LANDSCAPE MODIFICATION AT MOUNDVILLE:

AN ENERGETICS ASSESSMENT OF

A MISSISSIPPIAN POLITY

by

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A DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Anthropology
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2009

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ACKNOWLEDGMENTS

This research was made possible by several people whom without them, the project would not have been possible. I would like to thank my family for guidance and support. Also a special thanks to my love, Sarah. I would also like to extend my appreciation to my advisor Dr. Jim Knight for direction, support, and for always being there.

Thanks in particular to Dr. Graettinger for assisting me in learning more about his discipline. Without his generosity and excitement about working with someone outside his own field, the geotechnical engineering procedures and energy assessment of the dissertation would never have existed. I am also grateful to the other committee members, Dr. Blitz, Dr. Dressler, and Dr. Jacobi. In addition, I would like to thank Dr. Bindon, though not a committee member, for assisting me in the formulation and defense of the project.

Special thanks to Mary Bade and Mike Dressler at the Alabama Museum of Natural History for helping me track down old maps and dusty pictures. I would also like to extend my gratitude to Eugene Futato and the Office of Archaeological Research in Moundville, Alabama for information and support in my fieldwork. Also from OAR, I specifically wish to thank John Lieb for helping photograph the original Jones and Sons topographic map from 1930. In tracking down further maps, I would also like to extend my appreciation to Joseph Giliberti of the U.S. Corps of Engineers for helping me secure additional maps of the Moundville site.

I also wish to thank Sarah and James Caldwell, the Department of Anthropology of the University of Alabama, and the College of Arts and Sciences of the University of Alabama for their financial support.

Excavations at Moundville were completed largely by the efforts of friends, students, and enthusiasts, who willingly gave up their weekends. Three ladies in particular, Jennifer Gault, Ann Marshall, and Erin Phillips, donated several weekends for no pay except cold-cut sandwiches, Oreos, and the pursuit of knowledge, but mostly I think it was the Oreos. Thank you ladies and I hope one day I can return the favor. I also would like to send a special thank you to Tom Lewis who assisted in the auger testing and contour mapping of parts of the plaza.

Several other volunteers were essential to the planning and excavation stages of this research. I would like to thank my fellow graduate comrades as well as the undergraduates searching for the proverbial extra credit. These wonderful people are listed below: Thanks again. Sarah Szurek, Tom Lewis, Shauna McDaniel, Candice Griffin, Ashley Atkins, Lauren Downs, James Galbreath, Stephanie Castro, Brooke Persons, Andrea Adams, Daniel LaDu, Andrew Scruggs, Steven Meredith, Ashley Dumas, Treveor Clarke, Matthew Griffin, Krista Garcia, Anna Rich, Hood Mullican, Teresa Ingalls, Kim Vasut, Lynn Funkhouse, Daniel Martinez, Jennifer Clinton, Justin Nance, Jessica Brown, Matthew Trammell, Chase Fraley, Charles Greenlaw, Matthew Collins, Hannah Box, Kate Joseafiak, Beau Brown, Brittany Magee, Davis Simmons, Helen Barnes, Cathie Jerry, Mark Lent, Grace Fleming, Bobby Jagoe, Chase Kolaczek, Angela Fabrizi, and Colonel Frank Atkin.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

In this dissertation, I attempt to quantify the amount of human energy employed in earthen monumental construction at the Moundville polity in west-central Alabama, as a means of exploring the organizational variability of the control of surplus labor and material resources in an emerging complex society. To help reconstruct the scale of sociopolitical differentiation invested in mound building, I create an assessment that calculates the energy necessary to excavate, transport, and compact mound and plaza soils. Theories and methods from other disciplines such as geotechnical engineering, human physiology, human biology, and ergonomics combined with archaeology provide a rational for reformulating the units of measure in energetic studies from person-hours to kilojoules.

The analysis supports a model in which the mounds on Moundville's plaza periphery were constructed using kin-based labor, whereas the mounds on the central axis of the site were constructed using work crews with laborers drawn from the population of the entire polity. This division indicates that while elite power, which was symbolically reinforced through conspicuous consumption of energy in the form of human labor, may have been responsible for the construction of the largest mounds at Moundville, there was still a strong emphasis on kin-based segments in terms of the allocation of labor and material resources.

Chapter 1

Introduction

Elite control over labor is an important factor in the sociopolitical organization of emergent complex societies. Energetics studies of monumental architecture are of benefit to archaeological inquiry because they provide a method of examining how labor and material resources were organized and controlled by ruling elites. Thus architectural energetics (Abrams 1989, 1994) is a tool that can be used in modeling social differentiation as it was reflected in the amount of energy deployed in the building of various monumental forms. According to Abrams (1989:53), “Architecture, by virtue of its capacity to absorb relatively large amounts of energy during production, can hypothetically reflect a significant range of organizational behaviors requisite for such construction, an important index of cultural complexity.”

Currently, there are contrasting sets of theory as to how surplus labor and material resources were organized within emergent complex societies. One theoretical framework suggests that monuments are fundamentally and universally indexes of elite power in societies possessing centralized hierarchical authority, and that elite power was symbolically reinforced through conspicuous consumption of energy as human labor (Trigger 1990). Under this “power perspective,” monuments are viewed as testaments to the ability of a centralized authority in a socially stratified situation, in which the political elites use their coercive power to exert control over surplus food production, to organize material resources, and to amass large quantities of labor for the construction of non-utilitarian projects (Price 1978; Renfrew 1983; Steponaitis 1978; Trigger 1990).

Recently, however, this power perspective as applied to emergent complex societies has been downplayed. Others suggest that sociopolitical differentiation within and between communities is not solely based on social rank or the degree of distinctions between elites and commoners (Blanton et al. 1996; Blitz and Livingood 2004; Brown 2006; Kelly 2006; King 2006; Knight 1998; Sullivan 2006; Welch and Butler 2006). As Brown states (2006:198) there has been an "inclination to seek some hierarchical control behind every engineered construction, a coercive power behind every substantial pile of earth or stack of stone, and an economic pull behind every accumulation of exotic good." Such scholars portray the notion that monuments are symbolic of elite power exercised over a subordinate population as too limiting, ignoring the roles of "heterarchical," horizontal, and communal relationships in constructing accurate narratives of prehistoric societies.

These two competing interpretations of emergent complex societies are embedded in current theories of Mississippian sociopolitical organization. Specifically in the case of Mississippian mounds, mound size has been viewed as a direct reflection of the organizational capabilities of a powerful sociopolitical hierarchy (Steponaitis 1978). In contrast, Muller (1986, 1997), Milner (1998), and Hammerstedt (2004, 2005) have argued that the labor involved in Mississippian mound construction did not necessarily require powerful leadership structures, as it was not as burdensome on the general population as is commonly believed. If the surplus was not organized by elites exercising their power over their subordinates, it is reasonable to conclude that labor and materials resources for mound construction were organized at a kin-based level.

Both top-down political economy perspectives and the recruitment of labor by segmentary kin groups have been previously suggested for the Moundville chiefdom, a Mississippian polity in West-central Alabama. Steponaitis (1978) argued for the existence of a strong hierarchical political leadership at Moundville based on the size and location of outlying single mound centers. The efficient spacing of these single mound centers accompanied by the increasing size of mounds as the distance between the secondary centers and the Moundville polity increased implied the allocation of labor as possible tribute. Others have argued for a strong political hierarchy at Moundville based on food tribute, prestige goods, and the distribution of material resources (e.g., Scarry and Steponaitis 1997; Welch 1996). Based on the elite control over tribute and material resources at Moundville, Welch (1996) suggests that mounds may have belonged to high ranking members of a paramount chief's own kin group, as opposed to the possibility suggested by Knight (1998) that mounds belonged to ranked kin-based social groups. Knight proposed that Moundville's layout represents diagrammatic ceremonial center, and that the plaza periphery mounds were devices for stabilizing societal relationships between ranked kin groups. This would imply that mound construction was organized and executed by segmentary kin groups, not the overseeing elites.

In this dissertation, I attempt to quantify the amount of human energy employed in earthen monumental construction at Moundville, Alabama, as a means of exploring the organizational variability of the control of surplus labor and material resources in an emerging complex society. To help reconstruct the scale of sociopolitical differentiation invested in mound building, I create an assessment that calculates the energy necessary to excavate, transport, and compact mound and plaza soils. I express the results in the form of kilojoules (kJ), as opposed to the traditional unit of measure, person-hours. Based on the energy expended for each monumental form, I address the manner in which power over surplus labor and material resources may have been controlled in a Mississippian (ca. AD 1000 – 1550) polity. Put simply, I attempt to answer the question of whether the Moundville landscape could have been constructed using labor entirely recruited within a segmentary system such as kin groups, or in contrast whether the scale of monument building required some form of political control whose power transcended the level of segmentary kin groups. I assume that if the calculated energy and number of laborers needed to construct a monument exceeds the quantity likely available to an average-sized kin segment, then the organization of labor was probably on a supra-kin basis (Fried 1960), in which case pooled labor was extracted from the entire polity.

Analytical Approaches to Monumental Architecture

The correlation between architecture and the degree of sociopolitical complexity was first explicitly stated by Lewis Henry Morgan (1881) in the late nineteenth century. Architecture continued to be a defining aspect of anthropological applications as an index of cultural stages well into the twentieth century (Childe 1950; Fried 1967; Service 1962). With the onset of processual theory in archaeology, archaeologists began to utilize the theories of Leslie White (1943, 1953, 1959), who was one of the first anthropologists to make a connection between the energy captured by a society and the degree of social complexity (Arnold and Ford 1980; Binford 1972; Erasmus 1965; Peebles and Kus 1977; Renfrew 1983; Sanders and Price 1968). The more recent emphasis by processual archaeologists on energy in archaeology naturally gravitated towards studies of monumental architecture, as these structures were the largest “consumers” of energy. This marked the beginning of the study of architectural energetics (Abrams 1989, 1994).

In examining monumental architecture, there have been two approaches used to quantify variation among types of structures. The first method, volumetrics, measures architecture in terms of the volumes of materials used in construction. This technique is the one most commonly used by southeastern archaeologists to quantify Mississippian platform mounds (e.g., Anderson 1994; Blitz 1993; Blitz and Livingood 2004; Hally 1994, 1996; Lindauer and Blitz 1997; Payne 1994; Steponaitis 1978; Williams and Shapiro 1996). The other method of quantifying architecture is by estimating the amount of energy required to build or modify a structure. This approach, frequently referred to as energetics, uses volume as well as other variables to calculate labor-cost estimates (Abrams 1989, 1994; Abrams and Bolland 1999; Craig et al. 1998; Erasmus 1965; Hammerstedt 2004, 2005; Milner 1998). Most energy assessment studies in archaeology rely heavily on middle-range theory, such as ethnographic and experimental data, to construct labor-cost estimates in the form of the amount of time invested in structures. The resultant measurement is typically expressed in person-hours (p-h) or person-days (p-d). This study will explore an alternative measure for energetics based on the amount of heat produced in energy expenditure, as used in physics or biochemistry.

Objectives for Creating the Energetics Assessment

The overall purpose of this dissertation project is to examine landscape modification at Moundville, a Mississippian polity in west-central Alabama (A.D. 1120 – 1550) (Figure 1.1). This research will not only investigate how the people of Moundville

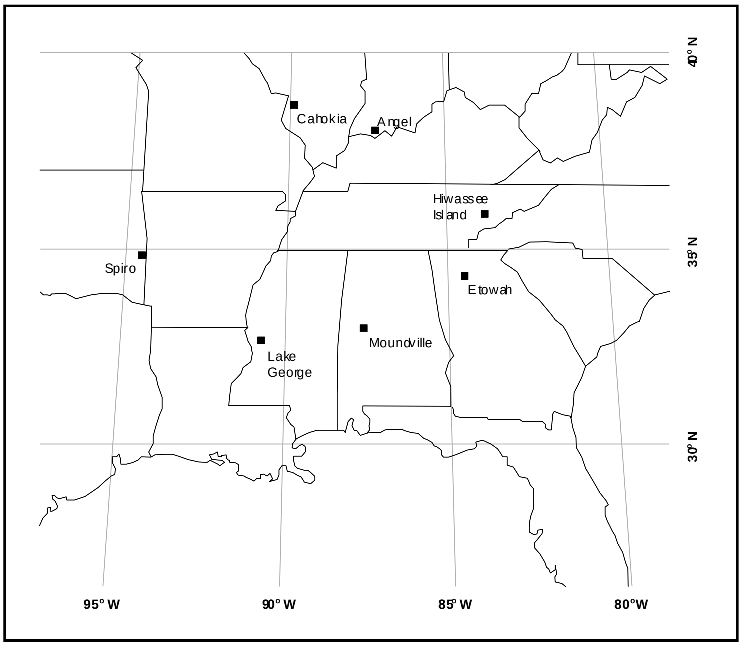


Figure 1.1. Location of Moundville in relation to other Mississippian sites.

altered their landscape with large amounts of soils strategically placed over 75 hectares (185 acres), but will attempt to measure how much human energy it took to create the overall design. To create an energetics assessment with the ending result expressed in kilojoules, four objectives had to be undertaken. First, the volume of all culturally positioned soils will be accurately accounted for including the soil needed to create the mounds as well as any soil that may have been used to level or flatten the plaza. The volume of 32 mounds was last calculated in 1936 by geologist Walter B. Jones, using an unknown method of estimation. Using both early and the more recent topographic and photogrammetric data, the volume of each mound will be recalculated using computer software.

Secondly, there is evidence to suggest that large amounts of soil extending outward from the plaza side of the mounds was laid down in order to level the outer edges of the plaza (Knight 2009b; Knight and Steponaitis 1998). This plaza-leveling construction would have required similar organization and energy to accomplish as did the mound building and thus is included in the energetics assessment. Auger testing and excavations are employed in this study to test for plaza leveling and determine the depth and horizontal extent of these soils. The volume of the plaza fill will be added to the newly calculated total volume of the mounds to provide a more accurate volumetric estimate of the culturally placed soil at the site.

Third, the distance from mound and plaza fills to their probable extraction locations is estimated based on a comparison of soil samples taken from around the site. Unlike other large Mississippian landscapes, Moundville does not possess numerous large borrow pits. There are four artificial water-filled formations presently at the site referred to as "lakes," but there has been some debate as to whether these are legitimate borrow pits or instead were created for ambience to attract park goers while dealing with drainage issues during park restoration projects in the late 1930s. The largest genuine borrow pit has a volume that only accounts for about 7% of the recalculated volume estimate for the site. Soil for most mounds and plaza modifications therefore probably came from the closest ravine on the north side of the site. These large, deep ravines are not typical of similar geological terrace formations along the Black River Valley. It is possible that they were originally much smaller and were artificially increased in size due to the borrowing of soil for landscape alteration. On the other hand, it is possible that there were several small borrow pits that were refilled by plowing and sedimentation from erosion. Soil samples from the ravines were collected and compared to soil descriptions from previous mound excavations and current plaza excavations in order to evaluate the idea that the majority of soil for mound and plaza construction came from ravines and not primarily from borrow pits at the site.

Fourth, in order to calculate the energy needed for mound construction, the mass and density of each earthwork are estimated in addition to its volume. Geotechnical engineering methods, such as the sand cone test and the Proctor compaction test, will be applied to the landscape in order to calculate the density, mass, and compaction of the earthworks. The density of each of the four plaza units possessing evidence of artificial plaza was measured, as well as the density from the outer-most construction stages of two mounds; Mounds R and V. The density calculated from the sand cone test, and the newly estimated volume of the mounds and plaza fill allowed the mass of each earthwork to be calculated, using the formula – Volume x Density = Mass.

The unit of measure for human energy expenditure will be kilojoules (kJ) as opposed to person-hours. In so doing, I am not challenging the energetics method as previously applied, but rather proposing a new unit of measure for human energy of earthen mound construction and deposits. The results are not meant to reflect prehistoric energy expenditure empirically, but meant to demonstrate a new model for classifying and differentiating among monumental landscapes. Informed assumptions will need to be made concerning variables such as the weight of the average basket load of fill, distance to fill source, and method and rate of transportation, to name a few. These variables will be estimated using data from both archaeology and other disciplines outside of anthropology. Although these assumptions may be open to question, the resulting model of Mississippian landscape modification energy can be applied to other Mississippian sites and refined as new information becomes available (e.g., Abrams

1994:79). One clear benefit of changing the unit of measure from person hours to kilojoules is to enable archaeologists to adopt methods and data from other disciplines such as physics, engineering, physiology, human biology, kinesiology, ergonomics, and military and sports medicine, as well as from subdisciplines of anthropology such as physical and medical anthropology. These disciplines have studied modern-day energy expenditures extensively for some of the assessment of work projects in some ways comparable to prehistoric projects such as energy needed to transport a weight over a given distance, to excavate soil or rock using various instruments, or even to create a engraved design upon a large piece of stone (e.g., Abe et al. 2008; Ainslie et al. 2002, 2003; Bastien et al. 2005b; Cavagna et al. 1976, 2002; ECAFE 1957; Edholm et al. 1970; Frisancho 1993; Gordon et al. 1983; Griffin et al. 2003; Hong et al. 2000; James and Scofield 1990; Knapik et al. 2004; Legg 1985; Legg and Mahanty 1985; Malhotra et al. 1976; Malville et al. 2001; Pierrynowski et al. 1981). Though using these present-day studies of energy expenditure to examine prehistoric energy expenditure may strike some readers as problematic, the governing principles of physics, physiology, and geology have and will continue to remain the same, making these studies more than comparable. Results of these cognate studies are expressed in kilojoules (kJ), kilocalories (kcal), Maximum Oxygen Consumption (VO_2 max), or other comparable units such as Metabolic Equivalent (MET), Physical Activity Ratio (PAR), or Integrated Energy Indices (IEI). None of these studies use person-hours, making them poorly relatable to archaeological studies at the present time. Using density or weight of building materials instead of volume enables the archaeologist to calculate an energetics assessment in widely comparable units ultimately allowing for a consolidation of the two types of

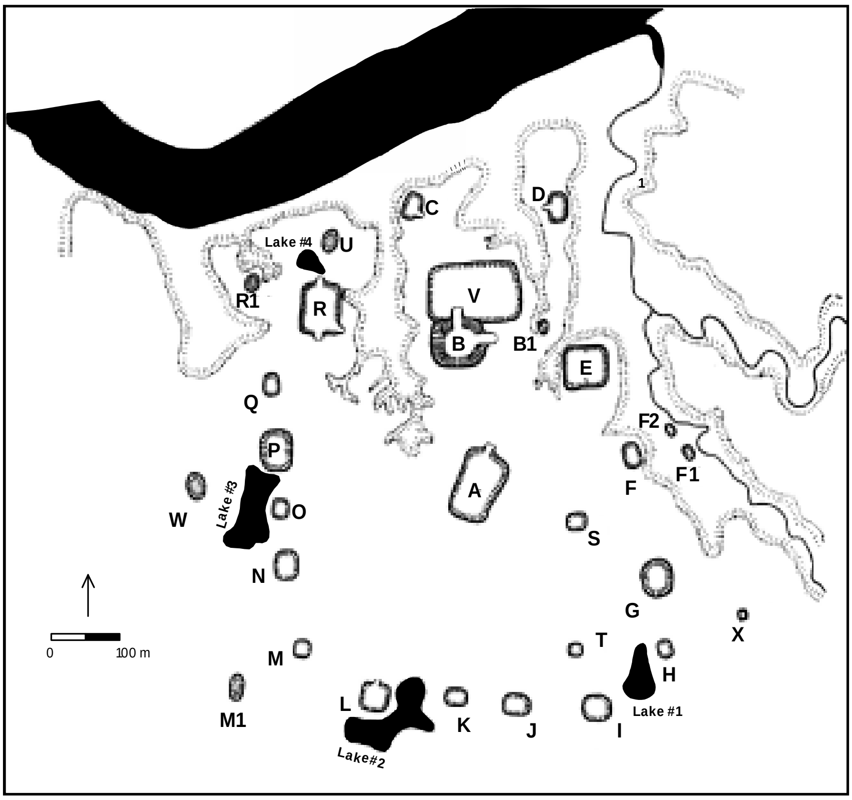


Figure 1.2. Moundville sketch map showing 28 mounds and four lakes.

studies in which human physiological data may be directly applied to archaeological problems.

Research Setting: Moundville, Alabama

Moundville is a large Mississippian mound complex located in west-central Alabama. The landscape is composed of at least 32 earthen mounds stretching over 75 hectares (185 acres) on a high level terrace overlooking the Black Warrior River (Figure 1.2). The mounds are arranged in a quadrilateral fashion around the oddly orientated Mound A and a large central plaza, with the Black Warrior River marking the northern boundary of the site. All of the mounds on the periphery of the plaza are aligned with the cardinal directions, with the longer sides of these mounds facing the plaza. The mounds range from less than a meter in height to more than 17 meters (3 – 56 ft), the average mound height being roughly 5 meters (16 ft).

The spatial arrangement of the mounds at Moundville is more orderly and methodical than the layout at many other Mississippian mound centers. A bilateral symmetry is believed to exist between the east and west halves of the site, creating an imperfect mirror image (Knight 1998; Peebles 1971, 1974, 1983). The bisecting north-south line runs through Mound B and a portion of Mound V on the northern end, continues southward through Mound A, and runs between Mounds J and K at the southern margin of the plaza. The fifteen largest mounds arranged around the plaza alternate between large earthworks without burials and small mounds containing burials. In addition, certain mounds appear to have a parallel counterpart in size and use across the plaza in relation to the bilateral symmetry of the site.

Accompanying the east-west symmetry, there is a north to south trend in the elaborateness of burials and the size of mounds. The most elaborate burials and grave goods occur at the northern end of the site and generally decrease in elaborateness as one moves south (Knight 1998; Peebles 1974). The size of the plaza periphery mounds without burials also decreases in a southward direction on either side of Mound B. The plaza periphery mounds without burials are larger monuments than the smaller plaza periphery mounds containing burials.

The layout of Moundville is believed to represent a sociogram, a physical design that inscribes the ranking of corporate segments within the community permanently upon the landscape (Knight 1998). It is hypothesized that the diagrammatic nature of the landscape was intentionally created to emphasize fixed social distinctions between kin groups, which determined the size and placement of mounds around the plaza. The larger mounds are believed to represent the higher ranking groups while the smaller mounds are believed to represent the segments of lesser rank. In addition, each large plaza periphery mound without burials has at least one, or in some cases two, corresponding smaller mound with burials, which supports the idea that pairs of mounds were associated with specific kin segments.

The Moundville polity is believed to encompass a 5 kilometer wide portion of Black Warrior River valley, extending northward from the Moundville site approximately 25 kilometers and approximately 15-35 km southward from the Moundville site (Bozeman 1981; Peebles 1987; Steponaitis 1983a; Welch 1990, 1998). The occupation of the polity is divided into four phases; Moundville I (A.D. 1120 – 1260), Moundville II (A.D. 1260 – A.D. 1400), Moundville III (A.D. 1400 – 1520), and Moundville IV (A.D. 1520 – 1650). The paramount center was first inhabited during the onset of the Moundville I phase (A.D. 1120 – 1260) (Figure 1.3). The only two mound constructions during the initial occupation of the site were the Asphalt Plant mound (1Tu50) (Steponaitis 1992; Welch 1998), a small mound less than 1,000 m northeast of Moundville, and Mound X (Blitz 2007). Physical transformation of the site also includes a defensive palisade, erected and maintained from approximately AD 1200 to AD 1300, being rebuilt six times (Scarry 1995, 1998). The Late Moundville I and Early Moundville II subphases represent the climax of physical modification to the site, which would thereafter continuously decline over the next 300 years.

The earliest evidence of food tribute from commoners in rural farmsteads to elites at the center also corresponds to this initial construction phase. Maize had become the

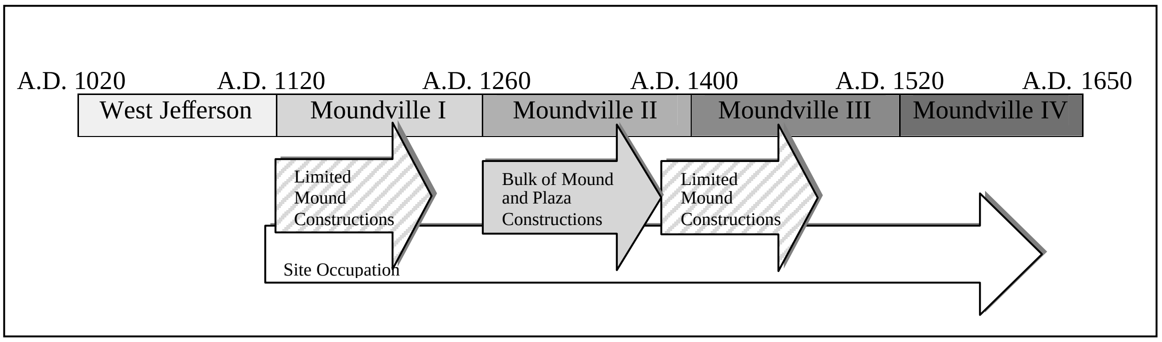


Figure 1.3. Moundville timeline.

primary dietary staple in the valley and evidence of tribute is indicated by the high ratios of corn cupules to kernels as well as nutshells at rural farmsteads compared to elite middens at the paramount center. This evidence suggests that food was processed to reduce the bulk of the tribute in staple food for transportation (Scarry and Steponaitis 1997). Other possible differences in the dietary practices of the elites that may have been supplied through tribute from non-elite members include choice cuts of deer, turkey, bison, and shark as well as other animals that may have possessed symbolic meaning such as bobcat, cougar, fox, black bear, and a number of different species of birds (Jackson and Scott 2003).

Additional data supporting the assumption of elite provisioning can also be found in Moundville's midden assemblages. Relatively large amounts of burnished service ware as opposed to utilitarian pottery have been found in elite middens (Welch and Scarry 1995). Further, elite middens and burials have relatively high concentrations of imported raw material and prestige goods including non-local chert, greenstone, mica, copper, marine shell, and galena (Knight 2004; Peebles 1974). The Late Moundville I/Early Moundville II subphases marked the beginning of the construction of single mound secondary centers, while other earlier mound sites were abandoned. These secondary centers included Jones Ferry, Poellnitz, and Hog Pen (Welch 1998), and were presumably created to aid in the flow of tribute to the paramount center.

Around the beginning of the Moundville II phase (A.D. 1260 – 1400) most of Moundville's inhabitants vacated the site, returning to farmsteads spread throughout the valley. This depopulation of the site occurred either before or shortly after the late Moundville I phase (A.D. 1190-1260) (Wilson 2008), possibly before any of the earthen monuments surrounding the plaza were constructed. Many secondary centers remained in use and more were created, presumably to manage an increasing rural population (Welch 1998) that could have reached as high as 10,000 people (Peebles 1987). The only people still residing at the center were perhaps elites, including those living on mounds and their retainers. Near the end of this phase, many elites, especially those previously occupying mounds on the southern half of the site, began to vacate as well. Mound construction and habitation stopped except for Mounds B, E, G, P, Q, R, and V. Evidence for the emptying of the site is indicated by the lack of late Mississippian architecture, the lack of domestic middens of this period, and a discontinuation of the palisade. However, the site maintained its mortuary role, with the deceased from throughout the valley imported to the site for burial (Knight and Steponaitis 1998). Elite burials were most elaborate during this time, marked by elaborate symbolism, non-local materials, and prestige items (Peebles 1974; Peebles and Kus 1977). Evidence suggests that elites were physically and symbolically distancing themselves from the general population. However, the tributary economy continued unabated.

Several additional mounds at the center were abandoned after the beginning of the Moundville III phase (A.D. 1400 – 1520). The only mounds still inhabited after about AD 1450 were Mounds P, B, and E, among the largest residential mounds on the north side of the center. The occupation of these three mounds lasted until approximately A.D. 1550, although there were no earthen constructions or modifications made at the site after A.D. 1450 (Figure 1.3). Moundville still retained its mortuary role after AD 1450, but its importance as such was declining. Cemeteries were being established at the functioning single mound centers instead of interring the dead at Moundville. Evidence of the provisioning of elites at secondary centers is also still evident during this period (Welch 1991). The settlement pattern of the Black Warrior River Valley inhabitants ultimately returned to that of large villages, for the first time since the West Jefferson phase five centuries earlier. All secondary mound centers were abandoned by A.D. 1550.

The Spanish explorer Hernando de Soto came through west-central Alabama in the fall of 1540 during his four year expedition (A.D. 1539-1543). This occurred at roughly the same time as the beginning of the Moundville IV phase, during which a small portion of the paramount center is believed to have still been inhabited. No evidence of De Soto has been found at the center. Hudson and colleagues (1990) believe that De Soto's travels passed through the Black Warrior valley and perhaps even to Moundville, although his arrival did not facilitate the decline of the site, which had already begun (Knight and Steponaitis 1998).

The details of the cultural chronology are important when studying the modifications of an archaeological landscape. Based on this information, we know that the majority of the mounds at Moundville were constructed in a short time, probably over little more than a century (A.D. 1250 – 1350). It also is known that constructions at a few mounds, mainly the ones on the northern side of the site, continued for another century after the remaining mounds had been abandoned. The simultaneous construction of the major mounds early in the site's history also indicates a deliberate community plan, not a landscape of mounds added gradually over time (Knight 1989). It also is suspected that the peak resident population was relatively small, being around 1,000 people (Steponaitis 1998), many who might have vacated the ceremonial center prior to the time of peak mound construction (Wilson 2008).

Energetics in Archaeology

One of the first energetics studies in archaeology was conducted by Charles Erasmus in the Yucatán peninsula during the summer of 1964. Erasmus (1965), in an experimental study involving Mexican peasants, calculated the volume of rock and soil that could be excavated and carried various distances per day in order to collect data on the amount of manpower needed to complete various construction tasks required for the creation of Maya ceremonial centers such as Uxmal. Having estimated a manpower value for the site construction, Erasmus was able to compare his measurement of labor investment with population density estimates and calculate the number of person-days per year invested by each household.

An important measure used by Erasmus was the unit referred to as man-days, referred to herein as person-days. For a given monumental structure, this measure is the total volume of rock or soil making up that structure divided by the amount of rock or soil a single person in an experimental study can move in one five-hour period. Thus person-hours or person-days are measures used by archaeologists for the purpose of quantifying human labor. In his experiments, he concluded that a single person could excavate 2.6 m^3 with a digging stick or transport 3.17 m^3 over a distance 50 meters in a five-hour day.[1] It should be noted that in most studies, unless specified otherwise, a person-day is composed of five person-hours, as Erasmus (1965) noted that the productivity of his laborers declined significantly after five hours. Using these data, Erasmus calculated that the total amount of labor including "fill, masonry, stonecutting, and stone sculpturing" to create the Uxmal ceremonial center equaled 7.5 million person-days (or 37,500,000 person-hours) over its 250 year occupation (Erasmus 1965:294).

To determine who fulfilled this person-day requirement, Erasmus considered average house size and population density among the modern Maya as a starting point, although he acknowledged the problems of using modern day comparisons based on changes in population, resources, and social structure. Using modern population density and consumption statistics of the natives of Tikul, Yucatán, Erasmus (1965:295) concluded that each family of five would need around 20 acres to produce enough food for the year. Erasmus applied these estimates to a five mile radius surrounding the Uxmal center. Five miles, or 2 to 2 ½ hours walking distance, was chosen because Erasmus's (1965: 296) informants claimed that this was the maximum distance one could walk to their fields and back without having to set up temporary shelters. Given the area, 1,200 families would have been included in the potential resident working population of Uxmal. Estimating 40 person-days contributed by each family per year, the total would amount to 48,000 person-days (240,000 person-hours) per year. At this rate the ceremonial center could have been constructed in approximately 150 years.

[1] These measurements have also been expressed as 0.52 m^3 soil excavated in one hour or 1.9 person hours per m^3 of excavated earth and 0.63 m^3 transported 50 m in one hour or 1.58 person hours to transport 1 m^3 a distance of 50 m.

Elliot Abrams (1994) revised the idea of labor estimates based on energy in his study of Maya architecture at Copan, a methodology which he referred to as "architectural energetics." For Abrams (1994:1-2), "architecture energetics involves the quantification of the cost of construction of architecture into a common unit of comparison – energy in the form of labor-time expenditure." Abrams applied this methodology in examining wattle and daub and stone Maya houses. However, even with new methods and estimates for quantifying energies used in procuring, manufacturing, transporting, and constructing various forms of Maya architecture, Abrams expressed his results in the same unit as Erasmus, that is to say, in person-hours.

Likewise, Scott Hammerstedt (2004, 2005; Milner and Hammerstedt 2004) has applied Erasmus's method to Mississippian stage architecture, in order to estimate the quantity of labor used in the creation of three stages of an earthen platform mound and the construction of three corresponding palisades at the Carlson Annis site in west-central Kentucky. He accomplished this, as did Erasmus (1965), by employing individuals to excavate and carry soil to a specific location using the most typical Mississippian digging instrument in Kentucky, the Mill Creek chert hoe. Labor was quantified using person-hours. He concluded that each phase at the Carlson Annis site was marked by increased mound volume and increased area circumscribed by the palisade. Yet overall, each phase utilized a relatively low labor cost even when accounting for only a small portion of the population participating.

Bernardini (2004) conducted an energetics analysis of five Hopewell geometric complexes (AD 1-500) in south-central Ohio. For the Hopewell, labor organization was accomplished without a large fixed settlement from which labor could be drawn.

Although, this absence of a large fixed settlement is not the case for the Moundville polity, Bernardini's (2004) methodology is applicable to this energetics study. Using the number of person-hours invested in construction of a monument, Bernardini estimated the number of laborers, the durations of construction for each monument, and the labor catchment areas for each complex.

Bernardini (2004) calculated the volume of each earthen embankment by using the formula for a trapezoid multiplied by the embankment length. The excavation energy was calculated by multiplying the volume of an earthwork by the experimental data collected by Erasmus (1965): 1.9 person hours per cubic meter of excavated soil using a digging stick. The transportation energy was calculated by multiplying 0.32 person hours for every 10 meters by the volume of the earthworks. Using the person hours calculated for the five Hopewell geometric complexes, Bernardini (2004) further estimated the duration of labor in terms of the number of days per year devoted to construction. Assuming that communal projects took approximately 25-50 productive work days (Erasmus 1965), Bernardini estimated labor crew sizes for each construction project based on three possible durations for construction; 1 year and 5 years for single geometric shapes and 5 and 10 years for entire earthen complexes. These work durations of 5 and 10 years, are not assumed to have been carried out consecutively. He concluded that the largest constructions of a single geometric shape would have required 1,000 to 2,700 laborers if it was to be erected in a single year. More conservative estimates of individual geometric shapes constructed in five years would have required between 200 and 550 laborers. For the construction of an entire geometric complex, 300 to 600 workers per year would have been needed working for 5 years, and 150 – 400 laborers would be needed per year working over ten years. Like Erasmus (1965), Bernardini (2004) uses the estimates of laborers per year to consider the size of the labor catchment areas needed to supply different numbers of laborers.

These are only a few published studies employing experimental mound construction and erosion (Bell et al. 1996; Breuning-Madsen et al. 2001; Macphail et al. 2003), labor estimates for building monumental structures (Carmean 1991; Craig et al. 1998; Millon et al. 1965; Milner 1998; Muller 1986, 1997; Reed et al. 1968), and architectural energetics (Abrams 1989, 1994; Abrams and Bolland 1999). In the interest of space, a synopsis will be presented and limited to the studies described above and how each differs from this current research. Neither Erasmus (1965), Abrams (1994), Hammerstedt (2004), nor Bernardini (2004) accounted for one important variable in their studies of earth moving activities, the density of the soil.[2] Geotechnical testing may be employed in similar research to determine the total mass of the earthwork being measured, instead of just the volume. Density is important because different soils of the same volume may have substantially different weights. Therefore, the amount of energy needed to create a monumental earthen mound could be dramatically affected by the density of the mound fill. For instance, two mounds of the same volume might be judged as requiring similar work forces and energy requirements. However, one may have been created using heavier soils, and would therefore represent a greater labor investment.

Another variable that has not been accounted for in previous energetics assessments of mound construction is compaction. Compaction, or the energy needed to compact soil, may have been applied in order for the mounds to retain their idealized

[2] Erasmus measured weight (mass) and volume of soil carried in his earth moving experiment but did not directly calculate density.

shapes. I propose that the compaction energy may vary among mounds. Obviously, compaction of earthen mounds would be highly variable due to factors such as the height of the mound, the type of soil used, the number of building episodes, the method of construction, or perhaps the importance of the mound, to name a few possibilities. Many Mississippian mounds are composed of different soils with different densities, chosen for their specific qualities. Often a heavy clay stage, used as sheathing and as a surface for occupation, alternates with a less dense stage used to increase mound size. Ideally, one would know the density of each construction stage in building an energetics assessment that accounts for various compaction energies.

Organization of Chapters

The following chapters are organized according to each of the four objectives needed to complete the energetics assessment. Chapter 2 reviews the relevant literature needed to achieve the first objective, recalculating the amount of soil needed to create the earthen mounds. Previous volume measuring techniques for earthen monumental structures, including those using solid geometry and planimetry are reviewed. In addition, a new technique is presented which measures volume of earthen monuments using computer software. Using this proposed method, the volume of each earthwork at Moundville is recalculated to provide a new estimate for the entire site. The newly calculated total for the earthen mounds at Moundville is then compared to other Mississippian mound centers.

Chapter 3 addresses the second objective of the energetics assessment, evaluating evidence of plaza modification at Moundville. Relevant information concerning plazas throughout the Southeast as well as previous excavations of Moundville's plaza will be reviewed. Concluding the discussion of the relevant literature, the auger tests and excavations undertaken specifically for this study will be summarized including data on soil stratigraphy, features, and the artifact collections. Using the same methods for calculating the volume of the mounds, the volume of the identified plaza additions will be calculated.

Estimating distances from each mound or plaza construction site to the extraction source, the third objective, is presented in Chapter 4. These distances are important when calculating the amount of transportation energy involved in the construction process. In order to accurately estimate distances, the authenticity of the four borrow pits at the site is examined and comparisons of the plaza and mound fill to soils collected from borrow pits and various other potential borrow areas around the site are discussed. Differences in the composition of natural terrace soils at different places may indicate general areas for soil extraction, whether from the ravines or borrow pits.

The final objective for the energetics assessment is to measure the density and compaction of the mound and plaza fills. Chapter 5 summarizes geotechnical engineering methods of the sand cone density test, a measure employed to calculate the density of an earthwork, and the Proctor compaction test, a test used to estimate the amount of mechanical compaction energy invested in an earthen structure. Then, using the new volume calculations of mound and plaza fills and the estimated density of these soils, the mass of the earthworks is obtained. For the density and compaction testing, I am forced to make uniform assumptions about mound density and compaction energy because of a limited sample and my overall soil density measurements for Moundville are unlikely to be very accurate due to the factors described previously. This research will however still attempt to test the earthworks at Moundville to estimate the density and the amount of mechanical compaction energy invested in mound and plaza construction.

Chapter 6 offers the equations and the methods for calculating the energetics assessment. This chapter will estimate the energy needed to excavate, transport, and compact mound and plaza soils and combine them to estimate the total human energy expenditure for Moundville's earthen landscape. This study differs from other energetics studies in archaeology, not only because of its conception of the three components of energy, but also because of the reformulated units of measure. Theories and methods from other disciplines such as geotechnical engineering, human physiology, human biology, and ergonomics combined with archaeology provide a means for reformulating the units of measure in energetic studies from person-hours to kilojoules.

In concluding this research, data obtained from the energetics assessment (Chapter 6) is used to make assumptions concerning the organization of labor at Moundville in Chapter 7. Control over non-kin groups has been a major theoretical assumption about complex societies and is one of the theoretically defining characteristics of both chiefdoms and early states. In this final chapter, three mound building episodes requiring various amounts of energy expenditure are compared to determine which constructions were created using kin-based labor and which ones were constructed using collectively pooled labor from the entire community. Results support a new model in which the plaza periphery mounds were constructed using solely kin-based labor, except for those largest mounds on the central axis of the site, Mounds A, B, and V and the palisade, which were constructed by collectively-pooled work crews under centralized leadership of Moundville's elites.

Chapter 2

Calculating Mound Volume at Moundville

Mound volume is an important variable when examining the sociopolitical implications of mound building (Blitz and Livingood 2004). Mound size is often thought to reflect the organizational capabilities of high ranking individuals who arrange and manage a large work force that invests a tremendous amount of labor on behalf of the elite (Haas 1982; Steponaitis 1978). However, recent research in the form of labor estimates suggests that mound building would not have distracted people from everyday activities and was not as demanding as originally believed (Hammerstedt 2004; Milner 1998; Muller 1997). In pursuit of creating an accurate model of energy expenditure concerning mound building at Moundville, I have begun to question previous methods for measuring mound volume. As volume is the central unit of measure in calculating the amount of effort involved in mound construction, an accurate assessment of size is essential.

The volume of the earthworks at Moundville was originally assessed by Walter B. Jones of the Alabama Museum of Natural History in 1936 (notes on file, Alabama Museum of Natural History) and others have subsequently used these data (Blitz and Livingood 2004; Knight 1998; Payne 1994). Jones did not specify the formulas or measurements he used to calculate the size of these 32 earthen structures. The majority of his estimates, however, are considerably larger than those obtained using geometric formulas of comparable solids. In this chapter, volume estimates of the mounds at Moundville are calculated using topographic maps and a technique for quantifying volume with the aid of computer software. Overall, the results indicate that the size of mounds has been exaggerated; the previously estimated volume of some earthworks is more than 50 percent higher than the current calculations (Table 2.1). Consequently, the estimate for the total volume of mound fill for the site is herein reduced from 275,000 m^3 to 192,000 m^3; a difference of almost 85,000 m^3. Various techniques for measuring the amount of earth moved for monumental constructions will be discussed with the intent to demonstrate that a certain technique, referred to in this study as the gridding method, is most suitable for calculating mound volume. Before introducing the gridding method, alternative techniques of measuring mound size will be briefly reviewed. Following the discussion of volume measuring procedures, new estimates for Moundville will be reported and compared to other Mississippian mound sites.

Previous Volume Measuring Techniques

In archaeology, several methods have been used to estimate the size of mounds. Most procedures use volume formulas derived by matching the shape of an earthwork, in both plan and profile, to a closely related geometric solid. Three-dimensional shapes including rectangular prisms, cones, cylinders, circular paraboloids, and various forms of frustums have been employed to emulate a mound's volume. Another method for measuring mound size involves using a topographic map and calculating volume using a combination of planimetry and solid geometry. For the purposes of this study, any procedure used to estimate mound volume using one or more geometric formulas from minimal measurements is classified as a solid geometry method. In addition, those

Mound	Jones 1936 (m^3)	Gridding Method 2008 (m^3)	Difference (±%)
A	38,610	30,150	-21.9
B	85,400	49,530	-42.0
C	5,125	5,080	-0.9
D	5,810	3,880	-33.2
E	23,395	10,820	-53.8
F	4,640	2,790	-39.9
G	8,135	6,730	-17.3
H	620	675	+8.9
I	5,385	2,690	-50.0
J	4,050	2,570	-36.5
K	2,525	1,855	-26.5
L	6,500	4,420	-32.0
M	1,455	590	-59.5
N	6,500	3,295	-49.3
O	3,670	1,220	-66.8
P	17,700	15,880	-10.3
Q	3,670	3,210	-12.5
R	31,195	21,820	-30.1
S	1,745	515	-70.5
T	770	705	-8.4
U	115	115	
V	17,585	22,460	+27.7
W	155	155	
X	105	105	
Y (M1)	55	55	
Z (R1)	95	95	
B' (B1)	55	55	
C' (C1)	55	55	
E'	110	110	
F (F1)	115	115	
F (F2)	115	115	
Z'	115	115	
Total	**275,575**	**191,975**	**-30.3**

Table 2.1. Volume estimates by Jones compared to the current gridding method estimate. Note that mound designations have changed for some of the smaller mounds. Jones's original labels are listed first and the current designations are listed in parentheses. Both estimates are rounded to the nearest 5 m^3.

techniques that employ both a topographic map and planimetry are referred to as the contour method. All techniques employ some form of geometry in estimating size. The difference between the solid geometry, contour, and gridding methods lies in the number of mensurations, or points of measure. Equations for geometric solids typically use data from less than ten measuring points. For instance, a radius would use two points, the center of the earthwork and the edge. Similarly, variables such as length, width, and height would each use two points. Planimetry and the gridding method trace individual contours providing hundreds of measurements per contour. The gridding method further divides the mound into multiple equal portions creating hundreds more points of measure.

Solid Geometry Methods

Archaeologists in the southeastern United States use the formula for a rectangular prism [*lwh*] [3] as one method of differentiating earthen monuments (Blitz and Livingood 2004; Payne 1994; Scarry and Payne 1986; Steponaitis 1978). This formula regards a structure as possessing a perfectly rectangular base and vertical flanks, which greatly exaggerates the volume estimate (Figure 2.1a). Due to the obvious inflation in size, archaeologists who employ this method utilize it as a relative index, not as a measure of actual volume. Volume calculations using other shapes, including cones [$h1/3(\pi r^2)$], cylinders [$\pi r^2 h$], and circular paraboloids [$h1/2(\pi r^2)$], have been employed in a similar manner. For instance, Jeter (1984) used the formula for circular paraboloid (also called a paraboloid of revolution) in estimating the volume of conical Copena burial mounds. Archaeologists in central California used the formulas for a cone as well as a

[3] For all formulas mentioned *l* is length, *w* is width, *r* is the radius, *h* is height, *a* is area. If there is a subscript designation, it refers to measurements for base and summit; the smaller designation is the lower measure.

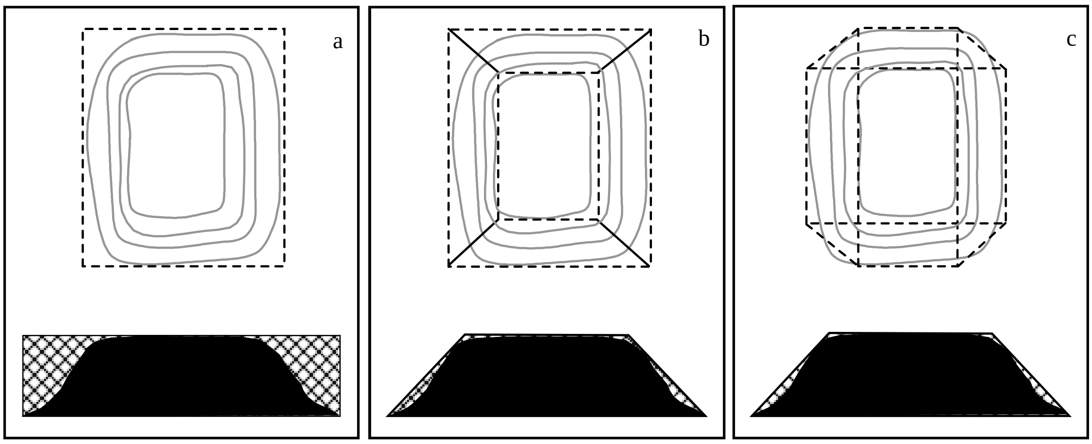


Figure 2.1. Left, plan and profile of a rectangular prism formula applied to earthen platform mound (a); center, frustum formula for a truncated rectangular pyramid (b); and right, multiple geometric shapes (c). The dashed lines indicate the area of measure.

spherical cap or hemisphere [$(3\pi r^2 h + \pi h^3)/6$] in estimating the volume of shell mounds (Cook and Treganza 1947:138; Treganza and Cook 1948:288-289).[4] Similarly, Seeman (1979:258) used a formula for a spherical cap to estimate the size of earthen Hopewell mounds. The common factor among all of these formulas is that they only account for basal area and height, and in doing so, use only minimum mensurations. Although accuracy is limited, these formulas still provide a reasonable comparative diagnosis of mound size, using simple calculations from easily obtainable data.

Other geometric solids used to represent the shape of an earthen mound include various forms of frustums. These shapes are mostly commonly employed to measure platform mounds, those earthworks possessing a summit. Using a frustum to replicate the volume of a mound enables the archaeologist to include both the basal and summit areas in the assessment, as well as accommodating, very generally, the incline between them (Figure 2.1b). Frustum formulas for the volume of a truncated rectangular pyramid

[4] Cook and Treganza give the formula for a spherical cap, a portion of a sphere marked by an intersecting plane, but wrongfully refer to it as a spherical segment, a portion of a sphere marked by two parallel planes.

[$1/3h(a_1 + a_2 + \sqrt{a_1 a_2})$] and truncated right circular cone [$1/3h\pi(r_1^2 + r_2^2 + r_1r_2)$] are the most commonly relied upon frustum formulas for measuring Mississippian platform mounds (Hammerstedt 2004; Jeter 1984:103; Milner 1998:145; Morgan 1980:xxxi-xxxii; Muller 1997:272). Other frustum shapes also have been suggested, including a spherical segment [$\pi/6(3r_1^2 + 3r_2^2+h^3)$] (Jeter 1984:92) and a truncated triangular pyramid [$1/3(Ah_1-(ah_2^2/h_1^2)h_2)$] (Shenkel 1986:204).

A variant of the frustum technique involves using multiple geometric shapes to measure mound size (Figure 2.1c). In a study of Cemochechobee, a Mississippian site on the Chattahoochee River, mound volume was calculated using a combination of a rectangular solid, four triangular prisms, and four tetrahedrons (Schnell et al. 1981:29). At Moundville, Gage (2000:90) also employed the same combination of geometric formulas in calculating volume of the building episodes of Mound R. This procedure is similar to the frustum method but uses more mensurations, which enables control for significant irregularities in shape such as rounded corners or a ramp (Jeter 1984:104). Furthermore, this variant also possesses the ability to accommodate variations in mound slope. In a typical frustum equation, the summit area is centered above the base, giving all sides of the solid the same incline. Using several different geometric shapes allows for minor adjustments in slope, as each triangular prism can possess different measurements.

Despite the convenience of the geometric formulas, they offer little in terms of accuracy. No geometric formula can replicate the exact shape of a mound, nor can these methods account for factors such as irregularities in base or summit shape, sloping premound surfaces, or abnormalities in mound incline. Shenkel (1974, 1986) noted problems with geometric estimations of large shell mounds in west Mexico when he compared his original analysis to a method combining contour maps and planimetry. Having realized the inconsistency between these two methods, Shenkel (1986) further compared solid geometry and contour method analyses for other large earthworks in the Eastern Woodlands, including mounds at Poverty Point, Cahokia, Toltec, and Pinson. Based on the comparison of these two methods, he determined that geometric frustum formulas produced a range of variation from -60 to +130 percent compared with a contour method of analysis (Shenkel 1986:213). Milner (1998:145) arrived at a similar conclusion when he compared the results of geometric formulas, including frustums and circular paraboloids, to contour method analyses for 11 mounds at Cahokia. Of these structures, seven were truncated platform mounds, while the other four were conical or ridge-shaped. His results indicated that geometric formulas produced an exaggerated size estimate in all seven platform mounds. In addition, Milner reported that the discrepancy between the two methods for the entire sample ranged from 2 to 27 percent, the average being approximately 6 percent.

Contour Method

The contour method involves using a topographic map and measuring device, typically a planimeter, to calculate the volume of a mound (Sorant and Shenkel 1984; Shenkel 1986). Planimetry uses numerous data points on the plane of a smooth contour as opposed to the minimal measurements employed in variants of the solid geometry method. In the contour method, the area of each contour is measured and the size of the space between them is calculated using a formula for a frustum (Figure 2.2). The results for each consecutive set of contours are added together to produce the total volume of an

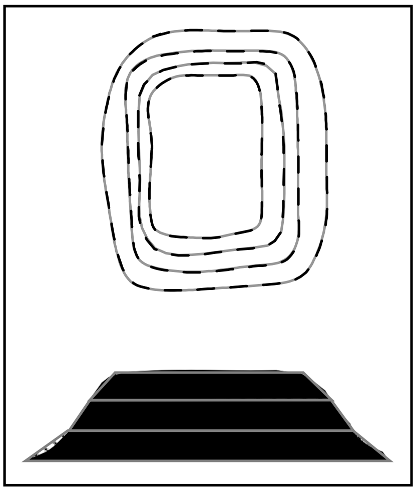


Figure 2.2. Contour method

earthwork. Thus, this method treats each set of contours as an independent frustum, stacked one on top of the other.

The space between two consecutive contours is measured using one of two variants of frustum equations. In one equation, referred to as the "engineers' formula" (Shenkel 1986:203; *cf*. Jeter 1984:103; Sorant and Shenkel 1984:600), the area of a lower contour (a_1) is added to area of the subsequent contour (a_2), multiplied by the contour interval, and divided in half [$1/2h(a_1 + a_2)$]. The second equation, referred to as the "limnologists' formula" due to its use in measuring the volume of lakes (Sorant and Shenkel 1984:601; Shenkel 1986:204), is the same as that for a truncated rectangular pyramid as used in the solid geometry methods. However, instead of using base and summit area, the upper and lower areas of a set of contour lines are employed. In both formulas, just as in the geometric equation of a frustum, mound slope is determined by the difference of two consecutive areas. The more comparable the areas, the more the sides of the frustum resemble a right angle. A cube, for instance, has a top and bottom of equal area, therefore all vertical sides of the solid are 90 degrees. Larger differences between the two contour areas will produce more acute flank angles. For example, a set of contours with an upper contour 50% smaller than the lower contour will produce a 45 degree slope. In addition, the same problem as found in the geometric formula for a frustum still applies, in that for the purposes of the formula the upper contour is centered above the lower contour, creating a uniform slope on all sides.

When executed using planimetry, the contour method has been shown to be fairly accurate. However, this accuracy of the contour method is dependent on factors such as the symmetry of the mound, the quality and contour interval of the map, and the method utilized for acquiring contour area. A symmetrical earthwork with uniform slope would be less affected by the limitations of the contour method, described above, than an unsymmetrical one. A poorly made or large contour interval topographic map will also produce an inferior volume calculation. In addition, if data are acquired for either of the two formulas (engineers' or limnologists') from measurements taken by hand instead of a planimeter, the precision of the estimate is greatly reduced. Executing the contour method accurately involves several steps using geometric equations and outdated instrumentation, making it complicated and fairly time-consuming. Given the availability of modern technology, a new method can be devised that is less problematic than planimetry and provides a greater level of accuracy.

Gridding Method

Like the contour map technique, the gridding method requires a topographic map of the earthwork, preferably at small contour intervals. Either traditional contour or photogrammetric procedures produce maps well-suited for the analysis, though the latter have been argued to be more accurate (Pierson 1959; Shenkel 1986; Young 1954, 1955). Although the method can be conducted using scaled contour and profile maps drawn on graph paper, as originally proposed by Heizer and Cook (1956:232) in measuring prehistoric mounds in California, currently the procedure is more accurately and conveniently executed using computer software designed for mapping three dimensional images. Several commercial programs exist for this purpose, including products by Science GL, ESRI, and AutoDesk. For this study, the program SURFER (version 8.0), a three-dimensional mapping and contouring software (Golden Software Inc. 2002a), was utilized to calculate mound volume.

The gridding method measures volume in a similar fashion as the procedure using contour maps and planimetry described above. The difference between these two techniques lies in the number and shape of geometric solids used to divide an earthwork. In the contour method, a consecutive set of lower and upper contour lines creates the unit of division. If the mound has five contours, there are four frustums and four calculations. This method considers mounds to be analogous to a stack of frustum-shaped pancakes; each set of contours equating to one flap-jack. In contrast, the volume procedure used by the gridding method superimposes a grid on the topographic data, dividing the earthwork and the surrounding terrain into a number of equal cubic portions (Figure 2.3). The extent of the grid, the size of the cell, and the beginning base elevation are established by the researcher's specifications. The volume of each cell is measured, using a formula similar to a rectangular prism and, like the contour method, added together to produce the total volume (Golden Software 2002b:447). A typical grid would divide a small mound of 1,000 m^3 into as many as 1,000 cells as shown in Figure 2.3. These small divisions

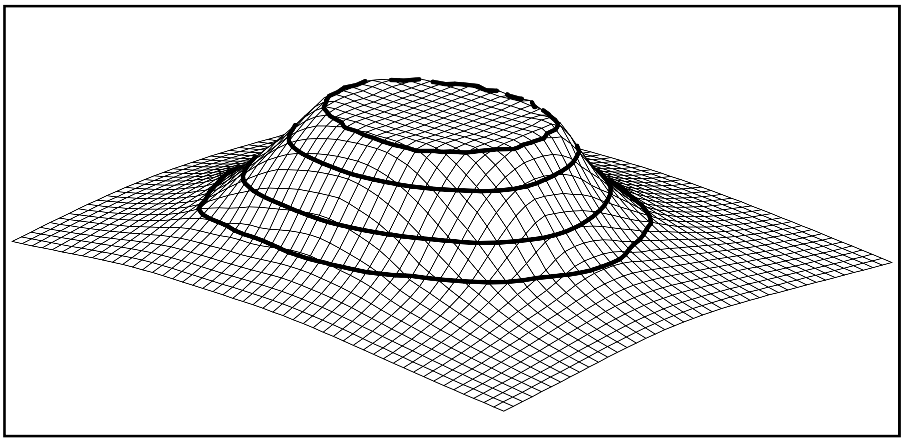


Figure 2.3. Wireframe map used to demonstrate the gridding method. For purposes of illustration the cell size of the grid has been doubled from that used in this study to make the cells visible.

allow aspects of an earthwork such as small irregularities in shape, elevation, or slope, the presence of a ramp or ramps, multiple terraces, or a sloping premound surface to be included in the assessment. To provide the reader with a better visualization of the gridding method, it is easy to imagine stacks of thousands of dice used to recreate a scale model of an earthen monument. Each stack of dice (or vertical prism) represents one grid cell and the top and bottom die of each stack are truncated to the surface. The volume of each stack is calculated and added to the volume of the other stacks, the result of which estimates the volume of the mound. The size and number of the dice correspond to the size and number of the grid cells that are superimposed on the mound.

Method of Present Study

In assessing the volume of earth needed to produce the monuments of the Moundville landscape, several topographic maps were digitized using the computer program DIDGER (version 4.0) (Golden Software Inc. 2007). This software is designed to trace images such as contour maps or aerial photographs, creating output scaled to Northing and Easting coordinates. Maps of Moundville used in this project consisted of two complete site maps; the Alabama Museum of Natural History "Topographic Map – Mound Park, Alabama" (ca.1937) and a photogrammetric map generated for the Moundville Mapping Project in 1991 by the Alabama Historical Commission and the University of Alabama. In addition, several maps of individual mounds were used, including those created by P. L. Cox of the National Park Service in 1938, David L. DeJarnette and the University of Alabama Field School in 1970, Vernon J. Knight and Richard A. Krause of the University of Alabama in 1989, and Knight and the University of Alabama Field School in 1993.

Topographic maps of mounds at Moundville were scanned, imported into the program, and calibrated to the site's grid coordinate system.[5] When digitizing these maps, each contour line of a mound was traced individually with the Northing and Easting coordinates being the output for each point taken. The elevation of a contour was added to the output after each line was traced. The first complete contour line encircling the mound was used as the structure's boundary and was given an elevation of zero. In cases where mounds where built on a sloping premound surface, two contour maps were digitized. First, a contour map of the proposed premound surface was created by connecting contour lines on each side of the mound in order to match the surrounding terrain (Figure 2.4). An arbitrary plane was established and given the elevation of zero. The second map traced was of surface contours including the mound and the adjacent topography. The volume of the premound surface was subtracted from the volume of the

[5] When digitizing previously drawn maps, the earthwork does not necessary need to be mapped into a larger grid system. Any scaled contour map will suffice, and control points can be fashioned in accordance with the map's scale. If one's data consist of Cartesian coordinates with elevations, the Didger step is eliminated and the XYZ data can be entered directly into the Surfer program.

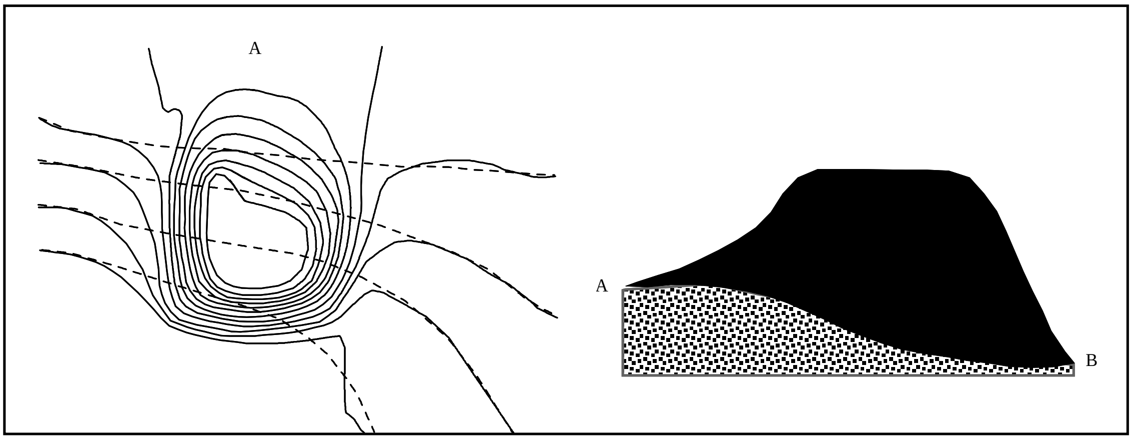


Figure 2.4. Left; contour map of mound constructed on sloping surface. The dashed lines represent the proposed contours of the premound surface. Right; profile of the mound showing boundary between the mound and the natural terrain. The volume below the premound surface is calculated and subtracted from the total.

mound using a feature of the SURFER program designed for the task. Mounds P and Q were the only mounds calculated that possess a sloping premound surface.

After the topographic maps had been digitized, the coordinates were entered into SURFER. When measuring volume, the Kriging algorithm was used to control for the interpolation or curvature between data points. The software manufacturer recommends this method or the similar method of Radial Basis Function to produce the most accurate contour maps (Golden Software, Inc. 2002b:151, 155). The volume of a mound was calculated using the program's Grid/Volume function. Results for each volume generated are tabulated in three categories: Positive Volume [Cut], Negative Volume [Fill], and Net Volume (Figure 2.5). For the purpose of measuring mound volume in archaeology, the only relevant report is the Positive Volume, which is the volume above a specific elevation designated by the researcher (Z).

In some cases, mound volume could be calculated from more than one map. Therefore, the factors considered when choosing a particular estimate of mound volume

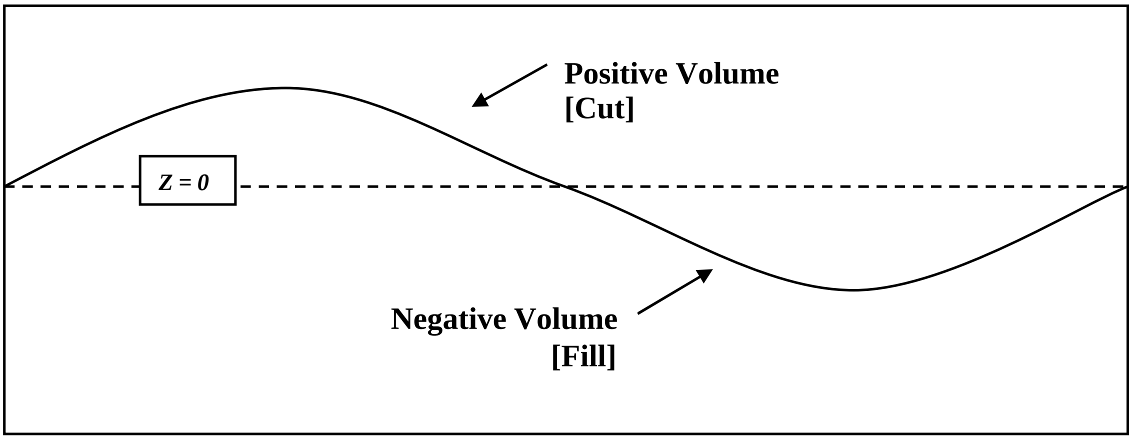


Figure 2.5. Image representing differences in Positive, Negative, and Net volumes. The solid line represents the current surface and the dashed line represents the idealized surface level (Z). The positive volume is any feature above that idealized level and the negative volume is the open volume below that line. The net volume is the positive volume minus the negative volume. In the case of the figure, the net volume is zero, as the positive and negative volumes are the same.

over others in the current tabulation require discussion. Because photogrammetric contour maps are generally believed to be more accurate than traditional contour maps (Pierson 1959; Shenkel 1986;Young 1954, 1955), one would assume that estimates generated from the 1991 photogrammetric contour map should take precedence over the results from the earlier, hand- drafted Alabama Museum of Natural History contour map. However, according to the "Mound State Monument Central Development Plan" of January 1939 (notes on file, Alabama Museum of Natural History), Mounds J, K, L, R, S, and T were modified during the Alabama Museum of Natural History and the Civilian Conservation Corps (CCC) restoration projects in 1937. These endeavors included but were not limited to the excavation and reshaping of mounds damaged by erosion and the creation of lakes where prehistoric borrow pits or ponds were believed to have once been located (Jones 1941; Knight 1989). Based on an aerial photograph from 1938 (Figure 2.6) and a visual inspection of the two site maps, Mounds H and I also were modified during Depression Era restorations (Knight 1989, 2009b). Restoration consisted of

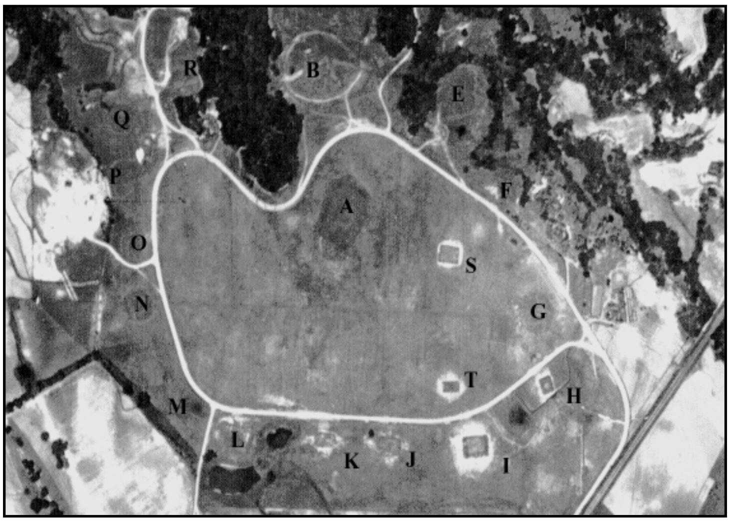


Figure 2.6. Aerial photograph of Moundville in 1938. Note the exposed soil shown by the white reflections around Mounds L, K, J, I, H, S, and T.

scooping up slumped earth around eroded margins of earthworks with heavy machinery, adding the soil back to the summit, and reshaping it. The materials used for re-contouring a mound were either eroded mound soil, the volume of which was determined by excavations (Jones 1941), or in some cases, imported earth.

These historic modifications provide a quandary for this study. The Alabama Museum of Natural History contour map (ca. 1937) was made prior to mound reconstruction, but the later photogrammetric map made more than 50 years later provides what might be a superior assessment. All individual mound maps were made after restoration work. To make matters worse, Jones did not record an estimate for the amount of soil used in mound renovation except in one case, Mound R. A handwritten list on file at the Alabama Museum of Natural History dated December 1932 gives an assessment for the soil, sod, and labor that would have been needed to repair 20 mounds should reconstruction projects occur (Table 2.2). In this pre-restoration estimate, Carl T.

Mound	Est. Volume of Restoration Soil (m^3)
Mound A	321
Mound B	306
Mound C	191
Mound D	306
Mound E	145
Mound F	229
Mound G	88
Mound H	424
Mound I	612
Mound J	46
Mound K	50
Mound L	153
Mound M	96
Mound N	69
Mound O	57
Mound P	191
Mound Q	218
Mound R	474
Mound S	170
Mound T	222
Total	**4,368**

Table 2.2. Projected estimates for mound restoration recorded December 11, 1932 by Carl T. Jones

Jones believed less than 500 m^3 of earth would be needed to restore Mound R, but after completion, it reportedly took more than 7,600 m^3 (Jones 1941:2). Moreover, the list requests soil for 20 mounds, but only six are mentioned as being restored and it is not specifically reported in which cases eroded mound soils or imported fills were employed as construction material. Knight (2009b) found imported restoration fill on Mounds A and V. The summits of Mounds B, E, and G were probably “repaired,” as well as others. In summary, there is no way at the present time of knowing how much soil was used or modified in this restoration work, either per mound or for the entire site. In choosing an estimate, the dilemma is one of either trusting the restoration work as replacing soil eroded over time, or of assuming that modifications using imported soils cloud the true volume. To resolve this dilemma, I chose to use volume estimates derived from the photogrammetric map of the restored mounds as opposed to the 1937 pre-restoration map. Based on the 1938 aerial photograph (Figure 2.6), there is good evidence to suggest that Mounds H, I, J, K, L, S, and T were modified using slumped soil as opposed to imported fill. The photograph shows sizeable scars adjacent to these where earth was removed. Further support for this claim is demonstrated in the minimal size differences of these mounds between the two maps (Table 2.3). Assuming that no imported fill was used, the volume of these earthworks should only vary slightly.

The other restored mounds are suspected of being modified using imported fill. Given the special circumstances of erosion on Mounds A and R, and that their summits and ramps were plowed (Moore 1905; Jones 1941: Gage 2000: Knight 2009b), the restoration soil is assumed to have been added back to the original prehistoric volume.[6] Due to lack of evidence, the same must be assumed for the other mounds believed to have been modified, including Mounds B, E, and G. However, nothing was taken from around the flanks of these mounds, unlike the mounds on the south plaza margin, so the added fill must have been trucked in. Regardless, given the minimal differences between the Alabama Museum of Natural History site map (ca. 1937) and the individual mound maps of these restored mounds it is believed here that the present volume approximates the original sufficiently.

For the mounds that have not been restored, results from individual mound maps, when present, were given precedence over either of the more general site map

[6] Moore (1905:220) mentions plowing but also provides an alternative explanation for the summit shape of Mound R. Moore suggests that the summit was once surrounded by rampart or earthen wall that had collapsed leaving a ridge surrounding the outer ring of the summit.

calculations, as they were generally more detailed and were drawn with smaller contour intervals. It is, however, noteworthy that the individual mound maps showed only minor discrepancies in volume compared to the results from the photogrammetric site map. In cases where there was not a suitable individual mound map, as with the restored mounds priority was given to the photogrammetric map estimates over the Alabama Museum of Natural History contour map results. However, in three cases, Mounds C, D, and V, the Alabama Museum of Natural History contour map was the only available representation.

Results

The volumes of 21 mounds at Moundville were calculated from various contour maps using the gridding method (Table 2.3). The results indicate that the unknown methods used by Jones in 1936 greatly overestimated several mounds, while his estimates for others were much closer to the gridding method results. Survey data concerning the smaller mounds at the site, those outside the plaza periphery, are limited. Mounds U, W, X, M1, R1, B1, C1, E', F1, F2, and Z' were not measured for this study, so Jones's original volume estimates were used in the current volume assessment. Although his calculations tended to exaggerate the size of the mounds, the combined volume of these eleven earthworks accounts for less than 1,100 m^3, or half of one percent of the new site estimate. Therefore, any potential error in the size of these eleven small mounds would have a negligible effect on the mound volume of the site as a whole.

Using the gridding method and the principles for privileging estimates described above, it is estimated here that the total volume of the earthworks at Moundville as 191,975 m^3, in contrast to the 275,575 m^3 suggested by Jones; a difference of almost 85,000 m^3. Even if the largest value for each mound calculated by the gridding method

Mound	Jones 1936 *Method Unknown*	AMNH Ca. 1937 *Gridding Method*	AHC/UA 1991 *Gridding Method*	Individual Mound *Gridding Method*	Current Best Estimate
A	38,610	30,920	30,740	30,150[1]	30,150
B	85,400	42,860	49,530		49,530
C	5,125	5,080			5,080
D	5,810	3,880			3,880
E	23,395	8,950		10,820[3]	10,820
F	4,640	1,920		2,790[3]	2,790
G	8,135	8,675	6,570	6,730[3]	6,730
H	620	490	675		675
I	5,385	2,620	2,690		2,690
J	4,050	2,250	2,570		2,570
K	2,525	1,510	1,855		1,855
L	6,500	3,610	4,420		4,420
M	1,455	620	625	590[2]	590
N	6,500	1,800	3,295		3,295
O	3,670	1,930	1,220		1,220
P	17,700	14,100	14,390	15,880[4]	15,880
Q	3,670	2,920	3,320	3,210[4]	3,210
R	31,195	19,490		21,820[3]	21,820
S	1,745	550	515		515
T	770	425	705		705
U	115				115
V	17,585	22,460			22,460
W	155				155
X	105				105
Y/M1	55				55
Z/R1	95				95
B'/B1	55				55
C'/C1	55				55
E'	110				110
F"/F2	115				115
F'/F1	115				115
Z'	115				115
Total	**275,575**				**191,975**

Table 2.3. Volume estimates based on various sources including Jones's volume estimates from 1936 using an unknown method of estimation, gridding method results from the Alabama Museum of Natural History topographic map ca. 1937, the photogrammetric map by the Alabama Historical Commission and the University of Alabama 1991 and individual mound maps produced by the National Park Service in 1938[1], the University of Alabama Field School1970[2], the University of Alabama Field School 1993[3], and Knight and Krause of the University of Alabama 1989[4].

from the various topographic maps is summed, the site total still only amounts to only 195,575 m^3. It is worth noting that Jones's estimates were calculated prior to any restoration projects, so the volume of imported soils could not have caused the discrepancy. Muller (1997:272-274), using an unspecified frustum formula, calculated the total mound volume of Moundville as 153,337 m^3, some 39,000 m^3 less than the present estimate. In relation to Muller's other volume estimates for large Mississippian mound sites, Moundville does, however remain the second largest in overall mound volume. The total mound volume at Moundville is exceeded only by Cahokia, estimated at more than 1,000,000 m^3 (Milner 1998:145; Muller 1997:274), some six times larger than Moundville. If Muller's values for Etowah are roughly accurate, Moundville's mounds contain some 50,000 m^3 more volume than those at Etowah, the third largest Mississippian mound center by volume (Muller 1997:274). Therefore, even though Jones inflated the total mound volume of Moundville by approximately 85,000 m^3, an overestimate equivalent in volume to the Angel or Kincaid site total, the overall ranking of Moundville in relation to other major Mississippian mound centers remains the same. [7]

Concerning the relative size ranking of individual mounds at Moundville, changes do occur in re-estimating their volume. Mound B is actually half the volume once believed, but is still the largest mound at the site. Morgan (1980:xxxi) gives Mound B as 112,000 m^3, while Jones reported it to be 85,700 m^3, Muller (1997:273) estimated it to be 53,000 m^3, and my estimate is 49,530 m^3. Mound V is larger than originally given by Jones, increasing from 17,584 m^3 to 22,460 m^3, and with the re-estimate is now the third

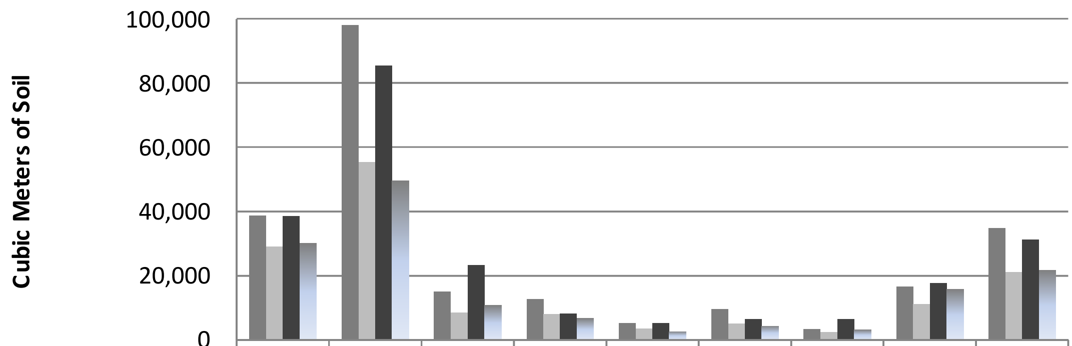
[7] Pauketat (2004:71) argues that the East St. Louis and St. Louis sites are the second and fourth largest Mississippian mound centers respectively, with Moundville being third based on the number of mounds, not mound volume.

largest mound at the site behind Mounds B and A. These three mounds account for approximately 100,000 m^3 of soil; more than half of the total mound volume of the site.

Further Comparison of Volume Methods

Comparison of Contour and Gridding Methods

At this point, one may wonder how we know that the gridding method does not consistently miscalculate the size of these earthworks. The gridding method, to the best of my knowledge, has not been applied previously to estimate volume of Mississippian earthen mounds. This method therefore needs an independent point of reference. In view of this, the volume of Monks Mound at Cahokia, the largest Mississippian earthwork, was calculated using the gridding method. The results were compared to contour method analyses conducted by Reed et al. (1968) and Shenkel (1986). Reed and his colleagues estimated volume from a photogrammetric map produced by Washington University in St. Louis, Missouri in 1966 (Reed et al 1968:139). Their estimate was 622,291 m^3 (Reed et al. 1968:145). Shenkel (1986), using a different undated topographic map (Reed 1973:34), estimated Monks Mound as 610,187 m^3. Using these maps, the results calculated using the gridding method are almost identical to the ones generated using the contour method. My volume estimate using the gridding method from the photogrammetric map of Monks Mound (Reed et al. 1968) is 625,700 m^3; a difference of only 0.5 percent. Gridding method calculations using the undated contour map (Reed 1973:34) results in a volume of 612,665 m^3, a difference of only 0.4 percent. These minor differences indicate that the gridding method and the contour method using planimetry can produce very similar results.



	A	B	E	G	I	L	N	P	R
Prism	38,695	97,930	14,965	12,720	5,385	9,635	3,465	16,705	34,840
Frustum	29,090	55,270	8,470	8,050	3,490	5,050	2,420	11,050	21,100
Jones 1936	38,610	85,400	23,395	8,135	5,385	6,500	6,500	17,700	31,195
Gridding Method	30,150	49,530	10,820	6,730	2,690	4,420	3,295	15,880	21,820

Figure 2.7. Bar chart and table showing the volume estimates using two geometric formulas, a rectangular prism and a truncated rectangular pyramid, compared to Jones and the current volume assessment.

Comparison of Solid Geometry and Gridding Methods

To further demonstrate any systematic differences between the gridding method and the solid geometry methods, the original and current estimates for the largest mounds at Moundville were compared to the results using the formulas of both a rectangular prism and a rectangular truncated pyramid (Figure 2.7). The dimensions for the geometric formulas were obtained from the Alabama Museum of Natural History topographic map (ca. 1937) and the Alabama Historical Commission/University of Alabama photogrammetric map from 1991. The graph shows that the solid geometry method using a rectangular prism formula consistently exaggerates mound size, whereas the frustum formula tends to be more comparable to current estimates using the gridding method. Jones's calculations using an unknown method typically fall between the results of the prism and frustum formulas, but in some cases even exceed prism estimates.

These results indicate that the formula for a rectangular prism produces systematically larger volume estimates than the gridding method, with values ranging +5 to +62 percent larger; an average difference of +35 percent (Figure 2.7). The rectangular prism formula does, however, still rank the largest mounds at Moundville in the same relative order. The identical ranking of these mounds demonstrates that the formula for a rectangular prism works for relative mound comparisons, but cannot provide a result that estimates the true volume of an earthwork.

The results of the frustum formula for a truncated rectangular pyramid are more similar to those of the gridding method than the results obtained using the rectangular prism formula. The volume of mounds generated using the frustum formula ranged from -55 to +45 percent when compared to the gridding method, with an average difference of +4 percent. The frustum formulas are more accurate, but one should still be wary of using volume information generated from this type of equation, especially conducted on earthworks that are more irregularly shaped than those at Moundville.

Other Mississippian Mound Comparisons

Because the gridding method estimates the mound volumes at Moundville to be substantially smaller than originally believed, it is pertinent to check other Mississippian mounds for comparable overestimations calculated using geometric equations. To determine if the volume of mounds has been exaggerated at other sites, maps of four large Mississippian mounds were digitized, including Mound 42, Mound 48, and Mound 60 at the Cahokia (Fowler 1989) and Mound A at the Angel site (Black 1967). All four of these mounds are in Muller's (1997:273) top twenty largest Mississippian mounds in the Eastern United States, and their volumes were calculated by him using geometric

Mound / Site	Solid Geometry Method (Muller 1997)	Gridding Method	Percent Difference
Mound A Angel, Indiana	72,000	51,035	-29
Mound 48 Cahokia, Illinois	60,000	42,230	-30
Mound 60 Cahokia, Illinois	42,000	36,460	-13
Mound 42 Cahokia, Illinois	41,000	34,620	-16

Table 2.4. Previous volumes of other Mississippian mounds from Muller (1997) compared to current estimations using the gridding method.

equations, presumably a frustum formula (Muller 1997:272-273). More mounds would have been digitized but suitable topographic maps are not readily available for certain mounds, such as Mound A at Etowah, reportedly the second largest Mississippian platform mound.

The results from these other sites point to the same conclusion; the volume of these earthworks has been overestimated relative to the more accurate gridding method (Table 2.4). For example, Muller gives the volume of Mound A at the Angel site, listed as the third largest prehistoric Mississippian mound in the Southeast, at 72,000 m^3 (Muller 1997:273). However, by digitizing a topographic map (Black 1967) and using the gridding method, the volume is estimated at 51, 035 m^3, approximately the same size as Mound B at Moundville. Using a truncated pyramid formula, Morgan (1980:xxxi) estimated the volume of Mound A at the Angel site as 51,788 m^3; a result similar to the one generated using the gridding method. The reported size of Mounds 48, 60, and 42 at Cahokia also are overestimated relative to the results generated by the gridding method ranging from 13 to 30 percent (Muller 1997:273).

Given that only a few earthen mounds have had their volume assessed using techniques other than simple formulas for geometric solids, I would argue that the size-rank of the majority of mounds in the Eastern United States should only be thought of as relative based on current data. I am not surprised about this fact given the inherent difficulties (outdated instrumentation and long-hand arithmetic) associated with the contour method. Geometric equations are much simpler and far less time consuming, but lack sufficient accuracy to warrant their use and, therefore, should not be relied upon except when no other method is employable. The gridding method, on the other hand, can be considered a replacement strategy for the outdated contour method. When employed with the aid of computer software, the gridding method can be used to create a more accurate assessment in a time-effective manner. New technology including computerized mapping and contouring software, electronic/optical surveying instruments, and optical remote sensing such as LiDAR (Light Detection and Ranging) give the archaeologist the ability to more accurately measure earthen structures and there is no reason not to take advantage and incorporate this technology in one's research instead of relying upon data from previous, less technologically-advanced methods of volume calculation. In short, if one possesses a suitable contour map or XYZ data, the gridding method should be one's first resort. In cases where contour maps are not available, then the next possible alternative should be the frustum formula assuming one also has elevations and a manner in which to calculate summit dimensions, if not already given. In cases where neither summit dimensions nor a suitable contour map are available, then estimates calculated using geometric formulas of comparable solids would be considered acceptable.

Chapter 3

Plaza Modifications at Moundville

Plaza, a Spanish word originally from the Latin *platea* meaning broad street, is defined as an open public area usually found in an urban setting (Merriam-Webster 2004). Plazas are found worldwide as communal spaces and as the center of formal communities. They are not simply negative space, but are integral to the architecture and to what surrounds them. The concept of the plaza in prehistoric North American societies, also referred to as a town or public square in ethnohistorical accounts, represents a large open space used for communal activities, both sacred and secular (Kidder 2004; Lewis et al. 1998; Rogers et al. 1982; Stout and Lewis 1998). Physical modifications to Native American plazas support the idea that these spaces were an essential part of the landscape, not just open areas between mounds. Mississippian plazas at Cahokia (Dalan 1991, 1993, 1997, Dalan et al. 2003; Holley et al. 1993; Pauketat 2004), Etowah (King 2001; Larson 1989; Sears 1958) and Moundville (Knight 2009b; Knight and Steponaitis 1998), as well as those at Coles Creek sites (AD 700-1200) such as Raffman (Kidder 2004) and Greenhouse (Ford 1951), have provided evidence of physical modification in the form of imported soil and rock used to raise, level, refill, or delineate this space. However, the amount of labor involved in modifying artificial non-mound fills is rarely included in energy expenditure studies. In this chapter, the results of an auger survey and test excavations used to locate physical modifications to the plaza at

Moundville are presented. Then, the gridding method (Chapter 2) is used to estimate the volume of these artificial plaza fills to be included in the total volume of soil that was prehistorically excavated, transported, and compacted in modifying the Moundville landscape for the proposed energetics model (Chapter 6). I will conclude that imported soil within the confines of the plaza has been verified in several places and its combined volume, approximately 15,150 m^3, when added to the volume of total mound fill at the site (Chapter 2), elevates the overall estimate of imported fill at Moundville to almost 210,000 m^3.

The Moundville Plaza

The Moundville plaza is a quadrilateral area approximately 520 m wide (E-W) by 475 m long (N-S) covering roughly 23 ha[8]. Its boundaries are demarcated on all four sides by earthen mounds (Figure 2.1). Mounds F through H mark the eastern boundary of the plaza, Mounds I through L define the southern boundary, Mounds M through Q delineate the western edge and the northern portion of the plaza is demarcated by the largest mounds at the site, Mounds B, E, and R (Knight and Steponaitis 1998). Most scholars of the site agree that this area is one continuous plaza (Knight 1998; Knight and Steponaitis 1998; Moore 1905, McKenzie 1964; Pauketat 2007; Peebles 1978, 1998; Steponaitis 1983a), but its extent and the number of its flanking mounds varies as it is envisioned differently by different researchers.[9]

Peebles (1978, 1998) states the plaza is surrounded by 20 mounds and measures approximately 40 ha. In this view, the plaza extends to the northernmost mounds, Mounds C and D, and places Mounds A and B in the center. The 40 ha estimate

[8] This estimate excludes ravine heads that intrude into the plaza
[9] Morgan (1980) considers Moundville to possess four plazas.

incorporates areas such as ravine heads and the footprints of mounds that would have been unusable for plaza activities. Steponaitis (1983a:6) at one time argued that the same 20 mounds enclose the plaza but estimates its size at 32 ha, presumably subtracting the unusable areas. In more recent estimates of the plaza boundaries, and as also envisioned in this study, its northern border does not extend past Mound B, placing only Mound A in the center (Knight 1998; Knight and Steponaitis 1998; Pauketat 2007). This argument maintains that fifteen mounds surround the plaza, excluding Mounds A, C, D, S, T, and V as plaza flanking monuments. Even using the conservative estimate of 23 ha, the Moundville plaza is at least 4 ha or 15% larger than the Grand Plaza at Cahokia (*cf*. Holley et al. 1993; Pauketat 2004), making it one of the largest Native plazas in the eastern United States.

Knight (1998:52) argues that the formal architectural configuration at Moundville, including the plaza and its peripheral mounds, were used simultaneously as early as the latter half of the 13th century A.D., the beginning of the Moundville II phase. Given this information, it is assumed that the mound and plaza arrangement was designed to fit a predetermined plan. The plan involved segregating space by using an arrangement of earthen mounds around the plaza periphery. It has been previously stated that physical modifications other than mound constructions were also undertaken in order to achieve the design, including moving earth to construct a level building surface and to expand the breadth of the plaza (Knight 1995, 2009b; Knight and Steponaitis 1998).

Previous Plaza Investigations

Until recently, interest in the plaza at Moundville has been minimal. Figure 3.1 shows the work that has been undertaken in the plaza thus far. Not included in the figure

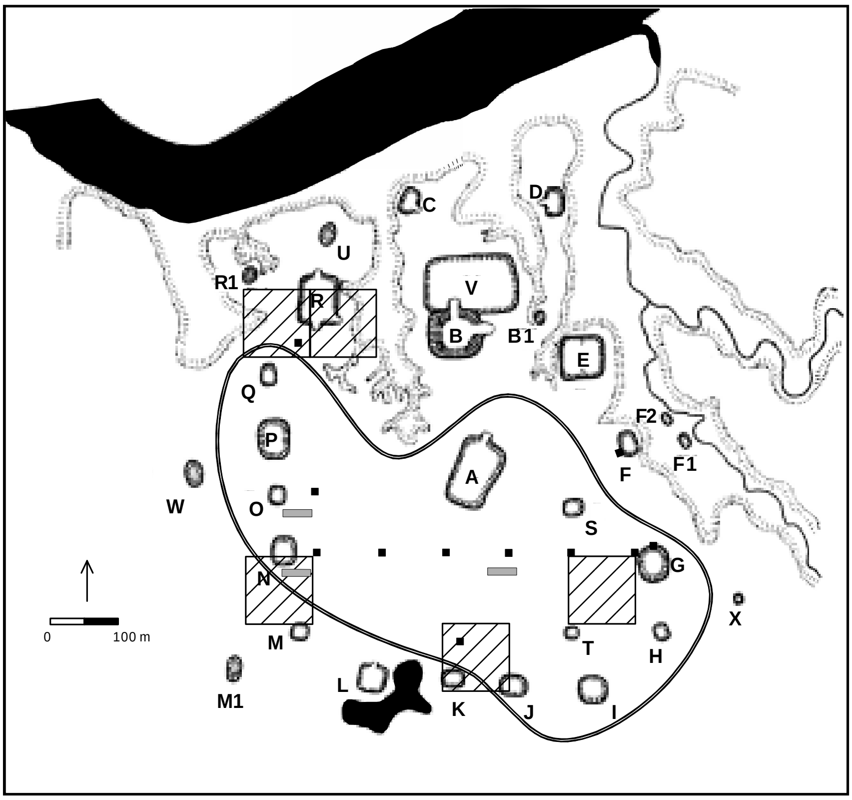


Figure 3.1. Plan map of Moundville showing previous plaza investigations. The 1937 Roadway excavations are marked by the black line encircling the site. Surface collections are shown in gray, excavations are shown in black, and hectares where shovel or auger testing has been conducted are shown with diagonal lines. Excavations and surface collection areas are not to scale but slightly enlarged for visibility.

are Moore's (1905:218) excavations of "a number of trial-holes east of Mound O" and on the "level ground near the western side of Mound A" (1907:340). The first formal plaza excavations were conducted by the Alabama Museum of Natural History and the CCC in 1938 to construct the current roadway encircling the site. The roadway weaves in and out of the plaza, but crosses through the northern half, from Mounds G to Q, and the southwest corner, from Mounds K to M. Depths and profile drawings of these excavations were not recorded, so there is no way of knowing if artificial plaza fill was encountered. Numerous houses, mostly domestic, were uncovered during the Roadway excavations (notes on file, Alabama Museum of Natural History; Lacquement 2007;

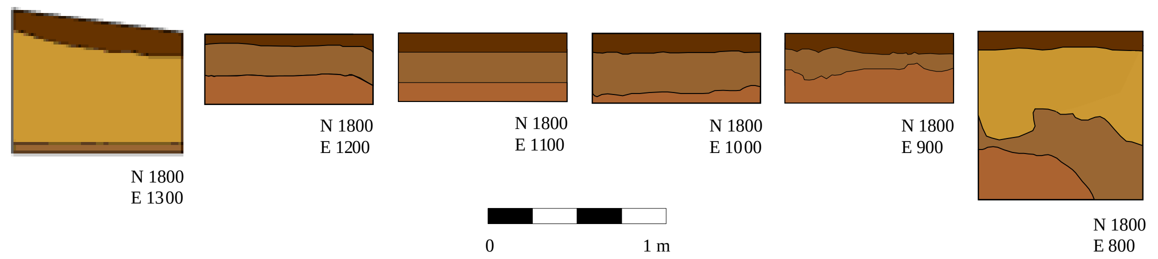


Figure 3.2. South wall profiles of six units crossing the plaza excavated by Driskell in 1988. Each unit is separated by 100 m. The absolute elevations have been shifted for the purposes of illustration. The four units in the middle posse ss the same stratigraphy; humus, brown sandy clay followed by reddish-brown sandy clay. The subsoil is sometimes yellowish-brown. The two end units possess an additional layer of yellowish-brown sandy clay, which is thought to be plaza fill. The unit illustrated on the left, unit N 1800 E 1300, is located at the base of Mound G, showing the layer of fill that runs beneath the mound. Also note that no drawn profile was available for unit N 1800 E 1100. The illustration here was created based on the field notes, which only gave one elevation per stratum.

Wilson 2008). Nearly all of the houses within the confines of the plaza appear to predate AD 1250, the approximate date of the initial use of the mound-plaza arrangement, and were probably erected before the landscape design had fully evolved.

After a forty-year hiatus of plaza investigations, Boyce Driskell surface collected and excavated in the plaza as part of a University of Alabama Field School in 1988 (notes on file, Alabama Museum of Natural History). Three 100 m^2 sections (5 m x 20 m) in the plaza were disked and surfaced collected including south of Mounds A, N, and O (Figure 3.1). According to the inventory forms, no prehistoric artifacts were recovered during surface collections.

In addition to the surface collections, Driskell also excavated two 1 x 2 m and five 1 x 1 m test units. The two larger units were placed in the plaza 100 m apart, one east of Mound N and one east of Mound O. The five 1 x 1 units were positioned 100 m apart and formed a line across the center of the plaza, starting 100 m east of the 1 x 2 m unit east of Mound N and continuing eastward to the base of Mound G (Figure 3.1). Relatively few artifacts and features were recovered in these plaza units, but the varying depths at which artifacts were found and the profile drawings suggest that imported fills were used to level portions of the eastern and western edges of the plaza (Figure 3.2).

The four units in the center of the east-west line were excavated to roughly 30 cm below the ground surface and possessed the characteristics of the unmodified plaza terrace stratigraphy (Figure 3.2). In contrast, the unit directly abutting the west flank of Mound G was excavated to 60 cm, while the two 1 x 2 units east of Mounds N and O ranged in depth from 90 to 100 cm. In these three units, yellow sandy clay was encountered above a buried A-horizon, which is thought to be imported fill. Both 1 x 2 m units are at least 30 m away from a mound, making it doubtful that the additional fill was caused by the erosion of earthworks. Furthermore, based on the profile drawing and description of the soil, I believe that Driskell's unit N 1800 E 1300, the unit at the base of Mound G, was not completely excavated down to the sterile terrace subsoil. The deepest level excavated consisted mostly of sand ranging from light tan to dark orange, not the typical yellowish-orange sandy clay subsoil. Knight's (2009b) excavations abutting the northern flank of Mound G, less than 10 m away, support this claim, as sterile subsoil there was more than one meter deep.

In the spring of 1993, Vincas Steponaitis and colleagues (1994) conducted a series of systematic auger tests at Moundville. Two devices were used, including a hand-held split-core auger, 2 cm in diameter, capable of depths of 80 cm, and a gasoline powered auger, 30 cm in diameter and capable of drilling to depths of 50 cm. Two hectares were surveyed, but only one was inside the plaza boundary, located southwest of

Mound G (Figure 3.1). Split core augering was employed at 10 m intervals and the power auger was employed at 20 m intervals. Unfortunately, depths were not reported, but an interesting distribution of artifacts was discovered. The positive and negative auger tests were clustered, with positives occurring in the south and east of the hectare and negative tests grouped in the north and west. Based on this distribution, the authors believed they had pinpointed the plaza's edge, marked by a rich artifact concentration outside and virtually nothing inside.

In the fall of 1993, Knight (1995, 2009b) conducted excavations on the summits and/or flanks of several mounds at Moundville, including Mounds E, F, G, and R. Stratigraphic evidence from a 2 x 8 m trench unit on the western flank of Mound F indicated that mound fill may have continued off the mound and into the adjacent plaza. That same year, a unit at the base of Mound G (Figure 3.1) revealed large amounts of artificial fill beneath the mound on the north side, indicating the plaza was raised significantly to produce a level building surface for construction. In 1996, Knight returned to Mound F and excavated a 2 x 2 m unit in the plaza directly abutting the western flank (Figure 3.1). Based on the depth of the original ground surface, 130 cm below the mound, Knight concluded that soil was used to the level the plaza leading up to Mound F, but this was done after the mound's initial building stage (Knight 1998, 2009b; Knight and Steponaitis 1998).

In the fall semesters of 2005, 2006, and 2007, John Blitz excavated in two places in the Moundville plaza. The 2005 excavations, which consisted of eight adjoining 2 x 2 m units, were executed in the northwest corner of the plaza, south of Mound R (Figure 3.1). There were no indications of plaza fill in this area. Additionally, a 2 x 2 m unit, started in 2006 and expanded to a 4 x 4 m unit in 2007, was excavated north of Mound K. Sterile subsoil in this unit was not uncovered until approximately 90 cm below the surface, suggesting to me that this was perhaps another area where soil may have been imported to level the plaza (field notes on file, Department of Anthropology, University of Alabama).

Also in 2006, Claire Thompson (2010) conducted systematic shovel tests in eight hectares around the southeastern corner of the site and two hectares south of Mound R. Of the ten hectares tested, only four were partially within the confines of the plaza. These include two partial hectares south of Mound R, a hectare partially overlapping the plaza between Mounds M and N, and a hectare north of Mounds K and J. In this testing, 50 x 50 cm shovel tests were employed at 10 m intervals. Each test was excavated until sterile subsoil was reached. As in Blitz's formal excavations, no artificial plaza fill was discovered south of Mound R. However, in several shovel tests around Mounds J, K, and N artifacts were found at depths exceeding those expected for soils developed on the sterile terrace deposits, indicating that artificial plaza fill may be located in these vicinities.

Based on evidence presented above, Driskell, Knight, Blitz, and Thompson all encountered artificial fills on the flat ground around the plaza's outer margin, providing evidence of physical modification to the Moundville plaza. All such evidence of artificial plaza fill thus far has been restricted to the outer edge of the plaza near the peripheral mounds. No evidence has come to light that the center of the plaza was modified. Thus, based on prior work, plaza areas suspected of modification include west of Mound F, surrounding Mound G, east of Mounds N and O, and between Mounds J and K.

Moreover, visual inspection of the terrain by the author suggested two other possibilities: east and northeast of Mound P, and south of Mound E.

Archaeological Methods for Determining Plaza Fill

To determine the location, size, and chronology of modified plaza fills, two procedures were employed. First, an auger survey was conducted in the spring of 2007, using a hand-held 5 cm diameter bucket auger. The device is twisted into the ground, churning up and removing approximately 20 cm of soil per insertion, and is capable of reaching depths of up to 2 m. Transects for the survey were oriented in a manner to best test for fill in the suspected areas as outlined in the previous section. In all cases, 10 m intervals were used along these transects, except in the area west of Mound F, in which 8 m intervals were employed.[10] Areas for the auger survey consisted of south of Mound E, west of Mound F, surrounding Mound G, and east of Mounds N and O. These areas were selected based on the results from previous excavations by Driskell and Knight, as well as visual abnormalities in the terrain. The area south of Mound E was tested given its close proximately to the suspected fill west of Mound F.

The second method employed for investigating plaza fill consisted of small test excavations. Six units were excavated in the fall of 2007, including one west of Mound F, one southwest of Mound G, one southeast of Mound N, one east of Mound O, one east of Mound P, and one northeast of Mound P. Each unit was excavated by observed stratigraphy and soil was dry screened through ¼-inch mesh. Excavations continued until sterile subsoil was reached, which consisted of yellow, orange, or reddish sandy clay terrace soils. Units were named based on the numerical coordinates of the southwest

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[10] The survey area west of Mound F was limited by the Park roadway, mound and ravines. The interval was decreased here to accommodate more auger tests.

corner of the unit within the Moundville site grid system. The artifacts from each of the six units are tabulated in the Appendix.

Following these field procedures, the method of measuring the volume of the plaza fill in each area was the same as the method used in calculating mound fill (Chapter 2). In short, computer software was used to calculate volume by gridding the region into equal cubic portions. The suspected fill area was determined based on the depths of sterile subsoil from the auger survey. The bucket auger could easily detect the contrast between the sterile terrace deposits and everything lying above, but could not so easily detect the top of the buried A-horizon. For volume calculations, 40 cm – the average depth of sterile subsoil in areas with no plaza fill – was subtracted from the depth of each auger test (Figure 3.3). Subtracting the average depth of naturally and culturally modified soils developed over sterile terrace deposits as a correction factor, provided a method of correcting for the depths of the humus and cultural levels above sterile terrace deposits. The reason for this correction is to create a zero point for volume calculations for tests with no fill. However, plaza fill would have been added on top of the naturally and culturally-modified A-horizon soils, and their depth should not be included in measurements of artificial plaza fills.

Though the plaza area north of Mounds J and K appears to be a promising location of artificial fill, no investigation was undertaken there for this study. Instead, the depths of deposits within the 50 x 50 cm shovel tests conducted by Thompson (2010) at 10 m intervals within the hectare were employed to calculate an estimated volume of artificial plaza fill. The volume estimate of fill within this hectare from the 2006 shovel test survey should be treated with caution however, as artifact recovery, rather than

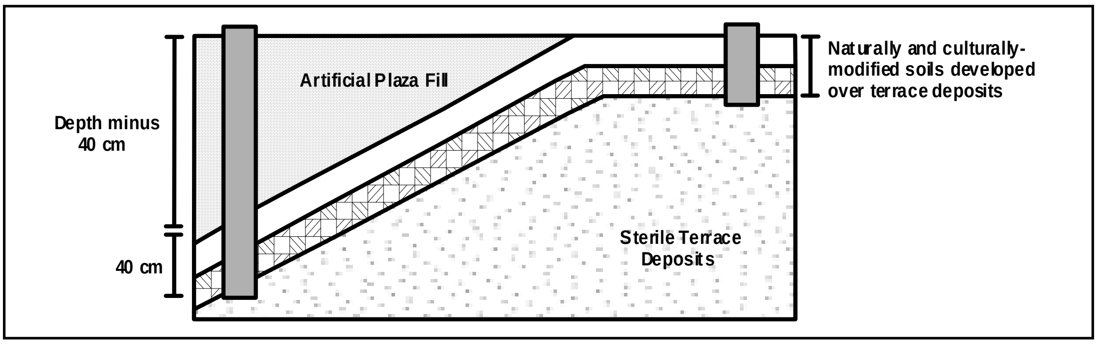

Figure 3.3. Hypothetical profile drawing illustrating auger tests at difference levels of fill. Subtracting measurements for the average depth of soils developed on the sterile terrace deposits enabled the use of a correction factor of 40 cm.

recording of soil profiles, was the primary objective of Thompson's work. Shovel tests were dug to sterile subsoil, except in cases where subsoil exceeded 80 – 90 cm below the surface.

Results

The results from auger survey and excavation confirmed that artificial fill had been added to several places around the outer margin of the plaza (Figure 3.4). These areas include west of Mound F, north, west, and south of Mound G, and east of Mounds N and O. Also, as discussed, there is possible evidence of plaza fill extending northwest from Mound J, based on the depth of Thompson's shovel tests. However, this investigation also disconfirmed the presence of fill in the vicinity of Mound P, and only very slight evidence of such was found south of Mound E.

The total amount of artificial plaza fill is roughly 15,150 m^3, or 7% of total site volume (Table 3.1). The combined volume of these artificial fills is approximately equivalent to that of Mound P, the fifth largest mound at the site (Chapter 2). Individually, the volume of each formation would have made an average-sized earthwork at Moundville, had they been constructed as mounds. Plaza investigations were in no way comprehensive, so other areas of fill may exist that have yet to be located.

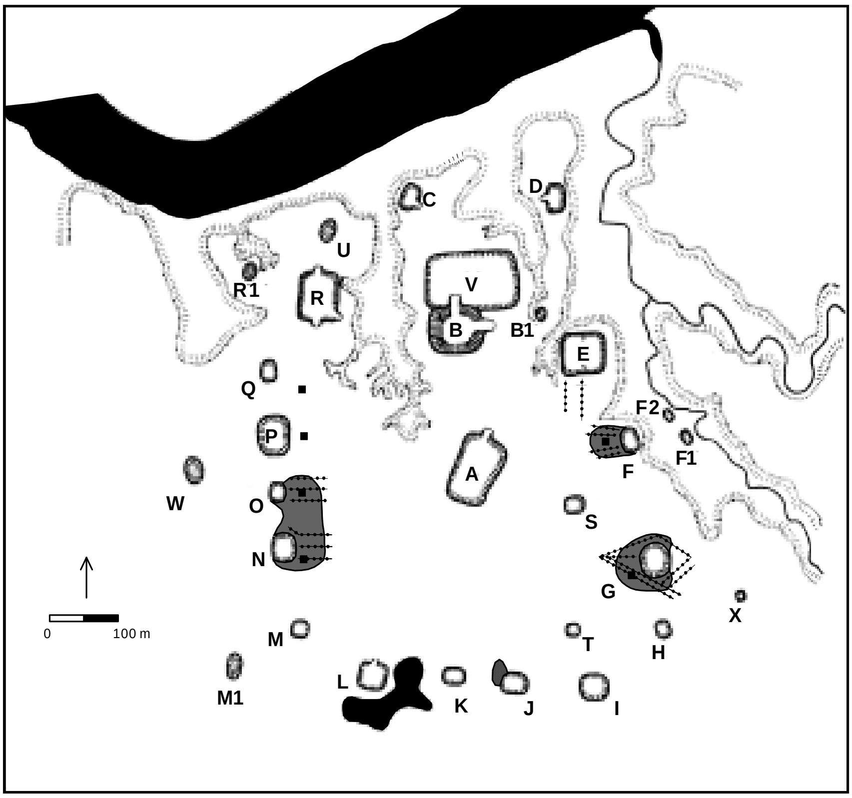

Figure 3.4. Plan view of the auger survey (dotted transect lines), test excavations (black squares), and areas of suspected fill (shaded areas). The suspected area of fill northwest of Mound J was not part of the auger survey and is indicated differently.

Location	Amount of Fill m^3
West of Mound F	2,545
North, West, South of Mound G	5,480
East of Mound N and O	6,540
Northwest of Mound J*	580
Total Plaza Fill	15,145
Total Mound Fill	191,975
Site Total	**207,120**

Table 3.1. Plaza fill locations and the estimated amount of soil added in each location, obtained using the gridding method, added to the total fill estimated for the site. *Soils were estimated from Thompson's data, not from auger tests.

In the following sections, the auger survey and excavations for the areas that possess plaza fills are discussed individually. Based on the ceramic artifacts recovered from each unit, an estimated age of the fill is offered. Concluding the presentations for these positive areas, I will briefly summarize the investigated areas where plaza fill was not found.

Plaza Area West of Mound F

Mound F is a small mound situated on the eastern side of the plaza, constructed on a sloping surface at the head of a large ravine. In 1993, Knight (1995, 2009b) excavated a 2 x 8 m trench unit on the west flank of the mound. In 1996, he returned to Mound F and placed a 2 x 2 m unit, slightly offset from the original trench, at the base of the mound (Figure 3.1). The intent of the follow-up excavations was to determine whether artificial fill extended off the mound, leveling the plaza. Based on the profile and the depth of the premound midden, which was found to be almost a meter and a half deep at the toe of the mound, Knight concluded that artificial plaza fill was added, which continued out into the plaza perhaps some 50 m. He also noted that the fill was stratigraphically contiguous with the second construction episode of the mound. The ceramic and radiocarbon evidence recovered at that time indicated that the second stage of Mound F and the corresponding plaza fill date to the cusp between the early and late Moundville II phase (Knight 2009b).

To more fully determine the size and extent of the plaza fill, I conducted an auger survey in the plaza west of Mound F (Figure 3.4). Four transects, each 48 m in length, were employed with tests at 8 m intervals. Depths to sterile subsoil in this survey area ranged from 40 cm to 135 cm, increasing as the tests moved closer to the mound. The auger survey also revealed a midden layer deep below the surface in the center of the survey area, overlapped with a small layer of yellow clay. Upon visible inspection, the north and south margins of this formation of artificial plaza fill are quite obvious. A lobe extending west of the mound was clearly constructed to bring the naturally sloping terrain southwest of the mound up to the common grade. Based on the depths of the auger tests, the estimated amount of plaza fill west of Mound F is approximately 2,545 m^3 (Figure 3.4, Table 3.1).

A formal 1 x 1 m excavation unit, N 1930 E 1263, was placed in the center of the formation. The unit was positioned approximately 20 m from the mound and was excavated to a depth of 105 cm (Figure 3.5). The uppermost level (Level A), while originally fill, is plow-disturbed. The profile of the unit shows a layer, of artificial fill (Level B), overlying the old humus (Level C), a buried A-horizon /midden (Level D), and the sterile terrace subsoil (Level E). The distribution and size of artifacts per excavation level supports the idea that imported fill was used, that is, artifacts recovered at the top and bottom of the unit were much larger and more frequent, while the fill in between yielded relatively few sherds.[11] The only pottery recovered from the suspected fill consisted of small sherds, none much larger than 1 cm in size. In contrast, a thin occupation level marked by dark rich organic soil (Level D) was discovered below the fill, which contained several large pottery sherds and bits of fired clay. The profile (Figure 3.5) also shows a portion of the pure yellow clay layer above the midden seen in the auger tests.

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[11] The counts in the Appendix for Unit N 1930 E 1263 may appear deceiving. One should note that the artificial fill layer in all units containing artificial plaza fill is two to three times larger by volume than any other level. In addition, although the ceramic frequencies are roughly equal between the fill and underlying strata, the total weight of artifacts recovered from the underlying humus and a-horizon is more than triple that of the overlying fill.

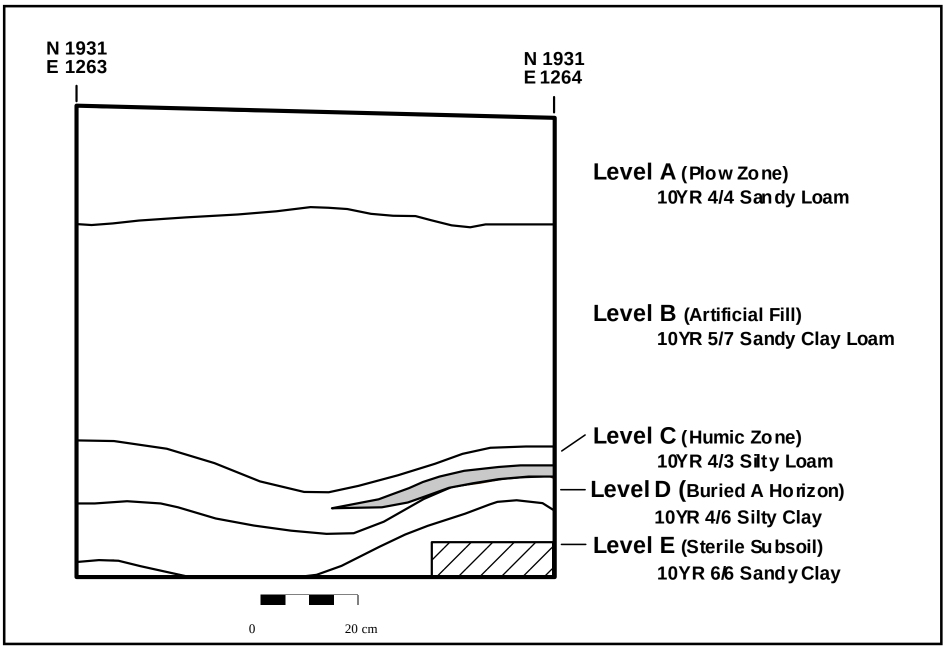

Figure 3.5. East profile of unit N 1930 E 1263. The small layer of yellow found above the midden is shaded in gray.

The small size of the artifacts in the fill (Level B) suggests that the soil may have come from a nearby ravine or another area that was previously used to discard waste.

According to Knight (2009b), all three of the construction episodes of Mound F are believed to have occurred within the Moundville II phase (AD 1260 – 1400). The first stage of the mound was constructed during the early Moundville II phase and the latter two episodes during late Moundville II phase. As already noted, Knight (2009b) equates the artificial plaza fill stratigraphically with the second construction episode. In unit N 1930 E1263, good pottery diagnostics are present beneath the suspected artificial fill, including 38 sherds (151 g) classified as Moundville Engraved, *variety Elliots Creek*, which dates to the late Moundville I phase (Knight 2009b; Steponaitis 1983a:315-316). The existence in this level of Moundville Incised, *variety Moundville*, which occurs throughout the Moundville I and II phases, may indicate a date as late as the late

Moundville II phase. However, all 17 sherds (126 g) within this category found beneath the artificial fill possess relatively long, closely spaced incised lines radiating from the incised arch, characteristic of earlier as opposed to later designs (Steponaitis 1983a:324-325). Diagnostic pottery modes also indicative of a late Moundville I date include two folded jar rim sherds and one large scalloped rim bowl sherd. Thus, all ceramic evidence recovered from beneath the fill seems to support a late Moundville I date for the old humus and A-horizon/midden level, which is consistent with Knight's dating of the stratigraphically later plaza fill to the late Moundville II phase (Knight 1995, 2009b).

Among the small sherds found in the suspected fill from the Mound F plaza unit, eight sherds (25 g) of Baytown Plain, *variety Roper*, a Moundville diagnostic of the early Moundville I phase, and a folded-flattened jar rim sherd, also characteristic of the early Moundville I phase (Scarry 1995:62-64; Steponaitis 1983a:131, 304-305, 1992:6) were discovered. The most obvious explanation for late Moundville I phase pottery superimposed by early Moundville I phase pottery is that the deposits above the original occupied surface consisted of imported artificial fill including a few earlier sherds. Thus, the best estimate for the age of the artificial fill west of Mound F is the early Moundville II phase.

Plaza Area Surrounding Mound G

Mound G is a slightly above average-sized mound, by Moundville standards, situated on the eastern side of the plaza. The mound was constructed on the margin of a shallow basin that drains to the east and northeast. In 1993, Knight (1995, 2009b) excavated two 2 x 2 m units, one at the base and one near the top of the northern flank of the mound. In the base unit, he uncovered four mound construction stages overlying a thick deposit of artificial fill. Underneath the fill lay a shallow old humus with overlapping wall trenches from structures built on the original ground surface. The ceramic and radiocarbon evidence indicates that the fill was added either prior to or at the same time as the earliest construction episodes of the mound, which began during the late Moundville I phase. It appears that the fill was added to expand the level plaza to the north and east, so that the earthwork, or at least the majority of it, could be constructed on a common grade with the remainder of the plaza. This expansion may also have modified the natural surface drainage, diverting water to the east and southeast instead of to the north. Knight (2009b) speculated that this change in the landscape may have created the depression between Mounds H and I, later to be named Lake #1 (Chapter 4).

I conducted an auger survey on all four sides of Mound G in a diamond-shaped pattern (Figure 3.4). Seven transects ranging in length from 50 m to 80 m were employed, with tests conducted at 10 m intervals. The results indicate that plaza leveling occurred to some degree on all sides of the mound except to the east. Artificial fill zones on the northern and southwestern flanks of the mound were especially thick. The depths from the auger survey indicate that the artificial plaza fill in this area as calculated using the gridding method is approximately 5,480 m^3 (Figure 3.4, Table 3.1). This artificial fill constitutes a lobe-like protrusion, slightly off-center from the mound, feathering into the natural terrace surface of the plaza. This formation is less obvious visually than the area of fill west of Mound F, but is still notable, especially when standing slightly southeast of the mound looking west across the plaza.

A 1 x 1 m test unit, N 1780 E 1294, was placed to the southwest of Mound G, approximately 10 m away from the mound. Results were similar to the excavation unit west of Mound F, in that a layer of artificial fill lay above the original ground surface (Figure 3.6). Sterile subsoil was not reached until the unit was 115 cm below the surface. Level A, though plow disturbed, was considered to have originally been artificial fill. Several layers of strata, including evidence of artificial fill (Level B) and water-laid sediments, appeared above the old humus (Level C), the buried A-horizon (Level D), and the sterile terrace subsoil (Level E). When looking at the north and east wall profiles, one can see how the original surface once sloped to the northeast, not to the southeast as it does presently. Except in the plow zone, in which an unusual quantity (3.2 kg) of fire-altered Pottsville sandstone was found, artifacts were sparse throughout the entire unit. However, the few ceramic diagnostics that were recovered indicate that the original humus dates to the late Moundville I phase, based on a single folded jar rim sherd (Scarry 1995; Steponaitis 1983a). No diagnostic pottery other than the jar rim was found below the old humus, but non-diagnostic sherds and charcoal were scattered throughout both the humus and buried A-horizon soils. Thus, the ceramic evidence recovered, minute as it may be, seems to support a late Moundville I date for the old humus level, consistent with Knight's dating of the plaza fill to the same phase (Knight 1995, 2009b). Artifacts discovered in the plow zone, including a beaded rim bowl sherd and a short-necked bowl sherd suggest an occupation above the fill which dates between the late Moundville II and the late Moundville III phases. Regardless, it appears that the artificial fill on the north, east, and south of Mound G dates to the late Moundville I phase.

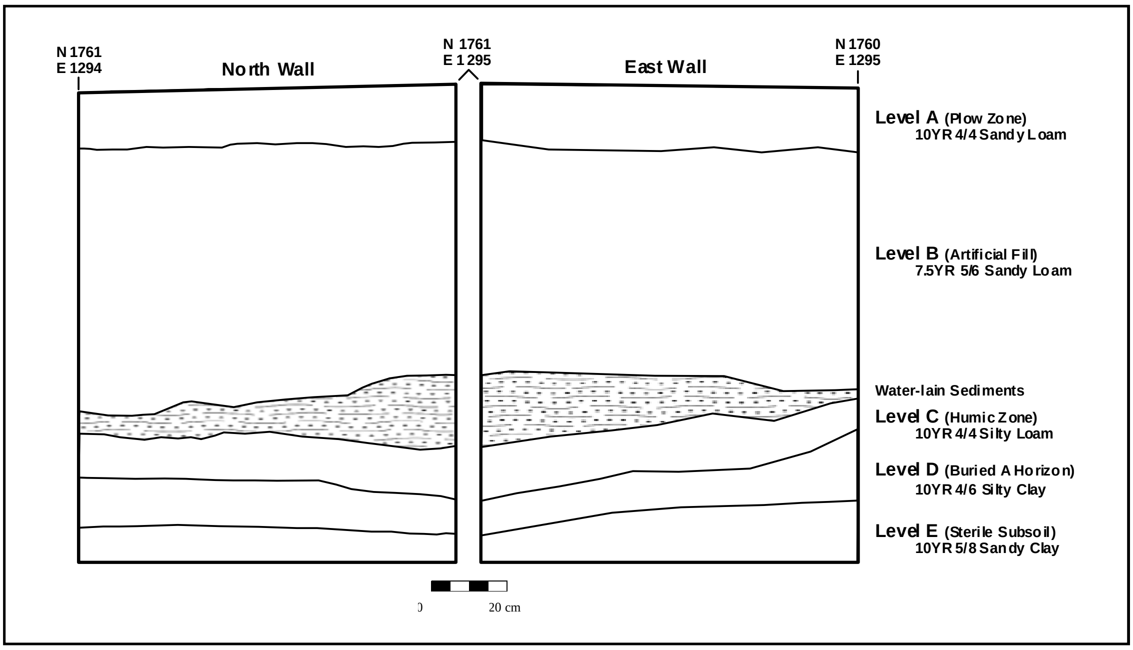

Figure 3.6. North (left) and East (right) profiles of Unit N 1760 E 1294.

Area East of Mounds N and O

By Moundville standards, Mound N is an averaged-sized mound on the southwest corner of the plaza. Mound O is approximately 100 m to the north of Mound N and is considerably smaller in size. Both mounds sit on the edge of a shallow linear drainage sloping to the west and draining to the north into a deep ravine. A section of this drainage, which may have been the remnant of an old creek bed, was dug out in 1937 to create Lake #3 between the western plaza mounds and the museum (Figure 1.2). As previously noted, Driskell excavated two 1 x 2 m test units in this area, one within the vicinity of each mound on the plaza side (Figure 3.1). In both of these units, a zone of artificial fill covered the original ground surface.

Based on the supposition that there were two independent fills east of Mounds N and O, the auger survey was divided into two areas. First, three transects ranging from

60 m to 70 m in length with 10 m intervals were established to the east of Mound N. Second, three transects of 60 m were tested east of Mound O, also at 10 m intervals. Auger tests revealed that in both areas the depth of the subsoil increases as one moves from east to west, towards the mounds. Given that a decrease in the depth of the subsoil was not indicated on the transects closest to the space between these two mounds, it appears that the lobe is one continuous formation, not two independent fill areas as originally suspected (Figure 3.4). In addition, midden was found deep below the surface, over 110 cm in depth, in close proximity to the southeast edge of Mound N. Like Mounds F and G on the opposite side of the plaza, Mounds N and O were not built on level ground. Artificial fill was only added on the plaza side of the mound; the opposite side was not modified. Based on the auger survey and my interpolation of the depths of the original ground surface between these two mounds, the artificial plaza fill measures some 6,540 m^3.

Two 1 x 1 m test units, N 1791 E 778 and N 1891 E 776, were placed east of Mounds N and O, respectively. In the unit east of Mound N, I encountered part of an individually-set post structure, including one large posthole and three smaller postholes just beneath the plow zone (Level A). This is a house form characteristic of the Moundville III phase (Lacquement 2007). Associated with the structure in this level were large amounts of daub and charcoal. There was also some evidence of underlying fill beneath the structure, as subsoil was uncovered approximately 95 cm below the surface. However, the buried A-horizons[12] (Levels C1, C2) overlying the sterile terrace deposits (Level E) were much thicker than usual in this area, so the fill (Level B) appears to be less than 60 cm thick (Figure 3.7). This limited depth makes sense given that the

[12] There was not strong evidence of an old humus, but instead two buried A-horizons.

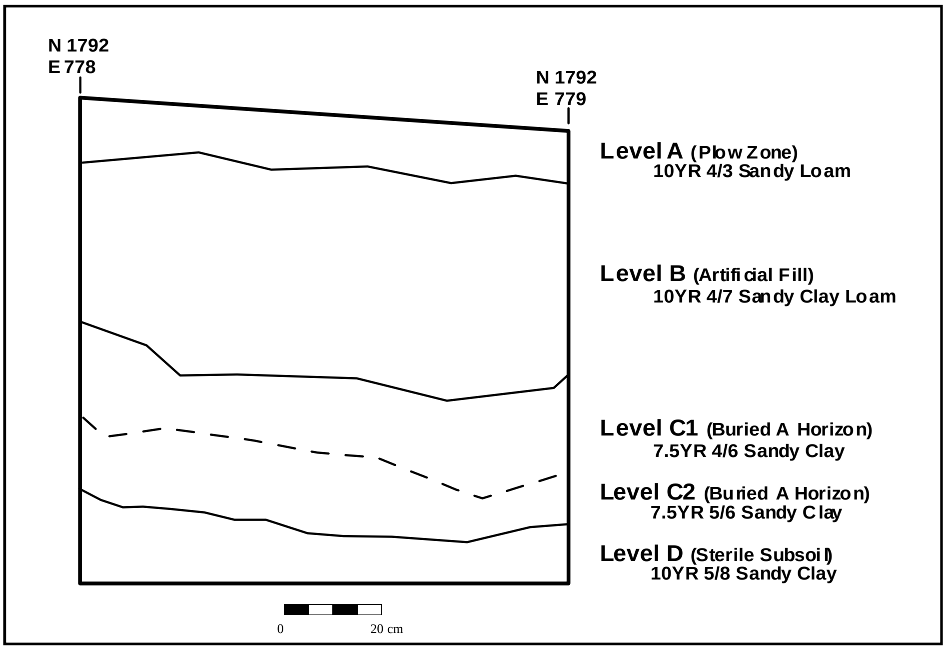

Figure 3.7. North Profile of unit N 1791 E 778, east of Mound N.

position of the unit is situated near the edge of the artificial fill formation (Figure 3.4, Figure 3.9).

The only diagnostic artifacts recovered from Unit N 1791 E 778 which pertain the age of the fill include two nonlocal sherds, presumably from vessels imported from the Lower Yazoo Basin, one classified as Carter Engraved, *variety Sara* and the other Carter Engraved, *variety Unspecified*. Carter Engraved, *variety Sara* dates to the earlier half of Winterville phase (AD 1200-1350), one of the latest Carter Engraved varieties (Williams and Brain 1983:139). Based on these two sherds alone, the plaza fill presumably dates to the late Moundville I/early Moundville II phase. The architectural style, the large amount of daub (4.9 kg), and a single beaded rim bowl fragment indicate that the upper surface dates to the Moundville III phase or later. To reiterate, the artificial fill east of Mound N

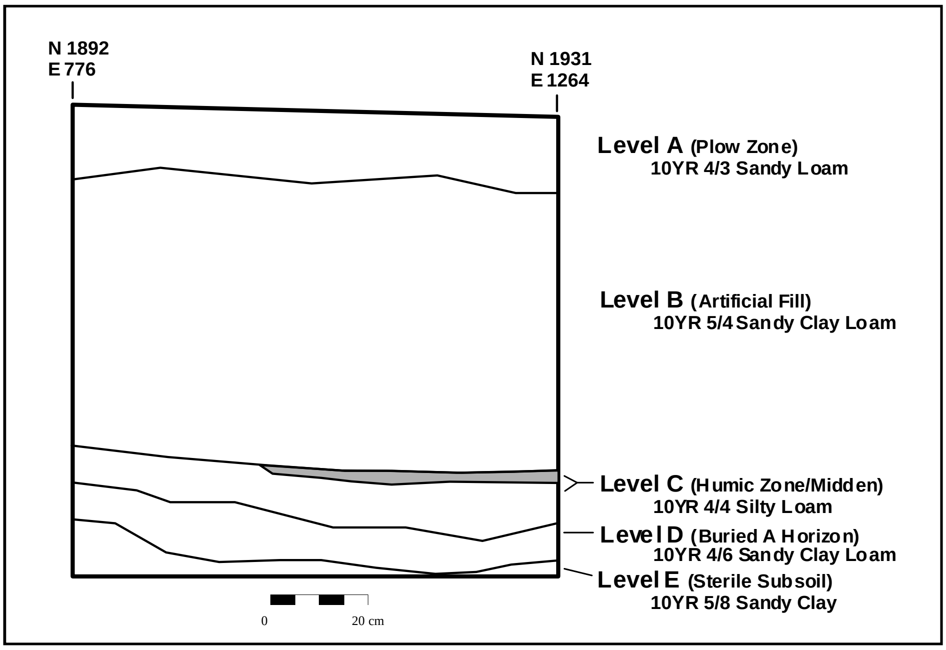

Figure 3.8. North Profile of unit N 1891 E 776, east of Mound O. A small midden layer found in Level C is shown in the shaded area.

appears to date to the late Moundville I/early Moundville II phase based on limited evidence.

Unit N1891 E 776, east of Mound O, yielded results similar to Mound F, in that concentrations of artifacts were found both above and below a layer of artificial fill, which itself contained much smaller and less frequent cultural debris. The unit was approximately 15 m from Mound O, and was excavated to a depth of 100 cm (Figure 3.8). The uppermost level (Level A), though plow disturbed, was originally plaza fill. Artificial fill (Level B) was found above an old humus containing a small midden layer (Level C), a buried A-horizon (Level D), and sterile terrace deposits (Level E). However, as with the units near Mounds G and N, very little diagnostic pottery was recovered. A diagnostic pottery mode recovered from Level C, the suspected original ground surface, includes a single folded jar rim sherd dating to the late Moundville I phase, suggesting that the fill was placed during or after that phase. The estimated age of artificial plaza fill east of Mound O thus corresponds to the age for artificial fill in other locations investigated for this study; to the late Moundville I/early Moundville II phase.

In addition to the auger survey, the depths recorded from Thompson's (2010) shovel test survey support the conclusion that artificial fills were used in the part of the plaza east of Mound N, even though only a small portion of the hectare surveyed by Thompson overlaps the auger survey area for this study. Figure 3.9 color-codes the depths of Thompson's shovel tests within this hectare. The shovel tests were offset from the grid corners shown, such that each test was excavated in the center of one of the 10 x 10 m units shown in the figure. The results show that a cluster of shovel tests in the northeast corner of the hectare exceeded the average depth of the natural sterile terrace deposits. This cluster of tests would correspond to the edge of the artificial fill formation discovered during the auger survey for this study (Figure 3.4). Two other areas within the hectare but outside of the plaza also show relatively deep fills, including one north, east, and west of Mound M, and a second cluster in the western portion of the hectare southeast of a junction between the Park roadway and a service road. However, the depth of the shovel tests surrounding Mound M and those southeast of the junction were probably caused by mound slump (Astin 1996) and drainage erosion, respectively, and are therefore not considered plaza fills.

Northwest of Mound J

Mound J is a relatively small mound located on southern portion of the plaza. It sits on fairly level ground, with a gradual rise surrounding all sides that appears to pedestal the earthwork, though the rise is more prominent on the plaza side of the mound.

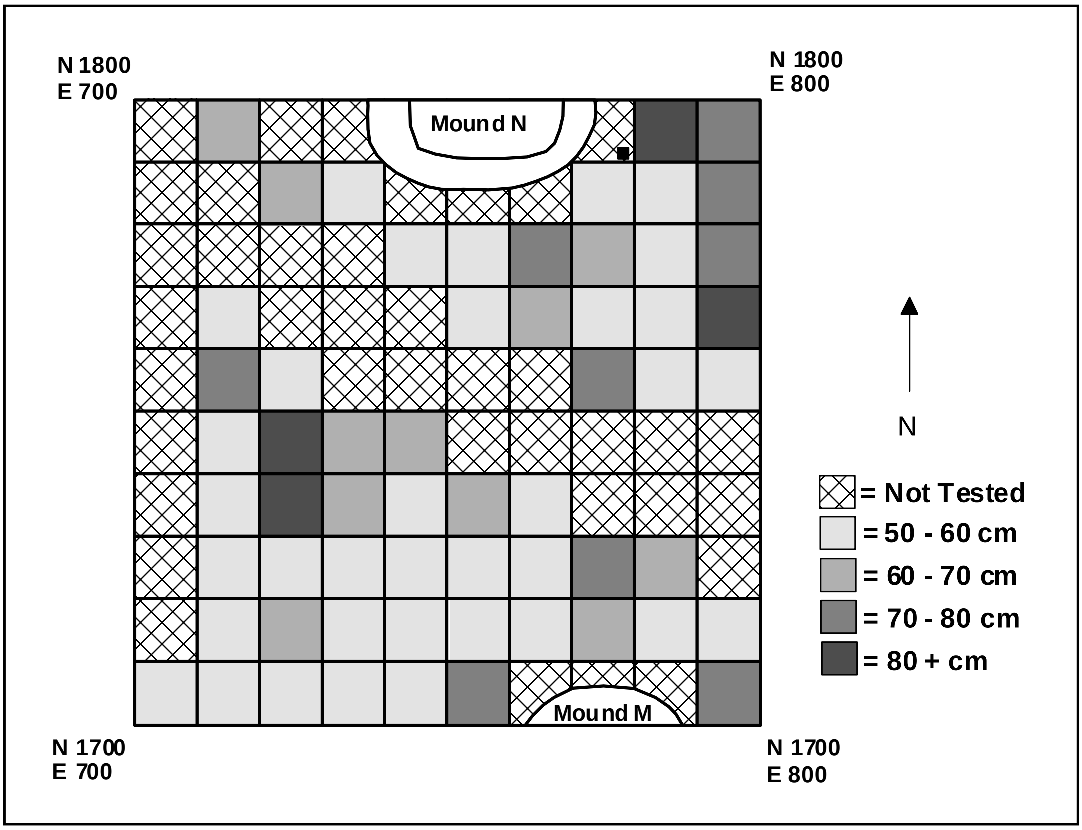

Figure 3.9. Hectare N 1700 E 700 showing the depths of shovel tests by Thompson. Each square of the grid is 10 m by 10 m and the small black square in the upper right is unit N 1791 E 778, excavated for this study. Note that shovel tests were conducted 5 m offset from the grid, such that each shovel test was placed in the center of units shown (data from Claire Thompson, used by permission).

As previously mentioned, Blitz and Thompson excavated and conducted shovel tests respectively between Mounds J and K. However, neither auger survey nor excavations were conducted in this area as part of the present study. Based solely on Thompson's shovel test depths, areas of possible fill are shown in Figure 3.10. At first glance, there appear to be three or possibly four locations of fill. However, among these I am only comfortable including the area northwest of Mound J as an area of possible artificial plaza fill. Even so, there is a possibility that the formation there is the result of mound restoration projects conducted by the Alabama Museum of Natural History and the CCC in the late 1930s in which heavy machinery was used in this area (Jones 1941; Knight

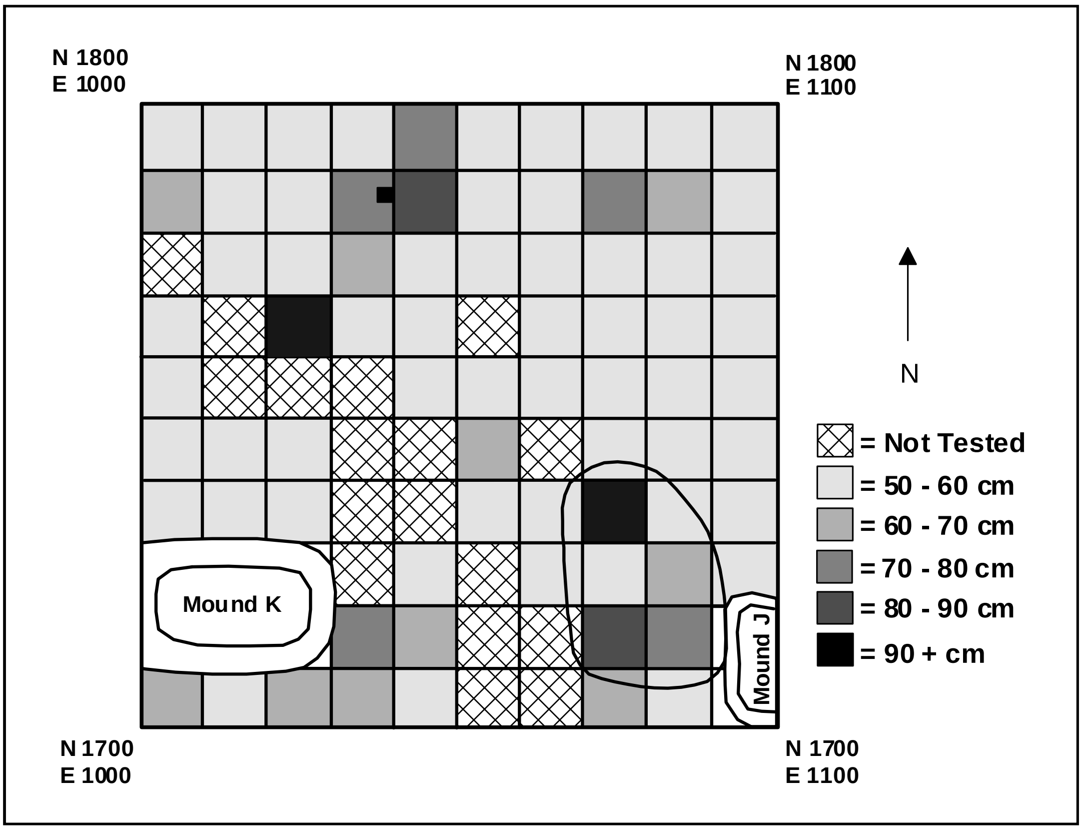

Figure 3.10. Hectare N 1700 E 1000 showing the depths of shovel tests conducted by Thompson. Each square of the grid is 10 m by 10 m and the small black box in the upper center is the 4 x 4 m unit excavated by Blitz in 2006 and 2007. Note that shovel tests were conducted 5 m offset from the grid, such that tests were placed in the center of th e units shown (data from Claire Thompson, used by permission).

1989). The volume of the fill northwest of Mound J is estimated at some 580 m^3. The other areas yielding unusually deep shovel tests, north and southeast of Mound K and north of Mound J, seem suspect to me. The area surrounding the southeast margin of Mound K appears to be mound slump. It is also not on the plaza side of the mound, as are all of the other verified artificial plaza fill areas at the site. It is possible that the other areas were at one time small borrow pits that were refilled by plowing and erosion. Moore (1905:130) indicates depressions near several of the mounds outside the plaza, created by extracting soil for construction. Some contained water, while others had ditches dug to drain them during the late 19th and early 20th century. James D. Middleton also made note of several small depressions during his visit to Moundville in 1882 (Steponaitis 1983b).

Areas in Which Plaza Fill was Not Found

Three other areas were tested either by auger survey or by test excavations. These areas, which provided limited or no evidence of fill, include south of Mound E, as well as east and northeast of Mound P.

The plaza area south of Mound E was systematically auger tested given its close proximity to Mound F. Mound E is a broad but low mound in the northeast corner of the plaza, situated near the head of a ravine which surrounds the north and east of the mound. However, due to the presence of a documented prehistoric cemetery on the east side of the suspected formation (Peebles 1979), only the western half was tested. Two transects of 80 m with 10 m intervals produced varying depths of subsoil ranging from 40 to 80 cm and virtually no artifacts. It also should be noted that the subsoil south of Mound E was very difficult to distinguish from overlying strata in both color and textural characteristics. At this point, therefore, only limited evidence of fill exists south of Mound E based on the deeper readings of a few auger tests, and if anything, it appears to be filling in low isolated points instead of attempting to alter the slope.

In addition, two 1 x 1 m test units were placed in the vicinity of Mound P. Unit N 1960 E 762 was placed in the plaza, 5 m east of the base of the mound. The other test unit, N 2021 E 784, was 30 m northeast of Mound P. Other than an occasional exploratory test, no systematic auger testing was conducted in these areas.

Unit 1960 E 762 was excavated to test for fill in the plaza east of the mound, just as it was discovered east of Mounds N and O. Based on visual inspection of the terrain, it appeared that only a small strip leading up to the mound might be artificial, if anything, thus the unit was placed very close to the mound. Unit N 1960 E 762 produced many artifacts given its shallow depth; however, this abundance should probably be attributed to mound slope erosion (Figure 3.11, Level A). Diagnostic artifacts recovered below the mound slump in the old humus (Level B) and A-horizon (Level C) include several modes that appear during the Moundville I phase, such as five folded jar rim sherds, a folded-flattened jar rim sherd, and five sherds (30 g) of the type Baytown Plain, *variety Roper.* An artifact from the overlying slump, a single rim fragment possessing vertical lugs, dates to the Moundville IV phase (Steponaitis 1983a:131). The stratigraphy in Unit N 1960 E 762 was almost identical to those units excavated by Driskell in the center of the plaza, except for a thick layer of overlying mound slump. Thus, it does not appear that any artificial plaza fill occurs in the plaza east of Mound P.

As for the unit northeast of P, N 2021 E 784, the unit was also similar to those excavated in the central plaza (Figure 3.12). An abrupt ledge between this unit and Mound Q looked to be artificial, and it was for this reason the area was tested. However, there was no evidence of any artificial fill. The only surprise was the color of the subsoil, which was a deep dark red (5YR 4/6) sandy clay. Diagnostic artifacts indicate a date relatively late in the Moundville sequence for the occupation of this area. Based on the presence of two sherds (7 g) classified as Moundville Engraved, *variety Taylorville* and a fragment from a beaded rim bowl, the deposit appears to date to the late Moundville II/early Moundville III phase.

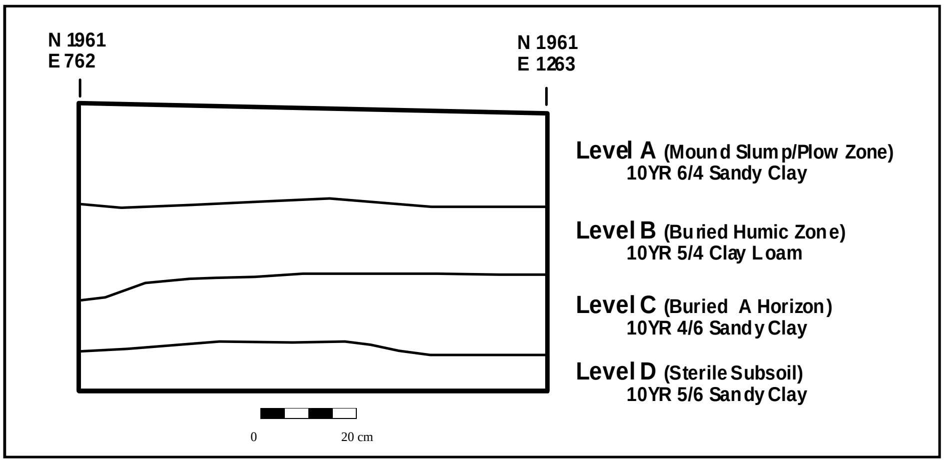

Figure 3.11. North profile of unit N 1960 E 762.

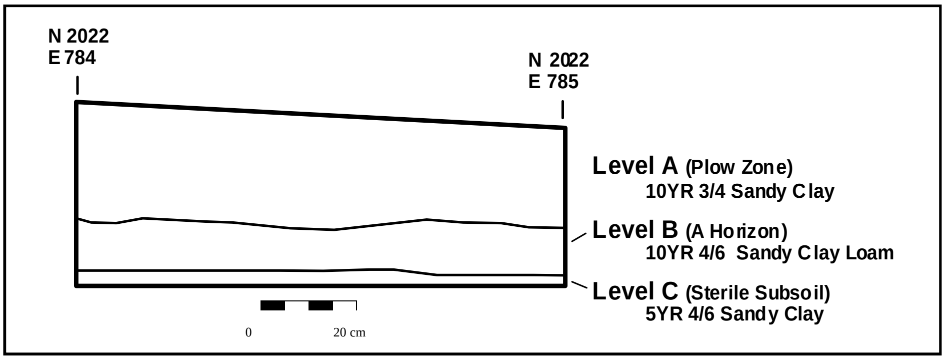

Figure 3.12. North Profile of Unit N 2021 E 784.

Discussion and Chronology

Based on auger survey and test excavations, the use of artificial plaza fill around the outer margins of the plaza is confirmed for certain areas but disconfirmed for others. Plaza fill appears to be added in at least four locations: west of Mound F; north, west, and south of Mound G; east of Mounds N and O; and perhaps northwest of Mound J. The artifacts and radiocarbon evidence from previous research as well as excavations for this project indicate that the modifications took place relatively early in the Moundville sequence, between the late Moundville I and early Moundville II phases, beginning roughly the same time that mound construction began around the plaza margins (Knight 1989, 1998). This chronology indicates that the physical modifications were envisioned and completed before many of the mounds were constructed or had reached their final form. Furthermore, all of the areas tested which were modified by plaza fills possessed old surfaces were previously occupied during the late Moundville I/early Moundville II phase. Then, after the plaza fill episodes, many of the areas tested were subsequently used later in the Moundville sequence, as near Mounds G and N, as late as the Moundville III phase.

The point of the auger survey was to determine the volume and spatial extent of each of the artificial plaza fills, and the excavations were to determine their chronology. The volume of the plaza fill as estimated by the gridding method has added to the total volume of earth construction, to improve the accuracy of the energetics assessment yet to come. These physical modifications to the plaza must be considered monumental constructions, having consumed large amounts of energy and labor that are not typically considered in the site's construction.

Obviously, the level appearance of the plaza was highly important to Moundville's inhabitants. The volume of the fill abutting some mounds is almost as much soil as was used to construct the mounds themselves. If only the size of the mounds were important, then devoting this much labor to plaza leveling would have subtracted from that purpose. Evidence of plaza modifications at Mississippian mound centers that must have taken large quantities of labor to complete have been slowly surfacing in the last several decades. For example, Lewis Larson (1989) maintains that the plaza fronting Mound A at Etowah was artificially raised half a meter in height and was covered in clay. Based on cases like Etowah and Moundville, I would argue that such plazas at major centers needed to meet certain physical requirements and that appropriate action was taken to achieve that end. Ignoring aspects such as plaza modifications greatly underestimates the planning and energy that was involved in modifying landscapes by Mississippian people.

Chapter 4

Location of Soil Extraction Areas

In formulating the energetics assessment proposed for this study, it is necessary to calculate transportation energy. The energy expended in transporting soil from extraction area to construction site would have been substantial. Calculating transportation energy involves knowing, or at least making an educated guess, where soils for construction were extracted. At many mound sites, the locations of borrow pits - depressions where soil was removed to create the earth monuments - are quite obvious, as they are either still visible or can be detected using excavation, augering, or various forms of remote sensing. For example, at McKeithen, a Weeden Island culture mound site in northern Florida, at least seven borrow pits have been identified (Milanich et al. 1997). At the large Mississippian center of Cahokia in southern Illinois, several rather large borrow pits exist, including some that were refilled by prehistoric inhabitants (Holley et al. 1993). However, at many mound sites, such as Moundville, borrowing locations are not as easy to recognize. Soil may have come from areas not readily identifiable as soil extraction locations, or from smaller borrow pits that have been refilled naturally through erosion or agricultural plowing, or filled by original inhabitants with debris. The objectives of this chapter are to approximate where soil was extracted for the mound and plaza constructions at Moundville, to report soil samples taken from these localities, and to report the distance between probable borrow areas and mound constructions. The distances from the source of earth to the construction sites will be factored into the energetics analysis (Chapter 6).

To determine these distances, two approaches were used. The first was to conduct an examination of the modern-day history of Moundville. This investigation was mainly concerned with the restoration projects carried out by the Alabama Museum of Natural History in the 1930s, but also was attuned to earlier accounts, maps, and photographs of the site to determine if the localities currently labeled as borrow pits were in fact those used by prehistoric inhabitants of the site. Knowing which borrow pits are true soil extraction locations is important in estimating the distances of each construction to the nearest source. By measuring from a misidentified borrow pit or by overlooking a genuine one, the distances between construction and excavation locations may be severely skewed. An examination of early records will show that it is probable that not all of the four formally named borrow pits at Moundville were created prehistorically. Second, to confirm that soil from suspected borrow locations is comparable to archaeologically excavated mound and plaza soils, soil samples from 42 locations at Moundville, mainly from the northern portion of the site, were collected, described, and compared to the descriptions of soil from various reports of mound excavations (Driskell, notes on file, Alabama Museum of Natural History; Gage 2000; Gage and Jones 2001; Knight 1995, 2009b). Based on the combined information obtained from the historical survey and the soil samples, distances from each mound and plaza fill location to the nearest plausible extraction location were calculated.

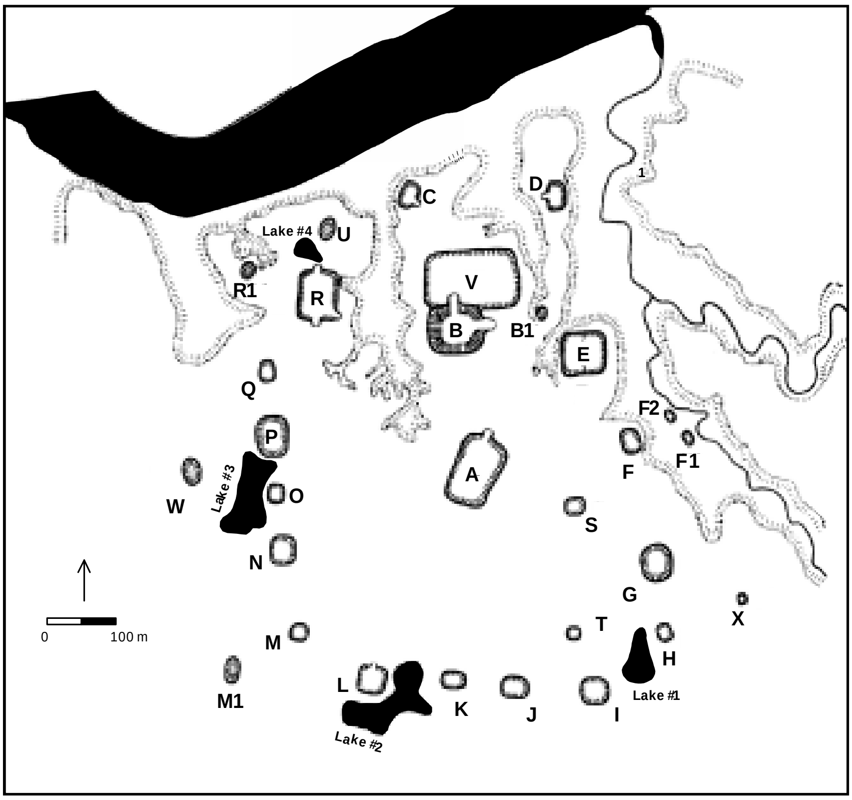

Figure 4.1. Map of Moundville and the location of the current borrow pits.

Moundville's "Borrow Pits"

Currently at Moundville, there are four large depressions that have long been considered as borrow pits (Figure 4.1). These were labeled Lakes #1 through #4 during the late 1930s as Moundville was transformed into a public park by the Alabama Museum of Natural History. Lake #1 is a shallow tear-drop shaped depression, currently less than one meter deep, between Mounds H and I. Using the volume calculating techniques of the gridding method described in Chapter 2 and the photogrammetric map generated in 1991, the volume of this lake is approximately 1,400 m^3. Lake #2 is a large deep depression that partially surrounds Mound L to the south and east. This is the largest and deepest of the four lakes, measuring roughly 2 meters deep and possessing a volume

“Borrow Pit”	Volume m^3
Lake #1	1,400
Lake #2	14,800
Lake #3	6,400
Lake #4	2,100
Total	**24,700**

Table 4.1. Current volume of the four borrow pits at Moundville.

of 14,800 m^3. Lake #3 is large rectangular depression on the west side of Mounds N, O, and P and adjacent to the Moundville museum, which overlooks the lake on the east. The lake is currently less than a meter deep and is roughly 6,400 m^3 in volume. Lake #4 is a shallow tear-drop shaped depression north of Mound R, currently about 1.25 meters deep and approximately 2,200 m^3 in volume (Table 4.1). As noted, there has been some debate as to whether these four lakes are truly borrow pits used by prehistoric inhabitants to construct the Moundville landscape. Regardless, even if all four borrow pits were used, their volume only accounts for 24,700 m^3 or less than 12 percent of the total earth moved to create the Moundville landscape (Table 4.1., Chapter 2, 3). Therefore, even if all four borrow pits are prehistoric, the bulk of the soil for mounds and plaza construction must have come from somewhere other than Lakes #1 through #4. The subsequent discussion is a chronologically-based presentation highlighting significant information regarding the number, size, and location of prehistoric borrow pits. It should be noted that the numerical designations were not assigned to these depressions until December 1937, just months prior to the creation or re-contouring of these lakes.[13]

[13] The first appearance of a numerical designation of a lake appears in December 1937, that of Lake 2 [no #], in a letter from Walter B. Jones to the Regional Director of the National Park Service (see Jones 1941:9 for excerpt).

James D. Middleton of the Smithsonian Institution's Bureau of American Ethnology surface collected at Moundville in 1882 and produced a badly-drawn sketch map of the site (Steponaitis 1983b). In sketching the site layout, his positions and distances between mounds were almost completely inaccurate. Interestingly, though, Middleton noted ponds, ditches, and sloughs (or marshes) surrounding certain mounds. This is the earliest record describing such depressions at the site. In his unpublished report, Middleton noted ponds adjacent to Mounds K, L, and Q, a ditch around Mound L, and a slough encompassing three sides of Mound E. Middleton placed a ditch and a pond around Mounds K and L in the vicinity of where Lake #2 is today. Also indicated in Middleton's notes is a small pond northwest of Mound L. Other more recent indications of this particular depression include a topographic map by G.W. Jones and Sons dated 1930 (on file, Alabama Museum of Natural History); it also may be visible in an aerial photograph from 1933 (Figure 4.3). Using the gridding method as described in Chapter 2, the volume of this depression is estimated to have been approximately 530 m^3 based on the contour information from the 1930 topographic map. There is a possibility that this depression was at one time a very small borrow pit, but this seems odd as it closely borders the plaza's edge. Concerning the other main borrow pits, Middleton makes no mention of ditches, ponds, or sloughs southwest of Mounds H and I, west of Mound P, or north of Mound R where Lakes #1, #3, and #4 respectively are currently located.

In 1902, a photograph taken by Dr. Robert S. Hodge shows a large depression at Moundville abutting an earthen mound, which at the time was holding water (Figure 4.2.). Decades later in a letter from Jones to the Regional Director of the National Park

Figure 4.2. Photograph by Dr. Robert S. Hodge taken in 1902. The photograph shows the large depression behind Mound L, later to be named Lake #2 (photo courtesy of University of Alabama Museums, Tuscaloosa, Alabama).

Service in 1937, Walter B. Jones stated that this photograph shows the depression south of Mound L, Lake #2. It appears that the photograph was taken south of the depression facing north, looking over the southwest portion of the pit.

Clarence B. Moore mapped and excavated at Moundville in 1905 and 1906, but he did not discuss individual borrow pits at the site, nor include any on his map. However, Moore did generally describe depressions near many mounds that he believed were formed by excavating soil for mound construction. Moore (1905:130) stated that:

> Near many of the mounds are depressions, formed by excavating the material for their building, some containing water, others drained by means of ditches. These depressions are not present within what, for convenience, we call the circle formed by the mounds (although it is not exactly circular), but are sometimes to one side of the mounds, sometimes outside the circle; and the mounds within the enclosed space do not have such depressions. It is evident, then, that the mounds were built according to some fixed plan, and that these shallow ponds were intentionally placed outside the area of the circle, perhaps that those living on the plain within could have convenient access to the mounds.

Moore did not provide any evidence to support or refute their use as borrow pits, but he does allude to the fact that there were more than one extraction location and that these areas probably held water at one time.

Chronologically, the next information regarding the borrow pits comes from the 1930s, once the property had been purchased by the Alabama Museum of Natural History. It was during this time that the lakes, like many of the mounds, were excavated and re-contoured. The details of their construction are somewhat sketchy. Though this was a prominent part of the excavation and restoration projects conducted by the Alabama Museum of Natural History, only a few photographs and records exist showing the borrow pits prior to restoration and the excavations that took place in their renovation. It was during this time, presumably late in 1937, that the lakes were given their numerical designations.

The first topographic map of Moundville created in 1930 by G. W. Jones and Sons of Huntsville (on file, Alabama Museum of Natural History; also see Chapter 2) shows three unlabeled depressions with standing water, what are today Lakes #1, #2, and #4, with drainage ditches in Lakes #1 and #4 hand-drawn on the map. There is no indication of a depression in the vicinity of Lake #3. Where Lake #3 is situated today, a small linear depression is shown, but it appears to be an old creek bed or perhaps a depression caused by the altering of the natural drainage due to the creation of Mounds O and P.

An aerial photograph from 1933 shows the Moundville landscape prior to park restoration (Figure 4.3). A depression, later to be named Lake #1, is present in the photograph and appears roughly similar to its current size and shape. Also shown is a modern ditch that was dug to drain the lake. The largest depression, which partially surrounds Mound L, later named Lake #2, is present and appears to match its current size and shape. There is no sign of a depression in the vicinity of what is today Lake #3.

Figure 4.3. Aerial photograph of Moundville, 1933 (courtesy of University of Alabama Museums, Tuscaloosa, Alabama).

Instead, there is a small road cutting directly though the area where the lake resides today. The same level area is visible in an aerial photographs taken in 1936 (Figure 4.4) and 1938 (Figure 2.6). No depression in the area of Lake #4 is visible in the 1933 photograph, though it is labeled on the photograph simply as "Lake." In addition, as noted, there also appears to be a smaller depression within the plaza northwest of Mound L, one that appears in Middleton's notes and also on the 1930 topographic map. Walter B. Jones and the Alabama Museum of Natural History dug exploratory trenches in at least one, perhaps two, of the four borrow pits (Lake #4, and possibly Lake #3) in 1938. Lake #4 is the best-documented of the four lake restorations. In the depression north of Mound R, what is today Lake #4, at least three five-foot-wide excavation trenches running north to south and one five-foot- wide trench running east to west, perpendicularly intersecting the other three trenches, were dug in January of 1938. There are no notes, artifacts, feature or burials forms, and no excavation plans or profiles from this work. For the restoration of Lake #4, however, there does exist a series of three

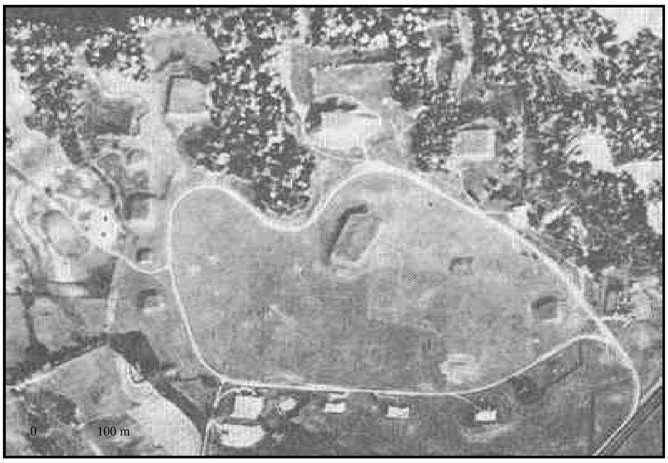

Figure 4.4. Aerial photograph of Moundville, 1936.

photographs, each taken from the same location, indicating the sequence of events that had taken place (Figure 4.5). The first photograph, taken in January 1938, shows the pre-landscaped terrain and excavation trenches. It should be noted that the prior 1936 aerial photograph does clearly show a depression where the lake is located today, and Jones states that the trenches revealed the depth and extent of the silt at the base of this lake. This evidence would rather strongly indicate that Lake #4 was in fact a silted-in borrow pit.

Like Lake #4, Lake #3 has no notes, feature forms, or plans or profiles documenting formal excavations in advance of lake construction. There is a photograph taken by Walter B. Jones in 1938 showing the museum construction, which also inadvertently shows a rather level terrain west of Mounds O and P, where Lake #3 is currently located (Figure 4.6). A collection of artifacts is located at the Alabama Museum of Natural History from the January 1938 excavation of Lake #3. If formal excavations took place, the excavation area is not shown on any extant maps and there is no documentation as to the size, method, or location of excavated units. The only

Figure 4.5. A series of three photographs taken between January 1938 and August 1939 showing the excavations and restoration of Lake #4 (courtesy of University of Alabama Museums, Tuscaloosa, Alabama).

Figure 4.6. Photograph taken in August 1938 of museum construction. The photograph was taken looking north-northwest, from atop Mound N, and shows two mounds, Mound O the closest and Mound P in the distance. Note the fairly level ground and road running directly through where Lake #3 is located today. The original caption by Jones reads "Across lake and new museum looking northwest from Mound N. White stakes represent shore line" (courtesy of University of Alabama Museums, Tuscaloosa, Alabama).

evidence of an excavation is an entry in the Mound State Monument Administrative Records, Moundville Alabama, which simply describes the corresponding artifact collection (on file, Alabama Museum of Natural History). According to this description, no burials were encountered in the excavations but there were 5,067 ceramic sherds and 44 field specimens (non-ceramic artifacts) recovered.

There is no evidence of any formal archaeological excavations in Lakes #1 and #2. Both lakes appear very similar in size and shape as the depressions evident on maps and aerial photographs prior to restoration. In addition, there is no documentation of excavation or any cataloged artifacts from either location. There is no question that these depressions were there prior to restoration projects. However, during the late 1930s a small island was added in the center of Lake #2, very similar to the islands sculpted in the construction of Lake #4 as shown in the middle photograph of Figure 4.5. Several smaller islands were also created in Lake #3.

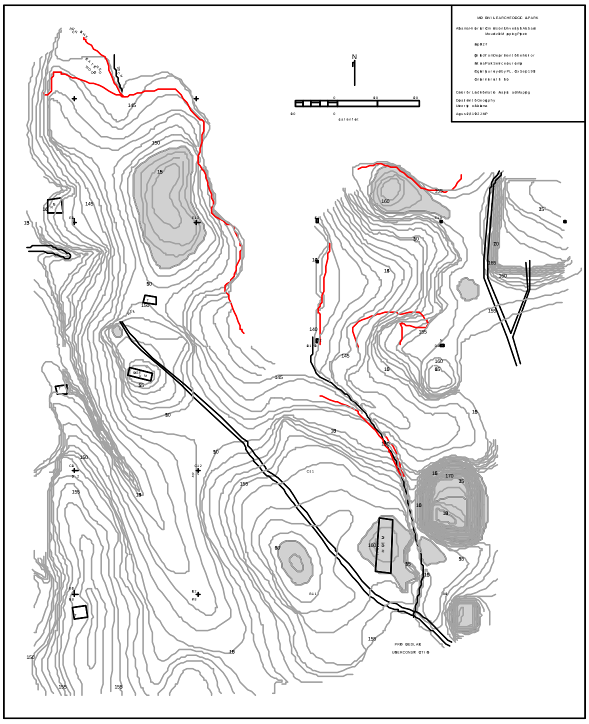

Figure 4.7. Digitized version of a topographic map originally created by P.L. Cox and the National Park Service, 1938. Note that the drainage ditch shown on this map running between the museum and Mounds O and P is also shown in the 1938 photograph (Figure 4.6.). In addition, the shaded areas shown on this map are rises, not depression, and that a small rise is shown where part of Lake #3 is located today.

Subsequent to the 1930 topographic map already discussed, a series of additional maps were produced, which also include significant details. A topographic map made ca. 1937 by the Alabama Museum of Natural History shows only a single depression in the vicinity of Lake #2, that is depicted as roughly 1/3 the size of that shown on other maps and aerial photographs. This map also includes a number of drainage ditches, including one that was made to drain Lake #2, which appears to run west behind Mound L, turns north and continues northward, west of Mounds N, O, and P, until reaching the ravine. Another topographic map of the western margin of the site created in 1938 by P.L. Cox of the National Park Service marks the area of Lake #3 as "Proposed Lake Under Construction" (Figure 4.7). On this map, as in Figure 4.6, there does appear to be a small depression southwest of Mound P and two modern drainage ditches leading away from this depression, one running north to drain the area behind Mounds O and P and one running northwest coming from the southern portion of the site used to drain Lake #2. I do not however believe the depression west of Mounds O and P is a true borrow pit. There was no mention of deeply buried artifacts covered by silt as was the case with Lake #4, and given the terminology used it probably instead was a topographic low caused by the creation of the mounds on the western edge of the plaza.

In addition to the series of topographic maps produced in the 1930s, there is a hand-drawn, undated map in the archives of the Alabama Museum of Natural History (Figure 4.8). Though the map is undated, I would estimate that it was generated ca. 1939, based on the fact that the new roadway is depicted, which was excavated and constructed in 1939 and 1940 respectively. The map is drawn in pencil, and the locations of Moore's excavations are colored in crayon and marker. There are at least two different peoples' handwriting on the map. The first is probably that of Jones, while the second is more than likely that of E.C. Chapman, who was in charge of record keeping at the Alabama Museum of Natural History around the time of World War II. The mounds on the map are depicted simplistically and are inaccurately spaced, but what is important is the names and locations indicated for the borrow pits. Lakes #1 and #3 are labeled as Pro. and Prop. Lake, presumably meaning proposed lakes, indicating perhaps that they had not yet been created. The proposed shape of Lake #3 is different from the current shape of the lake, because in the drawing the lake bends around and wraps east of Mound P. Lake #2 appears to have the same basic shape and size as at present, and Lake #4 is not shown.

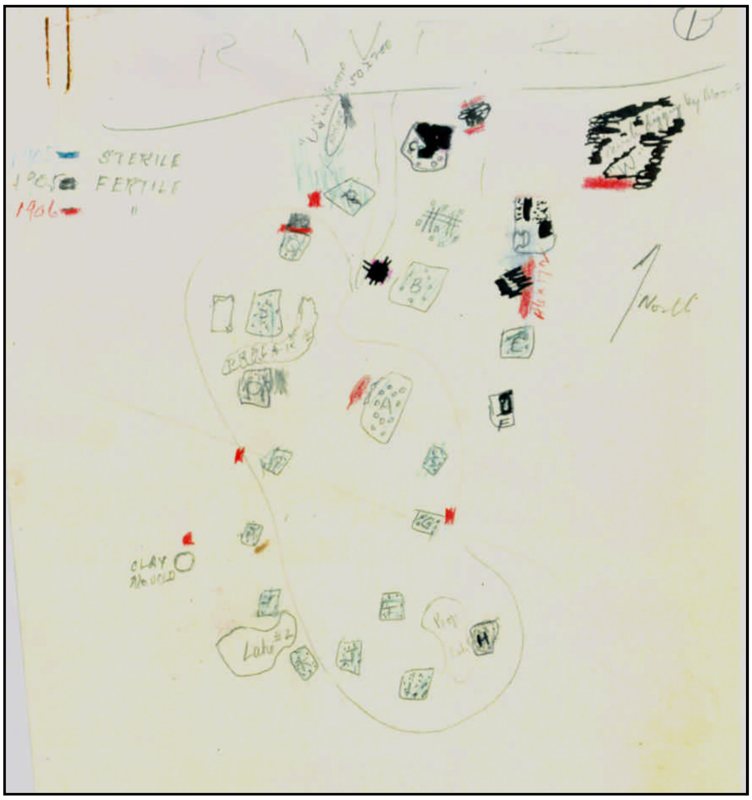

Figure 4.8. An undated, rough sketch of the Moundville site ca. 1939.

The labeling of these lake areas as “proposed” indicates that they were either created or enlarged during these restoration projects.

Based on the information described above, it appears that Lake #2 has the strongest evidence for being a prehistoric borrow pit. Its existence and location appear as far back as Middleton’s account in 1889, and it was present in its current form before park restoration projects, as shown in the photograph by Hodge in 1902. The size and general position of this depression on the landscape also supports its validity as a prehistoric borrow pit. As there were no other known areas for soil extraction near the southern plaza periphery mounds, Lake #2 is ideally located to save laborers a long walk clear across the site and back in order to retrieve soil from ravines. Furthermore, this depression is large enough that it would have provided enough soil to have had a significant contribution of building material for the mounds on the southern plaza margin.

There is also very strong evidence to suggest that Lake #4 was also a prehistoric borrow pit. A depression in this area appears on maps and photographs prior to restoration work and archaeological investigations supports that the depression contained three feet of silt (Jones 1941). Yet the size and position of this depression fails to meet the same logic described for Lake #2. Lake #4 was probably used to supply building material for Mound R or maybe Mound U, which however makes little sense as the ravine is only a few meters farther away. Its position thus does not appear to be very advantageous for mound laborers, unlike that of Lake #2. In addition, the volume of this depression accounts for less than 10% of the total volume of Mound R, hardly enough to warrant its creation. If 90% of the soil was coming from a location just a few meters away, then why go to the trouble to borrow only 10% more from another location in the same general area? In my opinion, the only explanation for this depression, in part originally provided by Jones (1941), is that it was used to hold water and fish. It would have been easy to stock with both water and fish being so close to the river, which would also explain the copper fish hook found at the bottom. In short, unlike Lake #2, I doubt that the primary purpose of Lake #4 was to supply builders with soil for mound construction, and therefore, its distance from mounds is not included in my results.

Lake #1 on the other hand may have been a prehistoric borrow location, but the evidence is not as strong as that for Lakes #2 and #4. Although the depression referred to as Lake #1 does appear on some photographs and maps prior to park restorations, the depression may have developed because of a change in the topography created by Mound

G and the plaza fill (Knight 2009b), supplemented by modern ditches dug to drain water east of the lake. Furthermore, like Lake #4, it is located very close to possible soil extraction locations and is not really large enough to have made a difference in the amount of building material provided.

Lake #3 is the most suspicious of the purported borrow pits. There was only a minuscule depression located in the area prior to restoration work. Although this depression would be more advantageously located than Lakes #1 and #4, and large enough to have made a substantial contribution to the building material, I believe that it was not a prehistoric borrow pit, but instead a low linear drainage, perhaps an old creek bed or drainage basin. There are no records describing or photographs showing any substantial depression in the vicinity of Lake #3, whereas the topographic map from 1930 shows all of the other borrow pits except this one. The lake in its present configuration is very clearly an artifact of 1930s park landscaping, complete with interior "islands" like Lakes #2 and #4.

In the next section, which describes the taking of soil samples from around the Moundville landscape, Lake #2 will be treated as the only genuine borrow location when measuring the distance from a mound to its nearest source. Although there is limited evidence that Lake #1 and Lake #4 were also prehistoric borrow locations, given their small volume and the fact that the distances are not greatly different from those to the nearest ravine, they are not considered as significant extraction locations for mound soil.

Soil Samples from Possible Borrowing Locations

To determine if soils from the surrounding ravines and Lake #2 are comparable to soils used to create mounds and modify the plaza, soil samples were collected and

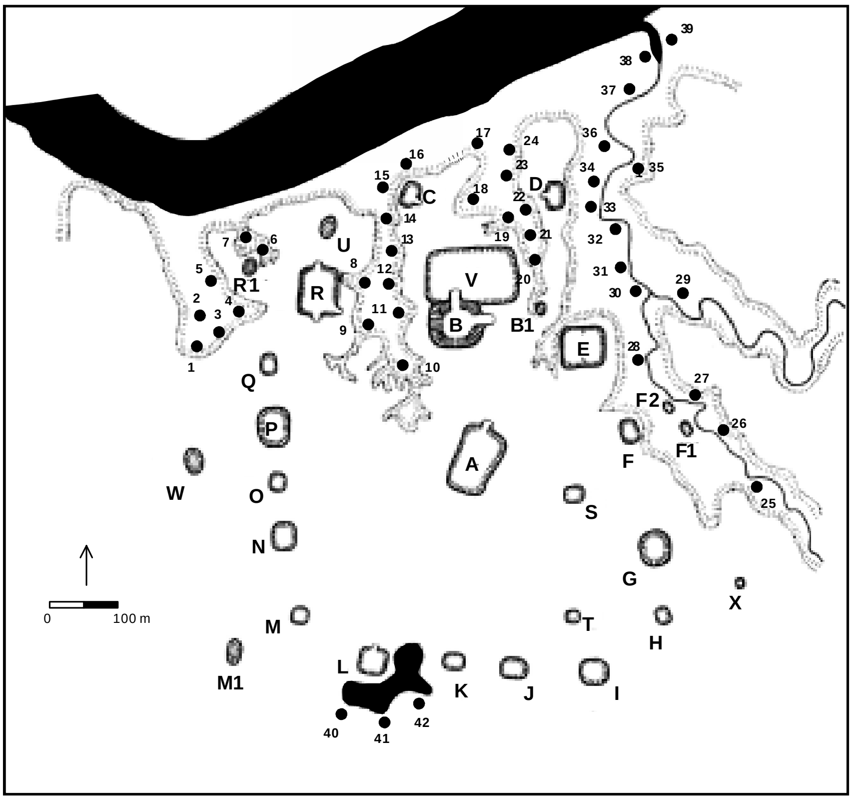

Figure 4.9. Map showing the locations of soil samples.

analyzed from 42 locations around the Moundville site (Figure 4.9). Soil was collected in the field by clearing the topsoil from an eroding slope using a small shovel. The samples were collected from terrace deposits at least 30 cm below the topsoil. The soil composition and color of these samples are tabulated in Table 4.2.

According to the soil descriptions from mound (Gage 2000; Gage and Jones 2001; Knight 2009b; Driskell, notes on file, Alabama Museum of Natural History) and plaza coring and excavations (Driskell, notes on file, Alabama Museum of Natural History; Chapter 3), most of the soils used in the construction of the Moundville landscape were either sandy clay or sandy silt soils usually within the color range of yellowish-brown to brown, although loamy soils were encountered as well. For example, Gage (2000) and

Location	Texture	Munsell Color	Description
1	Sandy Clay Loam	10 YR 4/3	Brown
2	Sandy Clay Loam	2.5 YR 4/6	Red
3	Clay	10 YR 5/4	Yellowish Brown
4	Clay Loam	10 YR 4/3	Brown
5	Sandy Clay	7.5 YR 5/6	Strong Brown
6	Sandy Clay	10 YR 3/4	Dark yellowish Brown
7	Sandy Clay	10 YR 5/4	Yellowish Brown
8	Sandy Clay	7.5 YR 3/4	Dark Brown
9	Sandy Clay	10 YR 5/6	Yellowish Brown
10	Sandy Clay Loam	10 YR 3/4	Dark Yellowish Brown
11	Sandy Clay	7.5 YR 6/8	Reddish Yellow
12	Sandy Clay Loam	10 YR 4/6	Dark Yellowish Brown
13	Clay Loam	10 YR 3/3	Dark Brown
14	Sandy Clay	10 YR 4/4	Dark Yellowish Brown
15	Silty Clay	7.5 YR 5/6	Strong Brown
16	Silty Clay	7.5 YR 5/3	Brown
17	Silty Clay	7.5 YR 5/6	Strong Brown
18	Sandy Clay	10 YR 3/4	Dark Yellowish Brown
19	Sandy Clay Loam	7.5 YR 3/4	Dark Brown
20	Sandy Clay	10 YR 3/4	Dark Yellowish Brown
21	Sandy Clay	7.5 YR 3/4	Dark Brown
22	Sandy Clay	10 YR 4/4	Dark Yellowish Brown
23	Sandy Clay	10 YR 3/4	Dark Yellowish Brown
24	Silty Clay	10 YR 5/4	Yellowish Brown
25	Sandy Clay	10 YR 6/4	Light Yellowish Brown
26	Sandy Clay	10 YR 6/3	Pale Brown
27	Silty Clay	10 YR 3/6	Dark Yellowish Brown
28	Silty Clay	7.5 YR 4/6	Strong Brown
29	Loamy Sand	2.5 Y 6/6	Olive Yellow
30	Sandy Clay	10 YR 5/6	Yellowish Brown
31	Sandy Clay	10 YR 6/3	Pale Brown
32	Sandy Clay	7.5 YR 5/6	Strong Brown
33	Clay Loam	10 YR 4/6	Dark Yellowish Brown
34	Sandy Clay	7.5 YR 4/3	Brown
35	Sandy Clay	7.5 YR 5/4	Brown
36	Sandy Clay	10 YR 5/4	Yellowish Brown
37	Clay	7.5 YR 5/6	Strong Brown
38	Silty Clay	7.5 YR 4/6	Strong Brown
39	Silty Clay	10 YR 3/3	Dark Brown
40	Sandy Clay Loam	7.5 YR 5/6	Strong Brown
41	Sandy Clay	10 YR 5/6	Yellowish Brown
42	Sandy Clay Loam	10 YR 5/4	Yellowish Brown

Table 4.2. Texture, color, and description of soil from tests.

Knight (1995, 2009b) reported that many of the stages of Mound R were constructed using sandy clays and sandy silts, usually various shades of brown and yellow. According to Driskell's field notes (on file, Alabama Museum of Natural History; Knight 2009b), the soil composition of Mound P fills are generally sandy loams or clay loams, which are readily available in the ravine northwest of the mound. The texture of the mound stages of Mound F ranged from sand and clayey sand to clay of various colors (Knight 1995, 2009b). Knight (1995, 2009b) reported that the construction fills of Mound G consisted of either sandy clay or dark loamy soils and that Mound A was constructed mainly with silty fills consisting of a mixture of sand, clay and loam soils. The plaza fills (Chapter 3) consisted mostly of either sandy clay or sandy clay loam soils. All of these soil types were encountered in the sampling of various locations around the site. Based on the similarity of the soils encountered in my sampling and the soils reported from mound fills, I would argue that the soil types are comparable.

Results

There appears to be fairly strong evidence that most of soil for the mound and plaza construction at Moundville came from the nearest ravine. Consequently, there is a possibility that the extensive mining of construction fill from the ravines may have artificially widened them. The only exception appears to be the mounds on the southern portion of the site which were probably constructed primarily using soil from the borrow pit known as Lake #2. The volume of Lake #2, 14,800 m^3, is large enough to accommodate all of the mounds on the southern margin of the plaza (Mounds I, T, J, K, L, M, and M1), which together total 11,020 m^3. The distance from the center of each mound to the closest probable extraction area was drawn on a scaled map and then

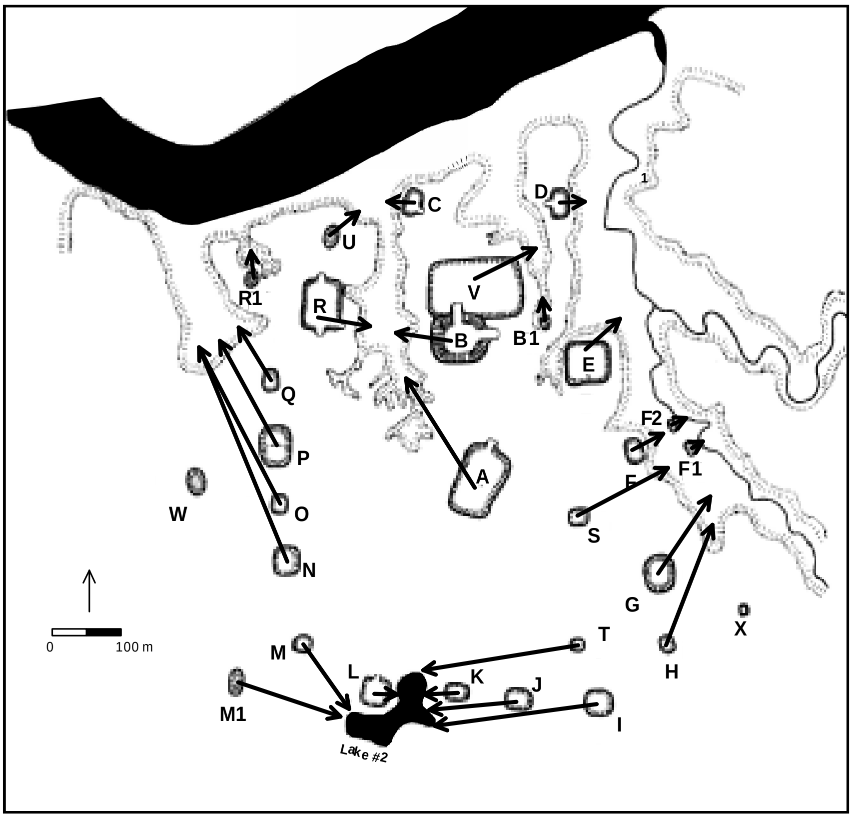

Figure 4.10. Map showing the distance from each mound to the nearest borrowing location. The distances from plaza modifications to the nearest borrowing locations are not shown, but are believed to be to the same location at a similar distance as the mounds in the vicinity of the plaza modifications.

measured (Figure 4.10). These distances for each mound are shown in Table 4.3. It seems possible that the soil for the mounds on the northern portion of the site came from multiple borrow areas. For instance, Mounds B and V are sandwiched roughly equidistantly between two ravines. Nonetheless, for my purposes the distance to the nearest ravine is the measure that was used, as designated by the arrows in Figure 4.8. In addition, the arrow for the distance from Mound A to the nearest ravine was extended roughly 50 meters northward due to the modern-day active southward encroachment of the ravine northwest of the mound.

Location	Distance (m)
Mound A	160
Mound B	110
Mound B1	25
Mound C	45
Mound D	45
Mound E	50
Mound F	50
Mound G	115
Mound H	190
Mound I	250
Mound J	145
Mound K	60
Mound L	25
Mound M	125
Mound M1	165
Mound N	300
Mound O	230
Mound P	150
Mound Q	50
Mound R	70
Mound R1	25
Mound S	180
Mound T	240
Mound U	25
Mound V	95
Plaza Fill – Mound F	75
Plaza Fill – Mound G	125
Plaza Fill – Mounds N and O	250
Plaza Fill – Mound J	135
Total Distance	**3,510 m**
Average Distance	**121 m**

Table 4.3. Distance from mound or plaza fill to nearest possible extraction source.

The distance from soil source to a mound ranged from less than 25 meters to 300 meters. These distances seems reasonable given Reed and colleagues' (1968) discussion of borrow pits at Cahokia, some being at least 700 meters from the nearest mound. It also appears that the mounds farthest from their extraction source are those on the western row of plaza periphery mounds. In contrast, the mounds on the northern part of the site are the closest to their borrow locations.

In summary, it appears that much of the soil used to construct the Moundville landscape came from the ravines along the northern margin of the site and one large borrow pit on the southern side. There may have been other smaller borrow pits, including three re-contoured by the Alabama Museum of Natural History and some smaller depressions that may have been filled in over time, such as the depression detected northwest of Mound L. The distance to retrieve soil for each construction would have a large effect on its potential size, as earthworks closer to borrow locations would have required less energy to create than those mounds at greater distance from their sources. This fact may in part explain why the largest mounds are on the northern side of the site although social and religious factors might be more important than simple efficiency in this regard. It is relevant that the three largest mounds, Mounds A, B, and V, which I will argue were the only ones constructed using pooled labor from the hinterlands, are among the closest to their borrow locations. Builders of these large mounds would have been able to focus more energy on excavation and compaction and less time on transportation.

Chapter 5

Applying Geotechnical Engineering to Prehistoric Earthen Constructions

In current literature, volume is the sole basis for evaluating prehistoric earthwork size and is the main variable for calculating the amount of labor involved in their construction (e.g. Abrams 1989, 1994; Abrams and Bolland 1999; Anderson 1994; Bernardini 2004; Blitz 1993; Blitz and Livingood 2004, Craig et al. 1998; Erasmus 1965; Hammerstedt 2004, 2005; Lindauer and Blitz 1997; Milner 1998; Muller 1986, 1997; Payne 1994; Steponaitis 1978). Yet, I would argue that the calculation of volume should only be a stepping stone in the process of mound quantification and the formulation of energetics assessments. Hypothetically, two prehistoric earthen mounds of the same volume need not have required the same amount of energy in their construction. Differences between them may have arisen in the distance needed to transport the soil (Chapter 4), the type of soil employed as construction material, the amount of compaction energy invested, or other factors not considered when a mound is quantified by volume alone. Thus, more information should be considered when quantifying earthen mounds and prehistoric landscapes. One factor I believe to be critical in examining differences between mounds is density. Density, first measured in the 3rd century BCE by the Greek scientist Archimedes, is defined as a ratio of mass to volume. Density is essentially a measurement of how tightly matter is compacted together.

The research presented herein will apply methods from geotechnical engineering, a subdiscipline of civil engineering, in order to obtain estimates of the density and mass of mounds and artificial plaza fills at Moundville, and attempt to quantify the amount of compaction energy involved in their creation. In this chapter, I calculate density and compaction of mound and artificial plaza fills using two geotechnical engineering procedures – the sand cone density test and the Proctor compaction test. Then, using the volume of both mound and plaza fills obtained using the gridding method (Chapters 2 and 3), the density and volume are multiplied producing an estimated mass of moved earth. Mass will be the predominant unit of measure utilized in the upcoming energetics assessment in calculating the amount of energy used to excavate and transport mound and plaza fills (Chapter 6). The Proctor compaction test, a laboratory procedure, will approximate the mechanical energy needed to compact mound and plaza fills to the same density measured in the field using the sand cone test. This test will determine if it is possible to quantify differences in the compaction energy of earthen structures. From these data, I will conclude that the total mass of mounds and plaza fills at Moundville is approximately 375,000,000 kg (827,000,000 lb). In addition, the mechanical compaction energy invested in mound construction ranged from approximately 120 kN-m/m^3 (2,500 ft-lb/ft^3) to 240 kN-m/m^3 (5,000 ft-lb/ft^3), whereas plaza fills averaged roughly 70 kN-m/m^3 (1,500 ft-lb/ft^3). I believe that these methods adopted from geotechnical engineering will shed light on Mississippian mound construction and improve the current quantification of earthen monuments and the labor invested in the creation of prehistoric landscapes.

Geotechnical Techniques

Geotechnical engineering has applied principles of soil mechanics to the design of foundations and earthen structures for nearly 80 years (Bowles 1979; Das 2002). The methods involved in soil mechanics are primarily concerned with testing the behavior and performance of different soils as construction materials. Geotechnical engineers are interested in the construction of earthen designs and foundation structures, and utilize concepts such as flow analysis, strength analysis, stability analysis, mechanical stresses, bearing capacity, and lateral earth pressures. As in archaeology, geotechnical engineering emphasizes empirical quantification to aid in testing the reliability of their data. Many of the methods and techniques of the geotechnical engineering field may be helpful in quantifying differences among prehistoric monuments. The reader should consider this research experimental, but hopefully I can demonstrate the merit of relating these two fields for future research.

Sand Cone Density Test

There are two test procedures utilized by geotechnical engineers, the results of which translate well to the archaeological study of prehistoric earthen monuments and landscapes. The first is an *in situ* or field test designed to measure the density of an earthwork. Density tests can be conducted with a number of apparatuses, but for this study I will focus on the simplest, the sand cone test (ASTM D 1556). The test consists of excavating a small hole, roughly 15 cm in diameter and at least 10 cm deep, in the earthen structure being examined and filling the hole with dry calibrated sand from a sand cone apparatus (Figure 5.1). The soil removed is weighed, dried, and then weighed again to determine its moisture content. The volume of the hole is measured by the amount of

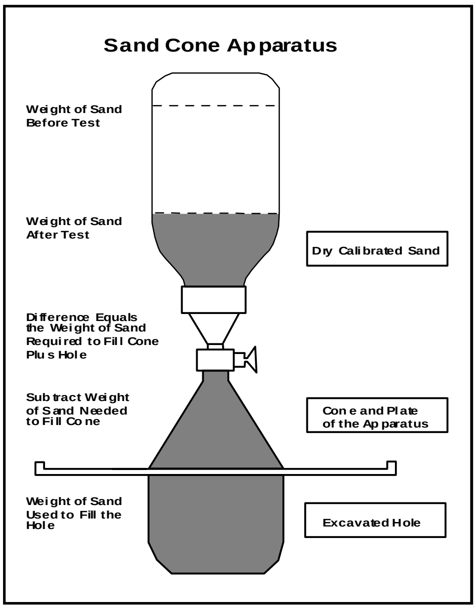

Figure 5.1. The sand cone apparatus and excavated hole.

the calibrated sand used to fill it. The mass of the dry soil removed divided by the volume of sand needed to fill the hole produces the density of the soil in a dry unit weight per volume measurement, such as pounds per cubic foot (lb/ft^3) or kilograms or kilonewtons per cubic meter (kg/m^3 or kN/m^3).[14,15] The measurement produced by the sand cone test is a ratio of the mass removed from a hole to the volume of that hole ($D = M/V$). Even though the sand cone test method is considered intrusive by geotechnical engineers because disturbing the soil is required (Holtz and Kovacs 1981), it is a relatively non-invasive method for archaeology. If applied during excavation of a prehistoric mound, the test can be used on each individual building layer to quantitatively determine differences in density, and therefore energy, per episode of construction.

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[14] Archaeology uses metric or SI units whereas geotechnical engineering uses U.S. customary or English units. Therefore, in this chapter the results are presented in both.
[15] Engineers make a distinction between mass density and weight density. Weight density (kN/m^3) is equal to the mass density (kg/m^3) multiplied by a constant for standard gravity (9.8×10^{-3}).

Proctor Compaction Test

A second test borrowed from geotechnical engineering that can be applied to prehistoric earthworks in conjunction with the density test is the Proctor laboratory compaction test (ASTM D 698). Soil compaction occurs when soil aggregates and particles are rearranged into a smaller volume through the addition of mechanical energy. As soil is compacted, the voids created by air and water decrease and the density increases. Whereas the sand cone test measures the *in situ* density of an earthwork, the Proctor laboratory compaction test measures the amount of compaction energy needed to achieve the density recorded from the sand cone. In other words, the density of an earthwork can be measured with a sand cone, and then a sample of the same soil can be compacted in the laboratory with known amounts of energy until the same density from the sand cone is achieved in the sample being compacted. The amount of mechanical energy, if any, that was invested in mound compaction, whether achieved by using a tool of wood or stone or by stomping energy applied by human feet alone, can be estimated using the laboratory compaction test. The resulting measure yields the amount of mechanic energy utilized to compact the loose soil expressed in the form of foot-pounds per cubic foot (ft-lb/ft^3) or kilonewton meters or kilojoules per cubic meter (kN-m/m^3 or kJ/m^3).[16]

These units of measure reflect the amount of mechanical energy applied with a force from a given distance to a given volume. Multiplying the amount of energy per cubic volume by the total volume of the earthwork produces an estimated amount of compaction energy invested in compaction. To clarify, one foot-pound (ft-lb) is the

[16] The kilonewton meter (kN-m) is a unit of force whereas the kilojoule (kJ) is a unit of energy. Both units are numerically equal (1 kN-m = 1 kJ).

amount of mechanical energy applied with one pound of force from a striking distance of one foot, but this measure does not reflect the amount of human energy invested in compacting the structure as calculated in Chapter 6. The measure only serves as a means of comparatively evaluating differences of compaction between earthworks. It is reasonable to assume that the more mechanical energy used to compact a mound, the more human energy was expended in compaction. Mound stages, or portions of mound stages that are heavily compacted would have required more human energy, perhaps in the form of more time spent stomping, marching, jumping, or using an instrument such as a flat stone or wooden pestle, than mounds that are less compact. The amount of human energy employed in compacting soil must be based on the methods used to compact, which are, unfortunately, unknown. Thus the human energy that was expended cannot be translated from mechanical energy in any straightforward way. Experimental work in archaeology is therefore needed to compile data for compaction measures in energetics studies. My compaction testing, although the samples are admittedly not representative and the measure is not in human terms, will hopefully act as a catalyst for future studies of the compaction of prehistoric earthen monuments.

In changing our modern-day physical environment, loose excavated soil added to preexisting topography to create highways, dams, airport-runways, embankments, and other structures must be compacted. Compacting soil rearranges the solid particles (soil) into a tighter configuration, which reduces the volume of voids. The degree of compaction is measured in terms of a soil's dry unit weight (γ_d or γ_{dry}), which is a measurement of the weight of dry soil for a given volume. The dry unit weight of a soil is correlated to geotechnical engineering design parameters such as shear strength, settlement resistance, and permeability. Compacting soils increases the strength and stability, while decreasing permeability and settlement. In terms of structures built on top of the compacted soils, compaction increases the bearing capacity for the foundations of the buildings, and decreases settlement of the structures. Today, large compaction equipment, weighing as much as 50 tons, is used to compact layers of soil to produce earthen structures suitable of withstanding the pressures of large architectural forms (D'Appolonia et al. 1969).

Additional mechanical compaction for the creation of earthen structures was not always necessary. Prior to the invention of large mechanical earth moving equipment, such as dump trucks in the 1920s, soils were moved primarily by hand in small portions. When large amounts of loose soil began to be used, mechanical compaction methods were needed to prevent soil failure (Holtz and Kovacs 1981: 110). Various methods to compact soil have been tried historically, including using elephants in developing countries to compact soils for earthen dams (Meehan 1967, 1981: 137-139).[17] As the compaction of soils became an important issue in soil construction, Ralph R. Proctor (1933) developed a laboratory test to measure the density of a soil after compaction and compare the maximum dry unit weight to the optimal moisture content of a soil for a given energy applied in the compaction process (ASTM D 698). To calculate the dry unit weight, soil is compacted into a mold using a "hammer," which is dropped a number of times on the loose soil from one foot above (Figure 5.2). For a given hammer weight, the energy is controlled by the number of times the hammer is dropped and the number of

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[17] The attempt to compact soil using elephants was unsuccessful. The elephants quickly learned to step on their previous footprints as opposed to the loose earth (Meehan 1967, 1981).

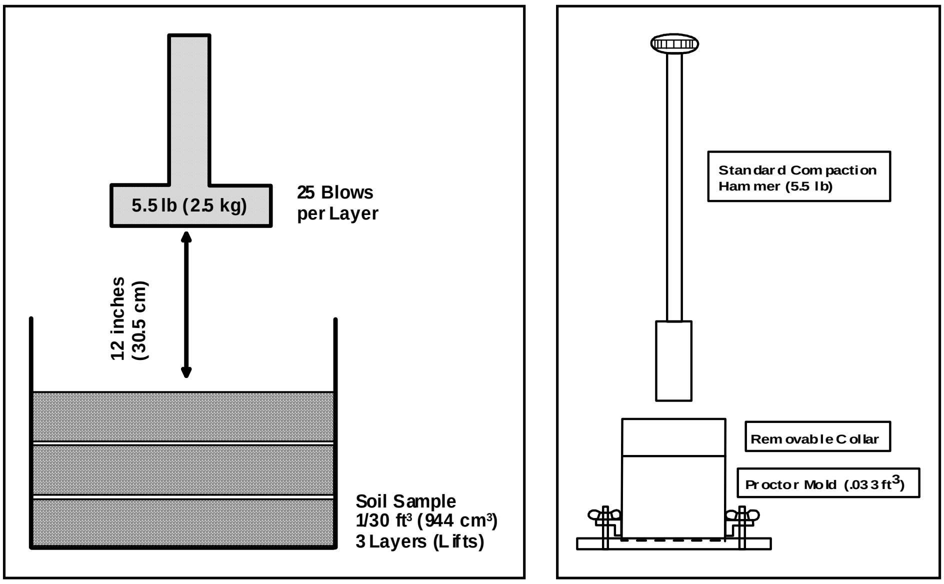

Figure 5.2. The Proctor compaction test. Left, view of the mold with soil being compacted; right, diagram of the mold and hammer

layers of soil used to fill the mold. The density is calculated based on the mass of the soil compacted in the mold divided by the volume of the mold.

Factors that Affect Compaction

Moisture content (ω) has a strong effect on the compacted density of a soil. Gradually increasing the moisture content during the compaction process causes particles to slide over each other more readily and move into a more densely packed configuration, thereby increasing the density of the soil. However, beyond a certain moisture threshold, any additional increase in the amount of water tends to reduce the density by allowing particles to slip out of a densely packed configuration, allowing the potential voids for soil particles to be filled with water. Therefore, when graphed the resulting compaction data for a specific amount of energy is typically shaped like a normal distribution curve as shown in Figure 5.3. This graph shows three compaction curves produced with varying levels of compaction energy. The uppermost curve corresponds to the most

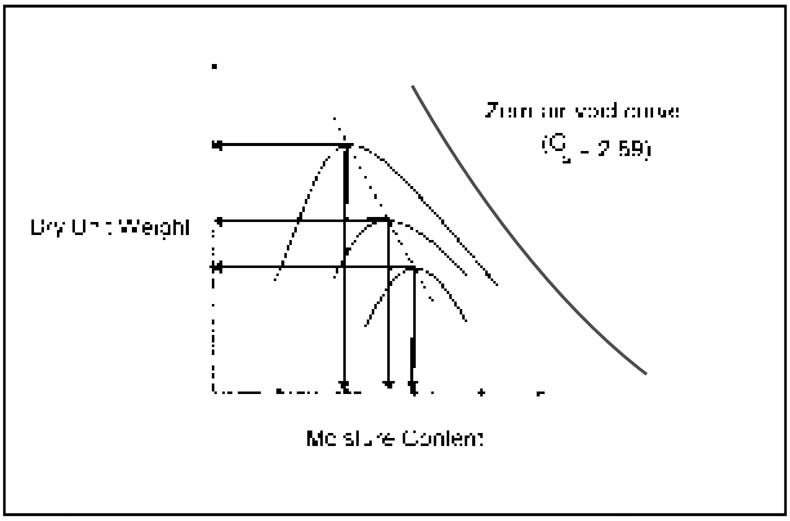

Figure 5.3. Diagram showing the relationship between compaction energy, moisture content, dry unit weight, and the zero -air-void curve. Each curve represents a specific amount of compaction energy applied to soil of variable moisture content. The maximum point of each curve represents the optimal moisture content for that amount of energy. The dotted line shows the optimal moisture content from each of the various amounts of energy applied.

energy invested in soil compaction. The peak point for each curve is the maximum dry unit weight and the optimal moisture content for the amount of energy applied to a soil. Note that as the amount of energy invested in compaction decreases, the optimal moisture content increases while the maximum dry unit weight decreases as shown by the dotted line in Figure 5.3. In other words, less compaction energy is required for soil possessing more water, but only up to a certain point.

The limit of the dry unit weight at a moisture content of a soil is obtained when all the voids in a soil are saturated with water. The line that illustrates the condition in which the soil is fully saturated is referred to as the zero-air-void curve and is shown in Figure 5.3. It is not possible for any portion of any energy curve to pass to the right of the zero-air-void. Thus, the right side of the compaction curve should be roughly parallel to the zero-air-void curve. Cross-referencing the right side of the compaction curve against the zero-air-void curve is one way of confirming the validity of compaction results.

All soils behave in the same manner with regard to optimal moisture content, unit weight, energy, and saturation levels. That is, regardless of soil type, the dry unit density increase and optimal moisture content decrease as energy increases. As noted, no amount of energy applied to a soil will achieve a compaction value to the right of the zero-air-void curve. However, specific valves of optimal moisture content, unit weight, compaction energy, and position of the zero-air-void curve vary between soil types (Das 2002). Therefore, a sample for compaction testing should be taken from the immediate vicinity of the sand cone to ensure that the same soil type is collected.

Reconciling Geotechnical Tests with Archaeological Variability

These two geotechnical tests, the sand cone test and the Proctor compaction test, can be applied productively to prehistoric earthworks. However, there are concerns in relating geotechnical procedures to the study of archaeology that should be addressed before continuing. All such concerns are a result of combining an approach used for quantifying modern-day structures and foundations with another focused on prehistoric inquiry. Geotechnical engineers only deal with contemporary earthen structures and foundations and the procedures involved in the discipline, though applicable to archaeological inquiry, were not originally intended to be used in the study of the past. However, modern forensic engineering techniques that typically evaluate the cause of an engineering failure can and do use these techniques retrospectively.

First, it should be noted that one cannot merely assume that Native earthworks, as they stand today, consist entirely of structural fills that are at their original density, compaction, and moisture content. Through archaeological work, we know that the vast majority of the bulk of most earthen mounds consists of mechanically undisturbed fills. Yet, there are several variables that are important in combining geotechnical engineering and archaeology that need to be controlled for. Time or age of an earthwork should not be considered a factor in studying compaction. Earthworks would have not increased in density because of their age unless there was additional mechanical energy or load applied or the particles were rearranged by strong vibrations such as earthquakes.

There are a number of kinds of alterations that may affect the original prehistoric density and compaction values. These include both prehistoric and modern day potential disturbances. For example, one kind of prehistoric alteration to originally compacted mound fill may include pit digging in to the mound summit by original inhabitants for storage, burials, structural posts, and so forth, which when refilled, typically with midden soil rather than clay, might not have been as compacted as the original fill. Thus, as midden soil is usually fairly distinctive, it should be avoided for both density and compaction testing.

Historical disturbances include modern deposits associated with mound reconstruction efforts and compaction associated with heavy equipment. These disturbances may have been caused by either digging up and relocating soil or operating heavy equipment on mounds and plaza fills, as is the case at Moundville (Jones 1941). Many disturbances at Moundville can be traced to the agricultural plowing of the 19th and early 20th century (Moore 1905) or the mound restoration projects of the 1930s (Jones 1941). Mounds that have been cultivated or re-contoured, even when the original mound soil was used for restoration as opposed to imported fill, would have had their density altered and testing within these altered soils would provide misleading compaction results. Regardless, to conduct these tests accurately, it is important to locate areas of modern deposits or alteration through controlled excavation and avoid conducting tests in these areas.

Other variables that can affect density and compaction testing include bioturbation from tree roots, ant nests, and rodent burrows, mostly found within the uppermost one meter. Slumping at the margins, a type of erosion peculiar to steep earthworks, will also affect *in situ* measurements. All of the variables listed thus far that affect density and compaction can be controlled by sampling only unaltered mound fill as determined archaeologically.

Another variable is the potential change in moisture content of the soil. Water may have been added to assist in compaction in prehistoric times. Also, the moisture content of the soil will change over time and currently may not represent the moisture content at the time of creation of the Moundville landscape. Typical compaction testing aims to correlate the maximum dry unit weight and optimal moisture content for a given amount of energy. For this study, the optimal moisture content is not considered in attempting to match compaction results with the results from the sand cone. Instead, only the dry unit weight is considered. In other words, the energy curve of a compaction sample, regardless of the soil moisture content, must be the same or less than the density obtained from the earthwork. For instance, a compaction curve can begin below the point of the *in situ* density sample, but can then increase and exceed the *in situ* dry unit weight as its moisture content is increased, only to fall below the *in situ* dry unit weight as it nears the zero-air-void curve. In this example, if I use this energy curve for the energetics assessment, I am assuming that prehistoric builders compacted soil that possessed a moisture content other than the optimal content. Therefore, in estimating the amount of energy involved in compaction, the entire compaction curve must be close to the *in situ* dry unit weight but not exceed the estimated density obtained from sand cone. This precaution eliminates error introduced by assuming a prehistoric moisture content and reduces the chance of overestimating the energy invested in compaction.

Another concern is the degree of variability in density and compaction within a single earthwork. Many prehistoric earthen mounds are constructed with different soils possessing different densities, chosen for their particular attributes. Ideally, one would want to know the density of each building episode, which can be highly variable even within a single mound stage. For example, mound flanks and upper margins are often buttressed with heavy clay to counteract flank erosion, while the material used to build up the mound center is often of looser material. In future testing, density measurements could be obtained using soil core samples at times when excavation is not possible by measuring the volume and the mass of samples from each construction stage. As mound cores are not available at this time, I am forced to make uniform assumptions about mound density based on only two construction episodes. Therefore, my overall soil density and compaction measures for Moundville are imprecise. However, as the results will show, the density and compaction results for Mounds R and V, as well as the results from the plaza are fairly consistent. These results are assumed to fall somewhere in the middle of the expected range of possible density and compaction values for prehistoric earthen mounds.

A final concern of applicability is the compression due to the self-weight of the overlying fill. Tests conducted deep within an earthen structure will be affected by the overlying soil, and it is important that this additional compression not be considered as part of the human investment of energy in compacting the mound. This problem does not affect the information in the present study, as all tests were conducted on the uppermost levels, just below the plow zone. However, in cases where these tests are conducted deeper within a mound, a correction factor based on soil mechanics should applied to remove densification of mound soil due to soil compression.

Methods

Before explaining the methods of the geotechnical engineering density tests employed in this study, it is important to note that there were no on-going mound excavations during the span of my fieldwork. This greatly limited the opportunity to test for differences in the density of mound fill. Thus, the only two density tests conducted on mounds for this study were done (1) in a previous excavation conducted by Vernon Knight on Mound V (Knight 2009a), and (2) an erosional blowout on the northwest corner of Mound R. Therefore, I am going to have to generalize from very few data, as my density and compaction energy constants are based on the results from these two tests. Differences in mound density will surely emerge once more tests have been conducted in the future. In the meantime, however, I think the two tests serve as an adequate initial estimate of mound density in the Moundville case.

A sand cone density test was employed on Mounds R and V in the fall of 2005. Mound R is a large mound by Moundville standards, situated on the northwest corner of the plaza. Mound V, on the other hand, is a large low mound constructed on sloping ground that makes a level plaza-like extension north of Mound B. These two mounds possess relatively similar volumes. Mound R is estimated at 21,820 m^3 and Mound V some 22,460 m^3 (Chapter 2). The density test on Mound R was performed on the west edge of the Mound, approximately 10 m from the northeastern corner, in an area of a large erosional blowout. Loose soil from a section of the blowout was removed and a level area was excavated. The density test on Mound V was performed on the northern edge roughly 15 m from the northwestern corner, in an area near the earth lodge previously excavated by Knight (2009a). The summits of both mounds were used for agricultural purposes (Moore 1905), so the test area was executed to below the plow zone, which was at least 40 cm deep. The placements of both tests were thoroughly considered to make sure that the samples consisted of undisturbed mound fill and not modern imported or disturbed soil. A 4 kg (8.8 lb) soil sample was also taken in the immediate vicinity of both tests for compaction testing, which was conducted in the winter of 2005.

The same procedures were conducted in the fall of 2007 during my excavations in the plaza (Chapter 3). Sand cone tests were employed within the plow zone, artificial fill, and sterile terrace deposits in four 1 x 1 m test units. Again, a 4 kg (8.8 lb) soil sample was taken from the same levels for compaction testing. Laboratory compaction tests of the plaza fills was undertaken in the fall and winter of 2007, with some follow-up testing in the spring of 2008. Only the imported artificial fill from the plaza units were used in compaction testing.

In addition to the mound and plaza locations, another sand cone test was conducted 150 m north of Mound G in September of 2008, near an unnamed tributary of

Carthage Branch (see #27, Figure 4.9). This test was conducted to gauge the density of soils as they occur naturally. Like the two mound tests, loose soil and debris was cleared off to a depth of 30 cm (1 ft) and special care was taken to ensure that the test was conducted in soil free from cultural debris or in this case large amounts of river gravel. The results for this particular test are discussed in Chapter 6 during the Energy of Excavation section, not in this chapter. Although only one test was conducted, the result, 1,440 kg/m^3 (90 lb/ft^3), is within the range of unaltered soil density, 1,362 to 1,842 kg/m^3, estimated by Goldsmith et al. (2001) and on the low end of the suspected natural density of fine grained soils estimated at 1,600 kg/m^3 (100 lb/ft^3) to 2,160 kg/m^3 (135 lb/ft^3) (Brady and Weil 2002; Lee and Lin 2007; McGhee 1991). Compaction tests were not conducted for this location.

Using the sand cone test, a density value was obtained using the *in situ* dry unit weight for each mound or plaza sample, which needed to be replicated in the laboratory in order to estimate the amount of compaction energy invested in the soil. Compaction tests were conducted at increasing energy levels in an attempt to reach the *in situ* density. The amount of energy used in the laboratory ranged from zero to 2,700 $kN\text{-}m/m^3$ (56,000 $ft\text{-}lb/ft^3$). In order to give the reader a tangible frame of reference for these values, 1 ft-lb is one pound dropped from one foot high. When a volume of soil is included such as 1 cubic foot of soil, then 1 ft-lb becomes 1 $ft\text{-}lb/ft^3$. If this amount of energy is applied across a site, then every cubic foot of compacted soil would receive 1 pound dropped from one ft. The upper energy applied in the laboratory was 2,700 $kN\text{-}m/m^3$ (56,000 $ft\text{-}lb/ft^3$) which is equivalent to 4-6 passes with a multi-ton mechanical compaction roller (D'Appolonia et al. 1969; Das 2002:118-119).

To compact the soil in the laboratory, a standardized hammer (5.5 lb) was dropped from a consistent height (1 ft) upon soil in a standardized mold ($1/30^{th}$ ft^3). The amount of energy invested in compaction was adjusted by changing the number of times the hammer impacted the soil (blows) and the number of soil layers used to fill the mold (lifts). For instance, for the standard compaction test, 3 layers (lifts) of soils are compacted; each lift being struck 25 times (blows) per lift for a total of 75 blows. After the energy has been applied, the soil is removed from the mold and weighed, to determine its moist density. After the sample is weighed, a small portion is removed, weighed, dried, and weighed again to calculate the moisture content. The dry unit weight and moisture content are than plotted on a graph as shown in Figure 5.3.

To calculate the energy involved for each compaction test, the weight of the hammer, the height of the drop, the number of lifts, and the number of blows per lift are multiplied together and divided by the volume of the container. The density or unit weight of the soil is calculated in kg/m^3 or kN/m^3 (lb/ft^3) respectively, whereas the energy to create that compaction is measured in $kN\text{-}m/m^3$ ($ft\text{-}lb/ft^3$); these should not be confused when viewing results. The unit weight measurement from the sand cone will be converted from kN/m^3 to kg/m^3 and multiplied by the volume to generate the mass.

Results

Based on the results from the sand cone density test, Mound R has an estimated unit weight of 18.1 kN/m^3 (115.4 lb/ft^3) or a density of 1,848 kg/m^3, whereas Mound V has a unit weight of 16.2 kN/m^3 (105.8 lb/ft^3) or a density of 1,695 kg/m^3. Obviously, these measurements do not account for the density of the entire mound, only the area tested. Different building episodes or fill areas of these massive earthworks no doubt vary substantially in density. These values do, however, fall within the expected range. Laboratory compaction testing of the mound fill samples from Mound R and Mound V are shown in Figure 5.4 and 5.5 respectively. The curves show how the dry unit weight of a sample increases to a maximum and then decreases as moisture content increases. Each curve represents a different amount of energy. On these plots a horizontal line is plotted which is the in situ measured by the sand cone method in the field. It can

be seen that the least amount of energy that could have been added to a mound to achieve the infield dry unit weight is approximately 10 blows per 3 lifts with a 5.5 pound standardized hammer for Mound R and 5 blows per 3 lifts with the same hammer for Mound V, Figure 5.4 and 5.5 respectively. This amount of energy is 240 kN-m/m^3 (5,000 ft-lb/ft^3) for Mound R and 120 kN-m/m^3 (2,500 ft-lb/ft^3) for Mound V. These values can be used in estimating the total energy use to compact these mounds.

In choosing a mean value from the samples to apply to the total volume of the earthworks, one concern needs to be considered, the construction methods of the mound. Based on core testing (Gage 2000) and excavations (Knight 2009b), Mound R is believed to have between 6 and 9 construction episodes, whereas Mound V appears to consist of only one large construction episode based on an auger core taken by Matthew D. Gage in the fall of 1999 and the profile of a large roof support post of the earth lodge excavations of the fall of 2002 (Knight 2009a). When soil is compacted in multiple layers, it enables greater compaction to be achieved, which increases density. Because most mounds at

Moundville were constructed in multiple episodes (Astin 1996; Gage 2000; Gage and Jones 2001; Knight 2009b), I have selected the density and compaction energy values

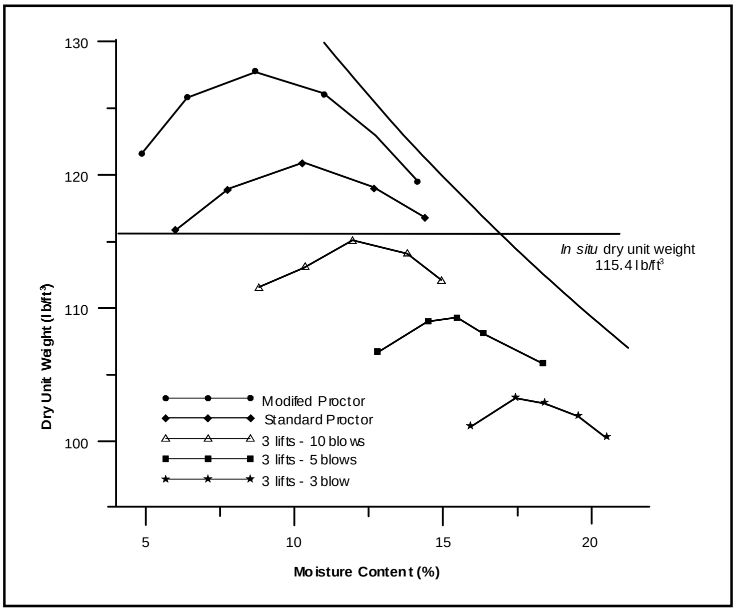

Figure 5.4. Diagram of the compaction and *in situ* dry unit weight of Mounds R. Each curve represents a specific amount of energy applied in the compaction process. Each point on a curve represents one test. The density of the mound is shown by the in situ dry unit weight running horizontally across the figure.

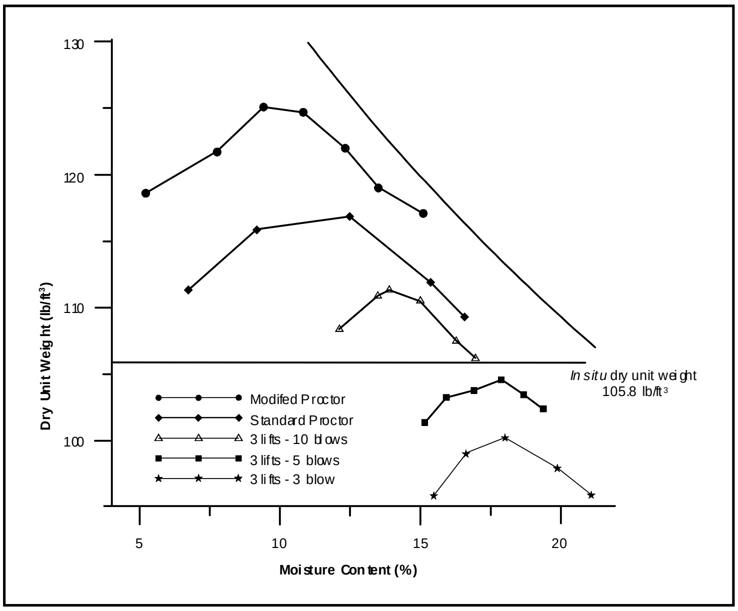

Figure 5.5. Diagram of the compaction and *in situ* dry unit weight of Mounds V.

for the Mound R samples as representative for mounds at the site as a whole, lacking at present the means to estimate these values for the mounds separately. A density of 18.1 kN/m^3 or 1,848 kg/m^3 (115.4 lb/ft^3), was thus applied to all mounds except Mound V, which was assigned its calculated value. In Table 5.1, the volume generated using the gridding method (Chapter 2) is multiplied by the estimated density in calculating the mass of each earthwork. In this manner, the total mass of the mounds is estimated at 351,100,000 kg. In addition, the volume is multiplied by a compaction constant taken from the Mound R data of 240 $kN\text{-}m/m^3$ (5,000 $ft\text{-}lb/ft^3$). The resulting value estimates the total amount of compaction energy invested in the mounds created by multiplying the volume of an earthwork by the compaction energy. This energy is approximately 43,300,000 $kN\text{-}m/m^3$ (31,500,000,000 $ft\text{-}lb/ft^3$).

The density and compaction results from the four 1 x 1 m plaza units possessing evidence of artificial fill yielded very similar results. Density tests and the soil samples for compaction tests within the plaza fill were executed at roughly the same depth below surface as those density tests conducted on the mounds; 40 cm. The plow zone in all of the units was very loosely compacted as expected, having an average density of 12.2 kN/m^3 or 1,247.8 $kg.m^3$ (77.9 lb/ft^3). The density of the artificial fills ranged from 14.8 kN/m^3 or 1,505 kg/m^3 (94 lb/ft^3) to 16.6 kN/m^3 or 1,697.9 kg/m^3 (106 lb/ft^3) with a mean for the plaza fills of 15.6 kN/m^3 or 1,589 kg/m^3 (99 lb/ft). The individual density and compaction results for the plaza fills are reported in Table 5.2. The average density of the sterile terrace deposits, often a meter below the plaza fill, averaged 19.6 kN/m^3 or 2,002 kg/m^3 (125 lb/ft^3). Because the artificial plaza fill around Mounds N and O is thought to be continuous (Chapter 3), the mean density and compaction for these two

Mound	Volume (m^3)	Density (kg/ m^3)	Mass (kg)	Compaction (kN-m/m^3)	Compaction Energy (kN-m or kJ)
A	30,150	1,848	55,700,000	240	7,200,000
B	49,530	1,848	91,500,000	240	11,900,000
C	5,080	1,848	9,400,000	240	1,200,000
D	3,880	1,848	7,200,000	240	900,000
E	10,820	1,848	20,000,000	240	2,600,000
F	2,790	1,848	5,200,000	240	700,000
G	6,730	1,848	12,400,000	240	1,600,000
H	675	1,848	1,200,000	240	200,000
I	2,690	1,848	5,000,000	240	600,000
J	2,570	1,848	4,600,000	240	600,000
K	1,855	1,848	3,300,000	240	400,000
L	4,420	1,848	8,200,000	240	1,100,000
M	590	1,848	1,100,000	240	100,000
N	3,295	1,848	6,100,000	240	800,000
O	1,220	1,848	2,300,000	240	300,000
P	15,880	1,848	29,300,000	240	3,800,000
Q	3,210	1,848	5,900,000	240	800,000
R	21,820	1,848	40,300,000	240	5,200,000
S	515	1,848	1,000,000	240	100,000
T	705	1,848	1,300,000	240	200,000
U	115	1,848	200,000	240	30,000
V	22,460	1,695	38,100,000	120	2,700,000
W	155	1,848	300,000	240	40,000
X	105	1,848	200,000	240	30,000
Y	55	1,848	100,000	240	10,000
Z	95	1,848	200,000	240	20,000
B'	55	1,848	100,000	240	10,000
C'	55	1,848	100,000	240	10,000
E'	110	1,848	200,000	240	30,000
F1	115	1,848	200,000	240	30,000
F2	115	1,848	200,000	240	30,000
Z'	115	1,848	200,000	240	30,000
Total Mound Fill	191,975		351,100,000		43,300,000

Table 5.1. Mass and compaction energy of mounds at Moundville.

Plaza Area	Volume (m^3)	Density (kg/ m^3)	Mass (kg)	Compaction (kN-m/m^3)	Compaction Energy (kN-m or kJ)
West of Mound F	2,545	1,489	3,800,000	70	200,000
North, West, and South of Mound G	5,480	1,521	8,300,000	70	400,000
East of Mounds N and O	6,540	1,610	10,500,000	70	500,000
Northwest of Mound J	580	1,589	900,000	70	40,000
Total Plaza Fill	15,145		23,500,000		1,100,000

Table 5.2. Mass and compaction energy of areas of plaza fill. Note that the mass, compaction, and compaction energy have been rounded.

excavation units, 15.8 kN/m^3 or 1,610 kg/m^3 (100.5 lb/ft^3) is reported. No density or compaction testing was conducted in possible plaza fill northwest of Mound J, so the average density and compaction energy from the other areas of plaza fill were applied instead. Using densities obtained from the sand cone tests, the estimated total mass of the plaza fill is some 23,500,000 kg. The compaction invested in artificial plaza fills per unit area was virtually identical based on the evidence from the four test units, 70 kN-m/m^3 (1,500 ft-lb/ft^3). The similarity is mostly a product of large increments between energy levels applied in the compaction tests (Figure 5.6). It took three blows per three lifts to achieve a curve representative of the *in situ* density. The next energy curve would have been 4 blows per three lifts, which would equal 95 kN-m/m^3 (1,980 ft-lb/ft^3), followed by five blows per 3 lifts equating to 120 kN-m/m^3 (2,500 ft-lb/ft^3). With the calculated energy multiplied by the volume, the total amount of compaction energy for the plaza fills combined, based on the Proctor compaction testing, is roughly 1,100,000 kN-m/m^3 (800,000,000 ft-lb/ft^3).

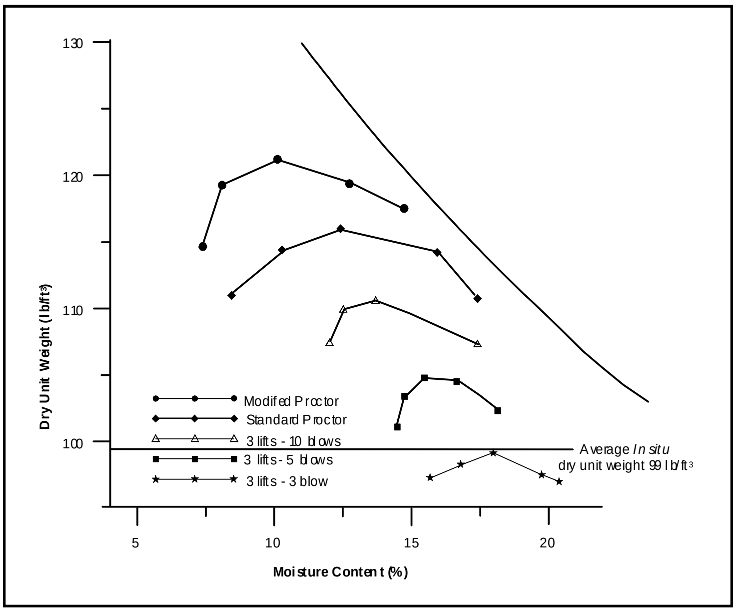

Figure 5.6. Diagrams of the average compaction and average *in situ* dry unit weight of plaza fills.

Given the information above, the total mass of soil used to create the Moundville landscape, both mounds and plaza fill, is estimated to be 374,600,000 kg (825,900,000 lb) (Table 5.3). This estimate will be used to calculate the amount of energy used to excavate and transport soil (Chapter 4). Moreover, approximately 44,400,000 kN-m or kJ (32,306,100,000 ft-lb/ft^3) of mechanical energy was invested in compacting the mounds and plaza fills.

Discussion

What does all this information mean archaeologically? First, it took an estimated 375 million kg of soil to create the Moundville landscape. Not only is this number a more tangible representation of the earthworks than volume, it also allows for a method to calculate the human energy invested in excavation and transportation of mound and a plaza fill. Measuring compaction energy also lends support to the idea that varying

	Volume	Mass (kg)	Compaction Energy (kN or kJ)
Mound Fill	191,975	351,100,000	43,300,000
Plaza Fill	15,145	23,500,000	1,100,000
Total	207,120	374,600,000	44,400,000

Table 5.3. Total volume and mass of plaza and mound fills at Moundville.

amounts of compaction energy may have been invested in earthworks, perhaps based on the size, the larger or taller earthworks requiring more compaction, or perhaps based on the number of construction episodes, or perhaps based on societal importance of a mound.

As already mentioned, there are several limitations of density and compaction data and to reiterate, the reader should consider this research experimental. Furthermore, due to the lack of on-going excavations, my sampling of mound fill was very minimal. However, I do believe the samples obtained fall within a normal range for human compaction of a large earthwork. If additional sampling were to be conducted, perhaps differences in density and compaction between individual earthworks or individual mound stages could be quantified. In the meantime, the averages obtained from the two mounds tested will be used to complete the energetics assessment using the proposed units of kilojoules as opposed to person-days.

Chapter 6

Formulating an Energetics Assessment of the Moundville Landscape

The labor expended in building Moundville's monumental landscape is conceived for this study as having three components: energy of excavation, energy of transportation, and energy of compaction (Figure 6.1). This chapter will estimate each measure and combine them to estimate the total human energy expenditure for Moundville's earthen landscape. Theories and methods from other disciplines such as geotechnical engineering, human physiology, human biology, and ergonomics combined with archaeology provide a means for reformulating the units of measure in energetic studies from person-hours to kilojoules. The result is that the total labor expended to create the earthen monuments and level the plaza at Moundville amounts to approximately 3.8 billion kJ.

In this chapter, I explain the methodology behind the current energetics study. Assumptions are made concerning several variables, including excavation rate and amount of material removed, transportation speed and the size of the load carried, and the rate and method of compaction. Based on a combination of archaeological and physiological data, estimates for these variables are provided. By using the data obtained from the volume of mound and plaza fills (Chapters 2 and 3), the distance from the source to the construction site (Chapter 4), and the density of each earthwork (Chapter 5),

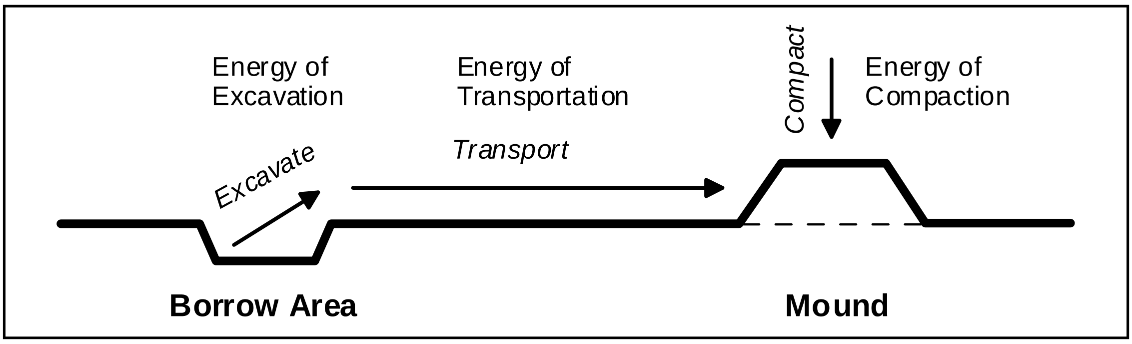

Figure 6.1. The three energy components as visualized for this study.

the energy of mound building and plaza construction at Moundville is calculated. Then, in order to provide some form of comparison to other energetics assessments, the measure is converted into a form of person-days by using estimates of the number of laborers participating in the construction process and how much energy they were expending per day.

Methods for Reformulating Energetics Units

The following section will explain the variables used in calculating energy expenditure within each component of construction. In every situation, the lowest amount of human energy required to complete tasks such as digging and walking is employed in energetics calculations. Using the minimum energy expended for these activities decreases the chance of overestimating the labor required from the prehistoric inhabitants of Moundville. In this sense what I am presenting is a least-cost model. In addition, all results have been rounded, which in some cases may cause slight variations.

Energy of Excavation

For the present study, the mass of the soil excavated to create an earthwork is determined by multiplying the volume of each construction by the average density of its soils, obtained using geotechnical methods, to provide the amount of soil in kilograms that was excavated (M = D x V; whereas M is mass, D is density, and V is volume). Based on previous experimental studies in soil excavation (Erasmus 1965; Hammerstedt 2005), the total volume of the soil of each mound is divided by the amount of time for a given unit of measure; Erasmus estimated 0.52 m^3 per hour, whereas for Hammerstedt estimated 0.29 m^3 per hour. This measurement, in the form of a volume of excavated soil per hour (v/hr), is converted to energy expended per given mass (kJ/kg). The average energy expenditure for one hour of excavating ranges between 1,200 and 2,000 kJ (Ainsworth et al. 1993; Edholm et al. 1970; James and Schofield 1990; Malhotra et al. 1976). Using Hammerstedt's (2005) value of 0.29 m^3 of excavated soil per hour multiplied by the estimated average natural density of soils at Moundville, 1,442 kg/m^3 (90 lb/ft^3), we obtain the mass of soil excavated per hour, which is 418 kg.[18] If it takes the average human a minimum of 1,200 kJ of energy to excavate soil for one hour, then we may assume that that amount of energy is expended in excavating 418 kg of soil or 2.87 kJ per kg. The mass of a mound multiplied by the energy to excavate a given mass (1,200 kJ per 418 kg), results in an estimate of the energy of excavation for that mound, as measured in kJ.

$$\text{Mass of Earthwork (kg)} \times \frac{\text{Energy (2.87 kJ)}}{\text{Mass (1 kg)}} = \text{Energy of Excavation (kJ)}$$

Thus, in the case of Mound R, the mass of the earthwork at 40,300,000 kg multiplied by 2.87 kJ per kg equals the energy of excavation at 115,700,000 kJ.

[18] The average density of natural terrace deposit soil at Moundville is calculated from a sand cone density test conducted approximately 150 meters north of Mound G, near an unnamed tributary of the Black Warrior River (see Chapter 5 and #27, Figure 4.9).

Energy of Transportation

Transportation energy is calculated in a manner similar to excavation energy, and also is expressed in kilojoules. However, to do this calculation, two additional measurements are needed; the mass of an average load, and the distance between the mound and the excavation source (Chapter 4).

There are two possible ways to estimate the average load carried. First, it is possible to estimate the mean body mass of Moundvillians from their skeletal remains. Given an average body mass, the weight of an average load can be based upon a percentage of the weight of the load in relation to the weight of the carrier. The mean height of people from Moundville can be calculated from a previous osteological study. Powell (1988) reported average femur and tibia measurements of skeletons recovered from Moundville. These average lengths may be inserted into a formula for stature (Bass 1995) with results indicating that an average male was 166.5 cm tall (5'5½") and an average female was 156.5 cm tall (5'1½") (also see Muller 1997:142 for similar measurements for Moundville and other Mississippian sites). Moreover, using a Body Mass Index (BMI) chart, an estimated body mass for average Moundvillians can be calculated.[19] Assuming that the population was fairly lean (BMI of 19 – 20), the mean mass of these individuals would average 54.4 kg (120 lb) for males and 47.6 kg (105 lb) for females. Finally, using ethnographic studies, an average load can be estimated based on the average mass. For example, if Moundville males carried the same percentage of their body mass as Nepalese porters (Bastien et al. 2005a), which would be on the higher

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[19] The Body Mass Index (BMI) is a statistical measurement that correlates a normal weight given a person's stature squared (kg/m^2). A desirable range for an individual's BMI is 19-25 (see Frisancho 1993:428-429).

side of the potential range as these porters use tumplines, then the average load would be 92% of their body mass or roughly 50.6 kg (111 lb).

A second method for calculating the average load is strictly archaeologically based. In several cases (Ford and Webb 1959; Fowke 1893, 1902; Gibson 2000; Porter 1974; Shetrone 2004), the sizes of basket loads can be distinguished in the archaeological record. James A. Ford and Clarence H. Webb (1959) estimated that an average basket load at the Late Archaic Poverty Point site in northeastern Louisiana was about 22.7 kg (50 lb). Jon L. Gibson (2000), also working at Poverty Point, estimated basket loads from 13.6 to 52.2 kg (30 - 115 lb). James W. Porter at the Mississippian Mitchell site in southern Illinois estimated six different loads based on excavations, the mass of which ranged from 7.3 to 14.2 kg (16 - 31.3 lb), and averaged 11 kg (26 lb), excluding a 2.3 kg (5 lb) outlier. For this study, 11 kg (26 lb) per basket load is used as the average load transported based on Porter's results from a Mississippian mound site. This weight represents 21% of the mean body weight for adult males for Moundville as calculated above.

With the distances from earthworks to the nearest borrow areas estimated (Chapter 4), the distance for each earthwork is multiplied by the energy to carry an 11 kg load over that distance, and then walk back the same distance unburdened. Sources in physiology, human biology, and ergonomics were consulted to calculate the energy needed to walk a given distance (m) with and without carrying a load. According to James and Schofield (1990:135), the average energy expended to carry an 11-16 kg load at an unspecified walking speed is 1,675 kJ per hour. Assuming that the laborers are walking at a speed comparable to Erasmus's (1965) workers, around 4.8 km/h (3 mi/h), a transport distance of 4,828 m (3 mi) would take approximately 1,675 kJ of energy (or 0.35 kJ/m) for the transportation of one basket load.[20] James and Schofield (1990:135) also estimated the average energy of walking 4-5 km/h (2.5-3.1 mi/h) without carrying anything over the same distance (4,828 m) as approximately 1,072 kJ. For this research, the distance from the earthwork to the nearest borrow area is multiplied by these values (1,072 kJ per 4,828 m or 0.22 kJ/m). The products of these two calculations (energy of a single trip with a load and energy of a single trip without) are added together to produce the energy needed for a single round trip during the construction of an earthwork. Then, the mass of each earthwork (Chapter 5) is divided by the estimated average load carried, 11 kg, which results in the number of round trips. The energy for a single round trip is multiplied by the number of trips. For example, Mound R is approximately 70 m from the

Distance - source to earthwork (m)	x	$\frac{\text{Energy w/load (0.35 kJ)}}{\text{Distance (m)}}$	=	Single Trip Energy w/Load
Distance - earthwork to source (m)	x	$\frac{\text{Energy w/o load (0.22 kJ)}}{\text{Distance (m)}}$	=	Single Trip Energy w/o Load
Single Trip Energy w/load	+	Single Trip Energy w/o load	=	Single Round Trip Energy
Mass of Mound (kg)	/	Average Load (11 kg)	=	Number of Trips
Single Round Trip Energy (kJ)	x	Number of Trips	=	Energy of Transportation (kJ)

nearest soil source. This distance is multiplied by 0.35 kJ/m, resulting in the energy required to carry the load from the source to the mound, which is 25 kJ. Seventy meters multiplied by 0.22 kJ/m would be the amount of energy needed to walk from the mound

[20] Erasmus's workers carried 28 kg (61 pounds) 20.6 km (12.8 mi) and 23.2 km (14.4 mi) when adjusted for a five hour day. This amounts to approximately 4.2 km/h (2.6 mi/h) and 4.7 km/h (2.9 mi/h). Given time to stop, dump the load and start a fresh load, I would estimate the average speed of these workers as approximately 4.8 km/h (3 mi/h).

back to the soil source, which is 15 kJ. Both are added together for the total transportation energy needed to make one round trip, 40 kJ. The mass of Mound R, 40.3 million kg, is divided by 11 kg, the estimated average basket load weight, to determine the number of times the trip was made. In this case, 3,663,636 round trips would be needed. The energy per trip (40 kJ) is multiplied by the number of round trips (3,663,636), resulting in the total transportation energy, 146,000,000 kJ.

It should be noted that the energy expended in carrying a load can be greatly affected by the manner in which the load is carried. It is greatly decreased when the center of gravity of the load is kept near that of the transporter. Keeping the centers of gravity of the load and the transporter close together also allows the transporter to maintain an upright posture similar to walking without a load (Knapik et al. 2004). There are numerous methods for carrying a load, including using a head basket, head strap (tumpline), chest strap, satchel, bag, or shoulder yoke. Prehistoric mound builders may have even been transporting soil using a bucket brigade method, in which the basket load is passed from one stationary person to another. A majority of present-day transportation energy studies have been conducted with the military in mind. The purpose of these studies in military science is to determine the optimal method and speed for soldiers carrying equipment of various weights. In many cases, the experimental participants of these studies carried the weight of the load on their backs. This method of transportation is consistent with ethnohistorical accounts of Native Southeast historic tribes, in which baskets were carried on the back employing either tumplines (head straps) or chest strap supports (Bushnell 1909; Hudson 1976; Hvidt 1980) (Figure 6.2).

Figure 6.2. Illustration of southeastern Indians showing baskets being carried on the back using either a shoulder strap or a tumpline. Left, photograph of a Choctaw woman from Bayou Lacomb, Louisiana, 1909 (Bushnell 1909). Top, sketch by Philip von Reck showing two Creek males in Georgia, 1736 (Hvidt 1980). Bottom, painting by Alfred Boisseau of Louisiana Indians walking along a bayou, 1847 (Hudson 1976).

For this reason, in this study energy calculations are based on the transporter carrying a load on their back.

Energy of Compaction

The amount of mechanical energy needed to compact the earthwork soils is calculated using the geotechnical compaction test described earlier in Chapter 5. In this test, the amount of compaction energy is measured by using a standardized device to compact the soil. To reiterate here, the result of the laboratory test expresses how much energy is needed for a sample of soil from an earthwork to be compacted to match the density measured in situ with the sand cone test. It should be noted that compaction energy in this form does not represent human energy but instead raw kinetic energy of compaction. As noted in the previous chapter, human energy expended when compacting earth is difficult to estimate due to the lack of appropriate energetics studies. It is known that to achieve a specific compaction level one has to drop a weight from a certain height. A log pestle, a rock, or a person jumping, marching, or stomping are all weights dropped from a height. The more highly compacted the earthwork, the more human energy that must have been invested. Clearly, additional research is needed to strengthen the relationship between the mound compaction and the amount of human energy expended. In the meantime, for this research, in order to calculate the amount of human energy expended in soil compaction, the mass of the earthwork will be multiplied by the energy expended in marching on level ground, essentially using a constant value for what was certainly a variable (James and Schofield 1990:134). It will be assumed that the method of compaction employed by the prehistoric inhabitants of the site was walking over the soil repeatedly with a stomping motion until it was compacted down. The amount of energy expended in marching, 1,440 kJ per hour, is multiplied by the mass of each earthwork and divided by 1,000 kg (2,005 lb) (or 1.44 kJ/kg), as it will be assumed that one person could compact 1,000 kg of soil per hour. There is no research to support this assertion, but it seems reasonable to assume that one laborer could compact almost twice as much soil as one laborer could excavate in the same amount of time. In the case of Mound R, the mass, 40,300,000 kg, is multiplied by 1.44 kJ/kg to estimate the amount of human compaction energy to be 58,100,000 kJ.

$$\text{Mass of Earthwork (kg)} \times \frac{\text{Energy to March (1.44 kJ/hr)}}{\text{Amount of Soil (kg/hr)}} = \text{Energy of Compaction (kJ)}$$

Estimating Total Energy of Construction

With these measures (energy of excavation, transportation, and compaction) calculated for each mound and each area of plaza construction, they can be added together to yield a total energy of construction for the Moundville monumental landscape. In Table 6.1, each mound or plaza fill has a volume, mass, excavation energy (kJ), horizontal distance from earthwork to nearest fill source, number of round trips, transportation energy (kJ), compaction energy (kJ), and total amount of energy required in kilojoules. These quantities are added together producing the total volume, total mass, and total energy required both per task (excavation, transportation, and compaction) and per construction project (mounds and plaza fill) in the creation of Moundville's monumental landscape.

Results of the Energetics Assessment at Moundville

Using these measures, I estimate that the earthen landscape at Moundville required approximately 3,838,100,000 kJ (2,830,837,300,000 ft/lb) to construct. This estimate of 3.8 billion kJ includes the amount of energy to excavate, transport, and compact mound and plaza soils. In terms of the energy invested per task, it appears that transportation energy was slightly more labor intensive than the energy needed either to excavate or to compact. The energy of transportation, 2,222,800,000 kJ, accounts for almost 58% of the total energy expenditure. The energy of excavation, 1,075,600,000 kJ, totals 28% while the energy of compaction, 539,700,000 kJ, totals 14%. These percentages reflect the entire construction energy for the Moundville landscape and are not representative of individual mounds. As shown in Table 6.1, depending upon the distance to the extraction source, transportation energy did not always exceed the energy

Mound	Mass (kg)	Energy of Excavation (kJ)	Distance (m)	kJ one round trip	Number of Round Trips	Energy of Transportation (kJ)	Energy of Compaction (kJ)	Total Energy (kJ)
A	55,700,000	159,900,000	160	91	5,063,636	461,100,000	80,200,000	701,200,000
B	91,500,000	262,700,000	110	63	8,318,182	520,800,000	131,800,000	915,300,000
C	9,400,000	27,000,000	25	14	854,545	12,100,000	13,500,000	52,600,000
D	7,200,000	20,700,000	45	26	654,545	16,700,000	10,300,000	47,700,000
E	20,000,000	57,400,000	50	28	1,818,182	51,700,000	28,800,000	137,900,000
F	5,200,000	14,900,000	50	28	472,727	13,300,000	7,400,000	35,600,000
G	12,400,000	35,600,000	115	65	1,127,273	74,000,000	17,900,000	127,500,000
H	1,200,000	3,400,000	190	108	109,091	12,300,000	1,800,000	17,500,000
I	5,000,000	14,400,000	250	142	454,545	64,300,000	7,200,000	85,900,000
J	4,600,000	13,200,000	145	83	418,182	35,600,000	6,800,000	55,600,000
K	3,300,000	9,500,000	60	34	300,000	10,600,000	4,900,000	25,000,000
L	8,200,000	23,500,000	25	14	745,455	10,600,000	11,800,000	45,900,000
M	1,100,000	3,200,000	125	71	100,000	7,100,000	1,600,000	11,900,000
N	6,100,000	17,500,000	300	171	554,545	94,500,000	8,800,000	120,800,000
O	2,300,000	6,600,000	230	131	209,091	26,800,000	3,200,000	36,600,000
P	29,300,000	84,100,000	150	85	2,663,636	227,700,000	42,300,000	354,100,000
Q	5,900,000	16,900,000	50	28	536,364	15,300,000	8,500,000	40,700,000
R	40,300,000	115,700,000	70	40	3,663,636	146,000,000	58,100,000	319,800,000
S	1,000,000	2,900,000	180	102	90,909	8,900,000	1,400,000	13,200,000
T	1,300,000	3,700,000	240	137	118,182	16,200,000	1,900,000	21,800,000
U	200,000	600,000	25	14	18,182	300,000	300,000	1,200,000
V	38,100,000	109,400,000	95	54	3,463,636	187,100,000	54,800,000	351,300,000

W	300,000	900,000	150	85	27,273	2,200,000	400,000	3,500,000
X	200,000	600,000	110	63	18,182	1,100,000	300,000	2,000,000
Y	100,000	300,000	165	94	9,091	900,000	200,000	1,400,000
Z	200,000	600,000	25	14	18,182	200,000	300,000	1,100,000
B'	100,000	300,000	25	14	9,091	100,000	100,000	500,000
C'	100,000	300,000	25	14	9,091	100,000	100,000	500,000
E'	200,000	600,000	25	14	18,182	300,000	300,000	1,200,000
F1	200,000	600,000	25	14	18,182	300,000	300,000	1,200,000
F2	200,000	600,000	25	14	18,182	300,000	300,000	1,200,000
Z'	200,000	600,000	25	14	18,182	300,000	100,000	1,000,000
Mound Total	**351,100,000**	**1,008,200,000**	**3,290**	**1,872**	**31,918,182**	**2,018,800,000**	**505,700,000**	**3,532,700,000**
Plaza F	3,800,000	10,900,000	75	43	345,455	14,700,000	5,500,000	31,100,000
Plaza G	8,300,000	23,800,000	110	63	754,545	47,200,000	12,000,000	83,000,000
Plaza N and O	10,500,000	30,100,000	250	142	954,545	135,800,000	15,200,000	181,100,000
Plaza J	900,000	2,600,000	135	77	81,818	6,300,000	1,300,000	10,200,000
Plaza Total	**23,500,000**	**67,400,000**	**570**	**324**	**2,136,364**	**204,000,000**	**34,000,000**	**305,400,000**
Landscape Total	**374,600,000**	**1,075,600,000**	**3,860**	**2,196**	**34,054,546**	**2,222,800,000**	**539,700,000**	**3,838,100,000**

Table 6.1. Summary of the total energy of construction at Moundville, including mound and plaza construction

of excavation. In the majority of cases, the energy to excavate exceeds the energy to transport mound soils, except when the transport distance is greater than 50 meters. The energy of excavation of a mound is reasonably consistent with its mass, whereas the energy to transport can be altered significantly depending upon the distance to the nearest source. In other words, substantial amounts of transportation energy could be conserved by careful planning and positioning of the borrow pit on the landscape.

Hypothetical Scenarios of the Working Population

The amount of energy invested in monumental constructions at the site, 3.8 billion kJ, does not take into account either the number of people participating or the length of time spent on the construction. Those inhabitants at Moundville participating in mound and plaza constructions, herein referred to as laborers, could have consisted of small kin-organized work groups or larger publicly sanctioned construction teams drawn from the entire polity. In order to examine the number of laborers for a given construction project, the measure is converted into person-days by dividing the total energy of construction by hypothetical estimates of the population and the amount of energy each laborer expended per day. The number of laborers cannot be determined archaeologically, but hypothetical scenarios can be developed that are suggestive of the work that could be accomplished by varying numbers of participants. The result will be a rough calculation of the amount of time it would have taken some given number of laborers to complete construction at the site. If the resulting time estimate is within range of the known construction history of the site, it may be considered a reasonable scenario. However, to do this, the approximate amount of energy expended by a single laborer in a single day needs to be explored.

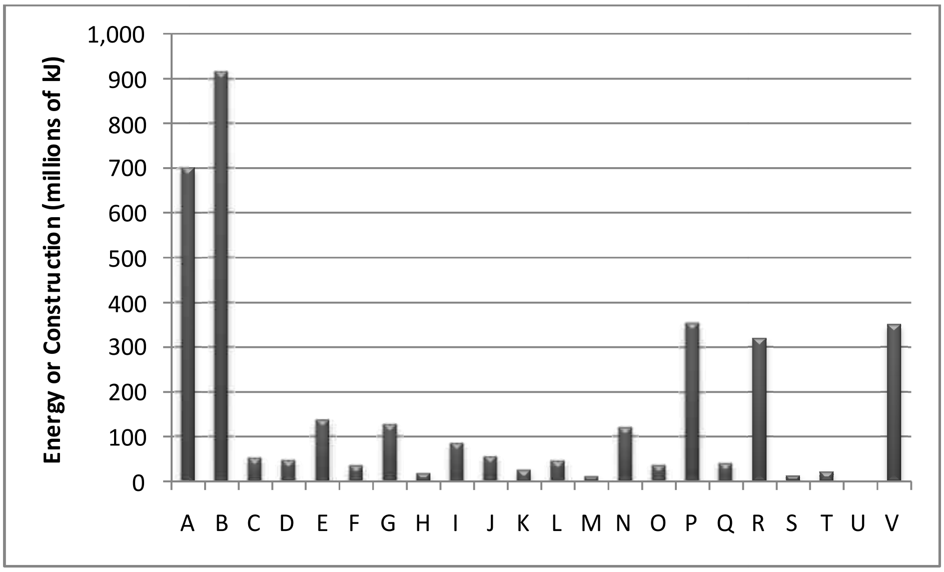

Figure 6.3. Bar chart showing total construction energy per mound.

According to a study in occupation ergonomics of present-day adult workers of industrialized societies, mainly focused on German laborers, (Kroemer and Grandjean 1997:251-252), a person with a sedentary job expends roughly 7,500 – 12,500 kJ per work day. A person engaging in heavy labor utilizes 12,500 – 17,000 kJ per work day, while energy expenditure over 17,000 – 21,000 kJ per work day indicates severe labor. Assuming that mound and plaza construction activities required in investment of energy equivalent to the minimum amount of heavy labor for one day, 12,500 kJ, hypothetical scenarios involving the number of laborers over a given amount of time can be estimated.

Although Moundville was occupied to various extents from 1050 to 1650 A.D., it is believed that the majority of mound construction took place over a 200 year period, from roughly 1250 A.D. to around 1450 A.D. (Knight and Steponaitis 1998). There was no meaningful construction after 1450 A.D. Moreover, Knight (2009b) claims that the vast majority of mound building took place over only 100 years, ca. 1250-1350 A.D.

Also, population estimates for creating reasonable scenarios are based on the amount of labor contributed per person during a full year. I am not arguing that mound construction was a yearly activity. On the contrary, based on the stratigraphic evidence of mound construction it appears that large construction stages were added to earthworks at rather lengthy intervals (Anderson 1994). The time-span of a site is important to know for creating realistic scenarios of the number of laborers participating in mound construction.

In considering the number of possible laborers, one must also examine population estimates for the site. Steponaitis (1998:43) has argued that roughly around 1,000-1,700 people lived at the center during the peak occupation in the Moundville I phase (1120 – 1260 A.D.), while Peebles (1987) estimates that 10,000 more lived in the hinterlands. Muller (1997:275) estimates that roughly 1/5 of any given Mississippian population worked on mound construction, basically one person per household of five. The merit of this assumption is debatable.[21] However, for sake of the example at hand, three approximations for the population from which the laborers were drawn, 1,250, 5,000, and 10,000, is divided by five, yielding 250, 1,000, and 2,000 laborers. Based on current estimated, the first figure might include the Moundville I phase population resident at the site while the latter two would certainly involve large contributions from some or all of the hinterland populations as well.

[21] To estimate the number of laborers, I am using a ratio of 1:5; one worker for every five people in a population (Muller 1997). It should be noted however that this ratio is debatable. Muller (1997) does not specify where this came from, though it is presumably meant to represent one worker per household. Scarry uses the range of Moundville house floor sizes (Peebles 1978; Scarry 1995, 1998) and Naroll's (1962) formula for calculating household size creating an estimate of 1.3-3.4 people per house. As this is low compared to ethnohistorical sources (Hann 1988:166; Swanton 1911:43), Scarry (1998:92 also see Steponaitis 1998:42) assumes 5-8 people per household in the Black Warrior River valley. Therefore, assuming one able-bodied per household the ratio 1:5 seems reasonable. Other ratios that have been used include 1:2 by Bernardini (2004:346) who assumes that half of the population was capable of participating in mound construction, while T.R. Kidder (Personal Communication) assumes a ratio of 1:3 in his energetics study of Poverty Point based on Kelly’s (1995) ethnographic study of hunting-gathering bands of approximately 25 people.

The total amount of energy implicated in earthwork construction, 3.8 billion kJ, can be divided by the product of: 1) 12,500 kJ per day, the minimum amount of energy of a human engaged in heavy labor multiplied by 2) the estimated number of workers; 250, 1,000, or 2,000, and 3) the estimated number of days per year for those laborers participating in mound building. For example, the energy of construction of the site, 3.8 billion kg, divided by the product of 12,500 kJ per day, 250 laborers, drawn from a population of 1,250 working an average of 10 days per year, is 116 years. Given that the Moundville landscape was constructed during a time span of 100 to 200 years, this estimate of people and time seems to be a reasonable scenario. The reader should note that simply dividing the total construction energy by the product of energy per day and estimated number of laborers will yield only the total number of work days, whereas the number of work days per year must also be assumed. In reference to the example above, 250 laborers at 12,500 kJ per day yields 1,164 total work days. The concept of work days per year is factored in to give the reader a more tangible idea of the amount of labor that would have been required over the 100-200 year duration of construction.

The results of all three estimates of laborers working 3 days per year are shown graphically in Figure 6.4. The graphic shows that 250 laborers (representing a population of 1,250) working 3 days a year (1,164 total work days) is an unreasonable scenario, as it would have taken them 388 years to complete the work, far in excess of the 200 year deadline. As shown in Figure 6.4, the most realistic minimum estimate at 12,500 kJ per day is roughly 1,000 laborers (from a population of 5,000) working 3 days annually (291 total work days) to complete the construction in 97 years. However, 2,000 laborers (representing a population of 10,000) working an average of 3 days per year (145 total

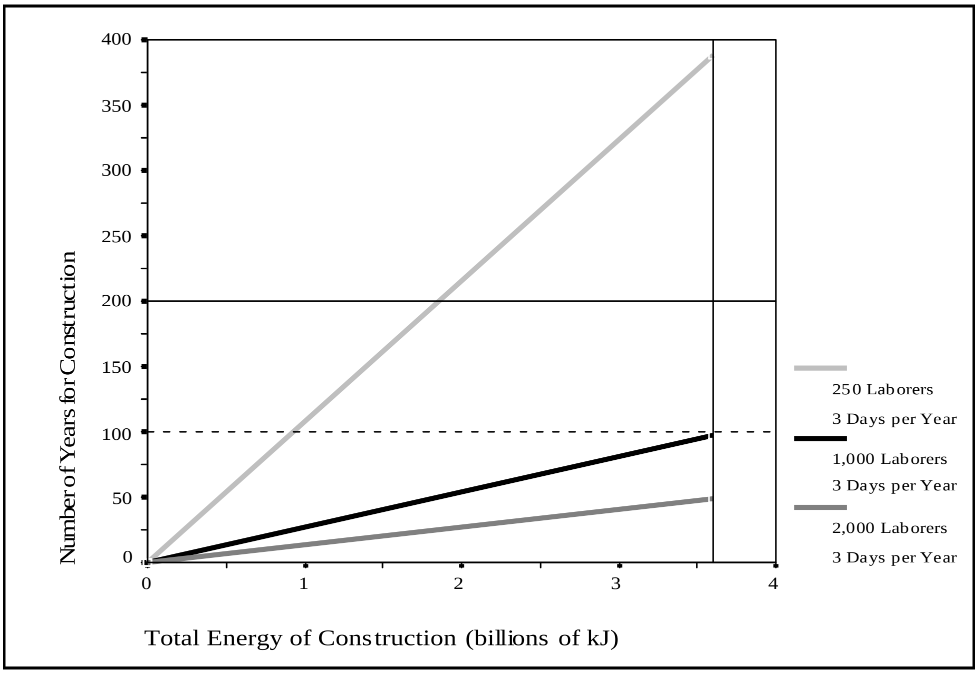

Figure 6.4. Hypothetical labor costs of earthwork construction at Moundville. Projections are calculated based on the assumption that laborers expended 12,500 kJ per day over 20 days of work per year.

work days) could complete construction of the site in only 49 years, an estimate that would appear far short what we know about the site. Yet, because constructions for an average mound were highly episodic, not annual, and about 20 years elapsed between mound additions (Anderson 1994), there could have been many years in which there was no construction anywhere on the site. In other words, I think 2,000 laborers working an average of three days a year is also quite plausible.

Using these estimates and comparing them to the site chronology, I would argue that Moundville was constructed in approximately 300 – 1200 total working days, meaning that the average year required three to ten days of labor depending upon the number of laborers. The number of laborers would probably have averaged around 1,000. Steponaitis (1998) estimates the peak population at Moundville to have occurred during Moundville I times (AD 1120 – 1260) and Knight (2009b) estimates that mound construction around the plaza began no earlier than AD 1250 and slowed down by AD 1350, which leaves very little overlap between a peak residential population and mound construction (also see Wilson 2008). Therefore, it one may reasonably conclude that laborers for mound constructions came from the hinterlands and not merely from Moundville's residential population.

When energy for earthen monumental construction is calculated in terms of the three components of construction energy, it appears that earthen constructions were slightly more labor intensive than some current scenarios suggest. For example, Muller (1997:274) states that 250 laborers (1/5th of a population of 1,250) working four days a year could have created Moundville in 160 years assuming that a single person could excavate and transport 1.25 m^3 in one day.[22] This is approximately 640 total work days. However, using the estimates calculated for this study, 250 laborers at Moundville working more than 1,120 total work days, or seven days a year could not have created the site in less than 160 years. This difference between these estimates amounts to almost twice as much labor to construct the site in my model. However, I believe the work sessions projects for this study per year are not excessive nor ethnographically unrealistic.

The Moundville landscape, like other Mississippian landscapes, was not created continuously over time. Instead, individual mounds were built in discrete stages, with long intervals in between (Knight 2009b; also see Anderson 1994). Some of these mounds stages were very large and would have required sizeable work crews. Some were relatively small. The manner in which Muller and I present our results, that is in

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[22] The mass of 1.25 m^3, assuming a density of 1,442 kg/m^3, is 1,803 kg (3,975 lb) or almost two short tons. Even as an able-bodied male, I think I would have serious difficultly excavating and transporting two tons in one five hour period.

days of labor per year, probably does not reflect a realistic timing in which these sites were constructed. It is these mound stages that are the true “packages” or units of mound construction and much more attention should be devoted to the labor needed for each of these smaller quantities. It is more anthropologically interesting than figuring the total labor over the course of many decades, which is abstract in human terms.

To get a better idea of the organization of labor required for individual mound stages, reasonable hypothetical scenarios were created for three mound stages at Moundville: 1) Stage III of Mound A, 2) Stage II of Mound F, and 3) Stage I of Mound R. These three stages represent the largest construction stage in each of these three mounds. Using volumes for these stages estimated from mound excavation records and coring results (Gage 2000; Gage and Jones 2001; Knight 2009b), the total amount of construction energy is calculated in the same manner as described for entire earthworks (Table 6.2).

Stage III of Mound A is approximately 10,850 m^3, the largest of the three mound stages examined for this study. The volume of this stage was loosely calculated using the ratio of the height of the building episode to the height of the entire mound assuming symmetry. Knight (2009b) reported this building stage to be roughly 2.38 m thick. As Mound A is currently 6.7 m high, the height of the stage was divided by the height of the mound and then multiplied by the volume calculated in Chapter 2 using the gridding method (30,145 m^3). The stage is approximately 36% of the total earthwork, thus the volume of the stage is theoretically the same, 36%. The density from Mound R was used (1,848 kg/m^3) to calculate the mass of the stage and the result was used in the equations discussed above for the energy of excavation, transportation, and compaction.

Mound Stage	Volume (m^3)	Mass (kg)	Energy of Excavation (kJ)	Energy of Transportation (kJ)	Energy of Compaction (kJ)	Total energy of Construction (kJ)
Mound A Stage III	10,850	20,100,000	57,700,000	168,100,000	28,900,000	254,700,000
Mound F Stage II	1,005	1,900,000	5,500,000	4,800,000	2,700,000	13,000,000
Mound R Stage I	7,030	13,000,000	37,300,000	47,300,000	18,700,000	103,300,000

Table 6.2. Energy of construction for three mound stages at Moundville. Results have been rounded.

The volume of Stage II of Mound F was calculated from a profile drawing (Knight 2009b) in a similar manner as Stage III of Mound A; a ratio of the height of the stage to the height of the mound was calculated to be 36%. The volume was multiplied by the density from Mound R and then the mass generated was used in the construction equations. The volume of Stage I of Mound R was previously calculated by Gage (2000). However, his final volume estimate for the mound, calculated using multiple geometry solids (see Chapter 2), was slightly larger than the estimate obtained using the gridding method. Thus, to estimate a more precise volume of the mound stage, the gridding method volume estimate (21,820 m) was divided by Gage's (2000) estimate of 30,700 m^3. This ratio, 0.71 was multiplied by Gage's estimate of Stage I, 9,900 m^3, resulting in a new estimate of the volume of Stage I proportional to the overall volume obtained using the gridding method, 7,030 m^3.

With the volume, mass, and various energies of construction of these three construction stages calculated, the total energy of construction for each stage can be divided by estimates of the number of laborers multiplied by the estimated number of kJ expended per day. The result would be the total number of work days invested in each construction stage. If it is true that the construction stages of the smaller plaza periphery mounds were built using kin-based labor, then they should have required smaller and perhaps more diverse groups of people (consisting of various family members as opposed to specialized work crews) than the larger central mounds, A, B, and V. Therefore, the estimates of laborers I use to create various scenarios here are smaller than previous estimates. I use 50, 250, and 1,000 laborers drawn from total populations of 250, 1,000, and 5,000. Because I am talking about specific work crews for specific projects as opposed to averages for the whole site over long spans of time, smaller work crew estimates of 50, 250, and 1,000 are appropriate. A single kin group might have mustered 50 laborers and perhaps even 250 (if they were 1,250 strong), but 1,000 (drawn from a population of 5,000) is unrealistic for one kin group alone.

For Mound A, 50 laborers could have constructed stage III in 475 days, whereas 250 laborers could have constructed the stage in 95 days. Both of these scenarios seem unrealistic, considering that the stage was probably constructed as one continuous building episode. This amount of time is also much longer than the typical estimates for the amount of time invested in monumental construction, except by state-level organizations (Bernardini 2004; Erasmus 1961, 1965; Hogbin 1939, 1951; Redfield and Rojas 1962; Stenton 1951; Tuzin 1980). I believe the most reasonable scenario for this stage is approximately 1,000 laborers working for 24 days. As for Mound F, 50 laborers could have constructed Stage II in approximately 20 days, whereas 250 laborers could have constructed it in four days, and 1,000 laborers could have completed it in little more than one day. Using the same three figures for number of laborers as the other two construction stages, it would have taken 50 laborers 169 days to complete the first stage of Mound R. On the other hand, it would have taken 250 laborers 34 days or 1,000

Number of Laborers	Mound A	Mound F	Mound R
50	475	20	169
250	95	4	34
1,000	24	>1	8

Table 6.3. Number of possible construction days based on the estimated number of laborers.

laborers 8 days to complete Stage I. Two hundred and fifty laborers working 34 days is a comparable time frame to those I believe are reasonable for the other two mound stages just discussed. It is possible that 250 laborers could have been drawn from a single kin group, however, 1,250 people might be pushing the upper limit for one kin group.

Discussion

I believe that the measure advocated here, calculated using the three components of energy and expressed in kilojoules, is a suitable one for measuring energy involved in the creation of a monumental landscape. Yet, this method is not without its shortcomings. Assumptions must be made concerning certain variables, and a majority of research concerning these variables is experimental. Nevertheless, I think this method emphasizes aspects of mound building that have previously been ignored, such as mound density, transportation distance, and compaction. Using only volume and expressing the measurement as person-hours or days appears to underestimate the amount of labor needed to construct an earthen monumental landscape. This method of calculating energy for constructing monumental earthworks will provide more opportunity to compare the amount of energy expended given different populations and different scales of landscape modification.

Chapter 7

Conclusions and Suggestions for Future Research

One important objective of this dissertation was to reformulate the units of measure in an energetics model for earthen monumental landscapes and to some degree standardize a comparative method for future research. To accomplish this objective, soil density was calculated using methods from geotechnical engineering in order to estimate the mass of an earthwork, rather than its volume. Then, the three most labor intensive activities employed in earthen construction were quantified: the energy to excavate, the energy to transport, and the energy to compact. One primary benefit of this research is that data from other disciplines can now be applied to prehistoric labor assessments in archaeology. I should note that this method also simplifies the addition of further activities to the original three tasks measured herein. The energy for loading, dumping (unloading), and walking up and down the mound or in and out of a borrow pit (or ravine) could also be included the assessment.

In the remaining portion of this chapter I will briefly discuss additional implications of the research, mainly focusing on its theoretical implications concerning the social and political organization of labor. Control over non-kin has been a major theoretical assumption about complex societies and has been one of the defining characteristics of both chiefdoms and early states (Arnold 1993, 1996; Bender 1985, 1990; Drennan 1991; Earle 1991, 1997; Fried 1960; Friedman and Rowlands 1978; Hastorf 1990; Johnson and Earle 1987; Kirch 1991; Saitta 1997; Saitta and Keene 1990; Steponaitis 1991; Webster 1990). Arnold (1993) defines complexity employing three characteristics: 1) hereditary inequality, 2) hierarchical organization, and 3) partial control over domestic labor. The first two have been well-addressed for the Moundville chiefdom (Peebles and Kus 1977; Steponaitis 1978). I am interested in applying my data to address the third characteristic, that is, whether or not labor was controlled above the level of the kin group at Moundville. The subsequent discussion addresses kin-based versus supra-kin-based labor in complex societies, followed by an examination of the amount of energy required to construct individual building episodes of three mounds of various size. Based on both the estimated amount of labor and number of laborers, I will argue that some mound stages at Moundville could easily have been constructed using only labor organized by a single kin group, whereas other constructions required more laborers than a single kin group could organize. These larger constructions arguably were built by labor crews assembled and presumably overseen by political elites at the apex of Moundville's organization.

In some segmentary societies, kin groups (such as clans, lineages, descent groups, and social houses) are strongly corporate and can potentially recruit fairly large labor pools. However, this is often a latent function, and labor is organized by smaller domestic groups (or minimal lineages) on an everyday basis. As needed (for example, for field clearing, etc.), kin group leaders emerge that can organize as many as several hundred workers, depending on the generational depth of the group. This authority is only temporary and is seldom, if ever used for monumental construction (Arnold 1993, 1996; Trigger 1990; Webster 1990).

In stratified societies, leaders gain control over non-kin labor using a combination of symbolic, economic, and military leverage (Earle 1997). The labor exploited in such political economies is drawn upon by relatively stable political officeholders, and large-scale labor projects occur with more frequency than in non-stratified societies (Arnold 1993, Kirch 1990). According to Webster (1990), the strategy for controlling labor in stratified societies involves an expansion from a kin-based labor force to one that supersedes domestic organization by binding non-kin clientele to elite activities. In short, as the social relations of production evolve, individuals gain partial control over labor by establishing a hierarchical organization transcending segmentary kin organization (Bender 1990; Earle 1991; Kirch 1991).

Labor Organization at Moundville

In order to examine the sociopolitical implication of labor at Moundville, and determine if labor was controlled above the kin group level, some parameters need to be addressed, including an estimate of the population and number of possible kin segments. Peebles (1987) estimated the regional population of the Black Warrior River Valley to be roughly 10,000. Peebles does not specify the source of this estimate for the hinterland population, but it is seems to be a reasonable assessment for the upper limit of the Black Warrior River Valley population. Recent assessments of the number of hinterland communities based on survey (Hammerstedt et al. 2009) suggest that this figure may be too high.

The possible number of kin groups or segments (clans, maximal lineages, etc.) that comprised the population also needs to be addressed. There is no way to know the exact number of major kin-based segments, but for the purposes at hand, it can be assumed that there were at least seven at Moundville based on the number of mound pairs (Knight 1998). Knight suggests that kin-organized groups controlled the mounds arranged around the plaza periphery, and that one can count the number of major social segments at Moundville by counting the number of structurally equivalent mound pairs. This number of kin-based segments is comparable to regional ethnohistoric data. For example, during the late 1700s, the Cherokee of western North Carolina had seven major matrilineal clans (Fogelson 2004), though Morgan (1877) reported that originally there might have been as many as ten. The Creeks of Alabama and Georgia were organized into nine major phratries (Walker 2004). The Chickasaw of Tennessee and northern Alabama had a least 12-15 named house groups (Speck 1907; Gatschet and Thomas 1907), though Swanton (1928) counted over 50. Therefore, it seems reasonable to assert that there were at least seven major kin-based segments for a model of Moundville organization based on ethnographic analogy applied to the number of structurally equivalent mound pairs at the ceremonial center.

Peebles's estimated regional population of the Moundville polity (10,000) divided by seven major kin-based segments is approximately 1,430 people per kin group. Assuming that one in every five people were able-bodied individuals capable of participating in mound construction (Muller 1997; see Chapter 6), a kin group of this size could recruit roughly 286 laborers. Because there probably were larger and smaller kin groups, I am assuming that the largest might have possessed a population of over 2,000 people (one-fifth of the total population) and could amass a work crew of approximately 400, while smaller kin groups might muster perhaps 50 laborers from an overall population of approximately 250. Following this logic, if a specific construction project, in this case a mound stage at Moundville, can be constructed with 400 or fewer laborers under a reasonable work scenario, then there is no need to invoke an organization of labor higher than that of the kin group. Note that the total population is likely a maximal estimate while the modeled number of kin segments is likely minimal. Thus, smaller work crews, especially smaller than 400, are much more likely than larger ones under this scenario.

Referring back to the estimates in Chapter 6 for individual construction stages, the difference in the estimated amount of labor necessary to construct one of these stages in roughly one month varies between 50 to 1,000 laborers. Stage III of Mound A in the center of the plaza must have required a large collectively pooled work crew of approximately 1,000 laborers drawn from a population of 5,000 in order to be completed in approximately 24 days. Stage II of plaza-periphery Mound F, on the other hand, easily could have been constructed by a small work crew of 50 laborers, drawn from a kin group with a population of 250 people, working over 20 days. The obvious difference in the size of work crews working for roughly the same amount of time indicates to me that, at least for the few largest earthworks, labor was controlled above the organizational level of the kin segment, whereas others constructions on the plaza periphery need not have been.

The construction of Mound R Stage I on the plaza periphery seems to fall between the estimates reported above for Mounds A and F. Two hundred and fifty laborers drawn from a population of 1,250, an averaged size kin group in terms of the estimates generated above, could have constructed the stage in 34 days. The difference in the labor required between these construction stages of plaza-periphery Mounds F and R probably indicate a difference in the ability of their respective kin groups to recruit labor. Although Mound R is quite large, there is no reason to believe that it or any other plaza-periphery mound was constructed using collectively pooled labor. The exceptions are the larger central Mounds A, B, and perhaps Mound V, which probably did require labor pooled from multiple social segments.[23]

Based on this examination of the organization of labor at Moundville, I argue that some form of control over labor above the level of kin groups was necessary for the construction of the major mounds on Moundville's central axis, but no other mounds of the group. The palisade, another large project, would probably also have required polity-wide as opposed to kin-based labor (Figure 7.1). Evidence indicates a rapid transformation in the Black Warrior River Valley from an egalitarian society in the terminal Woodland West Jefferson phase (AD 1020 – 1120) to a more complex society less than 100 years later. I believe that this regional population achieved a level of political complexity integrating several local communities with leadership capable of commanding labor from a broad hinterland (Arnold 1993, 1996; Peebles and Kus 1977; Steponaitis 1978).

To conclude, I would like to reiterate that these scenarios and values are largely speculative. Yet, creating plausible scenarios is worthwhile as they help us think more

[23] The argument that Mound V was constructed by a collectively pooled work crew is based on the fact that the mound appears to have been constructed in a single building episode (Gage and Jones 2001), it falls along the central axis of the site along with Mounds A and B, and is the third largest mound by volume behind Mounds A and B, according to revised estimates (Chapter 2).

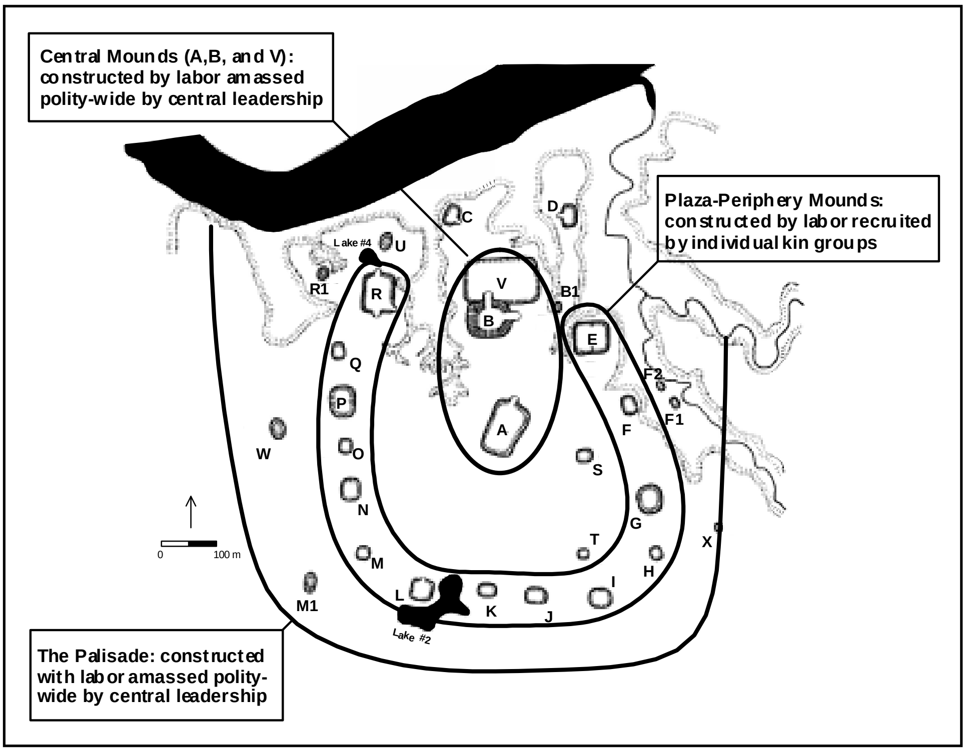

Figure 7.1. A model of labor organization for Moundville.

concretely about the number of laborers, the duration of labor, and the manner in which they may have been organized. Such models can be refined or replaced as better values for these variables are obtained.

Future Research

Information from this and similar studies can be used to address other archaeological issues. For example, the reformulation of the units of measure for an energetics assessment of the construction of a monumental landscape also enables research to be conducted concerning the degree to which labor may have been subsidized by staple food amassed by means of political economy. It is possible to estimate the average daily energy (or caloric intake) based on a form of subsistence practice and then determine how much additional food above typical domestic consumption was being subsidized by leaders during a time of monumental construction (eg., Erasmus 1965; Lewis 1951; Pimentel and Pimentel 2007; Pyke 1970; Rappaport 1968). Chiefs develop political economies in order to carry out projects, including mound construction. To do this, they amass surplus food, extracted from primary producers, in central storehouses (granaries, in the case of Moundville). So the issue here is how much they would have needed to extract to feed a given quantity of laborers. An energetics assessment measure in kilojoules, which are easily converted to kilocalories (1 kJ= 0.239 kcal), is capable of estimating such factors, in a way that person-hours cannot.[24]

It should be noted that it is a simple matter to re-express the human energy expended in the construction of Moundville's landscape entirely in the form of kilocalories instead of kilojoules. Such a conversion certainly benefits the reader in some ways. Kilocalories are more easily visualized than kilojoules, as they are the typical unit used to measure human nutrition. For example, I have stated that the average worker utilizes 12,500 kJ per day. This measure converts to 2,988 kilocalories, which is just slightly higher than the average daily caloric intake recommended for male adults by the World Health Organization. The typical measure of work energy is in the form of joules or kilojoules, not kilocalories. Nutritional information, in contrast, is typically expressed in kilocalories, although some countries give nutritional information in either kilojoules or a combination of kilojoules and kilocalories. As the objective of this study is the measurement of human energy rather than the nutritional requirements of prehistoric builders, I found it appropriate to maintain kilojoules as the unit of measure throughout

[24] Food energy is the amount of energy in food available through digestion. Like other forms of energy, food energy is expressed in kilocalories (kcal) or kilojoules (kJ) depending upon geographic region. In the context of nutrition and food labeling, calorie and kilocalorie are interchangeable.

the assessment. If one's research question is aimed more towards calculating the nutritional needs of prehistoric builders, the kilocalorie is the appropriate unit of measure.

The methods and results of this research lead to other realizations. First, Erasmus's (1965) research provides unrealistic values for use in energetics assessments in the Southeast United States. Not to denigrate his ground-breaking study, but there are obvious differences that some archaeologists seem to ignore in borrowing his 50 year-old data. First, the climates and soil types are completely different. Las Bocas, Sonora, Mexico, where Erasmus conducted his experiment, is a small fishing village in western Sonora, located on a narrow coastal plain between the Sierra Madre Occidental Mountain range and the Gulf of California. The climate here is very desert-like with an average annual temperature of 75° F (24° C) and yearly rainfall range of roughly 3-16 in (8-41 cm). More importantly, the soil in this region consists mostly of sand and rock; there is very little clay or silt. Central Alabama, on the other hand, is sandwiched between the East Gulf Coastal Plain and the southern end of the Cumberland Plateau and Appalachian Valley and Ridge Providence. This area has an annual average temperature of 65° F (18° C) and an average of 60 in (152 cm) of rain per year. Most of the soils in this region are silts and clays with various amounts of sand. The difference in the amount of rainfall increases the moisture content of the naturally heavier silts and clays, further increasing their unit weight. The soils of Sonora are generally much easier to excavate, especially using a digging stick, and are less dense. Therefore, the same amount of energy would have been expended to excavate and transport less volume per hour. Secondly, the manner in which Erasmus (1965) measured the volume of earth excavated was done using geometric volume equations, and as the research from Chapter 2 has shown, this method tends to overestimate the amount of soil utilized.

Hammerstedt (2005) took the initiative to conduct his own earth-moving experiments in the same area as his archaeological research, and in the resulting energetics assessments noted a rather large difference in the energy to excavate compared to Erasmus. His estimate for excavation volume, 0.29 m^3 per hour, is approximately half of Erasmus's (1965) estimate, 0.52 m^3 per hour. More often than not, original experiments to estimate energy are not conducted and the data are merely borrowed, which leads to unrealistic results. Secondly, archaeologists need to standardize the methods for conducting energetics assessments of prehistoric peoples. A plethora of information outside of archaeology has been published for disciplines from general construction to military medicine. These sources can and should be consulted.

Finally, the most up-to-date technology for identifying and quantifying earthen constructions should always be used in archaeological energy assessments. As I say elsewhere in this dissertation, the technology is readily available to more accurately measure mound volume and to identify less obvious earthen constructions, such as plaza fills. To conduct an energetics assessment and productively compare the results to other mound stages, mounds, or sites, one needs to be sure to include all soil used in the creation of a monumental landscape.

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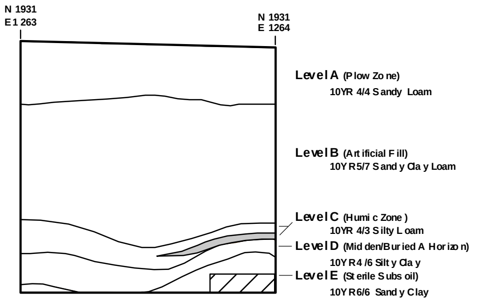
Appendix: Plaza Unit Artifacts

Unit N1930 E1263/Plaza Unit West of Mound F

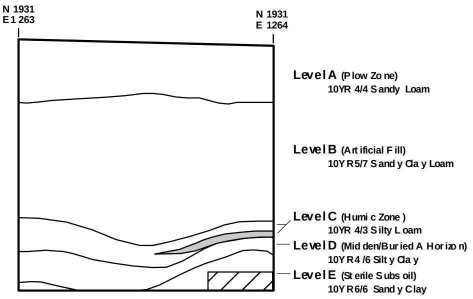
Ceramics (Frequencies)



Type	**Level A - Plow Zone**	**Level B - Artificial Fill**	**Level C - Humic Zone**	**Level D - Midden/A Horizon**	**Total**
Mississippi Plain	98	176	87	101	462
Moundville Incised, *var. Moundville*		5	10	7	22
Bell Plain	6	66	68	56	196
Carthage Incised, *var. Unspecified*		3			3
Moundville Engraved, *var. Elliots Creek*			14	24	38
Moundville Engraved, *var. Havana*		1			1
Moundville Engraved, *var. Unspecified*		3	30	33	66
Baytown Plain, *var. Roper*	3	5		1	9
Res. Fine Grog and Shell-Tempered Plain	4	1	1	7	13
Res. Fine Grog and Shell-Tempered Engraved		1		2	3
Res. Fine Grog and Shell-Tempered Incised				1	1
Res. Fine Sand-Tempered Plain	1			1	2
Res. Fine Sand and Shell-Tempered Plain		10		7	17
Res. Fine Shell-Tempered Plain		1	3		4
Res. Temperless Plain		3			3
Total	112	275	213	240	840
Diagnostic Mode					
Folded Jar Rim			2		2
Folded-Flattened Jar Rim		1			1
Total		1	2		3

Unit N1930 E1263/Plaza Unit West of Mound F

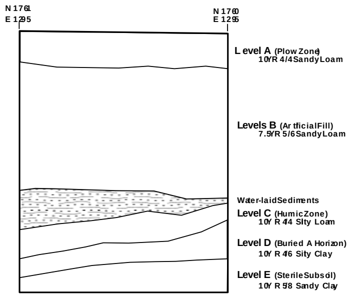
Lithics, Unmodified Stone, and Other (Weight in grams)



	Level A - Plow Zone	Level B - Artificial Fill	Level C - Humic Zone	Level D - Midden/A Horizon	Total
Flaked Stone					
Flake (Banger Chert)				0.3	0.3
Flake (Ft. Payne Chert)	1.4				1.4
Flake (Tuscaloosa Gravel Chert)	1.0				1.0
Flake (Heat Treated Tuscaloosa Gravel Chert)		0.7		0.3	1.0
Shatter (Greenstone)	2.9				2.9
Worked Stone					
Pitted Anvil Stone				569.6	569.6
Saw (Hematitic Sandstone)		12.5			12.5
Whetstone (Fine Grey Micaceous Sandstone)				371.3	371.3
Unmodified Stone					
Chert (Banger)	2.2				2.2
Hematite (Pigment Quality)		14.0			14.0
Mica				0.1	0.1
Pebbles	405.8	1,316.7	165.4	124.1	2012.0
Sandstone, Concretions	119.5	1,037.3	77.6	86.5	1,320.9
Sandstone, Fine Grey Micaceous	19.7	53.3	18.5		91.5
Sandstone, Hematitic	25.5	26.7	4.2	0.2	56.6
Soapstone		0.4			0.4
Other					
Bone		0.2			0.2
Charcoal	0.1	1.1	0.7		1.9
Daub		1.1	1.3	2.6	5.0
Fired Clay	9.2	149.0	191.7	129.6	479.5
Total	587.3	2,613.0	459.4	1,284.6	4,944.3

Unit N1760 E1294/Plaza Unit Southwest of Mound G

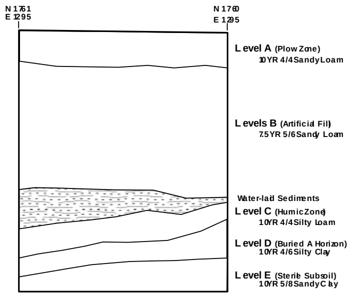
Ceramics (Frequencies)



Type	**Level A - Plow Zone**	**Level B - Artificial Fill**	**Level C - Humic Zone**	**Level D - Buried A Horizon**	**Total**
Mississippi Plain	112	38	14	14	178
Moundville Incised, *var. Moundville*		1			1
Moundville Incised, *var. Unspecified*	1				1
Bell Plain	26	8			34
Carthage Incised, *var. Unspecified*	4				4
Baytown Plain, *var. Roper*	3				3
Res. Fine Grog and Shell-Tempered Plain	3	2			5
Res. Fine Grog and Shell-Tempered Engraved	1				1
Res. Fine Grog and Shell-Tempered Burnished Plain		1			1
Res. Sand and Shell-Tempered Plain				1	1
Res. Fine Sand and Shell-Tempered Incised	1				1
Res. Grit-Tempered Plain			3		3
Res. Temperless Plain	2		1		3
Total	153	50	18	15	236
Diagnostic Mode					
Beaded Bowl Rim	1				1
Short-neck Bowl Rim	1				1
Folded Jar Rim				1	1
Total	2			1	3

Unit N1760 E1294/Plaza Unit Southwest of Mound G

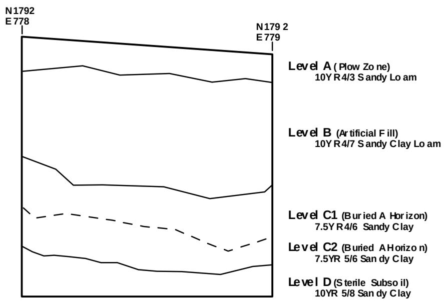
Lithics, Unmodified Stone, and Other (Weight in Grams)



	Level A - Plow Zone	Level B - Artificial Fill	Level C - Humic Zone	Level D - Buried A Horizon	Total
Flaked Stone					
Flake (Heat Treated Tuscaloosa Gravel Chert)				0.1	0.1
Worked Stone					
Ground		35.2			35.2
Saw (Hematitic Sandstone)	3.4				3.4
Unmodified Stone					
Mica		0.1			0.1
Pebbles	144.3	127.4	89.6	253.9	615.2
Sandstone, Concretions	104.9	133.1	327.9	331.9	897.8
Sandstone, Fine Grey Micaceous	3,222.2	54.8			3277.0
Sandstone, Hematitic	1.5	0.3			1.8
Other					
Bone	0.1				0.1
Charcoal	20.7	2.3	2.3	2.3	27.6
Daub	11.1				11.1
Fired Clay			1.0	9.9	10.9
Total	3,508.2	353.2	420.8	598.1	4,880.3

Unit N1791 E778/Plaza Unit Southeast of Mound N

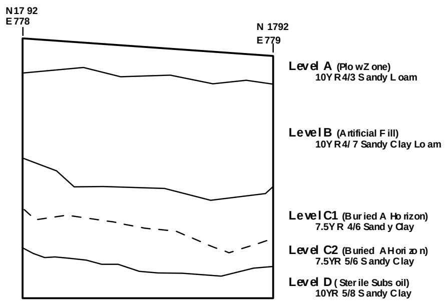
Ceramics (Frequencies)



Type	**Level A - Plow Zone**	**Level B - Artificial Fill**	**Level C1 - Buried A Horizon**	**Level C2 - Buried A Horizon**	**Total**
Mississippi Plain	17	80	6	11	114
Moundville Incised, *var. Unspecified*		2			1
Bell Plain	13	23	4	3	43
Carthage Incised, *var. Unspecified*	2				2
Moundville Engraved, *var. Hemphill*	1				1
Moundville Engraved, *var. Unspecified*		3		2	5
Carter Engraved, *var. Sara*			1		1
Carter Engraved, *var. Unspecified*		1			1
Baytown Plain, *var. Roper*		1			1
Res. Fine Grog -Tempered Plain		1			1
Res. Fine Grog and Shell-Tempered Plain	3	8	2		13
Res. Fine Grog and Shell-Tempered Burnished		1			1
Res. Grog and Shell-Tempered Plain		3			3
Res. Grog and Shell-Tempered Burnished (Addis Paste)	4				4
Res. Fine Sand and Shell-Tempered Plain	1				1
Res. Fine Shell-Tempered Plain	1				1
Res. Shell and Grog-Tempered Plain	2	2			4
Total	44	125	13	16	197
Diagnostic Mode					
Beaded Rim	1				1
Total	1				1

Unit N1791 E778/Plaza Unit Southeast of Mound N

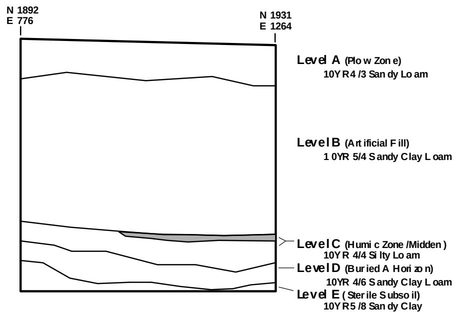
Lithics, Unmodified Stone, and Other (Weight in Grams)



	Level A - Plow Zone	Level B - Artificial Fill	Level C1 - Buried A Horizon	Level C2 - Buried A Horizon	Feature 1 – Post Hole	Total
Flaked Stone						
Flake (Tuscaloosa Gravel Chert)					1.5	1.5
Flake (Heat Treated Tuscaloosa Gravel Chert)		1.1				1.1
Unmodified Stone						
Hematite (Pigment Quality)	1.5					1.5
Pebbles	325.4	138.6	25.0	14.3	44.5	547.8
Sandstone, Concretions	79.0	122.5	33.0	58.6	5.2	298.3
Sandstone, Fine Grey Micaceous	82.1	42.6			39.7	164.4
Sandstone, Hematitic	24.6		0.4			25
Other						
Bone		1.6			0.6	2.2
Charcoal	1.1	14.7	1.5	0.6	6.9	24.8
Daub		2,320.1			2,578.6	4,898.7
Fired Clay	33.7	10.6	4.7	0.8		49.8
Historic Material	2.4					2.4
Silica Froth	0.6					0.6
Total	550.4	2,651.8	64.6	74.3	2677.0	6018.1

Unit N1891 E 776/Plaza Unit East of Mound O

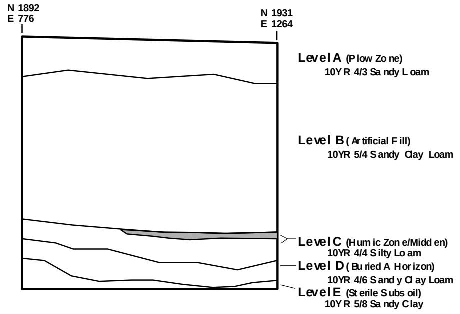
Ceramics (Frequencies)



Type	**Level A - Plow Zone**	**Level B - Artificial Fill**	**Level C - Humic Zone/Midden**	**Level D - Buried A Horizon**	**Total**
Mississippi Plain	175	75	45	89	384
Moundville Incised, *var. Unspecified*	1				1
Bell Plain	18	9	7	6	40
Carthage Incised, *var. Unspecified*	4		1		5
Moundville Engraved, *var. Unspecified*				1	1
Baytown Plain, *var. Roper*	1				
Res. Fine Grog -Tempered Plain	5	1			6
Res. Fine Grog and Shell-Tempered Plain	12				
Res. Fine Grog and Shell-Tempered Burnished	5				
Res. Sand/Grit Tempered Plain			1		1
Res. Fine Sand and Shell-Tempered Plain		1			1
Res. Fine Shell-Tempered Plain	1	2		1	4
Res. Shell and Grog-Tempered Plain	1				
Total	223	88	54	97	443
Diagnostic Mode					
Folded Jar Rim			1		1
Total			1		1

Unit N1891 E 776/Plaza Unit East of Mound O

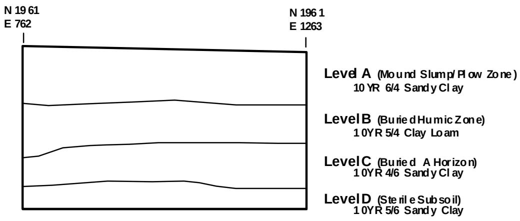
Lithics, Unmodified Stone, and Other (Weight in Grams)



	Level A - Plow Zone	Level B - Artificial Fill	Level C - Humic Zone/Midden	Level D - Buried A Horizon	Total
Flaked Stone					
Flake (Ft. Payne Chert)	0.9				0.9
Flake (Tuscaloosa Gravel Chert)	1.4				1.4
Scraper (Ft. Payne Chert)	2.6				2.6
Unmodified Stone					
Hematite (Pigment Quality)	4.8				4.8
Pebbles	372.3	229.4	124.1	65.8	791.6
Sandstone, Concretions	277.2	1,194.3	252.3	187.1	
Sandstone Conglomerate		21.0			21.0
Sandstone, Fine Grey Micaceous	158.5		5.0		163.5
Sandstone, Hematitic	2.7	0.7			3.4
Other					
Bone	0.8			0.2	1.0
Charcoal	0.6		0.8	0.7	2.1
Clay Disk (Molded)			5.7		5.7
Daub				30.0	30.0
Fired Clay	138.0	56.0	104.4	164.9	
Historic Material	2.0				2.0
Silica Froth		0.5			0.5
Total	961.8	1,501.9	492.3	448.7	3,404.7

Unit N1960 E 762/Plaza Unit East of Mound P

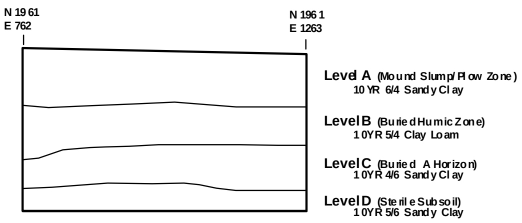
Ceramics (Frequencies)



Type	**Level A - Mound Slump/Plow Zone**	**Level B - Buried Humic Zone**	**Level C - Buried A Horizon**	**Total**
Mississippi Plain	94	33	118	245
Moundville Incised, var. Unspecified	1			1
Bell Plain	26		20	46
Carthage Incised, *var. Unspecified*	4			4
Carthage Incised, *var. Akron*	1			1
Moundville Engraved, *var. Unspecified*	1			1
Baytown Plain, *var. Roper*		2	3	5
Res. Fine Grog -Tempered Plain	1			1
Res. Fine Grog and Shell-Tempered Plain	2			2
Res. Fine Sand-Tempered Plain	1			1
Res. Fine Shell-Tempered Plain		1		1
Res. Temperless Plain	1		2	3
Res. Temperless Incised (Carthage Inc., *var. Akron* design)	1			1
Total	134	35	143	312
Diagnostic Mode				
Vertical Lug Rim	1	1		2
Folded-Flattened Jar Rim	1			1
Folded Jar Rim			5	5
Total	2	1	5	8

Unit N1960 E 762/Plaza Unit East of Mound P

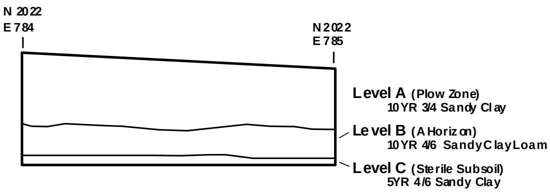
Lithics, Unmodified Stone, and Other (Weight in Grams)



Flaked Stone	**Level A - Mound Slump/Plow Zone**	**Level B - Buried Humic Zone**	**Level C - Buried A Horizon**	**Total**
Flake (Heat Treated Tuscaloosa Gravel Chert)	3.3	1.2	0.2	4.7
Shatter (Ft. Payne Chert)	9.3			9.3
Shatter (Tuscaloosa Gravel Chert)	7.6			7.6
Shatter (Heat Treated Tuscaloosa Gravel Chert)	5.2	2.5		7.7
Unmodified Stone				
Hematite (Pigment Quality)	1.9			1.9
Historic Material	4.6			4.6
Pebbles	259.1	75.8	36.6	371.5
Sandstone, Concretions	158.9	348.1	228.3	735.3
Sandstone, Fine Grey Micaceous	54.2	2.2	12.8	69.2
Sandstone, Hematitic	89.8			89.8
Unidentified Metaphoric	139.9			139.9
Other				
Bone	0.6		0.5	1.1
Charcoal	1.6	1.3	0.4	1.3
Daub		38.9		38.9
Fired Clay	138.6	219.7	137.9	496.1
Historic Material	4.6			4.6
Total	879.2	689.7	416.7	1,985.6

Unit N2021 E784/Plaza Unit Northeast of Mound P

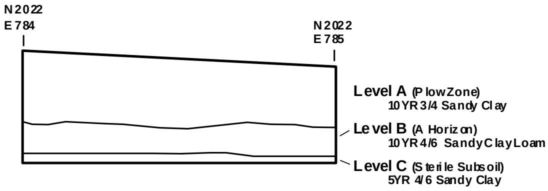
Ceramics (Frequencies)



Type	**Level A - Plow Zone**	**Level B - A Horizon**	**Total**
Mississippi Plain	88	27	115
Bell Plain	16	1	17
Carthage Incised, *var. Unspecified*	1		1
Carthage Incised, *var. Akron*	1		1
Moundville Engraved, *var. Havana*		1	1
Moundville Engraved, *var. Taylorville*	2		2
Baytown Plain, *var. Roper*	1		1
Res. Fine Grog -Tempered Plain	6		6
Res. Fine Shell and Grog-Tempered Plain	5		5
Res. Fine Grog and Shell-Tempered Engraved (Addis Paste)		1	1
Total	120	30	150
Diagnostic Mode			
Beaded Bowl Rim	1		1
Total	1		1

Unit N2021 E784/Plaza Unit Northeast of Mound P

Lithics, Unmodified Stone, and Other (Weight in Grams)



Flaked Stone	**Level A - Plow Zone**	**Level B - A Horizon**	**Total**
Flake (Tuscaloosa Gravel Chert)	3.8		3.8
Flake (Heat Treated Tuscaloosa Gravel Chert)	0.1		0.1
Flake (Identified Chert)	1.2		1.2
Shatter (Banger Chert)	0.5		0.5
Shatter (Tallahatta Quartzite)	11.9		11.9
Unmodified Stone			
Pebbles	258.0	82.5	340.5
Sandstone, Concretions		5.5	5.5
Sandstone, Fine Grey Micaceous	268.2	49.6	317.8
Sandstone, Hematitic	8.1	12.5	20.6
Other			
Bone		0.6	0.6
Charcoal		0.5	0.5
Fired Clay	155.2	70.4	225.6
Historic Material	13.2		13.2
Total	720.6	221.6	941.8