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The Laboratory Excavation of a Soil Block from Sylvester Manor

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This article describes a method of retrieving a large intact soil block from the midden area of the Sylvester Manor site. The soil was micro-stratigraphically excavated within a laboratory setting and analyzed using new approaches to the direct observation of micro-artifact distributions and trace residues on soil surfaces. Low technology analytical methods were selected from fields unrelated to archaeology but readily accessible to workers in a standard archaeological processing laboratory. Preliminary findings are presented in the hope that new low-cost field and laboratory methods can be developed. For example particle mapping of micro-artifacts by direct observation of soil profiles is explored as a possible method of determining the relative dates of bioturbated deposits. A method of visualizing degraded proteins on soil surfaces by ultraviolet fluorescence tagging is presented as a way of collecting soft tissue residues. Lastly, the use of density beads with an aqueous heavy liquid is shown as a promising method for the collection of heavy minerals from soil samples.

Cet article décrit une méthode pour l'extraction d'un bloc de terre intact de grande dimension provenant du secteur de la fosse à déchets sur le site du Sylvester Manor. Le sol a ensuite été fouillé de façon microstratigraphique en laboratoire pour ensuite être analysé à l'aide de nouvelles approches. L'utilisation de ces méthodes a permis d'observer des distributions de microartéfacts et des traces résiduelles en surface des sols. Des méthodes analytiques utilisant une technologie rudimentaire ont été sélectionnées dans des domaines non reliés à l'archéologie, mais tout de même accessibles aux gens travaillant dans un laboratoire d'archéologie. Les résultats préliminaires sont présentés dans l'espoir que de nouvelles méthodes peu coûteuses et applicables au travail de laboratoire puissent être développées. On explore, par exemple, le potentiel d'une méthode consistant à noter la distribution de particules de micro-artéfacts observées dans les échantillons de sol afin de déterminer la dates relatives de dépôts bioturbés. Une méthode permettant de visualiser les protéines dégradées en surface du sol grâce au marquage par fluorescence ultraviolette est présentée comme une façon de prélever les résidus de tissus mous. Enfin, il est démontré que l'utilisation de billes de densité avec un liquide aqueux lourd constitue une méthode prometteuse pour la collecte de minéraux lourds dans les échantillons de sol.

Introduction

This paper gives an overview of the rationale, methods and some of the ongoing analyses used in the micro-stratigraphic excavation of a large intact soil sample. The sample was taken as a soil block to serve as an experimental platform for the development of innovative approaches to the study of site development and to the detection of trace substances and perishable materials in situ. It is hoped that this work will help develop new field methods as well as new laboratory procedures appropriate to a standard archaeological processing laboratory.

The soil block, measuring 40 × 50 × 65 cm (D × W × H), was removed intact from the South Lawn midden deposit at the Sylvester Manor site, for the purpose of laboratory excavation. The large size of the block allows the study of undisturbed artifacts in situ so that the position of trace residues and micro-artifacts can be plotted accurately in the soil and related to the undisturbed strata of large artifacts. Traditional methods of taking undisturbed soil samples such as coring with PVC pipe have difficulty penetrating middens without disturbing artifacts larger than a few cm.

By excavating under controlled laboratory conditions the hope is that one could more easily develop multiple approaches to common questions. This paper describes the approach to the excavation and focus on the following observational and analytical techniques: 1) mapping methods for the measurement of the post-depositional movement of micro-artifacts; 2) isolation of micro-artifacts by density using a heavy liquid with density beads; and 3) imaging methods using visible and ultraviolet light.

Scale, Resolution and the Context of Excavation

Field excavation is done at a scale that has been termed the "human scale" meaning the range of phenomena that are directly visible with the unaided eye (Holliday 1993; Stein 1991). Archaeologists have often made advances by adopting methods that expand on this scale and alter the resolution of their observations. By parsing space and time in finer and coarser increments one can refine or condense one's data sets to gain new insights. Below the fine end of the human scale soil micromorphology has added a new set of data by introducing the technique of petrographic thin sectioning of sediments and soils to examine the geogenic, pedogenic and anthropogenic processes at work in site formation (Courty, Goldberg, and MacPhail 1989; Fedoroff, Bresson, and Courty 1985; Matthews 1997). Expanding the coarse end of this scale the technologies using geographic information data have allowed new ways of making intra-site and inter-site relationships of cultural environments.

Soil block excavation expands the human scale below the fine end of the unaided eye and also improves the human scale of field observations by allowing greater control and variety in lighting that a laboratory environment provides. It is defined as an approach that applies microstratigraphic excavation techniques and basic laboratory instrumentation to intact soil samples large enough to contain multiple whole artifacts in undisturbed soil matrix. Using this approach whole artifacts can be studied in situ and related to the micro-artifact distributions of the surrounding matrix.

While the resolution of the soil block analysis under discussion is similar to that of most archaeological processing laboratories, that is, at the level of optical microscopy up to that of the unaided eye, an important change is that analyses are done during the course of excavation and not as a separate post-excavation processing phase. The processing of analyses during soil block excavation can re-direct the focus of the excavator and alter the course of the excavation.

Since the soil block is not excavated until it is brought into the processing laboratory, archaeological excavation itself becomes a laboratory procedure and not a field procedure. This redefinition of excavation has implications that are only being discovered now. It expands the time frame for excavation from the limits of the field season. The soil block under discussion was excavated intermittently over one year. This change to the chronological scale of one's excavation has effects on data gathering procedures and resolution. The lengthened time frame allows increased documentation of the process and finer resolution in the scale of one's observations. More importantly the positioning of the unexcavated matrix within a laboratory allows one to add an experimental component to the excavation process. Under the controlled conditions of the laboratory one can experiment with new visualization methods and develop new field techniques.

Moving the excavation process to a laboratory setting also has the potential to involve a wide range of archaeologists and students in the process. As the work of the soil block excavation is done around other staff duties its pace slows creating deliberative periods of days or even weeks between the removal of successive strata. During these periods various members of the staff at the Fiske Center for Archaeological Research, University of Massachusetts Boston, were consulted to provide inferences regarding the finds, to suggest innovative methods and most importantly to situate the soil block within the context of the site as a whole.

The author, an archaeological conservator with over 30 years of experience in preservation in both laboratory and field, has had relatively little experience in field excavation. Close collaboration with the archaeological team of the Center has been essential to fill this gap in experience. This is important because the archaeological excavation process has no direct analog within the field of artifact conservation. While the isolation of finds in the soil block by the removal of soil matrix could be considered a very radical form of cleaning, no analog exists where the ultimate goal is the complete though orderly destruction of the object being "cleaned"!

And it cannot be said that there is a conservator's approach to the excavation process. The attitudes and methods used in the soil block under consideration may be more idiosyncratic than characteristic of the field of conservation. But it can be said that the conservator tends to approach artifacts differently from the archaeologist and that such differences may affect the outcome of excavations. One area, a difference of degree more than kind, is the extent to which conservators use photographic documentation including macro-photography. Repeated visible and at times ultraviolet light imaging is a standard component of all conservation treatments. It is also common for the conservator to interrupt the treatment process to carry out microscopic and micro-chemical analyses. In other words, there is no field season in laboratory artifact conservation.

Another possible area of difference between the conservator and archaeologist is the conservator's reluctance to view individual artifacts as examples of their class. Because of unexpected problems encountered during the treatment process conservators tend to treat each artifact as potentially unique no matter how well it fits within a known class of objects. This alters the concept of the archaeological data set by promoting attention to differences over the similarities within classes.

Finally archaeological conservators tend to function as adjuncts to the primary team and are often outside of the inference building traditions of archaeology. This has both positive and negative effects. The "fresh eyes" of the conservator as outsider can just as easily be re-invigorating to a long term inquiry as it can be a complete waste of time and resources. The work described here should be understood in the context of an experiment in the process of excavation and with all true experimentation the results are not guaranteed.

Site and Sediment

Sylvester Manor is located on Shelter Island at the eastern end of Long Island, New York. It is the site of a 17th-century Dutch provisioning plantation. For a short time a community was formed including enslaved Africans and Native American laborers working under the direction of the Sylvesters to furnish provisions for themselves and for an affiliated sugar plantation on the Island of Barbados. The laborers built the dwellings, barns and storerooms, tended the livestock and the fields from 1652 into the 18th century.

The manor is situated on the shore of a protected inlet allowing a shallow water site for loading Barbados-bound shipments and from which the large amount of coral we encounter in the midden was off-loaded as ballast. The buried midden layer under study covers an area of more or less 40 m^2 on the South Lawn of the manor. It is not a stratigraphically continuous deposit and shows lateral facies changes and pinching out of stratigraphic units across the feature. The soil block under study was taken from the south central section of the midden (FIG. 1).

The geology, climate, hydrology, and soil fauna were reviewed to understand the depositional and post-depositional effects acting on the site generally and on the buried midden. The native soils of Shelter Island have formed from a glacial till sheet deposited as part of a recessional moraine of the Wisconsin glaciation approximately 10,000 years ago (Fuller 1914). These soils generally are classified Inceptisols (Brady and Weil 2002) which are young soils with weakly developed profile features. Around Sylvester Manor we see them only as agriculturally altered forest soil profiles (Proebsting 2002). Plowing in these areas has lowered the typically shallow boundary between the A and B horizons and made that transition more diffuse.

While plowing disturbance is not evident in the immediate area of the soil block there is a second type of anthropogenic alteration to the soil profile. Sometime between 1735 and 1750 a landscaping layer approximately 25 cm thick was applied over the 17th-century surface surrounding the current manor house, burying the midden area under study. The applied loam is similar to that of the area and appears to have been locally built up by stripping soil from the environs.

As mentioned, the soil of the block and surrounding midden is a fine sandy loam with little clay present in the top 50 cm though the fine sand grades into silt with depth. Still deeper sporadic dusty clay coatings and infillings become visible in micromorphological thin sections at 60 cm below surface (FIG. 2). The level at which the clay infillings begin also marks the upper edge of the feather region of the water table where capillarity maintains the soil in a partially dampened state.

Eastern Long Island receives an average of 46 in (117 cm) of precipitation annually. It falls with little variation throughout the year at a rate of between three to five inches per month (NCDC 2001). The A horizon soils are porous and permeable, allowing rapid entry of precipitation into the soil column. The B horizon

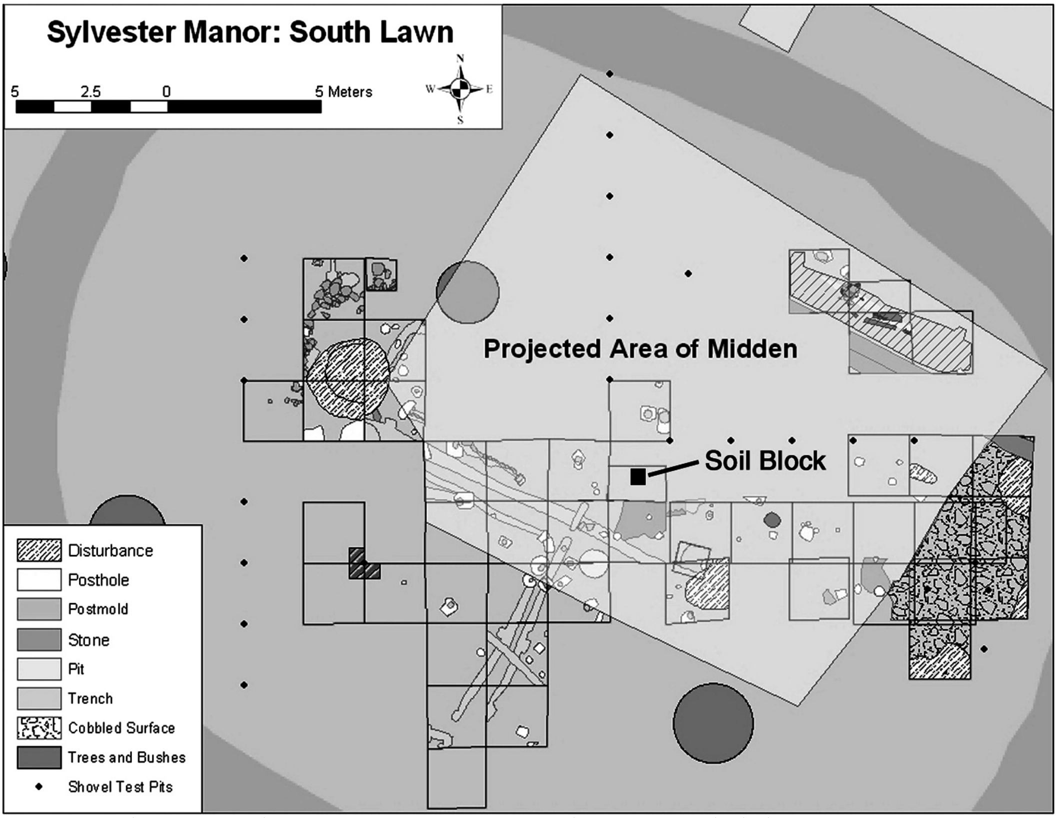
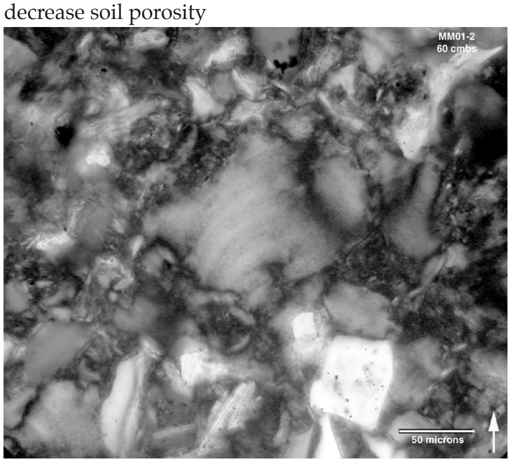


Figure 1. South Lawn area showing location of midden and the area from which the soil block was retrieved.

soils have an increased silt fraction with some clay but they still allow adequate rainwater percolation from the surface to the top of the water table to avoid waterlogging. Though the water table can rise to approximately one meter below surface during heavy rains, hydrologists measuring the residence time of soil water have found that the average age of water in the upper aquifer is relatively short, only five years at its surface (Schubert 1999). This rainfall and high drainage rate can be expected to degrade and remove perishables from the archaeological deposits unless protected in some accidental way by an atypical soil micro-environment.

Climate data (DeGaetano, Wilks, and McKay 1996) also suggest that while the winters are mild the soil surface temperatures nonetheless cycle repeatedly above and below freezing, thus leading to the possibility of frost damage to shallow archaeological strata and artifacts. On the other hand, the soil is well-drained which may limit the extent of frost heaving and cryo-fragmentation to the thin ice lensing evident in the top 5–10 cm of the modern soil surface. The high permeability and porosity of the surface loam allows rainwater to percolate quickly down to depths where

Figure 2. Photomicrograph under cross-polarized light showing B Horizon soil with clay infillings that decrease soil porosity



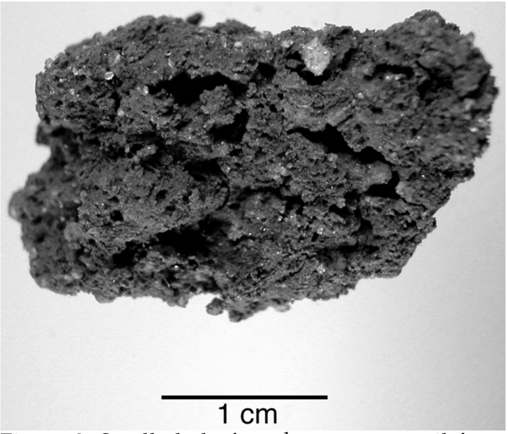


Figure 3. Small clod of earthworm cast soil from buried sheet midden showing its high porosity and good preservation.

frost does not penetrate. Without high amounts of available moisture in the frost-prone layers, thick ice lenses cannot develop at depth (Van Vliet-Lanoe 1985).

In its original mixed forest state the natural soil, known as Montauk series MfB, may have been strongly acid with a pH typically around 4 to 4.5 (Warner 1975). The pH of the modern soil profile varies from mildly acid above and below the midden layer to neutral near the midden layer (35 cm below surface) where the soil pH rises to 7.0 presumably due to the large amount of fragmented shell, coral and bone. The soil then gradually becomes mildly acid again below the midden and stabilizes at the B horizon with a pH around 6.0 at 47 cm below surface and lower. The mild acidity of the landscape layer may be the result of leaching of acid forest soils or the deliberate use by the landscapists of nearby Bridgehampton series BgB soils located just to the east of the manor and known to have a pH around 6.0.

The acidity of the forest soil normally limits the spread of earthworms (Edwards and Bohlen 1996). But in the midden area a historic explosion of that population occurred after the alkaline bone, shell and coral were deposited. Earthworm tubules appear to be the single greatest cause of the bioturbation and soil porosity increase we see below the midden layer. They have created, along with attendant root disturbances, a mixed A/B horizon. Separating two layers of midden deposits is an earthworm cast layer of approximately 5 cm. The crumbly, aggregated character of the cast layer is evident to the naked eye (FIGS. 3 and 4). The texture of surface earthworm casts is very sensitive to rainsplash and trampling. Its preservation may indicate a relatively short exposure of the midden surface before landscaping and/or protection from the elements by some overhanging roofline or dense shrubbery.

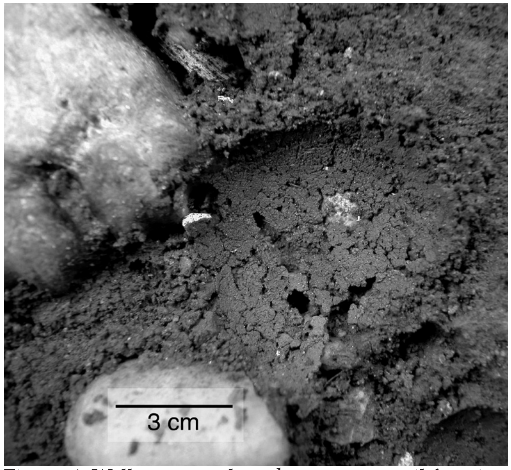


Figure 4. Well-preserved earthworm cast soil forming part of the bone layer of the buried midden layer. Note voids left by unfilled earthworm tubes.

The earthworm activity at the midden level appears to have been quickly stopped when the landscaping layer of sandy loam was applied. It is uncertain whether this is due to the formation of a new surface or due to the use of acid soils for the landscaping layer. Micromorphological examination of a thin section taken from the earthworm cast layer of the soil block suggests that the latter effect may have been at work. The earlier earthworm casts are shown to have been subsequently mined by enchytraeid worms, organisms that tolerate greater soil acidity (FIG. 5).

Field Retrieval

While blocklifting is a common archaeological practice it is usually done to retrieve artifacts or contexts that are extremely fragile (Beaubien 1993; Payton 1992). As such, the container for the unconsolidated soil is always custom tailored to the size of the object and its surrounding matrix. The work under discussion is unusual in that sampling of soil blocks of standardized size was planned from the outset; this allowed the construction of a reusable blocklift container. The size was limited

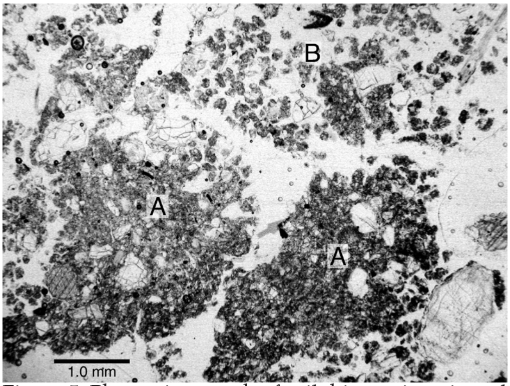


Figure 5. Photomicrograph of soil thin section viewed under plane-polarized light showing two earthworm casts in the bottom half (A) and a third cast that has been re-worked by enchytraeid worms in the upper right (B).

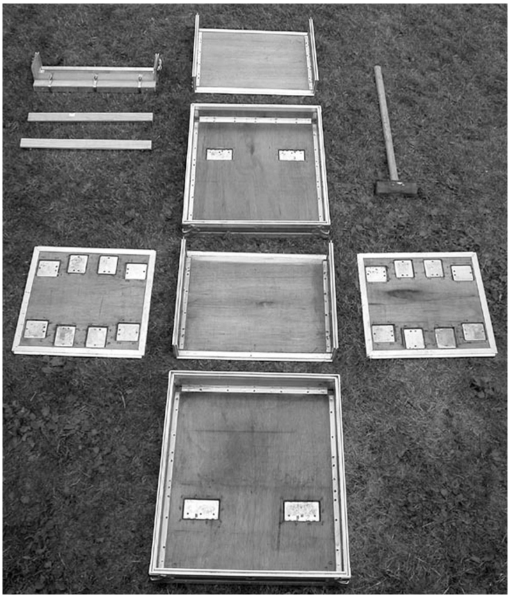


Figure 6. Disassembled six-sided soil block case.

by the maximum weight of soil that could be handled and transported without special equipment; this corresponded to a volume 50 cm wide, 40 cm deep and 65 cm high. At that volume soil density measurements showed that the block would weigh approximately 800 pounds. The height of 65 cm was selected because it would allow complete profiles to be retrieved from most areas of Sylvester Manor. The length and width dimensions were selected as minimums that would leave large artifacts undisturbed.

A crating design called a "knock-down" case commonly used for shipping museum sculpture was adapted as a re-usable support for blocklifting. It is made of six panels or sides. Each side is constructed of plywood that has been bonded to ABS plastic sheeting for extra strength and rigidity. All panels have aluminum tongue and grooved edges to allow strong and precisely aligned joins. When joined together using quick-release fasteners they form a box robust enough to support the 800 lbs (FIG. 6). Past experience showed that such a case could be re-used indefinitely. Because it was engineered to close tolerances any damaged panel is replaceable at low cost.

In addition to the case, a metal guide plate was constructed of two sections of sheet metal joined at the leading edge. It would be driven under the soil block, then the two plates separated to allow the bottom of the case to be driven in more easily. In the field the soil block was isolated by excavating around it to a depth of approximately 70 cm. To maintain cohesion the soil was kept damp and wrapped with layers of a semi-rigid twin-walled polyethylene sheeting. The case bottom guide was hammered into place. The upper sheet was bent upward and the case bottom was driven in between the two plates of the guide. The sides and top were then attached and any voids were filled with rigid foam insulation panels. The completed case was then slid out of the excavation pit on a wooden ramp and shipped to the laboratory (FIG. 7).

In the lab the case was placed in a cradle that tilted the soil block at a 45° angle. This angle provided stable plan and profile excavation surfaces. The cradle was then fitted for microscopy and given flexible work lighting, microscopy lighting using two LED lamps and two longwave ultraviolet lamps for fluorescence imaging. During work periods the top of the case and one side were removed to provide access to both plan and profile surfaces (FIG. 8). Because most soils shrink as they dry, the soil block was periodically sprayed with water and always stored under a dampened cloth. This helped to avoid shrinkage cracks in the unimpregnated soil block. It also maintained the population of living soil fauna. Samples of the live soil fauna provided a better understanding of the effect of the fauna on soil microstructure. Mites, enchytraeid worms, snails and arthropods were common.

Figure 7. Soil block being encased in the field.

Initial Overview and Development

Once in the laboratory the soil block was prepared by removing the duff layer from the plan surface and about three cm of disturbed profile surface from its North face. The first profile was labeled A-A′ and reviewed to plan the excavation strategy (FIG. 9). When viewed in profile the soil block was seen to be composed of at least four layers. The top landscape layer (A1) presented itself as approximately 25–30 cm thick and composed of sandy loam grading down to silty loam. It covered a midden layer (A2) approximately 10 cm thick that appeared to include at least two depositional events separated by a layer of earthworm cast soil about 5 cm thick. This two part layering was especially apparent when viewed under longwave (365 nm) ultraviolet light (FIG. 10).

It is common in American historical archaeology to adopt soil classification terminology such as "A" and "B" soils as a basis for describing the layering of archaeological deposits within a site. When viewed in profile the obvious color differences of soils that are high in organics versus the lower mineral soils provide an initial framework for the archaeologist's study of the depositional histories of the artifacts. This gross organization is then subdivided into natural and arbitrary sublevels in order to parse the spatial relationships of the deposits studied. At Sylvester Manor for instance the dark loam below the duff layer is referred to as the "A1 layer" and the relatively artifact rich midden layer is termed the "A2 layer." While this terminology has its origins in the tradition of soil classification, it should be thought of solely as a method of organizing the archaeological deposits within a soil matrix and not as a descriptor of that matrix.

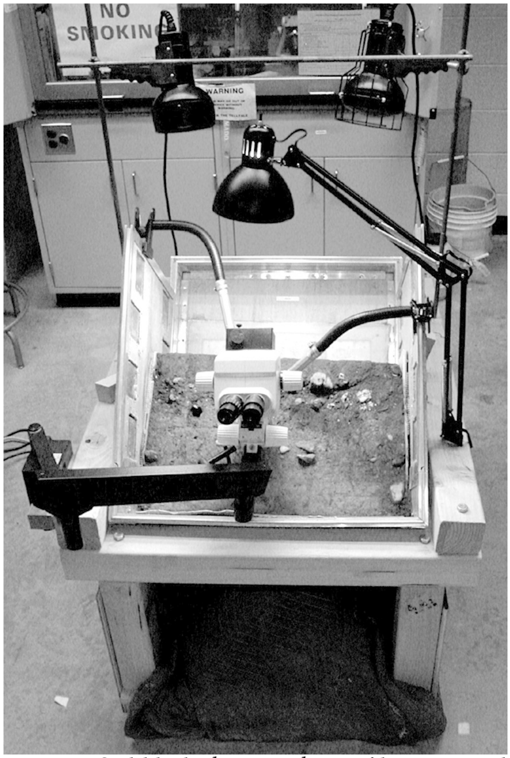


Figure 8. Soil block showing the profile positioned within a wood cradle at 45º angle and fitted for low power microscopy with LED lighting, incandescent lighting and two longwave fluorescent lamps.

The midden layers contained a variety of artifacts with some intermixing of layers. But each layer was clearly dominated by different material classes. The upper layer was chiefly composed of bone including butchered cow, sheep and pig remains along with some quahog shell. Below that was a richly organic earthworm cast layer, which showed good preservation, including a crumbly structure similar to fresh earthworm casts and a tendency to become increasingly brittle and fall away as it dried. Below that was a concentration of coral and some mortar. The midden deposits rested on about 20 cm of bioturbated soil (A/B) showing earthworm tubes and decayed root channels filled with loamy sediment. The center of this layer may have contained a collapsed rodent burrow. Isolated artifacts including a pipe stem and a butchered bone fragment were seen at the bottom of the A/B layer under the

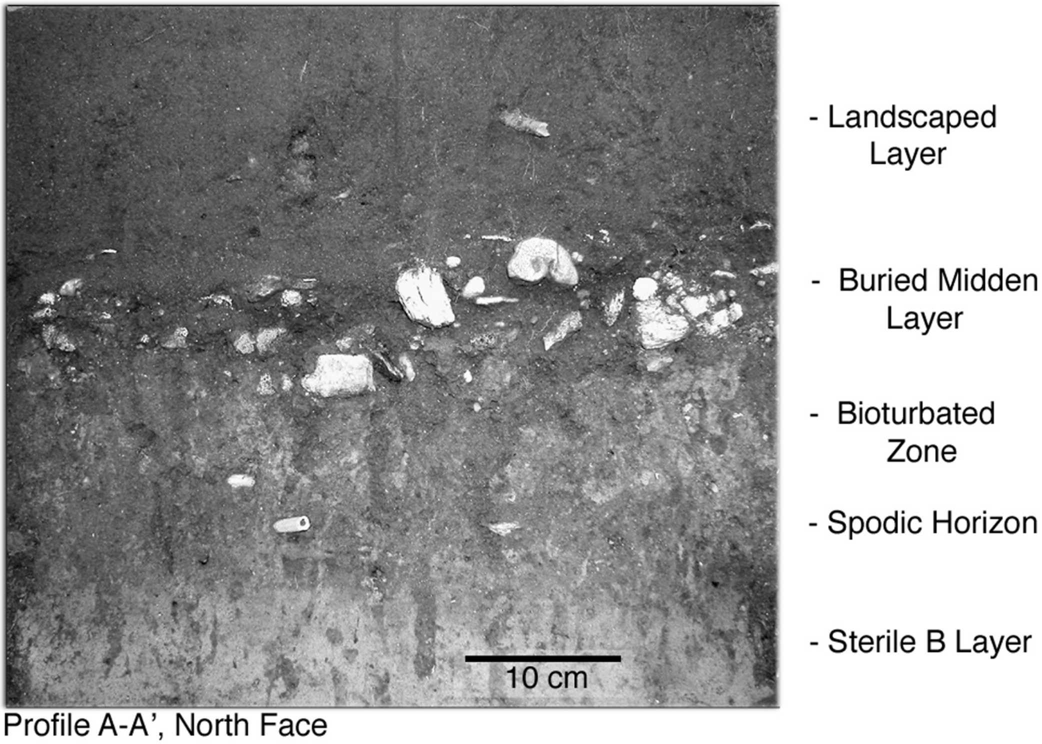


Figure 9. Profile A-A′ of soil block under visible light

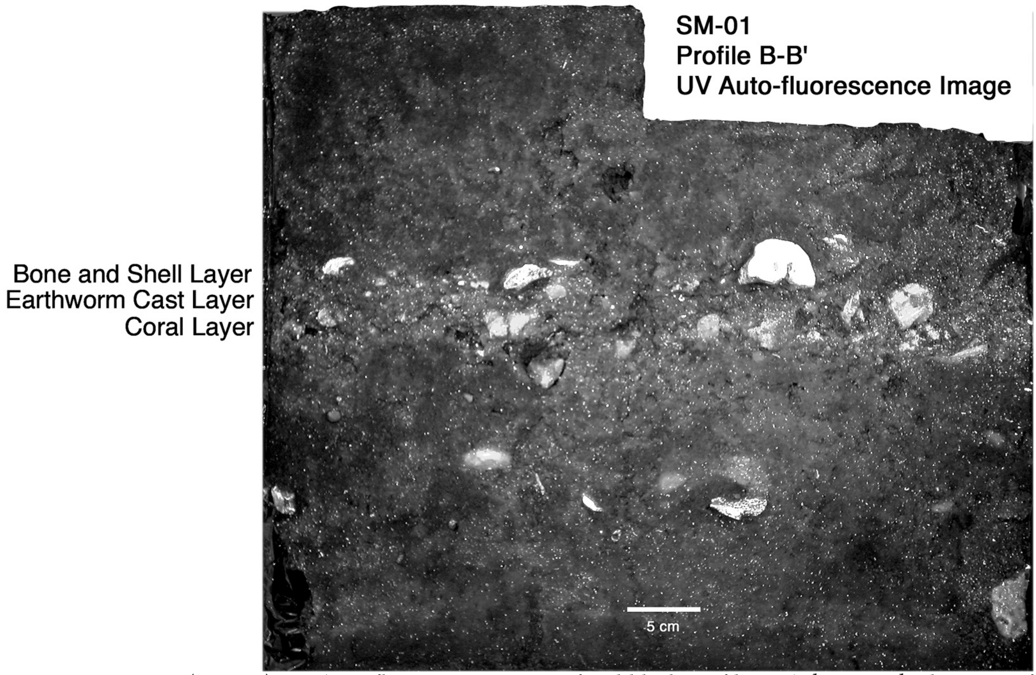


Figure 10. Longwave (365 nm) UV Auto-fluorescence image of soil block profile B-B′ showing the layering of the midden.

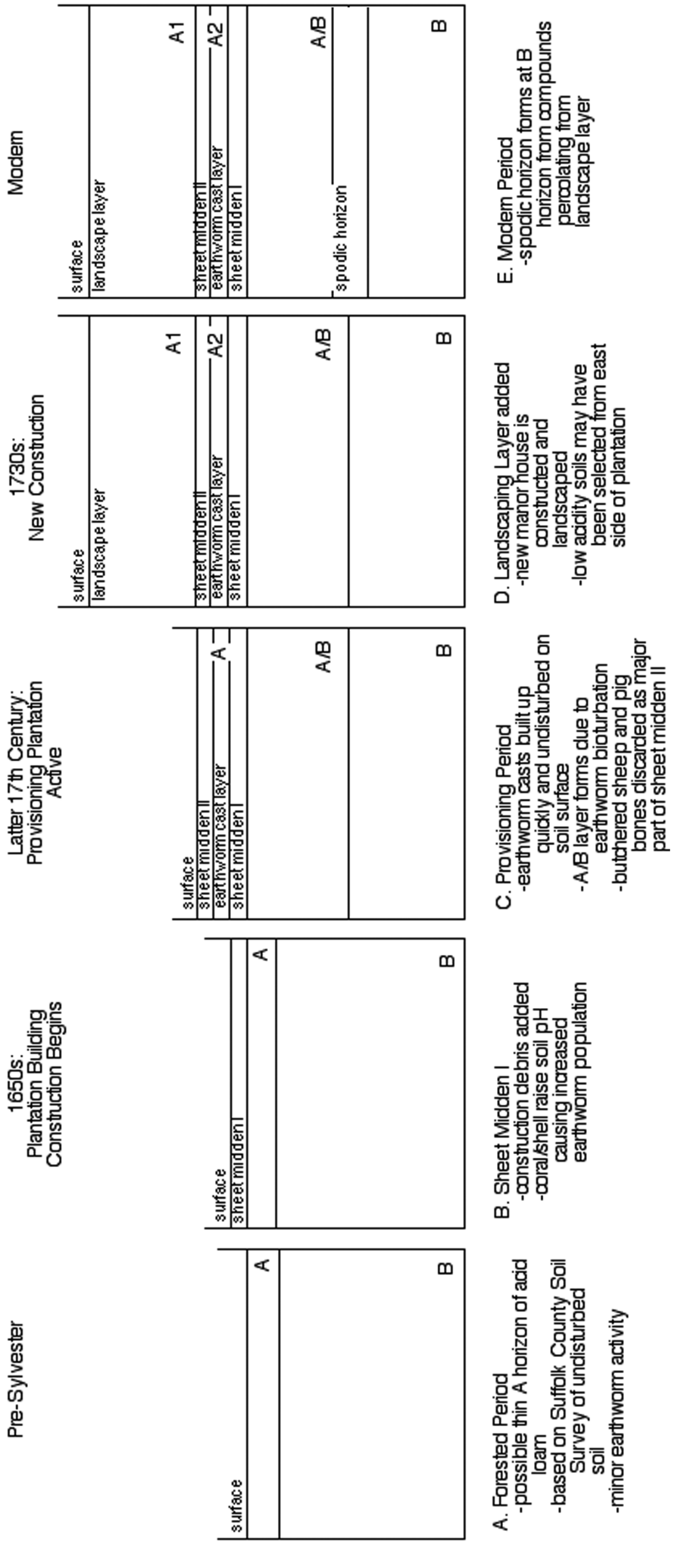


Figure 11. Schematic of soil block profile development based on previous archaeological data, historical documentation, soil survey data and an examination of the soil block facies.

relatively loamy center section of that layer. Also at the bottom of the A/B layer was a continuous dark band of stained soil 5–8 cm thick. After three centuries of leaching it appears that this is a developing "spodic" or accumulation horizon. Iron compounds and organics have been removed from the thickened loam layer by soil water and translocated through the porous bioturbated A/B horizon to accumulate at the top of the B horizon. The B layer is a clay-bearing layer showing reduced porosity compared with the upper layers. During laboratory observation it was seen to remain constantly damp while the top layers were prone to drying. The spodic horizon, a region of accumulation, is thought to have formed at the top of this layer because of its reduced permeability.

With this understanding of the block profile it was useful to hypothesize on the development of this area of the midden in order to help plan and focus the upcoming excavation of the soil block. It was kept in mind that the midden is a large feature with variable deposits and layering. So the development of the midden in the area around the soil block does not represent all of the feature. The soil profile development was divided into five stages of biogenic and anthropogenic progradation (FIG. 11).

Before the arrival of the Europeans, the soil profile would presumably have been that of a typical forested soil of Long Island with a shallow, acidic

A layer developing under a predominantly oak forest (Warner 1975) (FIG. 11A). The first European cultural deposit may date from the 1650s as the result of early transportation and construction-related activities. Coral, which may have served as shipping ballast, shell and mortar appear in the first layer in the midden. This changed the soil chemistry markedly by introducing carbonates and thus reducing the soil acidity (FIG. 11B). Responding to this chemical change the earthworm population grew dramatically and began forming the mixed A/B layer through worm tunneling into the B layer and the subsequent infilling of the worm tubes with earthworm casts and loamy soil translocated downward by rainwash. An earthworm cast layer began to develop at the historic soil surface and was intermixed with a second deposit of butchered bone and other cultural materials (FIG. 11C). The landscaping loam layer was then added and appears to have been associated with the construction of the new manor house at Sylvester Manor in the 1730s (FIG. 11D). The final alteration of the soil profile was the development over approximately 270 years of a darkened band or spodic horizon between the A/B and the B layers. This represents a concentration of leached organics and iron salts at the top of the less permeable B layer. Its importance here is that it appeared at first to be part of cultural deposits found elsewhere at the site that predated the midden. In fact it is now thought to be a pedogenic response to the application of the landscaping layer (FIG. 11E).

Micro-Excavation Plan

With the above in mind the exposed profile surface was re-examined closely under low powered magnification to plan the course of the excavation. The decision was made to use standard field methods (excavation in 5 cm arbitrary levels with 1/8″ screening) for the removal of most of the landscape layer. This layer had been well-described previously (Proebsting 2002) and its removal from the labor intensive process of micro-excavation would allow greater time to concentrate on the midden and underlying A/B layer. The A/B layer was selected as a particular point of interest because of the large number of micro-artifacts visible in it. These small artifacts appeared to be post-depositionally distributed as a result of the short but intense period of earthworm and root bioturbation of the midden layers. Since most of the disturbance occurred between the 1650s and 1730s it would provide a tight temporal timeframe for inferences on the rate of such vertical dislocation. With the midden layer being such a concentrated well-defined source layer for the translocated particles, it too would offer good controls on the comparison of particle densities to source materials. The question developed was whether direct low-power observation of carefully excavated profile surfaces would give micro-artifact particle distributions similar to those found by other researchers using the more labor intensive process of sieving soil samples by stratum.

Direct observation of profile surfaces required that excavation should begin by taking vertical slices of the soil block to create repeated surfaces for particle mapping. To accomplish this we removed two 5 cm slices from the original north face of the soil block. This yielded a total of three profiles of the buried midden for particle mapping. After these vertical slices were removed and the profiles mapped, the soil block was excavated more conventionally in horizontal levels. We removed the landscaping layer of soil on top of the buried midden as four 5 cm thick levels. Finally the buried midden was micro-stratigraphically excavated in a series of 23 1 cm levels from just above the buried midden down through the underlying turbated A/B layer (FIG. 12).

At this stage in the planning several other interests were developed unrelated to the micro-artifact study. Two of these activities are described here. As a routine conservation documentation procedure the profile had been examined under longwave (365 nm) ultraviolet light. The highly fluorescent coral, bone and shell materials were noted as well as the weakly fluorescent clay bearing areas. At the same time some highly UV absorbing areas were also noted especially in the midden layer. This was presumed to be due in part to the concentration of degraded organics in the earthworm cast layer. Some of the absorbance seemed related to the faunal remains in the midden and suggested that very degraded protein residues may still be present. So a novel

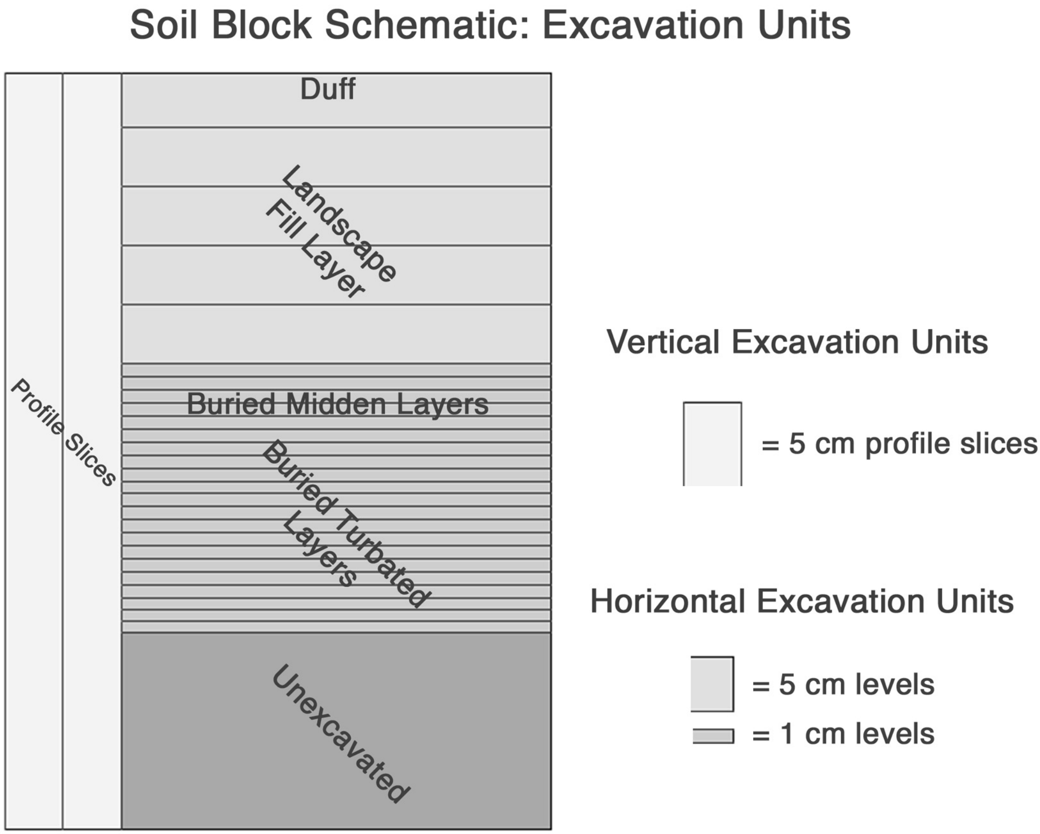


Figure 12. Plan for soil block excavation.

method of prospecting for protein residues was incorporated into the excavation plan. This method uses a chemical protein tagging agent that fluoresces under UV in the presence of proteins and is described below. The second interest was in exploring the potential for density flotation using heavy liquids and density monitoring beads to isolate metal artifact corrosion particles from the A/B layer. When metals corrode they can generate many small corrosion particles capable of descending with soil water into underlying soil layers. If the original metal object was for any reason removed from the site it may still be possible to detect its presence by the pattern of corrosion particles left underneath it.

Vertical Movement of Micro-Artifacts

The post-depositional movement of artifacts presents a common difficulty for archaeologists endeavoring to reconstruct human behavior through the spatial organization of cultural deposits. Attempts to describe that post-depositional alteration through the use of seriation curves and histogram plots have been made by many archaeologists, including Michie studying displaced artifacts at prehistoric sites in South Carolina (Michie 1990) and Leigh using micro-artifacts at Fort Bragg, North Carolina (Leigh 2003). Of the many forces working on artifacts some of the most significant are the two bioturbation forces: faunalturbation resulting from the tunneling and burrowing of animals and floralturbation including root disturbance. Also important at Sylvester Manor is cryoturbation or the alteration of surfaces due to freeze-thaw cycles (Leigh 2003). One form of cryoturbation that must be considered when studying the movement of artifacts is cryo-fragmentation—the breakdown of porous materials due to internal ice formation. It along with trampling has the

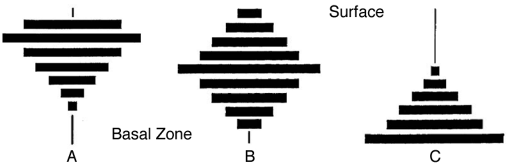


Figure 13. Effects of bioturbation and gravity on the achaeological record. A) Single component or recent assemblage in motion. B) Multi-component assemblage or deposit of long duration in motion. C) Single component assemblage or ancient deposit settling (adapted from Michie 1990).

tandem effect of displacing as well as disintegrating artifacts.

As the fragmentation of artifacts proceeds the small particles produced become more susceptible to movement. Archaeologists recovering these particles for grain-size analysis have used the term micro-artifacts to define the domain of their studies (Stein and Teltser 1989). This artifact category has been defined using sieving methods to include different particle size ranges depending on the researcher, the matrix studied and the magnifications used. The upper size limit for this category has been set as high as 6.23 mm (0.25 in.) and as low as 1.0 mm. Size range is important because the smaller the particle the more susceptible it may be to post-depositional movement.

For the purpose of this article micro-artifacts are defined simply as "small artifacts that generally require magnification for identification" (Sherwood 2001). The method of study here does not include a sieve-based approach to pre-define the data set. The mapping of particles in situ within an excavation profile using only low power magnification (10×) precludes the a priori definition of size ranges because particles are still partially embedded in the matrix. As such the upper and lower limits of the size range were not determined by sieving. However during the course of this study selected sample particles were removed completely from the matrix and measured. Using these sample measurements the range proved to be coarser than most micro-artifact studies, roughly from 16 mm down to 1 mm (-3 phi to 0 phi). The lower limit is set as that which can be resolvable at low-power (10×) magnification.

So while the artifact size class used in this study should be included in the category of micro-artifacts in that it requires magnification for identification, it should also be recognized that it is a coarser grouping when compared with sieve-based approaches. Because this size range may affect the results it was decided to use the micro-stratigraphic excavation to collect a separate set of sieve-based samples of micro-artifact of several size ranges from bulk soil samples of each layer. The analysis of that data is in progress now and will be reported in a future publication.

This study uses as its comparative test the work of Michie who showed that one could plot the vertical downward movement of artifacts and micro-artifacts as a function of time and display that movement graphically as a plot of artifact frequency distribution against depth (Michie 1990). He suggested that within a particular disturbed soil matrix characteristic distributions of these particles may develop over time. The shapes of these distributions could be used to indicate the relative age of the original deposit as well as the duration of the active deposition period (FIG. 13A-C). However Michie studied sites dating from the Early Archaic to Late Woodland periods using artifacts in size range of approximately 6.5 mm up to 65 mm and it was not clear whether the recent midden-related deposits of smaller particle ranges would show similar distribution.

This portion of the soil block analyses therefore addressed two research topics. First, while Michie found post-deposition artifact patterning that developed over more than 1,000 years, this study asks if the same patterning can be seen in a deposit of micro-artifacts that is no older than 350 years. The tight temporal controls on the midden deposition process suggested that the soil block would provide a good experimental platform to look for this distribution pattern.

A second goal was whether the method of profile mapping could be used to detect this patterning. Michie based his study on finds collected by excavation level. Profile mapping, if it worked, could be used in addition to or in place of the more labor-intensive method of collecting artifact distributions by screening and sieving excavation levels.

Given the large concentration of shell, coral and bone in the midden layers their distribution was examined first. These three substances were grouped because at the finest end of the size scale, 1 mm, they were not distinguish-

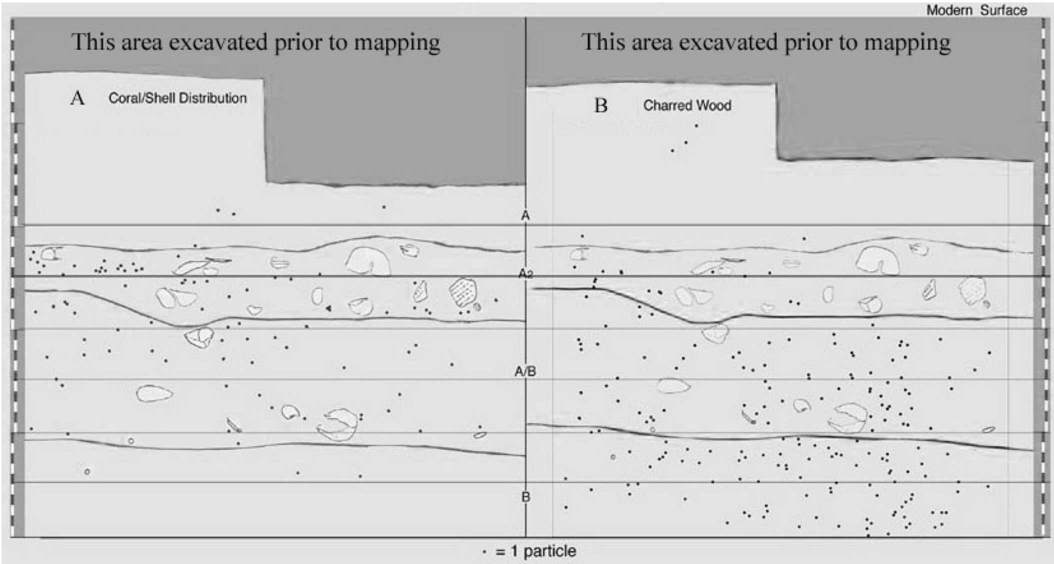


Figure 14. Profile map of B-B′ showing distribution of particles in the midden layer (A2), bioturbated layer (A/B) and the upper portion of the B layer. A) Distribution of coral, shell, and bone particles with in the size range of 0 to -3 phi (1 to 16 mm). B) Distribution of charred particles in the same range.

able from one another without removing them from the matrix. They also share the common property of being highly fluorescent under ultraviolet light. This proved useful in that, while all are visible under normal illumination, they proved easier to locate by reducing the visible light levels in the laboratory and adding ultraviolet illumination. As a group they also shared the tendency to be moisture absorbing and therefore prone to cryo-fragmentation. The question posed was whether the distribution of these materials might show the pattern shown in Figure 13A and described as a "single component assemblage in motion," that is, a group of materials derived from depositional events of short duration. From historical records we can be confident that all midden materials were deposited some time between 1650 and 1735.

During the preliminary examination of the profile a widespread distribution of charcoal particles was also noted. Since there was no concentration of charcoal visible in this area of the midden layer, it was decided to plot these materials and compare their distribution pattern to that of the coral, shell and bone group. In the absence of a discrete charcoal lens in the midden the charcoal pattern was thought to have developed over many millennia due to repeated forest fires and other burning events. Studies have shown that this is a common soil condition and that once formed charcoal can persist within the soil unaltered for millennia (Collins 1990; Skjemstad et al. 2002). Its distribution was expected to show different patterning from the coral, shell and bone group perhaps following the pattern of either Figure 13B or 13C, that is, derived from deposits laid down continuously over a long period of time or from ancient deposits.

To carry out this test a fresh profile surface labeled B-B′ was prepared by removing a vertical 5 centimeter slice from the north face of the soil block. It was illuminated under strong visible light to plot the charcoal distribution and under weak visible and strong ultraviolet light to plot the coral, shell and bone group. Using low power magnification these particles were directly plotted on clear plate glass sheets placed over the profile. Larger artifacts and layer boundaries were drawn onto the glass for orientation. Each glass was digitally photographed and the resulting profile image was divided into 5 cm levels extending from just above the midden to 30 cm below it to the bottom of the soil block (FIG. 14). The frequency of particles on each of the two particle maps was tabulated by 5 cm levels and compared (FIG. 15A and B). The comparison showed obvious differences with depth below the midden. The coral, shell and bone frequency

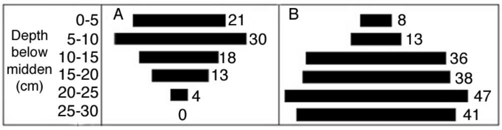


Figure 15. Frequency distributions of coral, shell, and bone (A) and charcoal particles (B) if size range 0 to -3 phi plotted by depth below the midden (in 5 cm increments) as recorded by direct inspection of soil block profile B-B′. Number of particles in each increment is shown to the right of the bars. A) Pattern typical of a single assemblage descending. B) Pattern of multi-component assemblage settling.

decrease with depth in the manner suggested by Michie (FIG. 13A) as indicating an "assemblage descending." This distribution confirms it as the recent, single component deposit we know it to be.

The charcoal frequency also conforms to one of the three test patterns but sample size limitations of the soil block make its exact interpretation uncertain. The pattern shows the particle density increasing with depth and shape; that of either a "multicomponent assemblage" (FIG. 13B) or an "assemblage settling at the base" of the strata (FIG. 13C). Even with this uncertainty it is clear that the shape of the frequency distributions reflects the natural versus cultural sources for the two material groups. The charcoal distribution is derived from a natural depositional process, the residue of millennia of forest fires. The coral, shell and bone profile is derived from a recent point in time, the 17th-century midden.

This comparison confirms that profile mapping of micro-artifact distributions can produce data that differentiates short-term recent events from long-term depositional processes. Further research is needed to understand the distribution of the charcoal and the reliability of profile mapping. It appears that particles extend well below the sampled B horizon. The character of the underlying soil layer in deforming that distribution must also be studied. The relatively undisturbed B layer has a decreased porosity due to its clay content and this appears to slow or stop particle migration thus forming a basal level with respect to the turbated zone.

Currently these preliminary results are being studied to see if they are supported by sieve analyses using samples taken from the corresponding micro-excavation levels mapped in the profile. The results, though limited, are significant in showing that the relatively easy

Figure 16. Flotation with heavy liquid showing glass bead descended with garnets collecting at stopcock.

method of mapping micro-artifact frequencies in bioturbated layers by directly inspecting profiles can produce data similar to the more labor intensive process of using grain analysis on bulk soil samples. They suggest that such a method, at least the variant using visible light inspection, may be easily adapted for field use. The method may be helpful in estimating the age of undated deposits and in separating precolonial deposits from relatively modern materials at sites that show post-depositional disturbance. It may also prove useful at looted sites where artifacts suspected as being removed from the site may be confirmed by plotting the frequency of micro-artifact particles below the supposed location of the missing artifact.

Two other studies of the bioturbated layer are also being conducted. Because of their preliminary nature they are described only briefly here to give a sense of the potential of the laboratory excavation of soil blocks.

Metal artifacts, primarily iron nails, were encountered in the midden layers of the soil block. While these do not have great interpretive value, their fragmentation patterns are being studied to test a method of density separation using a relatively new heavy liquid containing sodium heterotungstate marketed under the trade name of Fastfloat®.[1] This water-based heavy liquid provides a starting density of 2.95 gm/ml at 25° C. and can be used to isolate the high density iron corrosion products found in the bioturbated layer. It has been shown to be useful for the extraction of diverse archaeological materials from bulk soil

[1] Central Chemical Consulting Pty Ltd, PO Box 2546, Malaga, Western Australia, 6944

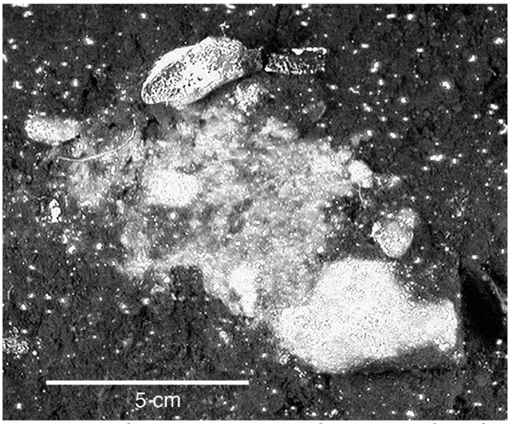


Figure 17. Fluorescent protein-bearing soil under sheep's scapula illuminated with ultraviolet light after spray application of fluorochrome, Polyfluor YG®, to soil.

samples (Coil et al. 2003). The low toxicity of this liquid and one's ability to alter solution density by the simple addition of drops of distilled water shows promise as an easy way of doing progressive flotation on small samples. Progressively lighter grains of sediment can be extracted as water is added to the sample solution contained in a separation funnel. To monitor the changing solution density, glass float beads are added to the solution. These are colored glass beads calibrated to a range of densities from 1.80–2.86 grams per ml.[2] As each bead drops it marks the density range of the collected fraction which speeds the process of identifying the grains in that sediment portion (FIG. 16).

This method is being developed not only for general grain analysis but for the retrieval of metal artifact corrosion products in particular. Corrosion products are among the heaviest mineral particles in archaeological deposits and are therefore easy to isolate with this method. It is a sad truth that metal artifacts are frequently sought after by looters. Research is being conducted on how sensitive this method would be for recovering traces of lost metal objects. The hope is that this method may find a use as a way of documenting the position of metals looted from sites by extracting "Michie-type" corrosion fragment patterns from the underlying soil.

As stated above ultraviolet light was used to map the coral, shell and bone particles by autofluorescence. During the course of that work some soils in the midden layer appeared unusually dark, suggesting that there may have been high levels of organics present. The large amounts of bone in the midden suggested that some of that organic substance could be protein. It is possible to induce ultraviolet fluorescence chemically to highlight the presence of selected classes of materials. Soil scientists have applied fluorescent tagging agents (also known as fluorochromes) to soil surfaces and soil water to study percolation patterns and transport processes (Vanderborght 2002). And DNA researchers routinely apply fluorescent tagging agents to proteins to isolate particular amino acids. It was decided to test whether a similar fluorochrome would highlight the residues of proteinaceous degradation products on excavated surfaces. The likelihood of preservation of such perishable materials was low given the soil conditions. But past experience had shown that minor quantities of perishables can persist in isolated pockets under the worst conditions.

Coumarin, a dye class which gives persistent fluorescence when in contact with a broad range of amino acids, was selected for the trial. Before applying the chemical to the soil block the technique was first developed on prepared soil samples. Dye concentrations, solvents and application were worked out by trial and error. The surface of a test soil was pretreated with drops of very dilute aqueous solutions of gelatin, from 0.1% down to 0.025% w/v. A type of coumarin soluble in ethyl alcohol and marketed as Polyfluor YG® was mixed with alcohol in varying proportions and applied as an even fine mist to the treated surface. It was found that when the coumarin was prepared as a 0.125% w/v solution in ethyl alcohol and sprayed onto the test areas it fluoresced brightly whenever it encountered the gelatin-treated areas of the soil.

With this technique the soil block was periodically sprayed with the fluorochrome solution. One positive response was detected under a butchered sheep's scapula (FIG. 17). It was sampled and submitted to a simple microchemical test, the xanthoproteic test, for protein. It proved positive and further sampling was done to investigate whether the proteins present can be shown to be derived from the butchered sheep bone. While this investigation

[2] Shale Density Beads available from U.S. Geosupply, Inc., PO Box 40217, Grand Junction, CO, 81504

is still ongoing it suggests that a variant of this method may prove useful in the field as well as the laboratory as a quick and inexpensive way to locate such protein deposits.

Conclusion

The laboratory excavation of intact blocks of soil removed from archaeological sites provides an opportunity to do basic and applied research, to evaluate novel technologies and new field methods. By placing an unexcavated soil block large enough to contain multiple large artifacts and archaeological strata in a laboratory setting, one creates an experimental platform for the re-examination of excavation itself. The development of methods to directly observe the post-depositional movement of micro-artifacts is one example of the experimental potential of soil block research.

We live in a world rich with rapidly developing high and low-technology tools. The work here focused on applying technologies that while unusual, are also accessible to most archaeological processing laboratories. By bringing the excavation process into the laboratory one can freely associate those tools with archaeological investigation. Retrieval methods adapted from the museum packing tradition and heavy liquid separation techniques used by sedimentologists are two examples of tools that may prove useful to archaeologists in the future. The application of fluorescent tagging chemicals to freshly excavated surfaces for the direct observation of trace proteins is also a prime example of the potential of such low technology methods.

The underlying belief is that if one removes the constraints imposed by the field setting from the excavation process while adding increased macroscopic and microscopic visualization techniques, one can make advances applicable to both field methods and theory. This work should be understood as an important but secondary component of a total site excavation strategy. In that light it is a valuable tool for leveraging advances in excavation technique and in archaeological inquiries generally. Soil block analyses are useful for any site but may find their best use at sites with complex deposits. While a conservator performed the Sylvester Manor work, it should be understood that it is not necessary for a conservator to be on staff. Any archaeologist with the patience needed for micro-excavation can perform innovative soil block analyses.

References

Beaubien, H.F.
1993 From Codex to Calabash: Recovery of a Painted Organic Artifact from the Archaeological Site of Cerén, El Salvador. *Journal of the American Institute for Conservation* 32(2): 153–164.

Brady, N.C., and Ray R.Weil
2002 *The Nature and Properties of Soil*. Prentice-Hall, Upper Saddle, N.J.

Coil, J., M.A. Korstanje, S. Archer, and C.A. Hastorf
2003 Laboratory Goals and Considerations for Multiple Microfossil Extraction in Archaeology. *Journal of Archaeological Science* 30: 991–1008.

Collins, S.L.
1990 Introduction: Fire as a Natural Disturbance in Tallgrass Prairie Ecosystems. In *Fire in North American Tallgrass Prairies*, ed. by S. L. Collins and L.L.Wallace, 3–7. University of Oklahoma Press, London.

Courty, M.A., Paul Goldberg, and Richard MacPhail
1989 *Soils and Micromorphology in Archaeology*. Cambridge University Press, New York.

DeGaetano, A.T., Daniel S. Wilks, and Megan McKay
1996 *Atlas of Soil Freezing Depth Extremes for the Northeastern United States*. National Regional Climate Center, Ithaca.

Edwards, C.A., and P.J. Bohlen
1996 *Biology and Ecology of Earthworms*. Chapman & Hall, London.

Fedoroff, N., L.M. Bresson, and M.A. Courty
1985 *Soil Micromorphology*. Association Francaise pur l'Etude du Sol, Paris.

Fuller, M.L.
1914 *The Geology of Long Island New York*. Government Printing Office, Washington.

Holliday, V.T., C.R. Ferring, and P. Goldberg
1993 The Scale of Soil Investigations in Archaeology. In *Effects of Scale on Archaeological and Geoscientific Perspectives*, ed. by J. L. Stein, and A. R.Linse, 29–37. The Geological Society of America, Inc., Boulder, CO.

Leigh, D. S.
2003 Buried Artifacts in Sandy Soils. In *Earth Sciences and Archaeology*, ed. by P. Goldberg, V.T. Holliday, and C.R. Ferring, 269–293. Kluwer Academic/Plenum Publishers, New York.

Matthews, W.E.A.
1997 Microstratigraphic Traces of Site Formation Processes and Human Activities. *World Archaeology* 29(2): 281–308.

Michie, J.L.
1990 Bioturbation and Gravity as a Potential Site Formation Process: The Open Area Site, 38GE261, Georgetown County, South Carolina. *South Carolina Antiquities* 22(1): 27–46.

NCDC
2001 *Climatography of the United States no. 81*. NOAA, U. S. Department of Commerce, Asheville N.C.

Payton, R. (ed.)
1992 *Retrieval of Objects from Archaeological Sites*. Archetype Publications, Denbigh.

Proebsting, E.L.
2002 "History from the Ground Up": Soil Micromorphology at a Long Island Plantation. M.A. thesis, University of Massachusetts, Boston.

Schubert, C.E.
1999 *Ground-Water Flowpaths and Traveltime to Three Small Embayments within the Peconic Estuary, Eastern Suffolk County, New York*. USGS Report 98–4181.

Sherwood, S.C.
2001 Microartifacts. In *Earth Sciences and Archaeology*, ed. by P. Goldberg, V.T. Holliday, and C.R. Ferring, 327–351. Kluwer Academic/Plenum, New York.

Skjemstad, J.O., D.C. Reicosky, A.R. Wilts, and J.A. McGowan
2002 Charcoal Carbon in U.S. Agricultural Soils. *Soil Science Society of America Journal* 66: 1249–1255.

Stein, J.L.
1991 Archaeological Sediments in Cultural Environments. In *Sediments in Archaeological Context*, ed. by J.L. Stein and W.R. Farrand, 1–28. University of Utah Press, Salt Lake City.

Stein, J.L., and P.A. Teltser
1989 Size Distributions of Artifact Classes: Combining Macro- and Micro-Fractions. *Geoarchaeology* 4(1): 1–30.

Van Vliet-Lanoe, B.
1985 Frost Effects in Soils. In *Soils and Quaternary Landscape Evolution*, ed. by J. Boardman, 115–156. John Wiley & Sons Ltd., New York.

Vanderborght, J.E.
2002 Imaging Fluorescent Dye Concentrations on Soil Surfaces: Uncertainty of Concentration Estimates. *Soil Science Society of America Journal* 66: 760–773.

Warner, J.R.E.
1975 *Soil Survey of Suffolk County, New York*. USDA Soil Conservation Service, Washington.

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