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THE USE OF SOIL ANALYSES TO LOCATE PREHISTORIC AGRICULTURAL FIELDS: OCMULGEE NATIONAL MONUMENT, MOUND D

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Athens

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by

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Chapter I. Introduction and Purpose

Maize agriculture played a significant role in the subsistence practices of Mississippian communities, particularly the larger mound centers. However, evidence suggests that the shift to field production of corn began prior to the construction of mound centers (Scarry 1986; Wymer 1993). There has even been speculation that the shift in population aggregation and ceremonial regimes may have been linked to a dramatically increased use of maize (Wymer 1993). Excavations beneath Mound D at the Macon Plateau site (9BI1) at Ocmulgee National Monument revealed topographic features that were identified as "rows" beneath the mound itself. These "rows", which resembled prepared furrows, were interpreted as evidence of maize fields (Kelly 1935, 1938), which are often prepared in elevated rows for planting. The accuracy of this interpretation has never been evaluated or confirmed.

Project Objectives

The intent of this project is to test the validity of the theory regarding this "maize field" on which a mound was constructed, using sediment, pollen, and phytolith analyses. To this end, this study strove to discern distinctive sediment characteristics and the presence or absence of maize pollen and/or phytoliths at the base of Mound D. The basic assumptions guiding this project are: 1) if sediment characteristics indicate a distinction between field and non-field soils and plant microfossils (specifically maize pollen and phytoliths) can be identified in sufficient numbers, the "cornfield" hypothesis is supported; 2) conversely, if such a distinction microfossils (specifically maize pollen and phytoliths) can be identified in sufficient numbers, the "cornfield" hypothesis is supported; 2) conversely, if such a distinction is made but maize microfossils are not identified and their absence cannot be attributed to soil conditions, the "cornfield" hypothesis is not proven and alternate explanations may need to be considered.

Research questions addressed by this study include:

1. Do the soil characteristics observed in the samples taken from Mound D suggest that the mound fill was placed on top of an agricultural field?
2. Are pollen grains preserved and do they represent a specific cultigen such as maize?
3. Are phytoliths present and do they represent a specific cultigen such as maize?
4. Have previous excavations at Ocmulgee accurately interpreted the undulating soil pattern beneath Mound D as an agricultural field?

Significance of the Study

This research will strive to confirm or refute previous theories regarding the construction of Mound D at the Macon Plateau site. It will authenticate the presence of maize agriculture in an upland setting at Ocmulgee National Monument. Addressing the stated research questions will contribute to our understanding of prehistoric urbanization and the subsistence activities practiced in order to support such an occurrence.

The Ocmulgee "cornfield" was the first feature of its kind to be discovered in the eastern United States (Riley 1994). Numerous archaeological features have subsequently been identified as agricultural fields based on their similarities to the Mound D feature. These similar features have been noted at sites from Wisconsin, Ohio, Illinois, and elsewhere (Fowler 1992; Gallagher 1992; Gallagher et al. 1985; Riley and Freimuth 1979; Riley 1994). Should this research reveal that Mound D at Ocmulgee does indeed sit on top of a cornfield, this would further substantiate these other features. However, should the results of this research dispute this classification, it may call into question those "agricultural features" identified elsewhere in the United States that have not been individually verified.

Additionally, neither pollen nor phytolith analyses have been widely employed in the southeastern United States. These analytical methods are frequently used elsewhere for such purposes as environmental reconstruction and confirming the presence of agricultural activities. This project will attempt to ascertain if these methods are viable research tools for broad based studies such as this one.

Chapter II. Project Setting

Study Area

Figure 1 illustrates the location of the Ocmulgee National Monument. The two primary sites within the National Monument boundaries are the Macon Plateau site (9BI1) and the Lamar Mounds (9BI2). Lying along the Fall Line, the Macon Plateau area consists of Piedmont uplands, enclosed by the Ocmulgee River and Walnut Creek. The Macon Plateau site is the largest Mississippian mound site in the state of Georgia (Hally and Williams 1994), containing eight platform mounds, including Mound D, the focus of this study (Figure 2). The Macon Plateau site was initially recorded as covering 1,050 by 660 m or approximately 70 hectares. This site has also yielded evidence of Paleoindian through historic Creek period occupations.

The earliest recorded description of the site of Ocmulgee was written in 1739 by a ranger who accompanied General James Oglethorpe along the Chattahoochee (Walker 1994). This report briefly described their party's campsite, which was "...where there are three Mounts raised by the Indians over three of their Great Kings who were killed in the Wars" (Ranger's Report 1916:219). In the Treaty of 1805, the Creek Indians relinquished the majority of their lands east of the Ocmulgee River, but held out a 15 square mile tract within which the Macon Plateau and Lamar mounds are located (Walker 1994), indicating the significance of the sites to the Native Americans. Creek legend states that on the Macon Plateau was located "...the first town or settlement, when they sat down (as they

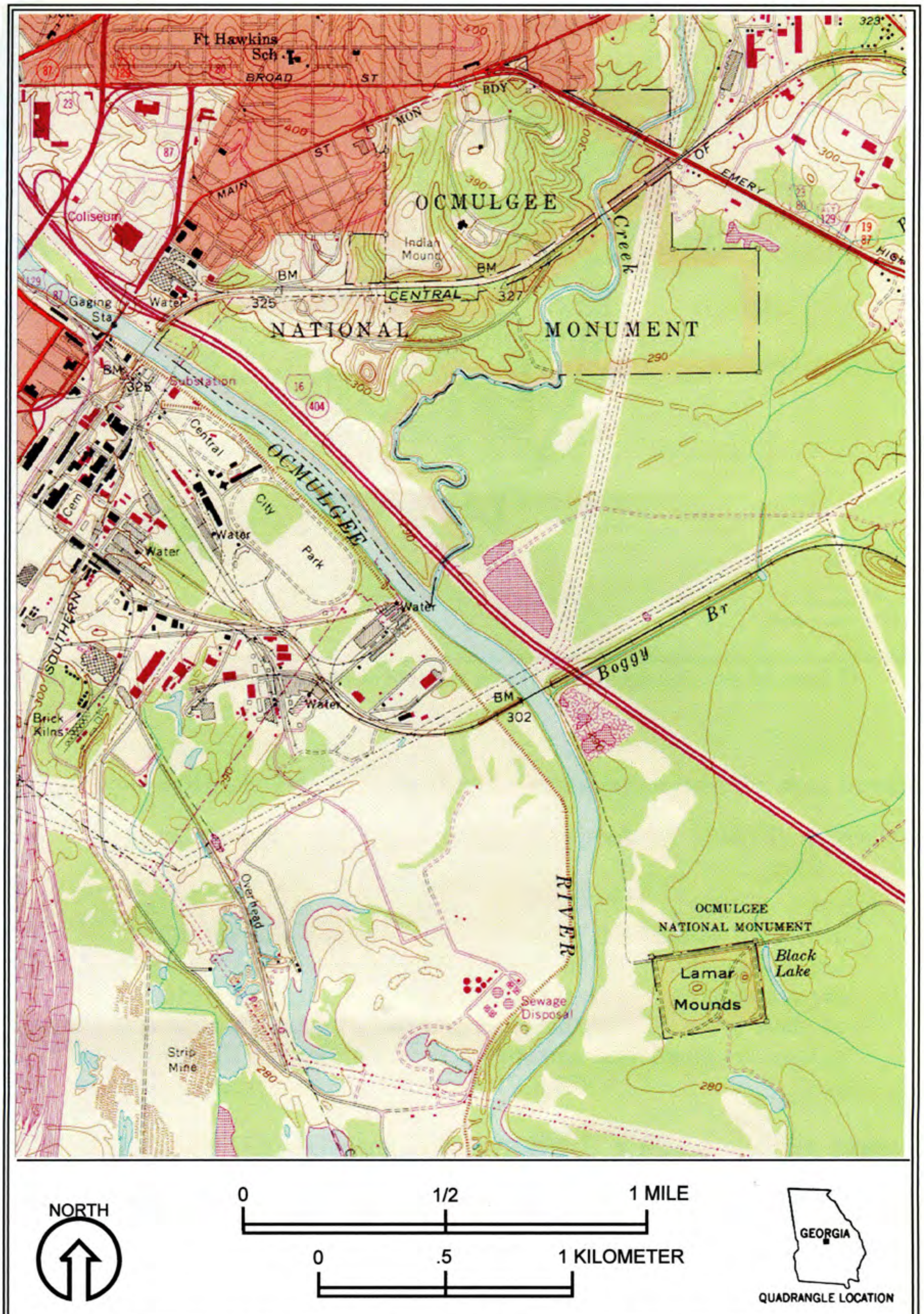


Figure 1. Location of Ocmulgee National Monument (1976 USGS *Macon East, Georgia* 7.5 minute topographic quadrangle).

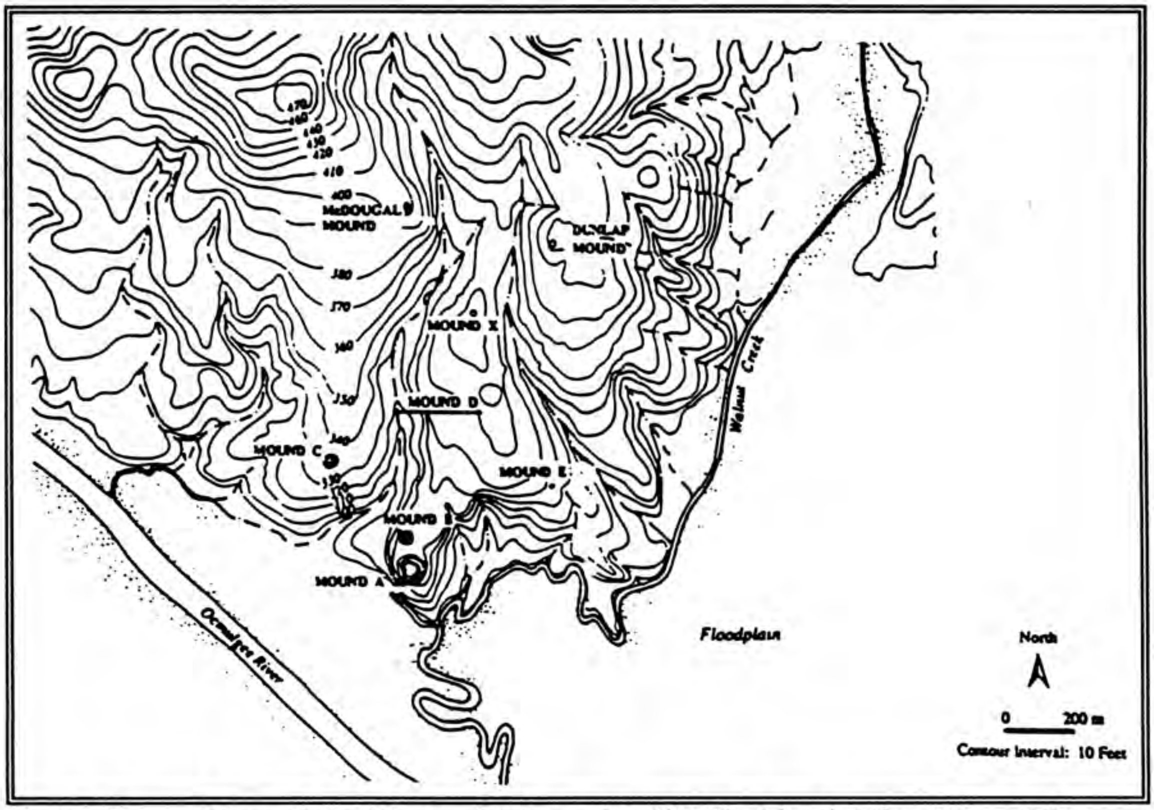


Figure 2. Map of the Macon Plateau site (9BI1), highlighting Mound D (Hally 1994).

termed it) or established themselves, after their emigration from the west, beyond the Mississippi, their original native county" (Van Doren 1928:68). William Bartram described the sites in 1791, stating

> "On the east banks of the Oakmulge, this trading road runs nearly two miles through ancient Indian fields...called the oakmulge fields...On the heights on these low grounds are yet visible monuments, or traces, of an ancient town, such as artificial mounts or terraces, squares and banks, encircling considerable areas..."(Bartram 1928:68)

In the early 1920s, General Walter A. Harris, a Macon attorney, began a campaign to preserve the archaeological sites on the Macon Plateau (Marsh 1985). Harris contacted the Bureau of American Ethnology and the Smithsonian Institution in his search for support for the preservation of these sites (Marsh 1985). Harris, with the support of the Society for Georgia Archaeology, was ultimately successful. Legislative efforts to establish the area as a national monument included house resolutions and presidential proclamations spanning nearly seven years (Southerlin et al. 1995:27). In 1936, the site of Ocmulgee was established as a National Monument by Franklin D. Roosevelt (Hally 1994). The Lamar Mound site was added to the monument in 1941 by Presidential Proclamation No. 2493-55 Stat. 1654 (Southerlin et al. 1995:27).

The national monument was not nominated to the National Register of Historic Places (NRHP) until 1973, when it was nominated by Norman D. Ritchie and Bernard Berg (NRHP Inventory-Nomination Form, on file) as a historic district that included all sites recorded within the monument's boundaries. In 1978, the Ocmulgee National Monument was placed upon the NRHP as a historic district with boundaries encompassing approximately 683 acres. The NRHP nomination form includes descriptions of each of the mounds recorded at the Macon Plateau site. The description of Mound D states:

> "This mound is located 1,800' northeast of the Mound A, near the visitor center, and is associated with the Earthlodge (#8). At the time of the excavations it measured 150' to the side and was 8' high. Extensive excavations through the mound to original ground surface revealed one of the finest preserved pre-historic farm plots yet found in the world. Only minimal backfill was done so the mound does not have its original appearance at this time. This mound is considered a prime archeological site." (Ritchie and Berg 1975, NRHP Nomination Form).

Previous Investigations at the Macon Plateau Site

The Ocmulgee Mississippian mound center did not become the focus of extensive excavations until the Civil Works Administration (CWA) funded the first project in December 1933 (Walker 1994). Excavations continued until the early 1940s at the various mounds within the National Monument boundaries (Walker 1994). These projects were overseen by the National Park Service and were funded by the Civil Works Administration, the Works Progress Administration, the Federal Emergency Relief Administration, and the Civilian Conservation Corps.

Mound D was given its alphabetical designation by C.C. Jones in the early 1870s (Jones 1873). Jones described Mound D as a "rectangular, truncated cone", suggesting that it had retained its flat platform on top at least until that time. A.R. Kelly began excavations at Mound D at the Macon Plateau site (9BI1) in 1933. When excavation of Mound D began, it was oval in shape (the original shape may have been modified by nearly a century of plowing along the mound borders) and measured 67 by 46 m at its base and 2 m in height (Nelson et al. 1974). The mound was oriented north-south and only the southern half was excavated (Nelson et al. 1974). The mound itself was excavated from 1933 through 1935 and was a complex structure with the remains of three structures within the mound fill (Riley 1994).

The field features were recognized early in the excavation and were designated as "Structural Layer 7" (Riley 1994:97). Mound D was dubbed the "cornfield mound" when, during excavation, a burned corncob was recovered from the mound fill (Kelly 1935). After further excavation, an undulating surface was discovered beneath the mound (Figure 3). This feature was described by one of the primary investigators, James Alfred Ford, as "garden beds, cultivation rows, or hills" (Walker 1994:19). Thomas J. Riley states that these ridges and furrows were "sealed" by Mound D (Riley 1994), thus ensuring their preservation. A compilation of the field notes by Nelson, Prokopetz, and Swindell (1974) from Florida State University describes the features of the theoretical agricultural field beneath Mound D:

1. "...regular ridges and furrows aligned in a northwest-southeast direction".
2. The ridges ranged from 30 to 50 cm apart.
3. The ridges were approximately 13 cm high.
4. Paths running perpendicular to the rows were observed.

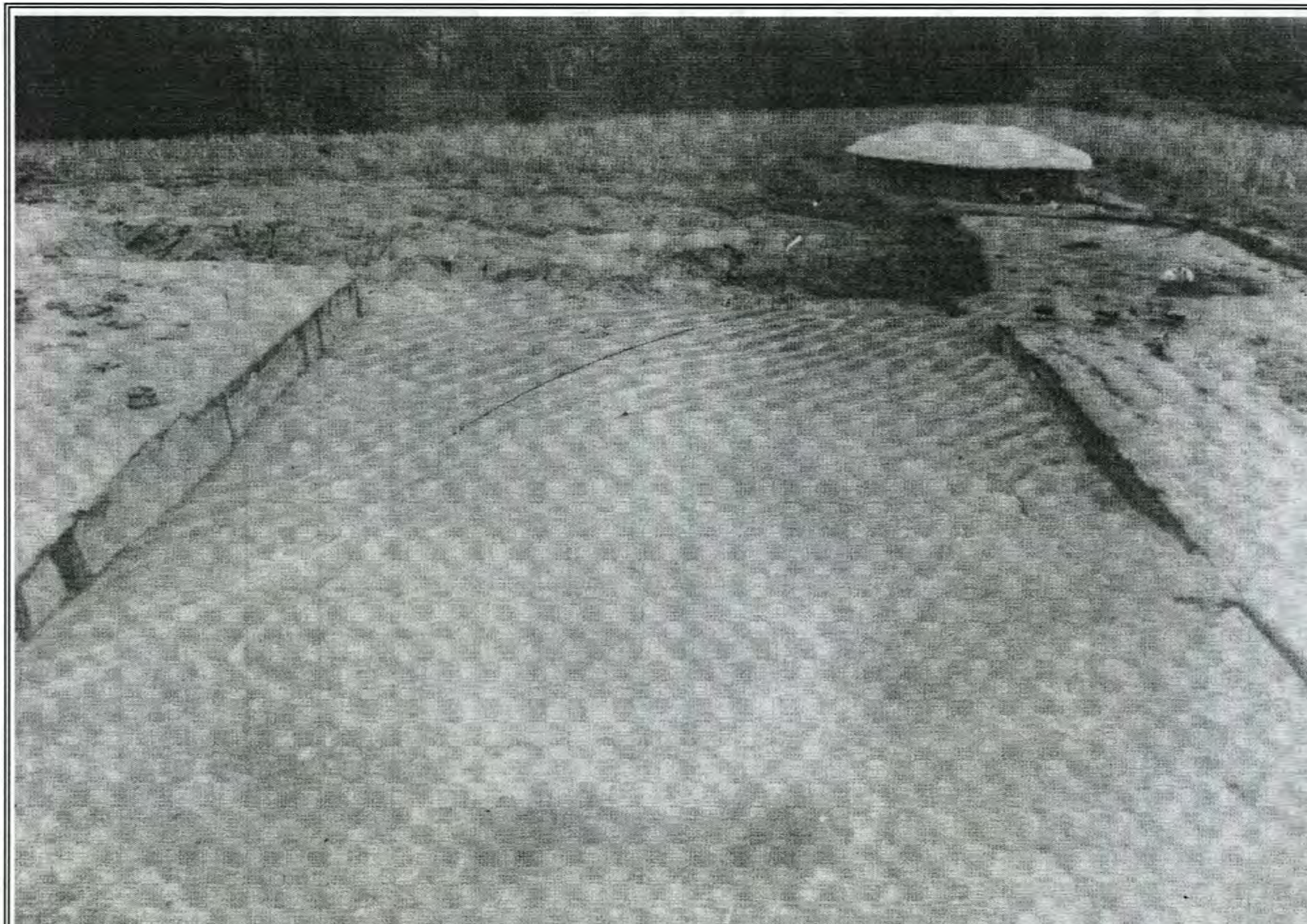


Figure 3. Photograph of the "cornfield" ridges and furrows beneath Mound D, 9BI1 (Photograph courtesy of the National Park Service, Southeast Archaeological Center).

Despite multiple observations of this "cornfield", no research has ever been conducted to either confirm or deny the accuracy of such a label. Thomas J. Riley writes "The questions of whether the feature that constituted Structural Layer 7 at Mound D represented agricultural fields was never satisfactorily addressed in Kelly's work, and other writers, most notably Nelson, Prokopetz, and Swindell (1974), have considered the point moot." (Riley 1994:99).

Cultural Background

Background material on the Mississippian period and sites associated with the Mississippian emergence is relatively plentiful. Large mound sites have been excavated in the southeast since the early nineteenth century, at varying levels of effort and control. This work has resulted in a theory of a Mississippian emergence and diffusion of Mississippian social and material practices throughout the region. In order to place this discussion in its cultural context, a brief cultural history is provided in Table 1.

Table 1. Cultural Chronology For The Eastern United States (adapted from Nassaney 1987:137-138).

TEMPORAL PERIOD	SETTLEMENT DISTRIBUTION	SUBSISTENCE STRATEGY
Paleoindian (10,000-8,000 BC)	Small, seasonal camps	Intensive foraging, focus on large fauna
Archaic (8,000-1,000 BC)	Larger, seasonal camps	Intensive foraging supplemented by horticulture
Woodland (1,000 BC-AD 900)	Small, dispersed villages; possible seasonal agglomeration; focus on floodplain areas	Intensive foraging supplemented by horticulture; beginnings of agriculture
Mississippian (AD 900-1,500)	Large, permanent villages; small dispersed farmsteads	Intensive agriculture, focus on maize; supplemented by wild resources

The earliest evidence of human settlement in the United States dates from the Paleoindian period (ca. 10,000 to 8,000 BC). This period has generally been interpreted as a time when small bands of roaming hunter-gatherers pursued megafauna of the late Pleistocene; in addition, the collection of wild foods was also practiced. The highly mobile social organization of the Paleoindians is inferred from the small dispersed sites of the period.

Following the Paleoindian period is the Archaic period (8000 to 1000 BC). Adaptation during this period was marked by a decreasing emphasis on large game, and an increased focus on seasonally available floral and faunal resources, including acorns and hickory nuts (Griffin 1952). Settlements were comprised of small seasonally stable base camps and smaller extractive loci (O'Steen 1983). There was also an increase in population, and a dramatic increase in the use of local Piedmont quartz as a raw material (Ledbetter et al. 1981). This pattern in raw material use has been correlated with a pattern of "settling in," involving denser locally adapted groups of decreased mobility. The presence of ground stone tools (e.g., manos, metates) suggests that an increased emphasis was placed on plant resources during the Middle Archaic. The latter portion of the Archaic period is characterized by a continuing trend toward localized adaptation and sedentism, and the development of interregional trade. Wauchope (1966) notes evidence for the development of long term habitation sites, possible precursors to the later village sites. Late Archaic sites are relatively common throughout the Southeast.

Following the Archaic period is the Woodland Period (1000 BC to 900 AD). During the early stages of the Woodland Period recognizable cultural additions and changes occurred which appear to have influenced patterns of life in populations of the Southeast. This transition, from Late Archaic to Early Woodland, is marked by a gradual increase in population and sedentism, and by the acquisition of a number of distinctive material and cultural traits. It is during this time period that technological advances in pottery manufacture became widespread, resulting in increased efficiency and productivity in food processing and storage (Dragoo 1975:17; Griffin 1967:180; Stoltman 1978:715). There is a notable absence of agriculture and a heavy dependence on gathered resources such as nuts. Horticultural activities focused on the domestication of different plants, such as chenopodium, sunflower, and amaranth (Garrow 1975). Large villages with permanent structures are common and are normally located in the flood plains of rivers and creeks. The emergence of agriculture; and the development of ceremonialism and a complex inter-regional trade network (Dragoo 1975:18-19; Griffin 1967:183; Stoltman 1978:717) occurred later in the period.

The Mississippian period (AD 900 to 1500) is seen as a time of permanent settlements of increasing size, increased religious and social complexity, and greater dependency on agricultural practices. The most dramatic characteristics of this period are observed in the construction of large fortified villages, and flat-topped earthen mounds utilized in political and religious functions. An elaborate and complex iconography became widespread throughout the Midwest and Southeast during this time (Dragoo 1975:20-21; Griffin 1967:189-190; Smith 1978; Stoltman 1978:727). Mississippian settlements were located primarily along major streams or rivers on large alluvial flood plains. These areas provided easily accessible and fertile soils suitable for agricultural activities, as well as ample access to other subsistence resources. This biotic diversity may have influenced community size and population (Dragoo 1975:20-21), allowing for larger settlements supporting larger numbers of people.

Population increases in the late prehistoric period in the eastern United States (east of the Mississippi River), and the southeast in particular, are well-documented archaeologically (eg. Asch et al. 1979; Buikstra et al. 1986). These population increases coincide with the shift from horticulture to agriculture and an increased dependence on cultigens, particularly maize. The impetus of the increase in both population and the reliance on maize is a source of debate among scholars in a variety of fields.

The controversy regarding the causal relationship between population growth during the time period between AD 500 and AD 1000 and the modification of subsistence strategies resulting in the domination of maize in the prehistoric diet appears to be focused on the sequence of events related to the change in subsistence strategy. There currently exist two very different schools of thought regarding these causal factors and their adaptive validity. The two perspectives addressing this phenomena each describe a different evolutionary chain. Each involves a separate series of human actions with different motivations, and therefore, it is important to examine each point of view in terms of its usefulness for explaining culture history. One school of thought believes that population pressure and the resultant decrease in resource availability led to the forced modification of the subsistence strategy, resulting in increased reliance on maize over other plant foods. The other school maintains that the increased availability of maize, due to changes in agricultural and technological processes, encouraged population increases. If Mound D is found to have been built on a maize field, this may indicate either an over-stressing of the available resources or a population decrease or disaggregation.

Advent of Agriculture in the Southeastern United States

There is no general consensus regarding when eastern cultures first began practicing horticulture. The overall subsistence strategy was based upon the availability of native cultigens such as starchy and oil seeds and nuts, as well as native vertebrate and invertebrate fauna. The encouragement of certain species of native starchy and oily seed plants are well documented, particularly in small household gardens. Maygrass, knotweed, and chenopods are frequently found in ethnobotanical samples and coprolites, as are sunflower, sumpweed, and squash/gourd as early as the Late Archaic period (Hastorf and Johannessen 1994; Scarry 1986). These plants are native to the eastern United States, particularly the southeast, but the modification of their physical make-up was brought about through human interaction with them and their environments.

Maize appears to have been adopted into an existing agricultural system which was composed largely of indigenous cultigens (Hastorf and Johannessen 1994). Following its adoption as a food source, maize remained a minor part of the subsistence strategy for several hundred years. Stable isotopic studies of human bone from various areas in the eastern United States, as well as data based on archaeological and ethnobotanical analysis, note the abrupt increase in the presence of maize beginning at approximately AD 750 (Ambrose 1987; Fritz 1993; Gremillion 1993). Still it was not a significant dietary contributor prior to approximately AD 1000, at which point it entered the "core diet" of the Mississippian communities of the Southeast (Hastorf and Johannessen 1994). Earlier dates for the inclusion of maize into the prehistoric diet have been noted in Alabama (Fearn and Liu 1995) and in south Georgia (Seielstad 1994). The dates determined for *Zea mays* in Alabama are approximately 3500 years before present (BP), but are currently under debate (see Eubanks 1997). Seielstad (1994) identified maize pollen in a peat core from Chatterton Springs in Coffee County, Georgia, that dated to 2000 BP. This date has not been verified by other researchers at present.

The increase in the availability of cultigens is seen by some as a conservative choice made by prehistoric populations who were economically tied to the river valleys but who needed a greater quantity of food than their catchment zone could provide (Adair 1988:115). The decision to increase the availability of cultigens was related to the existing parameters of social organization, division of labor, and technological skills. The increase in the consumption of agricultural foods was not an attempt to change the economic pattern but rather an attempt to retain it (Adair 1988:96). Griffin (1967:189) suggests that "it was the gradual shift to a substantial dependence on agriculture that tied the societies to specific localities, and emphasized territoriality and ownership of land."

Shifts in foodways, including the increased reliance on corn, with the extra labor and scheduling requirements associated with it, has been theorized to have been related directly to the process of "Mississippianization" (Hastorf and Johannessen 1994). These agricultural changes occur in association with subsequent Mississippian developments, including further political, social, and demographic reorganization and the building of mound centers (Johannessen 1993). The occurrence of significant social, political, and ideological shifts that occurred towards the end of the tenth century resulted in the expansion of social boundaries and the establishment of a hierarchical polity (Hastorf and Johannessen 1994). All of these cultural manifestations are discussed in terms of their being a direct result of the intensification of agriculture (see Hastorf and Johannessen 1994; Johannessen 1993).

Changes in settlement patterns, exchange networks, and inter- and intra-community hierarchies are all tied to the modification of subsistence strategies. Therefore, the establishment of domesticated agriculture as the primary subsistence activity and the reasons for this adoption of agriculture are important indicators of the pattern of human behavior. The modification of activities and cultural institutions associated with the practice of agriculture would have effected all levels of society. The demographic consequences of choosing a diet dominated by nutrient-poor maize were significant and irreversible. Population trends were modified by a combination of enhanced fecundity and decreased overall health (see Ambrose 1987; Buikstra et al. 1987; Buikstra and Milner 1991; Bumsted 1984;

Cohen and Armelagos 1984; El Najjar and Robertson 1976; Hutchinson and Larsen 1990; Larsen 1984; Larsen 1987; Larsen 1990; Larsen and Thomas 1982; Lynott et al. 1986; Smith 1992; Watson 1985). These factors cannot be considered as motivational in the choice to modify subsistence strategy as the widespread long term results could not have been foreseen. However, these consequences affected the population structure of the Mississippian society and may have particular relevance for this study.

Ridged Fields

The Ocmulgee Mound D "cornfield" was the first archaeological discovery of subsurface agricultural fields in eastern North America (Riley 1994). Since the discovery of the buried cornfield at Ocmulgee, numerous other such features have been discovered. Features such as the ridged-fields at the Lunsford Pulcher and Texas sites (Fowler 1992), near Cahokia, Illinois, and the ridges and furrows identified at the Valley View and Sand Lake (Gallagher and Sasso 1986) sites in Wisconsin have all been categorized as agricultural features based upon their similarities to the Ocmulgee field (Riley 1994). Figure 4 shows the locations of several reported ridge and furrow and cornhill agricultural fields in the eastern United States. A similar field pattern has been observed at the Ceren site in Central America (Sheets 1992). Palynology has only recently been used to confirm the agricultural nature of one of these features (Gallagher et al. 1985). Aerial (photography has resulted in vague indicators of ground patterns but currently these indicators have not been widely verified (Riley 1994).

The morphology of these ridged field features are remarkably similar despite their geographical setting. At the Sand Lake site in Wisconsin, the furrows ran parallel to each other and had small mounds formed every 75 cm (30 in)(Gallagher and Arzigian 1994). Avebury 1869) describes Native American agricultural fields

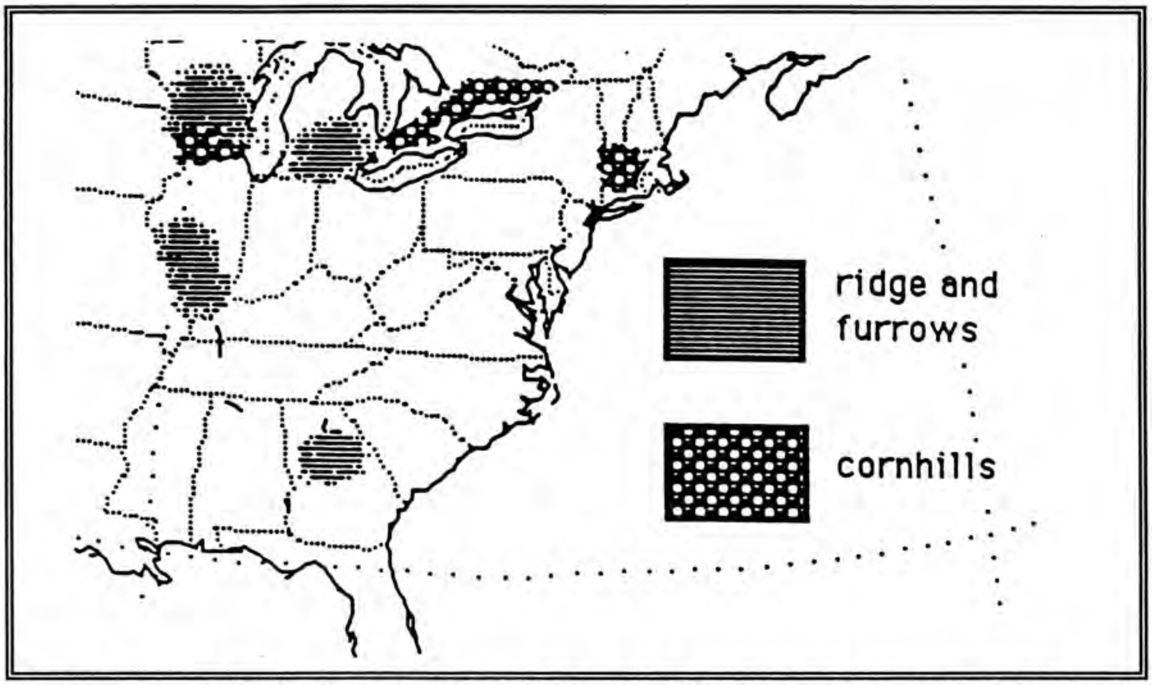


Figure 4. Distribution of reported ridge and furrow and cornhill agricultural fields in eastern North America (Riley 1994:Figure 9.4).

in the northeastern United States as being comprised of low parallel ridges averaging 15 cm (6 in) apart. The Ceren site fields are comprised of parallel furrows approximately 1 m (3 ft) apart with plants every 75 cm (30 in). The Ceren field also had perpendicular ridges intersecting the furrows. Sheets (1994) speculates that these ridges may have designed to limit erosion and increase water absorption.

Gallagher and Sasso (1986), excavators of the Sand Lake site, have speculated on an agronomic system of land preparation based on their identification of ridge and furrow features. They theorize that burning preceded the construction of ridges, which occurred both before and during planting (Gallagher and Sasso 1986). Riley believes that the construction of ridges fulfilled several goals, including "aeration, manipulation of ground temperature and fertilization through the addition of ash and midden on the fields" (Riley 1994:101). Riley goes on to say that the fields of Wisconsin and Ocmulgee are "significant as signs of what has to be a complex of agricultural techniques shared by Mississippian societies separated from one another in space by as much as 1500 km and in time by as much as 500 years" (Riley 1994:101).

Chapter III. Project Framework and Initial Procedures

This project was conducted in a multi-stage approach. The first step was to map the remaining portion of Mound D in an attempt to ascertain which portions might be the result of the original construction rather than of restoration following the 1930s excavations. The next step was to obtain the soil samples from beneath remnants of the mound itself as well as from modern cornfields. Once soil samples were obtained, a particle size analysis was conducted. Evaluation of the soil particle size composition served to distinguish between possible construction events and indicated the degree of spatial integrity that could be expected for any pollen and/or phytoliths identified. In addition to particle size analysis, charcoal collected from two distinct strata within the mound fill were submitted for radiocarbon dating, in an attempt to distinguish between various Mound construction sequences and the potential contamination of the soil as a result. The samples were then tested for sediment chemistry. This analysis provided insight into the degree of sediment modification due to human activity and potential for pollen and phytolith preservation. With these steps having provided a set of expectations, the sediments were then processed for both pollen and phytoliths.

Mapping of Mound D

Mound D, prior to the excavations carried out in the early 1930s (Kelly 1935), was oval in shape and measured 67 by 42 m with a height of 2 m. Since those early excavations, no further investigation of the mound has taken place nor has its current spatial dimensions been recorded in detail. In order to accurately identify the intact areas of the mound and pinpoint the exact locations from which the soil cores would be extracted, a detailed transit map was compiled. A datum was established on top of the mound, at its southeastern corner. Transit readings were taken at judgementally determined intervals from both interior and exterior points around the mound.

The transit map of Mound D is presented in Figure 5. This map clearly depicts Mound D, as it stands today, while illustrating the trench adjacent to the northeast edge of the mound and the nearby Council House. The locations of the two soil cores removed are also delineated. The mound itself has an average height of 1 m (300 cm) above the present ground surface (cmbs). This transit map of Mound D will remain on file with the National Park Service.

As reflected in Figure 5, Mound D is currently comprised of two half-moon shaped berms, with the interior appearing as if it has been removed. Kelly's field notes state that the entire southern half of the mound was removed during excavations (Kelly 1935). Kelly's field notes also state that the mound fill was used to reconstruct the mound's original form following the completion of excavations (Kelly 1935, 1938). Based on the hollow center, apparently not all of the mound fill was returned to its place of origin.

Obtaining Soil Samples

Mound D. Two soil cores were removed from the Mound D fill. The soil cores were obtained using a hand auger with a 2 inch diameter bucket. Core #1 was recovered in the northern portion of the mound; Core #2 was collected from the southern end of the mound (see Figure 5). The integrity of the soil stratigraphy was maintained as the soil was removed. Soil removed from each core was wrapped

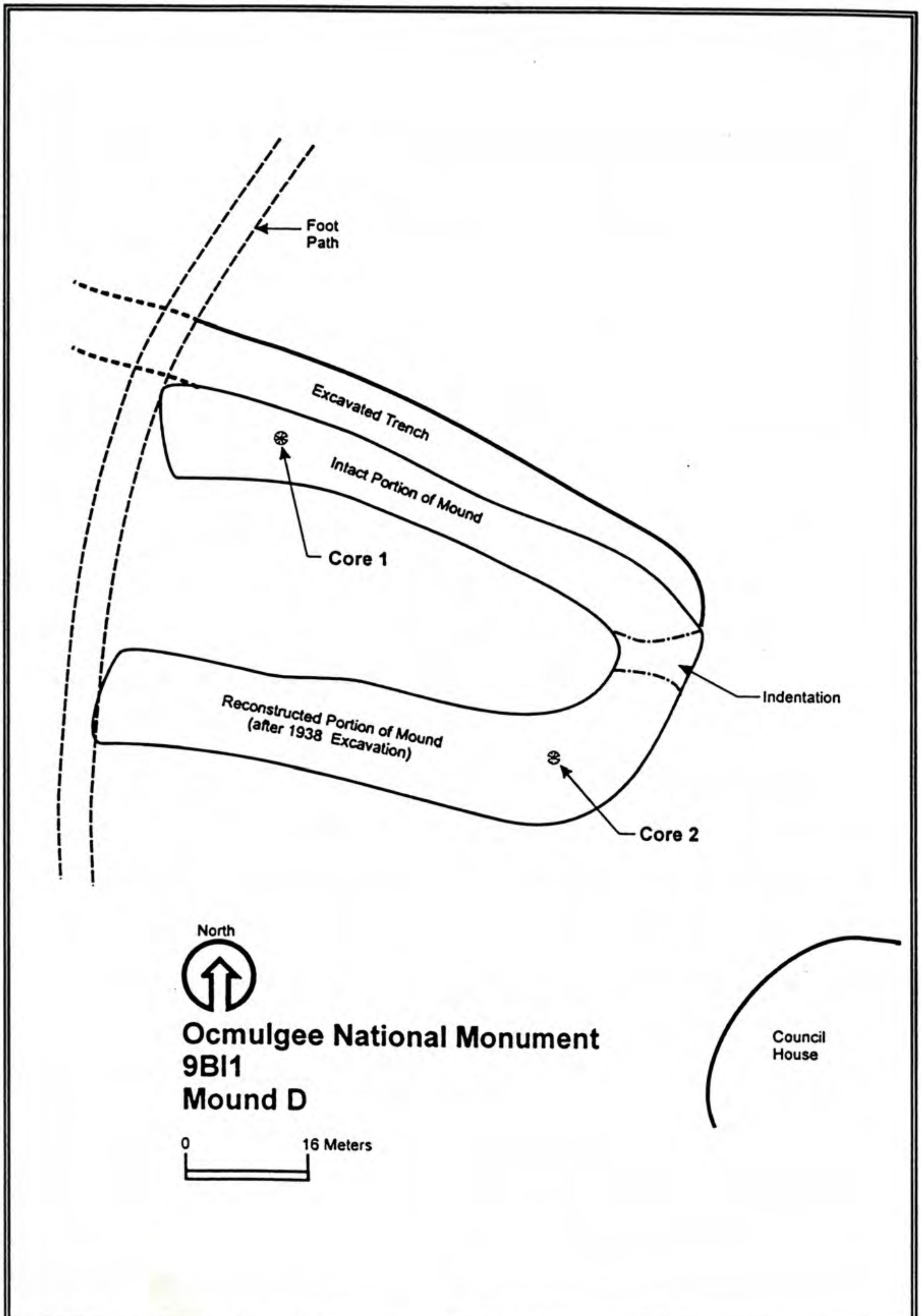


Figure 5. Transit map of Mound D, 9BI1 (plan view).

in heavy duty foil and stored in cardboard molds. Each sample was labeled with its core number, depth range, uppermost end, and the date of its removal. White sterile sand was used to completely backfill both cores, thus delineating them as core holes and mitigating potential dangers to people or animals. Prior to backfilling, a piece of pink flagging tape listing the core number, the date of its removal and the author's name was placed into the core hole. These precautions will clearly inform future researchers of the impact to the mound and from whom the results might be obtained should it be necessary or desirable. All soil not processed for this project will be submitted to the National Park Service for storage. A detailed description of each of these cores follows.

Core #1. Core #1 was recovered from the northern end of Mound D (see Figure 5), approximately 30 cm from the exterior edge of the mound. This core was excavated to a depth of 178 cm below ground surface (cmbs) and was terminated after several auger buckets yielded red clay, which was considered to be subsoil beneath the mound itself.

Core #2. Core #2 was recovered from the southern portion of Mound D. This core was placed so that a determination of the degree of fill disturbance could be made. As with Core #1, this core was terminated when two buckets of red clay were obtained, at a depth of 278 cm.

Modern Field. An additional soil core was collected from a modern corn field. This core was intended to serve as a control sample for which pollen levels present in reported maize fields could be determined. This core was collected from a field in which both corn and sorghum are cultivated in rotation. Located in Oconee County, in an upland setting, the soils in this modern field were very similar in acidity to those found within the Ocmulgee National Monument boundaries. The modern field core was excavated using the same methods as those used at

Mound D to ensure that the samples would be comparable. A 2 inch diameter bucket auger was utilized to excavate a core 40 cm in depth.

Following the field collection of the soil samples, each core was taken to the Paleoecology Laboratory in the Department of Geography at the University of Georgia, Athens, where the soil was allowed to air dry. The first step taken for this soil analysis was to determine the Munsell color for each sample. The visual variations between soil colors are generally slight and a Munsell classification can often be helpful in delineating soil differences. Based on the Munsell classifications, the cores were separated based on stratigraphic divisions. A 100 gram sample of each discernible soil stratum was then separated from the core material.

Soil Description

Core #1. Several distinct soil changes can be noted in the Core #1 profile (Figure 6). These soil changes may reflect construction sequences as they correspond with Kelly's (1935) estimate of three separate construction events for Mound D (Figure 7).

The base of the mound appears to lie between depths of 145 and 164 cmbs. At 145 cmbs, the soil reflects a dramatic distinction between the mound fill and the original surface soil. The 145-165 cmbs soil stratum is comprised of light brown sand with moderate mica content. At 165 cmbs, the soil undergoes another dramatic change from brown sand to red clay subsoil. The light brown micaceous soil directly overlaying the red clay subsoil is the stratum suspected of having been the cornfield and on which the bulk of the analyses will be focused.

Several of these soil strata contain charcoal. Samples of charcoal were collected from two strata: 80-120 cmbs and 145-165 cmbs. A radiocarbon date of

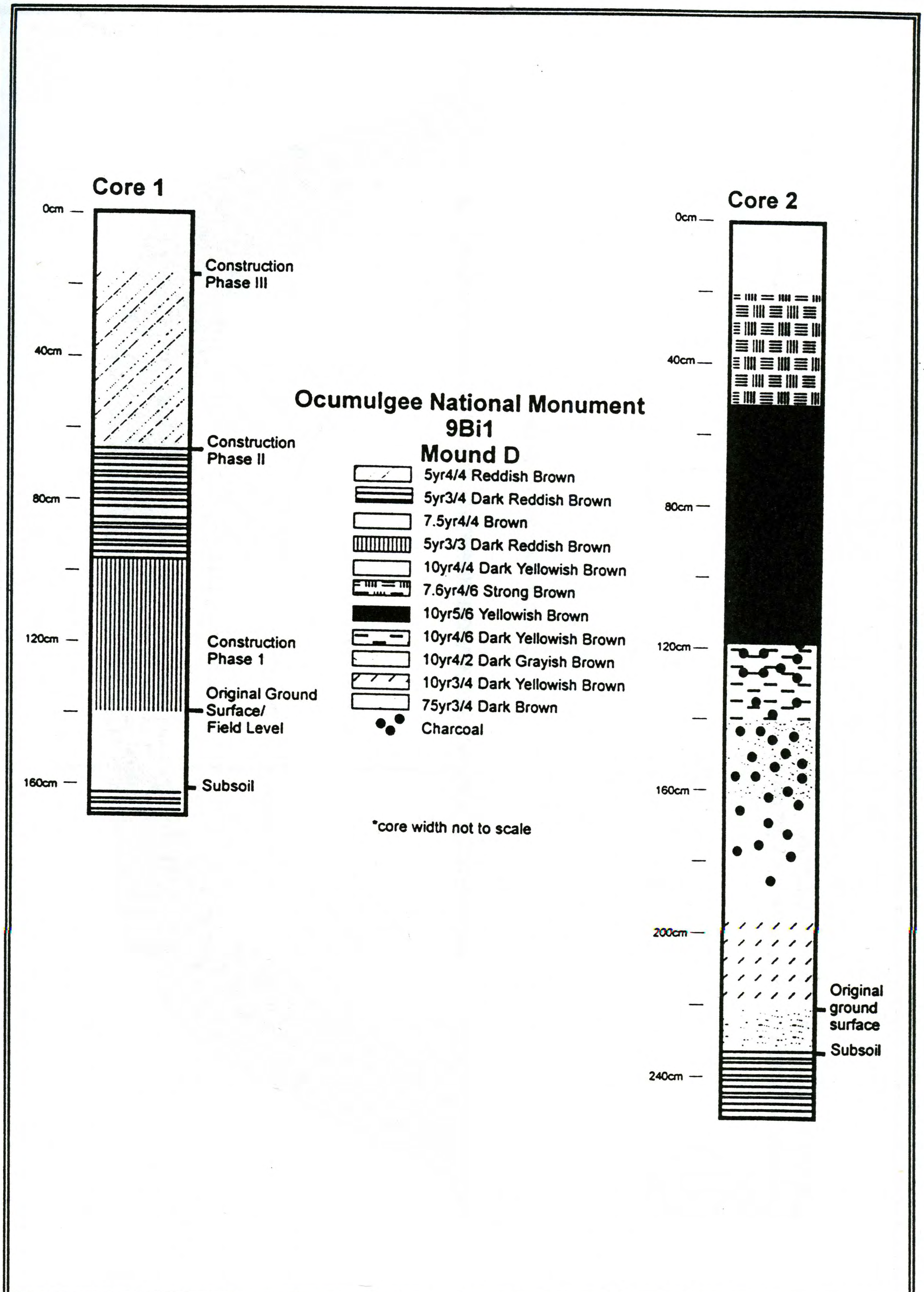


Figure 6. Core profiles from Core #1 and Core #2, Ocmulgee National Monument, 9Bi1, Mound D.

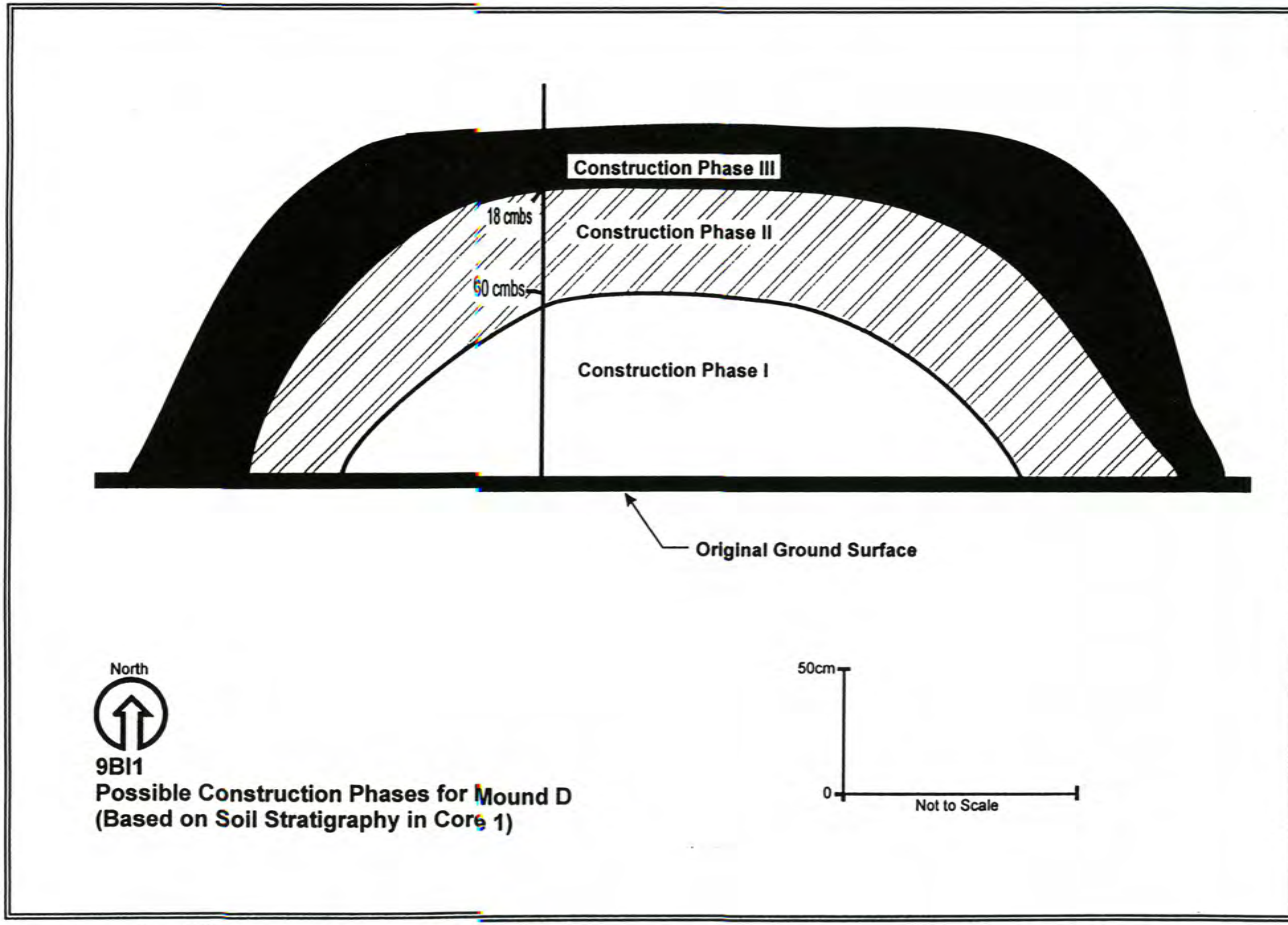


Figure7. Possible construction sequences for Mound D, based on Core #1 soil stratigraphy.

AD 1015 was obtained from the adjacent Council House (Wilson 1964), dates fromthe Mound D strata could have determined if the two structures were contemporaneous, as well as clarifying different construction sequences for the mound itself. Unfortunately, after the samples had been cleaned to isolate the charred material, insufficient amounts remained for traditional radiocarbon dating. These samples would be adequate for accelerator mass spectrometer (AMS) dating but funds were not available for this process.

Core #2. As in Core #1, a distinctive delineation can be observed between the mound fill and the original ground surface (see Figure 7). In Core #2, this break appears between 225 and 235 cmbs. Interestingly, the soils between 145 and 165 cmbs in Core #2 exhibit a soil change that may be similar to the soils at that same depth from Core #1. In Core #2, this soil change is expressed in a dark grayish brown lens measuring approximately 20 cm in depth. This lens divides approximately 100 cm of dark yellowish brown soil.

Soils in Core #2 were significantly less compact than those in Core #1, and exhibited a low degree of stratigraphic integrity. As stated above, Core #2 was removed from the portion of the mound excavated by Kelly in 1938. Upon the completion of the excavation, this section of Mound D was reconstructed (Kelly 1938). The core #2 sediments reflect a severe degree of disturbance probably due to this reconstruction. Unfortunately, the extent of the impact on the possible field level from the excavation and reconstruction could not be ascertained. Due to the high probability of contamination, only selected analyses were conducted on the sediments from Core #2.

Chapter IV. Sediment Particle Analysis

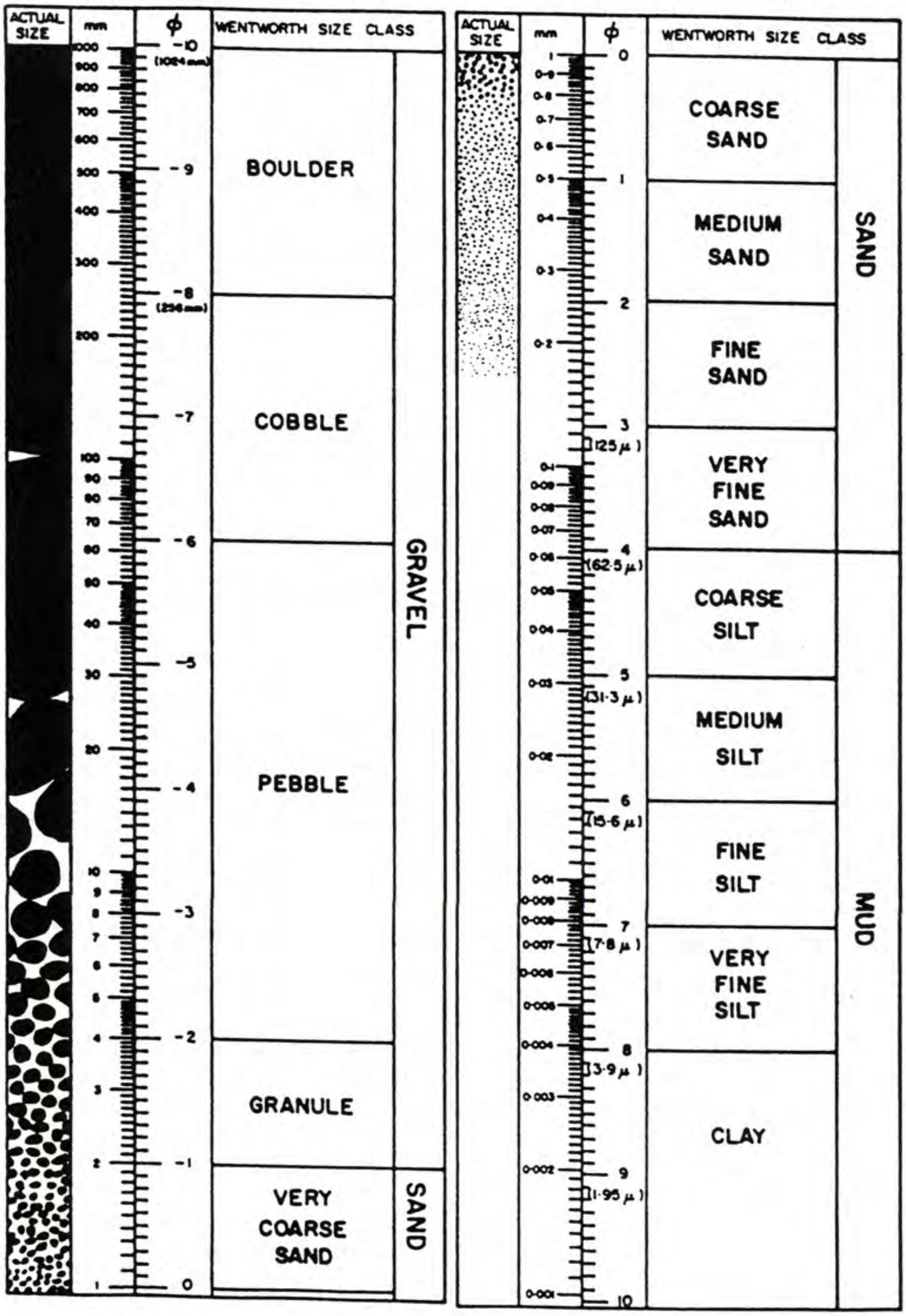
Overview

When undertaking particle size analysis, sediment, in its aggregated form, is dispersed into individual particles using a variety of methods. Chemical means were utilized in this study, but mechanical and ultrasonic techniques can also be used. Particle-size analysis measures the size distribution of individual particles comprising a sediment sample. These particles are divided into three major categories based on size: sand, silt, and clay. Table 3 presents the range of particle sizes assigned to each sediment category. Based upon the percentages of each particle size category within a sample, a number of sediment properties can be determined. Of particular interest to this project, is the degree of water retention or permeability of the sediments. These properties will directly affect the downward migration of both pollen and phytoliths.

Grain size depends on several factors, including the source rock, the weathering processes, and selective sorting during transportation (Lewis and McConchie 1994). Grain size and its degree of sorting can reflect the degree of downward percolation possible in sediments. For example, larger grains allow for a maximum of space to exist between grains, thus enabling leaching to occur unimpeded. In order to estimate microfossil spatial integrity, the grain size distribution was ascertained and combined with documented occurrences of pollen percolation, for which Dimbleby calculates 10 cm for every 300 years of burial (Dimbleby 1985).

Table 2. Particle Sizes by Sediment Category (Lewis and McConchie 1994).

The Udden-Wentworth grade scale for grain sizes, with σ/mm conversion chart



Laboratory Methodology

Soils from the Mound D cores were sifted in order to remove all macro-organic material. All visible plant fragments were removed and discarded. All sediment clods in excess of 2 phi in size were dispersed with a mortar and pestle.

Processing of the sediment samples for particle size analysis was conducted using procedures developed by Gee and Bauder (1986). For each core, a 5 ml sample was removed from each soil stratum. A solution of 10% hydrochloric acid (HCl) was introduced to each sample. If carbonates are present in sediments, the HCl will cause a fizzing to occur as the carbonates are burned off. No such reaction was observed for any of the samples from the cores removed from Mound D, indicating that treatment to remove carbonates from the samples was not necessary.

The samples were then treated for the removal of organic material. Organics are oxidized by the introduction of concentrated hydrogen peroxide (H_2O_2). As with the procedure for the removal of carbonates, an effervescence will occur as the organic material is oxidized. Organic material reduced by the H_2O_2 was determined by weighing the sample both prior to the introduction of the solution and after the sample was oven dried following processing. The amount of organic material removed ranged from 0.241 to 0.061 g. As would be expected, organic material was more abundant in the upper level samples, although there were variations from one level to another.

Following the removal of all extraneous material, the remaining sediments were oven-dried and weighed. Sodium hexametaphosphate solution was added to each sample and the samples were agitated for a period of 12 to 15 hours. Following agitation, additional distilled water was added to each sample to bring the volume up to 250 ml and they were allowed to settle.

Once settling of the samples had begun, subsamples were removed by pipette at a depth of 5 mm at appropriate intervals (Indorante et al. 1990). These subsamples represented silt and clay particles. One subsample was taken after a settling time of approximately 3 minutes in order to collect all material finer than 20 microns. A second subsample was taken after the samples had settled for approximately 4 hours in order to collect material finer than 2 microns. Each subsample was then oven dried and weighed.

The remaining sample was washed to remove all but the sand particles which were also oven dried. The sand was then agitated through sieves at full phi intervals. The material collected at each phi interval was weighed and recorded.

All data were recorded in a spreadsheet program. Calculations were made of particle size percentages as well as sample mean, skewness, and kurtosis. Statisics were calculated using the moments method.

Results

The resultant percentages of sand, silt, and clay and phi interval weights are summarized in Tables 4 and 5. Phi level weights represent coarse sand (0.0 phi), medium sand (1.0 phi), fine sand (2.0 phi), very fine sand (3.0 phi), coarse silt (4.0 phi), and medium to fine silt (>4.5 phi). Appendix C presents a full account of the sediment particle size analysis results.

The percentage of clay in the Core #1 sediments varies, although as would be expected, the stratum designated as subsoil (165-175 cm) has the highest percentage of clay (n=22.71%). The upper strata (0-18 cm and 18-41 cm) in Core #1 have the highest percentages of silt with 11.90% and 8.44%, respectively, and the lowest percentages of sand (n=72.79%, 72.22%, and 74.51%, respectively). In comparison to the upper levels, the percentage of sand increases notably in the

Table 3. Particle Size Percentages For Mound D Core Samples (9BI1).

Core #1		**Sample Weight (g)**	**% Sand**	**% Silt**	**% Clay**
Construction Phase III	0 - 18 cm	24.550	74.95	11.9	13.15
	18 - 41 cm	24.893	75.88	8.44	15.68
Construction Phase II	41 - 65 cm	25.390	75.74	8.11	16.15
	65 - 80 cm	25.185	74.93	8.01	17.06
	80 - 102 cm	25.182	74.18	7.84	17.98
	102 - 130 cm	25.145	75.4	7.64	16.96
Construction Phase I	130 - 145 cm	25.078	77.8	6.45	15.75
"Field Level"	145 - 165 cm	25.202	80.23	4.44	15.33
subsoil	165 - 170 cm	25.424	68.71	8.58	22.71
Core #2					
	0 - 10 cm	25.141	78.4	7.81	13.79
	10 - 20 cm	25.229	81.61	10.66	7.73
	20 - 50 cm	25.369	75.79	10.67	7.73
	50 - 90 cm	25.062	71.5	15.39	13.11
	90 - 120 cm	25.107	82.41	8.45	9.14
	120 - 143 cm	25.245	82.91	9.51	7.58
	143 - 165 cm	25.129	70.99	9.03	19.89
	165 - 200 cm	24.659	72.35	18.55	9.1
Original ground surface	200 - 225 cm	25.066	81.7	9.43	8.87
	225 - 235 cm	25.243	80.74	9.55	9.71
	235 - 255 cm	24.969	74.73	10.04	15.23

Table 4. Phi Interval Weights For Mound D Core Samples (9BI1).

Sample	Phi Interval 0.0	1.0	2.0	3.0	4.0	>4.0 (fines)
Core #1						
0 - 18 cm	0.00	2.50	9.04	4.90	1.54	0.42
18 - 41 cm	0.79	2.69	8.57	5.17	1.34	0.33
41 - 65 cm	0.96	2.82	8.33	5.27	1.47	0.38
65 - 80 cm	0.62	2.81	8.21	5.24	1.50	0.49
80 - 102 cm	0.56	2.99	8.65	4.93	1.25	0.30
102 - 130 cm	0.52	2.81	8.34	5.60	1.32	0.37
130 - 145 cm	0.55	3.22	9.13	5.06	1.25	0.30
145 - 165 cm	0.00	1.97	8.58	6.16	2.86	0.65
165 - 170 cm	0.36	2.65	8.32	4.54	1.28	0.32
Core #2						
0 - 10 cm	0.85	3.74	9.22	4.58	1.16	0.16
10 - 20 cm	5.01	2.93	9.53	5.81	1.42	0.39
20 - 50 cm	0.08	2.46	8.82	5.95	1.59	0.36
50 - 90 cm	0.43	2.13	7.00	5.10	2.39	0.87
90 - 120 cm	0.71	2.54	9.64	6.02	1.45	0.33
120 - 143 cm	0.00	2.05	11.06	6.20	1.29	0.29
143 - 165 cm	0.05	1.80	11.25	6.14	1.38	0.31
165 - 200 cm	0.80	2.91	8.20	4.49	1.18	0.26
200 - 225 cm	0.43	2.79	10.24	5.52	1.18	0.32
225 - 235 cm	0.00	1.92	11.13	5.76	1.29	0.28
235 - 255 cm	0.33	2.70	9.19	5.00	1.14	0.30

stratum directly above the field level (130-145 cm; 77.80% sand), reaching amaximum in the field level (145-165 cm; 80.2% sand), and dropping dramatically in the subsoil level (165-170 cm; 68.71% sand). The graph in Figure 8 illustrates the particle size profile for Core #1. As shown in Table 4 and Figure 8, the percentage of sand increases until it peaks in the field level (145-165 cm), which has the highest percentage of sand size particles (n=80.23%).

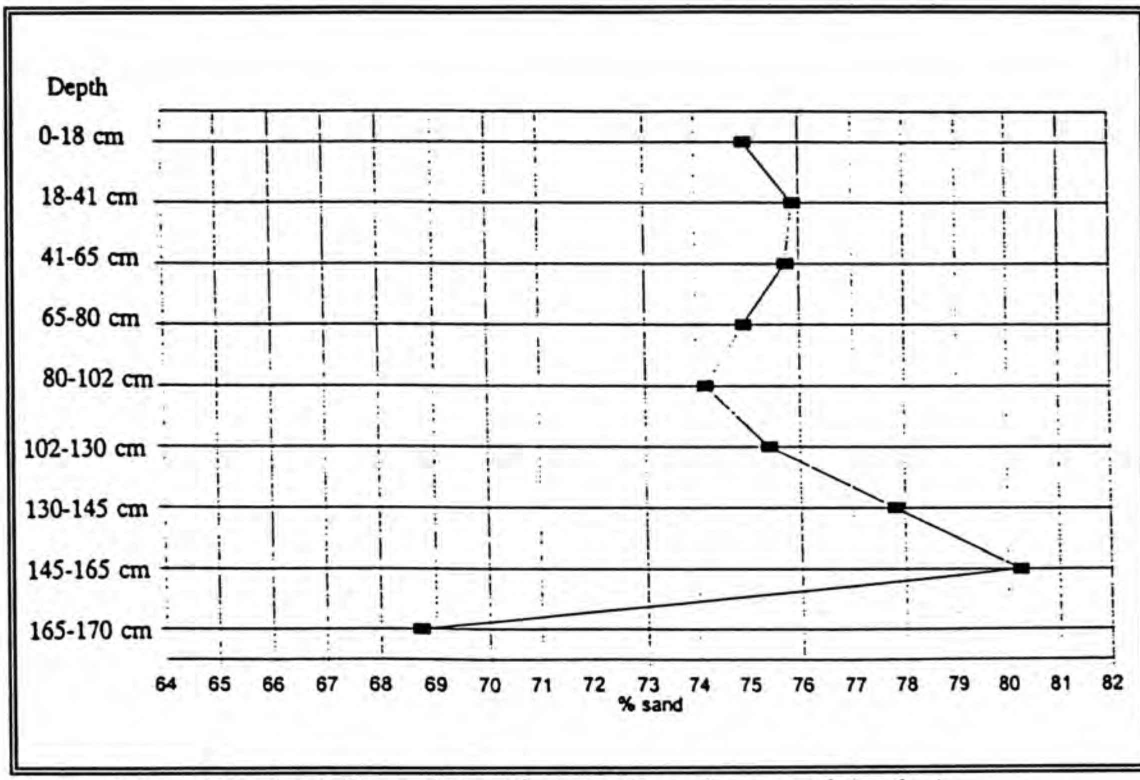


Figure 8. Graph of Core #1 sediments (based on particle size).

In the Core #2 sediments, percentages of sand, silt, and clay are extremely variable. These results are not surprising given the disturbed nature of the soil. However, as with the Core #1 sediments, the stratum designated as subsoil (235-255 cm) exhibits the highest percentage of clay (n=15.23%).

Three samples were processed from the modern field soils. These samples were taken from 0-25 cmbs, 25-30 cmbs, and below 30 cmbs (subsoil). Table 5 presents the particle size analysis results for the modern field soils.

Table 5. Particle Size Analysis Results For The Modern Field Soils.

Sample Depth	% Sand	% Silt	% Clay
0-25 cmbs	62.42	17.05	20.53
25-30 cmbs	74.72	11.31	13.97
>30 cmbs	50.05	13.07	36.88

Particle size distributions for the modern field soils are variable. In the sample from the 0-25 cmbs level, 0.0 and 1.0 phi size particles dominate. The 25-30 cmbs soils contain higher percentages of 1.0 and 2.0 phi size particles. The subsoil level (>30 cmbs) grades down gradually from 0.0 phi size particles to 4.0 phi.

Interpretations

The results of the sediment particle size analysis on the Mound D soils indicate several distinctive characteristics of the possible field level. In the Core #1 sample the percentage of sand in the 145-165 cm is the highest while the percentage of silt is the lowest. The sand particles are dominated by those classified as fine and very fine (3.0 phi-6.16%; 4.0 phi-2.86%), while the percentage of coarse sand particles is low (1.97%). While not conclusive, these value suggest that the original ground surface beneath Mound D was comprised of primarily eolian sands. Conversely, the mound fill contains higher percentages of coarse sand, indicating that perhaps the source of the fill was influenced by fluvial processes (such as soils from a floodplain).

The sediment particle sizes also indicate that, while pollen could have migrated downward into the field level, it is unlikely that it would have been able to flow freely from the upper levels of the mound due to the high percentage of silt and clay. The central levels (with their high percentage of silt) would have blocked the downward migration of microfossils the size of *Zea mays* pollen with their high percentage of silt. Based on these factors, it can be inferred that the soil stratum at the base of the mound is relatively free of extraneous material from the mound fill and will contain a satisfactory degree of spatial integrity for any microfossils identified.

The Core #2 sediments exhibit severe disturbance but do not reflect the reverse stratigraphy that might be expected in the simple backfilling of an excavation. As details on the reconstruction of the excavated portion of Mound D are sparse, the source of the fill material cannot be ascertained. The Core #2 sample resembles the Core #1 sample only in the high percentage of sand in the original ground surface level (200-225 cm; 81.70% sand); although the percentages of silt and clay in this level vary significantly from the Core #1 sediments.

The modern field soil samples contain significantly larger percentages of clay in the uppermost and subsoil levels than the soils from Mound D. The 25-30 cm level from the modern field contains the highest percentage of sand (74.72%) and a clay content comparable to the possible field level (145-165 cmbs) beneath Mound D. The particle size in the modern field soils falls primarily into the medium and coarse sand categories (1.0 and 2.0 phi). The percentage of clay in the modern field soils and the relatively large particle size may be significant factors in the downward migration and subsequent preservation of botanical microfossils.

Chapter V. Soil Chemistry

Twenty 100 ml soil samples from the Mound D cores (one from each stratum) were submitted to Chemex Labs in Sparks, Nevada. These samples were subjected to an ICP-AES Multi-Element Analysis (referred to as Triple Acid Total Digestion). Each sample was exposed to a mixture of hydrofluoric, perchloricn and nitric acids which dissolve all but the major oxides and base metals. This analysis provides the total parts per million (ppm) and content percentage of a number of elements present in the soil sample.

Overview

Kemp et al. (1976) have divided the elements commonly found in soils into five categories. These categories are:

1. *Major elements*: this group constitutes the main elements found in most soils and includes Si, Al, K, Na, and Mg.

2. *Carbonate elements*: this category constitutes the second most important group of elements found in soils, making up approximately 15% of the sediment. Elements in this group include Ca, M, and CO_3-C.

3. *Nutrient elements*: the nutrient elements constitute approximately 10% of soils. The elements are the organics and include C, N, and P.

4. *Mobile elements*: this class of elements react with changes in soil conditions (such as rates of oxidation-reduction) and contribute approximately 5% of the total elemental make-up of a soil. Elements in this grouping include Mn, Fe, and S.

5. *Trace elements*: this group of elements includes Hg, Cd, Pb, An, Cu, Cr, Ni, Ag, V, and others and contribute approximately 0.1% of the sediment. This group represents the heavy and toxic metals and usually reflects the influence of pollution and other soil disturbances.

This chemical analysis measures the majority of the elements categorized by Kemp et al. (1976). These elements can reflect human activity, such as agriculture, as well as indicating the soil's potential for microfossil preservation.

Of primary importance for this study is the total amount of phosphorous present, which can be used to calculate the level of phosphates in the soil. High levels of phosphorus, a nutrient element, are assumed to represent either domestic waste or human and animal excrement that was deposited in the past (Walker 1992). The main phosphates will accumulate in areas of human habitation as phosphorous is not only a major component of the human diet, but is also produced by the digestive tract to aid in digestion (Waggaman 1969). As a consequence, human occupation of a site will result in elevated soil phosphate levels, the intensity of which can reflect the intensity or duration of the occupation of a site (Woods 1975). While phosphate deposited on the ground surface, such as in the case of modern agricultural activities, is converted to iron, aluminum, and calcium, phosphates in the subsurface soils are highly insoluble (Wild 1950). Once in the subsurface, phosphates bond to soil particles and in this form the accumulated phosphate remains stable through time.

Phosphate levels cannot be estimated based on soil texture or color or on the amount of charcoal present, they must be determined through chemical analysis. The use of chemical analysis to determine the degree of phosphates in soil has been used by scientists in Europe since the early part of the century. A Swedish soil scientist, O. Arrhenius, was the first to note that the soils of abandoned village sites were highly enriched in phosphates (Arrhenius 1929, 1931). He went on to use phosphate analysis to locate Stone Age and Viking settlements. Soil phosphate analysis was not utilized in the United States until the 1950s, when Solecki (1950) used the technique to identify burial features at an Adena mound in West Virginia. The use of phosphate analysis is particularly useful for delineating areas associated with bone, such as burials. Swartz (1967) has discovered that modifications to the landscape, such as the construction of agricultural terraces, lowers the phosphate content of the soil. Studies at tell sites in Greece resulted in similar results with phosphate levels being higher in the upper levels of the tell (Cook and Heizer 1965). Their interpretation of the variation in phosphate values is that with the higher levels was an increase in either occupation density or in the number of livestock kept (Cook and Heizer 1965). The determination of phosphate levels is now a commonly used tool in archaeology.

As high levels of phosphates can indicate human habitation, significantly low levels of phosphorus are often encountered in cultivated A horizons (Sandor 1992). Phosphorous fractionation studies have shown that the degree of phosphorous directly available to plants is lost in cultivated fields, particularly fields that are not fertilized (Sandor et al. 1986). As there is no direct evidence that the Ocmulgee fields were fertilized by any means other than run-off and plant decay, it would be expected that the phosphorous levels in the possible field level beneath Mound D would be significantly lower than in the mound fill.

In addition to phosphorous, other elements can indicate human activity. Concentrations of chromium and nickel, which belong to the trace element group, are indications of point-source anthropogenic pollution; however these minerals are also naturally derived from fuchsite mica (Lewis and McConchie 1994), which is present in copious quantities in the soil beneath the Mound D fill. Nitrogen is a structural component in all organisms and is bound in organic matter. As such, high levels of nitrogen also reflect high levels of organic material in the soil and can be indicative of anthropogenic activity.

Results of the Soil Chemistry Analysis

A summary of the elemental measurements relevant to this discussion are presented in Table 6. A complete listing of the Mound D soil constituents is presented in Appendix B. The soil stratum from Core #1 deemed to be the potential agricultural level (145-165 cmbs) yielded the highest levels of a number of elements, including Ba, Ca, Fe, and K (Figure 8). This soil layer also yielded the lowest amount of phosphorous. The Core #2 sediments reflect an extreme degree of elemental diversity as would be expected in sediments lacking stratigraphic integrity (Figure 9).

The chemical analysis results from the sediments taken from Core #2, from the southern end of Mound D, exhibits the variation expected in extremely disturbed contexts. These results help to clarify the extent of the 1930s excavations and partial reconstruction of the mound itself. These chemistry results also suggest that the Core #2 sediments do not meet the standards necessary for an accurate microbotanical profile.

The Core #1 sediments; however, are intact and present an accurate picture of the mound stratigraphy. The high levels of the major elements, particularly potassium and magnesium are well within the normal range for organic soils or plant materials (Kemp et al. 1976) and are the highest for the presumed field level (145-165 cmbs; n=0.93% and 0.25%, respectively). Mobile elements, which react in a reducing environment, are well-represented in the Core #1 sediments manganese and iron, both of which are present in the highest levels in the field stratum (n=505 ppm and 1.65%, respectively).

As stated above, phosphate deposited on the ground surface, perhaps during fertilization of an agricultural plot, is converted to iron, aluminum, and calcium. The soil at the base of Core #1 (below 145 cmbs) exhibits high levels of aluminum (3.54%) and the highest levels recorded of both calcium and iron (n=0.43% and

Table 6. Summary Of Chemical Analysis Results For Soil Samples Taken From Mound D (9BI1).

Sample		Al %	Ca %	Cr ppm	Fe %	K %	Mg %	Mn %	Ni ppm	P ppm
Core #1										
Const. Phase III	0-18cm	2.76	0.09	23	1.11	0.33	0.10	495	10	480
	18-41cm	2.49	0.04	20	0.95	0.24	0.07	380	9	340
Const. Phase II	41-65cm	2.64	0.04	22	1.03	0.27	0.08	465	10	370
	65-80cm	3.03	0.05	23	1.20	0.30	0.08	460	10	470
	80-102cm	2.61	0.04	19	1.01	0.24	0.07	365	9	420
	102-130cm	2.79	0.04	22	1.09	0.25	0.08	410	10	430
Const. Phase I	130-145cm	2.67	0.05	20	1.05	0.28	0.08	455	9	390
"Field Level"	145-165cm	3.54	0.43	27	1.65	0.93	0.25	505	11	250
subsoil	165-175cm	3.79	0.09	26	1.45	0.33	0.11	435	13	370
Core #2										
	0-10cm	2.69	0.08	23	1.07	0.30	0.08	340	8	400
	10-20cm	3.94	0.06	34	1.53	0.28	0.09	310	13	420
	20-50cm	2.36	0.04	21	0.94	0.24	0.07	275	9	300
	50-90cm	2.89	0.20	22	1.07	0.56	0.12	490	8	250
	90-120cm	1.20	0.03	12	0.42	0.17	0.04	220	4	170
	120-143cm	1.75	0.05	17	0.67	0.29	0.06	395	7	290
	143-165cm	1.47	0.06	15	0.55	0.28	0.05	530	4	280
	165-200cm	1.50	0.04	17	1.56	0.26	0.05	320	6	230
Original ground surface	200-225cm	1.50	0.05	14	0.56	0.22	0.06	375	5	240
	225-235cm	1.83	0.05	16	0.67	0.24	0.06	470	6	280
	235-255cm	2.60	0.05	19	0.94	0.29	0.08	640	9	350
Modern Field										
	0-20cm	5.80	0.12	43	1.83	0.71	0.12	1425	14	800

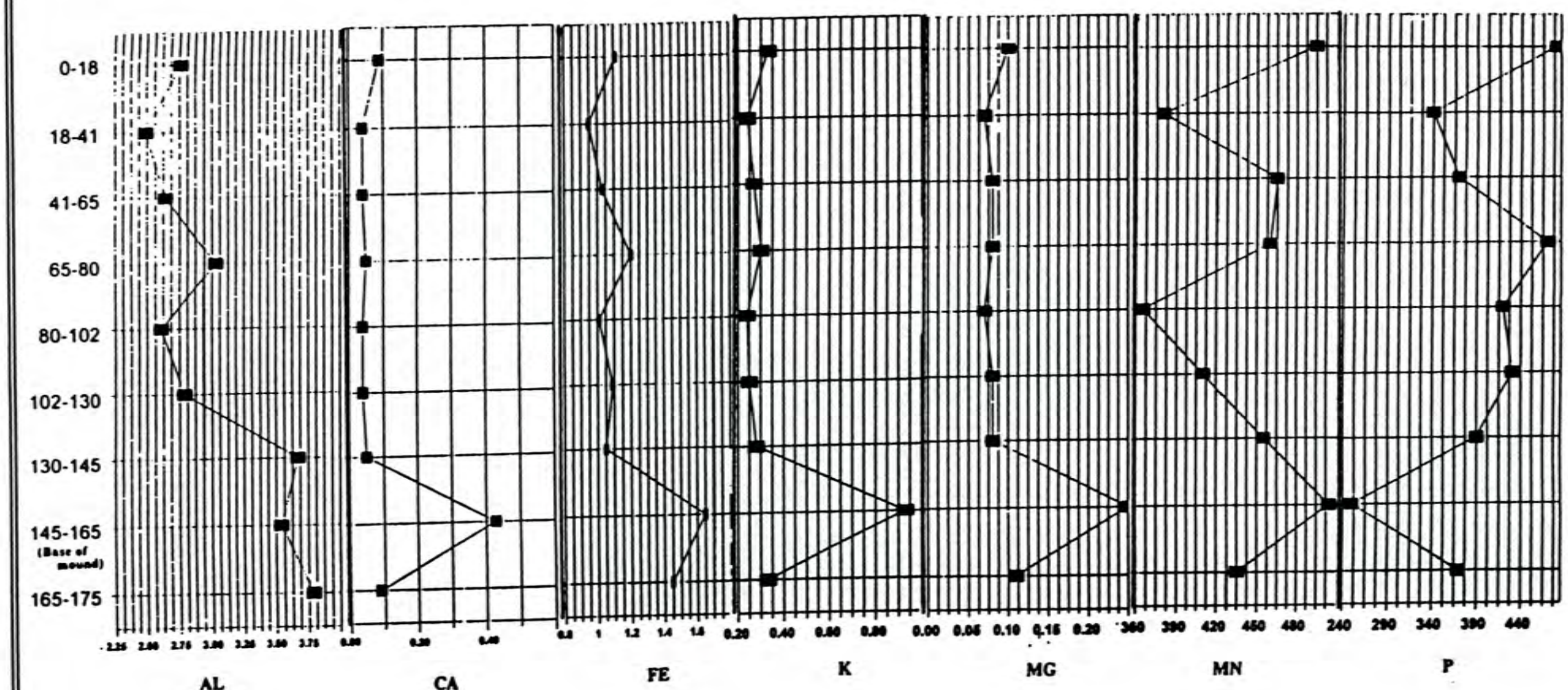


Figure 9. Graph of Core #1 soil chemistry by depth.

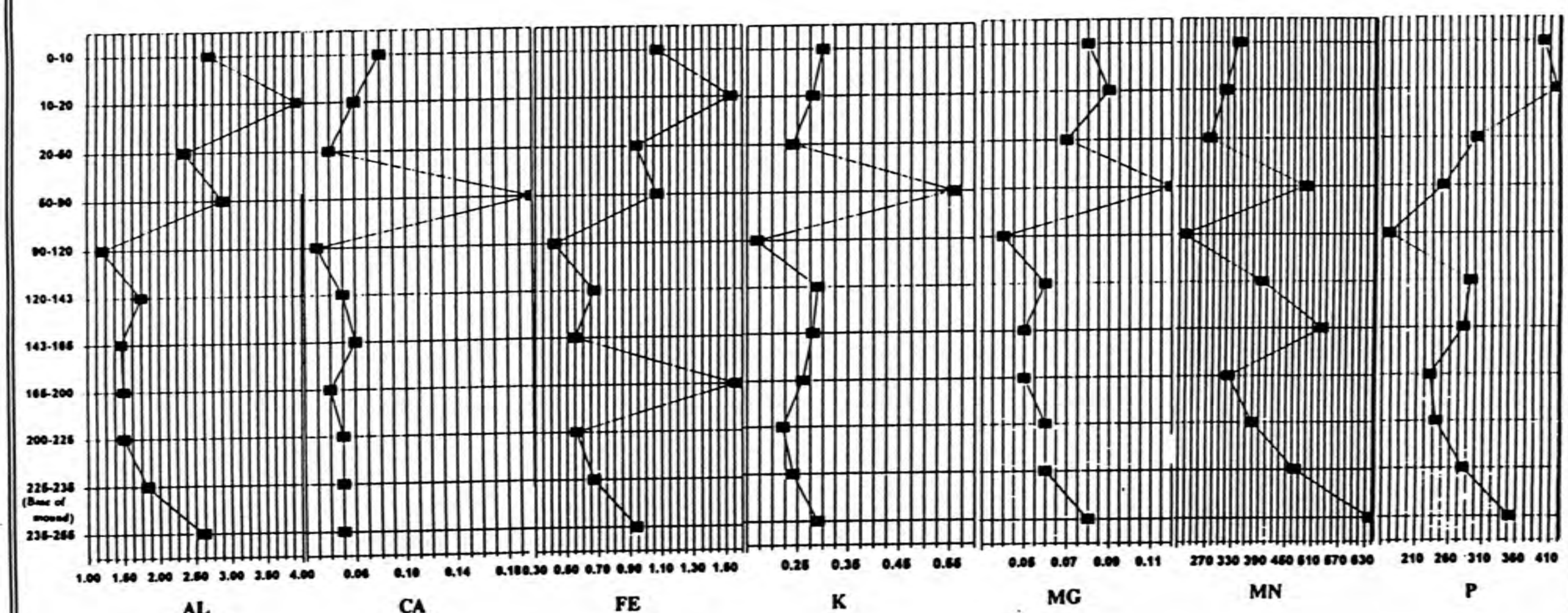


Figure 10. Graph of Core #2 soil chemistry by depth.

1.65%, respectively). Phosphates which remain in the subsurface soils become insoluble (Wing 1950). With the Core #1 sediments, the levels of phosphorus are at their lowest in the presumed agricultural layer (n=250 ppm), although they increase significantly in the subsoil below the field level (n=370 ppm). This result is consistent with a cultivated field surface.

In order to determine if a relationship exists between the percentage of clay and silt and the chemical analysis results a bivariate regression analysis was conducted. The independent variable was the percentage of silt and clay. The dependent variables were the specific chemical values for each element. R-squared values obtained are:

Aluminum	0.32
Calcium	0.02
Iron	0.08
Potassium	0.03
Magnesium	0.01
Manganese	0.14
Phosphorus	0.05

While a loose relationship between the clay and silt content of the sediments and the amount of aluminum present may exist, these calculations confirm that overall the sediment chemistry values obtained are not related to the particle size of the soils.

The chemistry results from the modern field soil sample reflect comparatively high levels of all elements except calcium. Where the possible field level in the Core #1 sediments contain very low levels of phosphorous, common in cultivated A horizon soils, the modern field levels of phosphorous are extremely high (n=800 ppm). This is due to the fact that the modern field is regularly treated with supplements, particularly nitrogen and phosphorous (Albert Hale [property owner], personal communication). The low levels of calcium are directly related to the high levels of phosphorous--the soil amendments have not yet been fully converted.

The pH of soils, a measurement of the baseness or acidity, is also of interest in determining the degree to which botanical microfossils will be preserved. As stated earlier, acidic conditions enhance pollen preservation, despite the detrimental effects on both faunal and macrobotanical remains (Shackley 1975). The pH values for the soils that comprise the Mound D fill are moderately acidic (measuring 3-4) as are the soils beneath the mound. The modern field soils are also acidic, with a pH of 4. These soil conditions should aid in the preservation of any fossilized pollen grains and/or phytoliths present.

Stable Isotope Analysis

Stable isotope analysis uses mass spectrometry to identify the elements present in a sample. These elements may have different isotopes, which contain nuclei with the same number of protons but a different number of neutrons. The variation in the number of neutrons results in differing masses and, consequently, differing behaviors. Elemental isotopes can be either stable or unstable. All stable isotopes can have both light and heavy expressions. The two most commonly measured stable isotopes are nitrogen and carbon.

As the actual isotopic ratio is difficult to calculate, stable isotope measurements focus on the variation between the sample's isotopic ratio and a standard. Carbon isotopic values are based on a Cretaceous marine fossil found in the PeeDee formation in South Carolina. This fossil, *Belemnitella americana* (known as belemnite), has an extremely high $^{13}C/^{12}C$ ratio and so is used as the standard against which all other samples are measured. The following formula is used to obtain a delta value (δ-value):

$$\delta(x) = (R_x - R_{std})/R_{std}) \times 10^3$$

In this equation R_x represents the sample's isotopic ratio and R_{std} is the standard ratio. PeeDee Belemnite (PDB) is given a value of zero (Coleman and Fry 1991), consequently, all other samples will have negative values for their $^{13}C/^{12}C$ ratio.

It is the ratio of these light to heavy isotopes (e.g. $^{13}C/^{12}C$ or $^{15}N/^{14}N$) that can be used as a "biological tracer" (van der Merwe 1982) in determining the presence and/or exploitation of C4 and C3 plants. Unlike other cultigens and most other grasses, which are C3 plants, corn is a C4 plant. C4 plants use a photosynthetic pathway that fractionates carbon differently from the pathway utilized by C3 plants. The Hatch-Slack pathway used by C4 plants converts carbon dioxide into a compound with four carbon atoms while the Calvin-Benson pathway used by the C3 plants produces a three carbon atom compound (Calvin and Benson 1948). The difference in carbon fractionation results in signature $^{13}C/^{12}C$ ratios in the materials that have incorporated the plant tissues, such as skeletal material and soils. Typically, C3 plants will have carbon isotopic ratios of -32 to -20 parts per thousand (o/oo). The ratio range for C4 plants is between -17 and -9 o/oo. This difference in the ratio is used to establish the degree to which C4 plants were present in the sample evaluated.

Samples from the Core #1 sediments were submitted for stable isotope analysis to the Stable Isotope Research Laboratory, at the Department of Ecology, University of Georgia. The samples submitted were taken from the subsoil level (165-175cm), the possible field level (145-165cm), and from the level directly above the field level (130-145cm). A sample from the modern corn field was also submitted for analysis. The goals for this analysis were to determine if a C4 plant signature could be observed and, if so, if it was sufficiently strong to indicate the cultivation of corn.

Results of the Stable Isotope Analysis

Each of the soil samples submitted for stable isotope analysis were processed twice to ensure accuracy and are shown in Figure 10. For the modern field soils $\delta^{13}C$ values of -21.6 and -21.63 were obtained. Nitrogen values for the modern field also fall at the edge of those values considered within the C4 plant range, at 7.00 and 7.06. The total carbon values were 2.22 and 2.05. The total nitrogen values were 0.17 and 0.16.

The possible field level beneath Mound D (145-165 cmbs) yielded $\delta^{13}C$ values of -23.04 and -22.91 with total carbon values of 0.34 and 0.37 (indicating very little organic material in the soil). Nitrogen levels in the 145-165 cmbs sample were 0.02

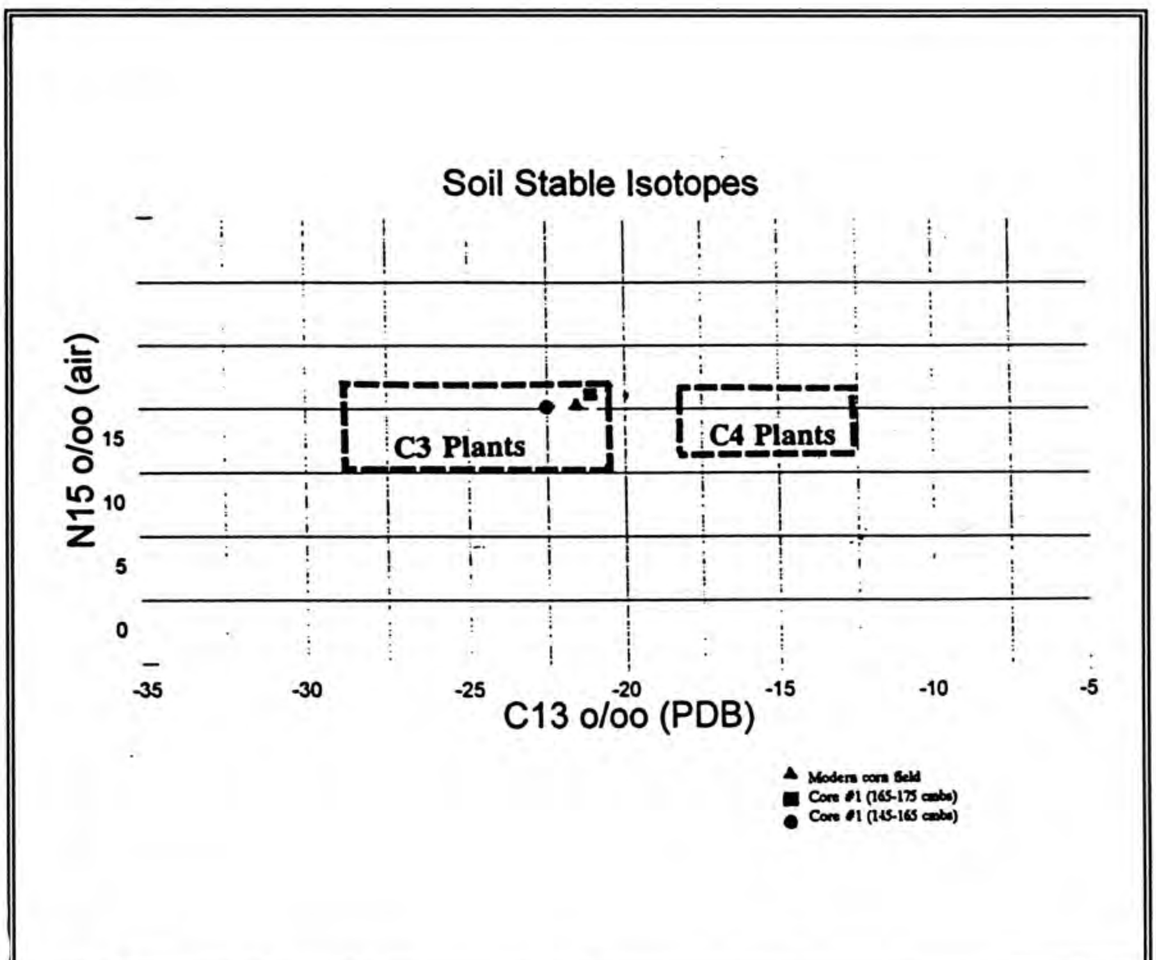


Figure 11. Stable isotope analysis results.

and 0.02, with $\delta^{15}N$ values of 6.04 and 6.07. The level beneath the possible field, classified as subsoil, yielded $\delta^{13}C$ values of -21.13 and -21.83, with total carbon values of 0.26 and 0.22. The subsoil level yielded total nitrogen values of 0.02 and 0.02, with $\delta^{15}N$ levels of 7.7 and 7.63.

Interpretations

The Core #2 soils recovered from Mound D are sufficiently disturbed to confirm their status as backfill from the early excavations of the mound and to prove them unacceptable indicators of the pristine soils beneath the mound fill. The Core #1 soils; however, indicate by the elemental composition, that the soil stratum beneath the mound fill (145-165 cmbs) is enriched by organic residues which could indeed be related to agricultural activity. Also, the soil pH is within a range that would allow for the preservation of pollen and other botanical microfossils.

The stable isotope analysis results for the modern field fall at the extreme end of the values considered to reflect the cultivation of C3 plants, but not within the range determined for C4 plants (see Figure 10). Despite the fact that this modern field is planted in corn and might be expected to reflect higher $\delta^{13}C$ values, both the $\delta^{13}C$ and $\delta^{15}N$ values for this field are consistent with modern day rotation cultivation (Tom Maddox, UGA Ecology Dept., personal communication 1998).

The stable isotope values for the Mound D subsoil level (165-170 cmbs) are also at the extreme end for C3 plants. The possible field level soils (145-165 cmbs) fall more squarely into the range of carbon and nitrogen values for the presence of C3 plants (see Figure 10). Overall, the stable isotope values indicate the presence of C3 plants, such as grasses, in the soils beneath Mound D and in the modern field soils. No overt evidence of C4 plants, such as corn, is present in the Mound D soils. However, the stable isotope analysis results also do not present conclusive evidence of corn being cultivated in the modern field, despite the fact that it is. Therefore, the possibility that corn was grown in the soils beneath Mound D cannot be ruled out based on the stable isotope data.

Chapter VI. Pollen Analysis

Overview and Background

Pollen grains represent the sexual generation of a flowering plant. Formed in the male portion of the plant and carrying the male genetic material, they are released into the female portion of the flower through a variety of means (Faegri and Iversen 1975; Pearsall 1989). Individual grains of pollen can be extremely resistant to decomposition and will preserve for long periods of time in a variety of sedimentary contexts. Preserved or fossilized pollen can be retrieved, isolated, and identified to genus (and often to species) by observing both the structure and texturing of the individual grains.

Pollen analysis has been used in a variety of archaeological settings with great success. It has been used in both wet and dry settings, and used to help identify habitation sites as well as agricultural fields. In a summary of the types of sites for which palynology has been successful, Pearsall (summarizing Dimbleby [1985] and Bryant and Holloway [1983]) lists sites deliberately buried, such as old surfaces under earth mounds, and agricultural features, such as buried field surfaces. Andersen (1986) also discusses the use of palynology in evaluating soils that have not been disturbed by plowing, citing pastures, woodlands and sites buried beneath archaeological earthworks or dunes.

Morphology. A grain of pollen is comprised of three concentric layers. These layers are the living cell, which is in the center of the pollen grain and is the portion that is instrumental in the germination. The living cell does not preserve. The middle layer is the intine. This layer surrounds the living cell and is made up primarily of cellulose. While the intine may be preserved, it is unsculptured and difficult to identify. It is the exterior layer, the exine, that preserves and is able to be identified in palynological studies. The exine is composed of sporopollenin (Pearsall 1989), which is an extremely resistant organic substance. Characteristics of the exine include distinct structure and various openings (pores) and apertures (furrows), and often sculpturing. These characteristics allow the exine to be identified to its family, genus, and rarely to species.

The exine, while relatively resistant to a large number of forces, is susceptible to oxidation, as well as to mechanical degradation and biological agents (Pearsall 1989). Pollen grains can be abraded by soil particles, which can destroy the identifiable features of the grain. Also detrimental to pollen preservation is high soil pH. Fungi and bacteria can also damage the exine of pollen grains, so pollen preservation can be severely inhibited due to microbiological decay (Dimbleby 1985). Factors which contribute to the preservation of pollen include aridity, high acidity, and high levels of salt or toxic metals in the soil (Pearsall 1989; Holloway and Bryant 1986; Dimbleby 1985; Bryant and Holloway 1983). Overall, pollen will be well-preserved in anaerobic conditions, with either waterlogged or very dry acidic soils.

The physical features of the exine are described in detail by, for example, Faegri and Iversen (1975) and Kapp (1969). Pore and furrow patterns are classified based on the number present on the exine and the shape of the grain as a result of this patterning. Major categories for pollen texturing are:

-Monoporate: a single pore
-Periporate: multiple pores
-Monocolpate: a single furrow

-Dicolpate: two furrows, encircling the grain
-Tricolporate: three furrows, grain resembles a clover leaf
-Stephano-colporate: four furrows, resembles a 4-leaf clover

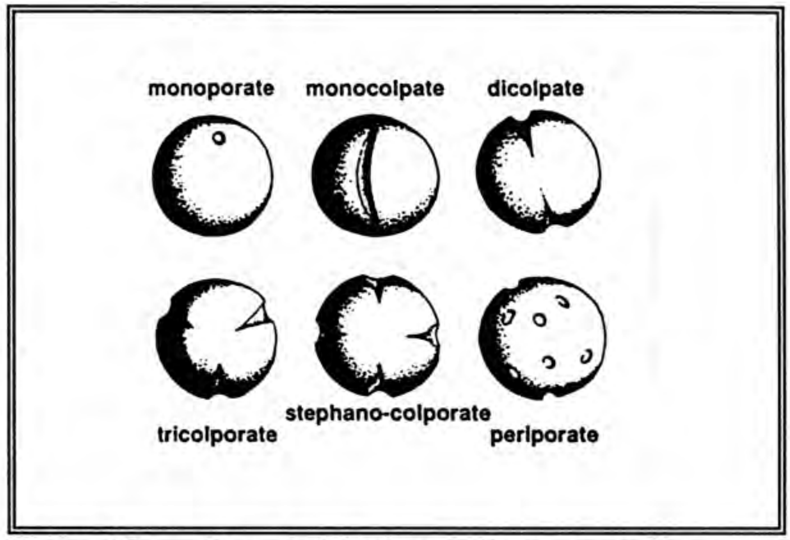


Figure 12. Pore and furrow patterns on pollen grains (Piperno 1989:Figure 4.3)

Examples of the variations of pollen grain texturing are shown in Figure 12. Sculpturing of the exine has a large variety of expressions. These surface patterns are comprised of projections of various sizes, shapes, and heights, that may or may not be connected to each other. Corn or maize pollen (*Zea mays*) is circular in shape, monoporate, and has a relatively smooth, non-textured exine. Corn pollen grains also have an extremely distinctive annulus surrounding the single pore. While pollen grains can range from 5 to 200 microns in size (with some exceptions [Faegri and Iversen 1989]), *Zea mays* pollen grains are commonly between 75 and 200 microns (Faegri and Iversen 1989; Gish 1994) and are more identifiable by virtue of their large size.

The longer a grain of pollen lies in the soil, the more it is susceptible to bacteria and other agents of degradation. Consequently, the actual number of grains declines with greater depth (Dimbleby 1985). There is a normal overall decline in the total amount of pollen in deeper strata; however, as noted above, the frequencies of older pollen will remain constant or will increase (Dimbleby 1985). Figure 13 illustrates a theoretical distribution of pollen in soils of different ages.

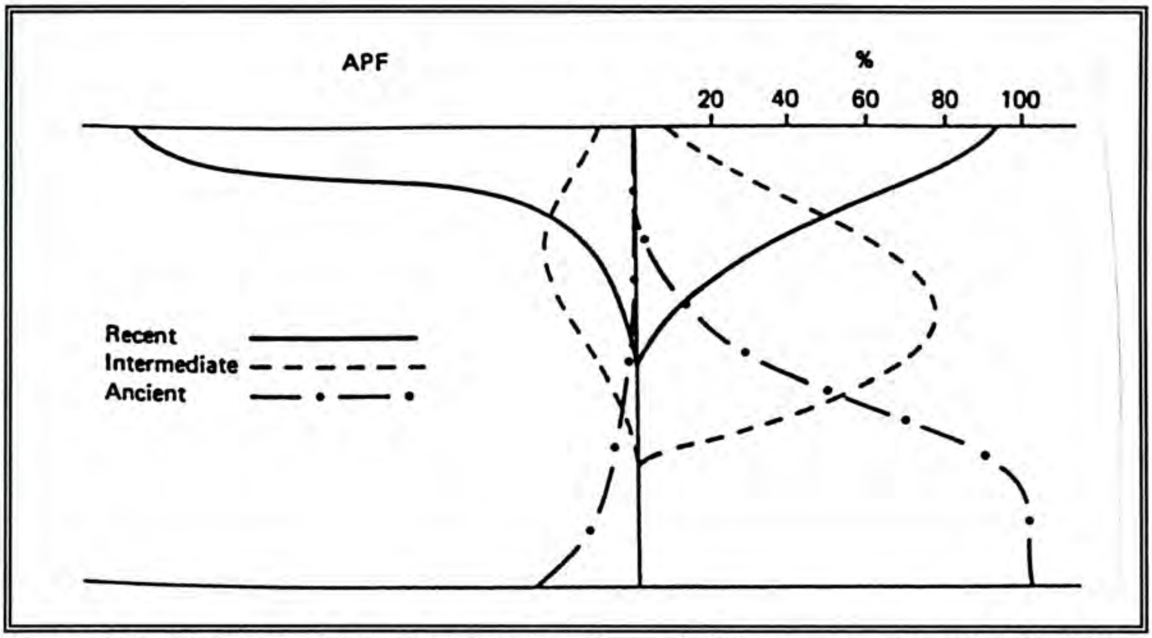


Figure 13. Theoretical distribution of pollens of different ages in soil (Dimbleby 1985:7).

Also, bioturbation can act to move pollen grains both up and down within a soil profile (Walch et al. 1970). In these cases, the prevalence of the pollen types is the guide to which grains are older. A larger percentage of the younger pollen will remain in the upper levels of the soil profile, while the largest percentage of the older pollen will remain at the base of the profile. This pattern of pollen distribution and degradation has been verified at numerous historic and prehistoric archaeological sites (see Dimbleby 1985; Kelso 1993; 1994; Pearsall 1989). However, the downward migration of pollen within a soil profile has been shown to average 10 cm in 300 years (Dimbleby 1985), as was noted in Chapter V. This downward movement of pollen is not solely determined by pollen grain size; although, intuitively, one would think that the smaller grains would move more quickly through the soil profile, particularly is the soil particles size reflects greater amounts of large particles (sand). Regardless of pollen grain size, the oldest pollen grains will be deeper in a soil profile. This trend can be disturbed by other forces, such as bioturbation, however, the highest frequencies of occurrence will remain the older pollens. Dimbleby (1985) suggests that a cover of approximately 40 cm will adequately protect a buried surface and its microbotanical components from contamination.

Dispersion. Pollen is dispersed by four mechanisms: wind; animals and/or insects; water; and self-pollination. Plants that rely on animal or insect vectors are called zoophiles. These species produce fewer pollen grains than those dispersed by wind and other means, and the grains are often covered with sticky oils or have very sculpted exines, which will adhere to the pollinating animal or insect (Pearsall 1989). Zoophilous pollen rarely becomes part of the pollen rain and tends to be recovered in close proximity to where the plant originally grew. Therefore, with plants of this type, if no pollen is found, there is only a small chance that the species grew locally (Faegri and Iversen 1975). Andersen (1986:167) concurs, stating that "pollen assemblages deposited on the land surface mainly reflect the vegetation at or near the sampling site".

Pollen grain size and weight is also important in its relative dispersion. *Zea mays* pollen grains are large compared to most other plant pollens and often weigh considerably more, resulting in a significantly low degree of susceptibility to wind dispersion (Faegri and Iversen 1975). *Zea mays* pollen relies primarily on insect or animal vectors for dispersal. The combination of these factors result in good spatial integrity--where *Zea mays* pollen is found, the plants were probably present nearby.

Studies of the dispersion and deposition of corn pollen have been conducted by Raynor et al. (1972). According to this study, the quantity of pollen released per unit time by a field of corn is significantly smaller than that released by other plants, such as ragweed (Raynor et al. 1972). The low release rate associated with corn and the rapid disposition of the corn pollen, results in dramatically decreasing numbers of corn pollen grains at greater sampling distances (Raynor et al. 1972).

Figure 14 illustrates the dispersion pattern of corn pollen, as established by Raynor and his colleagues. Their study concluded that only 5% to 10% of corn pollen disperses more than 10 m from its source, and only 2.5% extends beyond 20 m.

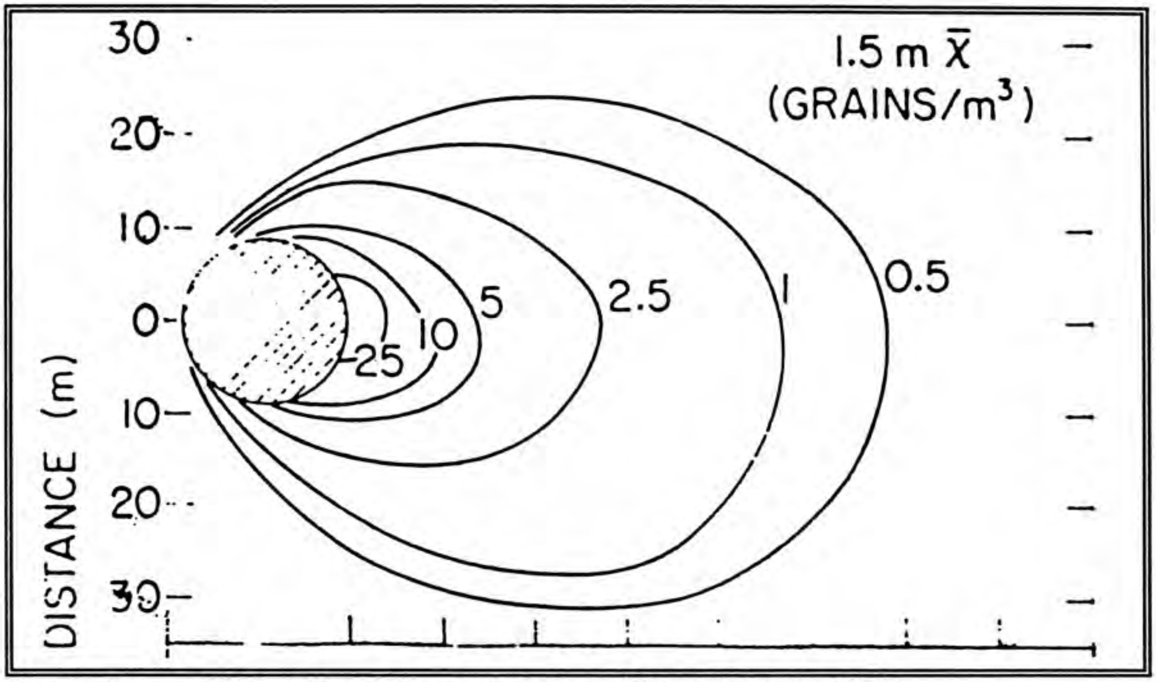


Figure 14. Corn pollen dispersal pattern (Raynor et al. 1972)

Laboratory Methodology

Sediment subsamples (1 ml) were removed from the core samples at various depths with several samples removed from the stratum beneath the mound fill (for Core #1 this sample was removed from the 145-165 cm zone). Three 1 ml subsamples were also taken from the modern corn field soils. These subsamples were then placed in 50 ml test tubes. The processing of these soil samples for pollen extraction followed procedures detailed in Faegri and Iversen (1989) as modified by Shane (1992).

The first step in the pollen extraction process consisted of the subsamples being treated with a 10 percent solution of KOH, placed in a water bath and allowed to boil for 20 minutes. This step breaks up the sediment and removes humic acids. The sediment was then screened through 180 micron mesh and washed with distilled water. The screening removes the larger particles of sand while allowing for the retention of smaller particles such as pollen. The remaining subsample was returned to the test tubes, and put through washes with distilled water. The washing process involves the filling of the tubes with distilled water, placing them in a centrifuge for 5 minute intervals, and decanting the liquid. The process must be repeated until the fluid is clear; in this case, two washes were required.

A solution of 48 percent hydrofluoric acid was then added to each test tube, which were then placed in a water bath and allowed to boil for 20 minutes. Following the boiling, the tubes were filled with 95 percent ethanol to cool the sample. They were then placed in a centrifuge for 5 minutes and decanted. This step is intended to remove silicates and generally needs to be repeated several times. For these samples, two complete series were required.

Following the removal of the majority of the silicates, a 10 percent solution of hydrochloric acid was added to each tube. Following 1 to 2 minutes of boiling, the samples were placed in a centrifuge and decanted. This series of steps was repeated 5 times, to insure that all colloids formed during the HF rinse were broken up.

The sediment was then washed with glacial acetic acid. Following centrifuging and decanting of the glacial acetic acid, a solution of 5 ml acetic anhydride and 0.5 ml of sulfuric acid was introduced into each test tube. The sediments were again placed in a water bath and boiled for 2 minutes. The subsamples were again washed with glacial acetic acid, followed by two distilled water washes. This step is referred to as acetolysis and serves to remove additional organic material from the sample as well as staining the pollen a golden brown.

Following acetolysis, a small amount of the remaining material was placed on a glass slide using a sterile pipette. Each sample was observed under a high powered microscope in order to determine if a sufficient amount of the crystalline material had been removed from the sediment. If so, slides of each sample were prepared using silicone oil as a lubricant to allow the particles to float free. Each sample slide was comprehensively examined under a microscope at a magnification level of 400x, in 1 mm transects. Once identified at 400x magnification, pollen grains were examined at 1000x magnification in order to record surface texturing.

For each sample processed, an attempt to identify all pollen present was made. Although the primary focus was on the identification of maize pollen, prior to commencing this project I studied pollen from other cultigens and native species so that it too could be identified if present. Several of the other species studied have been documented at prehistoric archaeological sites, including *chenopodium* (goosefoot), *Cucurbita* (squash/pumpkin), and *Ilex* (holly). However, as the presence of maize was the focus of this study, no non-maize pollen was quantified and degraded grains were excluded.

Two separate batches of sediment were processed to fully verify the validity of the results noted. University of Georgia palynologist, Ms. Jean Porter, was consulted following the processing of the second set of soils. Ms. Porter examined several of the slides prepared from the two processing episodes.

Results

Samples from 40 cm above the "cornfield" were examined to determine the degree to which downward percolation may have influenced pollen frequencies in the "cornfield" level (145-165 cmbs). Two slides were prepared from the sediments at a depth of 102-130 cmbs. This level contained very little pollen and what was present was extremely degraded. Pine was identified, as were several grains of grass pollen. Two slides were examined from a depth of 130-145 cmbs. Pine pollen was again identified; however, all pollen from this level was extremely degraded.

In the sample processed from the level directly beneath the "cornfield" level (165-175 cmbs), pollen was present but was highly degraded. Two slides were examined for this level. Pollen noted in this sample represents both tree (pine) and grass species.

Twenty slides were examined from the base of the mound (145-165 cmbs level). Pollen preservation was poor with grain density averaging only 3 grains per slide. Pollen grains were identified from *Pinus* (pine) and a variety of unidentifiable grasses. Grass pollen was relatively ubiquitous, with a minimum of 40 individual grains being identified in the twenty slides. These preserved pollen grains maintained their characteristic circular shape and, on the majority of the grains, the single pore was clearly visible. The grass pollen grains ranged in size from 20 to 80 microns. These pollen grains also closely resemble grains of *Zea mays* pollen, except that they are significantly smaller than the average size range for corn pollen.

Only pollen grains that could be definitively identified were recorded. The field stratum contained additional grains of pollen that were disfigured or abraded. These grains were not included in the final quantification. However, in all other levels for which pollen was identified, degraded pollen was present. The majority of this damaged pollen was comprised of small, presumably arboreal pollen grains that lacked an intact exine.

With the assistance of Ms. Jean Porter, a third batch of sediment from the 145-165 cmbs level were processed. This batch of samples, consisting of a total of 5 ml of sediment, was treated with KOH and heated as a first step. The material was then screened through a series of sieves. These initial steps were intended to concentrate all organic material and remove the larger particles of sand. The samples were then processed as detailed above.

An additional four slides were prepared from this third processed sample. These slides were examined at 400x magnification in 1 mm transects. As with the slides prepared from the two other processings, no corn pollen (or pollen from any other cultigen) was present. Both pine and grass pollen was observed, but grain density remained extremely low.

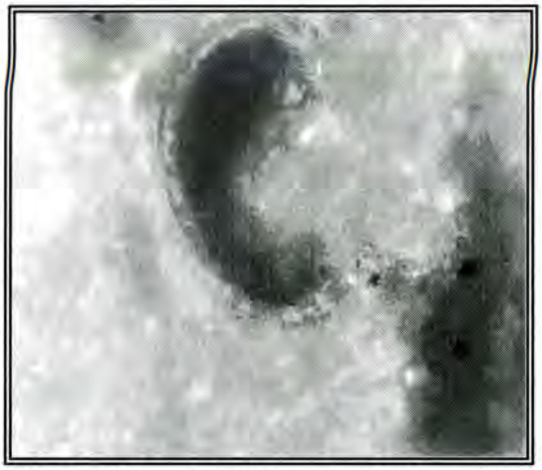


Figure 15. *Zea mays* pollen grain in modern field soil sample.

Three slides from the modern cornfield soils were examined. Pollen grains from *Pinus* (pine) and various grasses were identified, as were several *Zea mays* pollen grains. Figure 15 shows a grain of *Zea mays* pollen identified in the modern field soil sample.

As a side note, fungal spores were present in significant amounts in the 145-165 cmbs sediments. These spores were also present in small numbers in the levels both above and below the field level, but showed a marked increase in prevalence in the "cornfield" level. Figure 16 provides a comparison of the numbers of fungal spores by level. As illustrated by this graph, the possible field level contains a significantly large number of these spores, whereas levels both above and below contain relatively few.

Interpretations

All factors leading up to processing of the Mound D sediments for pollen indicated that pollen preservation could be expected. However, the extremely low grain density and the presence of severely degraded pollen grains indicate that, despite all expectations, pollen preservation in the Mound D soils is very poor.

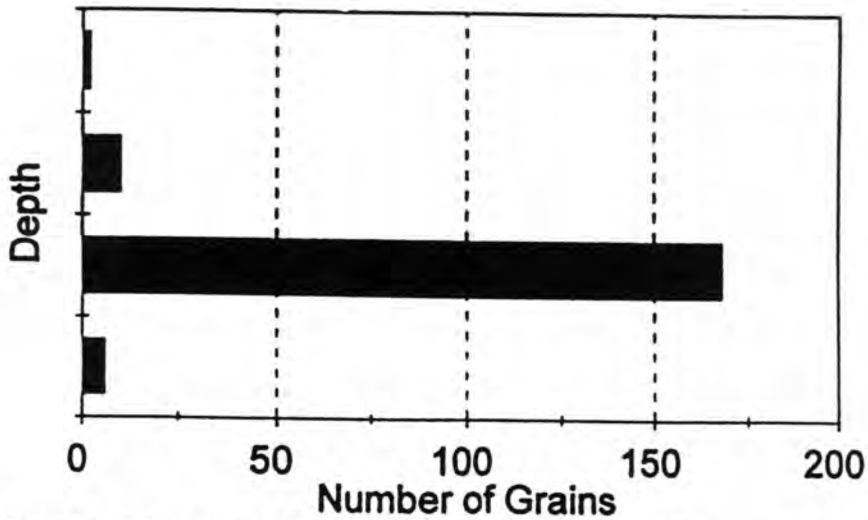


Figure 16. Graph of fungal spore frequencies (Core #1 soils).

The identification of grass pollen could indicate that the area had been cleared of trees to such a degree that grasses and weeds were allowed to proliferate. While the clearing of trees is often associated with prehistoric agriculture, no further evidence of the growing of cultigens was identified in the Mound D samples.

As stated, no corn pollen was identified in the Mound D sediments; however, it was present in the sample taken from the modern field (see Figure 15). These soils have a high clay content and have been continually supplemented by chemical fertilizers, and these factors did substantially affect the preservation of pollen, as illustrated by the low grain density. However, corn pollen is present despite these negative factors. Also, the sample size for both Mound D and the modern field are equivalent, suggesting that sample size is not a factor in the presence or absence of pollen.

Keeping in mind Dimbleby's expectation of 10 cm downward movement in a 300 year period, I have accounted for nearly 1200 years (40 cm) of pollen percolation. The presence of pollen grains and spores in the 145-165 cmbs level could not have been caused by the translocation of pollen through the soil strata, as insufficient numbers of both pollen and spores are present in the upper levels and they would not have been sufficiently preserved.

An unexpected result of the processing of the Mound D soils, was the dramatically high number of fungal spores present in the soil stratum immediately beneath the mound fill ("field level"). Presumably these spores reflect an in-situ occurrence. With the relatively small number of both pollen grains and spores in the strata above the field level and the implications of the particle size analysis, it is unlikely that the microbotanicals in the 145-165 cmbs stratum were leached down from the mound fill. The use of spore frequency may have the potential for identifying old ground surfaces, although, this avenue was not explored as it is outside the scope of this study.

Chapter VII. Phytolith Analysis

Applications of Phytolith Research

The analysis of phytoliths, microscopic pieces of silica formed within the cells of plants, is a relatively recent addition to archaeobotanical research in the United States (Carbone 1977; 1981; Pearsall 1978; Piperno 1984a; 1984b; Robinson 1983). Numerous archaeological research questions have been addressed in phytolith research. Studies of these opaline plant microfossils, that have been recovered from excavations, have enhanced the recovery of data at sites where preservation of plant macroremains is poor or lacking, and have added support to interpretations based on other plant remains (Piperno 1988; Pearsall 1989). Phytoliths have enormous untapped potential in many areas, including ecological and paleoenvironmental reconstruction (Piperno 1983; Rovner 1983, 1988), as well as paleodietary studies (Pearsall 1989; Rovner 1988; Middleton 1991; and others).

Phytoliths tend to be more sensitive to the earliest small-scale introduction of agriculture and a major current interest among prehistorians is the utility of phytoliths in demonstrating the presence of domesticated plants in the archaeological record, particularly in areas where recovery of macrobotanical remains is rare. Studies of farming practices include the identification of such cultigens as maize (Pearsall 1978; Piperno 1984), rice (Fjiwara et al. 1985), and various Old World cereals (Helbaek 1961; Rosen 1987), as well as the identification of field surfaces (Pearsall and Trimble 1984), and prehistoric irrigation systems (Rosen 1987).

Phytolith Overview

Formation. Phytoliths are defined as mineral deposits that form in and between plant cells (Rovner 1983). Many plants absorb various chemical elements in solution from groundwater, which are then deposited in controlled locations within the plant (Rovner 1986). The degree of development of phytoliths in a plant is related to a number of factors, including the climate in which the plant is growing, soil conditions, the age of the plant, and most importantly, the taxonomic tendency for the plant to produce these silica bodies (Piperno 1988). Increased silica deposition is induced by greater evapotranspiration in hot arid environments (Refrew 1973; Hutton and Norrish 1974). It has also been suggested that this process is enhanced by irrigation farming or in microenvironments with poor drainage that serves to add soluble silica from excess soil water (Rosen 1991).

The process starts when plants absorb soluble silica in groundwater through their roots and ends when the silica, sometimes at a very early stage of plant development, is laid down as solid infillings of cell walls, cell interiors, or intercellular spaces. Virtually any plant structure can serve as a repository of silica deposition. The following types of plant tissues and cells are commonly silicified and produce discrete phytolith types: epidermis (the outermost layer of cells), including hair cells, hair bases, and stomata; hypodermis; mesophyll (the leaf tissue enclosed within the epidermis); schlerenchyma (strengthening elements of mature plant structure); and vascular (comprised of the xylem and phloem and is concerned with the conduction of water, storage of food, and support). Within these structures, deposition can be highly localized in a single kind of tissue, or be distributed throughout the entire plant body.

Various studies indicate that phytolith production is high in many families of both monocots (which include grasses) and dicots (Piperno 1988; Franceschi and Horner 1980). Mulholland and Rapp (1992) list several families that are well known as consistent accumulators of identifiable silica bodies include Poaceae or Gramineae (grass), Cyperaceae (sedge), Ulmaceae (elm), Leguminosae (bean), Cucurbitaceae (squash). Piperno (1985) has also identified silica in many tropical plant families.

Deposition. Phytoliths tend to be liberated and deposited through decay-in-place mechanisms (Dimbleby 1978). Deposition normally occurs through surface or shallow subsurface decomposition of plant tissue; thus phytoliths are incorporated directly into soils and sediments. While fire and strong wind erosion can and do expose phytoliths to wind transport, phytoliths are more inclined to represent highly localized, in situ deposition. The local character of phytolith deposition and transport makes the archaeological phytolith record a very good indicator of on-site plant use.

Two conditions under which horizontal phytolith movement may occur are strong winds and vegetation-poor, open terrain (Piperno 1988). River and ocean currents may also carry phytoliths considerable distances (Melia 1980), possibly to be redeposited in lakes or on shores and terraces. In addition, horizontal movement of phytoliths can take place by means of soil erosion and surface run-off after rains. Each of these factors must be considered when interpreting phytolith data.

While the potential for horizontal secondary phytolith deposition does exist, the stability of phytoliths in vertical profiles is well-documented. Phytoliths are frequently used as an "index mineral" for the presence and location of buried 'A' horizons in paleosols. A major criterion used by pedologists for identifying buried 'A' horizons is the abundance of phytoliths found in them, whereas layers immediately above or below display a paucity of phytoliths (Beavers and Stephen 1958; Dormaar and Lutwick 1969).

Piperno (1988) notes that in numerous deposits from a variety of site types, occupations, and time periods extending back 23,000 years, phytolith distributions in soils that showed no visible sign of disturbance or mixing consistently displayed the following characteristics:

1. Culturally sterile contexts stratified immediately underneath artifact-bearing deposits were devoid or virtually devoid of silica. Cultural levels just above yielded considerable quantities of phytoliths.

2. The absolute phytolith quantity in site deposits peaks when cultural materials such as ceramics and stone tool debitage are found at their highest numbers; therefore, phytolith abundance is correlated with the intensity of human activity at sites.

3. Correlations of phytolith with pollen and macrofossil assemblages demonstrated close agreement in the types and frequencies of taxa and inferred vegetational associations.

4. Phytolith assemblages were discrete across stratigraphic boundaries, consistent within stratigraphic boundaries and showed little sign of scattered movement characteristic of intrusive or mixed particles.

Rovner (1986) sums up the case for phytolith stability by stating that "Vertical movement cannot be ignored, but it is a non-issue warranting no special attention. It is certainly no invalidation of phytolith analysis in archaeology."

The utility of phytoliths as a paleoecological tool also depends on its stability in soil environments. The degree of phytolith preservation will vary according to the chemical and physical nature of the environment, as well as the particular taxon that has left silicified remains (Piperno 1988). Some of the factors that influence the rate of solid silica dissolution are: iron and aluminum absorbed into the silica surfaces, protecting them from dissolution; phytolith surface area, as the greater the surface area, the more rapid the dissolution; and the presence of occluded carbon which also retards dissolution of the phytoliths (Piperno 1988). As discussed in Chapter 4, the levels of aluminum and iron in the field stratum are high, indicating that good conditions exist for the preservation of phytoliths.

Phytoliths are also susceptible to dissolution under strongly alkaline conditions (Iler 1979). Soil pH values of 9 and above tend to accelerate dissolution of the phytolith. Strongly alkaline sediments, such as shell middens, therefore would not be expected to contain many identifiable phytoliths. The pH values obtained for the Core #1 field stratum are advantageous for phytolith preservation. Under favorable normal conditions phytoliths can survive for long periods of time (Rovner 1988) and have been recovered from Paleocene sedimentary rocks approximately 60 million years old (Jones 1964).

Identification. Several taxonomic paradigms can be used to distinguish between phytoliths produced by different plant taxa. If possible, a typologic paradigm is the simplest and most practical. It is most effective when the taxa being considered produce individual or suites of phytoliths unique to that taxa, i.e. they produce significantly different shapes or types of phytoliths. In such a case, the simple occurrence of a characteristic phytolith indicates the taxon. In the absence of distinguishing types or shapes of phytoliths, a morphometric paradigm based on individual phytoliths would seem to be the next best approach for classification.

Initial attempts at phytolith classification systems were based on a typological approach (i.e. the presence or frequency of certain types and/or shapes of phytoliths were used as classification criteria). For grasses the taxonomic resolution of this approach has been marginal because phytoliths produced by individual grass species are usually polymorphic within, and redundant between taxa (Rovner 1983). Rarely have researchers been able to distinguish between grass taxa at the species level using a purely typologic approach (Ball and Brotherson 1992; Rovner and Russ 1992). Recently, however, research conducted by Piperno and Pearsall has indicated that opal phytoliths are often distinctive at the genus or species level

(Piperno 1988; Pearsall 1978). The degree to which plant taxa can be identified by phytoliths is an ongoing area of research.

There are two basic arrangements by which phytoliths can be classified. These are called taxonomic and nontaxonomic schemes. A nontaxonomic classification emphasizes shapes of objects under study with little emphasis on equating shapes to the organisms that produced them, or tying them into the larger taxonomy of the organism (e.g. subfamily, family, or order to which it belongs). A taxonomic classification, on the other hand, stresses the correspondence between phytolith shape, the species that produced it, and the evolutionary relationship of the taxon with other plants.

Nontaxonomic phytolith types are named after morphological, locational, and orientation characteristics (eg. saddles, spheres, horizontally elongated with sinuous edges). These types are based on geometric shapes, usually in outline. This method has the advantage of being easily applicable and understandable. Another identification method relates phytolith types to plant anatomy. Phytolith types are named after the plant elements that are silicified. For example, long cylinders may be sclereids or tracheids. This method requires greater knowledge of plant anatomy. Classification schemes designed by those seeking to apply phytolith studies to the solution of archaeological problems tend to focus on the geometric shape of the phytolith rather than on the element silicified (Mulholland and Rapp 1992).

Some of the more commonly identified phytolith shapes are: spherical, conical or hat-shaped, saddle shaped, dumbbells, cross shapes, and circular (Pearsall and Dinan 1992). The kinds of surface ornamentation include: spinulose (regular, evenly distributed pattern of small projections or spinules), nodular (unevenly distributed small prominences), rugulose (rugged or rough surface where the presence of spinules or nodules is not clearly evident), smooth (no exterior pattern), irregularly angled or folded, verrucose and tuberculate (denote wart-like projections), stippled, armed (short surficial spines), and nonarmed (Pearsall and Dinan 1992).

Zea mays, one of the most researched plants of our time, due to its significance as one of the earliest domesticates, has phytoliths that are often classified as crosses or dumbbells. Cross-shaped phytoliths consist of three or four lobes, each imprinted with several indentations, attached to a central body (Mulholland and Rapp 1992). Dumbbell shapes resemble the dumbbells used in weight-lifting.

As more work on phytolith classifications was done, a consensus emerged that phytoliths within subfamilies were highly redundant and could not be used to identify genera and species, particularly of grasses. This issue is currently being debated by phytolith analysts, including Piperno, Pearsall, and Rovner. Pearsall (1982) and Piperno (1984a) have suggested certain size parameters for distinguishing *Zea mays* phytoliths from those of other grasses (family Gramineae). Their method of measurement is based on the short axis width of the cross body phytoliths and the frequency of larger width cross bodies. This method relies on three factors:

1) short axis measurement: focus on phytoliths that are not more than 9 microns longer than they are wide. For maize the widths cluster around 13 to 15 microns, whereas wild grasses will cluster at widths less than 12.5 microns.

2) 3-dimensional structure: shape and structure on both sides. The most common structure for corn is plain/mirror image, accounting for approximately 60% of corn phytoliths.

3) percent of cross bodies measured against the sum of dumbbells and cross bodies. Corn has been found to have a mean of 40% cross bodies, when using this formula.

Piperno and Pearsall's studies have shown that *Zea mays* phytoliths are significantly larger than other non-domesticated grasses and that grass phytoliths can be identified beyond the family level (Piperno 1988; Pearsall 1978; 1982).

These same identification criteria were tested by Russ and Rovner (1989), using both teosinte and a number of different varieties of maize. The phytoliths from these control plants were compared with those from wild grasses. Russ and Rovner (1989) concluded that phytolith size distinctions are genetic rather than environmentally determined, and that the parameters suggested by Pearsall and Piperno have some validity; however, they continue to advocate caution (Rovner 1997, personal communication). Even Piperno (1988) advises that corn, even when present, may not be distinguishable from wild grasses for several reasons. These reasons include substantial decay of wild cross body phytoliths resulting in a skewed species ratio, phytolith contributions by related corn species with smaller sized cross bodies or lower percentages of mirror image structures, and the contribution of corn phytoliths due to husk, tassel, or ear decay.

Laboratory Methodology

Removal of phytoliths from sediments involves the use of a combination of clay removal (sodium pyrophosphate, Calgon, etc.) and heavy liquid separation (zinc bromide mixed without hydrochloric acid or sodium pyrophosphate, etc.). If carbonates are present, use of acids may be necessary to release phytoliths from the sediment matrix.

The method of extraction used for this project was that designed by Dr. Irwin Rovner and summarized by Owens (1997). This process began with the separation of 1 ml of sediment from each of the defined strata from the two core samples collected from Mound D and the sediment collected from the modern corn field. The sediment was placed in labeled tubes and saturated with distilled water.

Each sample was agitated then centrifuged and the water decanted. The purpose of this step was to allow for all light organic material to separate from the sediment, and to this end, it was repeated three times, until no visible material remained floating above the sediment. Following the removal of light organics, a solution of 5.25% sodium hypochlorite was introduced into each sample, agitated, and allowed to sit overnight. Sodium hypochlorite is a bleach that dissolves organic material. The bleach was then decanted and the samples were rinsed three times in distilled water (each rinse consisting of addition of distilled water to the sample, centrifuging, and decanting of the liquid).

Following the removal of organics, the samples were treated for the removal of calcium carbonate. Approximately 20 ml of hydrochloric acid was added to each sample tube. As the samples from Mound D contained little or no carbonate, virtually no reaction was noted. The samples were then rinsed three times with distilled water to remove all acid. The next step was intended to remove clay particles and consisted of adding approximately 20 ml of sodium hexametaphosphate to each sample tube. Sodium hexametaphosphate causes soil particles to disaggregate, allowing smaller clay particles to float. The samples were agitated, centrifuged, and decanted, then rinsed three time with distilled water. The remaining sediment was then oven dried.

The sediment residue was then poured into Tygon tubing which was folded in half. Zinc Bromide that had been calibrated to a specific gravity of 2.35 was poured into the tubing until it was half full. The tubing was then centrifuged. As phytoliths have a specific gravity of less than 2.35, during centrifuging, they float to the surface of the heavy liquid. Hoffman clamps were then placed on both ends of the folded tubing immediately below the liquid surface. This isolated the floating phytoliths and a small amount of heavy liquid, which was decanted into the labeled test tubes. Distilled water was added to the test tubes, lowering the specific gravity of the heavy liquid and allowing the phytoliths to sink. The samples were then rinsed with distilled water three times.

The remaining sample was transferred to labeled glass slides and placed in an oven to allow the residual water to evaporate. Using slide preparation procedures detailed by Owens (1997), a drop of Karo Syrup (a commercial corn syrup) was place on the sample slide prior to the placement of the glass cover slip. Owens explains that Karo Syrup is an effective mounting medium for phytolith samples due to its low refractive index, which allows the phytoliths to be clearly visible under a microscope (Owens 1997:10-11).

Examination of each slide was conducted in 1mm linear transects with a magnification level of 400x. As the primary goal of this study was to identify maize remains, only panicoid grass phytoliths were recorded. As each phytolith was observed, it was assigned to a variant (as defined by Pearsall 1989). These variants are presented in Figure 17 and include both cross and dumbbell shapes.

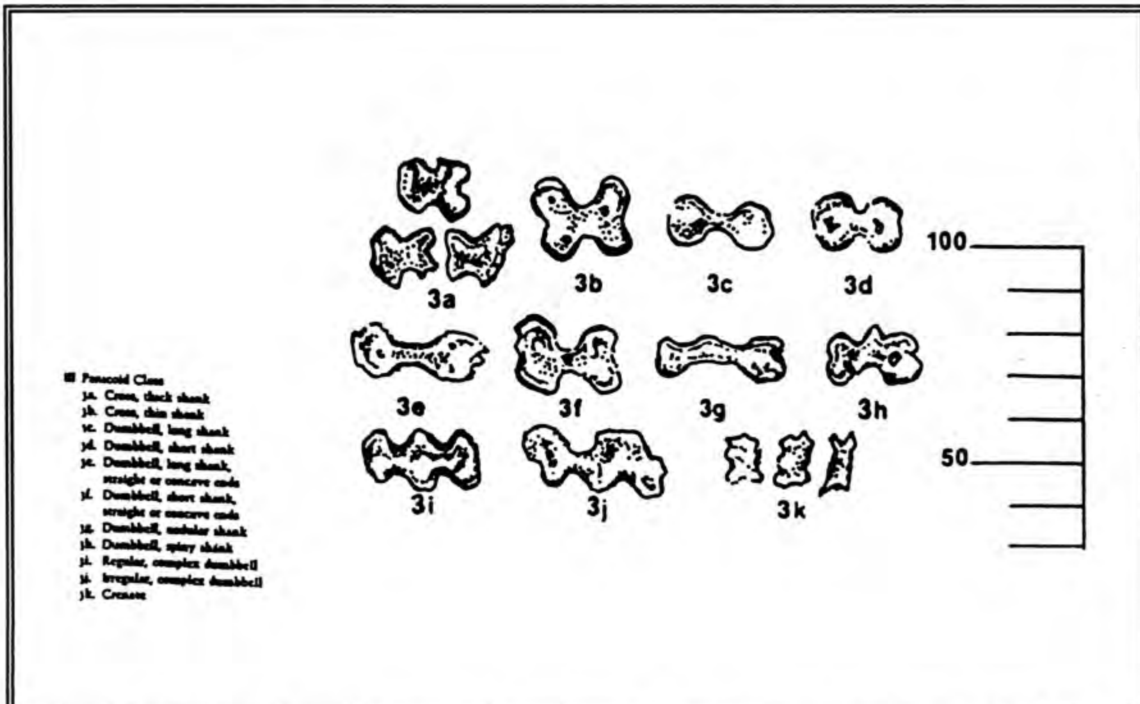


Figure 17. Panicoid grass phytolith variants, as defined by Pearsall (1989:318-319).

Results

Careful examination of samples from selected strata within the Core #1 sample resulted in the identification of four of Pearsall's (1989:318-319) panicoid variants (see Figure 12). Soil samples from the original ground surface (145-165 cmbs) contained thick shanked crosses (Variant 3a), long shanked dumbbells (Variant 3c), short shanked dumbbells (Variant 3d), and spiny shanked dumbbells (Variant 3h). Figures 18 through 20 present examples of phytoliths identified in the possible field level soils. No panicoid grass phytoliths were identified in samples from other strata in the Core #1 sediments, including the subsoil layer beneath the mound fill.

As both cross body and dumbbell phytoliths were identified, an attempt was made to implement Piperno and Pearsall's procedures for identifying corn phytoliths to species. Measurements were taken of all cross bodies and dumbbells and a ratio of the frequency was calculated. The cross bodies ranged from 2.0 to 2.4 microns in width and 7.0 to 7.2 microns in length. Dumbbell phytoliths ranged from 7.2 to 12.0 microns in width and 7.2 to 14.4 microns in length. Unfortunately, an insufficient number of cross body phytoliths were identified to provide an adequate sample. The frequency ratio of cross bodies to dumbbells was 1:3. Saddle shaped phytoliths were by far the most ubiquitous, with a ratio of 4:1 to both cross bodies and dumbbells. Flat towers, rectangular, and elongated phytoliths were also identified but were not quantified.

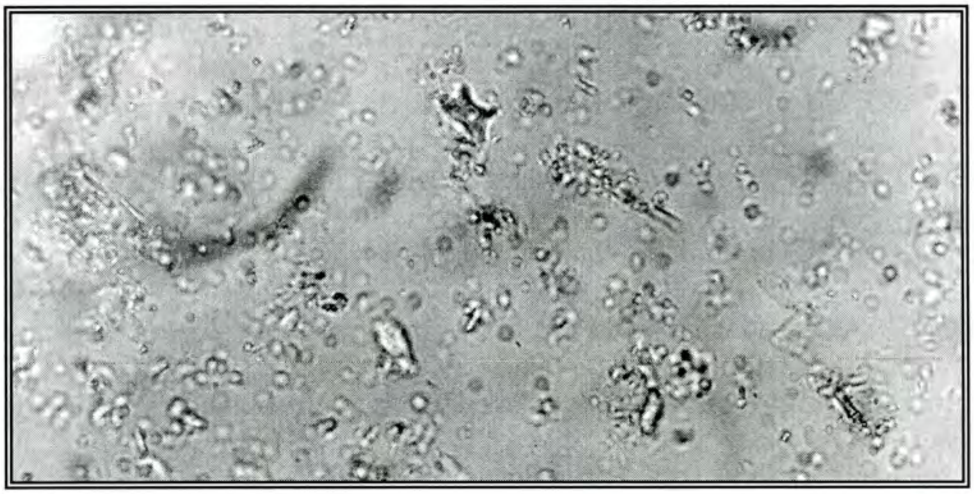
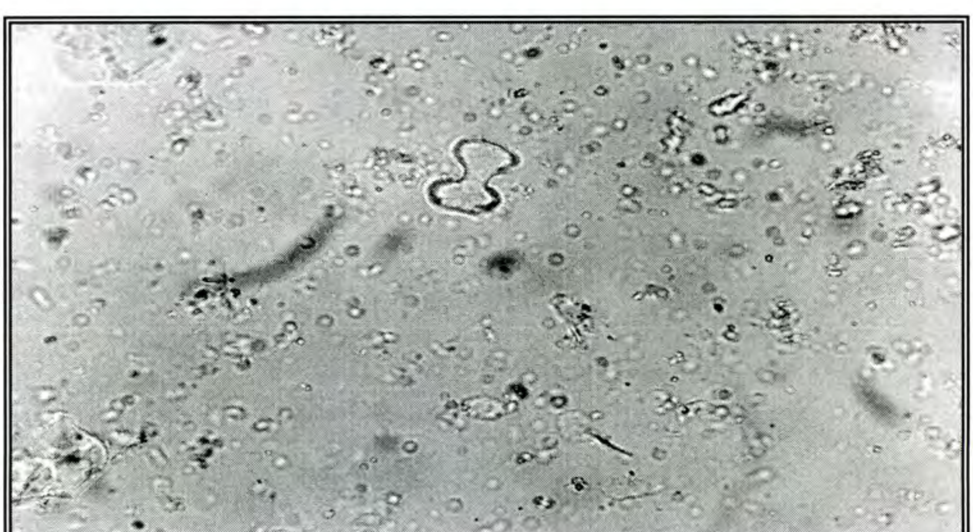


Figure 18 (above): Cross-bodied phytolith (Piperno's Variant 2) from Core #1 sediments.
Figure 19 (right): Dumbbell shaped phytolith from Core #1 sediments.
Figure 20 (below): Saddle-shaped phytolith from Core #1 sediments.



Interpretations

The identification of panicoid grass phytoliths in the Core #1 sediments confirms the presence of panicoid grasses at the site of Mound D. However, the lack of panicoid grass phytoliths throughout the mound fill does indicate strongly that such grasses were only present in the 145-165 cmbs strata. Corn is a panicoid grass and, as such, could possibly have been the bearer of the phytoliths that remain at the base of the mound. However, the crossbodied and dumbbell shaped phytoliths are also associated with non-corn grasses. In addition, the ubiquity of saddle-shaped phytoliths, which are generally associated with chloridoid rather than panicoid grasses, suggests that there is a higher likelihood that wild grasses were growing prior to the construction of Mound D.

Chapter VIII. Summary and Conclusions

This study has served to provide data on the sedimentology of the Ocmulgee "cornfield" mound (Mound D). The Mound D soils have not been available for study since Kelly's excavations in the late 1930s. With this in mind, as much data as possible on these soils has been recorded by this study, although the specific scope of the study was to confirm unsubstantiated theories regarding the building of Mound D at Ocmulgee National Monument on a corn field.

Study Results

Soil chemistry has provided a detailed accounting of the constituents present both beneath and within the mound fill. For the purposes of this study, the results of the chemical analysis indicated that the soils located beneath the mound fill could have been used in agricultural activities and that the soil elements were favorable for the preservation of botanical microfossils. The particle size analysis provided data on sediment texture and highlighted a significant rise in the percentage of sand in the soils beneath the Mound D fill. Particle size also served to reflect the degree to which downward percolation may have been a factor in the presence of microfossils at the base of the mound. Based on the results of the particle size analysis, estimated downward percolation was insufficient to have significantly contaminated the spatial integrity of microfossils beneath the mound fill.

Pollen was present in the soils located beneath Mound D (145-165 cmbs), albeit in small numbers. However, the pollen grains identified represent only pine trees and unidentifiable grasses. The grass pollen does resemble *Zea mays* pollen grains in physical characteristics, but differs significantly in grain size. Phytolith analysis of the soils from below the mound fill resulted in the identification of variants of both chloridoid and panicoid grass phytoliths, however, the size of the possible panicoid variants did not meet expectations for corn.

Table 7 presents a comparison of the analytical results obtained from the modern day cornfield and the Mound D soils, specifically those A.R. Kelly called the cornfield. The modern field soils contain a significantly larger percentage of clay than do those recovered from beneath the mound fill. Soil chemistry corresponds more closely. This is particularly true when comparing the elemental values between the other levels of the Core #1 soils and the modern field soils. Stable isotope analysis did not provide conclusive data for the cultivation of C4 plants, such as corn, in the modern field soils. The mound soils reflect stable isotope values in at the extreme end of the range expected for the growth of C3 plants, again providing inconclusive data regarding the growth of corn. Both corn pollen and phytoliths were identified in the modern corn field soils. Neither were identified in the mound soils. The absence of corn pollen and phytoliths in the Mound D sediments is not a factor of sample size, as the same size sample was taken from the mound and modern field.

While not entirely conclusive, this evaluation of the soils from a modern corn field provides some framework for the conditions necessary for the identification of prehistoric agricultural fields. Used comparatively, the analytical values obtained for the modern field can be used to advance a set of expectations to be met by

Table 7. Comparison Of Analytical Results Obtained From Modern Corn Field and Mound D (145-165 cmbs) Soils.

Sample	% Sand	Selected Chemistry Results	Stable Isotopes	Potential for Microbotanical Preservation	*Zea mays* pollen present	*Zea mays* phytoliths present
Modern Field	0-25cmbs 62.42% 25-30cmbs 74.72%	0-25cmbs Al 5.8% Ca 0.12 Fe 1.83 K 0.71 Mg 0.12 Ni 14 P 800 *	0-25cmbs $\delta^{13}C$ -21.6 and -21.63 $\delta^{15}N$ 7.00 and 7.06	moderate	yes	yes
Mound D, Core #1	145-165cmbs 80.23%	145-165cmbs Al 3.54% Ca 0.43 Fe 1.65 K 0.93 Mg 0.25 Ni 11 P 250	145-165cmbs $\delta^{13}C$ -23.04 and -22.91 $\delta^{15}N$ 6.04 and 6.07	moderate	no	no

***continually supplemented**

areas hypothesized to be prehistoric agricultural fields. Such criteria would include:

1) Morphological features consistent with organized planting (e.g. rows/furrows, mounds)
2) Significantly high sand content
3) High values of aluminum, calcium, iron, potassium, magnesium, and nickel; low values of phosphorus
4) $\delta^{13}C$ values above -22 for C4 plants only; below -22 for C3 plants
5) Presence of cultigen pollen and phytoliths (if conditions amenable to preservation are present)

The soils beneath Mound D, Kelly's "cornfield", meet several of the criteria for an agricultural field. Morphologically, they are similar to other fields for which agricultural production has been confirmed, such as the fields identified at the Ceren site. The percent of sand size particle peaks in the possible field level sediments (145-165 cmbs). The chemical signature of the Mound D field level sediments resembles that of the modern field soils, although certain variations may exist due to the supplementation of nutrients in the modern field. The stable isotope values for carbon in the Mound D field level sediments are very similar to those obtained from the modern field sediments. Based on this combination of factors, the hypothesis the Mound D was constructed on top of a field is supported.

All factors described above are consistent with the in-situ preservation of pollen and/or phytoliths in the Mound D field level sediments. However, no preserved corn pollen or phytoliths was identified. The botanical microfossils that were identified were from trees and non-cultigen grasses. The presence of corn pollen in the modern field suggests that the size sample taken from beneath Mound D was sufficient to encounter pollen if it was present. Also, as noted in Chapter VI, no other cultigen pollen was identified. Based on this combination of factors, the species grown in the Mound D field cannot be determined. It cannot be concluded that the field was a cornfield, nor can its identity as a cornfield be ruled out.

Fungal spores were particularly prevalent in the Mound D 145-165 cmbs level soils (as noted in Core #1). While it is not within the scope of this study to address such issues, identification of these spores, in tandem with the phytolith and pollen analyses results, could be utilized in environmental reconstruction studies. Also of potential significance is the apparent indicator value of the spores. As was discussed in Chapter VII, the frequency of spores in the soil samples clearly delineated the pre-mound construction ground surface. This avenue of research is worthy of additional attention.

Implications of Results and Conclusions

This analysis of the soil characteristics and microbotanical material has shown that while the species grown beneath Ocmulgee's Mound D cannot be determined, the function of the rows and furrows noted by A.R. Kelly can be described as an agricultural field. The data obtained from this overall analysis suggests that the mound was constructed in multiple phases in an agricultural area, unfortunately, the theory that Mound D was constructed on top of a cornfield has not been substantiated by the results of this study.

In addition to exploring the viability of the "cornfield" theory, this study has provided comparative data for future identification of prehistoric fields (particularly corn fields), based on a modern day equivalent. It has also highlighted the value of both pollen and phytolith research, when preservation of other microbotanicals is poor. Although more work is needed in identification procedures for phytoliths, this is a useful tool in ethnobotanical research.

While intuitive interpretations of visible ground surface features is a first step in determining the land use patterns of Native American peoples, this research has sought to provide a scientific basis for such interpretations. It is hoped that researchers will begin to more fully employ the wide variety of soil analyses available to explore and examine their ideas about past lifeways.

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Appendix A. ARPA Permit

Please use this number
when referring to this permit
No.: OCMU 97-001

DI Form 1991 (Sept. 1992)
OMB No. 1024-0037
Approved through 7/31/98

UNITED STATES DEPARTMENT OF THE INTERIOR

FEDERAL ARCHEOLOGICAL PERMIT

To conduct work upon public and Indian lands owned, controlled or held in trust by the Department of the Interior under:
☑ The Archaeological Resources Protection Act of 1979 (P.L. 96-95; 93 Stat. 721, 16 U.S.C. 470aa-mm) and its regulations (43 CFR 7).
☐ The Antiquities Act of 1906 (P.L. 59-209; 34 Stat. 225, 16 U.S.C. 431-433) and its regulations (43 CFR 3).

1. Permit issued to:

George A. Brook, University of Georgia

2. Under application dated:

6/26/97

3. Name, address and official status of person:

a. In general charge:

George A. Brook
University of Georgia, Athens
Department of Geography
Athens, GA 30602

b. In direct charge:

Dawn M. Reid
5890 Unity Dr. Ste A
Norcross, GA 30071

4. Activity authorized:

Mound D: soil coring with hand auger, two cores not to exceed 2 inches in diameter and 2 meters in length
Midden fill at Lamar: soil coring hand auger, two cores not to exceed 2 inches in diameter and 2 meters in length

5. On lands described as follows: Ocmulgee National Monument-Macon Plateau and Lamar sites– Mound D and Lamar
Control No.

6. For period: July 1, 1997 to September 30, 1997

7. University, museum or other scientific or educational institution in which the materials collected under this permit will be deposited for permanent preservation: (A copy of a current, valid curation agreement must be kept on file with the land managing agency (ies)).

Southeast Archeological Center, 2035 E. Paul Dirac Drive, Box 7, Johnson Building, Suite 120, Tallahassee FL 32310

8. Special conditions: This permit, as checked above, is subject to the provisions of the Archaeological Resources Protection Act of 1979 and its regulations (43 CFR 7), or the Antiquities Act of 1906, its regulations (43 CFR 3), and interdepartmental regulations (25 CFR 261) as to Indian lands. All permits are subject to the provisions of the Native American Graves Protection and Repatriation Act of 1990, the regulations for the curation of Federally-owned and administered archeological collections (36 CFR 79), and the special conditions attached.

9. Preliminary report: Within approximately 6 weeks of the conclusion of field work, a preliminary report of work performed under this permit, illustrated with representative photographs and listing new and significant collected materials, should be furnished to:

Dr. Bennie C. Keel, Regional Archeologist
Southeast Archeological Center
2035 E. Paul Dirac Drive, Box 7
Johnson Building Suite 120
Tallahassee, FL 32306

10. Signature and title of approving official:

John E. Ehrnehard, Chief, SEAC

11. Date

6/27/97

Paperwork Reduction Act Statement

This information is being collected to report on the results of archeological studies conducted on lands under the jurisdiction of the Department of the Interior. This information will be used to ensure that the work was conducted in accordance with statutory and regulatory requirements and any terms and conditions stipulated in the permit. Response to this request is required to obtain a benefit. The public reporting burden for the preliminary and final reports is estimated to average one hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining data, and completing and reviewing the reports. Direct comments regarding the burden estimate or any other aspect of this form to the Information Collection Clearance Officer, National Park Service, Washington, D.C. 20013 and the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, D.C. 20503.

8.(CONTINUED) Special conditions are checked (X) as appropriate to this permit:

a. X This permit shall not be exclusive in character, and there is hereby reserved unto the landowners the right to use, lease or p the use of said land or any part thereof for any purpose.

b. X Other institutions may be engaged in archeological research in the general area covered by this permit. In case there shou conflict with respect to a site not specifically designated in a permit, the parties concerned shall reach agreement bet themselves as to which shall work the site.

c. X The Department of the Interior, including its bureaus and employees and the landowners and their grantees, shall be blameless for any and all events, deeds or mishaps, regardless of whether or not they arise from operations under this permit.

d. X Such guidance and protection as is consistent with duties of the Department of the Interior official in charge of the area w afforded the permit holder and his party.

e. X Transportation in Department of the Interior vehicles cannot be furnished, except in cases where no extra expense t Department is involved.

f. X All costs shall be borne by the permittee.

g. X Excavation or removal of any Native American human remains, funerary objects, sacred objects, and objects of cultural patri must be preceded by consultation with or, in the case of tribal lands, consent of the appropriate Indian tribe or Native Haw organization. Consultation should be conducted with the lineal descendants, tribal land owners, Native American representa and traditional religious leaders of all Indian tribes and Native Hawaiian organizations that can reasonably be assumed culturally associated with the cultural items or, if the cultural affiliation of the objects cannot be reasonably ascertained, whose judicially established aboriginal lands the cultural items originated.

h. X All excavated areas shall be restored by filling in the excavations and otherwise leaving the area in as near to original conditi is practicable.

i. X The permittee shall conduct all operations in such a manner as to prevent the erosion of the land, pollution of the water resou and damage to the watershed, and to do all things necessary to prevent or reduce to the fullest extent the scarring of the lands.

j. X Any findings of mined or processed metals or other treasure or treasure trove in the area covered by this permit are the excl property of the landowners, and shall not be disturbed or removed from the site without specific written permission fro Department of the Interior.

k. X Two copies of the final report, accompanied by a completed NTIS report documentation form (optional form 272), wi submitted to the: Southeast Archeological Center
Any report formally submitted to a Federal agency is to be listed in the National Archeological Database (NADB-Re administered by the National Park Service. Procedures for submitting the required information for NADB listing are ava from the Archeological Assistance Division, National Park Service, P.O. Box 37127, Washington, D.C. 20013-7127.

l. _ Before undertaking any work on lands administered by the Bureau of Reclamation, clearance should be obtained from the of in charge of the area.

m. X Before undertaking any work on lands administered by the National Park Service, clearance should be obtained fron superintendent in charge of the area.

n. _ Before undertaking any work on lands administered by the Bureau of Land Management, clearance should be obtained fro Office of the State Director and from the BLM District Officer in direct charge of the area concerned.

o. _ Before undertaking any work on lands administered by the Fish and Wildlife Service, clearance should be obtained fro Office of the Regional Director and from the Refuge Manager in charge at the appropriate Fish and Wildlife Refuge. Posse or use of firearms in such areas is prohibited.

p. _ Before undertaking any work on Indian tribal lands or on individually owned trust or restricted Indian lands, clearance shou obtained from the Bureau of Indian Affairs official having immediate jurisdiction over the property.

q. X Other special conditions continued on attached sheet(s).

DI Form 1991 (Sept. 1992)
OMB No. 1024-0037
Approved Through 7/31/98

ARPA Permit Special Conditions

1. All artifacts will be catalogued to the NPS and SEAC standards. Collections will be bagged, labeled, and stored to NPS and SEAC standards. If the collections are less then 1 cubic foot in size SEAC will catalog, bag, and box the collection. If larger the permit holder will be responsible for these activities. Artifacts from NPS lands will be catalogued under **SEAC Accession Number 1312.** Questions relating to cataloging should be directed to Richard Vernon at the Southeast Archeological Center (9040580-3011 x 142). The permit holder should contact the park for the park accession number.

2. Specimens and data (original notes, maps, photographs, records, etc.) will be delivered to the Southeast Archeological Center, National Park Service, 2035 E. Paul Dirac Drive, Box 7, Johnson Building, Suite 120, Tallahassee FL 32310, at no cost to the government.

3. Draft and final reports will be submitted to Dr. Bennie C. Keel, Regional Archeologist, Southeast Region at the above address (904-580-3011 x124).

4. The Research Design will be followed. Any modifications will be approved in writing by the Regional Archeologist.

5. An Archeological Site Management Information System (ASMIS) data record form will be completed for each new site recorded or old sites visited on NPS lands. They will be submitted the Regional Archeologist. If necessary a copy of the ASMIS manual can be provided by contacting Richard Vernon at the Southeast Archeological Center.

6. State site forms will be prepared for each new site found on NPS lands and submitted to the Regional Archeologist.

7. The park will be notified prior to undertaking survey and testing on NPS lands. Contact Jim Davis at (912-752-8257)

8. Site location information developed on NPS lands is the property of the NPS. Restrictions on dissemination of locational information pursuant to the Archaeological Resources Protection Act of 1979 and the National Historic Preservation Act of 1966, as amended shall apply.