APPENDIX F

PHYTOLITH ANALYSIS OF SELECTED SOIL SAMPLES FROM THE PUNCHEON RUN SITE

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By

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I. INTRODUCTION

Phytolith analysis was conducted in support of archaeological investigations of the Puncheon Run Site, Delaware. The analysis was conducted in two parts. First, seven plant specimens were divided variously into structural parts (leaf, stem, and/or root) and were subjected to wet oxidation to extract phytoliths, if extant. Second, a set of 27 selected soil samples from archaeological contexts were processed to extract phytoliths (Table F-1).

Table F-1: Soil Samples for Phytolith Analysis

Cat. No.	Unit	Feature	Stratum & Level	Cat. No.	Unit	Feature	Stratum & Level
LOCUS 1				LOCUS 3			
1104	.	3	C-5	Feature 30 Block			
1118	.	3	E-10	272	321	30	.
1132	.	3	G-10	971	321	30	.
1308	.	7A	A-7	275	319	30	.
1322	.	7A	B-6	279	319	30	.
1126	.	46	A-6				
1133	.	46	C-1	Metate Block			
1134	.	46	D-1	849.1	356	36	B-3
878	.	47	B-8	849.2	356	36	B-3
1092	.	50	B-5	907	356	36	B-4
850	.	51	A-2	909	356	.	B-5
745	.	51	A-4	910	356	.	B-6
868	.	66	A-2	812	397	96	B-3
1341	.	98	B-8				
1342	.	98	D-10				

II. PHYTOLITH ANALYSIS IN THE EASTERN UNITED STATES

No general or comprehensive phytolith reference database developed from phytolith extracts of living plants in the region of the Puncheon Run site is available. This severely limits taxonomic specificity in interpreting phytoliths present and, predictably, leaves a substantial number of observed morphologically distinctive phytolith types in the category of “other,” or essentially “unknown.” However, some publications, especially Rapp and Mulholland (1992), provide substantial verification for both general and specific taxonomic assignments of many phytoliths.

In the absence of a regional phytolith database, published typological information was employed for classification of phytolith types. For grasses, the three-tribe classification of Twiss et al. (1969) into Festucoid (wet, cool habitat), Panicoid (wet, warm habitat), and Chloridoid (dry, warm habitat) phytolith classes is the conventional standard, along with elaborations by Brown (1984).

For angiosperms (e.g., deciduous trees and shrubs) and conifers, Rovner (1971), Geis (1973), and Klein and Geis (1978) provide some guidance for eastern woodland flora content. The most elaborate work to date in these taxa has been conducted by Japanese experts (Kondo 1974, 1976, 1977; Kondo and Peason 1981;

Kondo and Sase 1986; Kondo et al. 1987; Kondo and Sumida 1978) primarily on Asian flora. Fortunately, where illustrated phytolith forms at the genus level between American and Japanese plants are extant, considerable similarity of forms provides confident guidance in taxonomic assignment of distinctive phytoliths in these categories in general. Studies by Cummings (1992) and Bozarth (1987, 1990, 1992) have confirmed and refined the typology and taxonomy of phytoliths in dicotyledonous taxa. Distinctive phytoliths for critical cultigens, beans and squash, have been identified, as well as forms attributed specifically to Asteraceae (Compositae), which is a dicotyledonous group well represented and ethnobotanically significant in the eastern United States.

While soil phytolith studies in the general region of the mid-Appalachians and the Atlantic seaboard are few in number, general comparisons can be drawn from studies at such eastern historic period sites as Morven, New Jersey (Piperno 1988a); Monticello, Virginia (Rovner 1988); Hampton, Virginia (Rovner 1989); Harpers Ferry, West Virginia (Rovner 1994); Seabrook Plantation, South Carolina (Rovner 1996); and Crowfield Plantation, also in South Carolina (Rovner 1997a). Moreover, the number of sites tested in this region is increasing, and recent reports (Owens and Rovner 1997; Rovner 1983a, 1997b) provide a basis for general patterns of land use and botanical history for the historic period (seventeenth through nineteenth century), in conjunction with archaeological history.

Phytolith studies for the much-longer Prehistoric period are relatively fewer in number, but this figure is increasing. Prehistoric studies to date include Paleoindian and/or Archaic sites, such as Thunderbird and Fifty Sites, Virginia (Carbone 1977); Site 31MK683, North Carolina (Rovner 1995a, 1995b); and Site 32BK621, Pennsylvania (Rovner 1995c). In addition, more than a dozen sites or site components dating to the various Woodland periods from Massachusetts to Georgia have been subjected to a variety of phytolith studies (Rovner 1984, 1996, 1998a, 1998b, 1998c, 1998d). Thus, while the available background of comparable studies is rather spotty in space and time, the situation is improving. Consistent patterns are emerging, perhaps the most important being the consistent and reliable availability of phytolith data from virtually the full range of archaeological sites throughout the region.

III. METHODS

A. PHYTOLITH EXTRACTION FROM REFERENCE PLANTS

Seven herbarium specimens of common or significant flora from the Puncheon Run Site were tested for phytolith content. Each plant was divided into major segments, since human processing and/or use of plants results in biased deposition of plant remains that can be manifested in the phytolith record. Plants were divided as shown in Table F-2.

To remove surface dust, dirt, and contamination, each plant sample was swirled in a beaker of detergent water and left to soak for a minimum of 48 hours. Each sample was then rinsed with tap water followed by deionized water. Roots were particularly difficult to clean and were subjected to a prolonged water stream to remove dirt. Plants were then cut into small segments to increase the surface area exposed to oxidation. Samples were placed in a clean beaker, to which 200 milliliters of 5.25 percent sodium hypochlorite (i.e., household bleach) was added. Samples were first left to digest at room temperature. If after 24 to 48 hours plants were not responding well to digestion, samples were placed on a warming tray to accelerate the process. Fresh solution was added to any samples which were particularly resistant, and these samples were then placed again on the warming tray. At this stage, all samples were adequately digested. None required further treatment or more intensive treatment, for example, with nitric acid.

Table F-2: Reference Plants

Plant	Common Name	Parts Examined	Phytoliths?
Typha latifolia	broad leaf cat-tail	fruiting head, rachis, leaf, mid-stem, basal stem, roots	yes
Orontium aquaticum	golden club	leaf, stem	no
Pontederia cordata	pickerel weed	leaf, stem	yes
Symplocarpus feotidus	skunk cabbage	leaf, stem, roots	yes
Peltanda virginica	arrow arum	leaf, stem, roots	yes
Arisaema triphyllum	jack-in-the-pulpit	seed and seed bracts, leaf stem	no
Lilium superbum	Turk's cap lily	leaf, stem, roots	no

B. PHYTOLITH EXTRACTION FROM SOIL

Conventional soil extraction procedures for all soil samples were initially used, with modifications employed as required by the nature of specific samples. Standard procedures generally followed those found in Rovner (1971, 1983b). The soil was initially "cleaned" to promote disaggregation of all particles—inorganic, organic, and biolithic—as follows:

1. About 20-milliliter volume of soil placed into clean beaker.
2. Distilled water was added, and the sample was stirred and either placed in a centrifuge at moderate speed for 20 to 30 minutes, or allowed to settle for a minimum of 4 hours. Piperno (1988b) suggests that one hour is sufficient for tropical soils. The additional time provided here was an arbitrary caution, given possible factors of soil differences. Only small to very small amounts of macrobotanical fragments, fibers, or particles were observed.
3. The aliquot with suspended fine particles and very light fraction material, e.g., floating rootlets, fibers, charcoal, etc., was decanted and discarded.

1. To oxidize and eliminate (sticky) organic residues, the soil was treated with 5.25 percent sodium hypochlorite solution (i.e., commercial household bleach). This was successful, precluding use of concentrated hydrogen peroxide or nitric acid solutions, which are more difficult to handle and far less environmentally benign (with respect to disposal, for example).
2. Following oxidation, soil samples were rinsed 2-3 times with distilled water, stirred, settled or centrifuged, and decanted.
3. Dilute hydrochloric acid (20 milliliters) was added to each sample to remove carbonates. None of the samples reacted to the acid. Samples were allowed to settle, and the aliquot was decanted and discarded.
4. Each sample was rinsed 3 times with distilled water.
5. The soil was re-suspended in distilled water, to which a deflocculant (i.e., Calgon) was added to suspend very fine silt particles. After centrifuging or settling overnight, the aliquots with suspended fine particles were decanted and discarded. Step 8 was repeated as necessary until the aliquot was clean.
6. Soil was placed in a drying oven set at 90 degrees Celsius until dry.
7. Heavy liquid for flotation separation was prepared by dissolving zinc bromide powder in slightly acidified distilled water, until a specific gravity between 2.3 and 2.4 was achieved. This was easily determined using a commercial calibrated hydrometer.

8. An approximately 5-milliliter volume of dry soil was added to heavy liquid in a bent, clear tygon tube, which was squeezed gently to "wet" the soil. The bent tube was inserted into a lightly greased centrifuge shell and was centrifuged at moderate speed for 30 minutes to float phytoliths.
9. After centrifugation, clamps were placed on both vertical arms of the bent tube just below the flotant surface in the tube. A wash bottle stream of water was used to rinse the flotant from the tygon tube into a 50-milliliter centrifuge tube.
10. Distilled water was added to the centrifuge tube to about the 40-milliliter level. Centrifugation precipitated the phytoliths. The aliquot was decanted. This step was then repeated.
11. Phytoliths were decanted to a shell vial and placed in a drying oven to remove excess liquid.

C. MICROSCOPE SCANNING

The phytolith extracts were quick-mounted in distilled water and viewed in an optical microscope at 400X. Mounts were prepared by pressing a slide over the mouth of an open vial, which was then inverted. The extract was allowed to settle on the slide and was then reverted to its original orientation. The slide was quickly removed, retaining a drop of fluid that contained a portion of extract.

Whole slides were scanned at 100X to find clusters of particles, which were then scanned at 400X to determine the character of the individual particles. Representative and especially taxonomically significant phytoliths and other biosilica bodies (e.g., diatoms and sponge spicules) in each slide mount were noted.

Images of typical or frequent and/or distinctive unknown phytoliths were digitized as PICT files using a black-and-white CCD TV camera mounted on the microscope and connected to a Power Macintosh 7500 computer.

IV. RESULTS AND DISCUSSION

A. REFERENCE FLORA PHYTOLITHS

The following plants produced no phytoliths in any sample: *O. aquaticum, A. triphyllum, and L. superbum*. These taxa may be included in the category of "silica non-accumulators," a common condition, especially with dicotyledonous plants. These are obviously undetectable "blind spots" in phytolith analysis.

Unfortunately, particles observed in samples of other taxa (see Attachment A) were not particularly distinctive. They have been observed in other taxa with no regard for taxonomic relationships and are therefore of questionable significance. Particles were observed as follows:

T. latifolia:

a. Fruiting head and roots produced no phytoliths.
b. Leaf and rachis produced a large quantity of raphides and raphide bundles. Raphides are narrow, plain, clear, needle-like particles with pointed ends.
c. Stem produced disks (or spheres) with rough edges and rugous surfaces.
d. Large numbers of diatoms occurred in the root and basal stem samples. Apparently, these were not washed away by the cleaning process.

P. cordata:

a. Leaf and stem produced raphides and raphide bundles. These differed from those in *T. latifolia.* Raphides in this taxon were variously longer, especially wider (i.e., flat), with end tapering along one lateral side to pointed ends. Some short varieties were square at one end, possibly representing broken examples. Diatoms occurred in the leaf sample and many were present in the stem sample.

S. foetidus:

a. Leaf contained coarse stellate bodies, with triaguloid to conical bodies with rugous surfaces. The number of conical bodies varied from 3 to 6, with some individual examples suggesting that segments easily disarticulated.
b. Stem produced considerable irregular bodies, possibly contamination not removed during washing process. No distinctive phytoliths.
c. Roots produced substantial contamination and a high frequency of thin raphides.

P. virginica:

a. Leaf produced many raphides and raphide bundles of the long, narrow type and irregularly shaped rugous disks.
b. Stem produced many large crystalline druses, more or less spheroidal. A few raphides also appeared.
c. Roots produced many raphides, raphide bundles, and crystalline druses, but the numbers of these were clearly surpassed by a particularly high frequency of diatoms, along with fewer sponge spicules.

B. SOIL SAMPLE PHYTOLITHS

1. General Observations

Phytoliths were observed in all samples except one (Locus 3, Feature 30 block, Sample 279). The quantity of phytoliths ranged from scarce to common, but in no sample were they abundant. All samples retained a typical amount of inorganic silt, fine clay, and larger mineral particles, which are never completely removed by the procedures used. It is sufficient to allow extracted material to be readily dispersed on microscope slides and not inhibit scanning. However, given the limited number of distinctive phytoliths, considerable scanning was required in attempting to fulfill a standard count of 100 phytoliths per sample. This was rarely achieved with a single slide, and second slide mounts were made and scanned. Even then, most samples did not reach the standard count quantity attempted. The relative abundance of inorganic particles may have affected the ability to discern the frequency of irregularly shaped biosilica, such as irregular globules, angular plate segments, etc., which are commonly derived from non-grass taxa and were undercounted in the results.[1]

Preservation of phytoliths was very good with some qualification. A significant number of particles appeared corroded, and some apparently suffered mechanical breakage, presumably from transportation and redeposition. A bias toward larger grass particles at the expense of smaller silica bodies (i.e., grass "short-cells") in virtually all of the phytolith assemblages, which is the reverse of typical relative frequencies in

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[1] Such a problem may be overcome by using a complex procedure to stain biosilica. This requires dehydration, then successive rinses with absolute ethanol, acetone, and benzene before staining with methyl red dissolved in benzene. Inorganic silica is not affected, while biosilica takes the red stain. However, benzene is a known, highly toxic carcinogen, dangerous to use and difficult to dispose of safely. This procedure is therefore avoided except in special circumstances.

reference grass phytolith assemblages, may be the result of differential preservation. However, the short cells observed in the various samples did not appear to have suffered corrosion or breakage.

Soil phytolith assemblages were uniformly dominated by a set of types commonly observed in grasses: large water-storage (?) cells (symmetric and asymmetric bulliforms); large squares and rectangles; elongates (robust fundamental cells); and trichomes (marginal pointed prickle cells). The relatively low frequency of grass short cells is problematic and clearly the result of taphonomic biases. Such biased assemblages are not uncommon and have been observed elsewhere. A similar assemblage was described in a previous report of phytolith results from Wakefield Site 31WA1376, Wake County, North Carolina (Rovner 1998a). Although this site is centrally located in the North Carolina Piedmont and is not strictly wetland, it is directly associated with secondary/tertiary valley stream systems, and is subjected to seasonal flooding. The phytolith assemblage profiles from Wakefield Site 31WA1376 are quite similar to those from the Puncheon Run Site and are described below.

> All 12 samples in this series have a common phytolith assemblage—in greater or lesser degree. All mounts have some phytoliths, but most were impoverished so that a second mount and scan was conducted in any case where there were sparse phytoliths (10 of 12 samples). . . .
>
> The common phytolith assemblage consists of a biased assemblage of typically grass-derived phytoliths. Grasses produce a huge range of morphological forms, short cells, long cells, elongate plates, large blocky storage cells (keystone, fan-shape and "pork-chop" bulliforms; robust squares and rectangles), hooks (trichomes), etc. The short cells are useful for taxonomic division of grasses into tribe, sometimes genus and maybe (eventually) species. The common phytolith assemblage in this case consists of the large, blocky and robust forms —bulliforms, rectangles and squares sometimes with a few trichomes. Shorts cells and elongate rods are virtually absent in a majority of samples. These typically far outnumber the large blocky forms in reference samples from plant tissue, but they are absent leaving the biased or "truncated" grass assemblage.
>
> The assemblages were also impoverished with respect to non-grass phytolith particles, such as hair cells, epidermes, as well as the typically frequent amorphous globules and plate fragments that often abound in forest contexts.
>
> This is not a unique phytolith assemblage. I first noted it at Harpers Ferry, where it correlated weakly with flood deposits, but in any case, soil was often redeposited. I have also observed this assemblage in lake deposits, most recently from Burkino Faso, Africa. Clearly geography is not a common issue, but redeposited soil is. Non-grass phytoliths tend to be platey, thin, and essentially fragile; therefore, subject to mechanical destruction in the context of soil movement. Only the robust, blocky grass forms "survive" transportation. Particle size sorting may eliminate smaller short cells, but this is inconsistent with the abundance of small soil particles in the redeposited sediments. A full explanation is elusive [Rovner 1998a].

The phytolith assemblage configurations, combined with the consistent presence of aquatic sponge spicules, which indicates a dominance of alluvial sediments, is hardly unexpected at Puncheon Run. On the other hand, the virtual absence of diatoms, given the adjacent marsh and wetlands, is rather unexpected and potentially significant.

2. *Phytolith Assemblages by Context*

a. Locus 1: Silo Pit Area

With one exception, all assemblages from this area were dominated by the "truncated" grass phytolith assemblage (Table F-3). This serves as the "natural" background phytolith assemblage, so that significant deviations are clear candidates for evidence of ethnobotanical activities. The unusually high level of grass short cells, dominated by the Panicoid class lobate types in Sample 1342, suggests that the lower level of Feature 98 is culturally modified. Although maize is a producer of Panicoid short cells, the types represented—small crossbodies, simple long-shank lobates, etc.,—are not typical of maize. Therefore, a wild Panicoid grass is indicated. The presence of such a grass phytolith could be the result of either the unintentional introduction of grass as a pioneer weed responding to human disturbance of the immediate ecology, or the deliberate use of such grasses as pit liners, for baskets, etc. Greater specificity in taxonomic identification of the parent grass might shed light on the problem, but this is precluded by the current inadequacy of systematic classification of grass phytoliths from reference plants in the region.

The absence of cultivated plants is further supported by the absence of distinctive particles from squash or beans. Likewise, there is no support for the use of any of the silo pits, including Feature 98, for storage of *P. virginica* (i.e., tuckahoe) roots. There is no significant presence of raphides, and no crystalline druses that were noted in the reference plant extracts were observed in any sample from any loci. While this might be a problem of preservation, there is a more compelling reason to reject tuckahoe storage. Given the abundance of diatoms in the extracts of root and stem from the reference plant, it is reasonable to expect that a significant quantity of diatoms would show up in the sediments of any pit used to store *P. virginica*. Only one diatom was observed in all of the scans combined. Given the consistent presence of aquatic biosilica (sponge spicules), the absence of diatoms is quite unexpected. While sponges tend to occur in running water (sponges comb detritus from water flowing through internal channels) and diatoms tend to occur in brackish water, dynamic forces such as flooding tend to result in a coexistence (not necessarily in equal quantity) of sponges and diatoms in extracts from alluvial soils.

As backwaters and marshes exist in the vicinity of the Puncheon Run Site, the virtual absence of diatoms is surprising and is a clear indication that basal floral from marsh plants, such as tuckahoe, were not introduced into the silo pit features. Thus, unfortunately, the phytolith data suggest what the pits, including Feature 98, were *not* used for, rather than providing any direct evidence of their function. This is not a unique occurrence in phytolith analyses of sites in the eastern midcontinent. Wakefield Site 31WA1376 in North Carolina, noted above, produced similar findings.

No major modulations of the floral ecology occurred during the prehistoric phases. Maize agriculture is not indicated by the Panicoid forms that variously appear in the samples. Significant clearing of land for prehistoric agriculture is not indicated. At most, small, local clearings in the canopy inviting small populations of grass are indicated. No evidence of significant cultural uses of floral material is provided by the phytolith data in any of the samples, leaving by default such activities as hunting and fishing as likely local cultural functions (Rovner 1998a). In fact, the site was considered a small, special-activity fishing station for exploiting seasonal runs of migratory fish. As is the case at Puncheon Run, the phytolith data provide no direct evidence of fishing but are consistent with such a site function because of the unlikelihood of competing functional models.

Feature 51, distinguished by an earlier radiocarbon date (J. Bedell, Berger Archaeologist, personal communication 2000), is undistinguished in phytolith data.

Table F-3: Locus 1 – Phytolith Frequency by Category

Sample No.	N=	Bulliform	Elongate	Square	Trichome	Rectangle	Panicoid	Festucoid	Chloridoid	Misc.	Sponge	Other
Feature 3												
1104	22	7	3	4	1	5	.	.	.	2	4	.
1118	21	3	10	3	3	2	.	.	.	.	7	.
1132	47	10	10	9	4	8	.	.	.	3	24	.
Feature 7a												
1308	31	4	4	10	3	2	1	.	.	7	4	.
1322	41	12	7	10	2	9	.	.	.	1	10	.
Feature 46												
1126	17	4	6	2	.	4	.	.	.	1	1	.
1133	100	26	14	31	5	19	.	.	.	5	7	.
1134	96	23	21	24	3	18	.	.	.	7	13	.
Feature 47												
878	75	11	26	14	7	13	1	.	.	4	17	1 Diatom
Feature 50												
1092	100	22	28	21	7	16	1	1	.	4	5	.
Feature 51												
745	67	8	19	10	6	16	3	.	.	5	9	.
850	100	18	24	22	6	19	.	.	.	11	4	.
Feature 66												
868	89	15	20	24	10	10	.	1	.	9	6	.
Feature 98												
1341	81	19	20	12	2	25	.	.	.	3	6	.
1342	100	12	28	16	8	16	8	2	.	12	13	.

Note: Sponge spicules and diatoms are not included in phytolith population count (N=).

Since sponge spicules and phytoliths are derived from very different sources, the former being aquatic and the latter being terrestrial, a comparison of relative frequencies may yield significant insights. In most of the samples, however, the frequencies of the two categories are positively co-varied. When phytolith frequency is high, sponge frequency is high, and the same applies for low frequency. However, exceptions do occur. For example, sponge frequency is disproportionately high in Feature 3, Sample 1132, but nothing in the phytolith data provides a significant explanation for this anomaly.

Phytolith results from the Silo Pit area as a whole are very subtly distinguished from those of the two areas in Locus 3. Samples from Locus 3, Feature 30 block contained substantially fewer phytoliths. When the Silo Pit area is compared with Locus 3, Metate block, a difference in the pattern of grass short cells by subfamily is evident, in spite of woefully small and statistically inadequate frequencies.

b. Locus 3: Feature 30 Block

Phytolith assemblages from this area were notably scarce (Table F-4). Only Feature 30, Sample 272 produced a "typical" quantity and type profile of phytoliths and sponge spicules. The other Feature 30 sample was almost sterile. Unit 319, Sample 275 produced one of the lower frequencies of phytoliths in the typical range, while Sample 279 from this context was the only sterile sample, devoid of phytoliths or sponge spicules. Apparently, the taphonomic factors, natural or cultural, that affected phytolith and sponge deposition at Locus 1 and in the Metate block of Locus 3 were not operating in the lower levels of Feature 30 block or in the feature itself.

Table F-4: Locus 3 – Phytolith Frequency by Category

Sample No.	N=	Bulliform	Elongate	Square	Trichome	Rectangle	Panicoid	Festucoid	Chloridoid	Misc.	Sponge
Feature 30 Block - Feature 30											
272	65	8	20	14	5	8	1	.	.	7	3
971	7	2	1	2	1	.	1	.	.	.	1
Feature 30 Block - Unit 319											
275	37	8	11	6	3	3	1	.	.	4	13
279	(sterile)	.	.	.	.	.	.	.	.	.	.
Metate Block - Unit 397											
812	129	16	46	20	8	15	2	9	1	12	12
Metate Block - Unit 356											
816	95	15	29	10	17	10	1	3	.	7	9
817	35	4	15	3	6	2	1	.	.	4	6
849.1	80	21	16	11	7	11	3	1	.	12	5
849.2	60	9	14	12	3	17	.	1	.	3	5
907	80	15	32	10	7	11	3	1	1	10	11
909	78	9	29	7	10	8	3	1	.	11	15
910	51	9	16	9	4	6	.	.	.	7	19

Note: Sponge spicules are not included in phytolith population count (N=).

c. Locus 3: Metate Block

Phytolith assemblages from all samples in the Metate block are dominated by the "truncated" grass assemblage as at Locus 1. Significant differences occur in the small but taxonomically critical frequencies of grass short cells. At Locus 1, Feature 98, Panicoid grass short cells outnumbered Festucoid cells by a ratio of 4 to 1. In terms of simple presence/absence, Panicoid cells appear in four samples, and Festucoid cells appeared in two. In the Feature 30 block, Panicoid cells appear in three samples, and Festucoid cells appeared in none. No Chloridoid short cells were observed in samples from either of these two areas. In the Metate block, Festucoid and Panicoid short cells both appear in six out of eight samples, and Chloridoid cells appeared in two. This pattern suggests that there was a greater natural presence and diversity of grasses in the Metate block and/or cultural modulations of the "natural" floral assemblage with respect to grasses was somewhat greater in this area than the others.

Cultural activities indicated by the phytolith analysis are consistent with the artifact content in this area. The area-defining artifact, the metate, is typically an indicator of plant processing. However, given the low frequencies of short cells, the evidence is weak at best and must be viewed with caution. Moreover, the Panicoid phytoliths, as in the other areas, are not typical of maize, and squash and bean phytoliths are absent. The phytolith data are largely blind in this regard. If intensive plant processing occurred here, it involved flora that are not significant silica accumulators and not any of the flora whose basal stems and roots are associated with diatoms.

Unit 397, Sample 812 is particularly noteworthy. Like Sample 1432 (Locus 1, Feature 98), there is clearly a disproportionately high frequency of grass short cells, and cultural modulations are indicated. However, whereas short cells from Feature 98 are clearly dominated by Panicoid cells, the assemblage from Unit 397 is dominated by Festucoid cells to nearly the same degree, but in a taxonomically reciprocal ratio. Thus, in these two instances very different grasses were being manipulated, and it is likely that they served different functions.

On the other hand, Panicoid and Festucoid grasses tend to favor different temperature regimes; Panicoid grasses favor warmer temperatures and Festucoid grasses favor cooler temperatures. Given the differences in dating of the Silo Pit area and the Metate block, differences in climatic regime could be indicated, with the earlier period being cooler and the younger period being warmer. Alternatively, more localized factors, such as seasonality, can also account for the difference. In a single area, Festucoid grasses may ripen in early spring, retrench in summer heat, and perhaps flourish again in autumn, while Panicoid grasses flourish largely during the summer. Likewise, microecological conditions can cause significant differences in decay-in-place phytolith assemblages, in spite of relatively minor differences in lineal distance. For example, minor changes in elevation affecting near-surface ground water levels would favor Festucoid grasses where water levels are consistently high. However, this might also give way to Panicoid and/or Chloridoid grasses if water levels fluctuate, as in the summer when levels are lower. Thus, the phytolith data are complex and alone do not provide particularly clear insights into the natural or cultural factors that brought about such subtle differences. Therefore, for the same default reasons suggested for Locus 1, the phytolith data of the Metate block are also consistent with a function as a fishing station.

The grass phytolith assemblages also bear on the problem of bioturbation in this area. The grass short cell counts of these older deposits are consistently higher than those in assemblages from younger areas of the site. Mixing of phytoliths from various levels would tend to homogenize the phytolith assemblages, reducing or obliterating the distinctions in the short grass assemblages. It is conceivable that bioturbation could leave such assemblage patterns, but rather convoluted explanations would be required. For example, bioturbation must have operated *only* to bring younger sediments containing Panicoid grass short cells down into earlier sediments to mix with older Festucoid short cells. However, such mixing would have had to prevent significant movement of earlier Festucoid cells into younger deposits. A simpler explanation is that bioturbation was not a significant factor.

3. Postscript: Miscellaneous Types and Taxonomic Unknowns

A reservoir of potentially significant information exists in the category of "miscellaneous" phytoliths (see Tables F-3 and F-4). A variety of examples are illustrated in Attachment B. These constitute morphologically distinct forms placed into two arbitrary categories: the majority, which are taxonomically unknown because of the lack of comprehensive phytolith reference systematics, and the minority, which do not fit the type categories used. In addition, the morphological categories used to sort observed phytoliths are not necessarily taxonomically uniform. For example, robust elongates, including plain rods and denticulate rods, are typically derived from grasses. However, plate-like elongates, curved elongates, wavy-sided elongates, and irregular elongates are probably derived from non-grass taxa. The same is likely true of particles included in the rectangle category. Little more can be said about phytoliths whose taxonomic origin is not known at this time, except to underscore the need for greater investments in time, resources, and funding to ameliorate this problem.

Some of the miscellaneous phytolith forms are robust ovals that occur in grass; others are cellular plates, hair cells, etc., that are typical of dicotyledonous plants (i.e., deciduous trees) and are frequently observed in extracts from forest soils. A more-detailed taxonomic assignment, even to family level, much less genus or species, would certainly enhance the value of phytolith data. One particular case serves as an intriguing illustration. Three examples of small, ornamented spheroids were observed, two in Locus 1 (see Attachment B, Illustrations 1132-2 and 1342-14) and one in Locus 3, Metate block (see Attachment B, Illustration 907-

10). These are clearly not squash rind spheroid phytoliths, which are 2 to 3 times larger in diameter and have scalloped or dimpled surfaces similar to that of a golf ball. These spheroids are in the size range of palm phytoliths but differ in surface ornamentation. The three spheroids have rounded or knobby surface projections, while palm spheroid phytoliths have surfaces covered with pointed conical projections.

Spheroids similar in size range to the three examples noted above, with surface projections varying from conical to knobby, were observed in very high frequencies in shell midden samples from the coastal Seabrook Plantation Site (38BU323) in South Carolina (Rovner 1995c). They were also observed in low frequencies at the Crowfield Plantation Site (38BK1011), also in South Carolina, in an eighteenth-century context thought to represent attempts at early historic period rice farming (i.e., rather low, wet conditions confirmed by the presence of sponge spicules and diatoms) (Rovner 1997a). Similar spheroids were obtained from an extracted assemblage of palmetto leaf. Palmetto, popularly associated with South Carolina, is known throughout the southern Atlantic and Gulf Coast states coastal region. Whether it also occured as far north as Delaware at any time in the past is unknown to the author but could be of considerable paleobotanical and paleoecological interest. Of course, it is not certain that the Puncheon Run spheroids are palmetto; they may have derived from some other local plant. This simply reinforces the urgent need for a comprehensive study of systematic phytolith taxonomy of the flora in this region.

V. CONCLUSIONS

1. Phytolith assemblages from archaeological sediments at the Puncheon Run Site were reasonably well preserved, ranging from scarce to moderate in quantity.

2. All phytolith assemblages were dominated by a set of phytolith types that have been associated with alluvial deposits. Sponge spicules were ubiquitous and well represented, but diatoms were virtually absent.

3. Phytolith assemblage profiles were not homogeneous between the three context areas. The Feature 30 block of Locus 3 was the most impoverished with respect to phytoliths. The Metate block of Locus 3 and the Silo Pit area of Locus 1 shared similar dominant phytolith sets but differed in their profile of grass short cells. The Metate block had a higher frequency and greater diversity of short cells as compared with the Silo Pit area.

4. Assemblages within the Metate block and the Silo Pit area tended to follow similar patterns, respectively, each with one noteworthy exception. Feature 98 of the Silo Pit area had a notably high level of Panicoid grass short cells, and Unit 397 had a notably high level of Festucoid grass short cells. Cultural factors are probably the cause of these high levels, but the difference in grass tribe taxa suggests that these factors are not the same for both areas.

5. There is no evidence of maize, bean, or squash cultigens in any phytolith assemblage from any sample tested.

6. There is no evidence of tuckahoe root storage in any phytolith assemblage from any sample tested.

7. The homogeneity of the great majority of samples within the study areas, respectively, argues against the existence of substantial ethnobotanical activities in these loci. Other functions connected to hunting and/or fishing are consistent with the nature of the botanical data derived from phytolith analysis.

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1998c	*Phytolith Analysis of Selected Soil Samples from 31WA1137, Wake County, North Carolina*. Submitted to TRC Garrow and Associates, Chapel Hill, North Carolina.

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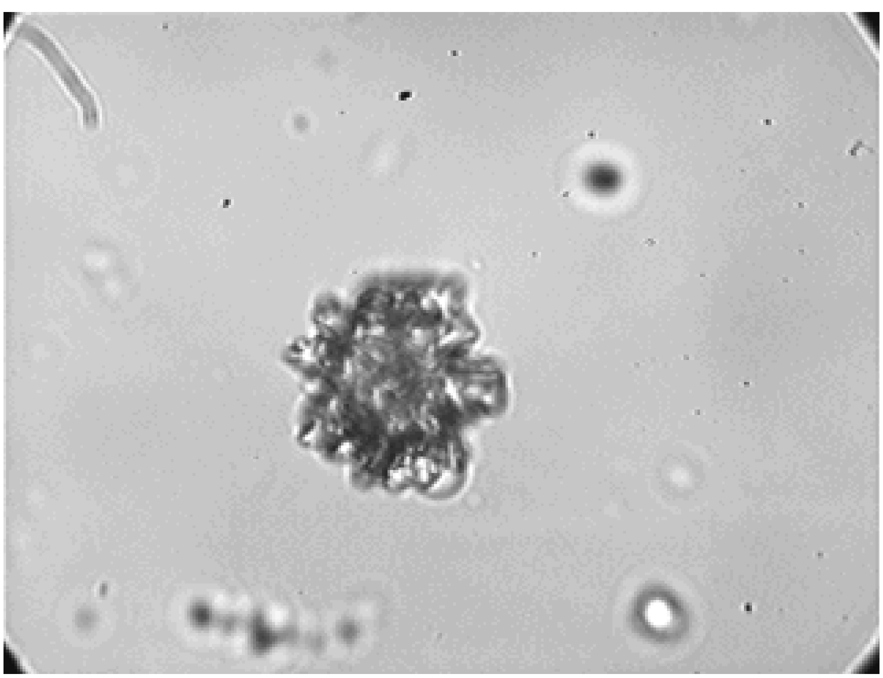
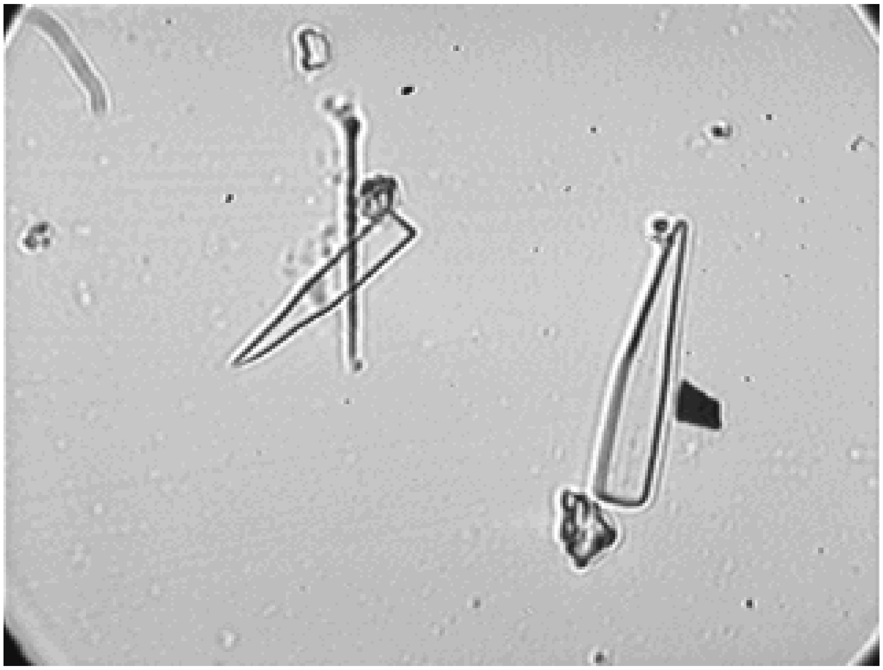
ATTACHMENT A

ILLUSTRATIONS OF PARTICLES FROM REFERENCE FLORA

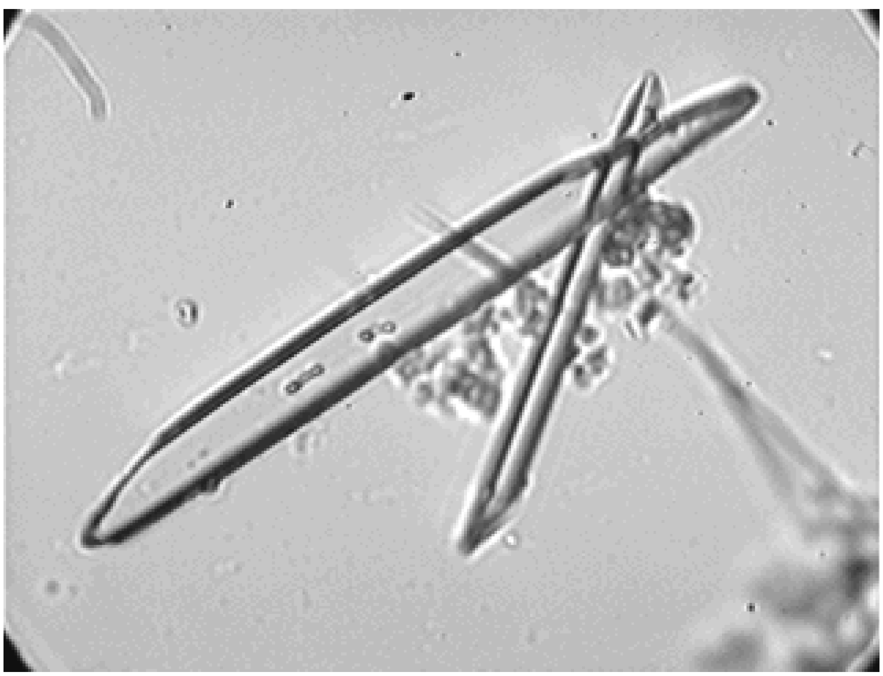
1. *Peltanda virginica* leaf. Druse (irregular sphere, calcium oxalate?) and raphides



2. *Pentanda virginica* stem. Druse (calcium oxalate?) (400X)



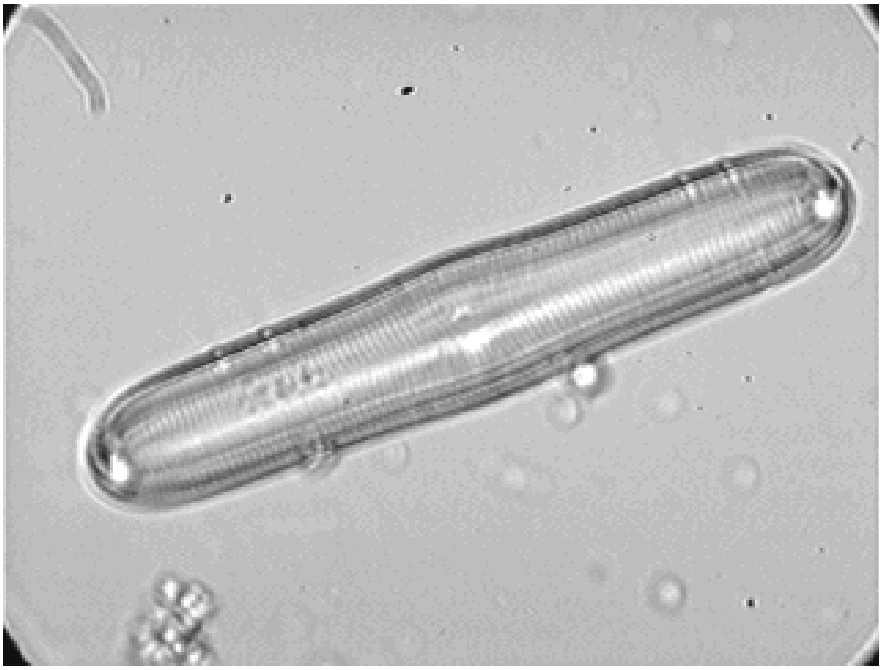
3. *Pondeteria corodata*, leaf, hairs or raphides (400X)



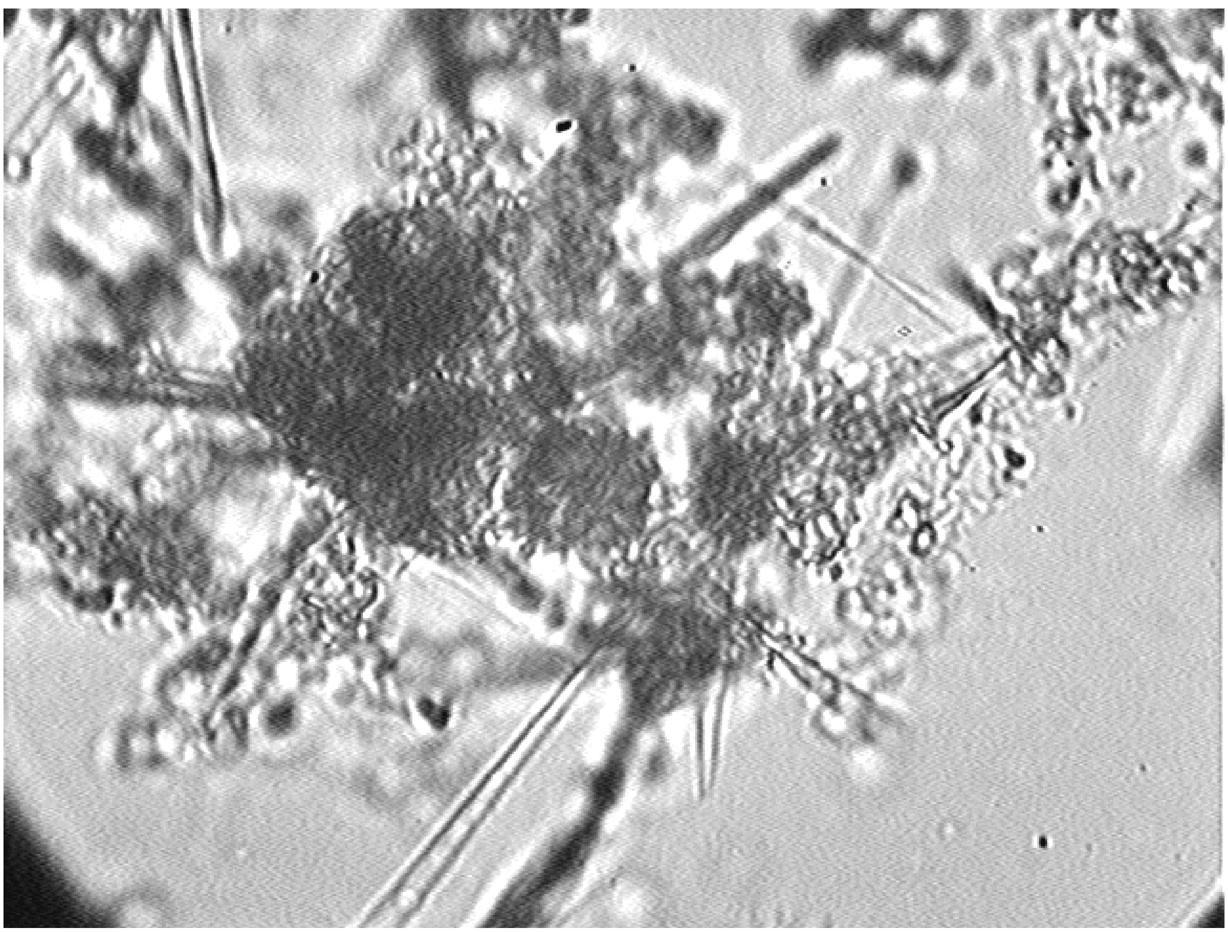
4. *Pondeteria cordata*, leaf, large raphides (400X)

5. *Pondetria corodata*, leaf, small raphides (400X)

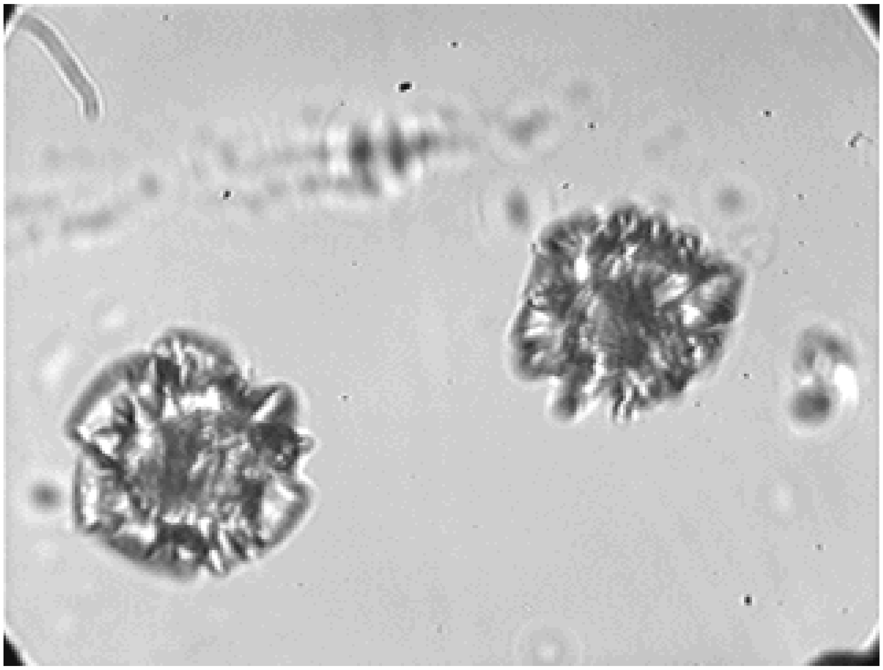
6. *Pondeteria corodata*, leaf, articulated rods or raphides (400X)



7. Diatom found with *Pontederia corodata* (400X)

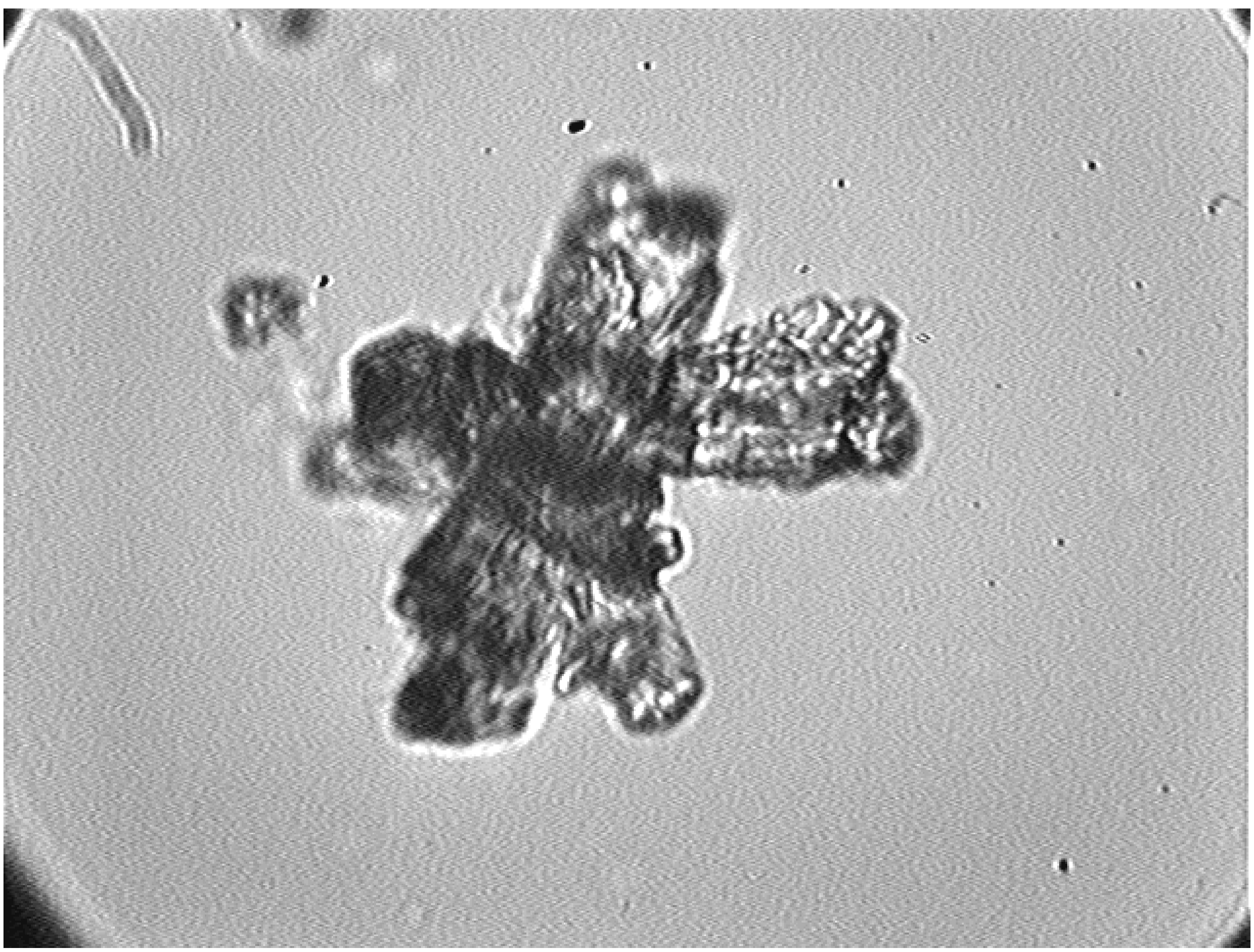


8. *Peltanda virginica*, leaf, Druses (irregular spheres) and raphides (400X)

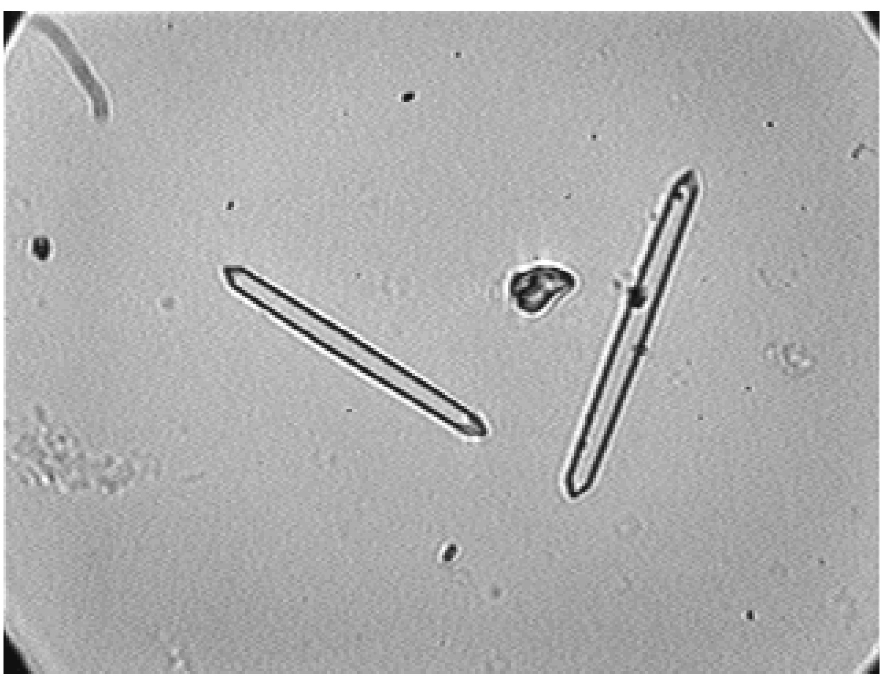


9. *Peltanda virginica*, stem, Druses (400X)

10. *Symplocarpus foetidus*, leaf, irregular stellate body (calcium oxalate?) (400X)

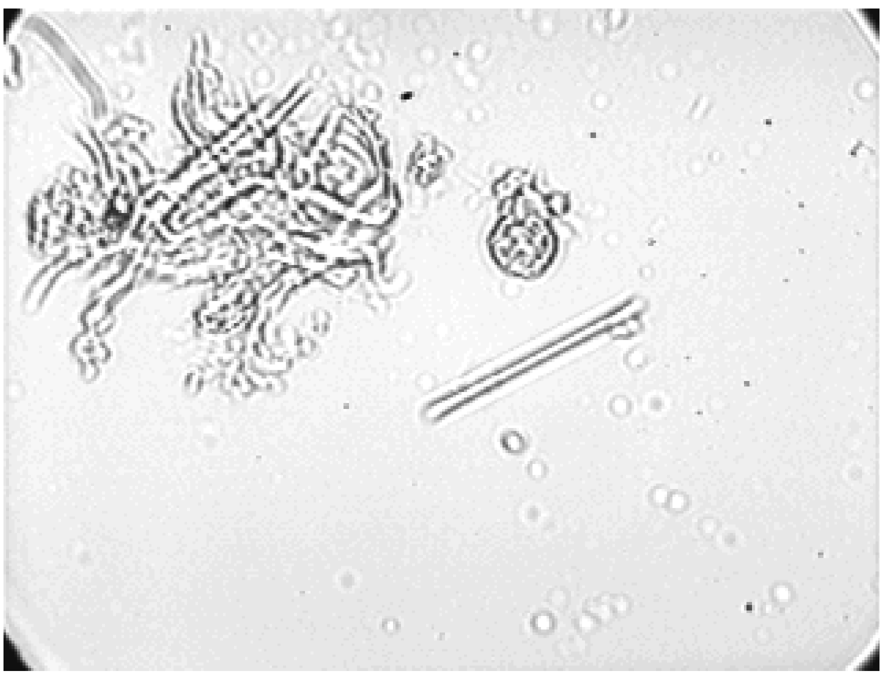


11. *Symplocarpus foetidus*, leaf, stellate body sections (400X)



12. *Typha latifolia*, leaf, raphides (400X)

13. *Typha latifolia*, stem, disks (400X)

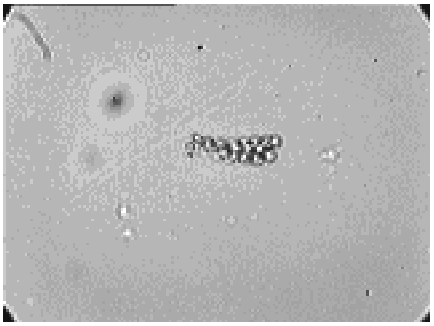


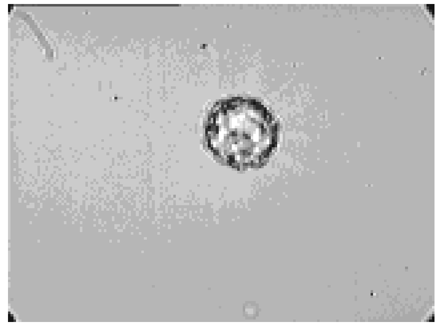
14. *Typha latifolia*, rachis, disk and raphide (400X)

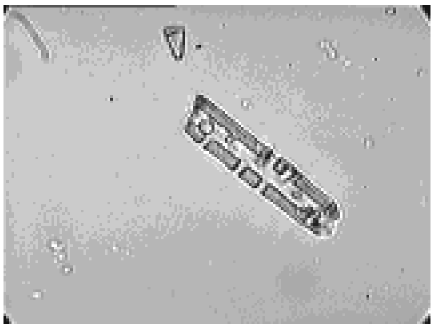
ATTACHMENT B

ILLUSTRATIONS OF PARTICLES FROM PUNCHEON RUN SOIL SAMPLES

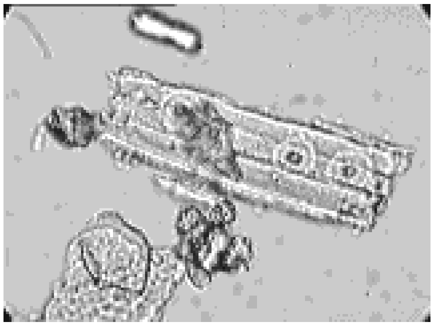
Feature 3, Stratum B, Level 6 (Catalog No. 1132)

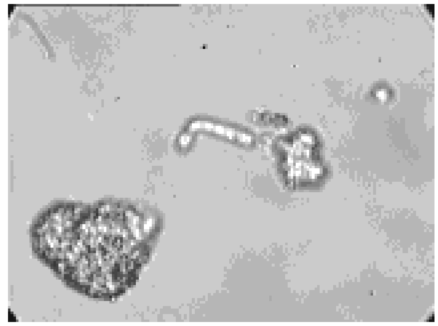

1. Cluster (400X)


2. Spheroid

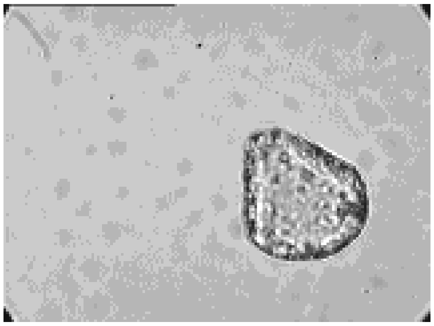

3. Sponge Spicule (400X)

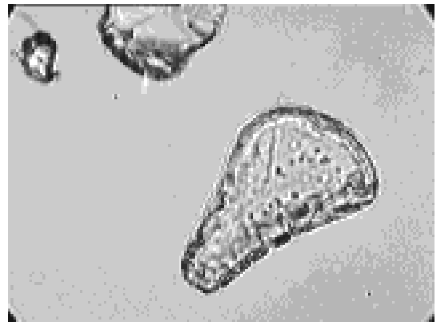
Feature 7A, Stratum A, Level 7 (Catalog No. 1308)

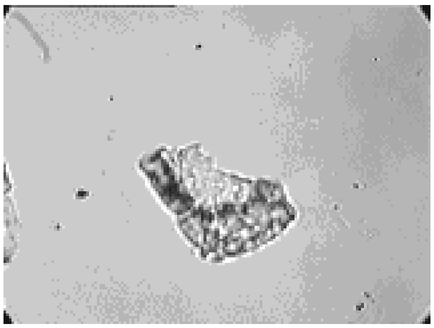

1. Epiderme (400X)

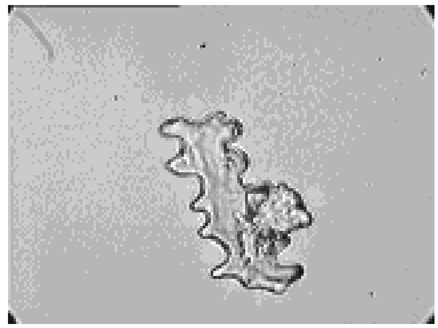

2. Panicoid Hair Cell (400X)

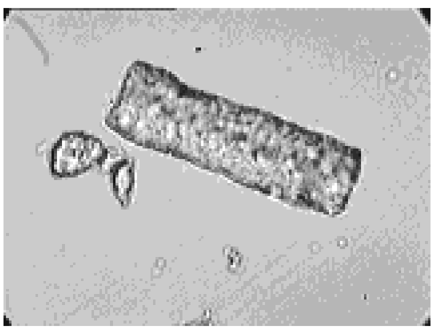
Feature 30, Stratum A, Level 10 (Catalog No. 272)

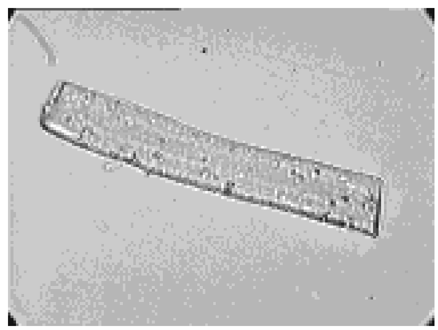

1. Bulliform (400X)

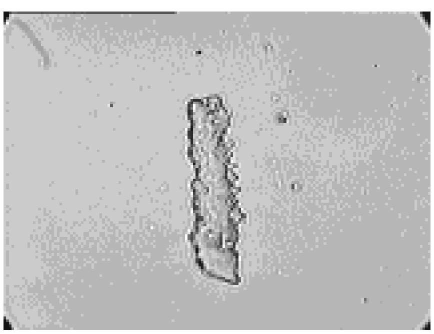

2. Bulliform (400X)

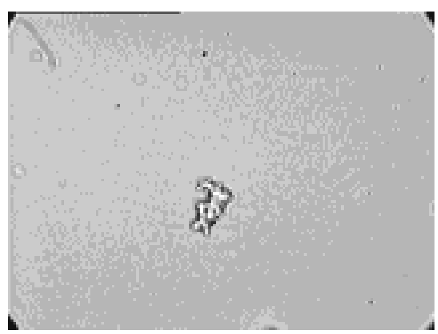

3. Cell, broken? (400X)


4. Irregular Denticulate (400X)

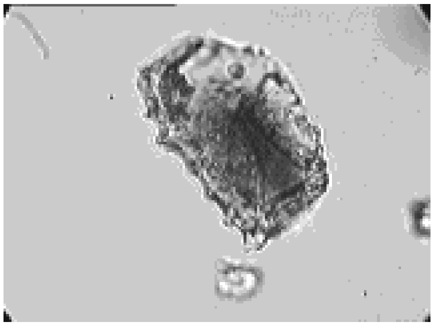

5. Elongate (400X)

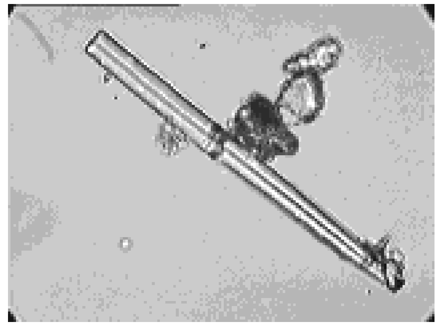

6. Elongate (400X)

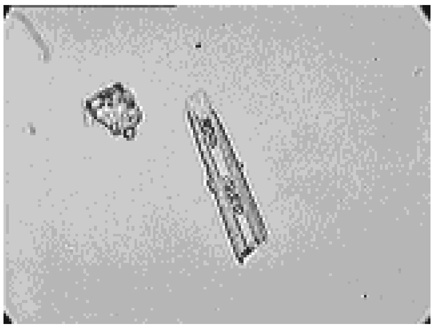

7. Irregular Elongate (400X)

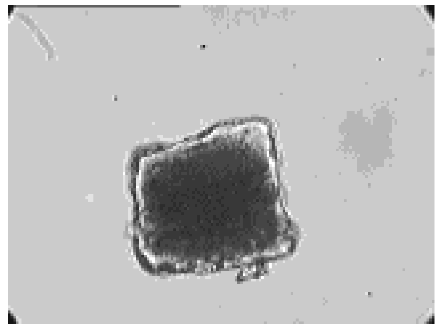

8. Irregular Denticulate (400X)

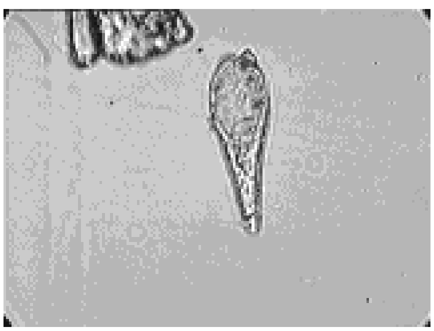
Feature 30, Stratum A, Level 10 (Catalog No. 272)


9. Rectangle, denticulated (400X)

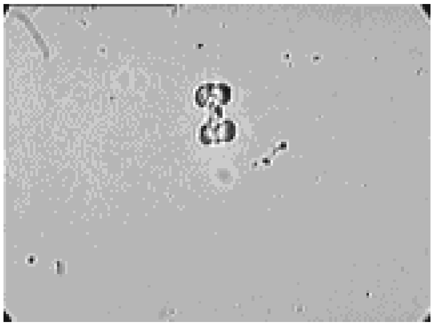

10. Sponge Spicule (400X)


11. Sponge Spicule (400X)


12. Square (400X)

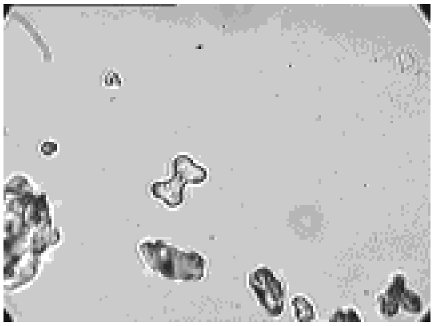

13. Trichome (400X)

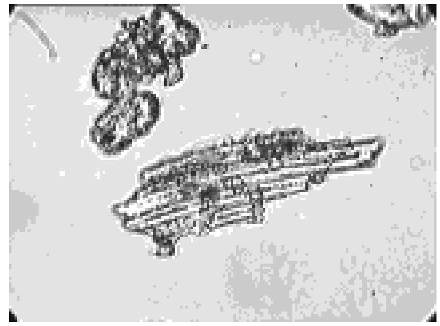
Feature 30, Stratum E, Level 10 (Catalog No. 971)

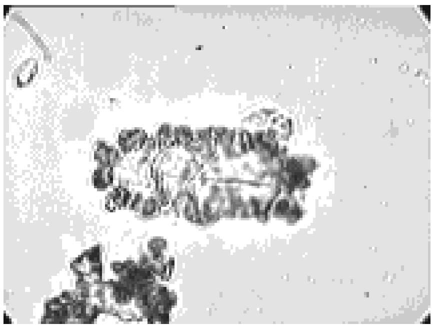


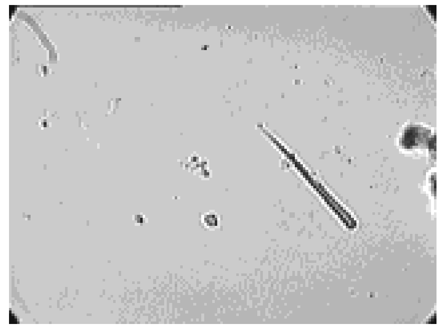
1. Panicoid Lobate (400X)

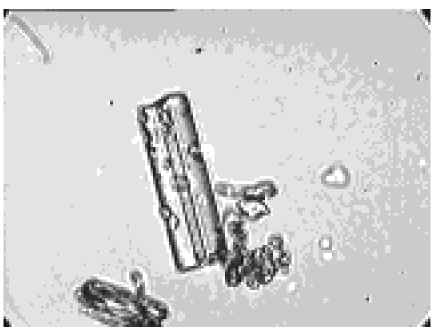
Unit 319, Stratum C, Level 4 (Catalog No. 275); outside Feature 30


1. Panicoid Lobate (400X)

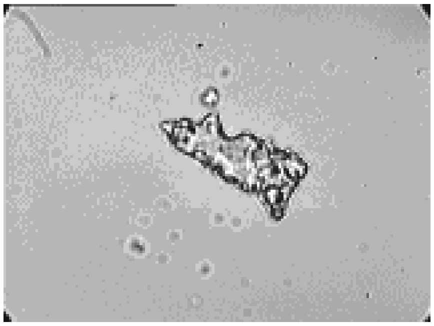

2. Epiderme? (400X)

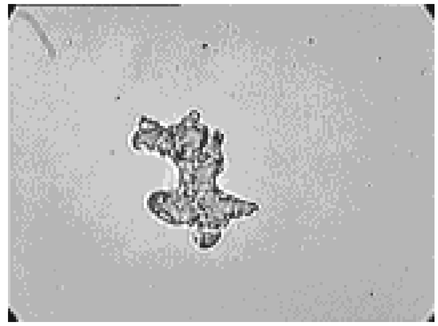

3. Irregular Cell (400X)


4. Raphide (400X)

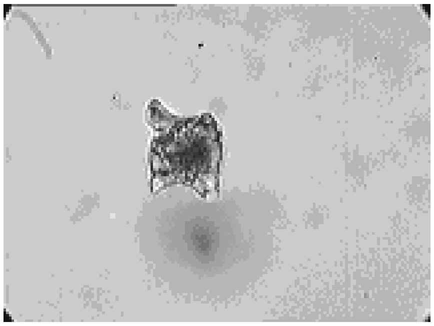

5. Sponge Spicule (400X)

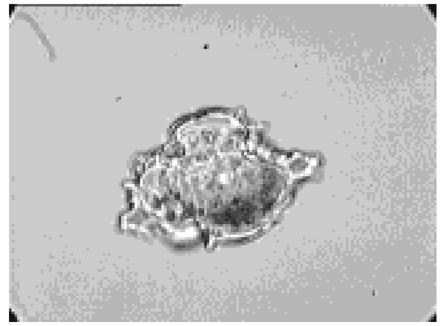
Feature 46, Stratum C, Level 1 (Catalog No. 1133)


1. Irregular Cell (400X)

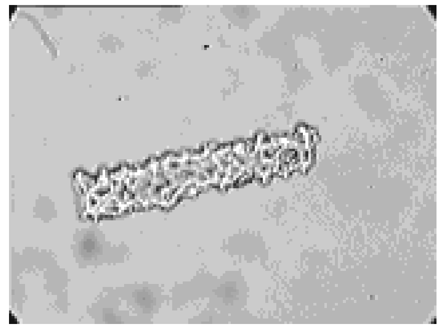

2. Irregular Cell (400X)

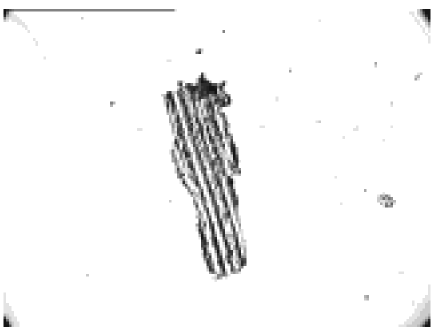
Feature 46, Stratum D, Level 1 (Catalog No. 1134)

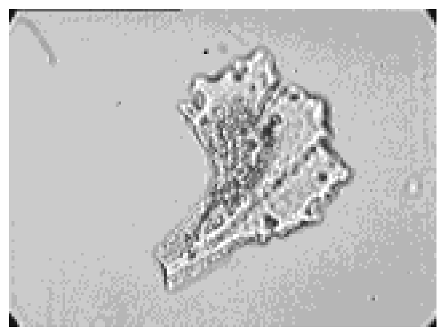

1. Biconcave (Grass) (400X)

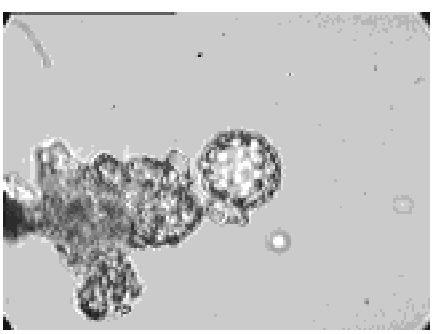

2. Irregular Cell (400X)


3. Irregular Cell (400X)

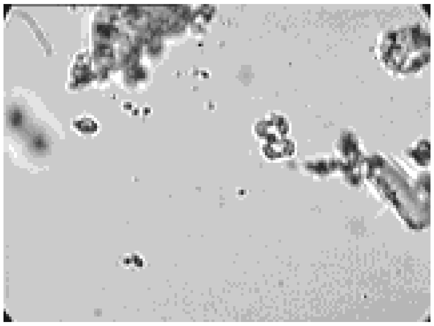

4. Denticulate Elongate (400X)

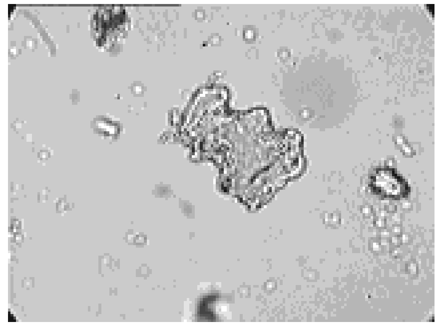

5. Epiderme (100X)

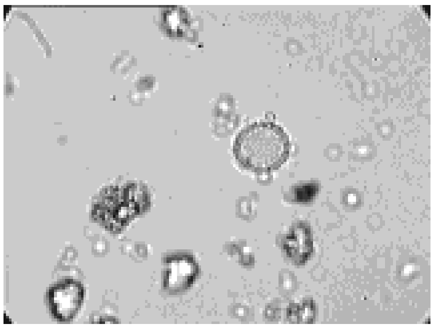

6. Plate (400X)

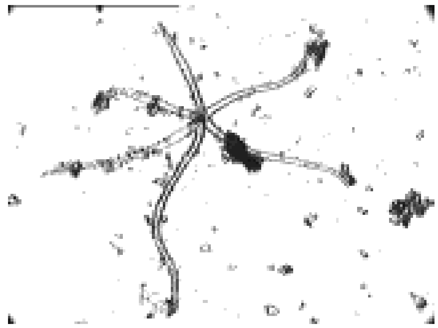

7. Sphere (400X)

Feature 47, Stratum B, Level 8 (Catalog No. 878)

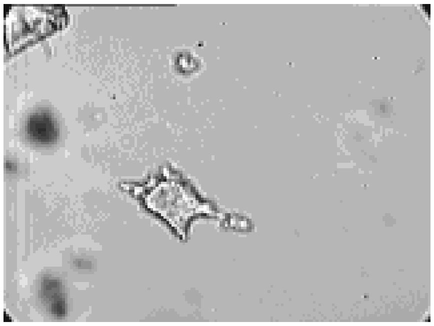

1. Panicoid Lobate (400X)


2. Irregular Cell (400X)

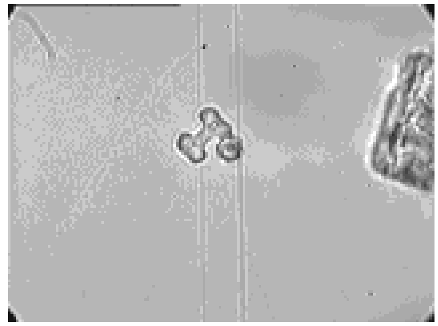

3. Diatom (400X)


4. Hexapus (100X)

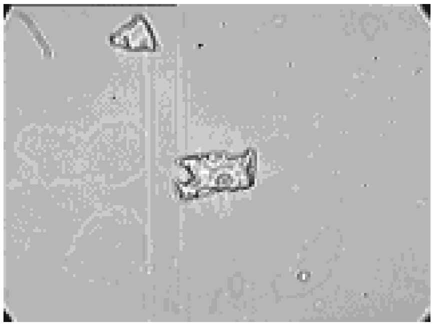
Feature 50, Stratum B, Level 5 (Catalog No. 1092)



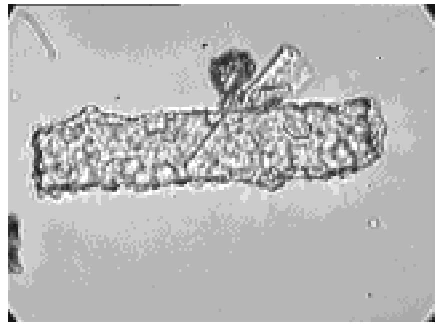
1. Biconcave (Grass) (400X)



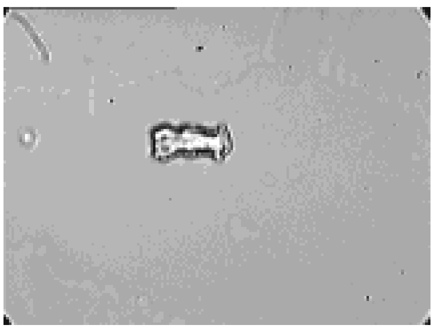
2. Panicoid Lobate (400X)



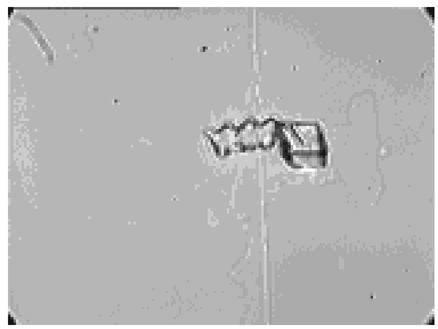
3. Irregular Cell (400X)



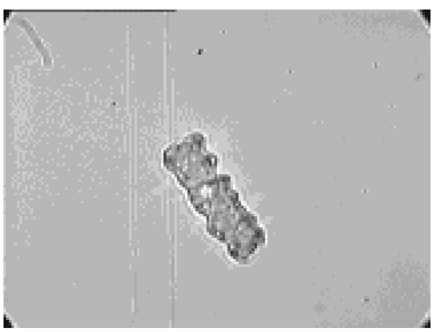
4. Elongate (400X)



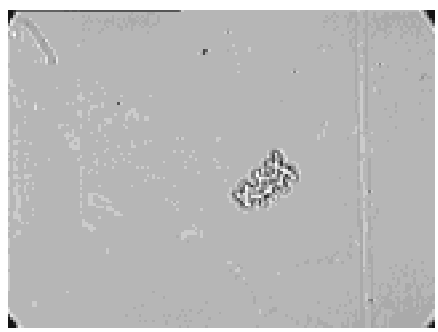
5. Irregular Cell (400X)



6. Wavy Elongate (400X)

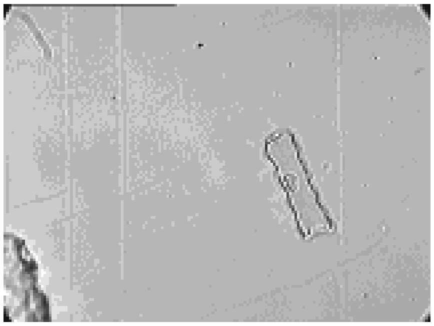


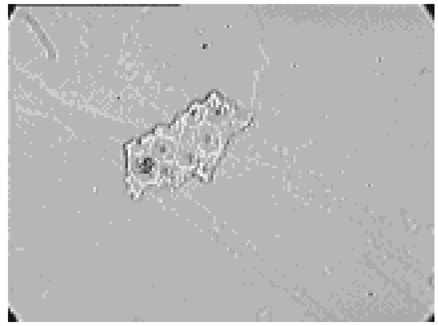
7. Wavy Elongate (400X)

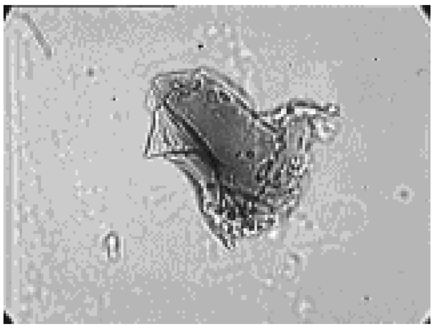


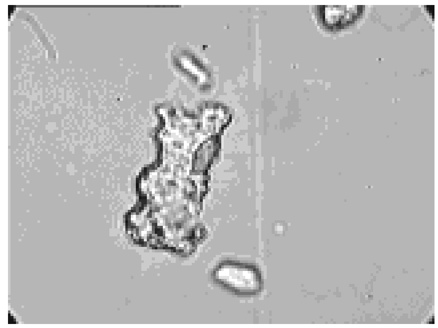
8. Wavy Elongate (400X)

Feature 50, Stratum B, Level 5 (Catalog No. 1092)

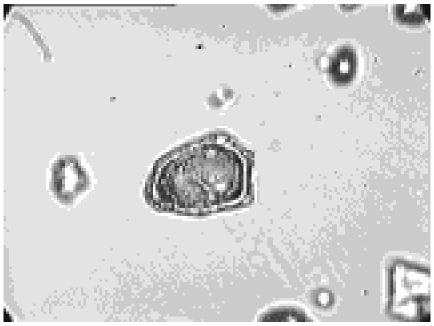

9. Festucoid Sinuous (400X)

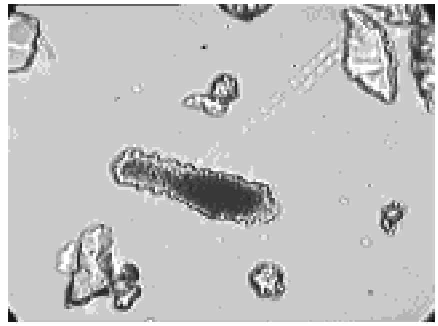

10. Plate (400X)

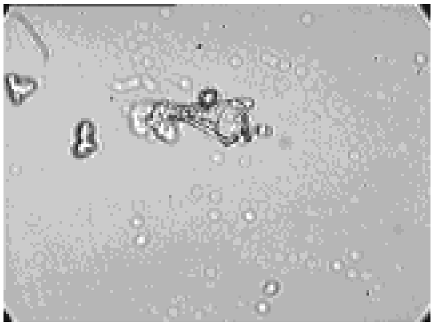

11. Plate (400X)

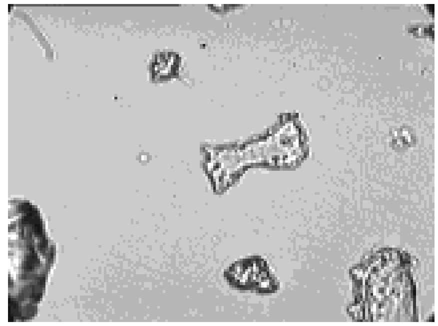

12. Wavy Elongate, corroded (400X)

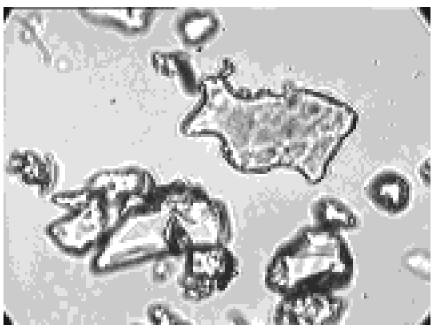
Feature 51, Stratum A, Level 2 (Catalog No. 850)


1. Cell (400X)

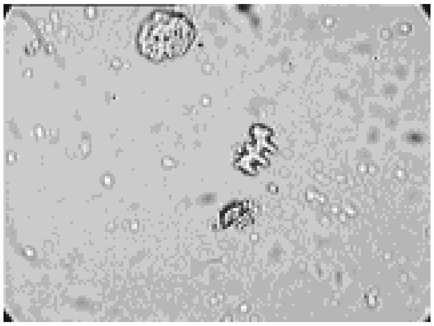

2. Irregular Elongate (400X)

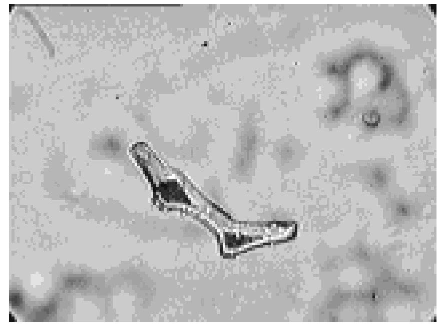

3. Conical Hair Cell (400X)

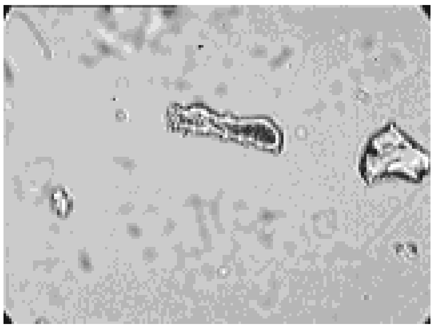

4. Irregular Cell (400X)

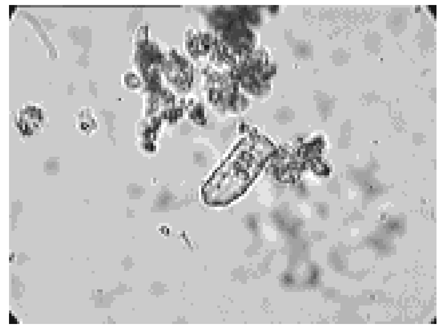

5. Irregular Cell or Plate (400X)

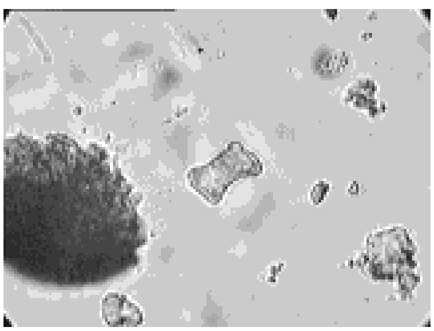
Feature 66, Stratum A, Level 2 (Catalog No. 868)

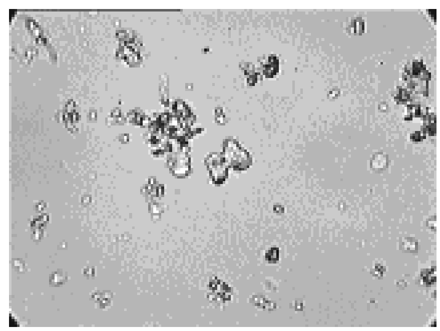

1. Irregular Denticulate (400X)

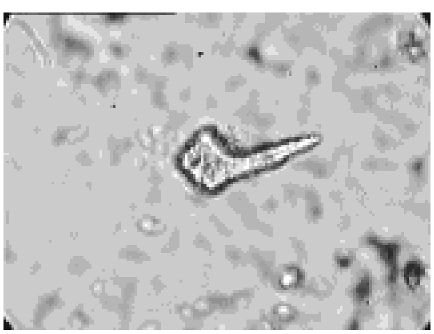

2. Exotic Cell (400X)

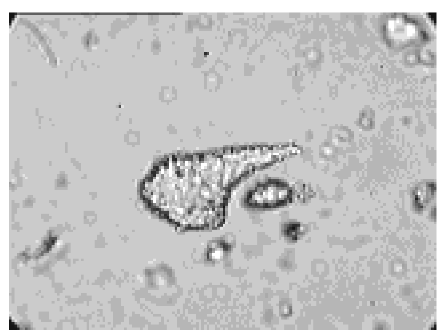

3. Exotic Cell (400X)


4. Festucoid Oval (400X)

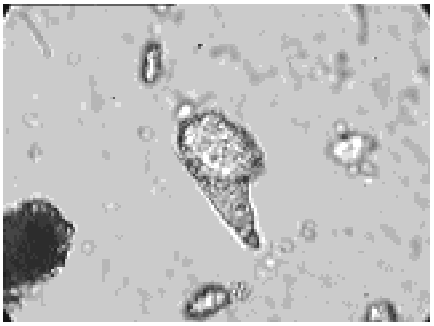

5. Hourglass Cell (400X)


6. Panicoid Lobate (400X)

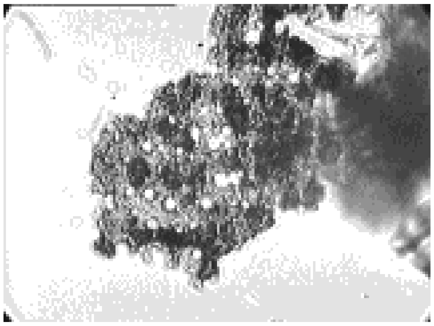

7. Pipestem Trichome (400X)

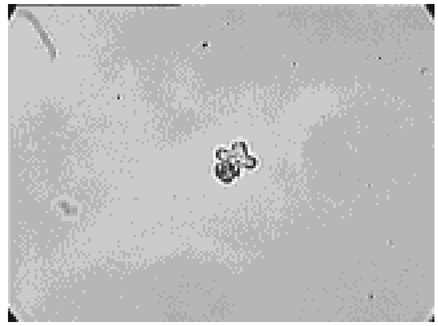

8. Trichome (400X)

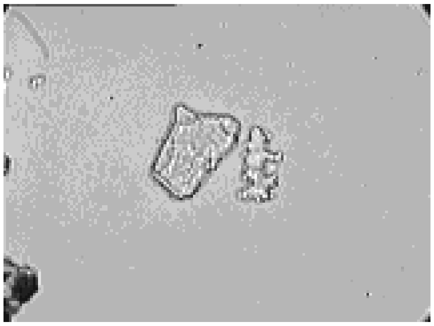
Feature 66, Stratum A, Level 2 (Catalog No. 868)

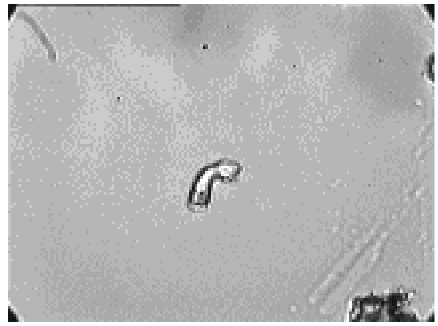

9. Same as #8 rotated (400X)

Unit 356, Stratum B, Level 3 (Catalog No. 849.1)

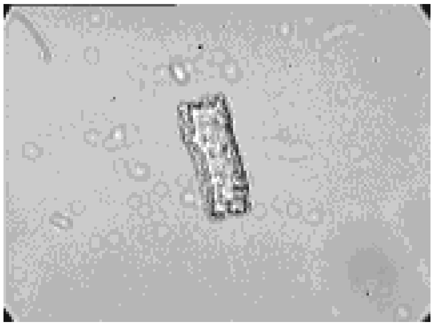

1. Ash? Endoderme (400X)

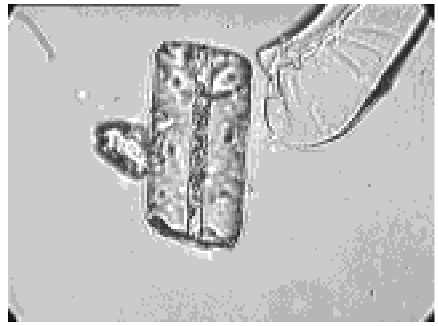

2. Panicoid Crossbody (400X)


3. Irregular Cell (400X)

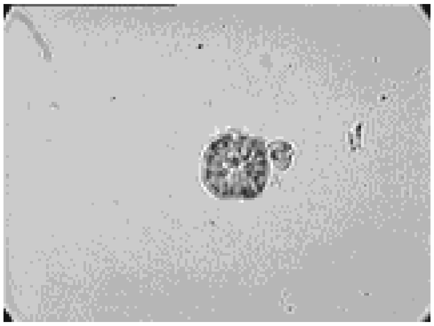

4. Panicoid? Hair Cell (400X)

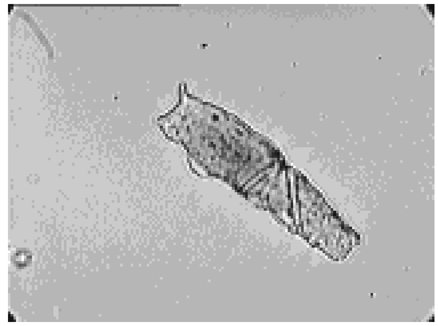
Unit 356, Stratum B, Level 3 (Catalog No. 849.2); beneath metate (Feature 36)

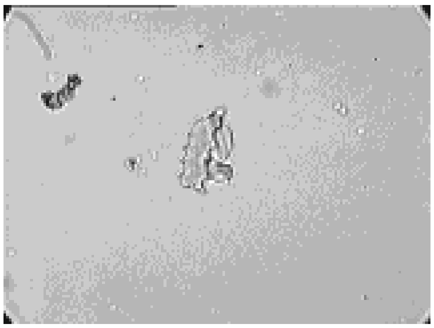

1. Rectangle (Grass) (400X)

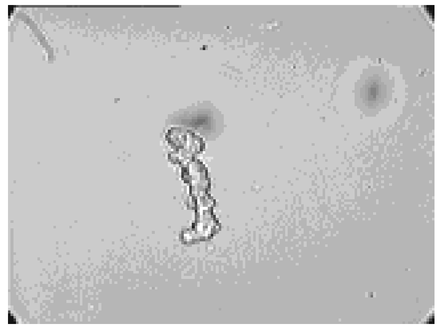

2. Sponge Spicule (400X)

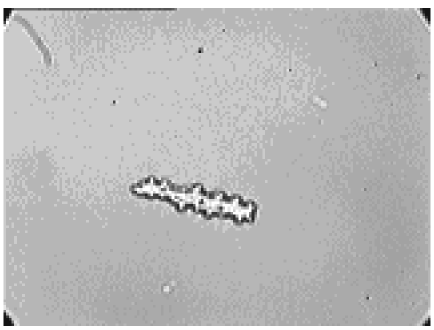
Unit 356, Stratum B, Level 4 (Catalog No. 907)

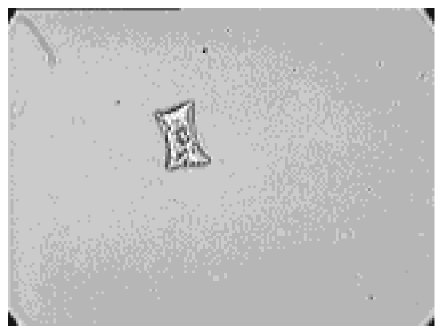

1. Disk (400 X)

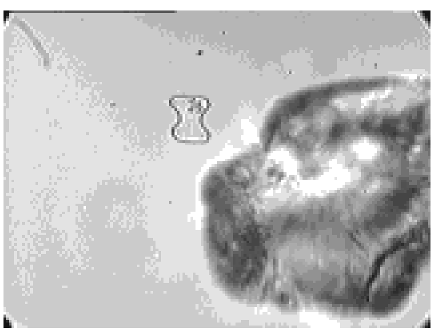

2. Irregular Elongate (400X)

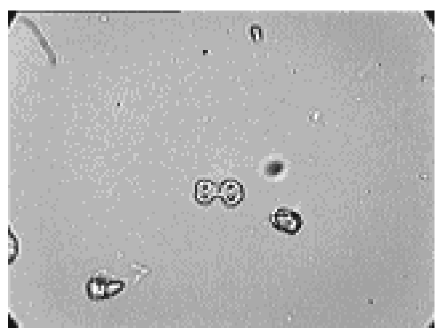

3. Denticulate Elongate (400X)


4. Irregular Elongate (400X)

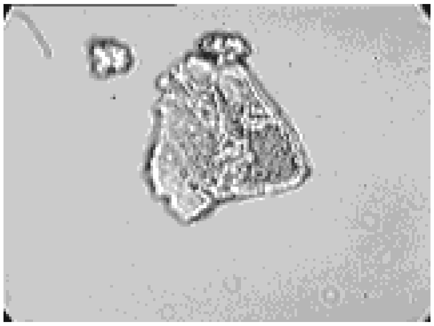

5. Denticulate Elongate (400X)

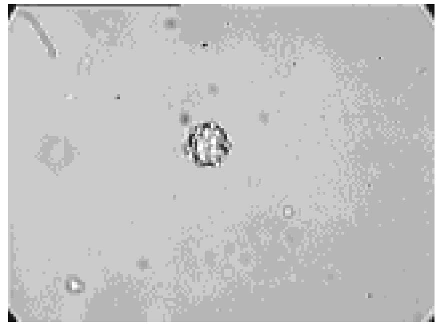

6. Festucoid Trapezoid (400X)

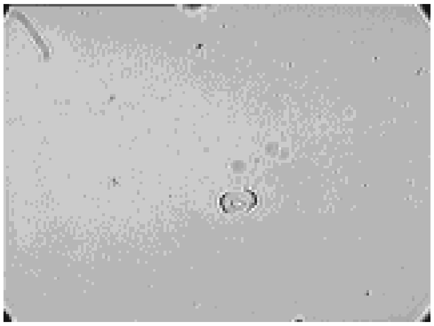

7. Panicoid Lobate (400X)

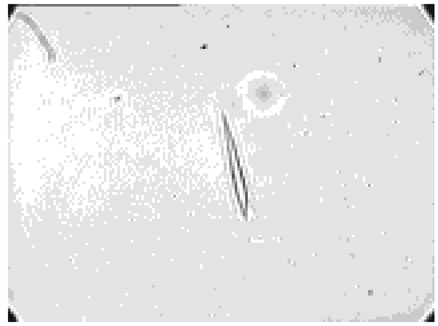

8. Panicoid Lobate (400X)

Unit 356, Stratum B, Level 4 (Catalog No. 907)

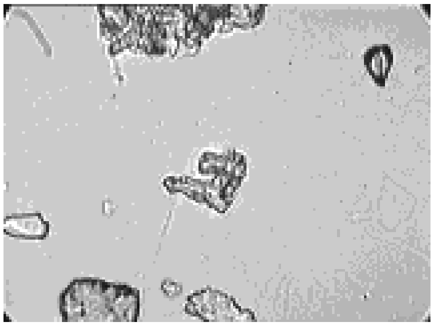

9. Plate (400X)

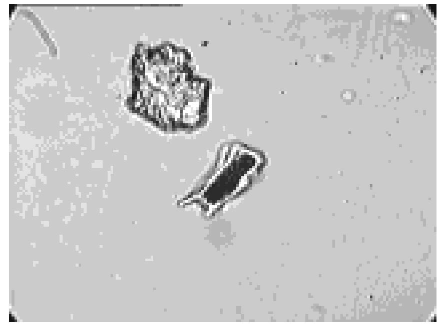

10. Spheroid (400X)

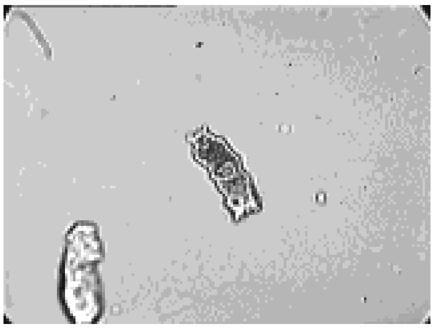

11. Chloridoid Saddle (400X)

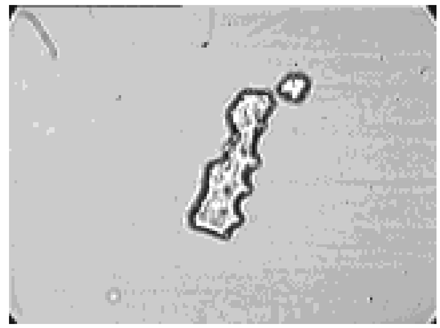

12. Tapered Raphide (400X)

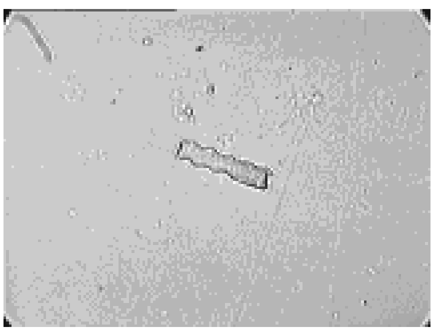
Unit 356, Stratum B, Level 5 (Catalog No. 909)

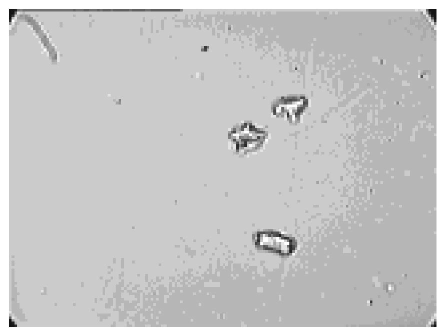

1. Irregular Cell (400X)

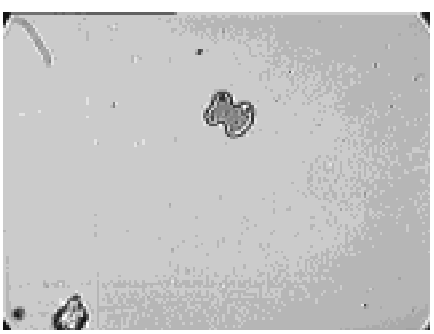

2. Irregular Cell (400X)

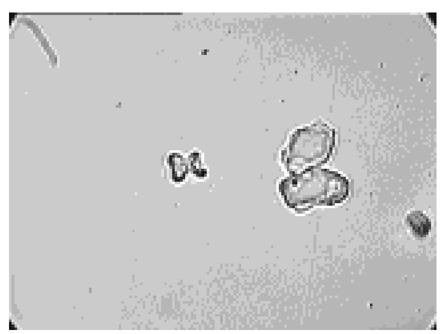

3. Irregular Cell (400X)


4. Irregular Elongate (400X)

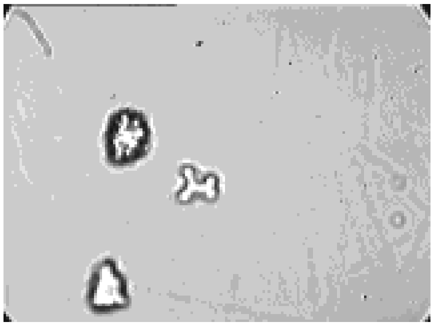

5. Wavy Elongate (400X)

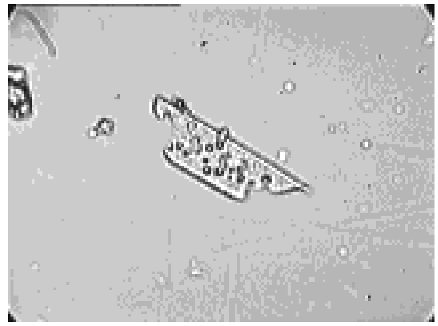

6. Festucoid “Hat-shape” (400X)


7. Panicoid Lobate (400X)

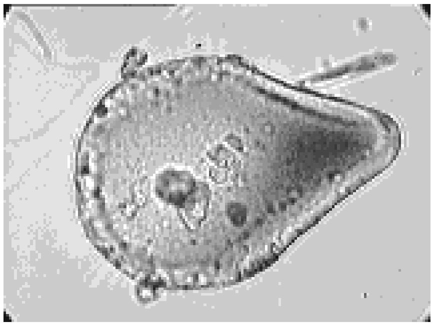

8. Panicoid Lobate (400X)

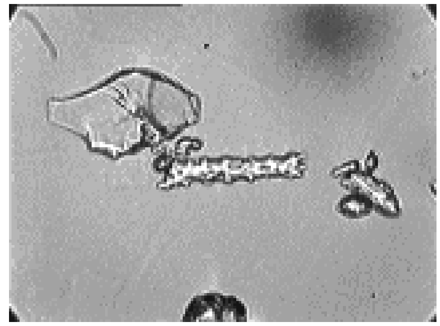
Unit 356, Stratum B, Level 5 (Catalog No. 909)

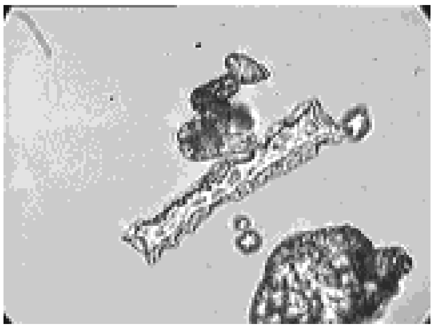

9. Panicoid Lobate (400X)

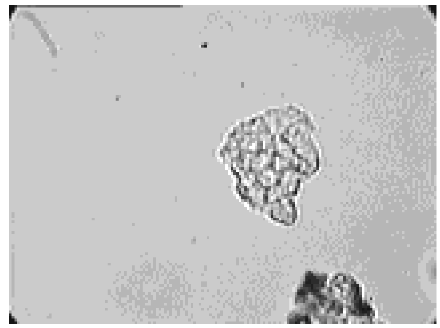

10. Plate (400X)

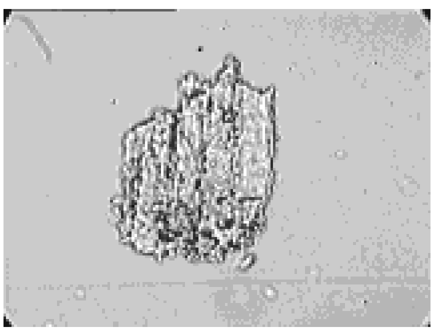
Unit 356, Stratum C, Level 6 (Catalog No. 910)

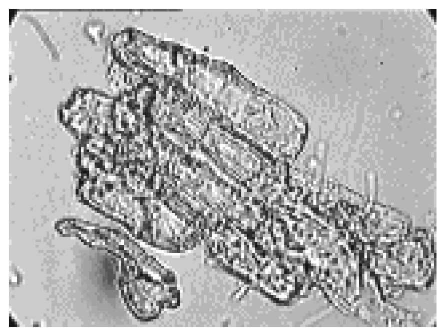

1. Bullform (400X)

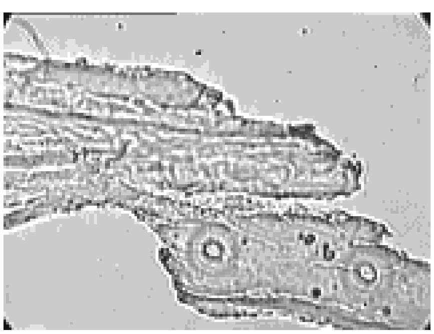

2. Irregular Elongate (400X)


3. Denticulate Elongate (400X)


4. Epiderme (400X)

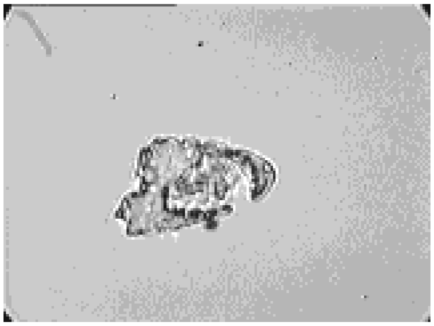

5. Epiderme (400X)


6. Epiderme (400X)

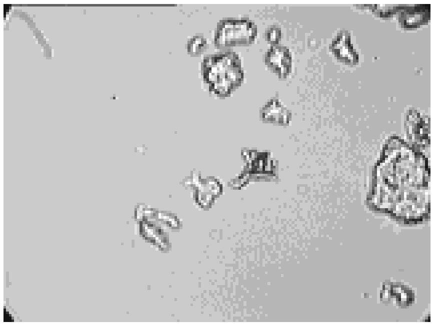

7. Epiderme or Plate (400X)

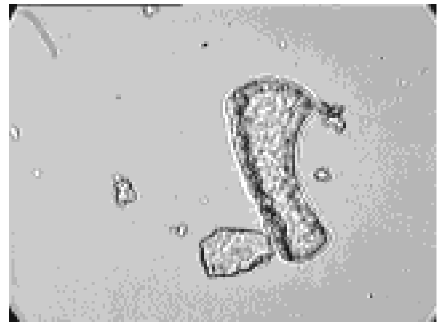

8. Trichome (400X)

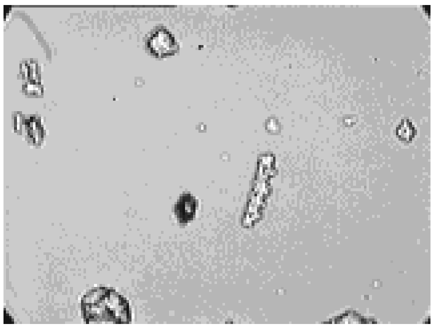
Unit 356, Stratum C, Level 6 (Catalog No. 910)

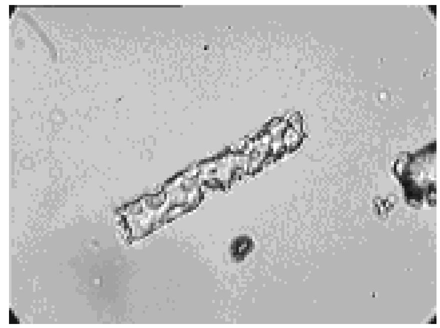

9. Trichome, corroded (400X)

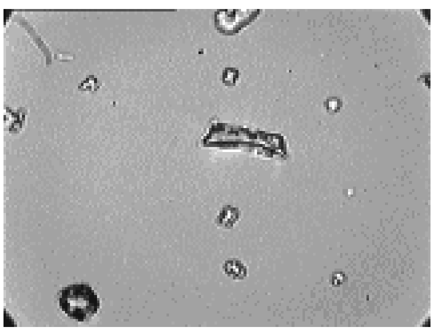
Unit 397, Stratum B, Level 3 (Catalog No. 812); beneath Feature 96

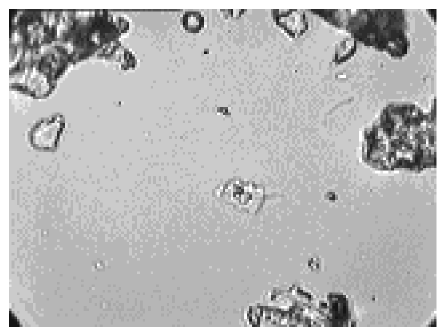

1. Panicoid Half Lobate (400X)

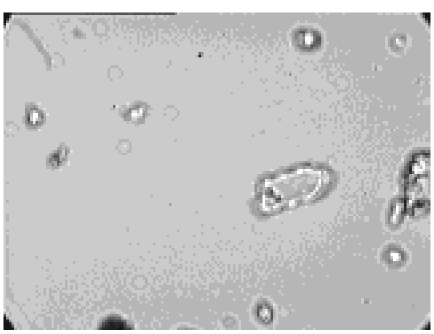

2. Bulliform (400X)

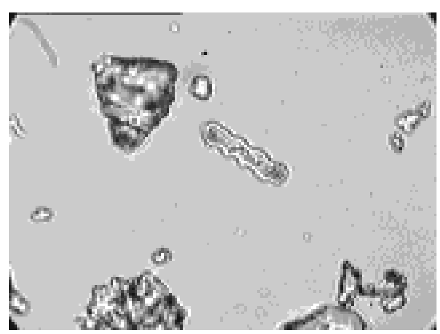

3. Irregular Elongate (400X)


4. Elongate, corroded? (400X)

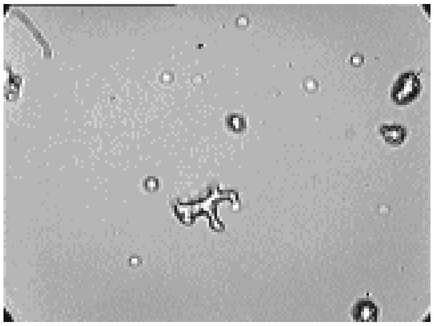

5. Festucoid “Boat-shape” (400X)

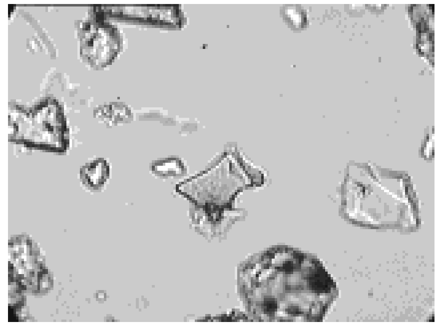

6. Festucoid Sinuous (400X)

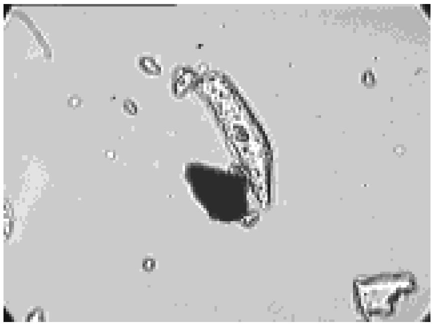

7. Festucoid Sinuous Trapezoid (400X)

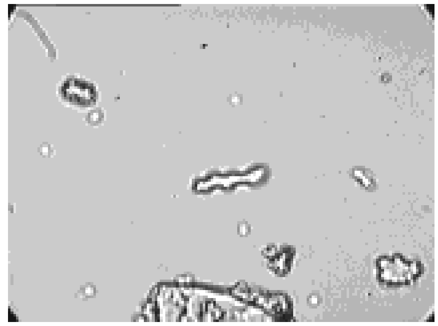

8. Festucoid Sinous (400X)

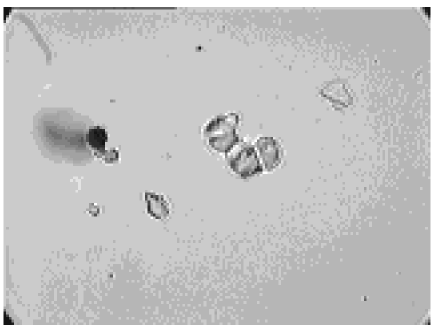
Unit 397, Stratum B, Level 3 (Catalog No. 812); beneath Feature 96

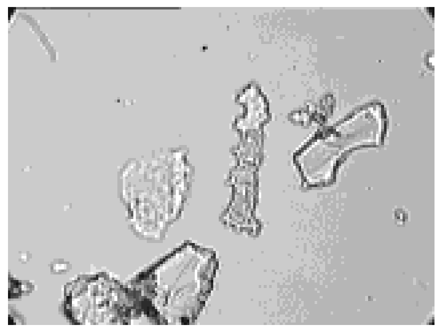

9. Intercellular Body (400X)

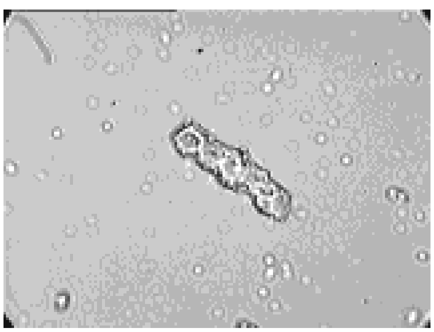

10. Cell (400X)

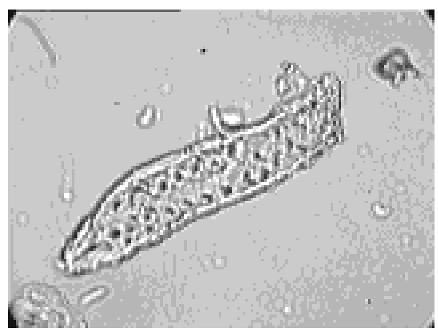

11. Tapered Cell (400X)


12. Sinuous Elongate (400X)

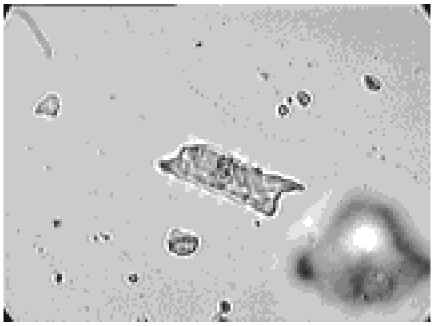

13. Irregular Cell (400X)

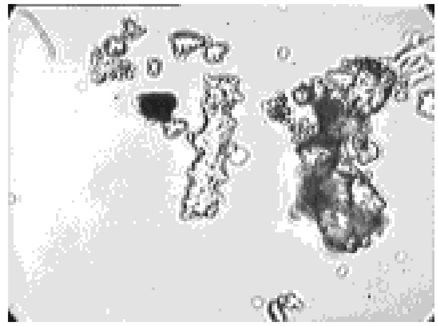

14. Irregular Elongate (400X)

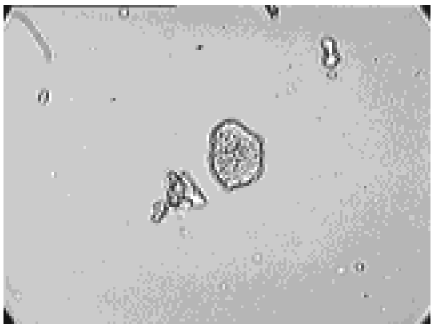

15. Irregular Elongate (400X)

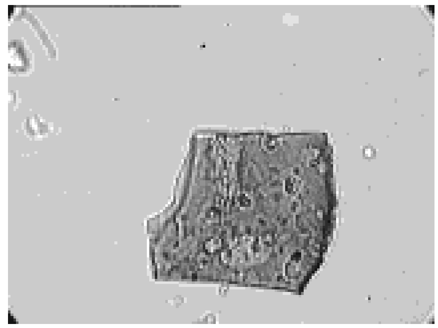

16. Perforated Cell (400X)

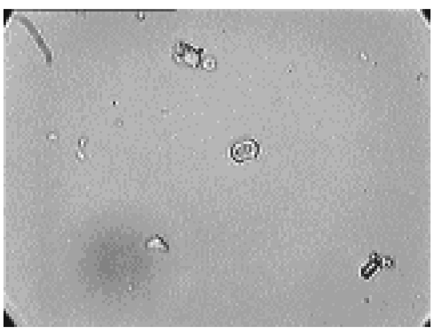
Unit 397, Stratum B, Level 3 (Catalog No. 812); beneath Feature 96

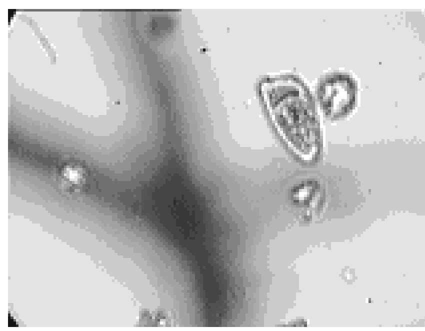

17. Irregular Elongate (400X)


18. Irregular Elongate (400X)

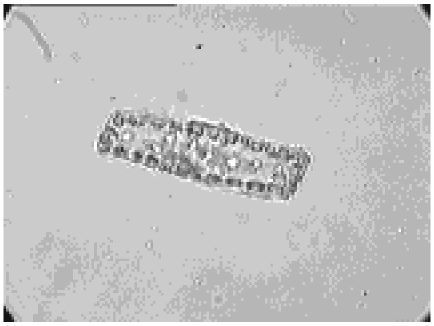

19. Cell Plate (400X)

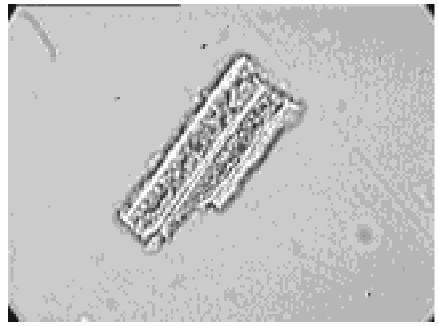

20. Plate (400X)

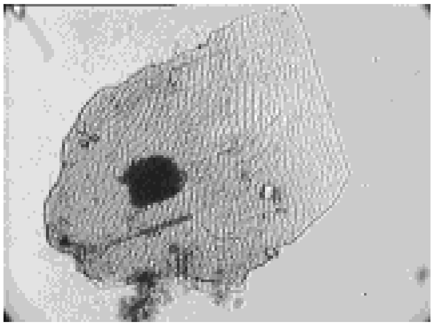

21. Chloridoid Saddle (400X)

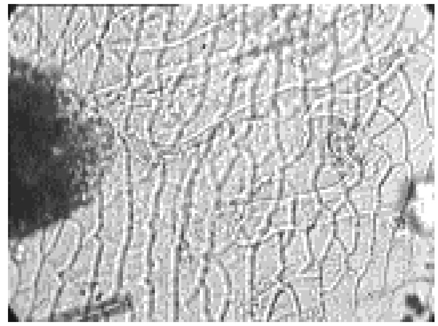

22. Trichome (400X)

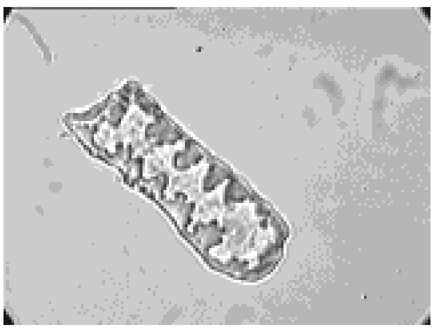
Unit 397, Stratum B, Level 4 (Catalog No. 816)

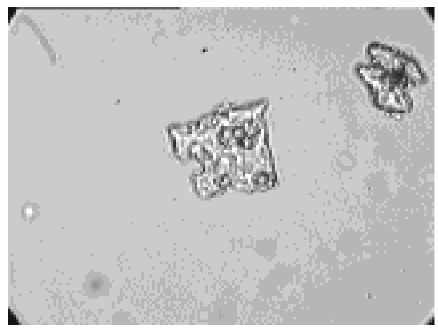

1. Ornamented Elongate (400X)

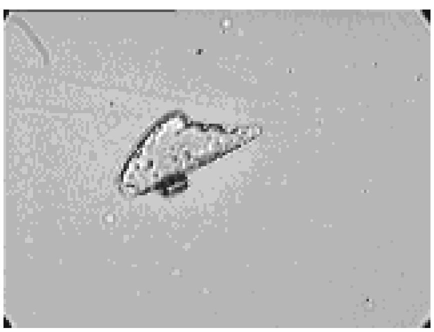

2. Elongate Plate (400X)

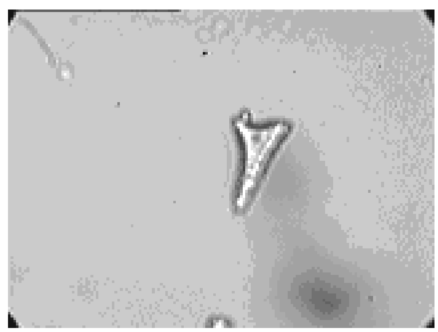

3. Epiderme (100X)


4. Same as #3 (400X)

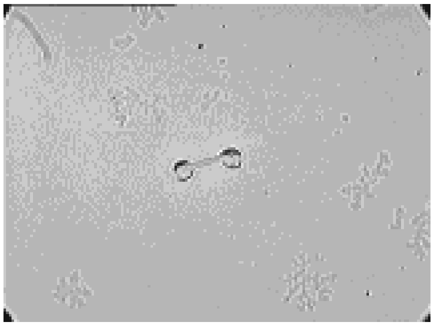

5. Festucoid? Long Cell (400X)


6. Square, corroded (400X)

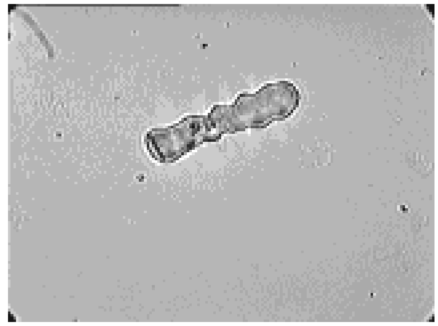

7. Trichome (400X)


8. Trichome (400X)

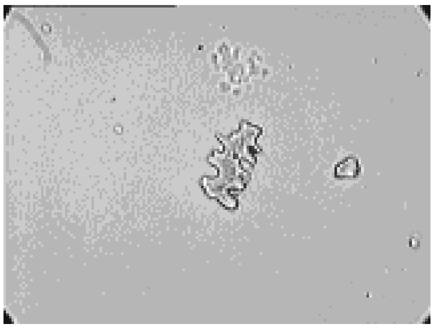
Unit 397, Stratum B, Level 5 (Catalog No. 817)



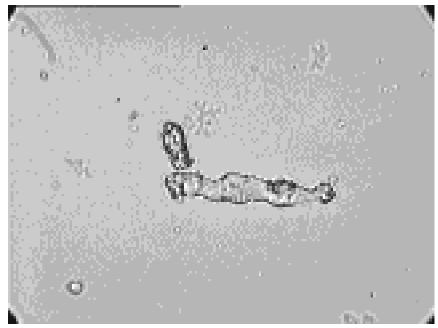
1. Panicoid Lobate (400X)



2. Wavy Elongate (400X)

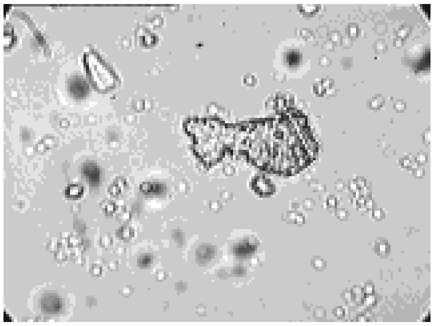


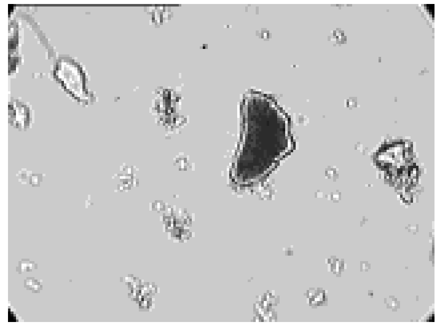
3. Irregular Denticulate (400X)

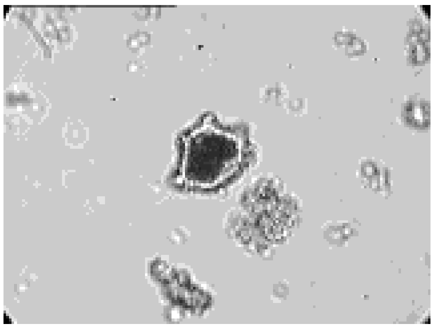


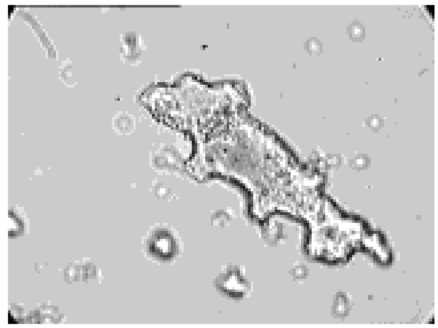
4. Irregular Elongate (400X)

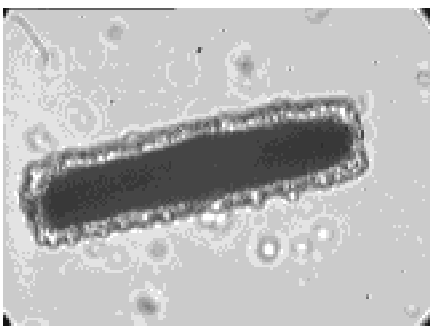
Feature 98, Stratum D, Level 10 (Catalog No. 1342)

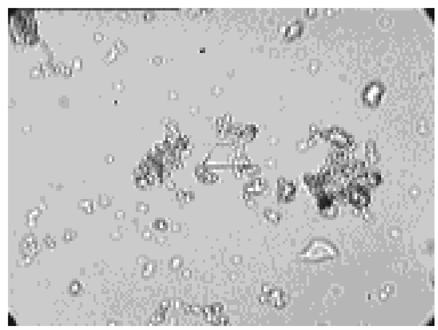

1. Irregular Cell (400X)

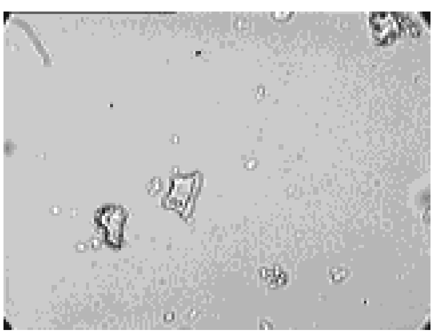

2. Irregular Cell (400X)

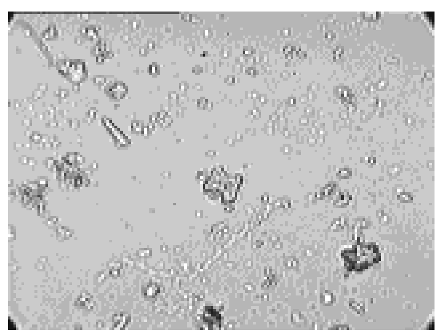

3. Irregular Cell (400X)


4. Irregular Cell (400X)

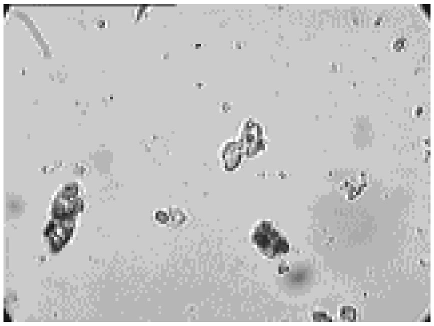

5. Denticulate Elongate (400X)

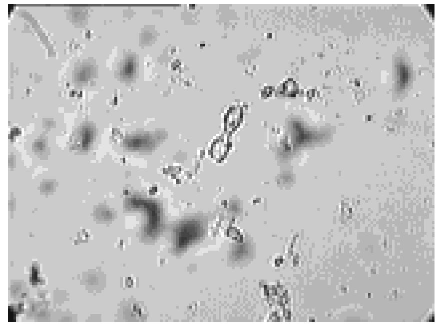

6. Festucoid Trapezoid (400X)

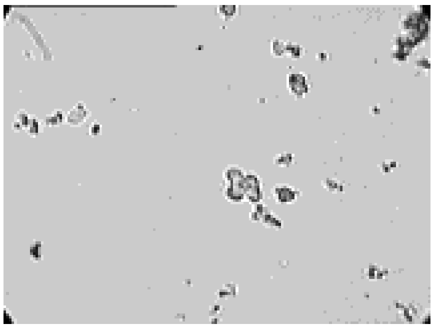

7. Festucoid Trapezoid / ”Hat” (400X)

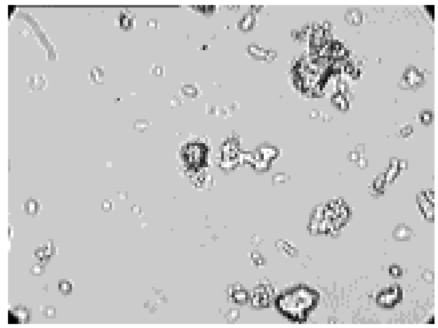

8. Panicoid Lobate (400X)

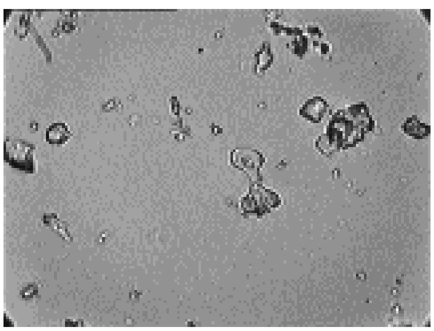
Feature 98, Stratum D, Level 10 (Catalog No. 1342)

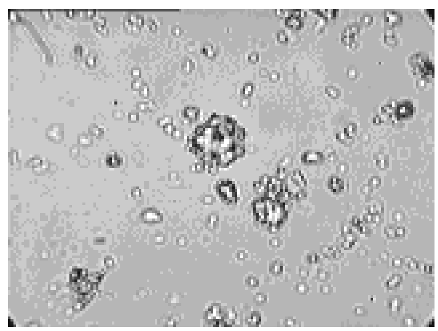

9. Panicoid Lobate (400X)


10. Panicoid Lobate (400X)


11. Panicoid Lobate (400X)


12. Panicoid Lobate (400X)


13. Panicoid Lobate (400X)


14. Spheroid (400X)