upland hill top domestic Mississippian site about 17 km east-south of Cahokia in the American Bottom (Pauketat and Alt 2004:780). The tightly packed cache of seventy complete and unfinished axe-heads was found immediately outside of a domestic building that stood eight meters north of the entrance to a large public building (Pauketat and Alt 2004:781). Production debris has also been found at the site (Pauketat and Alt 2004:784).

Southern Illinois Uplands Sites. Archaeological studies in the southern Illinois uplands have been rare and have generally been limited to larger Mississippian habitation sites (Cobb and Butler 1998:13). Surveys done in the 1970's suggest that smaller Mississippian occupations do exist, usually found along the terraces of small drainages (Rudolf 1977). Very little work has been done on these smaller sites. To date, only four large Mississippian sites in the southern Illinois uplands have been systematically excavated. These are the Great Salt Spring site, the Millstone Bluff site, the Hayes Creek site, and the areas associated with the Mill Creek chert quarry.

Great Salt Springs. The Great Salt Spring site was a transitory site that was the locus of salt-extraction from natural salt springs on the floodplain of the Saline River (Muller 1991). This site is comprised of a bluff top stone box cemetery, hilltop domestic area, and floodplain extractive zone defined by salt reduction hearths and saltpan sherds. This site was occupied for salt production starting around AD 800, and some areas near the saline spring have over 3 m of production debris. It can be argued that Mississippians continually occupied this site due to the presence of stone box graves and public architecture. However, Muller (1991:313) argues that archeobotanical data and architectural design of the large salt-reduction hearths suggest that the site was most heavily used on a seasonal basis, probably during the autumnal months.

Millstone Bluff. The Millstone Bluff site (11Pp3) is an unplowed late Mississippian site located in the interior upland of the Shawnee Hills. It is situated in the Bay Creek Drainage, about 20 km northeast of the Ohio River. The site is placed upon a large hill, which from a distance resembles a huge Mississippian conical mound (Butler and Cobb 2012:50-1; Cobb and Butler 1998:3).

The site displays a formal site plan. On the apex of the hill there is a central plaza encircled by 26 house depressions (Butler and Cobb 2012:51, Butler and DiCosola 2008). The site has a stone box cemetery on the eastern flank of the hill and displays complex Mississippian rock art carved into sandstone slabs on the north side of the site (Butler and Cobb 2012:50-53; Cobb and Butler 1998:8, Wagner et al. 2004). Millstone Bluff was occupied in the Late Woodland as a stone fort site; it was reoccupied by Mississippian's after a 300 year occupational hiatus in the late AD 1200's (Butler and Cobb 2012:55). It is thought that the site was occupied continuously, with declining populations occupying the site until approximately AD 1400 (Butler and Cobb 2012:57).

Millstone Bluff is unique for this region in terms of size and location. Archaeologists are unaware of any potential critical resources located nearby. This is unlike other Mississippian sites in this region; salt was procured at Great Salt Spring, and chert hoes were produced at Dillow's Ridge (Cobb and Butler 1998:14). The Millstone Bluff site is surrounded by smaller Mississippian occupation sites, which are typically found along the terraces of small creek drainages (Butler and Cobb 2012;

Cobb and Butler 1998:13), as well as ceremonial rock art sites found in rock shelters (Wagner et al. 2004, Crow et al. 2014).

Hayes Creek. Located about 4 km southeast of Millstone Bluff is an example of a small Mississippian terrace site (Butler and Cobb 2012; Cobb and Butler 1998:13). The Hayes Creek site is about a two-hour walk from Millstone Bluff (Butler and Cobb 2012:48; Cobb and Butler 2002:630). Occupation here occurred extensively over an area of approximately 10,000 m^2, with intensive house construction covering a small area of the site, a U-shaped midden deposit, and apparent plaza (Butler and Cobb 2012:58; Cobb and Butler 2002:630). The site also had a large communal building that is much larger than any known structure at Millstone Bluff, and a stone box grave site (Butler and Cobb 2012:58, 61; Cobb and Butler 2002:632). Hayes Creek is thought to have been occupied at roughly the same time as Millstone Bluff (and also Dillow's Ridge, the Mill Creek chert production site) (Cobb and Butler 2002:632). Occupation began in AD 1200; although the occupation sequence is unclear Hayes Creek seems to be occupied for some time after Millstone Bluff is abandoned in the AD 1400s (Butler and Cobb 2012:63-4).

St. Francois Region Sites. Archaeological investigations in the St. Francois Mountains have been scanty and the region is poorly understood (Weisman et al. 2007). Very few site reports or archaeological overviews of the region have been published, with the exception of technical reports produced by agencies such as the Missouri Department of Transportation (Eastman et al. 2002; Niquette and Donham 1986; Schroeder 1983; Weisman et al. 2007; Weisman et al. 2008).

In Missouri, the largest population of Mississippians lived near the American Bottom. It is known from previous studies (Emerson and Hughes 2000, Koldehoff 1987; Koldehoff and Brennan 2010; Walthall 1981) that the St. Francois Mountain region was utilized by the people of the American Bottom to provide the raw materials for exotic goods, such as galena, flint clay, chert, and igneous rock. In addition to the exploitation of resources by inhabitants of the American Bottom, there is also evidence suggesting the region saw the continued occupation of established Late Woodland groups. These groups are thought to have transitioned to the Mississippian cultural worldview as it spread along the stream valleys that connect the Mississippi Valley (Chapman 1980:152).

The Early Mississippians of the St. Francois region have been linked to inhabitants in the American Bottom via similar technological styles (Chapman 1980). Pottery is often used as a chronological and cultural marker; the transition from using mostly limestone temper to using mostly shell temper is often indicative of the adoption of Mississippian culture. Archaeological excavations of an early Mississippian permanent village located on the St. Francis River, 23We14, yielded evidence of an American Bottom connection and also the transition of Late Woodland groups to Mississippian material culture. Artifacts from this site include cordmarked pottery that has both limestone and shell temper, as well as equal amounts of pottery tempered with either limestone or shell (Chapman 1980:156). Excavations farther to the north, outside of the St. Francois Mountains along the Big River arm of the Meramec River, show evidence of stone box graves made in the same style as temporally similar graves in the American Bottom (Chapman 1980:155).

During the Middle Mississippian period, there are few permanent villages in the Ozark region. Cemeteries have been found with goods that are similar in style to the Sand Prairie phase (Chapman 1980:229) and a Powers phase homestead was excavated along the St. Francis River (Chapman 1980:234). Overall, the villages found in this region were small and it is hypothesized that they probably were used for the extraction of botanical and mineral resources (Chapman 1980:234). To date, no major platform mound sites have been found within the St. Francois Mountains.

To the south of the mountains, along the St. Francois River, is the Powers Fort site: a relatively larger site of four mounds enclosed on three sides by embankments, with eight associated subsidiary villages (Chapman 1980:244). It is not thought that this site was intrinsically linked to the outcrops used for axe-head manufacture to the north. Excavations 5 km southeast of Powers Fort, at the Turner and Snodgrass sites, recovered thirteen complete axe-heads, almost 30 axe fragments, and minimal evidence for production (Gilliland and O'Brien 2001:260-262). At this time, the geologic provenance of these axe-heads is unclear. The analysts described the raw material as "greenstone or limestone" (Gilliland and O'Brien 2001:260), but are probably referring to its coloring and not a suspected provenance.

Late Mississippian sites within the St. Francois region are of lesser importance to this study, because axe production in the Confluence Region shifts away from St. Francois materials. Nevertheless, it is important to note that knowledge of St. Francois area settlements during this period is as sparse as in the time periods that precede it.

In this study, axes-heads and production debris suspected of being Skrainka diabase have been tested from five St. Francois area sites and from one site to the north. These sites are: the Bonaker site (23Je400); 23Sg4; 23Sg77; the Wiegenstein Site #2 (23Mo1252); the Hunter Site (23We262); and the Bundy site (23Pi77). The objects tested for this study are curated by the Missouri Department of Transportation.

Bonaker Site (23Je400). The Bonaker site is an Early and Middle Mississippian period site (Schroeder 1983:22) located on a terrace overlooking the Big River (Schroeder 1983:6). It was excavated in 1980, in order to mitigate its destruction by Highway W in Jefferson County. One hundred seventy five features were uncovered, including six houses that were burned post-occupation (Schroeder 1983:6, 25). The small size of the houses, coupled with lithic evidence, indicate that this site was occupied only during the summer months (Schroeder 1983:23), possibly around AD 1050.

23Sg4. This site was threatened by the construction of a bridge during the MoDOT's St. Genevieve Route 61 Project (Eastman et al. 2002). It is located on a peninsula between the south bank of Saline Creek and a recently abandoned channel of the Mississippi River. It is a Late Woodland/Mississippian village site with an associated burial mound (23Sg91) that was recorded in 1914 but destroyed by 1940 (Eastman et al 2002:38). Archaeological excavation at the site revealed a high frequency of salt-pan sherds. It is hypothesized that salt was produced here as a specialized activity for both local use and exchange. The ceramic assemblage at

23Sg4 resembles ceramics found at Cahokia; however, the level of autonomy of producers living at 23Sg4 and the surrounding Saline Creek area is unclear (Eastman et al 2002:7-8).

23Sg77. This site was surveyed by minimal shovel testing during the St. Genevieve Route 61 Project. It is located on a terrace on the north side of the River Aux Vases. It is recorded as a Mississippian stone box cemetery site associated with the village site of 23Sg10, situated on an adjacent lower terrace (Eastman et al 2002:28-29).

Wiegenstein Site #2 (23Mo1252). The Wiegenstein Site #2 is a late Mississippian period habitation site and lithic workshop, excavated in 2008 by the Missouri Department of Transportation for the Route 72 Fredericktown Bypass (Weisman et al. 2008). It is located along the bank of Village Creek, north of Fredericktown, MO, in a privately owned pasture that had probably not been plowed in over 50 years.

Floral data from the site indicates a fall/winter occupation; ceramics are significantly underrepresented due to the acidic nature of the soil (Weisman et al. 2008:42). There is a strong indication for intensive axe-head making at the site. Diabase debitage (percussion flakes), broken unfinished celts, and rejected celt blanks were found across the site (Weisman et al. 2008:37). The recovered assemblage includes a celt blank and production debitage of probable Skrainka origin (Weisman et al. 2008:37-41). The style of celts found at Wiegenstein Site #2 are similar to celts found at Cahokia during the late 11th and 12th centuries, and Weisman et al. suspect the site may date to that time period (2008:42). Adjacent to the site is the possible source of the raw material used by the Mississippians for ground stone tool manufacture. Intrusive mafic dikes are exposed along road cuts nearby, but the archaeological and geological materials have not been compared (Weisman et al. 2008:37-41).

The Hunter Site (23We262). The Hunter Site is an Archaic period base camp and burial site. Although the time period of this site does not fit with this study, it is mentioned because testing here discovered an Archaic celt of possible Skrainka origin and this celt was examined in this study for comparative purposes.

The Hunter Site was one of forty sites investigated by MoDOT archaeologists during the Wayne Route 67 project. It is located on the slope of a hill banked by the St. Francis River in the Mark Twain National Forest. Shovel testing was done in 2001 and 2006 to determine its extent, and in 2006 eight 1x2 meter units were excavated (Weisman et al. 2007).

Bundy Site (23PI77). The Bundy site is not located in the St. Francois Mountains, but is to the north in the Salt River Valley near the confluence of the Salt and Mississippi rivers. Located on a low floodplain rise, the Bundy Site was excavated by MoDOT in the summer of 1983 for the Pike Route 79 project. It yielded 35 cultural features and a basaltic axe head. The site is interpreted as a series of short-term occupations dating from the end of the Middle Woodland Period through the Late Woodland Period (Niquette and Donham 1986). Again, although the period of its occupation does not fit with the other sites under study, I have included it for comparative purposes, as the axe-head from this site appears to be made of a raw material visually similar to Skrainka diabase.

Summary of Sites

The axe heads in this study came from a variety of Mississippian sites. These sites vary in size, from large densely populated mound centers to small seasonal camps. These sites encompass a wide range of topographic settings within the Confluence Region, including floodplains, wooded hills, and a small forested mountain range. These Mississippian sites are supplemented by one Archaic and one Woodland period site, which yielded axe-heads of possible Skrainka diabase provenance.

Mississippian Axe-Heads and Other Ground Stone Tools

Mississippian period artifacts demonstrate a variety of tools made using ground stone techniques. This class of artifacts includes (though is not limited to) axes, mortar and pestles, discoidals, pipes, plummets and net sinkers, bannerstones, gorgets, pendants, and whet-stones (Funkhouser and Webb 1928). Ground stone tools are designated as such because a grinding method was used in order to produce the desired form, although prior to this step considerable chipping is usually required to roughly shape the stone. The shaping process was usually achieved using a hammerstone made of an extremely dense stone and required a knowledge of fracture mechanics and a level of learned mechanical skill. Once roughly pecked into a desired form, grinding and polishing methods were used to achieve a polished look. This second step was usually done with a softer stone, such as sandstone, and required lesser skill but a greater input of time and patience (Funkhouser and Webb 1928, Koldehoff and Wilson 2011).

Ground stone tools with sharp bits may be described as either axes (aka celts) or adzes. Axes are used with a chopping-swing motion; they are symmetrical and have a straight, sharp bit end and a rounded poll end. In this study, the terms axe and celt are used interchangeably. Adzes were primarily used in woodworking, using a scooping-swing or scraping motion. Adzes are asymmetrical, having one curved face and one flat face. An adze will have a slightly curved, sharp bit, and if utilized, may have evidence of damage along the poll end due to the application of indirect percussion techniques during use.

In the Mississippian world, ground stone axes served a dual purpose. They served as a functional utilitarian tool for woodworking, but also were used as symbolic ceremonial objects. As utilitarian objects, axe-heads were often hafted onto long wooden handles and used to clear fields by cutting trees, used for woodworking, or used as a weapon. An example of a still-hafted axe was found in the Black Warrior River near Moundville, providing archaeologists with an example of a complete tool (Oakley 1982:1-3). As symbolic or ceremonial axes, the objects were typically unused and were sometimes placed into cache deposits unhafted. While ground stone axes were not considered high-status symbols, both utilized and hypertrophic axes have been found in temple refuse pits (Pauketat and Alt 2004:792).

The production of ground stone tools using St. Francois igneous rock has been associated with the “Big Bang” episode in the American Bottom (Pauketat 1997). In the

Late Woodland, American Bottom axes were made of igneous and metamorphic rock materials, probably from glacial till cobbles found in the surrounding river and creek beds (Koldehoff and Wilson 2010). These Late Woodland celts are smaller and the use of glacial till cobbles is consistent with expedient Late Woodland technological patterns. Koldehoff and Wilson (2010) argue that Late Woodland groups had no need to import stone from the St. Francois Mountains as local glacial till provided enough raw material. However, throughout the early Mississippian period, populations in the American Bottom increased in size and density. This populace was actively creating and expanding fields, villages, and mound centers. This created a need for an abundance of material with consistent working properties that could create bigger celts in greater quantities. The Cahokian economy required a steady supply of celts and glacial till deposits could not supply suitable preforms like the lithic materials found in St. Francois exposures (Koldehoff and Wilson 2010:238).

In the American Bottom, the widespread distribution of celts made from St. Francois igneous stone occurs primarily during Cahokia's Lohmann phase, 1050-1100 AD (see Table 1). Axe-heads from this time period have been analyzed using technological studies and some of the axes heads from cached deposits have been interpreted as having been made by a single artisan or group of artisans working for or near the centralized power of Cahokia (Pauketat and Alt 2004). The production of axe-heads made of St. Francois materials was eventually replaced by the manufacture of large spatulate celts made from chert and igneous stone by the end of the twelfth century (Kelly 2010:210).

Previous Research on Axe-Heads from the Confluence Region

Due to the American Bottom's close proximity to the St. Francois Mountains, and because of the frequency in which tools made of St. Francois stone are found at American Bottom sites, all previous studies of St. Francois tools have had an American Bottom centered approach. It should be noted that all of the researchers summarized here treat axe-heads from the St. Francois as a group, regardless of visual identifiers that distinguish them. My study complements their research by attempting to determine specific sources of raw material within the St. Francois Mountains.

American Bottom Cache Deposits

Pauketat and Alt (2004) examined a series of American Bottom caches, including the Grossman cache. In AD 1050, Cahokia converted from a small village to a large planned center through a rapid population nucleation. This region-wide resettlement of farmers resulted in the founding of upland villages which show evidence for cultural pluralism. During this settlement at Cahokia, the Grossman village was founded approximately 17 km east south east of Cahokia. Excavations uncovered over 100 buildings at Grossman, including evidence of several large public structures, unusual burial treatments, a miniature charnel house, and four suspected temple pits with exotic material refuse (Pauketat and Alt 2004:780).

The Grossman axe-head cache was found outside of a residential house, approximately 8 meters north of large public building. The cache feature measured one meter in diameter and contained seventy celts closely packed and covered in sterile fill (Pauketat and Alt 2004:781). The burial of these seventy celts probably dates to the first three decades of Grossman's fifty to seventy-five year occupation (Pauketat and Alt 2004:780). The researchers analyzed each axe for technological style and morphological characteristics. Based upon macroscopic characteristics, they linked these axes to the basalt, diabase, and gabbro rock outcrops of the St. Francois region. From this study, they developed a scenario involving social memory, cultural identity, and landscape studies. They conclude the Grossman cache was part of a series of production and distribution practices and commemorative rituals that helped to create a more centralized Cahokian polity.

The Grossman cache is the second largest of sixteen large axe-head caches that have been found in the American Bottom. Each of these caches seems to date to early Cahokia between AD 1050 and 1150 (the Lohmann to early Sterling Phase). These other American Bottom caches include 100 axes from Kunnemann tract excavated in 1900, fifty axe-heads from the Lohmann site, and thirty axes and six chipped stone hoe blades from a cache from an unknown site. In addition to these large caches, there are several smaller caches from the East St. Louis site, each of which contained a dozen or fewer axes and some of which were buried with chipped stone hoes (Pauketat and Alt 2004:781).

For this study, Pauketat and Alt examined the seventy Grossman axes, three axes from Cahokia's Kunnemann tract, thirty-eight axes from Cahokia's Lohmann tract, and twenty-one axes from other Cahokia area caches. They conclude that all axes were made using rock that can be macroscopically sourced to the St. Francois

Mountains based upon distinctive morphological characteristics such as “high olivine content, characteristic plagioclase phenocrysts, and angular iron stained surfaces” (Pauketat and Alt 2004:783).

The St. Francois Mountains are located 100 to 300 km south west of Cahokia, and it is known that Cahokians visited the St. Francois region from studies on other Ozarkian resources, such as Burlington chert, galena, and flint clay (Emerson and Hughes 2000). Pauketat and Alt did not do a mineralogical or geochemical study for this analysis, but note that the exposed rock in the St. Francois dikes are different in appearance from the igneous cobbles with variably weathered exteriors that are commonly found in the Pleistocene age glacial tills around Cahokia region (Pauketat and Alt 2004:783).

Using visual characteristics in the lithic material, the researchers recognized what seem to be at least twelve varieties of St. Francois rock represented in the Grossman cache. It is suspected that each rock type represents a separate dike within the St. Francois Mountain range. Each rock type is thought to originate from the same Precambrian volcanic episode; with structural differences (basalt, diabase, gabbro) caused by geological conditions of cooling (Pauketat and Alt 2004:783).

Pauketat and Alt found the axes of the Grossman cache to be more fully finished than the axes found in other Cahokia area caches. These other caches consist mostly of unfinished or hypertrophic axes heads. The seventy Grossman axes range from partially unfinished to finished, with fourteen showing some use wear, and one-third of the cache looking incomplete. Statistical analysis indicates a 12-cluster pattern ranging from clusters of one axe to fourteen axes; these clusters are based on morphology, technological style, raw material, and spatial placement within the cache pit. Pauketat and Alt conclude that the axe-heads were purposefully deposited as distinct groups in the pit, and suspect that technological and visual differences indicate different axe-head makers or communities of makers (Pauketat and Alt 2004:784).

They hypothesize that either the person(s) burying the axes recognized patterns in the axe-heads during burial; or, that the owner(s) or maker(s) of the axes helped to bury the axes together in a community ceremony. They hypothesize that the “axe-head styles signify specific individuals, collective bodies, or cultural identities” (Pauketat and Alt 2004:790). The theory is corroborated by other Cahokia finds: at Mound 72, a deposit of arrowheads was found to cluster around material type and typology. At other Cahokian region sites, eight instances of pairs of axes have been found left behind at abandoned Mississippian houses. Pauketat and Alt see these pairs of axe-heads as being “retained by domestic groups, highlighting the potential significance of the Grossman cache’s clusters of two or more axes” (Pauketat and Alt 2004:790).

Pauketat and Alt suspect that some of the Grossman cache axes were made locally. Around 100 small percussion flakes were found at the completely excavated Grossman site, probably from the manufacture of a single axe-head (Pauketat and Alt 2004:791). They note that there is not enough manufacturing evidence for production of seventy axe-heads, contrasting with evidence found at sites from the later Lohmann phase, where axe-head production was more intensive, as seen in production debitage quantities from Tract 15a and sub-Mound 51 pit (Pauketat and Alt 2004:792).

Indirect evidence for centralized axe-head production can be found when examining one of the morphologically distinct types of basalt, a type that Pauketat names “snowflake basalt.” This distinctive type appears in at least three or four caches around the Cahokia area, and Pauketat and Alt suspect that “it is plausible that the snowflake axe-head variety represents a single axe-head maker or a small, localized community of axe-head makers closely tied to the centralized production-and-distribution economy associated with Cahokia” (Pauketat and Alt 2004:792).

In conclusion, Pauketat and Alt deem it significant that people in the American Bottom region avoided glacial till in favor of a restricted exotic source. They suspect that the Bauman site near the St. Francois Mountains may have been an area where community specialists completed primary reduction, but actual axe-head production occurred at Cahokia, far from the source. They theorize that an axe-head making industry existed in late eleventh century; Cahokian people managed and distributed raw material to make axe-heads at and around Cahokia. Overall, Pauketat and Alt describe the caching of axes as part of a chain of creative practices; they assume that the economy of ground stone axes made of a St. Francois source was controlled by Cahokia.

<u>Desloge Study Area, St. Francois Mountains</u>

Koldehoff and Wilson (2010) summarized data from collections and sites in and near the St. Francois Mountains, but again from the perspective of the American Bottom. They link the Mississippian economy that surrounds galena with that of the extraction of lithic resources from the St. Francois Mountains. They conclude that the Mississippians living and quarrying in the St. Francois region carried out at least the initial stages of celt manufacturing on site and were probably part of the Cahokia polity.

Koldehoff and Wilson research the locations and process that were involved in axe-head raw material selection, extraction, and reduction during the Mississippian period in the St Francois area.

The authors analyzed celts from the Foshee collection; this collection includes 40 ground stone celts that were mostly production failures and rejects. They were all collected within the Desloge Study Area— a 10 km radius around Desloge, Missouri- where the Foshee family surface collected artifacts between 1930 and 1990 (Koldehoff and Wilson 2010:218).

The Desloge Study Area is in the St. Francois Mountains, in the Southeast Missouri Lead District. Walthall (1981) proved that Native Americans mined for galena in this region from the Late Archaic through the Mississippian period. Because this area is only 70 km from Cahokia, Walthall surmised that "Cahokia was a major export center for galena" (Walthall 1981:42). While no galena extraction sites or related settlements have been discovered, there are areas of possible association within the St. Francois Mountains. One such site is the Dorsey site (23Sf127), thought to be associated with galena extraction because of the large amount of galena found during excavation there (Koldehoff and Wilson 2010:218).

Koldehoff and Wilson attempt to associate the previous galena studies to the extraction of mafic igneous rock within the same region. However, basalt dike outcrops are harder to find than rhyolite or granite due to the fact that basalt weathers more quickly than the surrounding rocks (Koldehoff and Wilson:220; Tolman and Robertson 1969). The authors note that all of the celts from the Foshee collection look similar to St. Francois basalt, diabase, and gabbro. This is because the artifacts have distinctive features such as the presence of a reddish-yellow or brown oxidized rind, distinctive tiny white phenocrysts, and darker freshly broken surfaces when compared to weathered surfaces (Koldehoff and Wilson 2010:220).

Koldehoff and Wilson (2010:221) observe that Mississippians would have been able to gather glacial till cobbles from nearby streams for celt making, but evidence from the Foshee collection shows that all celts have a soft, unweathered cortex unlike that seen in the cobbles found in stream beds. Also, after testing the area, the authors found no basaltic cobbles in the gravel bars of Big River or other streamways around the study area. This may be because the Big River flows north and the nearest mafic igneous rock exposures are on the St. Francis River, which flows south. Koldehoff and Wilson thereby “suspect that the St. Francis headwaters were the scene of prehistoric extractive activities and the source of the fine-grained diabase used to make the celts in the Foshee Collection” (Koldehoff and Wilson 2010:221).

The Foshee collection includes over 600 prehistoric artifacts, including 40 suspected Mississippian celts. Using data from the projectile points, the Big River Valley was probably occupied most intensively during Late Archaic (55% of the Foshee collections’ projectile points come from this period). There are very few Mississippian artifacts in the Foshee collection, only one Madison point and three pottery sherds date to this period. The 40 celts in the collection are believed to be Mississippian based on a size comparison to Late Woodland celts from other collections. Over 73% of the celts in the Foshee collection were either broken or discarded during manufacture. Koldehoff and Wilson suspect that historically all of the celts were probably collected from one area (possibly a specialized celt production site), but the Foshee family kept no records of where artifacts were collected (2010:222-225).

The fact that the majority of the celts are broken is interesting, as this fact may help in understanding the political economy of ground stone tool production in the region. The authors state that “if celts were being made more for nonlocal (export) than for local use, like hoe blades were made at Mill Creek Quarry (Cobb 2000), we would expect to see more unfinished celts than finished celts. This, in fact, is the case—for every finished celt there are 2.6 unfinished celts” (Koldehoff and Wilson 2010:224-225). These data contrast with the Archaic component of the collection—only four of the twenty-four Archaic axes are unfinished. The Foshee Collection also contains 20 hammerstones. Through experimental archaeology, Larry Kinsella (1993) has proved that these tools are well-suited to the labor-intensive pecking process that is required to shape ground stone tools (Koldehoff and Wilson 2010:225).

All forty celts were analyzed based on the process of celt production and consumption, including use, maintenance, and recycling (Koldehoff and Wilson 2010:225). The celts were first separated into two groups based on shape: there were found to be twenty five utilitarian celts (shaped broad and rectangular), and five ceremonial celts (spatulate form, with a narrow stem and flaring bit).

The celts were then analyzed (Koldehoff and Wilson 2010:225-233) for production stage (Stage I-V). Eleven celt blanks represented Stage I of manufacturing, which is the process of extracting celt blanks. Stage I has nine utilitarian celts and two ceremonial celts that failed during this process. Stage II represents pecked celt blanks (15 utilitarian and one ceremonial). One of the celts was a production reject while the other fifteen were production failures. Stage III is represented by two ground and polished celt blanks (1 utilitarian, 1 ceremonial). The point of breakage of the utilitarian celt is unknown, but the ceremonial celt was broken during plowing. Due to nature of manufacture, and the low amount of force required to grind the object, few celts should break at this stage. Koldehoff and Wilson suspect that most celts at this stage were then exported, only some were fully finished and used locally. This is supported by the fact that only two celts represent Stage IV of manufacture. These two finished celts are atypical as both were expediently made from spalls. Stage V is represented by nine finished broken and recycled celts (eight utilitarian and one ceremonial). Interestingly, one of these celts may have been in the process of being shaped into a discoidal, a practice the authors had not previously seen (Koldehoff and Wilson 2010:233).

Koldehoff and Wilson conclude with a summary of celt manufacturing sequence. They theorize that celt blanks were obtained by prying or breaking tabular pieces from boulders or the bedrock using hammerstones and significant force. The spalls would be rejected if too thin (there are six examples of this happening in the Foshee collection). They conclude that in this region, fire was not used to generate spalls. They suspect that extra-large celts were probably extracted from jointed or frost fractured bedrock outcrops and not fallen boulders. The process of celt-making requires substantial flaking, pecking, and grinding to convert block preforms into finished celts and they suspect that this labor investment is why there are so many unfinished celts found in Cahokia area caches. They hypothesize that the acquisition and distribution of celts was likely controlled by elites, who may have controlled labor necessary to peck and grind them into finished celts (Koldehoff and Wilson 2010:233-236).

Due to the nature of manufacture, the pecking and grinding needed to finalize the celt-making process does not have to be completed at or near quarries. The finishing methods are a less technically demanding skill than celt-blank acquisition and initial shaping, which requires an expertise in facture mechanics. The acquisition and initial shaping processes also involve a much greater risk of failure due to the amount of force used. The authors note that this process is very unlike the processes seen during chipped stone hoe manufacture; the making of chipped stone tools requires skill and expertise throughout the entire manufacturing process. Therefore, the authors feel that Mississippian celt producers may have segmented celt production into two general stages: the celt blank acquisition/initial shaping stage; and the celt blank final shaping/polishing stage (Koldehoff and Wilson 2010:233-236).

The authors also summarized findings from archaeological investigations from the Big River Valley. Archaeology along the Big River is unlike that found along other Ozark rivers, as it has a higher density of Mississippian sites and all of these sites have a ceramic style similar to that found at Cahokia and the American Bottom. Wettstead (2000) questions whether agriculture was of major importance in this valley as there is less prime farmland in the Big River Valley than other Ozark river valleys. Koldehoff and Wilson also question this assumption and suggest that this river valley is being populated not because of agricultural potential but because of its proximity to rich lithic resources. Koldehoff and Wilson conclude that the Big River was “almost certainly” a major artery that linked the lithic resources of the Ozarks with the large Mississippian population centers in the American Bottom via the Meramec and Mississippi rivers. Along with igneous stone, the Big River may have served as a pathway for salt and

Burlington Chert from the Crescent Quarry area downstream (Koldehoff and Wilson 2010:239).

In addition to the similarity of ceramic style in the Big River Valley to that of the American Bottom, there is other evidence that the Mississippians probably floated galena and celt blanks down Big River toward the American Bottom region. A large igneous rock boulder weighing 225 kg, as well as an unfinished celt, were discovered near the town of Fenton on the Meramec River in 1949. This boulder could not have been the result of glacial ice movement as it is too far south so it must be the result of intentional transport (Koldehoff and Wilson 2010:239-240).

In summary, this article is one of the first to fit the sites along the Big River into a lithic extraction framework. Given the similarity of ceramics in the Big River to those in the American Bottom, Koldehoff and Wilson conclude that the Big River was part of the Cahokia polity, and "control over these resources must have been critical to the Cahokian economy" (Koldehoff and Wilson 2010:243). Overall, the forty celts in the Foshee collection were largely production rejects or failures. When divided into five stages of celt production, most failed in the first two stages: acquisition and initial shaping of the blanks, when the application of force was high. Koldehoff and Wilson conclude that the final stages of pecking and polishing did not have to be done at or near the lithic source, and when compared to chipped stone hoe-blade production, ground stone tool production is more time consuming and labor intensive, but hoe-blade production is more technically demanding (with a greater chance of failure throughout entire process).

pXRF Analysis of American Bottom Ground Stone Tools

Amanda Butler presented a paper at the 2011 Midwest Archaeological Conference on the preliminary results of a detailed pXRF study on American Bottom axe-heads. Her study conclusively proves the connection between St. Francois basalt, diabase, and gabbro sources and many of the ground stone tools found in the American Bottom and surrounding regions. Her results methodically proved Pauketat and Alt's (2004) and Koldehoff and Wilson's (2010) theories that the axe-heads in the Grossman cache (as well as other American Bottom region caches) were made of St. Francois Mountain material. She interpreted these results using landscape studies and animist theory. She postulates that early Mississippian ground stone tool production was part of a larger community-building process.

Butler examined over 400 samples using pXRF. Three hundred of the samples came from twenty-five Mississippian sites; the majority of axe-heads came from the American Bottom, but some came from Missouri and Central Illinois. Eighty samples were from geologic sources, 76 from the St. Francois Mountains, and five from the Great Lakes. The Great Lakes samples were chosen to represent the majority of the glacial till found in the American Bottom region, as it was displaced by glacial ice during the Illinois glacial episode.

Butler used the semi-quantitative data (Fe, Sr, Rb, Y, Nb, and Zr) produced by the pXRF study to conclude that nearly 99 percent of the cached celts match the elemental data of geologic samples from the St. Francois Mountains, proving that cached Mississippian celts from the American Bottom, as well as individual celts from Central Illinois and Missouri, were being made of igneous rock procured in the St. Francois Mountains. She suggests that glacial tills were not used “as it was important to tap the deep meaningful and sociopolitical relationships with place and landscape through raw material” (A. Butler 2011:9).

Evidence for Ground Stone Tool Production in the Confluence Region

One of the main questions this thesis addresses is: who is making the axe-heads found throughout the Confluence Region? Cobb’s political economy model of Mill Creek chert found that production of Mill Creek hoes was done by local residents at or near the Mill Creek quarry. Unfortunately, the picture here is not so clear. Abundant evidence of axe-head production is found in the heavily studied American Bottom region in the form of debitage, axe-head blanks, and axe-head production failures. Scant evidence of production comes from the insufficiently studied St. Francois region, where this material is being quarried. Additionally, there is no evidence of ground stone tool production in the excavation data of sites elsewhere in the Confluence Region. Presented here is a summary of the evidence of ground stone tool production in the American Bottom and St. Francois regions.

American Bottom

Evidence for the production of axe-heads is well documented at Mississippian sites in the American Bottom. Excavations have uncovered caches of igneous raw material and unfinished large celts (Esarey and Pauketat 1992:27-34, 123, 157-158; Kelly 1994; Pauketat 1993:7, 1997:6-8; Rau 1869) and manufacturing debris (Esarey and Pauketat 1992:123; Pauketat 1994:158-159; 1997; 1998:275-294). Here I provide an overview of the evidence for ground stone tool production in the American Bottom, but this summary is by no means exhaustive.

Within the Cahokia site boundaries, Moorehead collected ground-stone debitage, axe fragments, and hammerstones in an area to west of the Twin mounds. This may be indicative of a production area (Kelly 2006:251). Knapping debris and two large basalt blocks have been discovered the Fingerhut tract (Kelly 2006:251). Lohmann-phase excavations at Cahokia's Tract 15A and sub-mound 51 pits contain evidence for intensive axe-head production, such as broken unfinished axe-heads and production debitage (Pauketat 1998, Pauketat and Alt 2004:791). In addition to this, one large, unmodified, columnar block of basalt was found on Cahokia's Powell Tract (Pauketat and Alt 2004:784)

Many other indications of ground stone production have been found at American Bottom sites outside of Cahokia proper. Two other large, unmodified, columnar blocks of basalt were found at 11S62, a small site several kilometers to the south of Cahokia (Pauketat and Alt 2004:784). A pit containing what were probably basalt blocks was found by Rau (1869) in the East St. Louis Mound Groups during street construction (Kelly 2006:251). Subsequent work at the East St Louis site has produced knapping debris and large basalt blocks (Kelly 2006:251).

Excavations at the Hamel site, six kilometers north of the Pulcher mound center, yielded two large broken pieces of basalt (Kelly 1996:251). Excavations at a site 30 km south of Cahokia uncovered a Sterling-phase urn cremation that contained one very large unfinished axe-head in context with a cache of two other axes (Brouk 1978).

Production debris has been found at several small sites around Horseshoe Lake (Pauketat 1998, Pauketat and Alt 2004:784) and minimal evidence (around 100 debitage flakes) has been found at the Grossman site (Pauketat and Alt 2004:784). Four kilometers southwest of the Grossman site, at the Lehmann-Sommers site, three axe-heads were recovered from the surface. One of these axes is an identical match to the snowflake basalt described by Pauketat and Alt (2004). Other axe-heads and production debris were recovered during the excavation of this site (Kelly 2006:252).

Black Bottom

Excavation data from SIUC's continued exploration of the Kincaid site and Muller's 1970's Black Bottom Survey (Muller 1986; Pursell and Butler 2008, 2012; Brennan 2009, 2011; Welch 2013; Welch and Butler 2005) have produced no substantial evidence of ground stone tool production of axe-heads.

Upland Shawnee Hills

Excavation data from Upland Shawnee Hill sites, such as Millstone Bluff, Great Salt Spring, Dillow's Ridge, and Hayes Creek, have also produced no substantial evidence of axe-head production.

St. Francois Mountains

There is currently limited evidence of ground stone tool production within the St. Francois region. This may well be due to the limited survey and excavation that has taken place in this mountainous, heavily wooded, rural region. What excavation that has taken place in the St. Francois is almost strictly limited to salvage excavation, which by nature encounters its own limitations (such as budget and time constraints). Nevertheless, some archaeological data do point to the production of ground stone tools in this region (Weisman et al. 2008).

Already mentioned is the celt manufacturing debitage discovered during Missouri DOT excavations. Limited evidence (3 flakes) comes from site 23Sg4. A large amount of manufacturing debris came from Wiegenstein Site #2 (23Mo1252) in the form of basalt debitage, rejected celt blanks, broken unfinished axe-heads, and axe-head fragments. This site has been tentatively dated to 1050-1200AD based upon the diagnostic celts and lithics found at the site. Weisman et al. (2008:42) suspect the Wiegenstein Site #2 to be a habitation and workshop site that was occupied in the fall or winter months. Due to the fact that the excavations were limited, the level of craft production at the site cannot yet be determined.

There is also evidence of celt manufacturing at sites located along river-ways that connect the St. Francois Mountains and the American Bottom. There are indications that large celt blocks were floated north along the Big River. In the late 1940's, two sites located on differing sides of the Meramec River, near Fenton, Missouri, produced evidence of this transport. One site produced a huge igneous boulder (it was estimated to weigh over 225 kg) and the adjacent site contained an unpolished axe celt in a Mississippian archaeological context (Koldehoff and Wilson

2010:239-240; Mills 1949:9). Both were made of a visually similar material (likely diabase) and it is assumed the only way the boulder could have been transported so far north of the outcrop was via human agency (Koldehoff and Wilson 2010:240).

Evidence for production has also been found at sites located slightly south of the American Bottom, near the town of Ste. Genevieve. Surface collections from the Bauman site, situated where the River Aux Vases enters the Mississippi River, contains several finished and unfinished basalt celts, woodworking tools, and basalt debitage, as well as early-Stirling phase pottery and a large cache of galena (Koldehoff and Wilson 2010:241; Pauketat and Alt 2004:784; Voigt 1985). Nearby, basaltic debitage, and finished and unfinished igneous celts were found at the mound-and-town complex of the Common Field site near St. Genevieve (23StG100) (Koldehoff and Wilson 2010:241; Trader 1992). There is also evidence of minimal axe-head production at the Powers Phase sites of Turner and Snodgrass (Gilliland and O’Brien 2001:259-262).

Table 1- Comparison of Mississippian period growth, climax, and decline phases the Cahokia and Kincaid polities. (See: Butler 1991; Clay 1997; Muller 1986; Pauketat and Emerson 1997:Fig. 1.3; and Schroeder 2009).

Cahokia	**Kincaid**
Loyd, Merrell, Edelhardt Phases A.D. 900 to 1050 *(Rapid Growth)*	Jonathan Creek Phase A.D. 1000 to ca. 1150 *(Growth)*
Lohmann Phase A.D. 1050 to 1100 *(Development)*	
Stirling Phase A.D. 1100 to 1200 *(Climax)*	Angelly Phase ca. A.D. 1150 to 1300 *(Climax)*
Moorehead Phase A.D. 1200 to 1275 *(Decline)*	
Sand Prairie Phase A.D. 1275 to 1350 *(Sparse Use)*	Tinsley Hill Phase A.D. 1300 to 1450 *(Decline)*
Bold Counselor Oneota Phase AD 1350 to 1400 *(Sparse Reoccupation)*	

Figure 2- Distribution of sites in the Black Bottom (adapted from Butler 1971:221). The cluster of sites where collector Mark Benson probably gathered three of the celts under study (called the "West of Long Lake Site" by locals) is circled in blue.

CHAPTER IV

GEOLOGY, ANALYTICAL METHODS, AND SAMPLES

This chapter introduces the geology of the St. Francois Mountains. This is relevant to the geochemical studies that are also introduced in this chapter. Lastly, I discuss the geologic origins or archaeological contexts of the samples under study.

Geology of St. Francois Mountains

Geologic samples for this study were collected from the St. Francois Mountains region of southeastern Missouri; Amanda Butler (2011) confirmed that the St. Francois Mountains are the source for the lithic raw material of many Mississippian axe-heads found in the American Bottom. The general geological characteristics of this region are therefore relevant to the results and interpretations of this study.

The St. Francois Mountains cover 8,500 square kilometers with nearly 560 square kilometers of actual exposed outcrop (Tolman and Robertson 1969). The mountain range is centered in the St. Francois, Iron, Reynolds, and Madison counties of Missouri. As a portion of the Missouri Ozark mountain range, the St. Francois Mountains are comprised of igneous rocks; they are part of an anorogoenic terrain that extends from Oklahoma to Ohio that only surfaces in the St. Francois Mountains of

Missouri and a few square kilometers in Oklahoma (Bickford and Mose 1975:537). The mountains are the result of 1.48 billion year old volcanic lava plateaus and plutons that were later rifted with basaltic dike emplacement at about 1.1 billion years (Tolman and Robertson 1969). In the northeastern portion of the St. Francois Mountains, granitic rocks are the dominant lithology, whereas rhyolites are much more abundant in the southwest (Sides et al. 1981).

The mafic rocks of the St. Francois region are of primary interest for this study. Mafic rocks are dense, dark colored rocks high in magnesium and iron. Types of mafic rocks commonly found in the St., Francois region include basalt (an extrusive, fine-grained rock), diabase (a subvolcanic, medium grained rock), and gabbro (a plutonic, coarse grained rock). The primary minerals of the mafic rocks of the St. Francois studied here are olivine, clinopyroxene, and plagioclase (Walker et al. 2002:255).

The mafic rocks of the St. Francois Mountains are divided into two contrasting suites based on variable geologic, mineralogical, and chemical characteristics: (1) the Silver Mines suite; and (2) the Skrainka suite (Walker et al. 2002:256). The Silver Mines suite “includes basaltic lava flows and dikes, while the Skrainka suite is entirely plutonic, consisting of fine-grained dikes and coarser, gabbroic intrusions” (Walker et al. 2002:255). In addition, the Silver Mines rocks lack olivine, a mineral common in Skrainka rocks (Walker et al. 2002:256). Chemically, the Silver Mines rocks have generally higher SiO_2 wt% contents and show calc-alkaline affinities, whereas the Skrainka rocks are more basic and tholeiitic. The two groups are also characterized by different incompatible element ratios, such as La/Sm, Zr/Y and La/Hf (Walker et al. 2002:256).

Skrainka Diabase

Skrainka outcrops are found within the felsite and granite batholiths of Precambrian era exposures that occur in the east-central part of the St. Francois Mountains in Madison County, MO (Tolman and Robertson 1969). It is a diabase that is visually unique from the rest of the igneous rocks in the St. Francois (Figure 3) area due to its greenish or dark-bluish grey color, medium- to fine- grain texture, and large phenocryst inclusions of feldspar that range from 2 to 5 mm long (Tolman and Robertson 1969) (Figures 3 and 4). Previous petrographic studies of Skrainka diabase samples (Tolman and Robertson 1969:54) have shown the material to be comprised mainly of labradorite (65%), along with augite, pigeonite, olivine, magnetite, brown biotite, apatite, and pyrite.

Outcrops of Skrainka diabase have been located in Madison and Wayne counties; outcrops that occur in stream cuts or steep terrain are easy to access. These outcrops that are easily accessible are possibly not the ones utilized by Mississippians. Unfortunately historic and modern quarrying of Skrainka for paving blocks may have erased any evidence for prehistoric quarrying activities (Denham 1934, Mercantile n.d.).

Silver Mine Area Basalt

Two samples of basalt (Figure 5) were taken from the “Big Dike” (Kisvarsanyi and Hebrank 1985:165-166) that intrudes the Silvermine granite batholith at the dam about one half mile north of Roselle and south of Highway 72 along the St. Francis River (Tolman and Robertson 1969:47). The basalt dike is about 1.2 m wide with a N 65^{o} E strike; this narrow dike has a coarser grained interior and chilled margins.

Kisvarsanyi and Hebrank (1985:166) reported that this dike contain "a few small plagioclase phenocrysts in groundmass of andesine and augite with intergranular texture." Other minerals in the groundmass are euhedral magnetite, pyrite, and a small amount of intersitial quartz.

Other St. Francois Outcroppings

Pauketat and Alt (2004:783) visually identify twelve recognizable varieties of intrusive rocks from the St. Francois Mountains in the Grossman cache, which they suspect represents materials from separate dike formations. These rocks range in color and texture from "bluish basalt, fine grained diabase, and gabbro to distinctive greenish basalt with phenocrysts" and many "exhibit telltale iron coated or weathered surfaces" (2004:783). The geologic formations listed here are not meant to be exhaustive and a comprehensive study of St. Francois outcroppings and artifact lithic material sources is beyond the scope of this study. Listed here are different geologic materials suspected to be of St. Francois in origin that are recognized in the collection under study.

Snowflake Basalt. Pauketat and Alt (2004) have recognized one distinct variety of axe-head raw materials as a commonly used material in American Bottom axe-heads. It is easily recognizable by its distinctive blurry white phenocrysts and they call this material "snowflake basalt". They note specifically that some of the axes are made of a "greenish basalt with snowflake-like phenocrysts" (2004:783) that "may represent a single axe-head maker or a small, localized community of axe-head makers" (2004:792). The lithic material of these axe-heads looks very unlike the Skrainka diabase geologic samples and the other axe-heads I examined. The green matrix is a much paler, muted shade of green-grey. The “snowflake” phenocrysts are widely distributed, large (~1.5 cm), round, blurry white spots with indistinct margins. Although these phenocrysts are very unlike the sharp, needle-like phenocrysts of the Skrainka outcrop, one of the research questions of this thesis is to test if axes the snowflake ground stone tools can be sourced to the Skrainka outcropping.

Rhyolite. Rhyolite has a composition similar to granite but has a much smaller grain size. It is composed of the light-colored silicates and is aphanitic in texture. It frequently contains voids and glassy fragments, evidence of having erupted in a surface environment with rapid cooling. In the St. Francois Mountains, rhyolites are the dominant lithology outcropping in the southwestern region (Sides et al. 1981) and are found in archaeological contexts at sites in the St. Francois region. For this study, samples of rhyolite come from the Wiegenstein site #2.

Potential Non-St. Francois Lithic Sources

Discussed here are two potential non-St. Francois sources of raw lithic material for ground stone tool production are found outside of the St. Francois Mountains:. glacial till and greenstone.

Glacial Till

Glacial till is a heterogeneous mixture of unsorted or stratified material deposited beneath and within glacial ice. Although most glacial deposits in Illinois consist of sand, silt, and gravel, certain members do contain large clasts of resistant rocks, including basalts. Stones from glacial till were used throughout the Woodland Period to make axe-heads in the American Bottom region, and potentially could have been used by the Mississippians (see my previous discussion of Koldehoff and Wilson's [2010] summary of the history of axe-head making).

Glacial till deposits in the Mississippi River Valley date to the Illinois Episode around 200,000 to 130,000 years B.P. (Devera 2003). Any basalt material recovered from the till would ostensibly have originated from the Great Lakes region, or farther north. A previous study (A. Butler 2011) compared the geochemistry of the St. Francois Mountains igneous stone with samples from the Great Lakes and concluded that the two groups are very similar geochemically but can be differentiated using pXRF (A. Butler 2011).

Greenstone

Greenstone objects are found throughout the Mississippian region, including several artifacts from the Black Bottom and American Bottom collections. The term greenstone is used in two primary ways. Geologists use the term greenstone to describe low-grade metamorphism of mafic and ultramafic igneous rock (Gall and Steponaitis 2001:99). When used as an archaeological descriptor, greenstone often refers to a green-colored schist, usually a chlorite or epidote schist, used to make axe-heads. However, greenstone is often (incorrectly) used to describe any hard, greenish rock found in an archaeological context. For example, Dunning (1960) lists the following characteristics of archaeological greenstone: it is green in color and easily ground or pecked into shape in order to yield a serviceable tool that holds its shape and polish (Dunning 1960, Gall and Steponaitis 2001:99). Here, I use the term greenstone to denote material coming from the Hillabee Metavolcanic Complex outcroppings near Moundville, Alabama (Gall and Steponaitis 2001).

In a study of greenstone tools at the Moundville site in Tuscaloosa, Alabama, Gall and Steponaitis (2001) identified three sources of greenstone with 500 km of Moundville. These outcrops include (1) the Hillabee Metavolcanic Complex of the Northern Piedmont of Alabama, (2) the Talladega Group of the same region, and (3) amphibolite-facies of the Inner and Southern Piedmont of Alabama (2001:100). A geochemical and petrographic study concluded that the Moundville inhabitants exploited the Hillabee Metavolcanic Complex (Gall and Steponaitis 2001:112). The average elemental composition of the Hillabee greenstones are basaltic in composition (with SiO_2 contents between 45%-52% weight percent) with low sodium, potassium, and aluminum contents (Gall and Steponaitis 2001:105). Greenstone may also out crop in isolated, long narrow outcrops of the Piedmont province (Gall and Steponaitis 2001:100) and in the Appalachian Mountains, and may be found in gravel deposits of the Tennessee River along with quartzite cobbles

Greenstone from the Hillabee schist outcrop was frequently used to make axe-heads and other ground stone objects, some of which were traded across the entire Mississippian sphere (Gall and Steponaitis 2001). The geologic origins of greenstone are relevant to this study because a schistose axe-head has been found in a house basin context at the Kincaid site (Pursell and Butler 2011). This axe is made of a lithic material visually identical to objects sourced to the Hillabee Metavolcanic Complex; it is suspected to have geologic origins in Alabama.

Analytical Methods

This project has two geochemical components: a non-destructive elemental analysis using portable X-Ray Florescence (pXRF) and a semi-destructive supplemental study using a scanning electron microscope with electron dispersive spectrometry (SEM-EDS) for elemental data. All of the samples under study here (n=59) were analyzed using pXRF; only a small amount of the samples (n=10) were able to be analyzed using SEM-EDS due to the destructive nature of sample preparation.

Objects in this study sample that could be modified include all of the geologic samples, three partial celts from collector Mark Benson, and two samples of production debitage from Wiegenstein Site #2, Missouri. These objects were made into polished thick sections for SEM analysis. Discussed here are the scientific principles behind pXRF and SEM-EDS.

Portable X-Ray Fluorescence

Portable X-ray fluorescence (pXRF) is a method that can determine the elemental data of a sample both qualitatively and quantitatively. It is a non-destructive tool that can produce fast results with minimal preparation of samples. pXRF provides a high-precision, multi-element mass analysis of a sample (Bruker 2009, Shackley 1998) and because of this capability, it is used fairly often for the elemental analysis of archaeological and museum objects (Beckhoff et al. 2006).

The main benefit of pXRF is that the instrument is non-destructive; the sample being tested is not affected in any visible way. The majority of the archaeological objects tested in this study cannot be altered in any manner. Other, more reliably quantifiable methods, such as ICP (Inductively Coupled Plasma) or NAA (Neutron Activation Analysis) are destructive by nature and therefore inappropriate for this study (Wirth and Barth 2009).

By analyzing basalt, diabase, and gabbro samples from the St. Francois, and by comparing them with archaeological samples also potentially from this region, I hope to create a dataset of lithic geochemistry that will help researchers to better understand the political economy of the Confluence Region. Every geochemical analysis must comply with Weigand et al.'s (1977) *provenance postulate*: "that there exist differences in chemical composition between different natural sources that exceed, in some recognizable way, the differences observed within any given source." Neff (2000) set forth a set of steps that states that if sources are easily identified (such as the visually distinct mafic outcrops of the St. Francois), then analysis of samples can create a series of statistically characterized reference groups. The geologic samples I analyze in this study meet these criteria.

The scientific principles behind pXRF are fairly straightforward. In non-technical terms, an X-ray tube is used to emit high-energy electrons in the form of x-rays, which are directed toward the sample. When the x-rays hit the sample they cause inner orbital electrons to move temporarily to outer orbitals, when these “excited” electrons decay back to inner orbitals they emit photons whose energy is different for different elements. A sensor in the pXRF instrument measures the energies of these photons, and software converts the amount of photons detected at each energy level to an estimate of the abundances of elements in the sample.

In more technical terms, there are a restricted number of ways in which this x-ray fluorescence can happen. The main transitions are an L→K transition (K_α), where an L shell electron fills a vacancy in the K shell. Other transitions include an M→K transition (K_β), an M→L transition (L_α), etc. Each of these transitions yields a fluorescent photon with a characteristic energy, E, equal to the difference in energy of the initial and final orbital. The wavelength of this fluorescent radiation can be calculated from Planck's Law ($n\lambda=h*c/E$), where n is an integer, lambda (λ) is the wavelength of the incident wave, h is Planck's constant, and c is the speed of light.

<u>XRF Configuration.</u> The instrument used for this study was provided by Zack Dismukes, K-Alpha representative for Bruker Instrumentals. This handheld XRF machine has a detector area of 30 mm^2 and can analyze to an average thickness of 500 µm. This allows for detailed analysis of bulk chemical abundances of major elements (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, P), as well as the abundances of trace elements (>1 ppm; Ba, Ce, Co, Cr, Cu, Ga, La, Nb, Ni, Rb, Sc, Sr, Rh, U, V, Y, Zr, Zn) (Wirth and Barth 2009). The trace element data will be important to this study. These trace element abundances are a result of mafic formation and deposition, and can act as a kind of geochemical “fingerprint.”

A Bruker Tracer IIISD handheld x-ray fluorescence (XRF) device was used. This device employs a rhodium target and a silicone drift detector. Measurement parameters included a voltage of 40 keV run at 30 μA for 180 seconds in dry air. A 12 mil Al/1 mil Ti/6 mil Cu filter was used to allow for more optimal detection limits from Thorium ($L\alpha 1$ = 12.96 keV) to Nb ($K\alpha 1$ = 16.61 keV). Two measurements were taken on each artifact for comparison. All objects were tested in one day, at the Cahokia Mounds Museum.

Data were analyzed using Bayesian Deconvolution using Spectra software 7.4.0.0. Bayesian deconvolution is a process in which background photons and inter elemental peak overlaps are corrected using simulations of the data. This produced a net photon count rate for each element (Appendix Table D).

Scanning Electron Microscope with Energy-Dispersive Spectrometer

A scanning electron microscope (SEM) analysis can provide high-quality imaging abilities, but can also provide a semi-quantitative elemental analysis when using an energy-dispersive spectrometer (EDS).

In scanning electron microscopy, an electron beam is scanned across the sample surface. When electrons strike the sample, a variety of signals are generated and can be detected as an image or as the sample's elemental composition. The three signals which provide the greatest amount of information in SEM are the secondary electrons, backscattered electrons, and X-rays. Secondary electrons are emitted from atoms that occupy the top surface; these produce a high resolution image. Backscattered electrons are primary beam electrons which are reflected from atoms in the specimen. Backscattered electrons provide contrast in the image, determined by the atomic number of the elements in the sample (Leute 1987:121).

Interaction of the primary beam with atoms in the sample causes shell transitions which result in the emission of an X-ray. The emitted X-ray has a specific energy signature that is characteristic of the parent element. Detection and measurement of the energy permits elemental analysis (Energy Dispersive X-ray Spectroscopy or EDS). EDS can provide rapid qualitative, or with adequate standards, semi-quantitative analysis of elemental composition with a sampling depth of 1-2 μm. X-rays may also be used to form maps or line profiles, showing the elemental distribution in a sample surface (Leute 1987:121). Ten samples (five geologic and five archaeological) were cut and polished into thick sections for a comparative SEM-EDS analysis. The elemental data from these samples are analyzed using simple bivariate plots and central tendency statistics in order to supplement the pXRF data.

SEM-EDS Configuration. All testing was completed by Graduate Research Assistants at the IMAGE facility of Southern Illinois University Carbondale. The instrument used for this study was a FEI Quanta FEG450 SEM with EDS capabilities; the SEM had gone through general preventive maintenance by a FEI specialist the week prior to testing.

An area scan of 1.3 mm^2 was completed on each polished sample for detailed bulk chemical analyses of major elements (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, P). The SEM-EDS software was set to also scan for a bulk chemical analysis of certain trace elements relevant to this study (La, Nb, Rb, Sr, Y, Zr, Sm, Hf).

Description and Location of Samples

In this section, I will describe in further detail the contexts of the individual samples under study were collected. I give the specific locations for each geologic sample, as well as the known provenience and archaeological context for each artifact.

Description of Geologic Samples

Amanda Butler (2011) analyzed seventy-four geologic samples from the St. Francois Mountains in order to prove that ground stone tools from the American Bottom have a St. Francois origin. My study has a more narrow focus, examining samples from two well-documented geologic formations within the St. Francois Mountains. This is in order to test the hypothesis that many of the axe-heads found in the Confluence Region were made from Skrainka diabase. This hypothesis is grounded in visual identification; the Skrainka diabase material is visually identical many of the axe-heads in this study.

All together, these samples represent five different outcrops, and two varieties of material (Silver Mine Area basalt and Skrainka diabase). Four of these comparative samples were provided by Russell Weisman of the MoDOT, and one sample was found by Dr. Welch (SIUC) and me.

Skrainka Diabase Samples. In March of 2012, Dr. Welch and I investigated an outcrop of Skrainka diabase at the intersection of Captains Creek and Highway O, southwest of Fredericktown, Missouri in the northern central portion of the Rock Pile Mountain 7.5-minute USGS quad. This outcrop was located on private property and, with permission of the owner, several samples were obtained from boulders in a creek bed that seemed to delineate the trend of the dike. Rock samples found here are visually similar to the description of the Skrainka diabase and were also similar to the Mississippian ground stone artifacts with the exception of phenocryst size. Phenocrysts in the Captains Creek Skrainka samples range from 3-6 mm long (Tolman and Robertson 1969), whereas the archaeological specimens have phenocrysts that are only 1-3 mm long.

Other Skrainka diabase samples were provided by Russell Weisman, Senior Historic Preservation Specialist, Missouri Department of Transportation. All samples are from outcrops found in Madison County, Missouri. One set of samples comes from an outcrop in a tributary of the St. Francis River, in the field archery range at the Millstream Gardens Conservation Area. Another comes from along State Route H northeast of Fredericktown. A third sample of weathered Skrainka diabase material comes from an access road on the eastern approach to the St. Francis River Bridge on State Route E in Madison County near Tin Mountain. This last sample has a distinctive weathered rind that is similar to that seen on celts.

<u>Silver Mine Area Basalt Samples</u>. This set of samples comes from the large and small dikes that intrude the Silvermine granite formation on the left bank of the St. Francis River at the dam near the Einstein Silver Mine of the Silver Mines Recreation Area, located in the Mark Twain National Forest. The Silver Mine Area basalt is typically much finer grained than material commonly used to make axe-heads, and is usually too brittle to be very useful for celt-making (Weisman, personal communication 2013). However, the center of the large dike at the mine dam is a possible exception,

as it is coarser grained material than the quenched margins of the dike. This material was included as a comparative sample to the Skrainka diabase, as it is found nearby Skrainka outcrops, and dikes of both the Silver Mine Area basalt and the Skrainka diabase cross-cut the Silvermine granite formation.

Description of Archaeological Samples

For this study, I chose to test axe-heads made of lithic materials that are visually similar to outcroppings of Skrainka diabase found in the St. Francois Mountains. Discussed here is the archaeological context for each sample (See Table 3 and Appendix Tables A and B for a detailed description of artifact provenience).

Kincaid Mx^{o}8 Axe. One specimen tested using pXRF from the Kincaid site was uncovered during the 2011 excavations. A large, complete, flaring-bit axe-head was found lying atop an anthropogenic white/tan clay layer (a floor) at the base of Mound 8 (Mx^{o}8) (Pursell and Butler 2012:8-9). The axe-head looks visually similar to materials coming from the St. Francois Mountains. Using this identification, Pursell and Butler state that this axe-head is one of the only known pieces of evidence connecting Kincaid to Cahokian elite, or alternatively to the craftspeople living in the Big River and/or Mississippi Valley (Pursell and Butler 2012:8).

Kincaid West Mound Axe Fragment. During the 2005 excavations of a structure on the West Mound at Kincaid, an axe fragment was found. The West Mound at Kincaid is a Mississippian platform mound with diagnostic ceramics that date the Middle Kincaid era.

The house basin was chosen as an area of investigation due to its prominence on the magnetometery image; it was the most conspicuous of up to 16 possible structural remnants on the south face of the West Mound. The axe fragment was located in the fill of an extracted post pit that probably served as the center structural post of the structure (Welch 2005). This sample was tested using pXRF.

Northwest Kincaid Axe. During the 2008 archaeological field school at Kincaid, an axe was found during the excavation of a series of overlapping occupational structures in the northwest area of the site. Topographically, this area of the site is a low rise and excavations were undertaken to ground-truth presence of a structure discovered using magnetometery. The axe-head was found in Level 4 of Feature 1, a house basin that cross-cuts at least one other structure (Pursell and Butler 2008). It was tested using pXRF.

Kincaid Mx^{V}1E Axes. Two samples from this area were tested using pXRF. In 2009, part of the field school excavations at Kincaid centered on a relatively flat area west of Mx^{O}8 and Mx^{O}9 (named Mx^{V}1E). Within this area is Feature 8, a domestic structure that has been heavily damaged by modern agricultural practices. A small, schistose celt was found in the fill of Feature 8. This celt is visually similar to Hillabee Schist greenstone materials. In the northern wall trench of Feature 8, a large, green igneous celt fragment was found (Brennan 2009).

Surface Collected Axes. In addition to axes collected during SIU's archaeological field schools at Kincaid, Black Bottom region collector Mark Benson has fragments of axe heads that were surface collected at a location near Kincaid, known locally to collectors as the "West of Long Lake Site" (Benson, personal communication 2012). It is unknown if this site has an IAS number, but Benson can identify the site as being one of a cluster of three sites identified during Muller's Black Bottom survey (Figure 2) (Butler 1977; Muller 1978). pXRF was performed on all of the axe-head fragments, and SEM-EDS was performed on three of the axe-heads.

American Bottom Archaeological Samples. Six axe-heads were tested (using pXRF) from the seventy that were present in the Grossman Cache. These six axe-heads were chosen because they were identified as "snowflake-type variety" by Pauketat and Alt (2004), being made of a distinctive greenish basalt with snowflake-like phenocrysts. Four of the celts have "narrow bits, rounded and ground polls, wide and thick midsections, and opposing tapered bit and poll ends" (Pauketat 2004:785).

Southern Illinois Upland Shawnee Hills Archaeological Samples. At Millstone Bluff, six axe-head or axe-head fragments were found, all of which were tested using pXRF. All of these axes are made of an unknown igneous material that looks dissimilar to the geologic samples of Skrainka diabase. Two of the axes made of an unidentified material were found in the same unit and level (TU 40, N233 E190, Level 2, W 1/2) on the floor of House Basin 16. A third axe was found in House Basin 18 (TU55 N237 E210, Feature 98). Two axe-fragments (a proximal and medial end) were found in Level

4 of Unit 18. One small axe was found in the first level of Unit 27. In addition, one axe fragment from Hayes Creek was sampled; it is made of an unknown material and was found during the excavation of Unit 13.

After performing the geochemical analyses, I found an undocumented Mississippian style axe-head fragment in the Great Salt Springs collection. It has no provenience other than “Survey,” and was in a bag with an Archaic projectile point fragment and thick shell tempered salt-pan fragments. Dr. Brian Butler (personal communication 2014) thinks it may have come from an eroding stream bank on the site. Although this axe-head was unable to be geochemically tested, it is visually identical to the Mx^{O}8 axe from Kincaid.

St. Francois Region Archaeological Samples. I analyzed axe-heads, axe-head fragments, and debitage from six sites in the St. Francois region. None of these sites were directly related with any prehistoric quarry location, as none are currently known. All of these materials came from salvage excavations and were supplied by Russell Weisman (MoDOT). Only one set of axe-head fragments has a known feature context; these artifacts came from the Bonaker Site. All of these objects were tested using pXRF, and two debitage samples from the Wiegenstein Site were tested using SEM-EDS.

23SG4. Three flakes and a celt fragment (Catalog # 15) were recovered from Test Unit 2, Level 2 (10-20 cmbs). One celt fragment has surface polish indicating it was broken from a complete celt. These objects are probably made of Skrainka diabase based on visual similarities.

23SG77. One celt (Catalog #12) of probable Skrainka material was recovered from shovel test 4 at approximately 20 cmbs.

The Hunter Site (23We262). Recovered from Test Unit 4 Level 3 (20-30 cmbs) was a fully grooved axe (Catalog # 122) (Weisman et al. 2007:68) that appears to have been made of Skrainka diabase.

Wiegenstein Site #2 (23Mo1252). I analyzed a variety of axe-head fragments, axe blanks, and debitage from various test units and trenches from the 2008 excavations. None of these artifacts had a feature context (Weisman et al. 2008). Appendix A contains provenience information and Appendix B is a detailed description of materials that were tested, including suspected material type.

Bonaker Site (23JE400). Three celt fragments, two from House 10 (Catalog # 831-1), and one from Feature 95-B-1 (Cat. # 384-C), were recovered from the Bonaker Site. It is suspected that they are all made of Skrainka material.

Two celts came from House 10, which was excavated as one unit due to time constraints (Schroeder 1983:39). It was the smallest of six of houses at the Bonaker site, measuring 2 x 2.5 meters. This house was farthest from the village on the edge of the terrace (Schroeder 1983:18). The third celt has a provenience of Feature 95, which unfortunately is not mentioned in the report text or maps.

Bundy Site (23PI77). The Bundy site excavations recovered two celts; only one of the grooved abraded celts (Catalog #67-B) from this site was analyzed. It is a wedge-shaped tool with a sharp transverse bit. It has equal wear on both faces and a groove on the poll end (Niquette and Donham 1986:52). It was made of a greenish colored diabase, but was thought to not be Skrainka in origin (Weisman personal communication 2013).

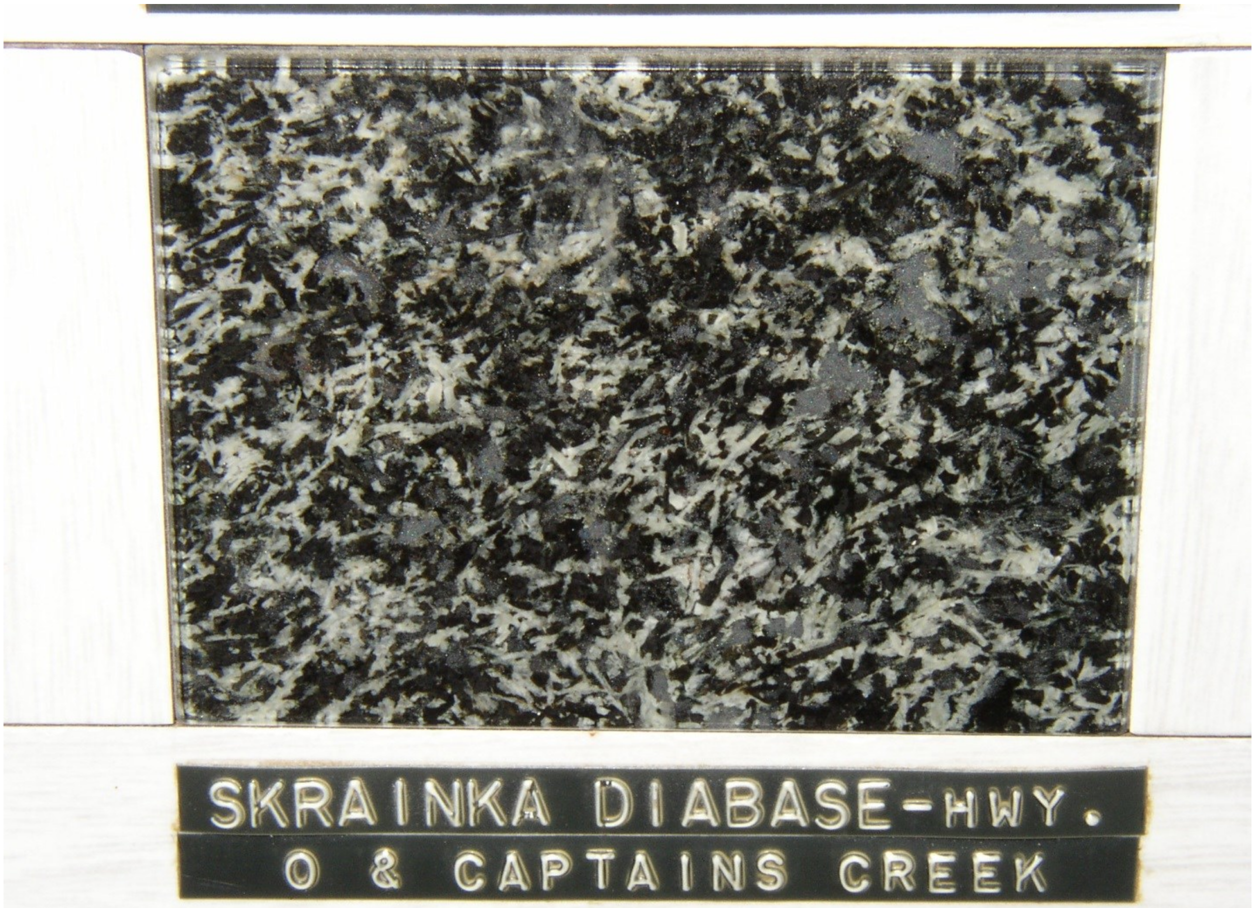

Figure 3- Polished slab of Skrainka diabase. (Photo courtesy of Patrick Mulvany, Missouri Department of Natural Resources.)

Figure 4- Geologic samples of Skrainka diabase. (Photo courtesy of Mike Walker, Kincaid Mounds Support Organization).

Figure 5- Geologic Samples of Silver Mine Area basalt. (Photo courtesy of Mike Walker, Kincaid Mounds Support Organization).

CHAPTER V

SUMMARY AND RESULTS

This chapter summarizes the results of statistical analyses done on the pXRF and SEM-EDS data. I interpret scatterplots of these analyses in order to try and distinguish between axe-heads with St. Francois origins and non-St. Francois origins. My interpretations of this data are also able to distinguish between some (but not all) of the present outcroppings in the St. Francois Mountains. Using these data, I compare the archaeological context of each sample in regards to their original provenance.

Results of Geochemical Analyses

Here, I discuss the results of the discriminant function analysis and principal component analyses done on the pXRF data and the results of the supplemental SEM-EDS analysis.

Statistical Analysis of pXRF Data

Data from the pXRF study was analyzed using two statistical methods: discriminant function analysis (DA) and principal components analysis (PCA). The raw part-per-million data produced by the instrument were log transformed. Log transformation can be used to make highly skewed distributions less skewed, which is helpful as it makes patterns in the data more evident and interpretable. Although pXRF analysis can discern a wide range of elements, only the trace element data were used for statistical analyses as they were found to be the most useful in distinguishing between samples.

Discriminant Function Analysis. The data from this study was first analyzed using discriminant function analysis; this method is useful in determining which variables discriminate between two or more naturally occurring groups. Five groups of known materials were classified (Table 2), the geologic samples represent either A) Skrainka or B) Silver Mine Area basalt , the six Grossman Cache samples represent the "snowflake basalt," two samples from Wiegenstein Site #2 represent rhyolite, and one sample from Kincaid represents a schistose material (which is visually similar to Hillabee Schist greenstone).

The discriminant analysis technique was able to predict the material type for the unknowns in this study using geochemical data, but is limited to the data given as imput. This technique will provide a classification for every sample given the input parameters, but cannot recognize outliers. Discriminant Analysis was helpful in exploring the data, but not useful in producing empirical results.

Principal Components Analysis. The geochemical data produced from this study were then analyzed using a principal components analysis (PCA). This quantitative method correlates a set of variables using orthogonal transformation, creating a set of principal components, each of which accounts for variance in the data (Shennan 1997:127-150). Using the minimum number of components needed to account for the majority of the variance in the data, the component scores are analyzed using cluster analysis. As in the DA analyses, the geologic samples of Skrainka diabase and Silver Mine Area (both from the St. Francois Mountains) are used as a comparative standard for the cluster analysis.

Bivariate scatterplots for each element revealed that Rb, Sr, Y, Zr and Nb were most useful for interpreting the pXRF data. All of the samples were analyzed using these five elements and two components were created. Principal component 1 (PC1) and principal component 2 (PC2) represent almost eighty-three percent of the variance in the data, as seen in Appendix E.

Figure 9 represents a scatterplot of the component scores of the first PCA analysis. It can be clearly seen that the rhyolites (red circle) are separate from the rest of the samples. The "snowflake" basalt artifacts (light blue circle) from the Grossman Cache also cluster tightly. Interestingly, included in this cluster are two celt fragments of unknown provenance from House 10 at the Bonaker site (23JE400) in the St. Francois Mountains. The largest cluster (green circle) includes geologic samples from Skrainka and Silver Mine Area outcrops, celts from Kincaid, Long Lake, Millstone Bluff, and Hayes Creek. It also includes celts and debitage from Wiegenstein Site #2 (23Mo1252), the Hunter Site (23We262), the Bonaker site (23Je400), 23Sg77, and 23Sg4.

Some of the celts from Millstone Bluff cluster together (purple circle). These celts are made of a rock that is denser and appears to be more felsic—it is visually distinct from the other samples. The small schistose celt from Kincaid (sample K1) is an outlier, which is to be expected as it appears visually identical to Hillabee Schist material from Alabama, and very unlike the other mafic igneous axe-heads (see Figure 7). In this scatterplot, the celt from the Bundy site (23Pi77) and three Kincaid celts (the larger of the celts from Mx^{V}1E, and two fragments from surface collections) do not conform to any of the clusters I identified.

In order to gain a more refined view of the lithic materials that are potenitally coming from the St. Francois Mountains, a second PCA test was run on a select number of samples (Figure 10). This dataset excluded all materials not made of igneous or mafic material (i.e., excludes the red and purple circles from Figure 9), and all of the samples from Millstone Bluff. Again, trace elements Rb, Sr, Y, Zr, and Nb were used and two components were created. This second analysis also created two unique principal components. Principal component 1 (PC1) and principal component 2 (PC2) represent over seventy-four percent of the variance in the data, as seen in Appendix F.

The results of this comparison (Figure 10) are similar to the previous scatterplot, though some refinement is gained. The largest cluster still contains Silver Mine Area and Skrainka geologic samples, as well as samples from Kincaid, Long Lake, and Wiegenstein Site #2. In the scatterplot of the second PCA it is obvious that the snowflake basalts of the Grossman cache are still tightly clustered (light blue circle), and the two samples from House 10 at the Bonaker site still have similar geochemical signatures. In this scatterplot, the celt from the Bundy site (23Pi77), and the Kincaid $Mx^V 1E$ igneous celt form a cluster (yellow circle), but the two other Kincaid celts (samples K6 and K8) that came from surface collections do not fit in to any cluster.

The largest cluster (green circle) still contains significant overlap between the Silver Mine Area and Skrainka geologic samples. It also contains samples from Kincaid, Long Lake, Wiegenstein Site #2 (23Mo1252), the Hunter Site (23We262), the Bonaker site (23Je400), 23Sg77, and 23Sg4. One of the geologic samples of Silver Mine Area basalt is a distant outlier for reasons unknown.

In order to gain a greater refinement of detail of the objects in this Skrainka/Silver Mine cluster, I created bivariate scatterplots of only the objects in this cluster using relevant trace elements (Zr, Rb, Sr, and Y). These scatterplots provided little clarity into distinughing between the Skrainka and Silver Mine Area basalt, as there was still considerable overlap between the geologic samples.

Analysis of SEM-EDS

The SEM-EDS analysis was conducted as a supplemental elemental analysis to support to pXRF findings. Ten samples were cut and polished into thick sections and an area scan of 1.3 mm^2 was analyzed to determine bulk elemental composition.

Results. The ten thick sections tested using SEM-EDS consisted of five geologic samples (four from Skrainka outcrops and one from a Silver Mine Area outcrop) and five archaeological samples (three celts surface collected in the Black Bottom, and two debitage fragments from Wiegenstein Site #2).

Using the SEM-EDS computer software, some diagnostic trace elements were specifically chosen to be included in the analyses, as their weight percent was so low the software would have excluded them by default. Overall, the SEM-EDS detected the presence of O, Si, C, Al, Fe, Mg, Ca, Na, Ti, K, Mn, Ba, P, S, La, Sm, Zr, and Hf in at least some, though not all, of the samples. Some of these elements were immediately discarded for analysis. The SEM-EDS can easily detect elements with an atomic number over 6; therefore carbon (C) was eliminated as this data may be flawed. Zirconium (Zr) was eliminated due to the fact that no sample had a weight percent of over .06%, a percentage too small to be considered accurate for analysis.

The SEM-EDS data were processed using bivariate scatterplots that compared the distribution of each element present within the sample. Scatterplots from this limited sample proved to be less conclusive than the pXRF data. Skrainka diabase showed considerable elemental variety in each elemental pairing. Often, the range of each element for the Skrainka samples overlapped the Silver Mine Area sample. The same was true for the archaeological samples. They neither clustered with each other, nor with the Skrainka or Silver Mine Area sample.

The ratios of La/Sm, Zr/Y and La/Hf have been determined to be useful in distinguishing between Skrainka diabase and Silver Mine Area basalt (Walker 2002:255). Using the SEM-EDS software, I selected La, Sm, Hf, Zr, and Y so that the machine would show the data results for each of these elements- they are in such small quantities the software would have eliminated them without this process. However, I eliminated Zirconium from the dataset due to its extremely low weight percent, and the scatterplots of the ratios La/Sm and La/Hf proved inconclusive. This ambiguity was in part due to the lack of sensitivity of the instrument. Lanthanum had a weight percent no higher than 0.29, and Hafnium no higher than 0.14%. These scatterplots showed no clustering.

Discussion of Geochemical Analyses

The two different methods of elemental analysis, pXRF and SEM, produced similar results. Each method proved that it is difficult to discriminate between the Skrainka and Silver Mine Area geologic samples. The pXRF data proved to be more useful than the SEM-EDS, especially due to the limited sample size of the SEM-EDS analysis. Trace elements (Rb, Sr, Nb, Y, Zr) proved to be most useful for determining provenance in the pXRF study.

pXRF Discussion. The manner in which I am using the pXRF data is inherently limited. This machine is extremely good at producing qualitative and semi-quantitative elemental analyses. I have used Bayesian Deconvolution to transform qualitative data into quantitative net photon data. This transformation from qualitative to quantitative is widely accepted as appropriate, but care must be taken when summarizing the results. What I discuss here is based upon the results the machine and software produced, but pending further geochemical testing using more sensitive instruments, the results cannot be understood as absolute.

In the first of the PCA analyses, the smaller schistose celt from MxV1E does not conform to any of the other artifacts or geologic sample clusters. Therefore, it is unlikely that this axe-head is coming from sources in the St. Francois Mountains. Visually, this celt looks like the Hillabee Schist material exported across the Mississippian sphere from a quarry near Moundville, AL (Gall and Steponaitis 2001), but this suspected provenance cannot be proved without further geochemical analysis. However, Hillabee lithologies are mafic phyllites which have similar major- and trace- element characteristics of basalts (Tull and Stow 1980). The fact that this sample is not radically different from the basaltic materials tested here is consistent with a possible Hillabee Schist origin.

Scatterplots from the second PCA analysis (Figure10) discriminate at least three distinct geochemical groups. The smallest of these groups contains only two objects, the celt from the Bundy site (23Pi77) and the larger Kincaid celt from Mx^V1E. These two objects have geochemical signatures that overlap each other, but none of the other objects under study. Elementally, they do not match with any objects of known provenance or material type and it is unclear whether they represent a distinct source. The Bundy celt has a greenish, rough textured matrix with small, needle like phenocrysts while the Kincaid celt is much smoother with tiny micro-phenocrysts and a grey matrix (Figure 8).

The second largest of these groups is mainly comprised of the “snowflake” basalts from the Grossman cache. These six celts are all visually identical to each other (and distinct from the other samples), due to their large snowflake-like phenocrysts and smooth green matrix. Also in this cluster, are the geochemically similar celt fragments from House 10 at the Bonaker site (Figure 6). Strangely, the material the Bonaker celt fragments are made of is not at all visually similar to the “snowflake” diabase identified by Pauketat and Alt (2002). They have much smaller, needle-like phenocrysts and a much greyer (as opposed to green) matrix. It is also interesting that these two Bonaker site celt fragments are so geochemically similar to the Grossman cache and to each other, but not to the third fragment of debitage found at the Bonaker site, which falls into the Skrainka/Silver Mine cluster.

It is evident from the scatterplots that pXRF does not provide a precise geochemical scope to discern between rocks from the Silver Mine Area and Skrainka outcrops. This cluster contains the majority of the artifacts under study and is represented by every archaeological region examined here. It is of note that the "snowflake" basalt artifacts distinguish themselves from this cluster; it seems that they come from a source that is neither a Skrainka nor Silver Mine Area outcropping. pXRF data can distinguish between the "snowflake" basalts (proven to be St. Francois in origin by A. Butler 2011) and the geologic Skrainka/Silver Mine material (also from the St. Francois). Therefore, the method is sensitive enough to distinguish between some outcroppings in the St. Francois region, but not all.

Amanda Butler (2011) proved that pXRF is able to discriminate between St. Francois igneous rock and Glacial till, the closest other source of raw material for ground stone production in the Confluence Region. Due to the strong overlap of Silver Mine Area basalt, Skrainka diabase, and many of the archaeological objects in this cluster (green circle), it can be assumed that archaeological artifacts are from the St. Francois Mountains. While the exact geological provenance of the archaeological objects in this cluster is still unclear, this study does not disprove that they have a St. Francois origin. Further analysis, possibly using trace element instrumentation, is necessary to understand the provenance of objects in the Skrainka/Silver Mine cluster more clearly.

Analysis of Artifact Provenance and Archaeological Context

This section summarizes what is known about the artifacts tested for this study. I examine the provenance of artifacts, distinguishing between objects with St. Francois origins and artifacts whose provenance is currently unknown. I also discuss evidence for production in the Confluence Region, which seems to be regionally segmented based upon the production process. Lastly, I discuss the final deposition of ground stone tools made of St. Francois mafic igneous rock. This information will be important for understanding the political economy of ground stone tools in the context of Cobb's (2000) model.

Provenance of Unknown Materials

Using scatterplots of the Principal Component Analyses (Figures 9 and 10), I was able to discriminate between objects that have a St. Francois origin and objects whose provenance is probably outside of this geologic region. The majority of the artifacts tested here (n=31) are suspected to be made of rock from the St. Francois, whereas four objects come from a source geochemically unlike that of the rocks tested from the St. Francois Mountains.

Artifacts with St. Francois Origin. Based on interpretations of the pXRF data, the majority of the axes, axe-head fragments, and debitage tested in this study have geological origins in the St. Francois Mountains. Unfortunately, the pXRF instrument does not appear to be sensitive enough to provide data that can discriminate between all of the different mafic rock outcrops in the St. Francois. For example, using the PCA scatterplots of the data from this study (Figures 9 and 10), one can discriminate between the "snowflake" basalts of the Grossman cache and Silver Mine basalts and Skrainka diabase geologic samples. However, the PCA scatterplots show considerable overlap between the Silver Mine and Skrainka geologic samples. My analyses of the data were unable to differentiate between the two outcrops, or the variety of archaeological unknowns that fall within this cluster.

Within this Silver Mine/Skrainka cluster are artifacts from all areas within the Confluence Region, with the exception of the American Bottom. This is probably due to sampling error. I suspect that if I had tested all of the Grossman Cache, at least some of the 63 other axe-heads in this cache would fall into this cluster, as some of Grossman cache axe-heads were made of materials visually identical to the geologic samples and axes from sites in Missouri and Kincaid.

<u>Artifacts with Unknown Origin.</u> The principal components analyses scatterplots (Figures 9 and 10) were able to discriminate axe-heads that are unlikely to be St. Francois in origin. At this time, their provenance is unknown. This cluster is composed of three axe-head fragments from Millstone Bluff and one axe-head from Kincaid.

One outlier of the first PCA is the Kincaid axe, the only sample of a schistose material in this study (Figure 9). It is morphologically different from the other green or grey igneous samples tested here. This small axe-head, one of two found in a house basin in Mx^{V}1E, is a green schistose stone with none of the visual identifiers common to St. Francois mafic igneous rock such as distinctive phenocrysts or iron-staining. It is suspected that this axe is from the Hillabee Schist source near Moundville, but this study was unable to determine its true origins.

Three other artifacts can be assumed to not to have come from the St. Francois Mountains (see the purple cluster in Figure 9). All of these artifacts came from excavations of the Millstone Bluff site. This subset is comprised of two axe-heads and one axe-head fragment; two of these objects came from the same excavation unit and level. Unlike the schistose Kincaid Mx^{V}1E celt, the lithic material of the Millstone Bluff artifacts appears to be granitic upon visual inspection. While all three artifacts look similar to each other, they do not have the classic hallmarks of St. Francois mafic igneous rock (i.e. needle-like or snowflake shaped phenocrysts, a green matrix with iron staining). The lithic source of these three objects is unknown at this time. They are potentially glacial till cobbles based on their small size and greyish appearance, but this hypothesis cannot be empirically proven at this time.

Results. The majority of artifacts tested here have geochemical signatures that are similar to those of geologic samples from the St. Francois Mountains. This leads to the conclusion that most of the artifacts tested in this study originally came from outcrops in the St. Francois. This is as suspected. The majority of the objects in this study were chosen for testing because of visual identifiers that linked them to the Skrainka diabase of the St. Francois Mountains.

Unfortunately, the method chosen for geochemical testing, pXRF, was not sensitive enough to distinguish between all of the different mafic rock outcrops that can be found in the St. Francois Mountains. One goal of this thesis was to try and identify objects that were coming specifically from Skrainka diabase rock outcroppings as many of the objects tested here are visually similar to geologic samples of Skrainka diabase. From scatterplots produced by a principal components analysis of elemental data gathered using pXRF (Figure 9 and 10). I was unable to distinguish between geologic samples of Skrainka diabase and Silver Mine basalt. Therefore, I could not source tools directly to the Skrainka diabase outcropping of the St. Francois Mountains.

However, the 'snowflake' basalts of the Grossman cache are readily distinguished from the Skrainka and Silver Mine Area outcroppings. Possibly, with a wider range of geologic samples from the St. Francois Mountains, the snowflake basalt axe-heads could be sourced to a specific set of basalt outcrops.

Evidence for Production

My findings support the theory that Mississippian producers in the American Bottom favored mafic rock from the St. Francois for axe-head production. The majority of the evidence for the making of axe-heads can be found in the American Bottom region, instead of near the quarry sites of the St. Francois. As previously discussed, production debitage, axe-head blanks, unmodified mafic blocks, and unused axe-heads are found with frequency within Cahokia proper and at periphery mound sites and farmsteads throughout the American Bottom.

In contrast, little production debitage is found within the St. Francois Mountain region, the source of the raw material. This may be due to the limited amount of archaeological survey and excavation that has taken place in this region. Some evidence of production has come from the Wiegenstein Site #2 (23Mo1252) in the form of axe-head production debitage, rejected celt blanks, broken unfinished axe-heads, and axe-head fragments. This seasonally occupied habitation site is suspected to be a workshop for axe-head production, but the level of intensity or nature of craft production here is still unknown. Furthermore, from investigations of the Desloge Study Area, Koldehoff and Wilson (2010) suspect that primary reduction and shaping of axe-head blanks was taking place in the St. Francois, but secondary knapping and the final shaping, grinding, and polishing of axe-heads took place in the American Bottom.

Cultural evidence of mafic rock transportation and some manufacturing debris is found along river ways that link the St. Francois Mountains and the American Bottom (Koldehoff and Brennan 2010; Koldehoff and Wilson 2010). Koldehoff and Wilson (2010:239) conceive of the Big River Valley as a major artery connecting the rich resources of the St. Francois to the people of the American Bottom. A large basalt boulder that was almost certainly moved by human agency has been found near a Mississippian site on the Meramec River. Another Mississippian site in the region, the Bauman site at the intersection of the River Aux Vases and the Mississippi River, contains basalt debitage and finished and unfinished basalt celts. The nearby Common Field site (23StG100) also produced basalt debitage, along with finished and unfinished celts.

Deposition of Tools Within Sites

Examining the archaeological context of the intentional deposition of ground stone axe-heads, axe-head fragments, and debitage can help to discern patterns that may be relevant to understanding the political economy of these tools.

Surface. Out of the thirty-five (35) axe-head or axe fragments tested here, only five came from surface collections, and all of these came from the Black Bottom. This subset includes three axe-heads and two axe-head fragments. These artifacts were recovered by the Benson family from the Black Bottom. Because these artifacts were probably brought to the surface via modern agricultural practices, their archaeological context has very little impact to this portion of the study.

Cache Deposits. The only materials tested in this study that came from a cache deposit are the six “snowflake” basalt axes from the Grossman cache. My sample size was limited, but the Grossman cache is only a small part of a series of large ground stone celt cache deposits that are found throughout the American Bottom. It has been argued that the quantity and density of cache deposits throughout the American Bottom suggests that caching in this region has significance far beyond a functional storage-and-redistribution purpose (Pauketat and Alt 2004).

Within the American Bottom, axe-head caches are found at major mound centers as well as in outlying hamlets and farmsteads. It should be noted that, so far, Confluence Region axe-head caches are geographically limited to the American Bottom. No ground stone axe-head cache has been found at any of the major mound centers or large Mississippian sites anywhere else within the Confluence Region. This is significant because it does not follow the pattern seen in Mill Creek chert hoe distribution (see discussion in following chapter).

Mound Deposit. Only one axe studied here, found at Kincaid, was deliberately buried in a mound context. The axe-head was found lying atop of an anthropogenic white clay layer at the base of Mound 8 (Mx^{o}8) (Pursell and Butler 2012:8-9). The confirmation of its St. Francois origins confirms a connection between Kincaid and the American Bottom, or alternatively to the craftspeople living in the St. Francois Mountains. Pursell and Butler (2012:9) suspect that this axe-head is one of the only known pieces of evidence to connect Kincaid to either of these regions.

The axe-head was found lying atop a prepared clay floor. This floor is suspected to be anthropogenic and part of the mound-building process due to the presence of underlying postholes and a superficial laminae indicative of exposure to water. Carbon-14 dates placed this clay floor in the 13th century (B. Butler 2012; B. Butler et al. in prep:12). Across the Mississippian sphere, the deposition of a singular axe within a mound context is far less common than other methods of deposition, such as within a cache deposit or domestic context. However, there are multiple instances of axe-heads in mound contexts in the American Bottom (Pauketat 1994:98-99)

House Basins. Out of the thirty-five (35) axe-heads and axe-head fragments tested for this study, seven came from within domestic structure contexts, and four of these seven came from Kincaid. This includes two complete axe-heads from the same structure in

Mx^{V}1E at Kincaid (one from the fill and another from a wall trench). One axe-head fragment came from a house basin located in the northwest region of Kincaid. A final axe-head fragment was found in an extracted post pit in the center of a structure beside the West Mound of Kincaid.

One axe-head fragment came from one of the sixteen houses tested at Millstone Bluff in the Shawnee Hills of southern Illinois. Two axe-head fragments came from a single house basin at the Bonaker site (23Je400) in the St. Francois. That this thesis has no American Bottom samples from domestic contexts is simply due to the limited sample size; axe-heads and axe-head fragments are often found in domiciliary structures throughout this region (Esarey and Pauketat 1992; Pauketat 1994, 1998).

Discussion of Artifact Provenience

Not all of the tools studied for this thesis have a distinct archaeological context (see Table 3, or for more detail Appendices A and B). Tools that do have feature contexts came from either cache deposits, mound deposits, or within household structures. This reflects patterns of axe-head deposition that are found across the Mississippian sphere, where ground stone tools are commonly found in either a household deposit or cache pit. This also demonstrates that axe-head consumption transcended hierarchal boundaries.

Tools found in household contexts are reflective of the nature of consumption of these tools. Axe-heads were probably considered as part of a set of mundane household tools. They are found in domestic contexts in every area studied in the

Confluence Region. This may be evidence of a preference for axe-heads made of St. Francois rock at sites outside of the American Bottom, as well as within.

Koldehoff and Wilson (2010) explain that Mississippians of the American Bottom may have preferred St. Francois rock over glacial till because rapid increases in population created the need for a consistent, abundant source that provided larger blocks of raw material, whereas glacial till occurrences are erratic and unpredictable, making locating a steady supply difficult. This same argument could be applied to sites like Kincaid and Millstone Bluff. But smaller sites outside of the St. Francois region did not have the need for an abundance of axe-head material that was created by an increasing population. At sites such as the hamlets of the Black Bottom, or at Hayes Creek outside of Millstone Bluff, it may have actually been easier to make axe-heads out of locally sourced stream cobbles or river gravels. The presence of St. Francois rock at these sites alludes to trade connections with local centers, as well as ideas of community identity. Another hypothesis is that St. Francois rocks made superior axe heads, or were easier to work into axes, although this has yet to be demonstrated.

These smaller local centers (Kincaid and Millstone Bluff) do not have the elaborate cache deposits of axes that are found throughout the American Bottom. The nature of caching in the American Bottom has been interpreted as having different meanings. They can be seen as functional storage deposits where axe-heads were held prior to redistribution. Pauketat and Alt (2004) see cache deposits in the American Bottom as having a symbolic, ritualistic purpose. The nature of cache deposits of ground stone tools will be discussed further in the next chapter, where axe-head cache deposits will be compared to cache deposits of Mill Creek chert hoes.

Figure 6- Bonaker site (23Je400) axe head fragments.

Figure 7- Kincaid Mx^{V}1E axe-head, possibly made of greenstone material.

Figure 8- Kincaid Mx^{O}8 and NW Mound axe head and fragment.

Table 2- Discriminant function analysis results for all samples, using elements Rb, Sr, Y, Zr, and Nb.

	Samples of Known Material Type	**DA Prediction**
Silver Mine Area Basalt	4	56
Skrainka Diabase	13	29
"Snowflake" Basalt	18	26
Rhyolite	4	4
Schist	2	12

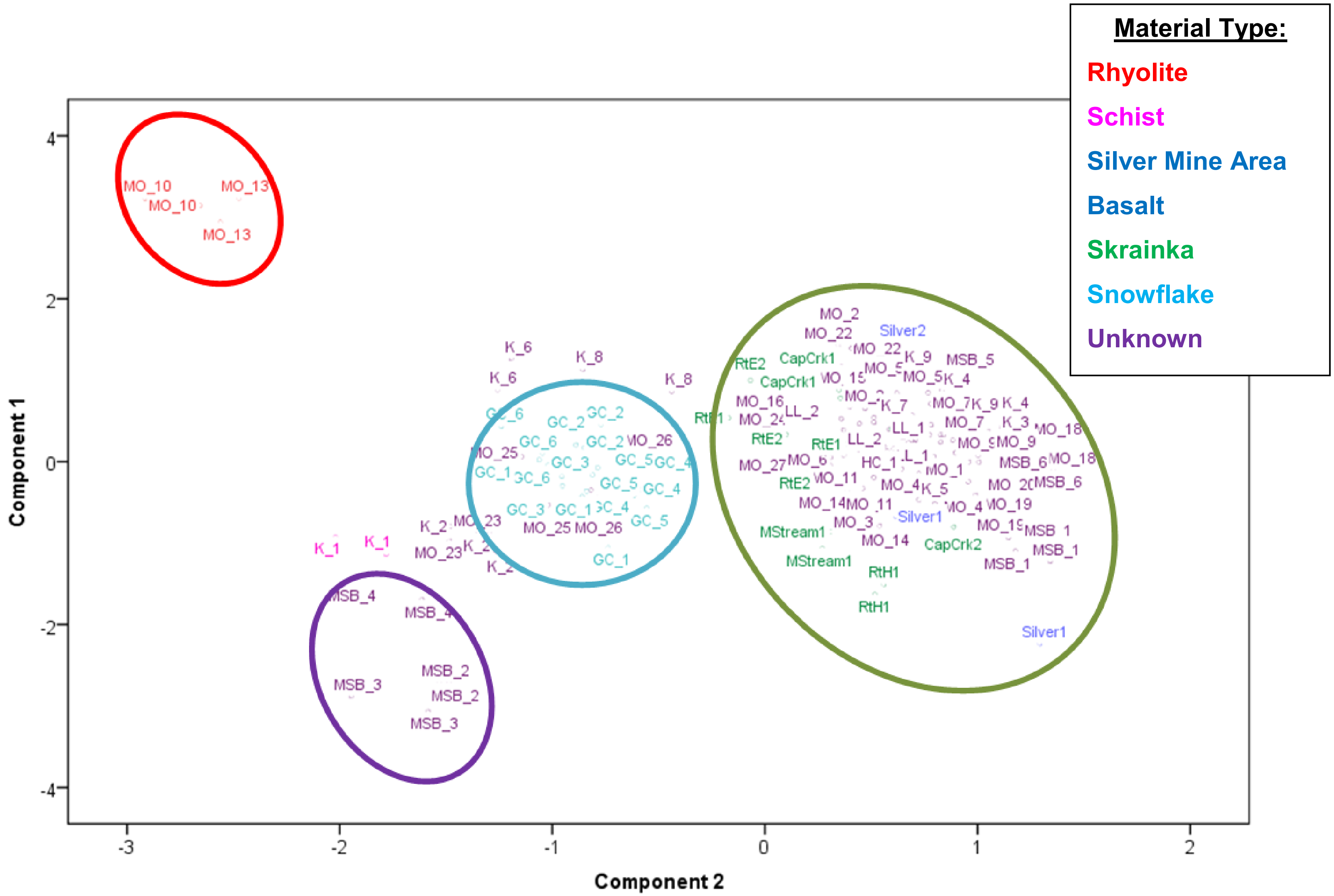

Figure 9- Scatter plot of component scores for the first PCA of all samples.

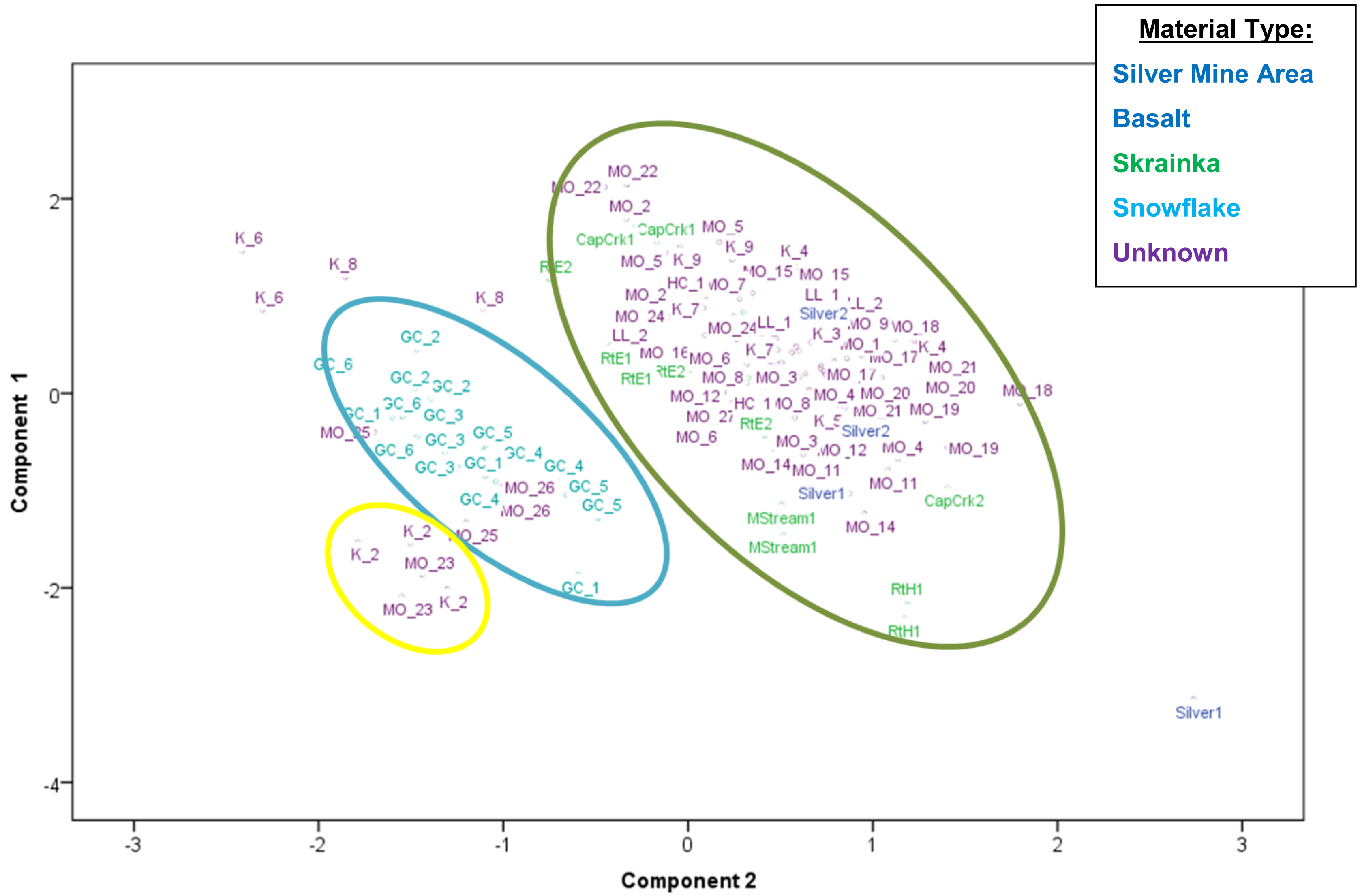

Figure 10- Scatterplot of component scores, when PCA was run on only mafic igneous samples and Millstone Bluff samples were excluded.

CHAPTER VI

TESTING A MODEL OF PRODUCTION AND DISTRIBUTION

Cobb's (2000) model of the movement of chipped stone hoes from the Mill Creek chert quarries of Southern Illinois to Mississippian sites throughout the Midwest and Southeast, has many similarities to the movement of mafic rock out of the St. Francois region. There are also distinct dissimilarities between how these lithic materials were quarried, produced, and exchanged. Therefore Cobb's model will be compared to what we know about the production and exchange of ground stone tools made of St. Francois rock in order to better understand the political economy of these objects.

Here, I address the geographic and environmental setting of the lithic sources. I compare the methods of quarrying and examine the archaeological evidence associated with each quarry area. Then, I expand upon the mechanisms of production and exchange associated with hoes and axes. I also examine the differences between cache deposits, redistribution, and consumption of these tools. The following discussion suggests that Cobb's model cannot explain all elements of axe-head manufacture and distribution in the Confluence Region.

Geographic and Environmental Setting

The geographic and environmental settings of the Mill Creek Chert quarry area and the St. Francois regions are similar. The Mill Creek Quarry is located in southern Illinois, a region that is bounded by two major river ways: the Mississippi and the Ohio. The Mill Creek quarry area is crisscrossed by small streams, most of which eventually empty into the Ohio River (Cobb 2000:111). The hilly terrain of southern Illinois is characterized by “rolling hills, deeply dissected ridges, and narrow drainages” (Cobb 2000:98). This is a geographic setting very unlike the bottomland settings that most Mississippian occupations favor for their crop production qualities. Nevertheless, Cobb suspects that the hilly environment was suitable to support Mississippian style agriculture supplemented by the rich natural resources of the area (2000:111-112).

Similarly, the St. Francois rock exposures are not located in a bottomland setting, but a series of low, rolling mountains that are part of the greater Ozark Plateau. These small mountains compose some of the highest elevations in Missouri. The closest major river is the Mississippi, approximately 80 km to the east, where the land terminates in high bluffs. Like the Mill Creek quarry region, the St. Francois Mountains are also crisscrossed by intermittent streams, most of which drain into the St. Francis River which flows south to the Mississippi. To the north of the St. Francis River source, an overland route would have to be used to connect this region to the Big River Valley, which contains evidence for the movement of rock towards the American Bottom.

Summary

Geographically, the St. Francois Mountains and the Mill Creek area are very similar. They are both hilly terrains crisscrossed with intermittent streams and contain rich lithic resources. Cobb suspects that the Mill Creek area could support Mississippian style agriculture supplemented by the surrounding woodlands environment; the same argument can be made for the St. Francois Mountain region. Neither area is located on a major river, though both are reasonably close (Mill Creek to the Ohio and St. Francois to the Mississippi) and each area can easily connect to these large rivers using smaller navigable waterways or overland trails.

Quarry Location

The processes of finding and quarrying these resources are fundamentally different. “Quarrying involves rudimentary extractive technologies to pry raw materials from parent materials, or to excavate shallowly in the earth’s mantle” (Cobb 2000:93). The Mill Creek chert quarries have long been studied as an area of Native American resource extraction; the quarries were first explored in a professional archaeological context by the Field Museum in 1899 (Phillips 1899, 1900; Cobb 2000:112). These early researchers found hundreds of quarry pits spread out over 5.5 to 6.8 ha. When the pits were later excavated, they were found to have been quasi-shafts dug between 2 to 6 meters in depth, dug and built in order to extract chert nodules from the surrounding clay. The surface of the quarry area was littered with primary reduction fragments such as broken chert nodules and early stage blank rejects and failures.

In contrast, at this time there are no known Native American mafic igneous rock extraction sites within the St. Francois region. This is may be due to a variety of reasons. The first may be due to the size of the geologic outcroppings. Unlike the Mill Creek chert source, which seems to be limited to two quarries within a 3 km^2 area, St. Francois igneous rock outcroppings occur throughout the St. Francois Mountains, a region that covers over 8000 km^2 with over 550 km^2 of actual exposed rock outcrop (Tolman and Robertson 1969). In addition to this problem of size, Pauketat and Alt (2004) identify over 12 varieties of raw lithic material represented in the Grossman Cache alone, leading to the conclusion that there are multiple quarry locales spread throughout the area.

The second reason that quarries for mafic rock may be so ephemeral in the archaeological record is related to the method of rock extraction. Koldehoff and Wilson (2010:220, 233) suspect that raw material was probably acquired from frost fracture areas in the bedrock or from fallen boulders. To acquire the raw material, Mississippians would have used force to pry or break blocky tabular pieces from the bedrock, or used a hammerstone to break spalls from the surface. This method of extraction may leave limited archaeological evidence, much less than the quasi-shaft pits dug to acquire Mill Creek chert nodules.

Lastly, it is suspected that any remaining quarrying evidence has probably been destroyed by historic and modern mining operations. The Skrainka Construction Company mined basaltic blocks for street paving in the late 1800's and modern operations still run today (Denham 1934, Mercantile n.d).

Summary

There are two major differences between quarrying processes that may affect the utility of Cobb's model. The first major difference between the quarrying process of Mill Creek chert and St. Francois rock is that each material type is quarried in a fundamentally different manner. Mill Creek chert is found beneath the surface and can only be accessed through explorative digging in order to harvest chert nodules. In contrast, mafic rocks are often found above the surface in large exposed rock outcrops or fallen boulders and must be pried or struck from the parent material. These methods leave very different archaeological evidence and make it much more difficult to locate ground stone tool quarry activity areas than chert quarry areas.

A second major difference between the two materials is the actual size of the quarry area. The Mill Creek chert area is much more concentrated (3 km^2) when compared to the St. Francois rock exposures (over 8000 km^2). In addition to this problem of size, it is suspected that a wide variety of lithic types were quarried from differing rock exposures in the St. Francois, whereas the Mill Creek chert area yields a similar lithic material regardless of individual quarry location.

The problem of ephemeral quarrying activity and the large distance between each basalt, diabase, or gabbro rock quarry (compounded by the limited archaeological research done in this region) means that so far, no actual quarry area has been found anywhere within the St. Francois Mountains. Fortunately, enough is known about aboriginal ground stone tool quarrying practices that we can assume how rocks were removed (Koldehoff and Wilson 2010) in order to fit this portion of ground stone tool production into Cobb's model. The methods for quarrying chert and mafic igneous rocks may differ, but this does not conflict with Cobb's model to the point of making it unhelpful in explaining the political economy of Confluence Region axe-head production.

Sites Associated with the Quarry Areas

In his study of the Mill Creek chert quarry, Cobb notes that there are at least two Mississippian mound sites (2000:130) and fourteen domestic/workshop sites (2000:127) within 15 km^2 of the largest of the Mill Creek quarry sites. Cobb describes these sites as representative of a series of loose-knit, interacting communities. It seems that exploitation of the quarry and the production of Mill Creek hoes at surrounding sites may have continued for almost four centuries (Cobb 2000:195).

From his systematic survey of the lands surrounding the Mill Creek quarry, Cobb determined that habitation in the region was dispersed between multiple domestic sites. From an analysis of surface collected and excavated material remains, he concludes that inhabitants were small-scale flint knapping specialists that produced chipped stone hoes in the absence of an elite-organized centralized production system (Cobb 2000:157). The sites hold no evidence of the presence of local elites (such as elite burials). Nor is there evidence (in the form of diagnostic ceramics or large amounts of exotic items) of direct contact with elites or individuals from major Mill Creek hoe consumer regions (Cobb 2000:193). This suggests an "underdeveloped" social hierarchy. However, this lack of formal social hierarchy is contrasted with a strong sense of community structure, demonstrated by the exportation of similarly made and fully formed large bifaces (Cobb 2000:194-195).

Unfortunately, unlike the Mill Creek chert locale, the St. Francois region has not undergone a rigorous pedestrian survey. As of now, there are no documented multi-mound sites or annually occupied Mississippian domestic sites identified within the St. Francois Mountains. The few Mississippian sites that have been excavated are limited to the constraints of salvage excavation work. A (possibly Mississippian) burial mound associated with a stone box grave site was documented in the early 1900's but was destroyed before the 1940's (Eastman et al. 2002:38). One possible ground stone tool workshop site has been identified (Wiegenstein Site #2) and other various seasonally occupied Mississippian sites have been recognized. Sites have been found in northern Wayne county that seem to indicate the transition between Late Woodland and Mississippian traditions, but their intra-site chronology has yet to be determined (Berry et al. 1940)

I consider this picture of the St. Francois as being only seasonally occupied is skewed by the limited amount of survey and excavation that has occurred in this region. During the Mississippian era, this region was sparsely populated. However, the presence of stone box graves (Eastman et. al 2002:38) in the area hints at a more permanent population. Cobb suggests that the sizeable creek floodplains in the valleys of the Mill Creek locale could support Mississippian agriculture; the same argument could be made for creek flood plains of the low mountains of the St. Francois. The lack of monumental architecture within the St. Francois area suggests a lack of an elite presence (similar to Mill Creek), but ceramic chronology suggests a closer tie to populations in the American Bottom. Hopefully with time, the St. Francois will see more intensive archaeological investigation and our knowledge of the Mississippian era of this region will become more complete.

The closest mound sites to St. Francois are to the east in the lowlands of Bollinger and Stoddard Counties. Both of these stone box grave sites (the Peter Bess and Lakeville sites) were excavated in the early 1900's and are poorly understood. Ceramics from the Peter Bess site seem to date to post-1200AD and what remains from the material assemblages of both sites does not seem to indicate an association with the extraction of material to make ground stone tools (O'Brien and Wood 1998:325-326).

The Shell Lake site, to the south of the St. Francois, in southern Wayne County, may have associations with axe-head manufacturing. At the Shell Lake Site, Price and Price (1984) recovered small flakes, large angular blocks, an axe blank, and a hammerstone. They believe that this material has St. Francois origins and emphasize the significance of the artifacts at this site.

Summary

A comparison of these two regions suggests that occupation patterns were radically different. The Mill Creek quarry area has undergone rigorous controlled survey, with the result that multiple domestic/workshop sites and two mound sites have been associated directly with chert quarrying and production activity. Evidence for the production of Mill Creek chert hoes has not been found at any site outside of the Mill Creek quarry area. In contrast, the St. Francois region has not undergone detailed archaeological survey and very few Mississippian sites have been found within the region's geographic borders. Of these sites, only one site, the Wiegenstein Site #2, has confirmed ground stone tool production activity. Unlike the localized production associated with the Mill Creek area, production of celt blanks has been confirmed at sites to the north of the St. Francois quarry region in the Big River Valley and to the south at the Shell Lake site.

The archaeological evidence of habitation and production areas in each region is significantly different. Here, the St. Francois Mountains do not fit into Cobb's model of Mill Creek hoe production. There are no long term domestic sites associated with quarrying or production within the St. Francois region, whereas in the Mill Creek area there are multiple domestic/workshop areas that were inhabited for long periods of time. The St. Francois region has no confirmed instances of monumental Mississippian architecture. Although the mounds at the Linn and Hale sites of the Mill Creek area are small, they indicate a surplus of labor in this region that probably did not exist in the St. Francois area.

Overall, the patterns of occupation in the Mill Creek and St. Francois areas were significantly different. Cobb's model suggests a long-term, established population of Mississippian famers/ hoe producers living in the Mill Creek locale after ca. AD 1200. This stage of Cobb's model is inappropriate to explain what seems to be the seasonal occupation of the St. Francois region.

Production

At sites associated with Mill Creek chert quarries, it does not seem that production was managed internally by elite power. Likewise, it does not seem that production was controlled by external polities. All sites associated with Mill Creek chert production seem to be autonomous. Access to resources was probably loosely stratified (Cobb 2000).

At the Mill Creek chert quarries, it seems that only chert extraction and primary reduction or shaping of hoe blanks took place. This is supported by the fact that artifacts found on the surface of the main quarry are restricted to primary reduction fragments. None of the secondary reduction debitage associated with the actual shaping and completion of chipped stone hoes is found near the Mill Creek chert quarry shafts. The evidence for this secondary stage of manufacture is found at nearby domestic/workshop sites, such as Dillow's Ridge. The fact that there are more production failures or unfinished hoes than finished hoes at these sites is strong evidence that they were being manufactured for nonlocal use (Cobb 2000).

At these workshop and long term habitation sites, Cobb concludes that hoe manufacture was carried out by part-time specialists (probably men) who manufactured tools alongside their yearly round of activities. Hoe manufacturing had a low per annum output, probably because manufacturing was done on a seasonal (late winter/early spring) cycle (Cobb 2000:186).

The control of production of St. Francois axe-heads is, at this time, still unclear. The evidence that is currently available points to communities in the American Bottom as the primary producers of ground stone axes made from St. Francois rock. Minimal production was taking place within the St. Francois (e.g., the Wiegenstein Site #2) and at sites to the north (e.g., the Bauman and Common Field sites) and south (e.g., Shell Lake) of the lithic extraction areas. The fact that there are many more celt blanks, production failures, and unfinished axes than completed axes within the St. Francois area suggests manufacture for export (Cobb 2000; Koldehoff and Wilson 2010:225)

Quarrying of rock may have been limited to the winter months. The Wiegenstein workshop site was occupied for only one fall/winter season. This habitation pattern is unlike the sites near the Mill Creek quarry, where producers lived in established year-round villages. It is, however, similar to the Mill Creek pattern in that quarrying was being done in the winter, a period when Mississippians probably had significant "down time" between planting seasons (Cobb 2000:186, Thomas 1997). Muller (1991) also found this seasonal pattern held true when examining salt extraction at Great Salt Spring.

Koldehoff and Wilson (2010:235) suspect that only the primary shaping of axe-head blanks occurred within the St. Francois Mountains. Currently, the strongest evidence for secondary production (pecking, grinding, and polishing the axe-heads into their final shape) comes from multiple sites within the American Bottom. This segmentation of the celt manufacturing process may be in part due to the fracture mechanics of ground stone tool production. A celt is highly likely to break during the acquisition and primary shaping processes due to the nature of hidden fracture planes and the high impact energy required to shape and form it into a celt blank. These primary processes therefore require a large amount of expertise. The secondary (grinding and polishing) processes require much less force and much less knowledge or knapping expertise. However, secondary shaping and celt completion does require quite a large amount of time and labor effort. This production process is very unlike chert hoe production, which requires “expertise in fracture mechanics throughout the production process” (Koldehoff and Wilson 2010:236).

In the St. Francois region, the lack of Mississippian domestic or workshop sites, monumental architecture, or known quarry sites all depart from Cobb’s model of Mill Creek hoe production and exchange. Evidence suggests that roughly shaped rock slabs or axe preforms were being transported directly from the St. Francois Mountains into the American Bottom. It is suspected that these mafic rocks were being obtained and moved alongside other items extracted from the St. Francois or greater Ozark area (such as salt, galena, or wood), but at this time this argument can be but poorly supported. It is known (A. Butler 2011; Emerson and Hughes 2000; Kelly 1991; Koldehoff 1987; Koldehoff and Wilson 2010; Walthall 1981) that a plethora of other goods were brought into the American Bottom in a raw or roughly altered shape, where they were then transformed into a final form.

At this time, it is unknown who was moving stone and other materials north from the St. Francois into the American Bottom. Kelly (2006, 2010) suggests that it could be residents of the St. Francois bringing material north when on pilgrimage to Cahokia. On the other hand, it could be that ground stone tool material and other items were transported by residents of the American Bottom, who would bring the material with them when returning from sacred journeys to the Ozarks.

Archaeological evidence suggests that secondary production phases began only after the rock slabs or axe-head blanks reached the American Bottom. The axe-heads were pecked, ground, and polished both centrally and in the hinterlands; there is evidence of intensive production found in central mound and village areas, and some production evidence found at the outlying farmsteads.

Summary

The nature of ground stone tool production in the St. Francois is a departure from Cobb's model of Mill Creek chert hoe production. At Mill Creek sites, autonomous villagers completed the entire process of hoe production at long term domestic sites located near the quarry area. The Mill Creek producers were free to trade their product to whomever they chose, without the restriction of a centralized power. It seems they were not under the influence of local elites or foreign polities. Contrastingly, in the St. Francois (using the Wiegenstein Site #2 as our only example) quarrying and primary shaping of axe-head blanks was done at temporary seasonal camps. Diagnostic ceramics from Mississippian sites in this area imply a direct connection to the people of the American Bottom. Once rocks were shaped into axe-head blanks, they were then exported to the American Bottom for completion. It is unknown who transported these roughly shaped blocks, but evidence for this movement of St. Francois rock to the north is found along the Big River Valley basin. Within the American Bottom, the distribution of rough slabs and axe-head blanks seems to be centrally controlled. The final completion of these objects was done both at local centers and farmsteads within Cahokia's hinterlands.

The method of production utilized in making an axe-head from St. Francois material was very unlike the processes involved in making a Mill Creek chert hoe. Therefore, at the production stage, Cobb's model cannot be applied to explain the political economy of axe-head manufacture in the Confluence Region.

Mechanisms of Exchange

Cobb suspects that on a local level fully-made chipped stone hoes were traded in multiple directions by Mill Creek residents. There is no singular waterway or known trail that transverses the Mill Creek region. It is not currently known if the hoes passed through one particular Mill Creek village or mound site prior to being exchanged outside the local area. The lack of elites structures and the small scale of earthworks in the Mill Creek area suggests there was no one centralized area used for non-local redistribution (Cobb 2000:188-190).

It is unknown what Mill Creek residents received in return for their product. The annual extent of their production was small and archaeological evidence suggests the Mill Creek residents received very few prestige or exotic goods in exchange for their hoes. Cobb (2000:190-191) suspects that the local environment provided ample resources to meet the needs of their subsistence economy, so during good years they would not need to trade for staple goods. Cobb speculates that the Mill Creek residents may have been trading for non-durable goods, such as large riverine fish from neighboring groups, or cloth and textiles from Wickliffe (Drooker 1992).

The magnitude of the exchange of Mill Creek chert hoes is impressive. Winters (1981) found Mill Creek chert hoes distributed over an area of 200,000 square miles. The major concentration of these hoes is around the American Bottom region of Illinois and Missouri. Nevertheless, Mill Creek chert artifacts are found distributed throughout Mississippian sites in the Midwest and Southeast, and archaeologists today are ever expanding this region (Welch 1991).

Cobb (2000:60-61) suspects that hoes were not exchanged as a singular item, but were moved via trade routes alongside other trade goods. These items were most likely transported along an extensive system of river ways and trails. Mill Creek stone hoes and hoe flakes are found at all levels of Mississippian sites, from the largest of mound centers down to the smallest hamlets. Access to Mill Creek objects permeated the Mississippian population; no matter one's station in life, or location in the settlement system, access to Mill Creek stone hoes was a given.

At this time, the presence of axe-heads of St. Francois provenance in sites outside of the American Bottom (such as at Kincaid or Millstone Bluff) cannot yet be definitively linked to either the American Bottom or the St. Francois as a point of manufacture. It could be assumed, because of the density of manufacturing sites in the American Bottom, that this is where these axes were made. However, this is a dangerous assumption. Prior to Muller (1997) and Cobb's (2000) models, it was thought that the Mill Creek chert source and/or redistribution of this material was controlled by Cahokia. Again, I bring into question the paucity of excavation done in the St. Francois as a source of uncertainty. Just because we do not know of many manufacturing sites in this area does not mean they do not exist.

The distribution of ground stone axes and other objects made of St. Francois material outside of the American Bottom is probably much more frequent than what is already known. Much of the research on these tools has been focused on or around the American Bottom. Amanda Butler (2011) proved that in addition to the American Bottom caches, tools with a St. Francois provenance are found in assemblages from the Orendorf and Collins sites of central Illinois. This thesis has empirically proved that axe-heads with a St. Francois origin can be found in assemblages from Kincaid, Millstone Bluff, and Hayes Creek. Artifacts of visually similar materials have been found in assemblages as far north as Aztalan, Wisconsin (Pauketat personal communication 2011) and as far south as Moundville, Alabama (Welch, personal communication 2012) (see Figures 9 and 10). Hopefully, further research will investigate axe-heads and other ground stone objects in assemblages outside of the American Bottom to reveal whether they have a St. Francois provenance. This information will help to determine the range through which objects made from St. Francois stone were traded.

Summary

Due to the fact that the production of St. Francois axe-heads was so different than Mill Creek chert hoes, it is impossible to fit the exchange of axe-heads into Cobb's model. Long-term Mill Creek residents traded fully formed chipped stone hoes directly out of their villages, probably to neighboring peoples. In the St. Francois, partially formed axe-head blanks were formed in seasonal camps prior to being moved north to the American Bottom where they were then completed.

At Mill Creek, residents received very little exotic or prestige items in exchange for their product. In contrast, it is unknown who was doing the quarrying and primary shaping of ground stone tools in the St. Francois and it is especially difficult to assess what motivated them to do such. It is suspected that elites controlled the distribution of axe-head blanks within the American Bottom; at this time there is not enough evidence to trace the trade economy of axe-heads throughout the greater Confluence Region.

The presence of Mill Creek chert hoes is ubiquitous throughout Mississippian sites in the Confluence Region and beyond. This study has proven that objects made of St. Francois rock may be more common in Mississippian assemblages than previously thought. More research on the distribution of St. Francois stone tools would be necessary to fully understand Confluence Region axe-head exchange. However, if axe-heads made of St. Francois rock are widely distributed common household objects, this portion of the exchange and consumption practices would fit into Cobb's model.

Caching and Redistribution

Generally, "the final resting place for a hoe appears to have been just as humble as its beginnings – typically within a household context, either in its original form or recycled into another tool" (Cobb 2000:198). However, cache deposits of Mill Creek chert hoes also occur with frequency (Cobb 2000:68). Cobb distinguishes between domiciliary and distributional caches. Domiciliary caches are normally within a residential context and contain fewer than ten hoes, sometimes with used or broken objects. Distributional caches are often found having a large number of unused hoes within a mound center context.

Domiciliary caches of hoes are most common in the American Bottom (Cobb 2000:68; Hoehr 1980; Latchford 1984; Milner 1984; Throop 1928), whereas distributional caches of hoes are found in multiple mound sites both within, and far from, the American Bottom (Cobb 2000:69). Cobb suspects that hoe caches may represent storage for the periodic oversupply of hoes prior to redistribution to the hinterlands (2000:199) and that deposition may help to maintain moisture in the chert and delay brittleness (2000:69).

Although this distinction between domiciliary and distributional caches is Cobb's working classification scheme, he notes that there are other archaeological examples that do not fit into this pattern (2000:70). For example, two caches (from northeast Arkansas and Mound Lake site, Illinois) are problematic because they have both used and pristine hoes. A cache of hoes from East St. Louis is part of a series of cached objects that seem to have votive or ceremonial elements. As I discussed earlier, caches have been found in the American Bottom that contain both chipped stone hoes and ground stone axes.

Nevertheless, from available evidence, Cobb concludes that distributional caches indicate that individuals at major mound centers had preferred access to the hoe trade. This is probably a function of both social status and the prime location of mound centers along major waterways that were used as trade routes. These larger caches were probably broken up and redistributed by elites to smaller communities as a part of the local exchange system (evidence of this can be seen in the domiciliary caches).

As of yet, no cache of Mississippian ground stone tools has been found outside of the American Bottom that has been empirically linked to St. Francois outcroppings. As previously mentioned, the only known axe-head caches within the Confluence Region are found at sites within the American Bottom. Some researchers (e.g. , A. Butler 2011; Pauketat and Alt 2004) do not see these American Bottom caches as fitting into Cobb's (1989, 2000) functionalist domiciliary/distributional scheme, but instead see these caches as having a community-building and ritual purpose. Koldehoff and Wilson (2010:237) suspect the reason that there are many large, unfinished axes found in cache deposits is due to the large amount of labor that is required to peck, grid, and polish an axe-head into its final form.

Summary

Although the methods of production and exchange of ground stone axes and chipped stone chert hoes are very different, both types of material are found deposited into caches. Confluence Region caches of axe-heads with a proven St. Francois origin are currently only found in the American Bottom, but Mill Creek chert caches can be found across the Confluence Region and wider Mississippian sphere. Cobb (2000) sees most caches of Mill Creek tools as functional storage deposits prior to redistribution. Pauketat and Alt (2004) see American Bottom caches of ground stone tools as being symbolic rather than functional. Consequently, Cobb's model cannot explain the caching of St. Francois axe-heads as being regionally limited to the American Bottom.

Consumption

Although elites at mound centers had differential access to Mill Creek stone hoes, hoes are ubiquitous tools found throughout the archaeological record of the Mississippian household. The consumers of Mill Creek chert hoes were probably typically female (Cobb 2000:74,199; Thomas 2001). This assumption is based on Mississippian iconography (e.g., the Birger figurine) and ethno-historic observation (Cobb 2000:73-74). They were used as agricultural digging implements and it is suspected that the hoes were owned on a household level as a part of a set of mundane tools. Chipped stone hoes have a low profile in Mississippian art and iconography (Cobb 2000:199). Ground stone axes were used (most likely by men) to cut down trees, primarily to clear fields for agriculture. Following Cobb, these tools were probably part of the same set of mundane household tools that chipped stone hoe blades belonged to. They also have a very low iconographic profile.

However, there are instances of tools made of Mill Creek chert and St. Francois stone that could not have served a utilitarian purpose. For example, monolithic hypertrophic axes found in the American Bottom have confirmed St. Francois origins (A. Butler 2011). There are rare examples of Mill Creek chert fashioned into large ceremonial bifaces, spatulate celts, and stone maces. There are less rare but still limited examples of Mill Creek chert chipped into functional/symbolic Ramey Knives (Cobb 2000:70-71). So, like chert hoes, ground stone axes are not often seen in Mississippian iconography or found in ritualized burial contexts, but specimens made of these materials have been found that must have been symbolic in nature.

Summary

In the Confluence region, the majority of axes were used as mundane, household tools and were probably used by men. Mill Creek hoes held a similar conventional status, but were primarily used by women. This household division of labor may have led to a gendered nature of exchange. Thomas (2001) examined the production of Mill Creek chert by men at Dillow's Ridge, in comparison to the production of salt at Great Salt Spring, a task she interpreted as being done exclusively by women. Extrapolating from this division of labor on the household level she speculates that Mississippians may have participated in dual homosocial trade networks; women may have traded exclusively with women, and men may have traded only with men. If such trade networks existed, it is possible that hoes traveled in a sphere of exchange dominated by women, whereas ground stone axes were traded in a sphere controlled by men. However, these gendered exchange networks would be difficult to access using only the archaeological record. Iconographic depiction could aid in this assessment, but both of these tool types have very low profiles in iconography. Thomas relied heavily on ethno-historic descriptions in her assessment of salt production, but flint knapping and ground stone tool production and exchange are largely ignored in these texts (Thomas 2001:33, Swanton 1946:544, 717).

The household nature of axe-head consumption fits into Cobb's model of hoe consumption, with this exception of gender. However, hypertrophic axes made of St. Francois material have been found in the American Bottom. These axes have no parallel in Cobb's model of hoe exchange because Cobb does not study the production or exchange of chert prestige or ceremonial objects made of Mill Creek chert.

Therefore, Cobb's model can be used to evaluate some, but not all, of the consumption practices surrounding Mississippian axe-heads.

Summary of Cobb's Model in Comparison to St. Francois Ground Stone Tools

In summary, Cobb's model can be used to explain some, although not all, of the political economy of axe-heads made from St. Francois rock. The regions are geographically similar, but the processes of quarrying chert hoes and stone axe-heads are very different. The distribution of archaeological sites in each region is also contrasting, as are the production phases and knowledge required to complete each object. Finally, the consumption and final deposition of these objects is similar in some cases and different in others.

Geographically, the St. Francois Mountains and the Mill Creek locale are very similar. Both regions could probably support Mississippian style agriculture supplemented by the surrounding woodlands environment. Both areas are connected to large rivers via smaller navigable waterways or overland trails.

Mill Creek chert and St. Francois mafic rock are quarried in fundamentally different manners. Mill Creek chert is dug up in nodule form from beneath the surface, whereas mafic rocks are struck or pried from large exposed rock outcrops or fallen boulders.

The size of the quarry areas vary drastically. The Mill Creek chert area is concentrated (3 km^2) and the spread of St. Francois exposures are vast (found over an area of 8000 km^2). Throughout this large area, a wide variety of different basalt, diabase, and gabbro rock types were quarried. In contrast, the Mill Creek chert area yields a similar lithic material throughout the smaller area of chert occurrence. In the St. Francois, no actual quarry areas have been found, but the main Mill Creek quarry has been excavated and analyzed.

At the Mill Creek quarry area multiple domestic/workshop sites and two mound sites have been associated directly with quarrying and production activity. In contrast, the St. Francois region has very few Mississippian sites and only one site has confirmed ground stone tool production activity. Unlike the Mill Creek area, where hoe production was completed in full in close proximity to the lithic source, production of celt blanks has been confirmed outside of the St. Francois region, to the north in the Big River Valley and to the south at the Shell Lake site.

The archaeological evidence of habitation and production areas in each region is significantly different. There are no long term domestic sites associated with ground stone tool quarrying or production, whereas in the Mill Creek area there are multiple domestic/workshop areas that were inhabited for long periods of time. There is no monumental architecture in the St. Francois, but the small mounds of the Linn and Hale sites are associated with hoe production in the Mill Creek area.

The nature of ground stone tool production in the St. Francois is a quite different from Mill Creek chert hoe production. At Mill Creek sites, autonomous villagers completed the entire process of hoe production at long term domestic sites and were free to trade their product without the restriction of a centralized power. In the St.

Francois, quarrying and primary shaping of axe-head blanks was done at temporary seasonal camps prior to being exported to the American Bottom for completion.

Once celt blanks reached the American Bottom, secondary shaping and finishing processes were completed at major mound and village centers, as well as farmstead sites in the hinterlands. All production of axe-heads within the American Bottom was probably done under the influence of elite labor. At this point, no evidence of secondary ground stone tool production done on St. Francois rock has been found outside of the American Bottom. Currently, it is unclear if this is because all secondary production was being done in the American Bottom, or if evidence of secondary production is not being recognized at sites outside the Confluence Region because of the ephemeral nature of the debitage produced during the secondary pecking and grinding phases.

Both ground stone axe-heads and chipped stone hoes are found deposited into caches. Mill Creek hoes are found in caches at mound centers across the Mississippian sphere, whereas St. Francois axe-heads are only found in caches within the American Bottom. Cobb (2000) sees most caches of Mill Creek tools as functional storage deposits prior to redistribution. Pauketat and Alt (2004) see American Bottom caches of ground stone tools as being symbolic rather than functional.

The presence of Mill Creek chert hoes is ubiquitous throughout Mississippian sites in the Confluence Region. This study (in conjunction with Amanda Butler's 2011 sourcing study) has proven that axe-heads made of St. Francois mafic stone may be more common in Mississippian assemblages than previously thought.

Overall, Cobb's model of the political economy of Mill Creek chert is unable to explain the production, distribution, and consumption of tools made from St. Francois rock. Nevertheless, it does provide a solid, testable model. I think that with further research into the nature of domestic sites in the St. Francois and the extent of trade of tools with a St. Francois provenance, Cobb's model could be altered to provide an alternative model that documents the political economy of objects made of St. Francois materials.

Table 3- Summary of artifact provenience for all artifacts sampled.

Archaeological Context *Artifact Type*	**Count**
Cache	
Axe-head	6
House	
Axe Fragment	5
Axe-head	3
Mound	
Axe-head	1
No Feature Context	
Axe Blank Reject	2
Axe Fragment	6
Axe-head	8
Surface	
Axe Fragment	2
Axe-head	3

Figure 11- Chunky stone from Moundville, AL with suspected St. Francois provenance. Geochemical testing on this object is needed to prove this hypothesis.

Figure 12- Mississippian sites where Skrainka diabase has been visually identified.

CHAPTER 7

CONCLUSIONS

My research has demonstrated that some of the axe-heads found at sites across the Confluence Region can be sourced to mafic rock outcrops found in the St. Francois Mountains. This data supplements Amanda Butler's (2011) study, which proved many of the axe-heads within American Bottom caches also came from outcrops in this region. I was unable to either prove or disprove that specific geologic outcrops (for example, the Skrainka diabase formations) are the definitive source for axe-head materials. pXRF provides a detailed enough analysis to make distinctions between some, but not all, outcrops in the St. Francois Mountains (e.g., "snowflake basalt" vs. the Skrainka/Silver Mine cluster).

I compared the production and exchange of axe-heads made of St. Francois materials to Cobb's (2000) model of the political economy of Mill Creek chert hoes. Cobb's model proved inappropriate to explain the political economy of axe-heads sourced to the St. Francois. Although the raw materials for ground stone axes and chipped stone hoes are found in geographically similar regions, they differ fundamentally in extraction processes and the knowledge required for different stages of manufacture.

Mill Creek chert hoes were fully-made in autonomous long-term villages near the Mill Creek chert quarries. What evidence we currently have of St. Francois manufacture suggests that axe-head blanks were made in seasonal camps in the greater St. Francois region, prior to being exported to the American Bottom for completion. It seems that within the American Bottom distribution of axe-head blanks was centrally controlled, but the final completion of axe-heads was done in both urban and hinterlands contexts. From this study, there is no conclusive evidence that can link axe-heads found throughout the Confluence Region to either the American Bottom or St. Francois producers.

Further Research

This thesis may have provided more questions than answers. It is unknown how axe-heads made of St. Francois rock came to be at sites such as Kincaid and Millstone Bluff in Southern Illinois. It could be argued that the axe-heads were redistributed via the American Bottom, but at this time there is no evidence to support such a claim. A technological comparison of Black Bottom and Shawnee Hill axe-heads to those found in the American Bottom may help to answer this question.

Another approach that may help to answer unresolved questions about axe-head production would be a concentrated effort at exploring the archaeology of the St. Francois region. The chronology and site distribution in this area is poorly understood, in part due to its rough and heavily wooded terrain, rural location, and hesitancy of landowners in this area to cooperate with state or federal institutions. It is almost certain that within the St. Francois Mountains there are more sites like Wiegenstein Site #2, where at least the preliminary stages of axe-head production were taking place. A greater understanding of quarrying and production practices in this region would help to solidify a larger-scale model of axe-head production during the Mississippian era.

Lastly, improvements in non-destructive geochemical techniques will be a boon to future researchers examining the provenance of museum-quality specimens, such as the fully formed axe-heads in curation with the MoDOT, Cahokia Mounds Museum, or the Center for Archaeological Investigations. Pauketat and Alt (2004) noted twelve distinct varieties of lithic materials in American Bottom axe-head caches. Butler (2011) sourced most of these axe-heads to the St. Francois Mountains. This study attempted to determine the provenance of the axe-heads *within* the St. Francois. Unfortunately, the instrumentation used did not have a refined enough sensitivity to discriminate between all outcroppings. Specifically, the geochemistry of the Skrainka and Silver Mine suites was too similar to pinpoint either set of outcroppings as an individual source for axe-head material. When non-destructive techniques are more fully developed, researchers will have a better understanding of where axe-head materials were being sourced. This could aid in localizing future archaeological expeditions within the St. Francois.

Further research into the archaeology of the St. Francois, non-destructive provenance methods, and the greater distribution of objects made of St. Francois stone would be required to create a model that can explain the political economy of axe-heads found in the Confluence Region.

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APPENDICES

APPENDIX A- Detailed Provenience of Artifacts

Site	**Sample No.**	**Context**	**Unit**	**Level**	**Feature**	**Bag No.**	**Artifact No.**	**Other Information**
Grossman Cache								
	GC_1	Cache Pit					206-1-47	
	GC_2	Cache Pit					206-2-18	
	GC_3	Cache Pit					206-2-29	
	GC_4	Cache Pit					206-2-50	
	GC_5	Cache Pit					206-2-64	
	GC_6	Cache Pit					206-2-68	
Black Bottom Region								
	K_6	General Surface						
	K_7	General Surface						
	K_8	General Surface						
	K_9	General Surface						
	LL_1	General Surface						
Kincaid								
	K_1	MxV1E	E542 N360	1 PZ		116		
	K_2	MxV1E			8	177		
	K_3	Kincaid NW	E43 N339	4	1	25		
	K_4	Mx^{0}8	E685 N300	7		74		
	K_5	West mound	E05 N47		23 E 1/2	166		

APPENDIX A- Continued

Site								
	Sample No.	Context	Unit	Level	Feature	Bag No.	Artifact No.	Other Information
Millstone Bluff (11Pp3)								
	MB_1		55		98	169		N237 E210
	MB_2		18	4		181		
	MB_3		18	4		180		
	MB_4		27	1		48		N227E180
	MB_5		40	2 W1/2		53		N233E190
	MB_6		40	2 W 1/2		54		N233E190
Hayes Creek (11Pp199)								
	HC_1		13					
23Sg77								
	MO_2			20 cmbs				Shovel Test 4
23Sg4								
	MO_4		2	2			16	
	MO_5		2	2			15	
Wiegenstein Site #2 (23Mo1252)								
	MO_1		1	2			10	
	MO_3		1	5			13	
	MO_6			0-40 cmbs			18	Trench 1
	MO_7			0-40 cmbs			21	Trench 2
	MO_8						26	Trench 6
	MO_9						27	Trench 7
	MO_10						28	Trench 8
	MO_11						29	Trench 19
	MO_12						30	Trench 10

APPENDIX A- Continued

APPENDIX A- Continued

Site	**Sample No.**	**Context**	**Unit**	**Level**	**Feature**	**Bag No.**	**Artifact No.**	**Other Information**
	MO_13						34	Trench 34
	MO_14		2	7			45	
	MO_15		4	8			66	
	MO_16		6	1			80	
	MO_17		6	4			85	
	MO_18		6	6			89	
	MO_19		7	2			9	
	MO_20		1	1			9	
	MO_21		1	1				
	MO_22						67-b	
Bundy Site (23Pi77)								
	MO_23				95	384-C	B-1	
Bonaker Site (23Je400)								
	MO_24							
	MO_25	House Basin				831		House 10
	MO_26	House Basin				831		House 10
Hunter Site (23We262)								
	MO_27		4	3 (20-30 cmbs)			122	

APPENDIX B- Artifact Descriptions

Site	Sample No.	Artifact Type	Suspected Material Type	Context
Grossman Cache				
	GC_1	Axe-head	Snowflake	Cache
	GC_2	Axe-head	Snowflake	Cache
	GC_3	Axe-head	Snowflake	Cache
	GC_4	Axe-head	Snowflake	Cache
	GC_5	Axe-head	Snowflake	Cache
	GC_6	Axe-head	Snowflake	Cache
Black Bottom Region				
	K_6	Axe-head	Unknown	Surface
	K_7	Axe-head	Unknown	Surface
	K_8	Axe-head	Unknown	Surface
	K_9	Axe Fragment	Unknown	Surface
	LL_1	Axe Fragment	Unknown	Surface
Kincaid				
	K_1	Axe-head	Unknown	House
	K_2	Axe-head	Unknown	House
	K_3	Axe Fragment	Hillabee Schist	House
	K_4	Axe-head	Skrainka?	Mound
	K_5	Axe Fragment	Unknown	House
Millstone Bluff (11Pp3)				
	MB_1	Axe Fragment	Unknown	House
	MB_2	Axe-head	Unknown	Unknown
	MB_3	Axe Fragment	Unknown	Unknown
	MB_4	Axe-head	Unknown	Unknown
	MB_5	Axe-head	Unknown	No Feature Context
	MB_6	Axe-head	Unknown	No Feature Context
Hayes Creek (11Pp199)				
	HC_1	Axe-head	Unknown	Unknown
23SG77				
	MO_2	Axe-head	Unknown	No Feature Context
23Sg4				
	MO_4	Axe Fragment	Unknown	No Feature Context
	MO_5	Debitage	Unknown	No Feature Context
Wiegenstein Site #2 (23Mo1252)				
	MO_1	Axe Blank Reject	Skrainka	No Feature Context
	MO_3	Debitage	Skrainka	No Feature Context

APPENDIX B- Continued

Site	Sample No.	Artifact Type	Suspected Material Type	Context
	MO_6	Axe Fragment	Skrainka	No Feature Context
	MO_7	Debitage	Diorite	No Feature Context
23Mo1252 (Continued)				
	MO_8	Debitage	Skrainka	No Feature Context
	MO_9	Debitage	Skrainka	No Feature Context
	MO_10	Debitage	Rhyolite	No Feature Context
	MO_11	Axe Fragment	Skrainka	No Feature Context
	MO_12	Debitage	Skrainka	No Feature Context
	MO_13	Axe Fragment	Rhyolite	No Feature Context
	MO_14	Debitage	Unknown	No Feature Context
	MO_15	Debitage	Skrainka	No Feature Context
	MO_16	Debitage	Skrainka	No Feature Context
	MO_17	Debitage	Skrainka	No Feature Context
	MO_18	Axe Blank Reject	Skrainka	No Feature Context
	MO_19	Debitage	Diorite	No Feature Context
	MO_20	Debitage	Skrainka	No Feature Context
	MO_21	Debitage	Unknown	No Feature Context
	MO_22		Unknown	No Feature Context
Bundy Site (23Pi77)				
	MO_23	Axe-head	Unknown	Unknown
Bonaker Site (23Je400)				
	MO_24	Axe Fragment	Skrainka	No Feature Context
	MO_25	Axe Fragment	Skrainka	House
	MO_26	Axe Fragment	Skrainka	House
Hunter Site (23We262)				
	MO_27	Axe-head	Skrainka	No Feature Context

APPENDIX C- Geologic Sample Locations

Material Sample No.	**Location**
Skrainka Diabase	
CapCrk1	Streambed at Captains Creek and Hwy O; Madison Co., Mo
CapCrk2	Streambed at Captains Creek and Hwy O; Madison Co., Mo
Mstream1	Outcrop at the field archery range at the Millstream Gardens Conservation Area; Madison Co., MO
RtH1	Outcrop along state Route H; Madison Co. MO
RtE1	State route E- road embankment; St Francis River Bridge
Silver Mines Area Basalt	
Silver1	Center of large dike, left bank St. Francis River at Silver Mines Dam; Madison Co., MO
Silver2	Small dike, left bank St. Francis River at silver Mines Dam; Madison Co, MO

APPENDIX D- Elemental data from pXRF in net photons

SAMPLE #	Ca K12	Cr K12	Cu K12	Fe K12	Ga K12	K K12	Mn K12	Nb K12	Ni K12	Pb L1	Pb M1	Pd K12	Pd L1	Rb K12	Rh K12	Rh L1	Sn K12	Sn L1	Sr K12	Ti K12	V K12	Y K12	Zn K12	Zr K12
GC_1	5825	80	573	218136	178	173	1910	383	385	170	281	24384	589	315	4570	20	2145	0	7794	4007	262	922	707	5255
GC_1	7259	262	723	163078	129	109	1728	161	547	56	223	24770	537	356	4303	14	2485	9	8256	2307	252	886	715	4655
GC_1	7869	369	679	126007	161	151	1504	66	285	136	128	23998	429	297	4290	58	2489	16	7768	1935	149	591	567	3105
GC_2	6110	120	614	203469	128	327	2341	520	425	109	172	24533	578	609	4421	16	2403	0	9123	3507	322	1094	754	5465
GC_2	6142	143	677	202493	192	328	2385	423	414	162	93	24116	505	732	4491	1	2473	4	9113	3389	248	969	811	5278
GC_2	6416	75	646	191153	172	328	2238	427	431	221	252	24684	514	724	4411	1	2287	0	10102	3313	201	1008	864	5759
GC_3	5676	150	802	195573	155	213	2225	244	399	205	173	24910	554	618	4803	1	3124	0	7611	3590	338	794	899	4779
GC_3	5890	156	715	174933	220	219	2007	267	394	159	287	24563	593	470	4546	72	2018	13	8322	3680	188	822	867	5401
GC_3	5861	245	616	167706	144	193	1921	222	278	181	207	23793	476	409	4638	1	2110	1	7188	2777	177	757	775	4424
GC_4	6840	221	714	189594	129	209	2185	253	415	116	228	24913	541	710	4546	4	2316	7	7223	3282	327	816	843	4163
GC_4	6800	277	620	172175	129	202	2222	330	446	98	185	24078	506	857	4097	1	2057	0	8195	3374	263	742	736	3561
GC_4	6163	36	689	177520	232	226	2173	308	362	169	215	24257	578	751	4350	1	2378	28	7504	3908	334	845	965	4465
GC_5	6765	174	685	171945	171	403	1900	297	368	139	149	24665	541	947	4880	1	2092	0	7459	3621	289	829	707	4391
GC_5	6179	194	672	162163	185	311	1926	387	337	118	256	24094	519	992	4268	1	2376	0	6749	3974	375	684	711	3785
GC_5	5932	286	731	145973	178	393	1658	193	363	69	134	23934	471	1116	4214	1	2222	0	6694	2828	180	794	689	3374
GC_6	5349	246	779	165491	154	294	1718	300	345	60	146	23838	446	624	4079	1	1997	0	7115	3075	323	824	704	4525
GC_6	4954	207	754	172520	116	327	1703	368	330	168	171	22918	570	709	4203	1	2033	0	5954	3264	277	1029	758	4668
GC_6	4138	116	770	193572	137	272	1944	554	373	170	118	23305	375	766	4017	9	2225	34	5407	3461	233	873	940	5881
CapCrk1	7464	54	667	108419	196	252	1876	296	70	148	183	23582	478	863	3319	3	2282	5	20192	1889	201	1595	580	8879
CapCrk1	3604	18	632	116093	222	248	1351	192	105	323	290	23595	406	838	3435	20	2323	0	18403	1241	123	1397	576	10232
CapCrk2	3255	91	543	67030	182	397	864	273	159	247	284	23842	521	1225	4096	1	2007	4	23435	3866	245	1108	338	6350
CapCrk2	2209	48	558	142947	178	393	2235	128	75	323	287	24542	561	840	3883	1	2447	0	20995	1883	148	520	533	4873
MStream1	5545	77	926	122192	139	74	1501	174	362	162	298	23444	517	263	4066	1	2135	52	21981	2443	126	593	480	2443
MStream1	4015	102	761	118566	189	98	1419	165	256	116	246	22707	434	413	3350	1	2180	-1	20493	3091	254	563	403	3313

APPENDIX D- Continued

SAMPLE #	Ca K12	Cr K12	Cu K12	Fe K12	Ga K12	K K12	Mn K12	Nb K12	Ni K12	Pb L1	Pb M1	Pd K12	Pd L1	Rb K12	Rh K12	Rh L1	Sn K12	Sn L1	Sr K12	Ti K12	V K12	Y K12	Zn K12	Zr K12
RtH1	6782	130	1075	100181	197	149	1187	59	373	143	195	25106	499	272	4376	93	2638	11	24565	2565	241	495	405	2168
RtH1	5779	164	823	106038	201	109	1297	-2	275	149	279	23947	438	367	3630	70	2386	0	23549	2386	200	365	377	2239
RtE1	3565	124	720	241061	152	661	3830	179	336	450	134	22229	502	2301	4309	23	2454	0	6193	6532	520	713	1562	6665
RtE1	3664	239	812	173718	148	376	2744	268	318	491	233	21954	424	2098	4026	1	2341	0	11805	4189	422	660	1533	4815
RtE2	4377	19	878	191241	122	480	3113	134	389	532	275	23089	607	2249	4736	62	2130	0	12700	4490	226	618	1538	5389
RtE2	2367	2	772	157235	164	326	2409	190	311	330	141	19330	433	1827	2792	1	1689	34	6153	3957	356	514	1401	4273
RtE2	2922	135	785	191041	155	548	2899	113	387	363	169	20440	433	2054	3160	1	1996	0	7287	4807	290	615	1436	5593
Silver1	6522	133	841	166399	139	181	1652	137	193	188	209	24024	577	1141	4264	1	2357	2	20087	3744	283	757	763	2101
Silver1	2927	117	628	79905	106	51	818	27	88	194	117	17062	438	643	1986	13	1725	1	11561	1776	172	310	362	1081
Silver2	1922	186	1039	131099	185	481	2627	482	233	711	197	24730	572	2536	3946	1	2603	0	20744	2303	164	654	994	5566
Silver2	4384	161	839	109166	158	421	1242	322	154	443	138	23711	518	2135	4013	1	2620	0	18756	2138	301	474	743	4187
HC_1	5181	148	691	193899	198	521	3280	229	287	338	232	24161	479	2035	4170	12	2100	0	16546	4781	282	1030	1006	6434
HC_1	2768	136	580	141448	111	420	1908	183	242	116	234	21035	451	1956	3481	53	1820	12	11960	2558	215	592	588	3704
K_1	5223	142	631	160014	228	598	2070	238	312	353	161	25351	364	3952	4291	1	2111	18	16360	3891	297	866	1101	7301
K_1	6041	169	601	179753	229	665	2450	306	297	274	238	25671	524	4966	4656	1	2635	1	17372	5961	487	741	1990	5432
K_2	7382	79	627	158836	151	448	2095	116	287	166	267	25081	525	1617	4301	1	2440	1	20926	4788	364	919	575	4300
K_2	7129	142	627	163842	165	428	2168	259	275	103	155	25298	442	1656	4932	1	2353	4	20205	4539	354	798	651	5247
K_2	6828	408	701	161426	164	41	2242	224	201	115	196	26084	578	16	4697	38	2715	0	3335	2401	101	885	874	3463
K_3	7957	416	1578	172194	125	26	2398	263	170	173	182	26480	605	76	4868	1	2301	0	4152	2193	155	682	1204	2902
K_3	8386	351	740	159598	99	1	2217	302	316	169	298	25948	543	60	4377	1	3179	22	6968	2694	332	1043	674	3406
K_4	7655	409	623	151769	142	45	2194	204	201	119	177	25451	468	45	4353	1	2321	15	6442	2135	164	875	591	2986
K_4	8385	491	692	150501	177	30	2038	165	291	120	352	25779	517	85	4414	1	2597	-9	7142	2378	329	1070	701	3281
K_5	5851	144	668	156420	151	414	1874	354	140	292	175	25646	534	2061	4686	30	2368	0	27332	4594	341	681	895	4500
K_5	5451	141	684	136523	203	566	1707	369	199	248	126	26057	601	2100	4781	23	2689	0	28286	3942	367	711	926	4652
K_6	6955	130	783	187440	182	565	2325	757	127	120	285	24279	584	1077	4795	1	2282	0	8747	3702	361	1161	819	7685

APPENDIX D- Continued

SAMPLE #	Ca K12	Cr K12	Cu K12	Fe K12	Ga K12	K K12	Mn K12	Nb K12	Ni K12	Pb L1	Pb M1	Pd K12	Pd L1	Rb K12	Rh K12	Rh L1	Sn K12	Sn L1	Sr K12	Ti K12	V K12	Y K12	Zn K12	Zr K12
K_6	7580	154	635	186857	186	320	2393	708	151	57	293	24191	475	843	4634	1	2266	26	8135	3719	310	881	767	6599
K_7	5618	159	731	169649	191	539	2002	402	212	258	247	25546	469	1436	4431	1	2183	0	27728	4967	421	926	935	5703
K_7	5877	119	683	168595	202	597	2043	289	150	371	282	25391	600	1521	4268	1	2685	0	29644	4577	386	915	924	4883
K_8	6254	116	845	184497	246	719	2336	419	80	215	228	23931	459	2321	4293	1	2335	0	9086	3999	425	1071	1001	5475
K_8	6675	45	925	180477	144	588	2234	584	84	289	96	23628	432	1825	4741	1	2231	0	8410	3634	466	1053	1069	5736
K_9	5503	123	903	134767	231	635	1639	427	219	257	168	26371	465	1050	4901	1	2576	12	45684	4950	458	864	1040	7669
K_9	5486	144	824	145440	196	626	1772	462	242	175	135	26111	536	1041	4136	1	2455	0	41915	4964	525	893	1120	7303
LL_1	6320	182	810	177638	204	469	2308	240	291	185	192	24974	562	1960	4880	1	2021	0	19335	5323	394	857	997	5906
LL_1	6452	181	756	170311	221	382	2021	163	294	216	248	25239	420	2087	4781	1	2479	0	20738	5042	452	804	855	5125
LL_2	5858	190	716	160146	198	493	1996	191	164	271	123	26167	492	1503	4285	9	2136	0	19101	4233	379	1032	1364	6075
LL_2	6002	85	736	162613	140	440	1964	320	272	187	278	26546	569	1657	5084	0	2546	0	18173	4577	220	945	1318	6083
MSB_1	5773	100	1468	181656	100	84	2277	277	150	113	128	25698	612	116	3998	40	2600	0	3284	1877	255	873	1794	1516
MSB_1	5195	110	1175	171007	174	57	2168	311	119	189	284	25239	548	201	4608	1	2032	-2	3533	794	141	698	2039	1999
MSB_1	5478	126	768	148290	256	740	1637	236	308	221	253	26569	540	2891	4662	1	2418	0	21750	4018	403	869	641	4853
MSB_2	4909	40	746	171887	232	580	1936	261	238	251	358	24812	603	2731	4442	1	1796	19	20491	5875	502	824	596	5127
MSB_2	3932	199	725	128014	202	341	1687	275	194	145	282	25896	495	1648	4098	1	2616	8	31503	3020	213	719	748	5099
MSB_3	3712	234	750	116975	243	424	1451	170	166	243	175	25031	538	1460	4035	0	2317	0	30962	2656	222	687	680	4879
MSB_3	7081	142	722	103537	183	547	1627	24	131	133	298	27518	561	2922	4462	41	2388	3	21745	1092	139	435	605	1729
MSB_4	7024	90	741	110316	179	408	1441	229	32	255	297	27608	555	3110	4182	21	2690	0	21482	996	157	498	691	2110
MSB_4	7098	61	706	115355	197	338	1535	13	76	138	238	27579	588	2643	4634	1	2222	1	20731	1231	1	416	592	1713
MSB_5	10046	119	644	114551	136	1	2052	54	274	288	199	28391	636	129	5381	60	3060	35	3307	519	126	366	398	870
MSB_5	9445	210	699	120893	99	19	2003	124	261	197	304	26948	465	195	4531	0	2637	10	2806	706	127	253	1190	666
MSB_6	9596	326	700	115262	72	139	1940	268	354	111	318	28360	465	100	4533	1	2524	1	2168	586	49	358	611	687
MSB_6	9648	421	765	107909	153	4	1873	88	201	41	204	27826	440	242	4883	1	3076	44	2514	510	81	298	1738	504
MO_1	4426	79	618	148988	165	362	1958	268	318	260	157	22484	554	2377	3922	1	2106	6	15181	3523	255	747	573	4509

APPENDIX D- Continued

SAMPLE #	Ca K12	Cr K12	Cu K12	Fe K12	Ga K12	K K12	Mn K12	Nb K12	Ni K12	Pb L1	Pb M1	Pd K12	Pd L1	Rb K12	Rh K12	Rh L1	Sn K12	Sn L1	Sr K12	Ti K12	V K12	Y K12	Zn K12	Zr K12
MO_1	4281	109	776	151011	230	389	1808	199	272	228	98	23576	415	2428	4080	21	2280	29	15094	3740	328	718	571	4619
MO_2	3794	151	642	152088	134	368	3062	343	333	280	116	23776	489	2161	3872	1	2169	-1	16725	4126	266	927	720	5181
MO_2	4258	59	624	155218	154	260	1924	233	395	245	341	23222	443	1711	3982	29	2048	0	15742	4151	344	901	604	5630
MO_3	4391	121	676	129893	161	331	1419	226	173	196	226	21476	440	1763	3752	1	2027	0	15250	3594	273	935	726	5130
MO_3	5025	76	681	166088	199	581	1918	309	209	109	104	23846	513	2087	4034	1	2558	0	17261	6135	415	1306	816	7499
MO_4	3625	115	712	128553	146	249	1523	202	293	162	182	21688	466	1096	3550	1	1841	0	16113	2620	266	751	462	4224
MO_4	5586	125	739	132520	216	518	1690	283	203	229	203	24550	474	1494	4472	1	2376	0	21392	2900	171	788	475	4893
MO_5	6215	94	750	183771	158	482	2287	173	375	404	202	24908	469	1318	4548	1	2468	0	20256	3257	221	833	1758	4942
MO_5	5942	125	702	181942	170	493	2225	91	397	452	109	24448	515	1406	4157	27	2196	6	18582	4038	310	613	1962	3695
MO_6	4568	125	716	132234	232	557	1695	371	161	153	166	25566	392	1179	4491	1	2436	3	40951	4830	351	987	947	7493
MO_6	3573	169	653	129070	248	641	1610	484	191	190	169	24291	431	960	3771	82	1944	0	34848	3566	228	891	1037	7823
MO_7	4659	134	671	149271	173	235	1745	474	163	336	179	23569	494	1355	3852	71	2148	0	24031	3756	249	663	772	4288
MO_7	3443	240	820	207468	153	321	2860	327	359	509	392	24074	469	1193	4201	1	2159	0	16595	5305	415	579	1303	5146
MO_8	5932	164	691	195217	190	365	2288	477	415	251	242	25667	522	2178	4514	1	2223	0	25743	5503	309	792	773	5307
MO_8	6103	106	632	186380	142	324	2349	248	278	150	245	25115	498	1660	4700	1	2768	0	25113	3936	279	946	758	6319
MO_9	4674	42	714	170755	279	517	2128	182	238	243	122	24369	487	1820	4145	25	2060	0	17344	4788	291	813	574	5247
MO_9	3445	288	751	168172	115	334	2048	198	271	241	172	22217	483	1441	4059	1	2280	0	13244	4530	426	701	610	5204
MO_10	4392	123	613	162124	220	369	2656	149	224	255	150	23894	504	2632	4160	1	2158	0	16326	4545	406	623	645	5245
MO_10	4316	95	691	158601	193	370	2306	230	315	245	281	23280	494	2538	3985	1	2328	0	15193	4875	402	707	578	4731
MO_11	126	78	715	39872	219	1567	661	1288	66	300	306	33881	583	7394	5035	1	3473	36	889	453	57	2883	264	28239
MO_11	2	60	652	25953	250	1021	480	1409	61	224	235	27442	510	5586	3341	1	2891	54	645	561	35	2081	281	21608
MO_12	4444	315	684	144677	208	450	1891	312	260	339	205	26822	496	1823	4588	2	2477	0	16851	2395	216	735	807	3778
MO_12	4922	136	741	150129	172	568	1852	101	245	391	197	27351	525	2146	4902	16	2841	0	18080	2456	150	595	787	3979
MO_13	4493	136	650	131356	119	244	1447	273	139	283	275	22894	493	1442	4054	1	2416	0	26607	3196	293	527	658	3954
MO_13	4534	189	697	127378	135	266	1466	377	158	165	295	23732	480	1346	4301	1	2367	0	26670	3432	230	687	687	4050

APPENDIX D- Continued

SAMPLE	Ca	Cr	Cu	Fe	Ga	K	Mn	Nb	Ni	Pb	Pb	Pd	Pd	Rb	Rh	Rh	Sn	Sn	Sr	Ti	V	Y	Zn	Zr
#	K12	K12	K12	K12	K12	K12	K12	K12	K12	L1	M1	K12	L1	K12	K12	L1	K12	L1	K12	K12	K12	K12	K12	K12
MO_14	81	83	760	57608	239	1121	1261	1078	37	199	251	33312	523	5677	4390	1	3707	1	1052	313	1	2793	575	24554
MO_14	240	130	805	55695	283	1269	1446	1120	73	336	334	32606	594	5588	4597	1	3162	0	1617	272	1	3393	547	24792
MO_15	3460	208	746	196486	152	386	2007	145	155	321	156	23138	420	992	3841	96	2223	0	15962	4673	561	402	938	3228
MO_15	4684	248	772	219798	186	472	2480	301	236	394	198	24634	434	1131	4714	1	2621	0	18875	5232	292	481	959	3643
MO_16	1786	77	633	220090	149	735	6225	345	326	536	228	23193	578	3230	3835	1	2033	1	14992	6609	495	792	1238	5602
MO_16	4953	125	706	138563	239	390	1788	348	154	212	364	24009	436	1910	3913	50	1888	0	26546	3824	444	727	680	4444
MO_17	5419	123	679	184584	197	473	2343	202	237	280	229	24554	524	2826	4174	1	2230	1	14460	4727	404	603	717	5447
MO_17	4117	141	624	168058	151	394	2333	150	296	203	218	23710	530	2516	4310	1	2479	0	13068	4460	347	743	673	5335
MO_18	5590	73	709	175746	223	504	2066	136	351	227	219	24984	518	2631	4592	22	2257	15	17783	4453	294	764	568	5244
MO_18	4784	152	640	169322	137	308	2146	259	276	154	144	23514	459	2441	3987	44	2248	-1	16500	4588	336	725	581	4868
MO_19	3481	65	723	140624	186	447	2109	168	209	347	182	22811	457	3234	4073	21	1890	0	17369	4225	201	514	557	5196
MO_19	4055	123	712	140834	123	539	2187	124	283	197	319	23063	434	3439	3509	0	1767	0	17433	4401	309	561	565	4376
MO_20	3573	105	788	152522	176	270	2864	161	370	269	226	21832	509	1811	2937	2	1920	19	14970	3905	330	653	715	4057
MO_20	3654	191	641	135854	129	224	2160	96	369	351	98	22396	408	1957	4075	39	2096	6	15845	3359	289	591	551	3508
MO_21	4786	56	823	191680	170	492	2352	298	303	299	156	23157	449	2343	4358	81	1935	0	15150	5622	524	636	682	4976
MO_21	5079	85	587	179059	196	429	1956	168	358	192	296	23638	443	2577	4252	9	2137	1	16925	4056	200	618	689	4760
MO_22	2042	170	985	111666	233	908	1565	730	179	303	240	31483	510	2689	4676	68	2899	1	27640	2403	333	927	945	15414
MO_22	1831	77	868	104751	236	752	1434	689	117	401	323	29623	508	2397	4031	8	2590	0	23900	2257	164	960	975	15033
MO_23	7850	310	800	175770	100	142	5054	249	215	187	323	24425	542	447	4536	1	2595	68	4546	2070	314	595	863	2380
MO_23	8791	266	680	172093	127	153	2052	262	165	222	262	25003	488	446	4518	1	2281	32	5095	2444	288	766	706	2828
MO_24	5009	133	631	167093	159	265	2252	464	217	192	343	26974	579	1595	4732	1	2743	0	24736	3104	237	1061	963	5381
MO_24	1511	105	617	100746	118	529	1131	248	114	372	137	22321	500	1599	3294	1	2068	1	16254	1684	149	986	623	5721
MO_25	8240	98	686	179436	173	148	2367	469	95	80	199	24494	507	651	4232	1	2532	19	6687	3705	356	986	575	4030
MO_25	8383	125	706	172665	119	177	2274	332	111	131	276	24613	613	673	4805	1	2287	0	6379	2040	124	772	635	2881
MO_26	7280	231	685	158411	125	253	2260	320	119	180	355	24565	567	850	4152	17	2700	0	7216	2485	313	758	625	3493

APPENDIX D- Continued

SAMPLE #	Ca K12	Cr K12	Cu K12	Fe K12	Ga K12	K K12	Mn K12	Nb K12	Ni K12	Pb L1	Pb M1	Pd K12	Pd L1	Rb K12	Rh K12	Rh L1	Sn K12	Sn L1	Sr K12	Ti K12	V K12	Y K12	Zn K12	Zr K12
MO_26	8103	119	723	170259	139	327	2184	277	152	213	186	26054	550	911	4651	27	2316	0	7074	2121	265	791	634	3686
MO_27	4055	75	932	140491	168	415	3091	173	332	362	242	23466	517	1420	4280	1	2402	0	15846	3248	274	736	909	4655
MO_27	5325	68	718	185284	204	356	4072	258	303	353	174	25457	553	1214	4347	26	2457	1	16959	4698	454	721	920	4936

APPENDIX E- First Principal Components Scores

Communalities

	Initial	Extraction
og	1.000	.685
og	1.000	.751
log	1.000	.739
og	1.000	.883
og	1.000	.742

Component Matrix

	Component	
	1	2
og	.638	.527
og	.516	.696
og	.772	-.378
og	.939	-.044
og	.541	-.670

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.444	48.874	48.874	2.444	48.874	48.874
2	1.356	27.126	75.999	1.356	27.126	75.999
3	.528	10.570	86.569			
4	.494	9.888	96.457			
5	.177	3.543	100.000			

APPENDIX F- Second Principal Components Scores

Communalities

	Initial	Extraction
og	1.000	.571
og	1.000	.728
og	1.000	.597
og	1.000	.581
og	1.000	.618
og	1.000	.777
og	1.000	.762
og	1.000	.685
og	1.000	.833
og	1.000	.755

Component Matrix

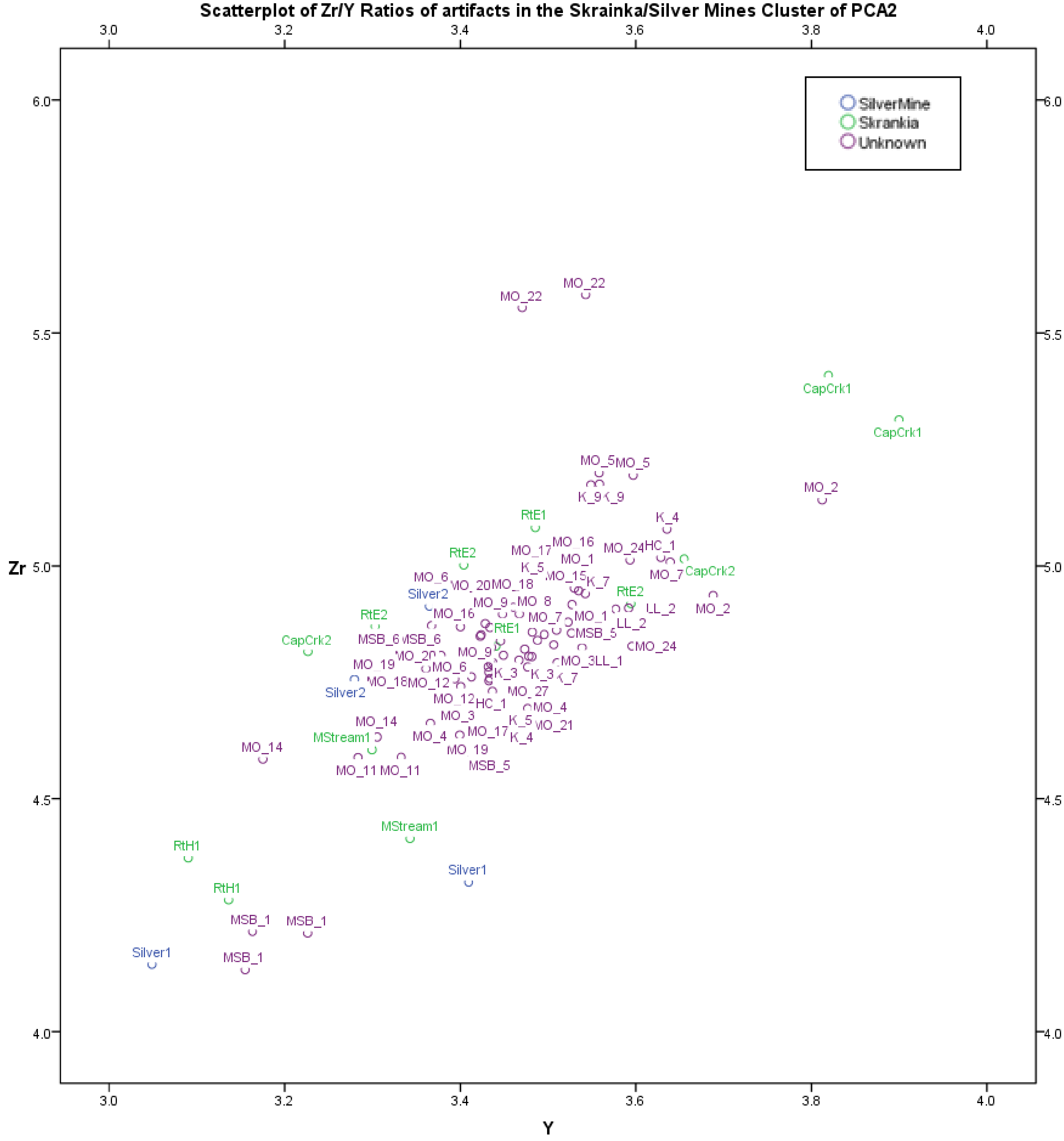
	Component		
	1	2	3
og	.349	.521	.423
og	.346	.775	.083
og	.623	.388	.240
og	.540	.506	-.183
og	.746	-.153	.196
og	.626	-.282	.552
og	.251	-.761	.346
og	.619	-.237	-.495
og	.728	-.523	-.171
og	.631	.072	-.593

APPENDIX F- Continued

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.244	32.438	32.438	3.244	32.438	32.438
2	2.296	22.961	55.399	2.296	22.961	55.399
3	1.366	13.664	69.063	1.366	13.664	69.063
4	.875	8.751	77.814			
5	.669	6.694	84.509			
6	.537	5.372	89.880			
7	.354	3.543	93.424			
8	.307	3.065	96.489			
9	.240	2.404	98.893			
10	.111	1.107	100.000			

APPENDIX G- Relationship between Zr and Y in the “green” cluster of PCA 2



APPENDIX H- Maps of Skrainka and Silver Mine Geologic Sample Sources

VITA

Graduate School

Southern Illinois University

Rosanna Y. Crow

rosanna.crow@gmail.com

University of North Carolina, Chapel Hill

Bachelor of Arts, Archaeology with Honors and Anthropology, May 2011

Special Honors and Awards:

SIUC Department of Anthropology Rice Graduate Research Award, 2013

Thesis Title:

Axe-Heads and Mississippian Political Economy: A St. Francois Provenance Study

Major Professor: Paul D. Welch

Publications:

2013 The Kincaid Archaic. Dr. Brian Butler, senior author. *Illinois Archaeology.* Vol.25: 106-140.