STRATIGRAPHY, LITHOLOGY, AND PEDOLOGY OF THE SOUTH WALL AT THE HOPETON EARTHWORKS, SOUTH-CENTRAL OHIO

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PREFACE

This report presents the results of geoarchaeological investigations conducted at the Hopeton Earthworks north of Chillicothe in Ross County, Ohio. Hopeton is located on a late Wisconsinan alluvial terrace on the east side of the Scioto River. The site spans more than 80 acres and was described by Squier and Davis (1848) as a rectangle with an attached circle. There are also two smaller circles that were integrated into the north side of the rectangle, and two parallel walls extend from the northwest corner of the rectangle approximately 730 m to the southwest. In 1848, the walls of the rectangular earthworks were about 4 m high and 17 m wide at their base. However, since the mid-1800s, land leveling for farming has greatly modified the walls of this enclose. Today, the earthworks are represented by low, subtle ridges that are barely visible on the landscape. Based on a suite of radiocarbon ages, the walls at Hopeton date from ca. A.D. 150 to as late as ca. A.D. 1000.

In 2001, the Midwest Archaeological Center of the National Park Service initiated field studies of the walls that form the rectangular enclosure at Hopeton. Additional studies were conducted in 2002 and 2003, and field research will continue in the summer of 2004. This report focuses on the 2001 investigation of the central segment of the southern wall (referred to here as the the South Wall) of the enclosure.

INTRODUCTION

A geoarchaeological investigation was conducted at the Hopeton Earthworks during test excavations in June, 2001. The investigation focused on Trench 1, a 48-m-long backhoe trench that transected a segment of the South Wall of the great square (Figure 1). The objectives of the study were to (1) describe and classify the wall fill, including its stratigraphy and lithology; (2) determine whether there were any significant hiatuses during wall construction; (3) assess post-construction pedogenic alteration of the wall fill; and (4) define the boundary between the wall fill and sub-wall sediment. Information gleaned from the geoarchaeological investigation is important for understanding site-formation processes and the nature and magnitude of post-occupation alteration of the earthworks. It also sheds light on possible Hopwellian symbolism as evidenced by the color and placement of different soil materials used in wall construction.

METHODS

Three soil-stratigraphic profiles were studied in Trench 1: Profile 1 in the middle of the South Wall, Profile 2 on the south flank of the South Wall, and Profile 3 on the north flank of the South Wall (Figure 1). The profiles were described using standard pedologic nomenclature (Soil Survey Staff, 1996; Birkeland, 1999) with one modification regarding buried soils. Buried soils were numbered with a suffix following "b" according to their stratigraphic position below the surface (e.g., Ap-Apb1-Bw/Ab1-Bw1b1-Bw2b1-Bw2b1-2Bt1b2-2Bt2b2). A numerical prefix (e.g., 2Bt1b2-2Bt2b2) was used only for soil horizons developed in sediments below the earthworks. In some of the soils developed in the wall materials, soil horizons were mixed. In other horizons, there are clay bands, or lamellae, composed of illuvial clay. The Soil Survey Manual (Soil Survey Division Staff, 1993:121) recommends the virgule (/) to designate combinations of soil horizons, with the dominant horizon placed in front of the subordinate horizon (e.g., Bw/A). It also states that illuvial clay bands (Bt horizons) within other horizons be designated using "and" rather than the virgule (e.g., Bw and Bt). The use of "and" better conveys the characteristics of lamellae and is used in this report, indicated by an ampersand (&), following Gile (1979), with the dominant horizon noted first, i.e., Bw&Bt.

Bulk soil samples, each weighing approximately 300 g, were collected by soil horizon from the three profiles in Trench 1. The soil samples were air dried and shipped to the Department of Geoscience at the University of Iowa for grain-size analysis. Particle-size distributions were determined using the pipette method (Walter et al., 1978). The silt fraction was subdivided into fine and coarse fractions. Sands were separated from the clays and silts using a 300-mesh sieve. The sands were oven dried and and separated into five fractions by sieving.

In addition to collecting bulk soil samples, 26 undisturbed, fist-size blocks of soil were removed for micromorphological analyses. The blocks were wrapped in foil, placed in sealed containers, and shipped to Spectrum Petrographics, Inc. (Winston, Oregon) for thin-section preparation. The thin-sections were mounted on large-format slides (51 X 75 mm) with cover slips and shipped to the Archaeology Department at Boston University for analysis. Thin-sections were observed with a petrographic microscope in plane polarized light (PPL) at magnifications ranging from 20X to 40X. Scans of the thin-sections were made using a Microtek Scanmaker 4 at 600 dpi. Digital photographs were taken with a Leaf Systems Lumina camera with a resolution of 1500 by 1200 dpi. Micromorphological terminology follows that of Bullock et al. (1985) and Courty et al. (1989). Certain textural features were observed in all of the thin-sections. These features are listed and described in Table 1.

The objectives of the laboratory analyses were to (1) characterize and confirm field descriptions of the wall fill, and (2) assess the magnitude of post-construction pedogenic alteration of the wall fill. Particle-size distribution, combined with field observations, is a good indicator of the source(s) of wall fill. It also may indicate post-depositional modifications within fill units. For example, a high clay content may be a product of *in situ* weathering and/or clay illuviation. Micromorphological analyses often yield information about the sequence of pedological events and processes that are not discernible in the field (Holliday et al., 1993). In this study, the major objectives of the micromorphological analyses were to characterize the wall fill, and to differentiate inherent properties of the soil material used to construct the south wall from properties associated with post-construction pedogenesis.

RESULTS OF INVESTIGATIONS

Profile 1

Profile 1 is located near the center of the South Wall (Figure 1). Three units of wall fill (units III, IV, and V) are represented above the sub-wall sediments in Profile I (Figure 1). The stratigraphy of Profile 1 is presented in the following discussion, beginning with a description of the sub-wall sediments.

Sub-wall sediments were exposed in the lower 40 cm of Profile 1. These sediments are very silty (82-84% silt content; see Table 2) and have been modified by soil development (Table 3). The origin of the sub-wall sediments has not been determined. However the terrace at Hopeton may have a veneer of loess or silty slack-water deposits. A few well-rounded pebbles and cobbles are scattered in the silty matrix of the sub-wall deposits. These clasts may have been derived from the overlying wall material or underlying alluvium and incorporated into the silty matrix through bioturbation.

The soil developed in the sub-wall sediments is represented only by well expressed Bt horizons; the A horizon was stripped off before the wall was emplaced. Hence, the South Wall was constructed on a prepared surface. The 2Bt1b2 and 2Bt2b2 horizons consist of light olive brown (2.5Y 5/3, dry) silt loam and yellowish brown (10YR 5/4, dry) silt loam, respectively. An abrupt, wavy boundary separates the 2Bt1b2 horizon from the overlying wall material. This boundary is marked by a dramatic decrease in silt content and an increase in sand content (Table 2).

In Profile 1, Unit III of the South Wall overlies the sub-wall sediments (Figure 1). Unit III is 76 cm thick and consists of three subunits: IIIa, IIIb, and IIIc (Figure 2). The subunits are described in the following discussion, beginning with Subunit IIIa in the lower part of Unit III.

Subunit IIIa is 18 cm thick in Profile 1, but is as much as 27 cm thick in segments of the wall. It consists of reddish brown (5YR 4/4, dry) loam with many granules, common pebbles, and few cobbles. The Bw3&Btb1 horizon of the modern soil is developed in Subunit IIIa (Table 3). This horizon has very weak, fine and very fine, subangular-blocky structure with few distinct, discontinuous, reddish brown (5YR 4/3, dry) clay films on ped faces and in pores. Also, there are common 2-5 mm-thick reddish brown (5YR 4/3, dry) lamellae, as well as fine and very fine iron and manganese oxide nodules.

Micromorphological analysis of a thin-section of the lower-third of subunit IIIa revealed an abundance of silty and clayey material intermixed with very loose, quartz-rich rock fragments. There is little evidence of bioturbation in the sample. Hence, the jumbled appearance of the material is attributed to basket loading. Although there are abundant type 5 depletion features, a band of well-developed type 1 coatings cuts diagonally across the center of thin-section (Figure 3). The most interesting feature is a band of clay coatings approximately 5 mm thick in the lower right corner of the thin-section (Figure 3). Organic silty material with extensive type 5 depletion zones lies above and below this band. Also, a fragment of a finely laminated slaking crust occurs in the lower right corner of the thin-section (Figure 3). The bands of clay coatings and the laminated slaking crust are associated with the formation of soil lamellae.

Based on the micromorphological analysis, the middle-third of subunit IIIa is generally similar to the upper-third of the subunit. The matrix is a poorly sorted loam with masses of silty and clayey material intermixed with sandy sediment. In addition, there are numerous rounded charcoal grains. There appear to be extensive type 5 depletion zones, but some of these may be due to over grinding of the thin-section. With the exception of a few lamellae, there is very little evidence of clay illuviation. Clay coatings were detected in the interior of a porous chert fragment, but the fragment may have been coated before it was incorporated in the wall fill. In general, the fill looks like it was deposited and quickly depleted of silt and clay coatings.

Micromorphological analysis of a thin-section of the upper-third of Subunit IIIa revealed that the matrix is poorly sorted, with silty and clayey material intermixed with sand grains. Type 5 depletion zones are more extensive compared to the samples from underlying portions of the Bw3&Btb2 horizon, giving this sample an overall lighter color. It also has a lower proportion of coarser material compared to the other samples. There is a band containing both type 1 and thin type 4 clay coatings. The two types of coatings occur in the same zone but generally do not overlie each other; hence, it is not clear which coating developed first.

Subunit IIIb is 35 cm thick in Profile 1 and has a mixed matrix of strong brown (7.5YR 4/6) and reddish brown (5YR 4/4, dry) coarse silt loam with many granules, common pebbles, and few cobbles. In addition, there are a few fine masses of brown (10YR 5/3) silt loam with common fine, distinct, strong brown (7.5YR 4/6) and few fine, faint, light yellowish brown (2.5Y 6/4) mottles. The Bw2&Btb1 horizon of the modern surface soil is developed in Subunit IIIb (Table 3). This horizon has very weak, fine and very fine, subangular-blocky structure with few distinct, discontinuous, reddish brown (5YR 4/3, dry) clay films on ped faces and in pores. Also, there are common 2-8 mm-thick reddish brown (5YR 4/3, dry) lamellae, with many concentrated in a zone 10-15 cm below the top of Subunit IIIb.

Micromorphological analysis of a thin-section of the lower-third of Subunit IIIb revealed a greater abundance of silty clay in the matrix compared to the sample above it. A band of type 1 and type 4 coatings, as well as type 2 infillings (Figure 4), cuts across the sample. The type 1 coatings generally occur in the smaller voids and look post-depositional. The lithology of the clasts is more variable in this sample compared to other thin-section samples from the site, and small fragments of bone and charcoal were observed in the matrix.

Micromorphological analysis of a thin-section of the middle-third of Subunit IIIb revealed a fairly homogeneous matrix with local boundaries created by iron staining. The sample was relatively intact, but the upper 5 cm consisted of loose aggregates and abundant vughs indicative of bioturbation. A well developed band (lamellae) of type 1 coatings in voids was recorded at the base of the sample.

Micromorphological analysis of a thin-section of the upper-third of Subunit IIIb revealed that the Bw2&Btb1 horizon has more extensive evidence of illuviation than the samples above and below it. Type 1 coatings are common and tend to be thick and laminated. A 2-cm-thick band (lamellae) of type 1 coatings extends across the center of the sample and is bordered by type 4 coatings. Also, there is a moderate amount of manganese oxide nodules in the matrix, including a discontinuous band with at least one nodule coated by limpid clay (Figure 5). The clay-coated manganese may have been inherited from the sediment used in wall construction. However, the presence of many thick, laminated clay films in the matrix surrounding the manganese (Figure 5) indicates that significant clay illuviation occurred after wall construction.

Subunit IIIc composes the upper 23 cm of Unit II and consists of strong brown (7.5YR 4/6, dry) coarse silt loam with common granules and pebbles and few cobbles scattered through the matrix. The Bw1&Btb1 horizon of the modern surface soil is developed in Subunit IIIc (Table 3). This horizon has weak, medium and fine, subangular-blocky structure and common biogenic features (worm casts, worm burrows, etc.). Field observations included few, distinct, discontinuous clay films on ped faces and in pores, and common, distinct, reddish brown (5YR 4/3, dry) lamellae.

Micromorphological analysis of a thin-section from the lower 7 cm of Subunit IIIc also revealed that the matrix is jumbled. Specifically, masses of cleaner silty material are mixed with the coarser material, and both materials exhibit coatings. Furthermore, there are dark, dusty coatings between inter-aggregate voids. These coatings are probably derived from the Ap horizons. At the top of the thin-section, a well developed band (ca. 1 cm thick) consisting of type 1 coatings cuts across different materials. These coatings seem to fill recent (biological?) voids. Charcoal and woody material were observed throughout the matrix but were more common near the top of the thin-section.

Micromorphological analysis of a thin-section from the upper 7 cm of Subunit IIIc revealed that the matrix has a jumbled appearance consistent with basket loading. A thick (1.5–2.0 cm) band (lamellae) of type 1 coatings and dark reddish brown organic void coatings was observed at the top of the thin-section. Elsewhere in this sample, type 4 coatings were visible in the larger voids.

In Profile 1, Unit III is mantled by Unit IV (Figures 1 and 2), and an abrupt, wavy boundary separates these units. Unit IV is 9 cm thick and consists of light yellowish brown (10YR 6/4) silt loam with common granules and few pebbles. The BAp horizon of the modern surface soil is developed in Unit IV (Table 3). This horizon has weak, fine subangular-blocky structure parting to weak medium and fine granular structure. There are common biogenic features, especially worm casts and burrows, but they are not extensive. Furrows are common in the BAp horizon, indicating that Unit IV was plowed before it was buried by sediment composing Unit V. The grain-size distribution of materials composing Unit IV and subunit IIIc are remarkably similar (Table 2). However, subunit IIIc, like all of Unit III, is much redder than Unit IV. Hence, materials composing Unit IV and subunit IIIc were derived from different sources. An abrupt, wavy boundary separates Unit IV from the uppermost wall fill (Unit V).

In Profile 1, Unit V is 15 cm thick and consists of light yellowish brown (10YR 6/4) silt loam. The Ap horizon (modern plow zone) of the surface soil is developed in Unit V (Table 3). This horizon has weak, medium and fine, platy structure parting to moderate, fine and medium, granular structure. Although the color of Unit V is the same as the color of Unit IV, there is a dramatic decrease in clay content and an increase in silt content going from Unit IV to Unit V (Table 2). Hence, these units are lithologically different. Given the presence of a plow zone in the underlying fill (Unit IV), it is reasonable to assume that Unit V consists of material that was stripped off the South Wall and redistributed by heavy machinery and plowing.

Summary of Profile 1

In Profile 1, the South Wall is underlain by a truncated soil (2Bt1b2 horizon) developed in silt loam that may be loess or silty slack-water sediments. The absence of an A horizon beneath the wall suggests that the surface was stripped in preparation for wall construction. The wall material above the truncated soil mostly consists of rubified, poorly-sorted loam and coarse silt loam with common granules, pebbles, and cobbles (Unit III). There is evidence of bioturbation, especially in subunit IIIc, but it is not extensive in this profile. Hence, the jumbled appearance of Unit III material is attributed to basket loading; there is no evidence for wall construction with sod blocks. Unit III has been affected by soil development since the wall was constructed. Evidence for this includes soil horizonation (Ap-Bw&Bt profile) and pedo-features, such clay films. Although a few clay films were detected on ped faces and along vertical cracks, most occur as 1–2 cm-thick bands that cut across somewhat mixed lithologies. Examination of thin-sections revealed that clay films in these bands are limpid, yellowish-brown void coatings. The clay films are never disturbed or broken; hence they are not inherited features associated with the wall-construction material. Instead, they are associated with post-depositional formation of soil lamellae.

Units IV and V collectively form the upper 24 cm of Profile 1. These units consist of light yellowish brown silt loam with few clasts, and they have been affected by modern pedogenesis. The sediment composing Unit V appears to have been spread across the site by heavy machinery, and Unit IV was plowed before Unit V was emplaced. Hence, cultural deposits associated with these two units probably lack vertical and horizontal integrity.

Profile 2

Profile 2 is located on the south flank of the South Wall (Figure 1). Four units of wall fill (units II, III, IV, and V) are represented above the sub-wall sediments in Profile 2 (Figures 1 and 6). The stratigraphy of Profile 2 is presented in the following discussion, beginning with a description of the sub-wall sediments.

Sub-wall sediments were exposed in the lower 17 cm of Profile 2. These sediments are predominantly silt (82.9% silt content), with fine silt dominating the silt fraction (Table 2 and Figure 7). However, a few well-rounded pebbles and cobbles are scattered through the silty matrix (Table 4).

The soil developed in the sub-wall sediments is represented by a well expressed Bt horizon; the A horizon was stripped off before the wall was emplaced. The 2Btb2 horizon consists of yellowish brown (10YR 5/4, dry) silt with weak, medium and fine, prismatic structure parting to moderate, fine and very fine, subangular-blocky structure. There are common discontinuous clay films on ped faces.

Micromorphological analysis of a thin-section of the 2Btb2 horizon revealed localized domains of coarse silt and fine quartz sand grains. These domains contain some charcoal and appear to be burrows filled with material from the overlying wall. There is differential iron staining around some of the voids, and well-developed type 1 and type 2 features are common throughout the thin-section (Figures 7 and 8).

An abrupt, wavy boundary separates the 2Btb2 horizon from the overlying wall material. As is the case in Profile 1, this boundary is marked by a dramatic decrease in silt content and an increase in sand content (Table 2).

In Profile 2, Unit II of the South Wall overlies the sub-wall sediments. A wedge of Unit III cuts through the middle of Unit II (Figure 1). The portions of Unit II below and above this wedge are designated IIa and IIb, respectively (Figure 6). A soil with A-Bw horizonation is developed in Unit IIb, the wedge of Unit III, and Unit IIa.

Unit IIa consist of dark yellowish brown (10YR 4/4, dry) loam with many granules and pebbles and common fine cobbles. The Bw2b1 soil horizon is developed in Unit IIa (Table 4). It has weak, fine, subangular-blocky structure and common biogenic features. Micromorphological analysis of the lower half of the Bw2b1 horizon revealed that it is fairly coarse (Figure 9), but silt-sized sediment is common. Also, the matrix is very bioturbated. Type 1 coatings are common in the upper 1.0-1.5 cm of the sample, and there are a few type 1 coatings and type 2 infillings in the lower portion of the sample. Also, a few, thin type 4 coatings occur, particularly in the upper part of the sample. In at least one instance, type 4 coatings overlie type 1 coatings, and one fragment of charcoal was observed with type 4 coatings around it.

Based on the micromorphological analysis, the matrix of the upper half of the Bw2b1 horizon is similar to the matrix in the lower half of the horizon, i.e., it is fairly coarse but has common silt-sized sediment. The upper portion of the sample contains type 3 coatings, and the lower portion of the sample contains type 1 coatings and type 2 infillings.

The wedge of Unit III is the parent material for the Bw1b1 soil horizon. This material is brown (7.5YR 4/3, dry) loam with common granules and fine pebbles. The Bw1b1 horizon has weak, fine, subangular-blocky structure and common biogenic features. Although the matrix of the Bw1b1 horizon (Unit III) is redder than the matrix of the Bw2b1 horizon (Unit Ia), micromorphological analysis revealed that the materials in these horizons are similar. Specifically, samples from the Bw1b1 horizon are fairly coarse, but they contain common silt-sized sediment. They also contain many charcoal fragments. There are type 3 coatings in the upper portion of the sample collected from the lower half of the Bw1b1 horizon, but type 1 and type 2 features occur in the lower portion of this sample. The type 3 coatings are more common in the lower half of the Bw1b1 horizon than in the Bw2b1 horizon, and these features do not seem to overlie each other. Some of the coatings are in voids that clearly post-date the emplacement of Unit II. There is well developed secondary iron staining in the lower half of the Bw1b1 horizon, which in places occurs as ferromanganese concretions and impregnations. The sample from the upper half of the Bw1b1 horizon is very porous and looks biologically reworked (Figure 10). A few voids have type 4 coatings that are locally quite thick, but most voids are clean.

Unit IIb consist of brown (10YR 4/3, dry) to dark yellowish brown (10YR 4/4, dry) silt loam with common granules and fine pebbles and many charcoal fragments. The Apb1 soil horizon is developed in Unit IIIb (Table 4). It has weak, fine and very fine, granular structure and many biogenic features. Micromorphological analysis of the lower-third of Unit IIb revealed that the matrix is very open and loose; it looks like an Ap horizon. The material appears to be heavily bioturbated, and there are common biologically produced voids, including two large burrows (0.5-1.0 cm in diameter). There are abundant type 4 coatings, rare type 3 coatings, and localized textural (type 5) depletion features. The type 4 coatings generally occur within the biologically produced voids.

The thin-section of the middle-third of the Apb1 horizon resembles the thin-section of the lower third. The material is biologically reworked, and there are common charcoal fragments (Figure 11). Also, there are rare type 3 coatings. However, it has more channel voids compared to the sample from the lower-third of the horizon.The vughy microstructure is frequently associated with type 4 coatings. In sum, it has the appearance of a plow zone.

The thin-section of the upper-third of the Apb1 horizon is slightly finer grained than the samples from the middle- and lower-third of the horizon, but is overall quite similar to the other samples. The matrix is very open and biologically reworked, and there are abundant type 4 and occasional type 3 coatings, as well as occasional type 3 infillings. It contains an intercalation/micropan typical of material close to the land surface.

An abrupt, wavy boundary separates subunit IIb from Unit IV. In Profile 2, Unit IV is 20 cm thick and consists of brown (10YR 5/3, dry) to yellowish brown (10YR 5/4, dry) silt loam with common granules and fine pebbles (Table 4). There is a dramatic decrease in clay content and an increase in silt content going from subunit IIb to Unit IV (Table 2). Distinct plow scars were observed in the upper 10-15 cm Unit IV, and information gleaned from the micromorphological analysis suggests that this unit has been extensively reworked by plowing.

A thin-section of the lower 10 cm of Unit IV contained abundant roots, insect excrement, and charcoal, as well as occasional phytoliths (Figure 12). Phytoliths were observed in other samples from the South Wall, but they are more abundant in Unit IV. There are abundant manganese segregations, both reworked and primary, and textural depletion features (type 5). Relict type 3 material is broken up and reworked into the matrix, and *in situ* coatings of any type are almost completely absent.

The micromorphological analysis revealed that the upper 10 cm of Unit IV is very similar to the lower 10 cm of the unit. However, as expected with disturbance from plowing, material in the upper 10 cm is even more broken up than the underlying material. Papules of type 3 material were visible in the thin-section, as were some textural depletion features (type 5), but coatings were extremely rare.

In sum, Unit IV has been greatly disturbed by plowing. Furthermore, it is likely that Unit IV consists of soil dragged off the wall by machinery when the field was leveled for farming. Hence, mechanical emplacement of Unit IV buried the A horizon developed in subunit IIIb. It is also reasonable to assume that archaeological materials in Unit IV lack horizontal and vertical integrity. Unit V composes the upper 15 cm of Profile 2 (Figure 6). The Ap horizon (modern plow zone) of the surface soil is developed in this unit (Table 4). Unit V in Profile 2 is litholgically similar to Unit V in Profile 1; it consists of light yellowish brown (10YR 6/4) silt loam. The grain-size distribution of material in Unit V is very similar to the grain-size distribution of material in Unit IV (Table 2). These materials appear to be derived from the same source, probably loess or silty slack-water deposits, and like Unit IV, Unit V consists of soil dragged off the wall by machinery when the field was leveled for farming. Hence, archaeological materials in Unit V lack horizontal and vertical integrity.

Summary of Profile 2

In Profile 2, the South Wall is underlain by the truncated soil (2Btb horizon) observed in Profile 1. As noted in the description of Profile 1, the sub-wall material may be loess or silty slack-water sediments, and the absence of an A horizon beneath the wall suggests that the surface was stripped in preparation for wall construction. The wall material above the truncated soil is represented by units II, III, IV, and V. Unit III bisects Unit II. Hence, Unit II was divided into a lower component (subunit IIa) and an upper component (subunit IIb). The materials composing subunits IIa and IIb and Unit III are poorly sorted; they are dominated by silt-sized sediment (47-51%), but there is a fairly large proportion of sand-sized sediment (34-37%), especially in Unit III. Hence, the materials composing units II and III were not derived entirely from loess or silty slack-water deposits. In contrast, the materials composing units IV and V are fairly well sorted and have high silt contents (67% and 64%, respectively); they were probably derived mostly or entirely from loess or silty slack-water deposits. However, the materials composing units IV and V were redeposited during the past ca. 150 years. In addition to being mixed as a result of plowing, these materials were dragged off the wall by machinery when the site was leveled for farming.

A soil with a weakly expressed A-Bw profile is developed in units II and III. Since the time of Euro-American settlement in the region, this soil was buried by materials (units IV and V) dragged off the center of the wall and spread on its flanks. There is virtually no evidence for clay illuviation in the buried soil or overlying materials. Instead, brown, silty coatings (type 4) occur throughout Profile 2. These coatings increase in abundance and thickness up the profile, but their traces are even visible in the sub-wall sediment. They seem to be relatively recent soil features and are almost certainly associated with plowing. Type 1 and 2 features, on the other hand, are common in the truncated sub-wall soil. Bioturbation is extensive in all the wall units, and becomes more pronounced up the profile. Although artifacts were not observed in any of the thin-sections from Profile 2, charcoal that may be cultural in origin occurs as very small fragments, and many have been broken up by bioturbation.

Profile 3

Profile 3 is located on the north flank of the South Wall (Figure 1). Three units of wall fill are represented above the sub-wall sediments in Profile 3: units I, II, and V (Figure 1). The former surface soil, which was recently buried by material composing Unit V, is developed in units I and II. The stratigraphy of Profile 3 is presented in the following discussion, beginning with a description of the sub-wall sediments.

Sub-wall sediments were exposed in the lower 34 cm of Profile 3. These sediments are predominantly silt (85.8-84.0% silt content), with fine silt dominating the silt fraction (Table 2). However, like the sub-wall sediments on profiles 1 and 2, a few well-rounded pebbles and cobbles are scattered through the silty matrix.

The soil developed in the sub-wall sediments is represented by well expressed Bt horizons (Table 5); the A horizon was stripped off before the wall was emplaced. The 2Bt1b2 and 2Bt2b2 horizons consist of yellowish brown (10YR 5/4, dry) silt with weak, medium and fine, prismatic structure parting to moderate, fine and very fine, subangular-blocky structure. There are common discontinuous clay films on ped faces.

Micromorphological analysis of a thin-section of the 2Bt1b2 horizon revealed a fine-silty matrix with many iron depletion zones, common type 1 coatings, and common charcoal fragments. Some of the charcoal fragments form discontinuous bands near the base and in the upper-third of the sample. Also, there are rare type 3 void coatings in the lower third of the sample.

Micromorphological analysis of a thin-section of the 2Bt2b2 horizon recorded soil features similar to the ones observed in the 2Bt1b2 horizon. Specifically, the 2Bt2b2 horizon has a fine-silty matrix with numerous iron depletion zones and few well developed type 1 coatings (Figure 14). There are common type 3 coatings and few slightly developed type 4 coatings. Also, papules of type 3 material occur.

An abrupt, wavy boundary separates the 2Bt1b2 horizon from the overlying wall material (Unit I). However, unlike profiles 1 and 2, this boundary is not marked by a dramatic decrease in silt content and an increase in sand content (Table 2). Instead, the silt content remains high across this boundary.

Unit I is 56 cm thick and consists of two subunits: Ia and Ib (from bottom to top). These subunits are separated by abrupt, wavy boundaries. Hence, the duration and intensity of pedogenesis since emplacement of the subunits have been insufficient to obliterate these boundaries.

Subunit Ia is 33 cm thick and is yellowish brown (10YR 5/4, dry) silt. The silt fraction is strongly dominated by fine silt (Table 2). The Bw2b1 soil horizon is developed in Unit Ia (Table 5). It has very weak, fine, subangular-blocky structure and common biogenic features. Micromorphological analysis of a thin-section of the upper half of the Bw2b1 horizon revealed that the material has a very silty matrix but is not as well sorted as it appeared during the field investigation. Sand grains, charcoal, and organic matter are scattered through the matrix. There are abundant iron-depletion zones, and type 1, 3, and 4 coatings are present but limited to the base of the sample. The type 3 coatings are well developed.

Based on the micromorphological analysis, the material in the lower half of the Bw2b1 horizon is similar to that in the upper half and it also resembles the sub-wall material. Iron depletion is very extensive (Figure 15), and incipient type 4 and well developed type 3 coatings are present but do not appear to overlap. There are charcoal fragments scattered through the matrix, but they decrease in frequency with depth. Vughs, circular pores, and root fragments are common, and the sample seems to be biologically reworked. This appears to be the deepest penetration of intensive bioturbation in wall material among the three profiles studied in Trench 1.

Subunit Ib is 23 cm thick and is brown (10YR 5/3, dry) to yellowish brown (10YR 5/4, dry) silt loam. The Bw1b1 soil horizon is developed in Unit Ib (Table 5). It has weak, fine prismatic structure parting to weak, fine, subangular-blocky structure, and there are many biogenic features, especially worm casts and burrows.

Micromorphological analysis of a thin-section of the lower 10 cm of the 2Bw1b horizon revealed that the matrix is dominated by fine silt, but is coarser than the underlying wall fill. Also, this sample is lighter in color than the previous thin-section samples and may be more completely depleted in iron. There are abundant phytoliths and some organic material. In addition, there are type 1 coatings, type 2 infillings, and well developed type 4 coatings throughout the sample.

Micromorphological analysis of a thin-section of the upper 10 cm of the 2Bw1b horizon yielded evidence indicating extensive biological reworking of the material (Figure 16). There are also extensive textural depletion features (type 5) and localized iron-stained organic matter.

An abrupt, wavy boundary separates subunit Ib from Unit II. In Profile 3, Unit II is 32 cm thick and consists of two subunits: IIa and IIb (from bottom to top). Subunit IIa is 24 cm thick and contains the parent material for the Bw/Ab1 soil horizon (Table 5). The Bw/Ab1 horizon consists of yellowish brown (10YR 5/4, dry) loam (Bw horizon) with common inclusions of brown (10YR 5/3, dry) to yellowish brown (10YR 5/4, dry) silt loam (A horizon). Also, there are common granules and pebbles and few fine cobbles. The Bw/Ab1 horizon has weak, fine, subangular-blocky structure and many biogenic features.

Micromorphological analysis of a thin-section of the lower 10 cm of the Bw/Ab1 horizon revealed that the material is fairly compact; it is not porous and biologically reworked, nor is it texturally depleted (Figure 17). This sample displays abundant type 1 coatings and type 2 infillings and occasional type 3 and type 4 coatings (Figure 18).

Micromorphological analysis of a thin-section of the upper 10 cm of the Bw/Ab1 horizon revealed that the material is very porous and biologically reworked. This evidence suggests that subunit IIIa may have been exposed long enough for intensive bioturbation to occur, but not long enough for an A horizon to develop. Also, the upper 10 cm of the Bw/Ab1 horizon contains abundant iron mottles and type 3 coatings, and type 4 coatings occur in the larger voids.

An abrupt, wavy boundary separates subunit IIa from subunit IIb. In Profile 3, subunit IIb is 8 cm thick and consists of brown (10YR 5/3, dry) to yellowish brown (10YR 5/4, dry) silt loam with common granules and pebbles and few fine cobbles. Plow scars were detected in subunit IIb; hence, there is an Apb1 soil horizon in this subunit (Table 5). In addition to being affected by plowing, the Apb1 horizon has been heavily bioturbated. Many worm casts and burrows were observed throughout the horizon.

Micromorphological analysis of a thin-section of the Apb1 horizon revealed that the matrix consists of poorly sorted sediment. It has been extensively reworked by soil fauna and contains some small biological pellets. Iron nodules look inherited, though some localized iron staining occurs.

An abrupt, wavy boundary separates subunit IIb from Unit V. This boundary is marked by dramatic changes in silt and clay contents. Going from subunit IIb to Unit V, silt content increases from 51.4% to 71.3% and clay content decreases from 22.7% to 4.4% (Table 2). In Profile 3, Unit V is 13 cm thick and consists of light yellowish brown (10YR 6/4,dry) silt loam. The Ap horizon (modern plow zone) of the surface soil is developed in Unit V (Table 5). This horizon has weak, medium and fine, platy structure parting to moderate, fine and medium, granular structure. As noted earlier, the material composing Unit V was dragged off the wall by machinery when the site was leveled for farming.

Summary of Profile 3

In Profile 3, the South Wall is underlain by a truncated soil (2Btb2 horizons) developed in silty sediments (see profiles 1 and 2). The wall material above the truncated soil is represented by units I, II, and V. Materials composing subunits Ia and Ib have a high silt content (84.8% and 74.2% silt, respectively), with fine silt dominating the silt fraction. The lithology of these materials strongly resembles the lithology of the sub-wall sediments. Hence, materials composing subunits Ia and Ib may have been locally derived from loess or silty slack-water sediments that were stripped off the surface when it was prepared for wall construction. In contrast, subunits IIa and IIb are composed of poorly sorted loam and silt loam, respectively. At least some, if not all, of these materials were derived from a different source compared to Unit I materials. Profile 3 is capped with a thin veneer of poorly sorted silt loam (Unit V) that was dragged off the center of the South Wall and spread on its flanks by machinery when the site was leveled for farming.

A soil with a weakly expressed A-Bw profile is developed in units I and II. This soil was plowed and subsequently buried by Unit V. Overall, this soil resembles the buried soil in Profile 2. However, many of the morphological features of the buried soil in Profile 3 are not as well developed as the ones in Profile 2, though there is evidence of clay illuviation in Profile 3. Also, bioturbation is more sporadic in Profile 3 than in Profile 2. No artifacts or bone fragments were observed in any of the thin-sections from Profile 3, but charcoal is scattered throughout the buried soil and tends to occur as sub-horizontal patches.

SUMMARY AND CONCLUSIONS

One of the primary objectives of the geoarchaeological investigation was to describe and classify the materials used for construction of the South Wall. This information was used to define the stratigraphy of the wall. Five major units of wall fill, numbered I through V, were distinguished on the basis of lithologic properties (matrix color, grain-size distribution, etc.). The primary characteristics of these units are summarized below.

Unit I: This unit is limited to the north flank of the South Wall (Figure 1) and is subdivided into two subunits: Ia and Ib. Materials composing subunits Ia and Ib have a high silt content (84.8% and 74.2% silt, respectively), with fine silt dominating the silt fraction. Subunit Ia (lower subunit) consists of yellowish brown (10YR 5/4, dry) silt that has been moderately affected by post-depositional pedogenesis. There are type 1, 2, 3, and 4 coatings and abundant iron depletion zones. Subunit Ib (upper subunit) consists of brown (10YR 5/3, dry) to yellowish brown (10YR 5/4, dry) silt loam that also has been moderately affected by post-depositional pedogenesis. There are abundant phytoliths and some organic material. In addition, there are type 1 and 4 coatings, type 2 infillings, and extensive textural depletion features (type 5). Subunits Ia and Ib have been strongly affected by bioturbation

Unit II: This unit occurs on the north and south flank of the South Wall, but barely extends into the middle of the wall (Figure 1). It is subdivided into two subunits: IIa and IIb. Subunit IIa (lower subunit) consists of poorly sorted yellowish brown (10YR 5/4, dry) loam with many granules and pebbles and common fine cobbles. Silt content ranges from about 43% to 49%, and sand content ranges from about 34% to 37%. Subunit IIb (upper subunit) consists of brown (10YR 5/3, dry) to dark yellowish brown (10YR 4/4, dry) silt loam with common granules and fine pebbles. Silt content ranges from about 43% to 51%, and sand content ranges from about 26% to 34%. Both subunits have been slightly to moderately affected by post-depositional pedogenesis. In Profile 2, there is virtually no evidence of clay illuviation in Unit II, but type 4 coatings are common to abundant. In Profile 3, there is slightly more evidence for post-depositional pedogenesis, including abundant type 1 coatings and type 2 infillings and occasional type 3 and type 4 coatings.

Unit III: This unit is primarily in the center of the South Wall, i.e., it forms the core of the wall, though a portion of it underlies the south flank (Figure 1). Unit III is very distinct because of its reddish matrix color. In Profile 1, Unit III consists of three subunits: IIIa, IIIb, and IIIc (from bottom to top). These subunits have several properties in common. First, they are somewhat rubified (reddened), with matrix colors ranging from strong brown (7.5YR 4/6, dry) to reddish brown (5YR 4/4, dry). Second, they consist of poorly sorted sediment. Third, they have relatively high sand contents compared to the underlying sub-wall sediments and most of the other wall units (Table 2). Fourth, very coarse sand (2-1 mm) dominates the total sand fraction (Table 2). Finally, there are thin bands of limpid clay coatings concentrated in voids. The bands of limpid clay coatings are associated with the formation of soil lamellae. The lamellae are about 5 mm to 2 cm thick and increase in frequency with depth in Unit III. The subunits of Unit III are separated by abrupt, wavy boundaries. Hence, the duration and intensity of pedogenesis since emplacement of the subunits have been insufficient to obliterate these boundaries. Nevertheless, there is unequivocal evidence for post-depositional pedogenesis in the three subunits composing Unit III.

Unit IV: This unit occurs as a thin veneer on the center of the South Wall and is draped across its south flank (Figure 1). It consists of brown (10YR 5/3) to light yellowish brown (10YR 6/4) silt loam with common granules and pebbles and few fine cobbles. Silt content ranges from about 51% to 67%, and sand content ranges from about 26% to 29%. Unit IV consists of soil dragged off the wall by machinery when the field was leveled for farming, and it has been thoroughly mixed by plowing. Hence, archaeological materials associated with Unit IV lack vertical and horizontal integrity.

Unit V: This unit is only 10-15 cm thick and caps the entire South Wall (Figure 1). It consists of light yellowish brown (10YR 6/4) silt loam. Silt content ranges from about 64% to 71%, and sand content ranges from about 24% to 31%. Like Unit IV, Unit V consists of soil dragged off the wall by machinery when the field was leveled for farming, and it has been thoroughly mixed by plowing. Any archaeological materials associated with Unit IV are not in situ.

The five units of fill identified in the South Wall can be grouped into two general categories based on matrix color and texture:

1. Moderately to strongly oxidized loam and occasionally silt loam with 7.5YR and 5YR hues.
2. Slightly oxidized silt, silt loam, and occasionally loam with 10YR hues.

Unit III, which forms the core of the wall, fits the first category, and all of the other units fall into the second category. The second category can be subdivided into fills that have silt contents exceeding 70% (Unit I), and those that are predominantly silt, but also have fairly high sand contents (24% and 37%).

The categorization of the wall fills described above provides a means of inferring the sources of the fill materials. For example, the first category of wall fill strongly resembles the Ockley soil series mapped across the eastern two-thirds of the site (preliminary soil map provided by Dan Lemaster, Natural Resources Conservation Service, 2001). The Ockley series has brown, strong brown, and reddish brown matrix colors (7.5YR and 5YR hues) and is developed in silty and loamy sediment above sandy and gravelly glacial outwash. The second category of wall fill resembles the Mentor soil series mapped across the western-third of the site (preliminary soil map provided by Dan Lemaster, Natural Resources Conservation Service, 2001). The Mentor series has brown and yellowish brown matrix colors (10YR hues) and is developed in silty slack-water deposits above loamy and sandy alluvium.

In order to classify the wall fill at Hopeton, an existing classification system was considered. Van Nest et al. (2001) developed a classification of mound fills that is quite applicable to the Hopeton earthworks. They distinguish three major types of fill: loaded, massive, and stratiform. The material composing the South Wall at Hopeton meets the criteria for loaded fills. In loaded fills, which have been referred to as "basket loaded" materials (Fowke 1902), the individual masses of soil or sediment used for earthwork construction are discernible (Van Nest et al. 2001:636). Van Nest et al. (2001) distinguish two subtypes of loaded fills: compositional loading and sod blocks. The west wall at Hopeton is a good example of compositional loading. According to Van Nest et al. (2001), key features of compositional loading are: (1) varying composition and texture of individual loads, and (2) abrupt boundaries between loads. They use the following quote from Squier and Davis (1848:144) as a succinct description of compositional loading:

> "Beneath this layer of gravel and pebbles, to the depth of two feet, the earth was homogeneous, though slightly mottled, as if taken up and deposited in small loads, from different localities. In one place appeared a deposit of dark-colored surface loam, and by its side, or covering it, there was a mass of clayey soil from greater depth. The outlines of these various deposits could be distinctly traced."

Other major objectives of the geoarchaeological investigation were to determine whether there were any significant hiatuses during wall construction, and to assess post-construction pedogenic alteration of the wall fill. Any significant lapse of time between phases of wall construction would be represented by a buried soil. However, no buried soils separate in situ wall units. The only buried soil occurs where machinery dragged material (Units IV and V) off the South Wall during land leveling and spread it on top of Unit II. Hence, wall construction appears to have been a fairly rapid process.

After the Hopwellian people completed the South Wall, the earthworks were affected by soil development. Evidence for post-construction pedogenesis is apparent at the macro- and micro-level, but soil development is relatively weak (A-Bw and A-Bw&Bt horizonation). Despite the presence of in situ pedo-features, such as clay films, pedogenesis has not obliterated boundaries between the units composing the South Wall. In fact, all of the units and subunits are separated by abrupt boundaries. Weak soil development in the South Wall may be related to insufficient intensity and/or duration of pedogenesis. Cambic (Bw) horizons can form in less than 500 years (Birkeland, 1999), and lamellae (Bt horizons) can develop in less than 150 years (Thoms, 2000).

It is important to note that the portion of the South Wall exposed in this study was formerly at great depth (ca. 3-4 m) below the top of the wall. Hence, it may have been insulated from strong weathering and associated soil formation until most of the wall was knocked down in the late 1950s.

In sum, this investigation yielded information about the stratigraphy of the South Wall and lithology of its fills. It also shed light on how the wall was constructed, i.e., compositional loading, and points to possible Hopwellian symbolism as evidenced by the color and placement of different soil materials used in wall construction. Although the specific source areas of the wall materials have not been identified, the lithologic properties of the individual wall units, combined with information gleaned from general soil maps, provide clues about where the materials were collected. Geomorphological investigations planned for the 2003 and 2004 field seasons at Hopeton will attempt to locate specific sources (i.e., borrow areas) of wall materials. That information will help us gain a better understanding of the magnitude of labor required to construct the Hopeton earthworks.

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REFERENCES

Birkeland, P.W., 1999, Soils and Geomorphology (Third Edition): Oxford University Press, Oxford, United Kingdom, 430 p.

Bullock, P., Federoff, N., Jongerius, A., Stoops, G., Tursina, T., and Babel, U., 1985, Handbook for soil thin section descriptions: Waine Research Publications, Wolverhampton, United Kingdom, 152 p.

Courty, M.A., Goldberg, P., and Macphail, R.I., 1989, Soil, micromorphology, and archaeology: Cambridge Manuals in Archaeology, Cambridge University Press, Cambridge, United Kingdom, 344 p.

Fowke, G., 1902, Archaeological history of Ohio: the mound builders and later Indians: Ohio State Archaeological and Historical Society, Columbus, Ohio.

Gile, L.H., 1979, Holocene soils in eolian sediments of Bailey County, Texas. Soil Science Society of America Proceedings, v. 42, p. 994-1003.

Holliday, V.T., Ferring, C.R., and Goldberg, P., 1993, The scale of soil investigations in archaeology; *in*, Effects of scale on archaeological and geoscientific perspectives, Stein, J.K. Stein, and Linse, A.R., eds.: Special Paper 283, Geological Society of America, Boulder, Colorado, p. 29-37.

Lemaster, D., 2001, Preliminary soil survey of Ross County, Ohio: Natural Resources Conservation Service, U.S. Department of Agriculture, Washington, D.C.

Soil Survey Division Staff, 1993, Soil survey manual: U.S. Department of Agriculture Handbook No. 18, U.S. Government Printing Office, Washington, D.C., 437 p.

Soil Survey Staff, 1996, Keys to soil taxonomy: Natural Resources Conservation Service, U.S. Department of Agriculture, U.S. Government Printing Office, Washington, D.C., 644 p.

Squire, E.G., and Davis, E.H., 1848, Ancient monuments of the Mississippi Valley comprising the results of extensive original surveys and explorations: Contributions to Knowledge 1, Smithsonian Institution, Washington, D.C., 304 p.

Thoms, A.V., 2000, Environmental background, land-use history, and site integrity; *in*, Uncovering Camp Ford: archaeological interpretations of a Confederate prisoner-of-war camp in east Texas, Thoms, A.V., ed.: Reports of Investigations No. 1, Center for Ecological Archaeology, Texas A&M University, College Station, Texas, p. 8-25.

Van Nest, J., Charles, D.K., Buikstra, J.E., and Asch, D.L., 2001, Sod blocks in Illinois Hopewell mounds: American Antiquity, v. 66, p. 633-650.

Walter, N.F., Hallberg, G.R., and Fenton, T.E., 1978, Particle size analysis by Iowa State University Soil Laboratory; *in*, Standard procedures for evaluating Quaternary materials in Iowa, G.R. Hallberg, G.R., ed.: Technical Information Series 8, Iowa Geological Survey, University of Iowa, Iowa City, p. 61-74.

Table 1. Textural pedo-features observed in the thin-sections.

Feature Number	Description
Type 1	Limpid (translucent), yellowish-brown void coatings. These coatings are occasionally laminated and were found in all three profiles. They vary in thickness from very thin (30 microns) to thick (125 microns), to complete infillings of voids.
Type 2	Limpid, yellowish-brown intercalations. These features are composed of the same material as type 1 features, but they appear as intercalations within the matrix rather than as void coatings.
Type 3	Dark reddish brown organic void coatings. These features were found only in profiles 2 and 3, and they occur as very thin to thick, bedded coatings.
Type 4	Very silty, brown coatings.
Type 5	Textural depletion of silt and clay features.

Table 2. Particle-size distribution of soils exposed in the west wall of Trench 1, South Wall, Hopeton Earthworks.

			Grain-Size Distribution										
			Sand*						Silt~				
Depth (cm)	Unit	Soil Horizon	VC Sand	C Sand	M Sand	F Sand	VF Sand	Total Sand	C Silt	F Silt	Total Silt	Total Clay	Textural Class^
			%										
			Profile 1										
0-10	V	Ap1	33.0	12.0	12.0	17.0	26.0	**27.6**	21.2	46.7	**67.9**	**4.5**	SiL
10-24	IV	Ap2	61.0	11.0	7.0	8.0	13.0	**25.9**	20.3	31.0	**51.3**	**22.8**	SiL
24-47	IIIc	Bw1&Btb1	60.0	12.0	8.0	9.0	11.0	**28.3**	16.9	33.9	**50.8**	**20.9**	SiL
47-82	IIIb	Bw2&Btb1	62.0	12.0	7.0	8.0	11.0	**30.4**	18.3	41.0	**59.3**	**10.3**	SiL
82-100	IIIa	Bw3&Btb1	61.0	11.0	7.0	8.0	13.0	**36.7**	10.6	32.7	**43.3**	**20.0**	L
100-115	Subwall	2Bt1b2	22.0	13.0	12.0	18.0	35.0	**3.9**	24.3	58.1	**82.4**	**13.7**	SiL
115-140	Subwall	2Bt2b2	27.0	11.0	10.0	15.0	37.0	**3.2**	19.2	65.6	**84.8**	**12.0**	SiL
			Profile 2										
0-10	V	Ap1	31.0	14.0	12.0	16.0	27.0	**30.7**	19.1	44.6	**63.7**	**5.5**	SiL
10-39	IV	Ap2	32.0	14.0	12.0	17.0	25.0	**29.4**	20.0	47.2	**67.2**	**3.5**	SiL
39-55	IIb	Ab1	21.0	19.0	17.0	20.0	23.0	**34.5**	15.7	35.6	**51.3**	**14.2**	SiL
55-83	III	Bw1b1	24.0	19.0	16.0	19.0	22.0	**36.9**	17.1	30.1	**47.2**	**15.9**	L
83-103	IIa	Bw2b1	31.0	17.0	14.0	18.0	22.0	**34.0**	16.6	32.7	**49.3**	**16.7**	L
103-120	Subwall	2Btb2	27.0	15.0	12.0	18.0	28.0	**8.3**	23.7	59.2	**82.9**	**8.9**	Si

Table 2 (continued).

Depth (cm)	Unit	Soil Horizon	Grain-Size Distribution* Sand: VC Sand	C Sand	M Sand	F Sand	VF Sand	Total Sand	Silt: C Silt	F Silt	Total Silt	Total Clay	Textural Class~
			%										
			Profile 3										
0-13	V	Ap	31.0	13.0	12.0	17.0	27.0	**24.2**	20.2	51.1	**71.3**	**4.4**	SiL
13-21	IIb	Apb1	31.0	13.0	12.0	16.0	28.0	**25.9**	20.3	31.1	**51.4**	**22.7**	SiL
21-45	IIa	Bw/Ab1	22.0	11.0	11.0	17.0	39.0	**36.7**	10.6	32.7	**43.3**	**20.0**	L
45-68	Ib	Bw1b1	16.0	12.0	13.0	18.0	41.0	**7.2**	21.0	53.2	**74.2**	**18.6**	SiL
68-101	Ia	Bw2b1	21.0	14.0	13.0	17.0	35.0	**6.3**	19.9	64.9	**84.8**	**8.9**	SiL
101-125	Subwall	2Bw1b2	28.0	12.0	11.0	17.0	33.0	**4.6**	18.5	67.3	**85.8**	**9.6**	Si
125-135	Subwall	2Bw2b2	85.0	3.0	2.0	5.0	5.0	**6.8**	14.5	69.5	**84.0**	**9.3**	Si

* Particle-size limits (mm) - Sand: Total = 2.0-0.05, VC = 2.0-1.0, C = 1.0-0.5, M = 0.5-0.25, F = 0.25-0.10, VF = 0.10-0.05
Silt: Total = 0.05-0.002, Corse silt = 0.05-0.008, Fine silt = 0.008-0.002
Clay: Total = <0.002
~ Textural classes: Si = silt; SiL = silt loam; L = loam

Table 3. Description of Profile 1.

Depth (cm)	Fill	Soil Horizon	Description
0-10	V	Ap1	Light yellowish brown (10YR 6/4) silt loam, yellowish brown to dark yellowish brown (10YR 5/4 to 4/4) moist; weak medium and fine platy structure parting to moderate fine and medium granular; friable; many fine and very fine roots; abrupt wavy boundary.
10-24	IV	Ap2	Light yellowish brown (10YR 6/4) coarse silt loam, yellowish brown to dark yellowish brown (10YR 5/4 to 4/4) moist; weak fine subangular blocky structure parting to weak medium and fine granular; friable; common fine and very fine roots; common worm casts and open worm burrows; common granules and few pebbles; common fine and medium pores; abrupt wavy boundary.
24-47	IIIc	Bw1&Btb1	Strong brown (7.5YR 4/6) coarse silt loam, brown (7.5YR 4/4) moist; weak medium and fine subangular blocky structure; friable; few distinct discontinuous reddish brown (5YR 4/3) clay films on ped faces and in pores; common distinct reddish brown (5YR 4/3, dry) lamellae; common fine and very fine roots; common worm casts and open worm burrows; many granules, common pebbles, and few cobbles 4-6 cm in diameter; common fine, medium, and coarse pores; abrupt wavy boundary.
47-82	IIIb	Bw2&Btb1	50 % strong brown (7.5YR 4/6) coarse silt loam, brown (7.5YR 4/4) moist, 50% reddish brown (5YR 4/4) coarse silt loam, dark reddish brown (5YR 3/4) moist; few fine distinct yellowish red (5YR 5/6) mottles; few masses of brown (10YR 5/3) silt loam with common fine distinct strong brown (7.5YR 4/6) and few fine faint light yellowish brown (2.5Y 6/4) mottles; very weak fine and very fine subangular blocky structure; friable; few distinct discontinuous reddish brown (5YR 4/3, dry) clay films on ped faces and in pores; common 2-8 mm thick reddish brown (5YR 4/4) lamellae 10-15 cm below the top of the horizon; common fine and few medium roots; common worm casts and open worm burrows; many granules, common pebbles, and few cobbles 5-8 cm in diameter; common fine, medium, and coarse pores; abrupt wavy boundary.
82-100	IIIa	Bw3&Btb1	Reddish brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) moist; few fine distinct yellowish red (5YR 5/6) mottles; few masses of brown (10YR 5/3) silt loam with common fine distinct strong brown (7.5YR 4/6) and few fine faint light yellowish brown (2.5Y 6/4) mottles; very weak fine and very fine subangular blocky structure; friable; few distinct discontinuous reddish brown (5YR 4/3) clay films on ped

Table 3 (continued).

Depth (cm)	Fill	Soil Horizon	Description
			faces and in pores; common distinct reddish brown (5YR 4/3, dry) lamellae; common fine and very fine, soft, iron and manganese oxide segregations; common fine and few medium roots; common worm casts and open worm burrows; many granules, common pebbles, and few cobbles 5-8 cm in diameter; common fine, medium, and coarse pores; abrupt wavy boundary.
100-115	Sub-wall	2Bt1b2	Light olive brown (2.5Y 5/3) silt loam, olive brown (2.5Y 4/3) moist; common fine distinct dark yellowish brown (10YR 4/6), yellowish brown (10YR 5/6), and strong brown (7.5YR 4/6 and 5/6) mottles; weak fine angular blocky structure; very hard, very firm; common distinct patchy grayish brown (2.5Y 5/2) clay films on ped faces; common very fine, soft, iron and manganese oxide segregations; few fine roots; common very fine pores; clear smooth boundary.
115-140	Sub-wall	2Bt2b2	Yellowish brown (10YR 5/4) silt loam, dark yellowish brown (10YR 4/4) moist; common fine faint yellowish brown (10YR 5/6) and few fine prominent red (2.5YR 5/6) mottles; weak medium and fine prismatic structure parting to moderate fine and very fine subangular blocky; very hard, very firm; common distinct discontinuous brown (10YR 5/3) clay films on ped faces; few well-rounded pebbles and small cobbles in lower 5 cm of horizon; few very fine, soft, iron and manganese oxide segregations; few fine roots; common very fine pores.

Table 4. Description of Profile 2.

Depth (cm)	Fill	Soil Horizon	Description
0-10	V	Ap1	Light yellowish brown (10YR 6/4) silt loam, yellowish brown to dark yellowish brown (10YR 5/4 to 4/4) moist; weak medium and fine platy structure parting to moderate fine and medium granular; friable; many fine and very fine roots; abrupt wavy boundary.
10-39	IV	Ap2	Brown (10YR 5/3) to yellowish brown (10YR 5/4) silt loam, brown (10YR 4/3) to dark yellowish brown (10YR 4/4) moist; weak fine subangular blocky structure parting to weak medium and fine granular; friable; common fine and very fine roots; common worm casts and open worm burrows; common granules and pebbles and few fine cobbles; common fine and medium pores; abrupt wavy boundary.
39-55	IIb	Ab1	Brown (10YR 4/3) to dark yellowish brown (10YR 4/4) silt loam, dark brown (10YR 3/3) to dark yellowish brown (10YR 4/4) moist; weak fine and very fine granular structure; friable; common fine and very fine and few medium and coarse roots; common worm casts and open worm burrows; common granules and fine pebbles; many fine, medium, and coarse pores; gradual smooth boundary.
55-83	III	Bw1b1	Brown (7.5YR 5/3) loam, brown (7.5YR 4/3) moist; weak fine subangular blocky structure; slightly hard; common pale brown (10YR 6/3) to very pale brown (10YR 7/3) silt coats on ped faces; few fine and very fine roots; common worm casts and open worm burrows; common granules and fine pebbles; many fine, medium, and coarse pores; clear smooth boundary.
83-103	IIa	Bw2b1	Yellowish brown (10YR 5/4) loam, dark yellowish brown (10YR 3/4) moist; weak fine subangular blocky structure; slightly hard; few fine and very fine roots; common worm casts and open worm burrows; many granules and pebbles and common fine cobbles; common fine, medium, and coarse pores; abrupt smooth boundary.
103-120	Sub-wall	2Btb2	Yellowish brown (10YR 5/4) silt, dark yellowish brown (10YR 4/4) moist; common fine faint yellowish brown (10YR 5/6) and few fine prominent red (2.5YR 5/6) mottles; weak medium and fine prismatic structure parting to moderate fine and very fine subangular blocky; very hard, very firm; common distinct discontinuous brown (10YR 5/3) clay films on ped faces; few well-rounded pebbles and small cobbles in lower 5 cm of horizon; few very fine, soft, iron and manganese oxide segregations; few fine roots; common very fine pores.

Table 5. Description of Profile 3.

Depth (cm)	Fill	Soil Horizon	Description
0-13	V	Ap	Light yellowish brown (10YR 6/4 silt loam, yellowish brown to dark yellowish brown (10YR 5/4 to 4/4) moist; weak medium and fine platy structure parting to moderate fine and medium granular; friable; many fine and very fine roots; abrupt wavy boundary.
13-21	IIb	Apb1	Brown (10YR 5/3) to yellowish brown (10YR 5/4) silt loam, brown (10YR 4/3) to dark yellowish brown (10YR 4/4) moist; weak fine subangular blocky structure parting to weak medium and fine granular; friable; common fine and very fine roots; many worm casts and open worm burrows; common granules and pebbles and few fine cobbles; common fine and medium pores; abrupt wavy boundary.
21-45	IIa	Bw/Ab1	Yellowish brown (10YR 5/4) loam, dark yellowish brown (10YR 4/4) moist; common fine distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; friable; common inclusions of brown (10YR 5/3) to yellowish brown (10YR 5/4) silt loam; common very fine and fine, soft, iron and manganese oxide segregations; common fine and very fine roots; many worm casts and open worm burrows; common granules and pebbles and few fine cobbles; many very fine, fine, and medium pores; abrupt wavy boundary.
45-68	Ib	Bw1b1	Brown (10YR 5/3) to yellowish brown (10YR 5/4) silt loam, brown (10YR 4/3) to dark yellowish brown (10YR 4/4) moist; common fine distinct yellowish brown (10YR 5/6) mottles; weak fine prismatic structure parting to weak fine subangular blocky; hard; few pale brown (10YR 6/3) silt coats on ped faces and in pores; many very fine and fine, soft, iron and manganese oxide segregations; common fine flecks of charcoal; common fine and very fine roots; many worm casts and open worm burrows; common very fine, fine, and medium pores; abrupt wavy boundary.
68-101	Ia	Bw2b1	Yellowish brown (10YR 5/4) silt, dark yellowish brown (10YR 4/4) moist; common fine prominent yellowish brown (10YR 5/6) mottles; very weak fine subangular blocky structure; friable; common very fine and fine, soft, iron and manganese oxide segregations; common fine and very fine roots; common worm casts and open worm burrows; many very fine, fine, and medium pores; abrupt wavy boundary.
101-125	Sub-wall	2Bt1b2	Yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/4) silt, dark yellowish brown (10YR 3/4) moist; weak medium and fine prismatic structure parting to moderate

Table 5 (continued).

Depth (cm)	Fill	Soil Horizon	Description
			fine and very fine subangular blocky; very hard, very firm; common distinct discontinuous brown (10YR 4/3) clay films on ped faces; few well-rounded pebbles and small cobbles; common very fine and fine, soft, iron and manganese oxide segregations; few fine roots; common very fine pores, gradual smooth boundary.
125-135+	Sub-wall	2Bt2b2	Yellowish brown (10YR 5/4) silt, dark yellowish brown (10YR 4/4) moist; common fine faint yellowish brown (10YR 5/6) and few fine prominent red (2.5YR 5/6) mottles; weak medium and fine prismatic structure parting to moderate fine and very fine subangular blocky; very hard, very firm; common distinct discontinuous brown (10YR 5/3) clay films on ped faces; few well-rounded pebbles and small cobbles; few very fine, soft, iron and manganese oxide segregations; few fine roots; common very fine pores.

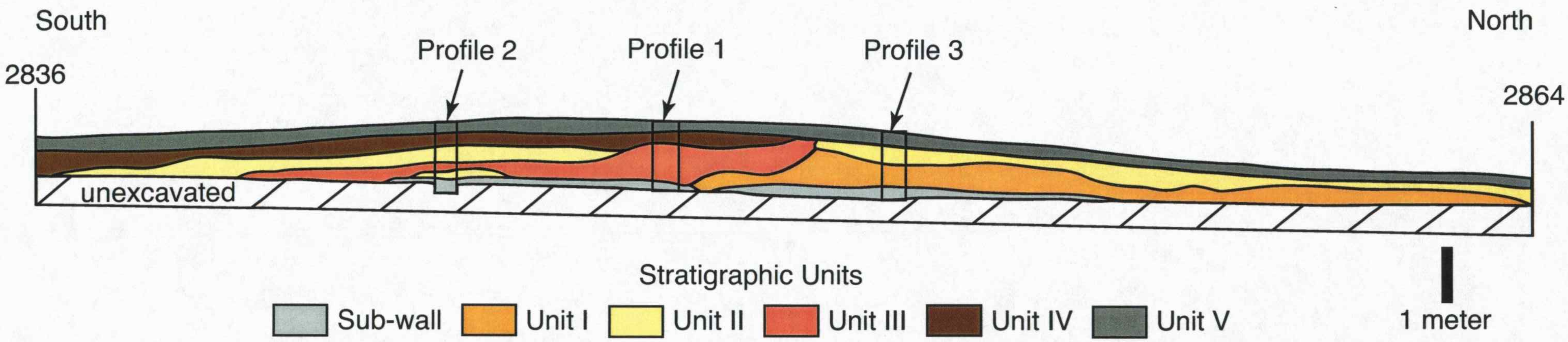

Figure 1. Stratigraphy of the South Wall at Hopeton Earthworks (exposed in the west wall of Trench 1).

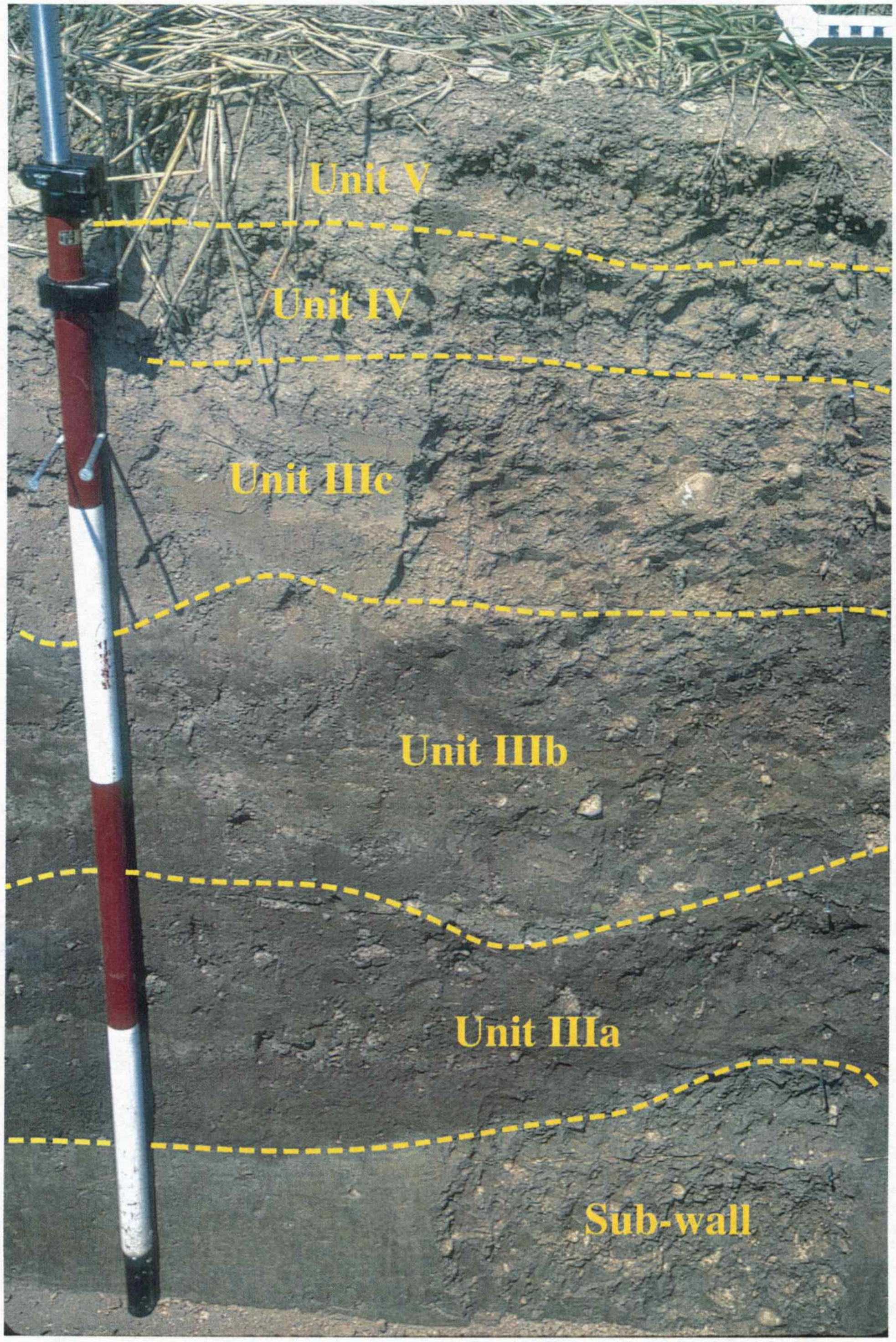

Figure 2. Photograph of Profile 1 in the west wall of Trench 1

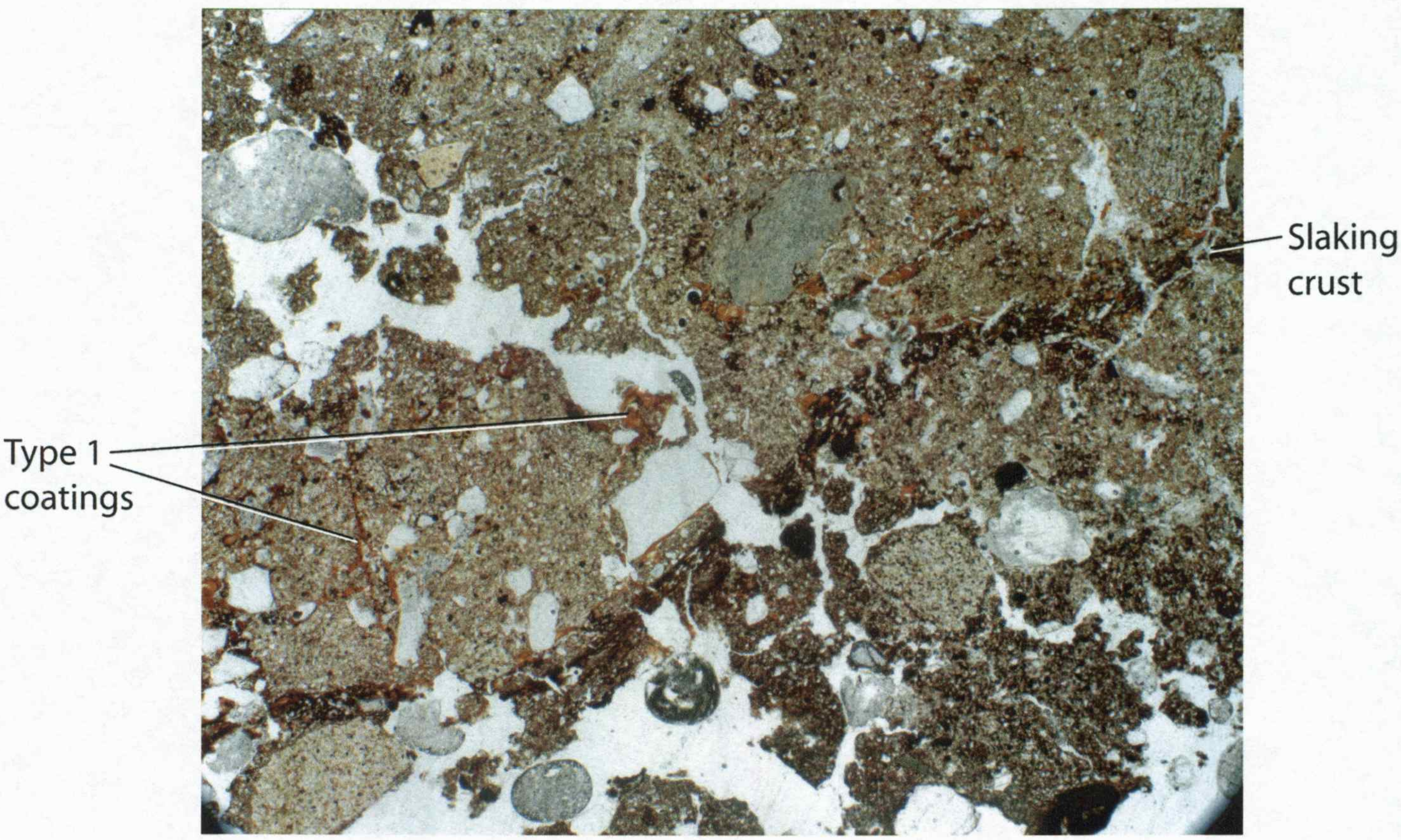

Figure 3. A portion of the band of type 1 void coatings in a sample from the Bw3&Btb1 horizon developed in Unit IIIa (Profile 1) is visible here, as is the slaking crust. Both features are likely associated with the formation of soil lamellae. (PPL, field of view is ca. 6.5 mm.)

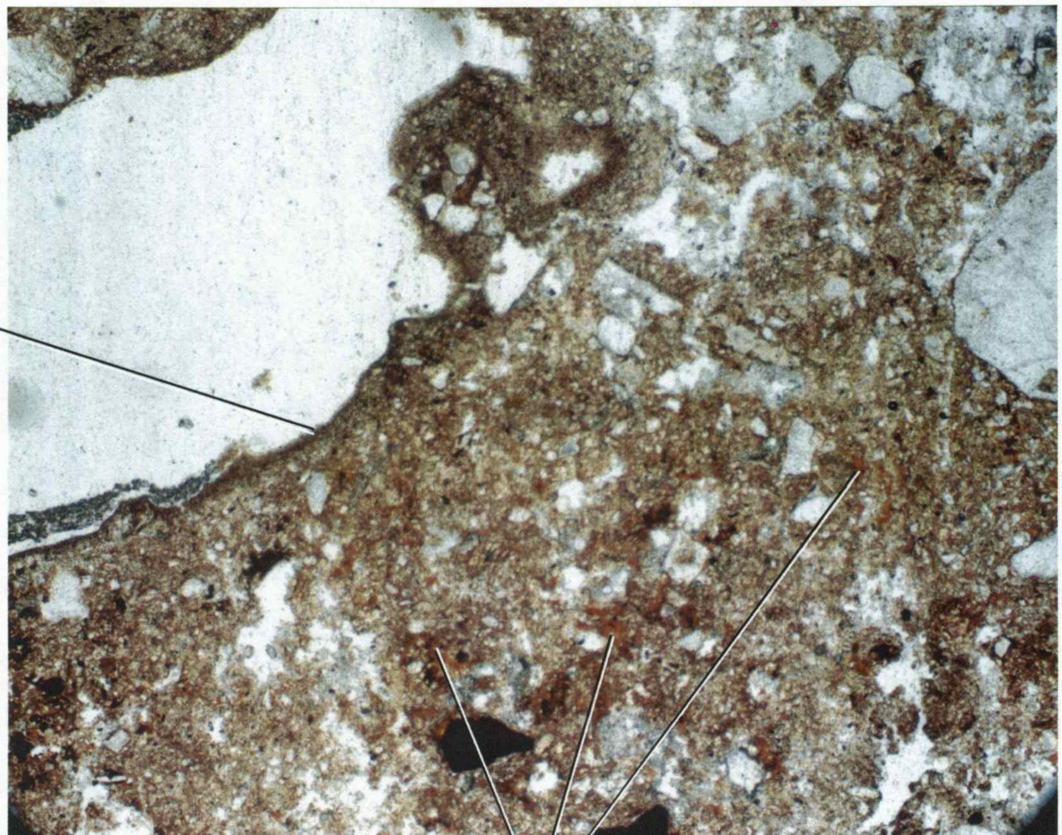

Figure 4. This photomicrograph of a sample from the Bw2&Btb1 horizon developed in Unit IIIb (Profile 1) shows type 2 infillings and a type 4 coatings around the large void in the upper left of the image. (PPL, field of view is ca. 3.2 mm.)

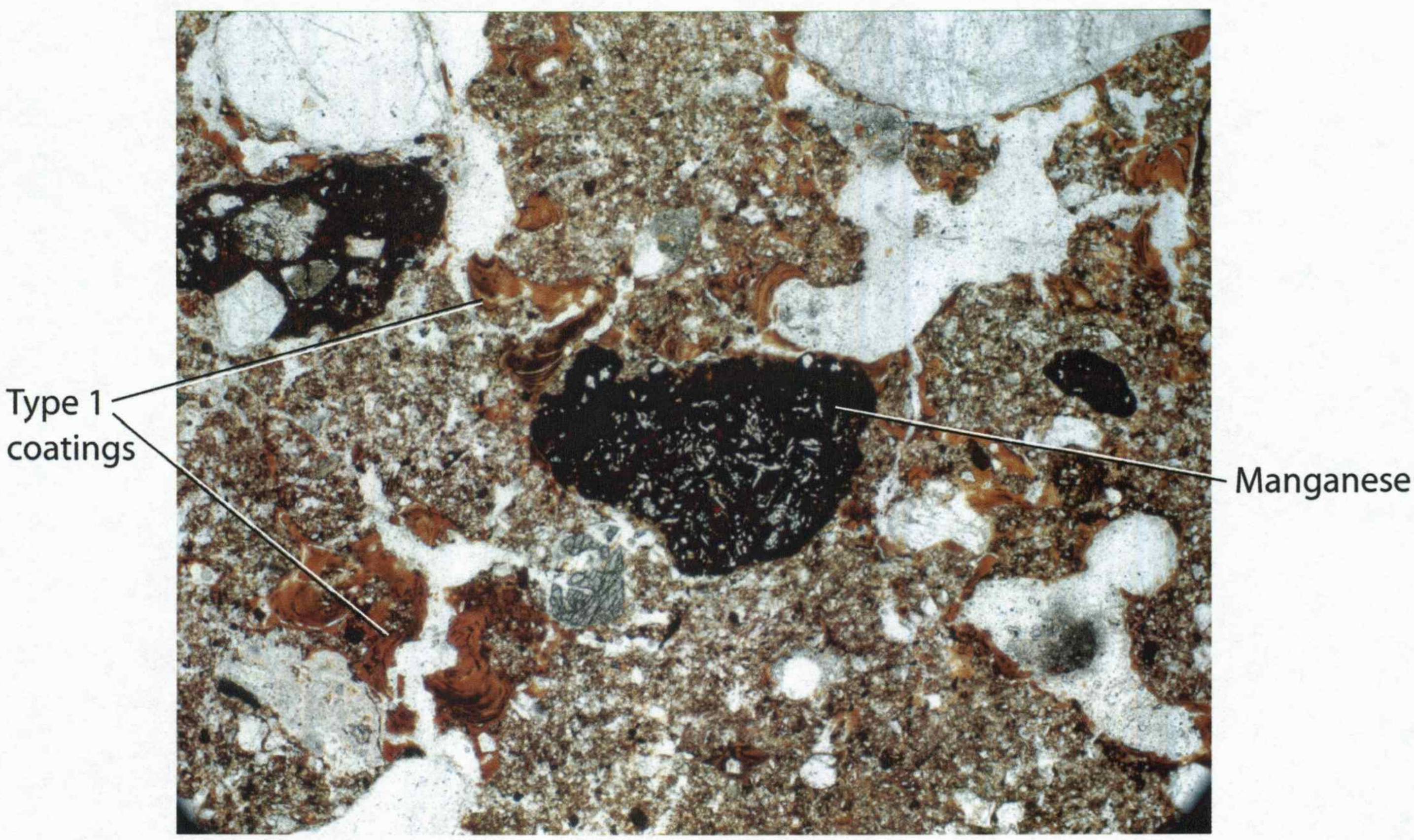

Figure 5. Manganese is visible in the center of this photomicrograph of a sample from the Bw2&Btb1 horizon in Unit IIIb (Profile 1). The manganese is surrounded by type 1 void coatings. (PPL, field of view is ca. 3.2 mm.)

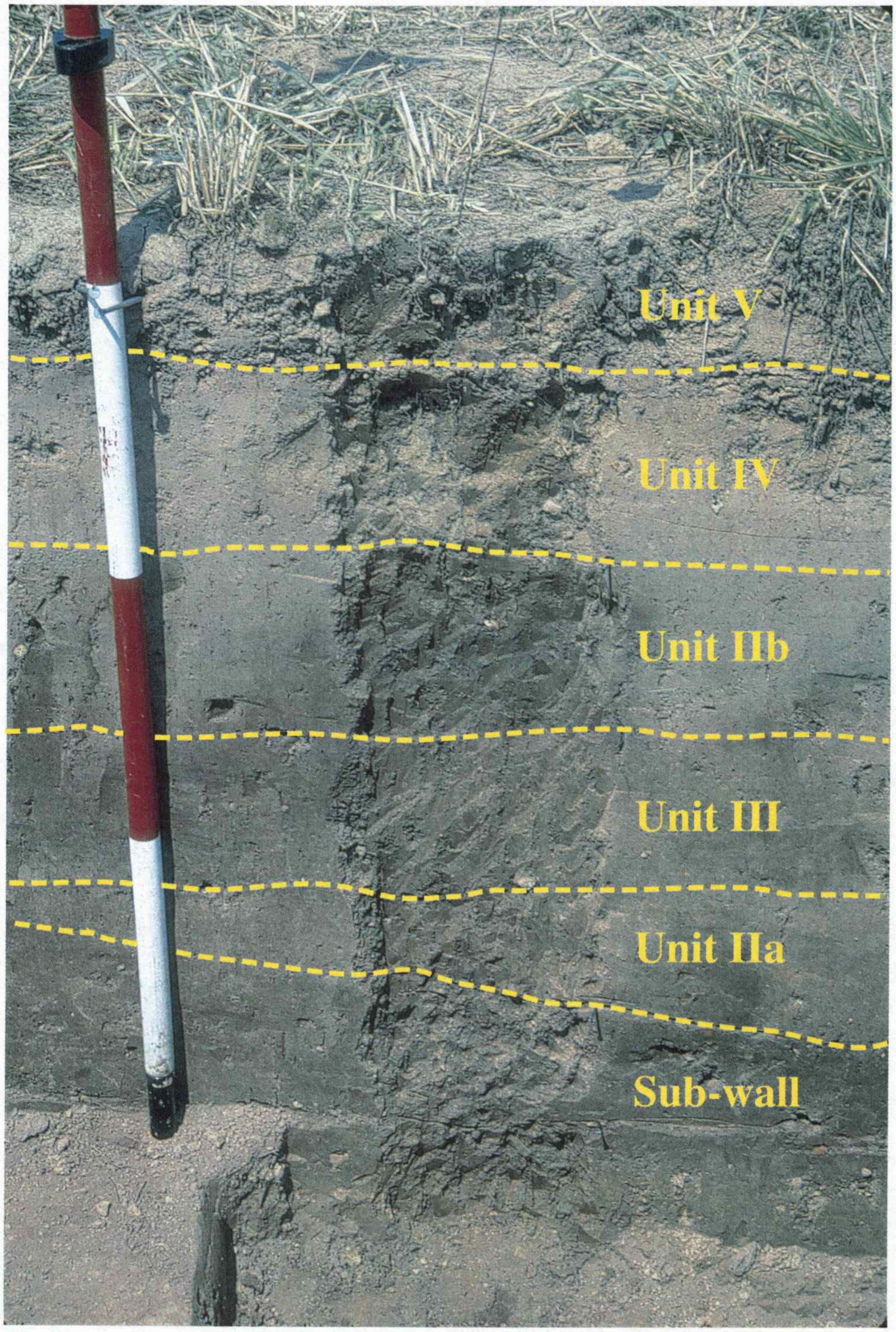

Figure 6. Photograph of Profile 2 in the west wall of Trench 1.

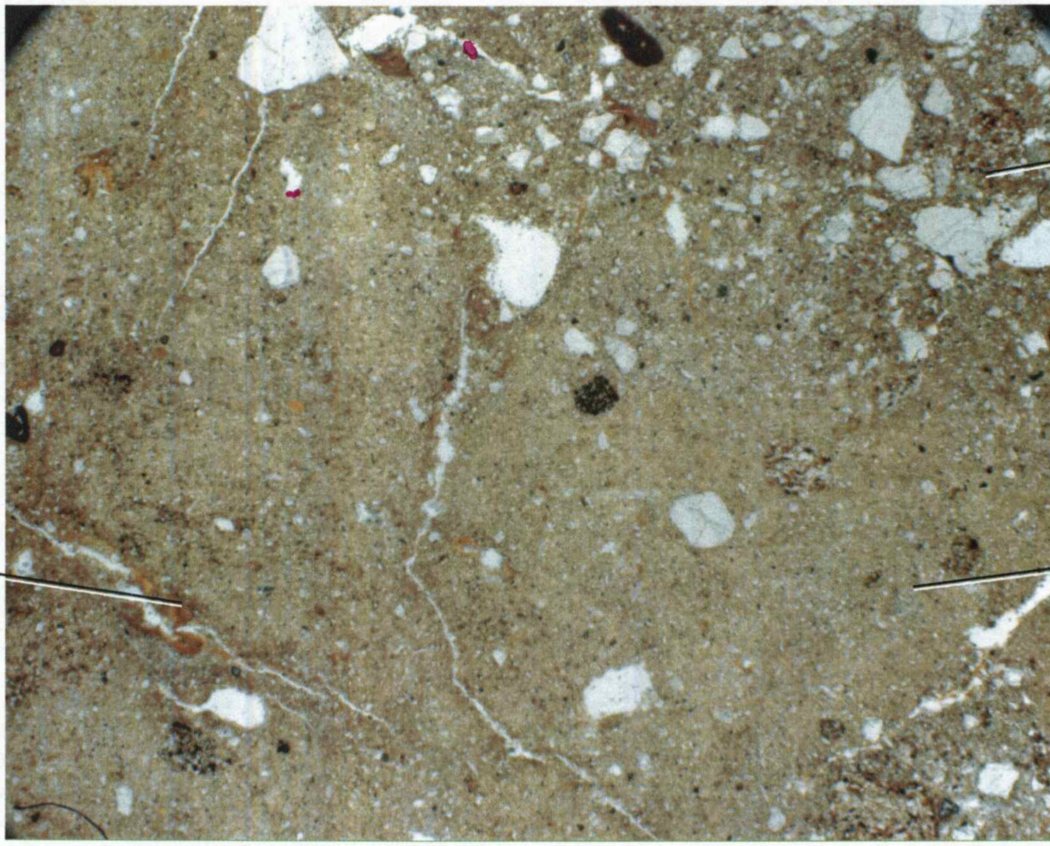

Figure 7. The fine-grained sediment underlying the wall in Profile 2 is clearly visible here, as are occasional type 1 void coatings. The coarser grained material visible in the top of the photograph is similar to that found in the infilled burrows elsewhere in this sample. Here it appears as a band that may be part of the overlying layer (PPL, field of view is ca. 6.5 mm.)

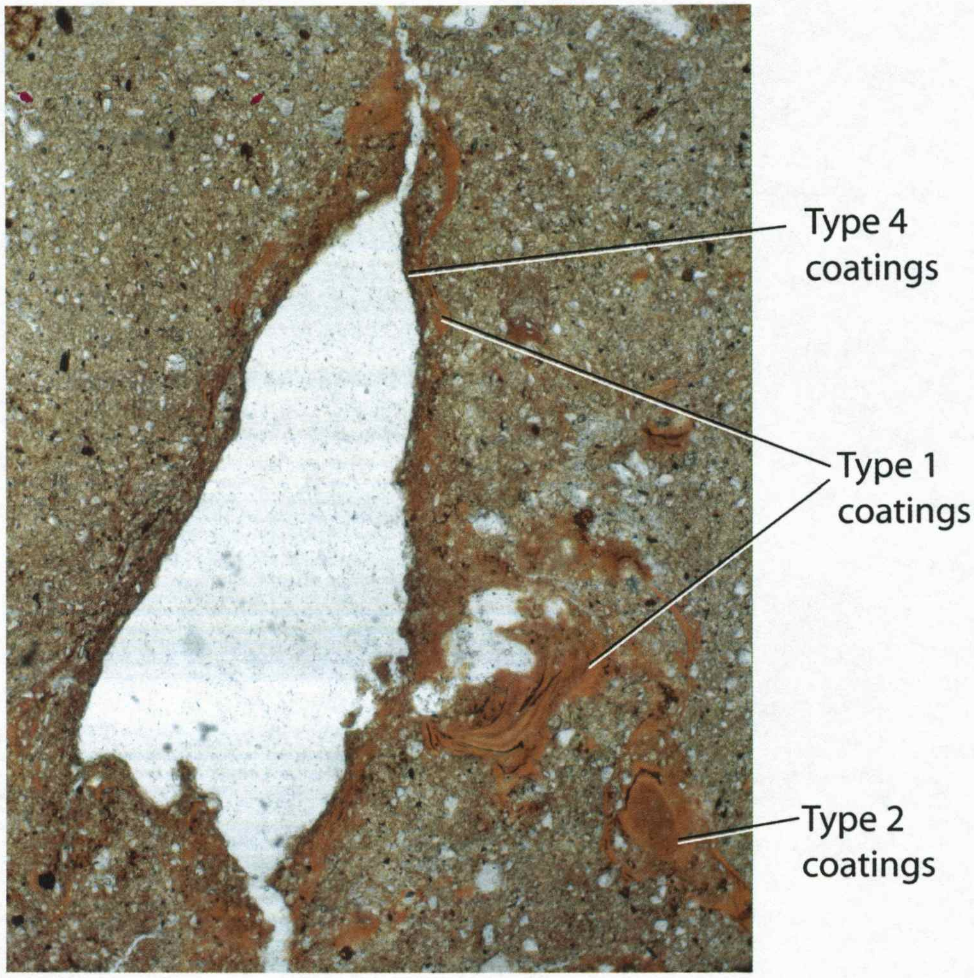

Figure 8. The limpid clay (type 1) void coatings and (type 2) infillings are both visible in this photomicrograph of a sample from the 2Btb2 horizon developed in sub-wall sediments (Profile 2). The type 1 void coatings are overlain by type 4 coatings. (PPL, field of view is ca. 6.5 mm.)

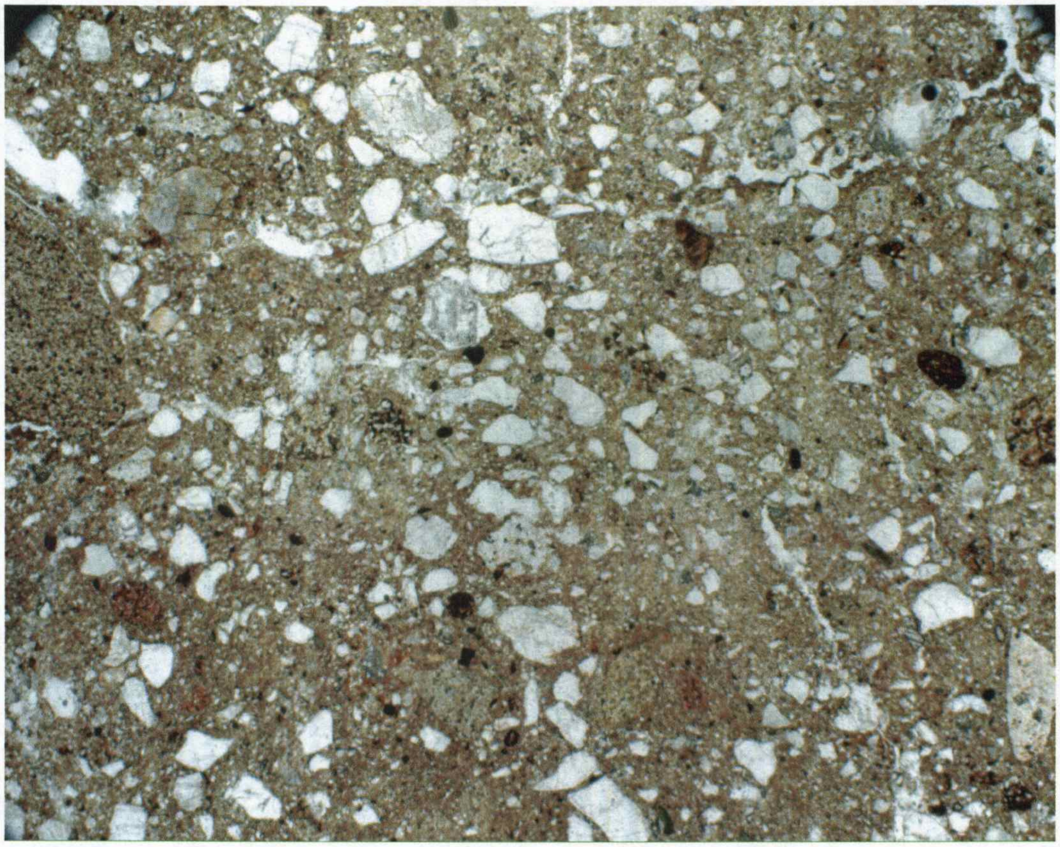

Figure 9. The relatively coarse texture of sediment composing Unit III in Profile 2 is apperent in this photomicrograph. Note the difference between this material and the underlying sub-wall sediment shown in Figure 7. (PPL, field of view is ca. 6.5 mm.)

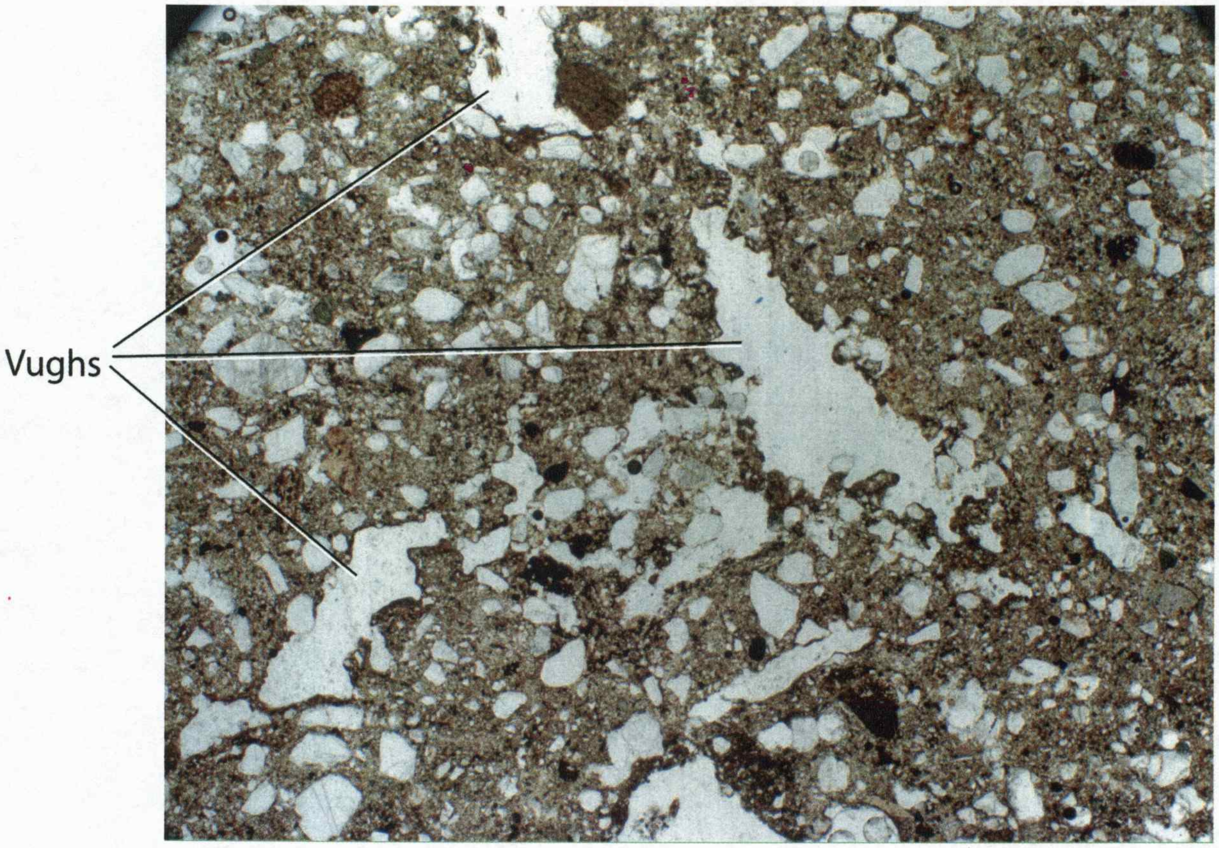

Figure 10. Illustrated here are the abundant vughs, produced by bioturbation, that are characteristic of much of Unit III in Profile 2. (PPL, field of view is ca. 6.5 mm.)

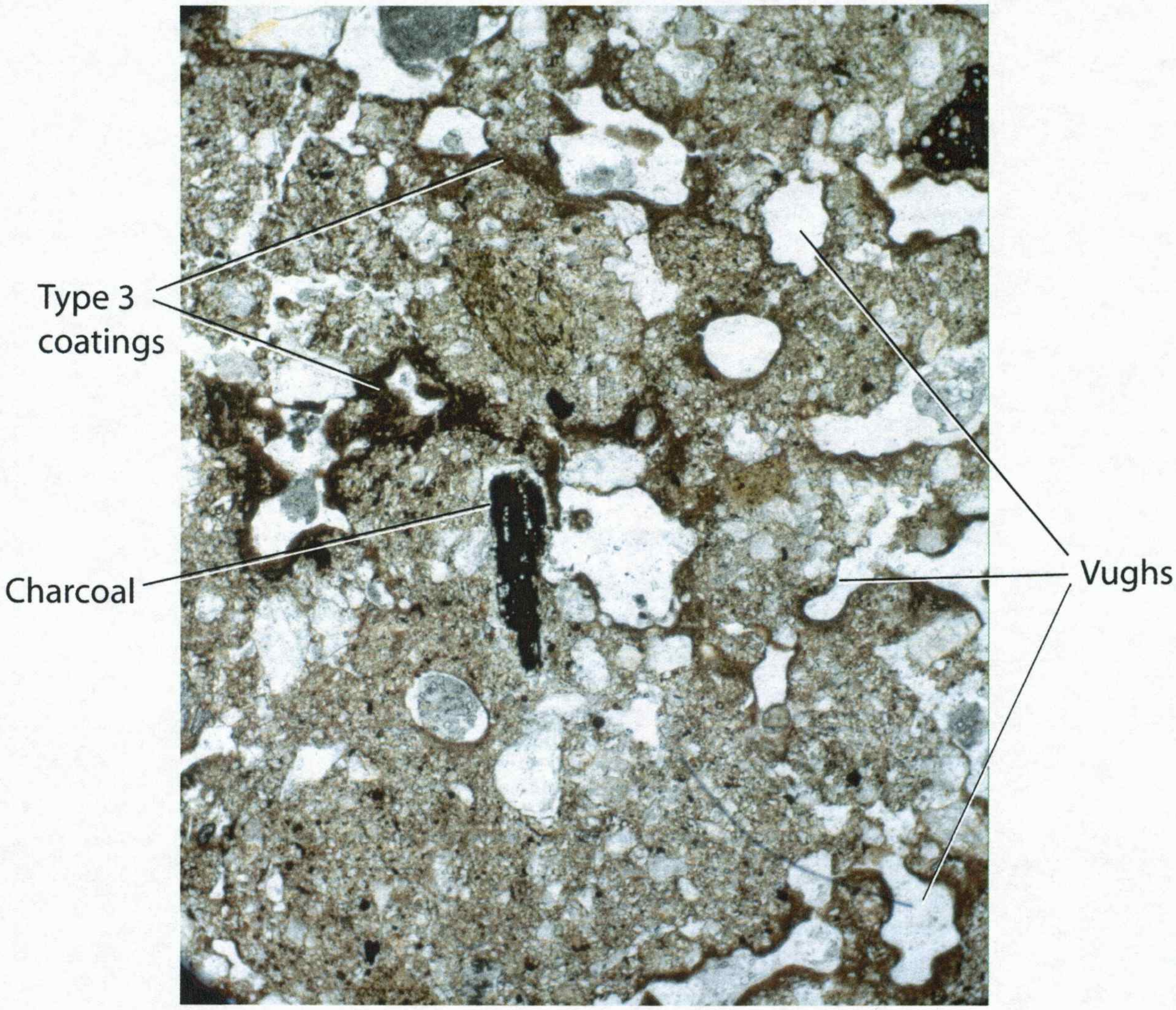

Figure 11. Both the dark type 3 coatings and the structure of vughy, bioturbated material are visible in this photomicrograph of a sample from the Ab1 horizon developed in Unit IIb (Profile 2). There is a charcoal fragment in the center of the photomicrograph. (PPL, field of view is ca. 3.2 mm.)

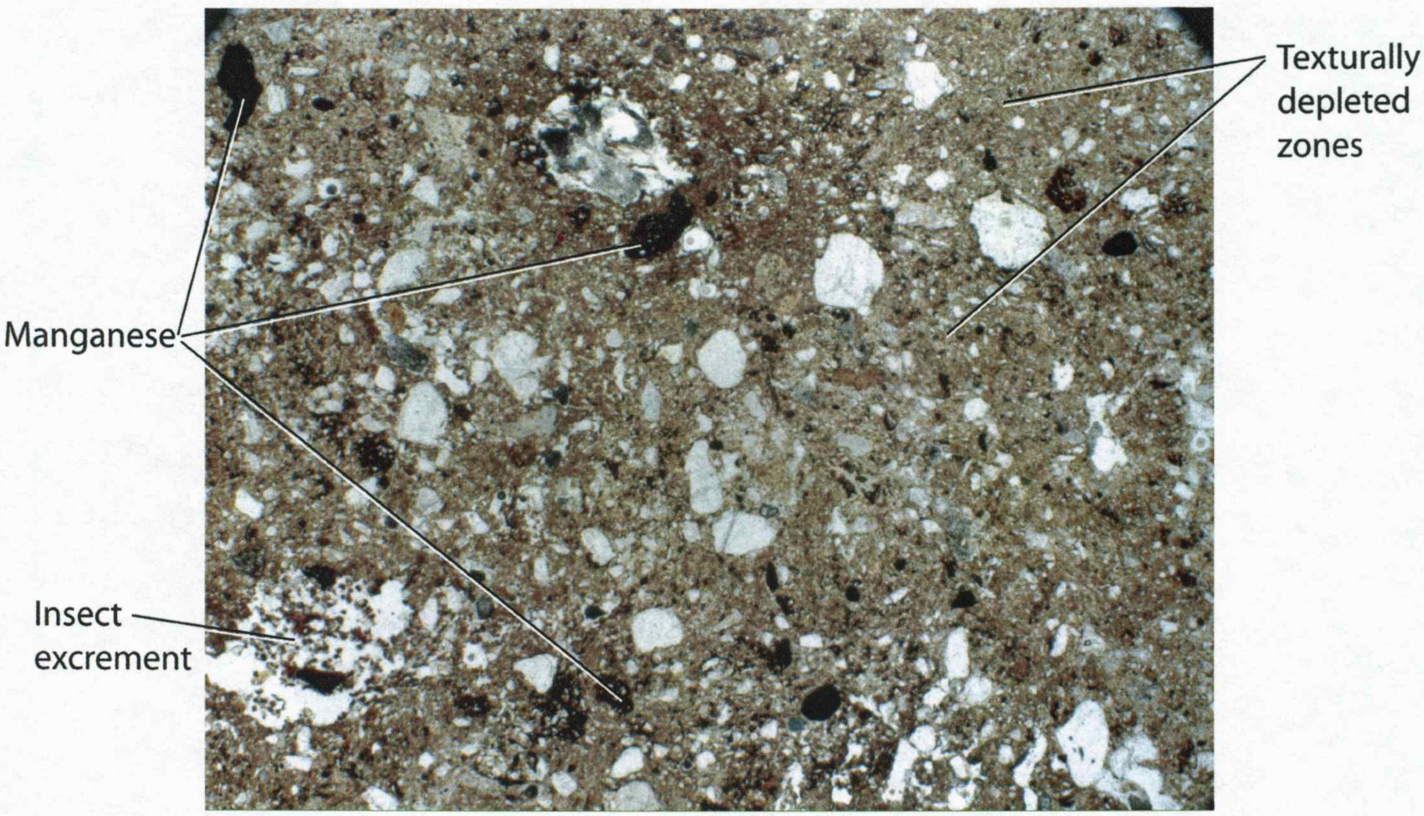

Figure 12. In this photomicrograph of a sample from Unit IV (Ap2 horizon) in Profile 2, insect excrement is visible as very small aggregates in the vugh in the lower left. Texturally depleted zones are visible at right, and manganese is visible throughout. (PPL; field of view is ca. 6.5 mm.)

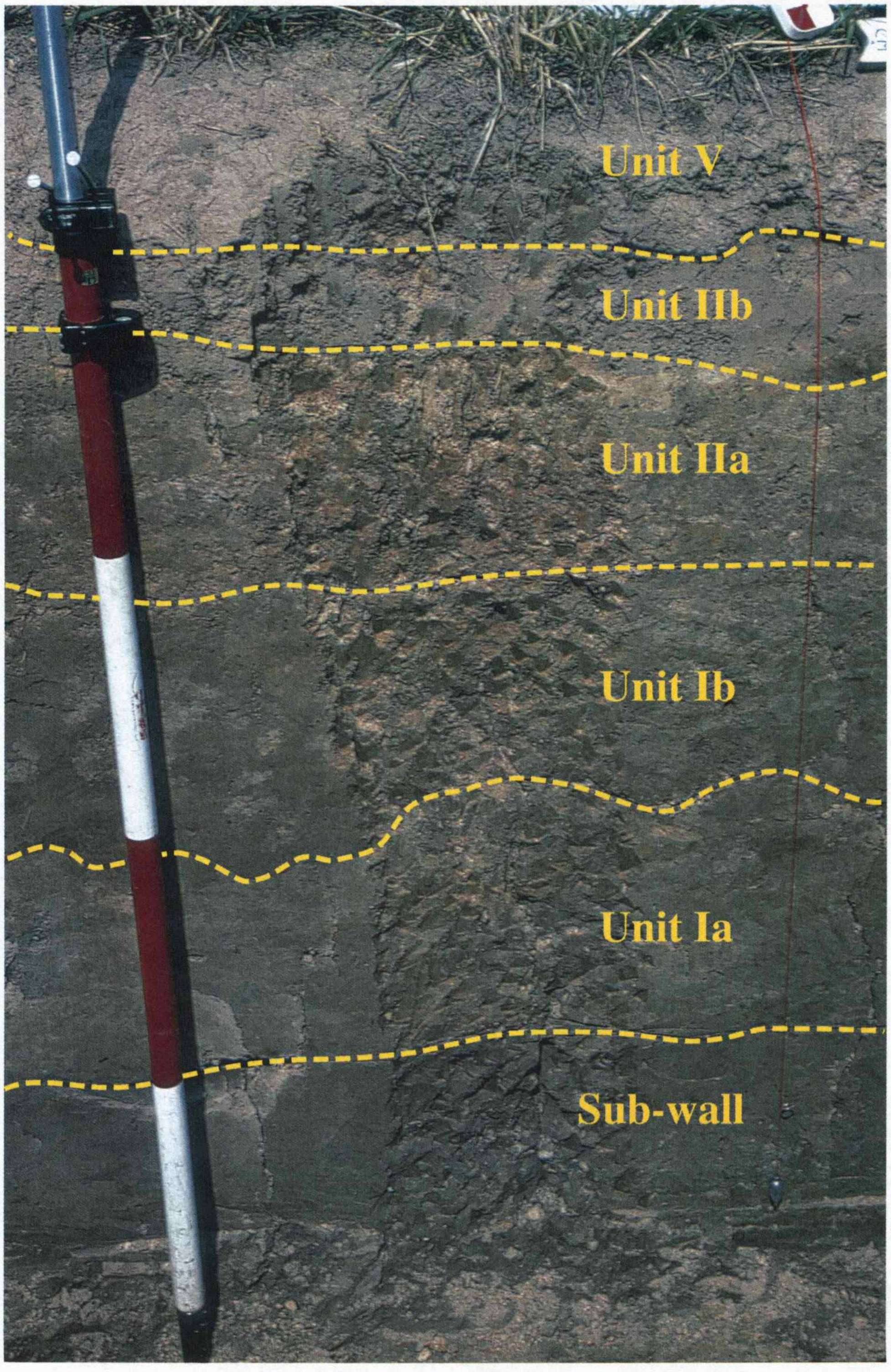

Figure 13. Photograph of Profile 3 in the west wall of Trench 1.

Figure 14. The fine-grained nature of the sub-wall sediment in Profile 3 is shown in this photomicrograph, along with well-developed type 1 coatings. This sediment resembles the sediment observed beneath the South Wall in Profile 2 (Figure 8). The dark stains are artifacts of the thin-section preparation and are not part of the sediment. (PPL, field of view is ca. 6.5 mm.)

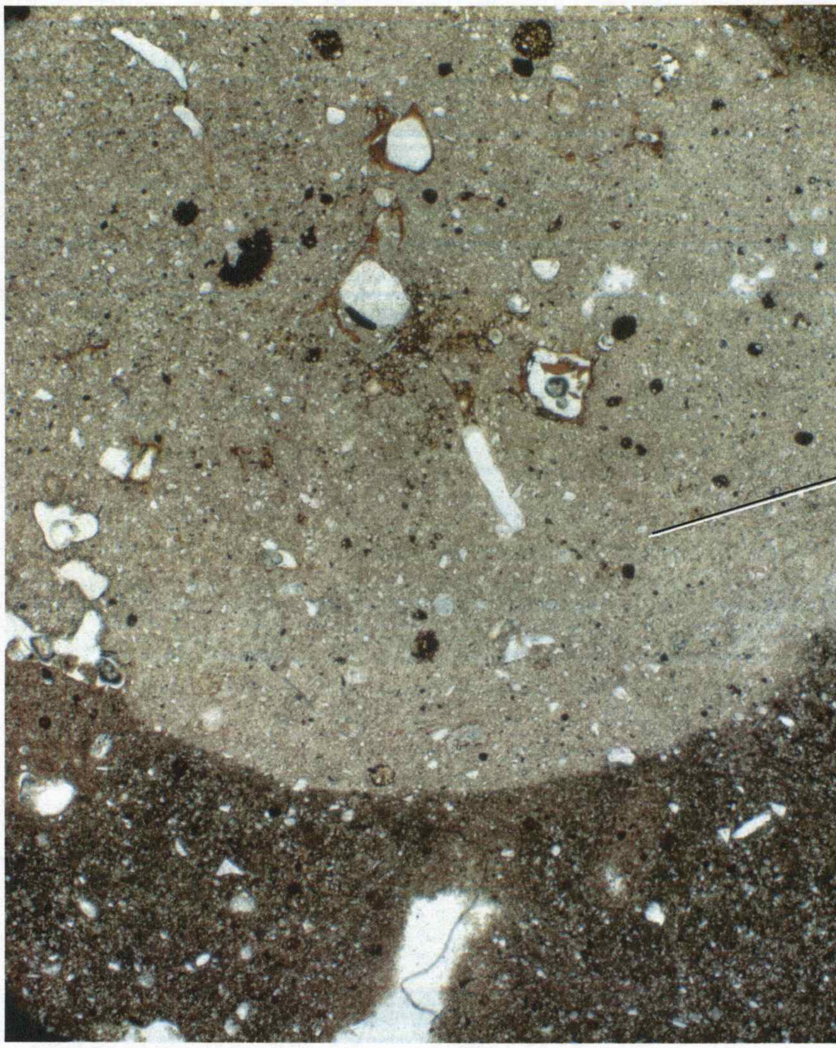

Figure 15. A zone of extensive iron depletion is visible in the center of this photomicrograph of a sample from the Bw2b1 horizon developed in Unit Ia (Profile 3). (PPL, field of view is ca. 6.5 mm.)

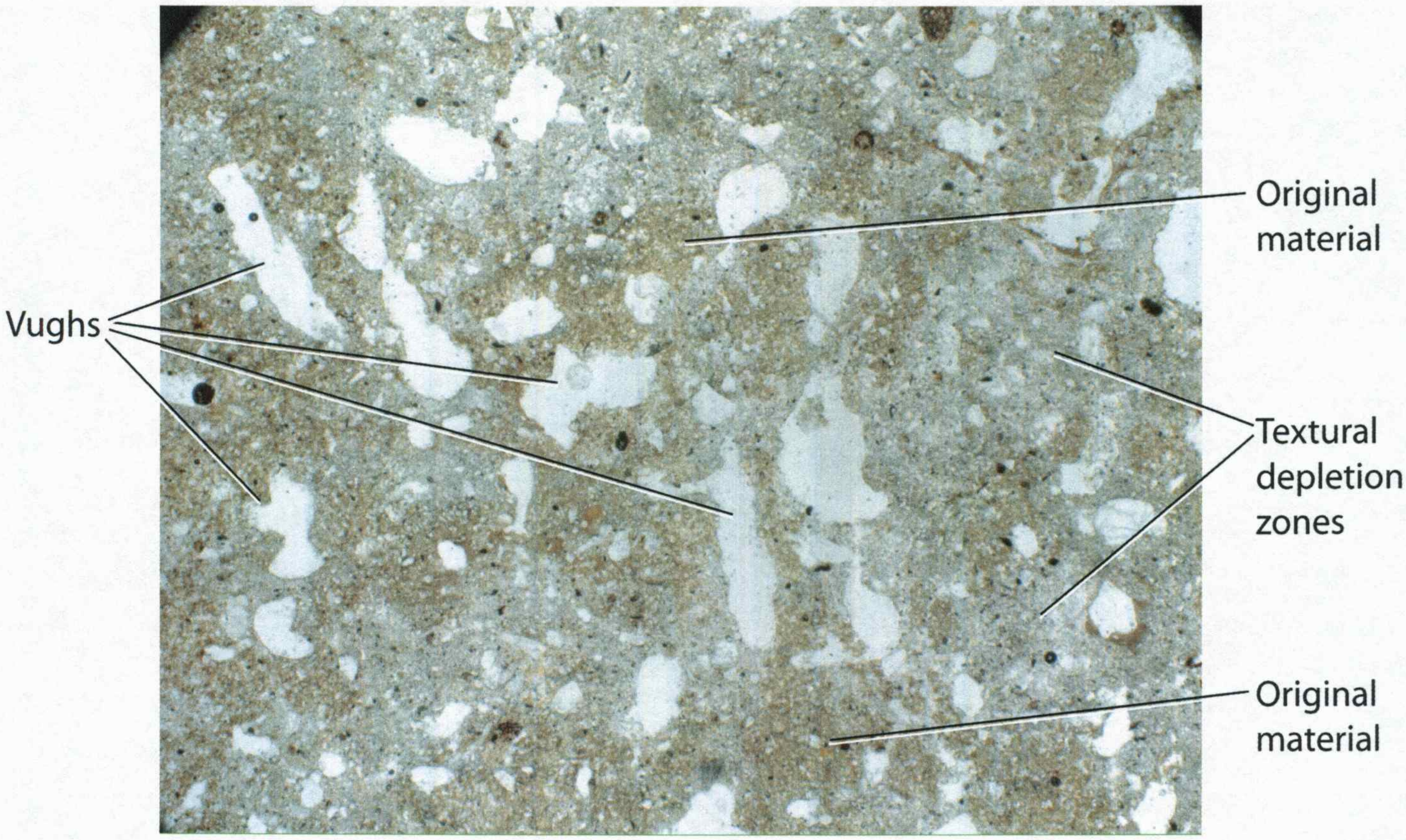

Figure 16. In this photomicrograph of a sample from Unit Ib (Profile 3), the abundance of vughs is caused by bioturbation. The extensive, lighter colored, textural depletion (type 5) features are clearly visible throughout this photomicrograph and contrast with the original material which is darker and more yellow. (PPL, field of view is ca. 6.5 mm.)

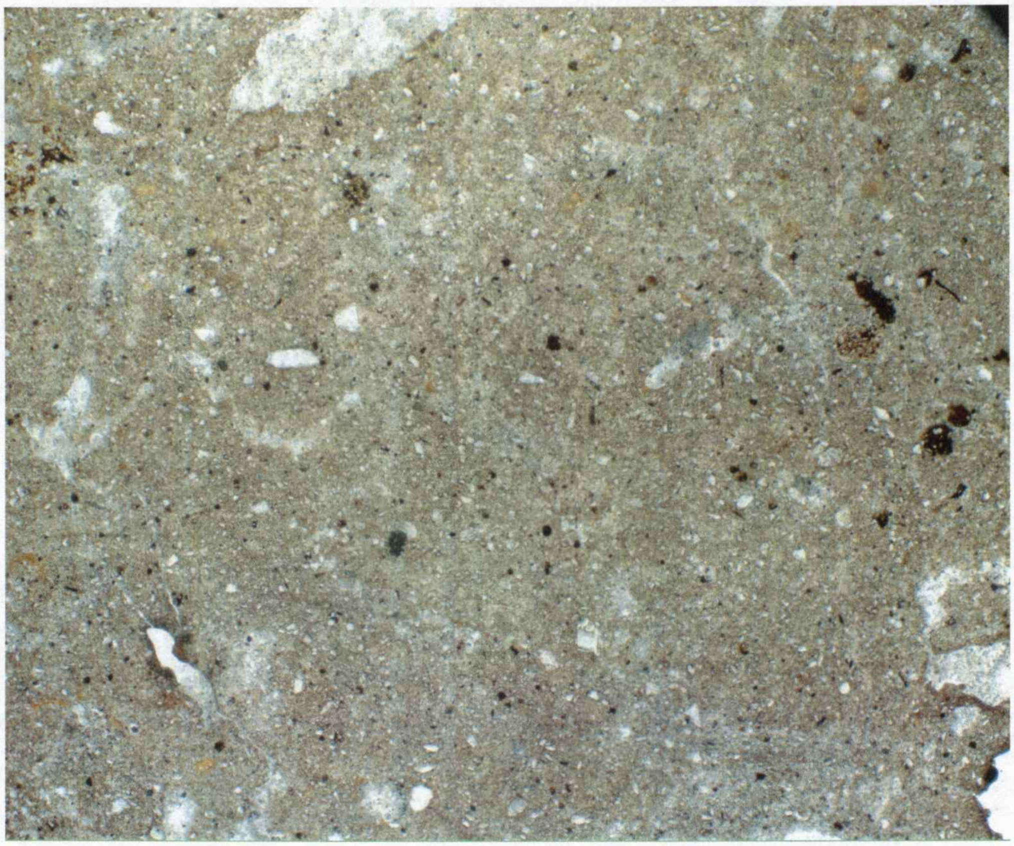

Figure 17. This photomicrograph shows that Unit IIa in Profile 3 is much more compact than the underlying wall fill seen in Figure 16. This fill layer also lacks the textural depletion found in the underlying layers. (PPL, field of view is ca. 6.5 mm.)

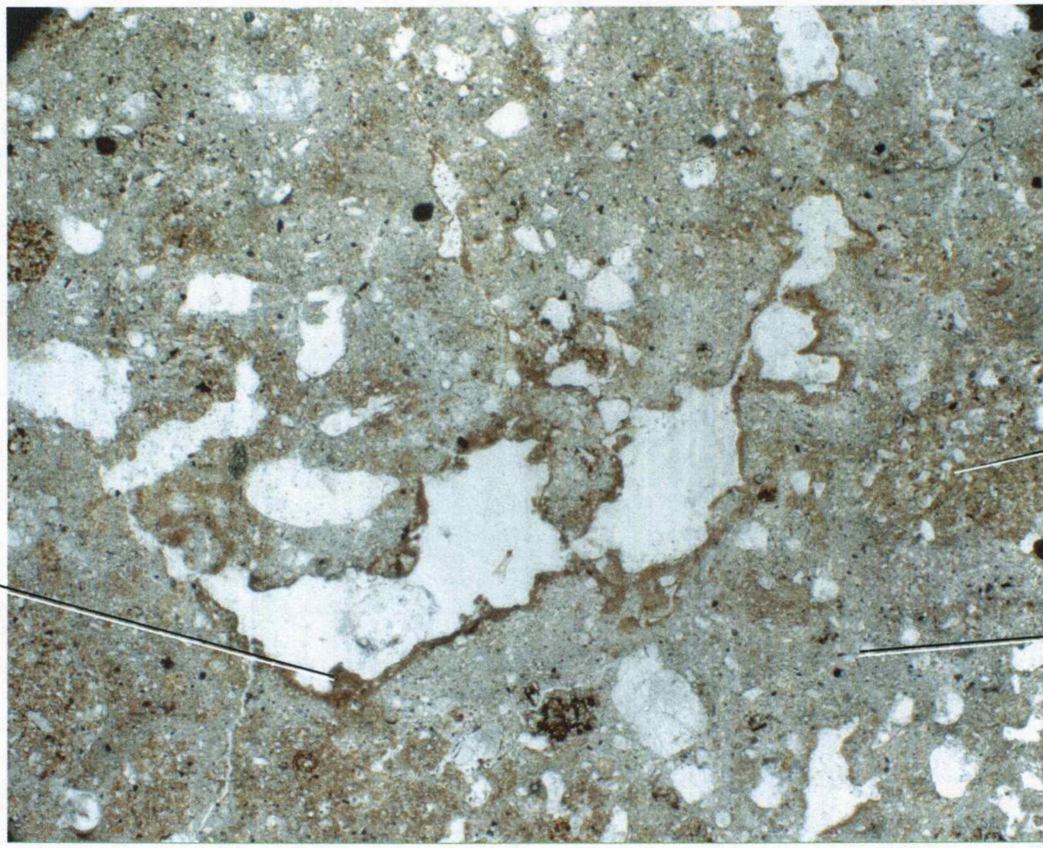

Figure 18. This photomicrograph of a sample from the Bw/Ab horizon in Unit IIa (Profile 3) shows both the silty clay type 4 void coatings and the extensive textural depletion of the matrix (visible above the voids), likely caused by cultivation of the surface above the profile. (PPL, field of view is 6.5 mm.)