Root-Be-Gone (41YN452): Data Recovery of Late Archaic Components in Young County, Texas Volume II

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Appendix E

Phytoliths Present in a Buried Soil and Selected Cultural Features at 41YN452

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E.2 INTRODUCTION

This appendix reports the analytical procedure used and the results obtained during the isolation, recovery, and study of phytoliths present in soil samples from the Root-Be-Gone archeological site (41YN452), Young County, Texas, U.S.A. One buried soil sample (2Akb) served as a reference/control sample, and the soils from six contemporaneous cultural features were also processed and analyzed. The cultural features were located within the 2Akb buried soil. The occupational zone is interpreted to represent a Terminal Late Archaic component dating to approximately 1100 to 1300 years old.

E.3 PHYTOLITHS AND BIOGENIC SILICA

Phytoliths, meaning "plant stones", are amorphous siliceous deposits that form in and around the cells of living plants. In nature, silica is slightly soluble in water; as plants take up water via their root system, they also take in trace amounts of dissolved silicon in the form of silicic acid. The soluble silicon is transported throughout the plant with the water. When plants respire and evaporate water through their leaves, water is lost; however, as silicon is not volatile it concentrates in plant cells where it precipitates out as an amorphous solid, chemically referred to as $SiO_2 \bullet nH_2O$ (more commonly known as phytoliths). When plants die or are ingested, the organic material decomposes; however, the inorganic phytoliths survive and ultimately end up as a mineral component of the soil.

Due to the size of plant cells, the majority of the phytoliths of archeological interest occur in the silt fraction of the soil (2 to 50 microns [fine human hair is generally 20 to 40 microns in diameter; red blood cells are 7 to 8 microns in diameter]). The added water in the amorphous phytolith matrix makes phytoliths less dense than quartz-based minerals such as sand (sand, or SiO_2, has a density of 2.65 g/cm^3, whereas phytoliths have a density range from 1.50 to 2.30 g/cm^3). It is this density difference that enables phytoliths to be readily isolated from the bulk of the other soil minerals for study.

Other biological organisms that produce the same silicon compound as an essential component of their life cycle do exist; these are diatoms ("frustule"), glass sponges ("spicule"), and radiolarians ("scleracoma"). Collectively, the amorphous silicon from these four groups is referred to as biogenic silica. As they have the same chemical composition, their particle density is also the same; thus, if they are present in soil, these particles will be recovered together during the phytolith isolation procedure. Of these four biogenic silica categories, phytoliths, diatoms, and glass sponge spicules were recovered from 41YN452. This section focuses primarily on the phytoliths.

Phytoliths were first observed and described in the mid-1800s (Darwin 1846, Ehrenberg 1846, Gregory 1855). Subsequent early work was conducted primarily by botanists, with researchers in other disciplines gradually taking notice as new applications were developed. Soil scientists began to recognize biogenic silica in the 1950s (Smithson 1956, 1958, 1959; Kanno and Arimura 1958; Beavers and Stephen 1958; Baker 1959a, 1959b), and archeologists were soon to follow. As with pollen, diatoms, and other microscopic particles, phytoliths can suitably serve as environmental and/or climatic proxies. Although the phytolith literature has grown significantly the past several decades, the best overall stand alone resources remain Piperno (2006) and Pearsall (2000).

Table E-1. Poaceae Short Cell Phytolith Metabolic Types

Morphologic Form	Metabolic Type	Predominant Season	Figure
Keeled	C_3 (cool and moist)	Spring and Fall	1 A-F
Conical	C_3 (cool and moist)	Spring and Fall	1 G-I
Pyramidal	C_3 (cool and moist)	Spring and Fall	1 J-L
Crenate	C_3 (cool and moist)	Spring and Fall	1 M-R
Stipa	C_3/C_4		
Lobate, Simple	C_4 (hot and moist)	Summer	2 A-B
Lobate, Panicoid	C4 (hot and moist)	Summer	2 C-J
Lobate, Panicoid (compound)	C4 (hot and moist)	Summer	2 K
Cross, Panicoid (<10 um)	C_4 (hot and moist)	Summer	2 L-N
Cross, Panicoid (>10 um)	C_4 (hot and moist)	Summer	2 O-P
Saddle, squat	C_4 (hot and dry)	Summer	3 "S"
Saddle, tall	C_4 (hot and dry)	Summer	3 "T"

Regarding the climate proxy potential of Poaceae (i.e., grass) phytoliths in prairie settings, the metabolic difference between C_3 (cool season) and C_4 (hot season) plants is reflected in their cell structure (Table E-1; see representative examples in Figures E-1 through E-3),which is in turn recorded by their silicon deposits which are preserved in the soil record as phytoliths. It is this potential that Twiss recognized when he initially reported the various distinctive Poaceae short cell phytolith forms (Twiss et al. 1969). Later Mulholland worked on phytolith grass typology and classification issues from the northern plains (Mulholland 1986a, 1986b, 1989, 1993; Mulholland and Rapp 1992; Mulholland et al. 1988) while Bozarth concentrated primarily on food plants of the Great Plains (1986, 1987a, 1987b, 1990, 1992, 1993). There have been numerous other researchers contributing important pieces to the puzzle, but Fredlund and Tieszen's work studying the entire Great Plains from Canada to Texas and developing a temperature calibration based on the phytolith signature was a major contribution (1994, 1997).

Recent work on sites in alluvial settings revealed that the temperature formula does not transpose well to alluvial settings, although excellent temperature correlation was obtained for several dry upland prairie settings (Sudbury 2010).

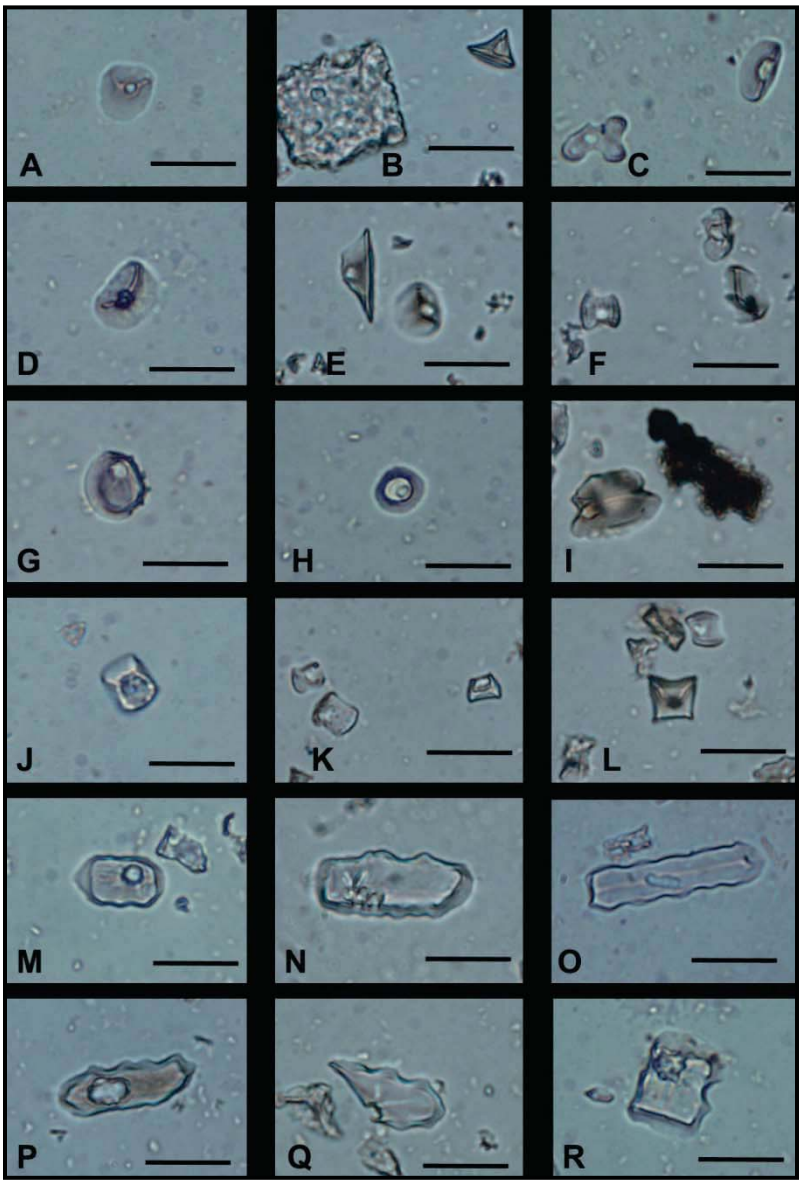

Figure E-1. Representative Pooid Phytoliths (from cool season C3 plants). Specimens A-F, Keeled [the specimen in B is on edge as is one of the specimens in E]; specimens G-I [specimen I is rolled on edge], Conical, specimens J-L, Pyramidal; and specimens M-R, Crenate. (Specimen Provenience: specimens A, G, and H - Buried 2Akb; specimens B, specimens C, J - Feature 1; specimen D - Feature 2; specimens I and M - Feature 7; specimens E, K, and L - Feature 10, specimen F – Feature 15; and specimens N-R - Feature 17. The bar scales are 20 microns.

Early phytolith work in Texas was reported by Robinson (1979a, 1979b, 1982), while the most recent major study was that at Wilson-Leonard site (Fredlund 1998), as well studies of playa deposits (Fredlund et al. 1998; Holliday et al. 2008) and creek bottoms (Bozarth and Woodburn 2010). Other important Texas-related studies include those by Jones and Bryant (1992), Holliday (1995), Bozarth (1995), Danielson and Reinhard (1998), and Nordt (Nordt et al. 2002; Nordt 2004).

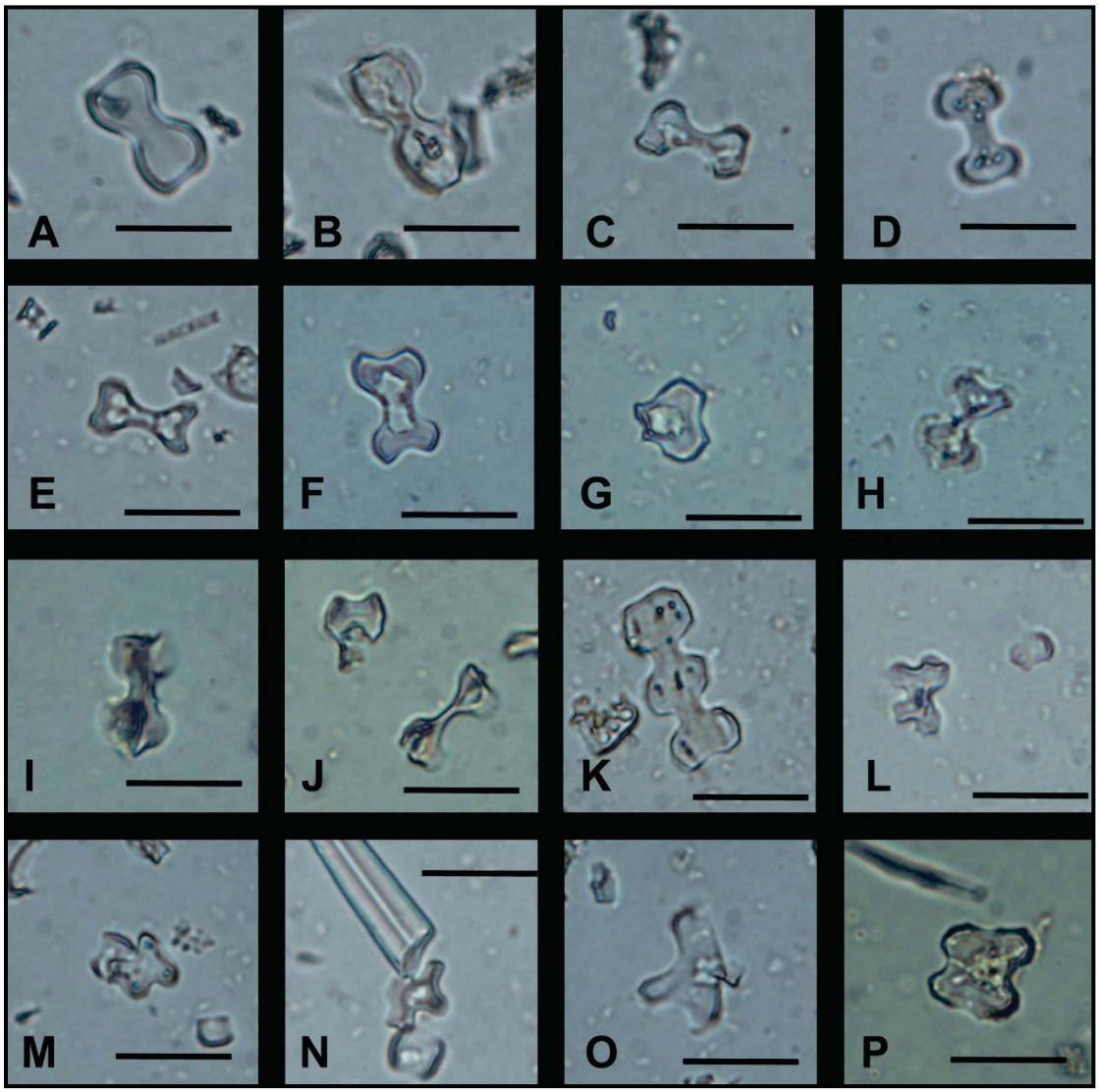

Figure E-2. Representative Panicoid Phytoliths (from hot moist season C4 plants) Specimens A-B, Panicoid simple lobate; specimens C-J, Panicoid lobate; specimens I-J, Panicoid lobates turned about 45 on edge; specimen K, Panicoid polylobate (compound); specimens L-N, small, Panicoid crosses; and specimens O-P, large Panicoid crosses. (Specimen Provenience: specimens G [half specimen] and L - Buried 2Akb; specimens F and H - Feature 1; specimens I, J, and P - Feature 2; specimens B, D, E, and N - Feature 7; specimens A, M, and O - Feature 10, and specimen C - Feature 17.) The bar scales are 20 microns.

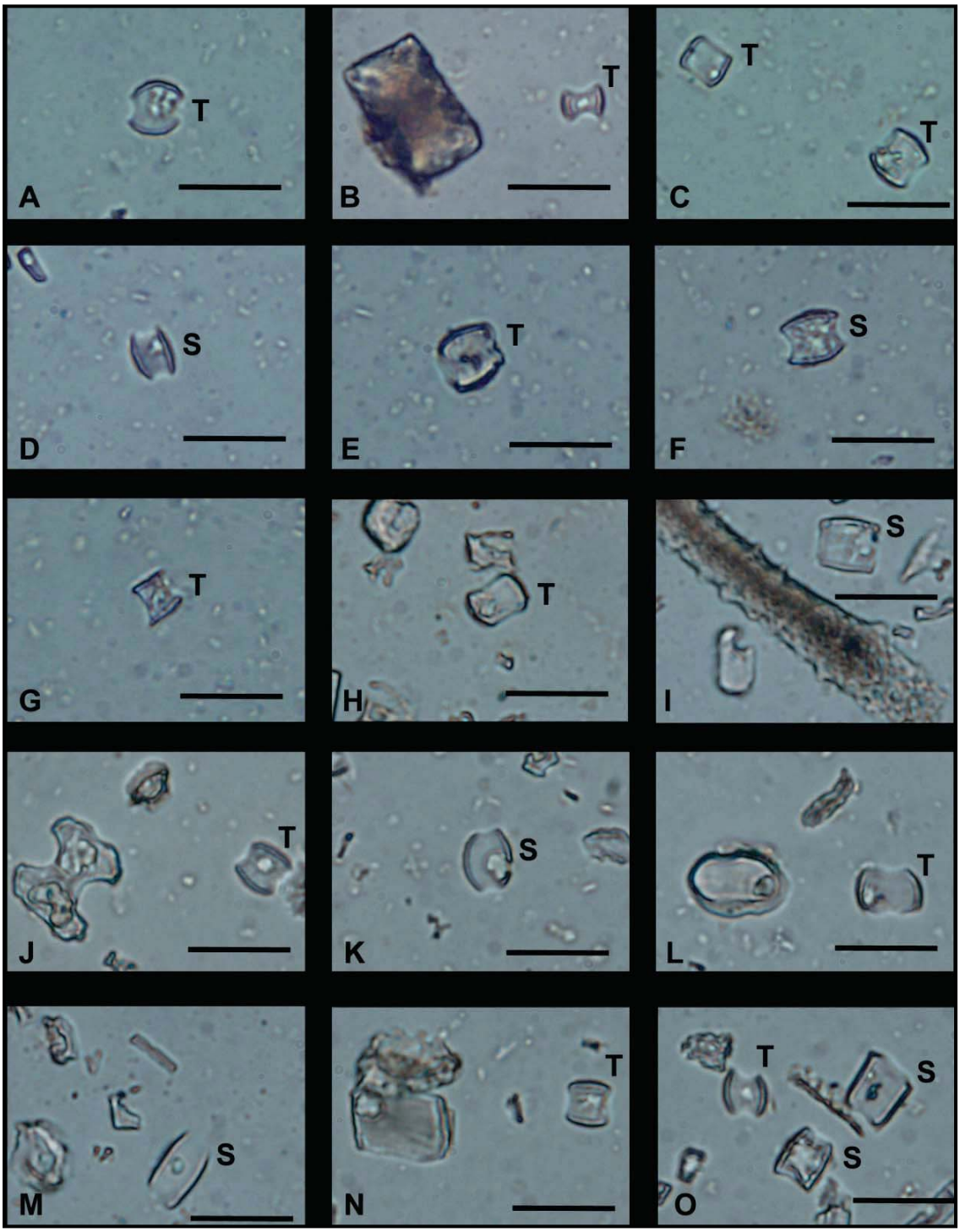

Figure E-3. Chloridoids—the Saddle-shaped Phytoliths (from hot and dry weather C4 plants). Specimens A-G, recovered from buried 2Akb reference soil sample; specimens H-L, from Feature 7, and specimens M-O, from Feature 10. "T" denotes a tall saddle (i.e., taller than wide) and "S" denotes a squat saddle. The bar scales are 20 microns.

E.4 LABORATORY PROCEDURE

The soil samples were inspected upon receipt. A mussel shell fragment was removed from the Feature 17 soil sample. The small very friable soil samples were not sieved prior to processing. This helped conserve limited sample and also preserved larger fragile specimens incidentally present in the samples (Figure E-4).

The seven soil samples were oven dried in preweighed 250 ml glass jars, cooled in a desiccator, and then reweighed to determine initial soil sample weight. After adding 5 percent Calgon® solution to the jars, the samples were shaken vigorously for 24 hours on an Eberbach® shaker to disaggregate the clays. The next processing step was to decant the combined clay and silt fraction [< 50 microns] away from the larger sand particles (> 50 microns); to execute this, the clay, silt, and sand were re-suspended in fresh water, the sand allowed to settle, and the suspended silt and clay and poured off repeatedly and pooled in two-liter bottles until the supernate was clear leaving only the sand fraction behind (Figure E-5). The clean sand fractions were oven dried, cooled, weighed, transferred to labeled plastic vials, and returned to the sample originator. The clean sand fractions did contain some organic debris (Figures E-4 and E-6).

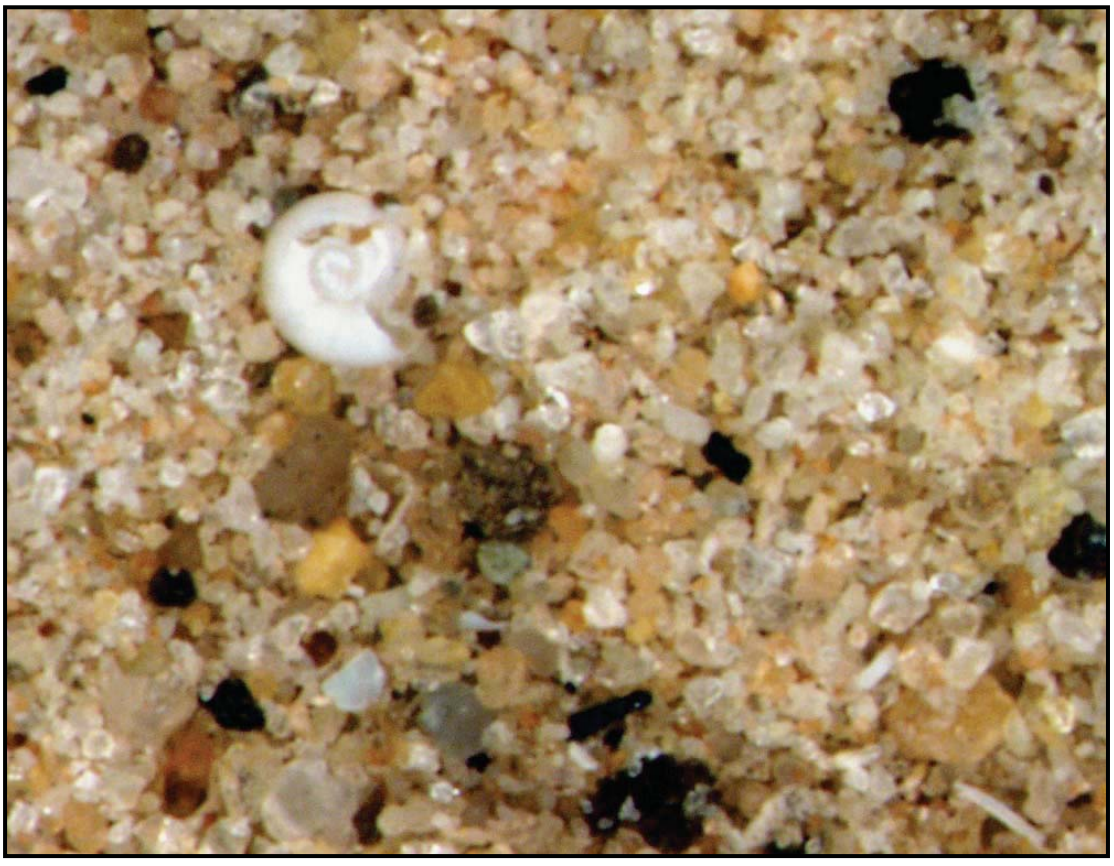

Figure E-4. Sand Fraction from the 2Akb Buried Soil Sample. This included a small snail shell as well as various cultural debris. (31.5x; the snail is ~3 mm across). [Based on this photograph, the snail was tentatively identified as Gyraulus sp. (identification courtesy of Luther Leith)].

Figure E-5. Removal of Silt and Clay from the Sand Fraction
The suspended small (i.e., < 50 micron) particle fractions were transferred to a 2-liter container for future processing (A, see far left [edge of funnel and bottle are visible]). Following complete silt/clay fraction removal, only the sand remained behind (B, left, 2Akb sample). The Feature 1 soil sample (B, right) still has all three soil fractions present (i.e., sand, silt, and clay) prior to decanting.

Figure E-6. Wet Sand Fraction(i.e., nominally 0.05-2 mm) from the Buried 2Akb Soil Sample Containing Some Obvious Black Organic Debris

The decanted sample fractions containing the mixed silt and clay were further processed to separate the clay from the silt fraction via differential sedimentation rates (Figures E-7 through E-12). As with the sand isolation process, the relevant particle settling times were calculated using Stoke's Law. Due to the height of the solution column in the two-liter receiving containers used to collect and pool the clay/silt fraction decants during the sand cleanup (~30 cm [Figures E-7 and E-10]), a ~24 hour settling interval was used to enable the silt particles to settle out (the phytoliths of morphologic interest are in the silt fractions (i.e., 2 to 50 microns) leaving the smaller clay particles (< 2 microns) suspended in solution. In order to speed up the total processing time for these relatively small samples (i.e., fine silt has a very long settling time [~8 hours/10 cm] compared to sand [~40 seconds/10 cm]), the suspended clay fraction was removed by pipetting the clay fraction from the settling container (rather than decanting) without disturbing the deposited silt bed.

Figure E-7. During Clay Removal. The clay remains suspended while the larger silt particles settle out.

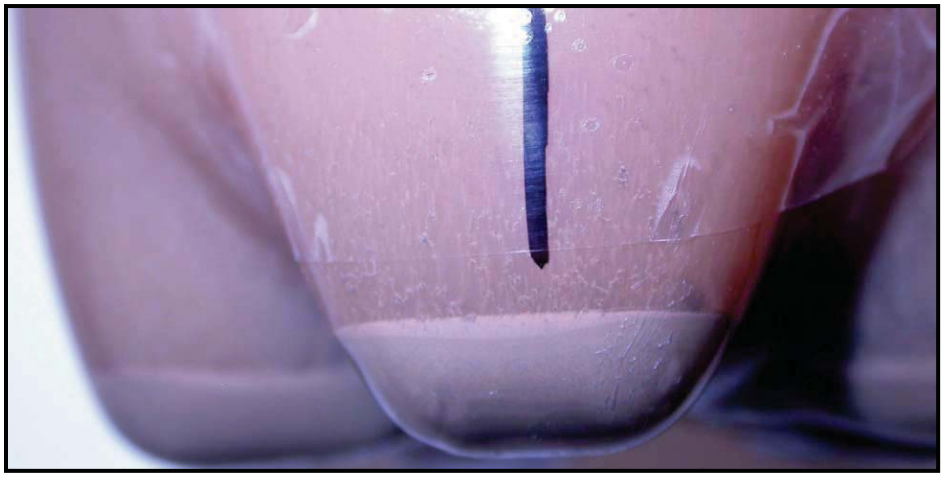

**Figure E-8. Settled Silt Nearing Time for Recovery;
The Remaining Suspended Clay Still Has to be Removed to Provide a Pure Silt Fraction.**

About 80 percent of the solution of suspended clay is removed each time. In order to retain the complete clay fraction, clay removal is performed via vacuum using an aspirator and a two-liter plastic receiving bottle with two small holes drilled in the lid—one hole to transmit the aspirated clay solution and the hole downstream from the solution to convey the vacuum as the bottle was gradually evacuated (Figure E-9). Plastic micro-pipette tips inserted tightly into the holes in the bottle lid are used to connect the Tygon® tubing to the two-liter bottle making an air-tight seal.

Figure E-9. Aspiration was Used to Generate Vacuum to Siphon the Clay Solution from the Sample Container. The white tube keeps the transfer line vertical (the solution pick-up line is Tygon® tubing with a 2 ml. glass pipette on the end). The binder clip on the tubing above the white tube keeps the pipette suspended the correct distance above the silt bed. The withdrawn clay fraction solution is collected in the receiving bottle (right) via vacuum, allowed to settle, and the entire clay fraction later recovered and dried.

The receiving bottle partly collapses during collection as the solution is withdrawn from the separation container confirming the vacuum held (Figure E-9).

To speed up laboratory processing, after multiple decants the relatively clean silt fractions were transferred back to the original 250 ml containers; use of these smaller jars enabled three ~eight hour settling intervals per day rather than one per 24 hour interval (i.e., 10 cm vs. 30 cm settling distance) and also cut down on water usage (Figures E-11 through E-12). The colored banding observed in the settled silt is a result of particle composition, particle density, relative particle size, and effective settling rate (Figure E-11).

The preceding laboratory soil sample fraction isolation detail is provided as this is a new method variant. The remainder of the procedure used to process these samples has been thoroughly detailed elsewhere (Piperno 2006, Pearsall 2000, Sudbury 2010) and will be briefly summarized.

The silt fractions were oven dried in the same 250 ml bottles, and the final clean isolated silt fraction weight obtained. The silt fractions were quantitatively transferred to porcelain crucibles and thermally processed in a muffle furnace at 535°C to eliminate organic material. After cooling, the dried silt fractions were treated with 10% hydrochloric acid to remove any carbonates present it the samples. The acidified silts were then transferred to centrifuge tubes, and washed repeatedly with ASTM Type A water, centrifuged, decanted, washed, centrifuged, etc. until the wash water pH returned to neutrality. The silts were then oven dried, and 2.35 g/cm^3 zinc bromide solution added to each centrifuge tube. The tubes were frequently vigorously agitated during the course of a week. Next, the tubes were centrifuged resulting in the phytoliths (< 2.30 g/cm^3) floating on the 2.35 g/cm^3 zinc bromide solution while the quartz-based silt fraction (i.e., ~ 2.65 g/cm^3) remained as a pellet below the heavy liquid in the tube.

Figure E-10. The Silt/Clay Mixtures Nearing the End of Removal of the Suspended Clay Fraction (the silt and remaining clay is repeatedly re-suspended and allowed to settle to enable removal of as much clay as possible).

Figure E- 11. Settled Silt Fraction with Some Possible Clay (dark band) Remaining on Top

The floating biogenic silica fractions were transferred to other tubes, and fresh zinc bromide solution added to the silt pellets which were remixed and centrifuged resulting additional phytoliths being floated, recovered, and pooled with the first phytolith decants. Once no more phytoliths are released by this repetitive procedure, the extraction step is complete (normally, 5 to 15 passes are required for quantitative phytolith recovery via heavy density liquid flotation).

Next the isolated floating biogenic silica fraction (consisting predominantly of phytoliths) and zinc bromide solution (2.35 g/cm^3) is mixed well and then centrifuged to remove any denser material that may have been inadvertently transferred with the lighter phytolith fraction. If contaminant is detected by this procedure, the floating phytoliths are again decanted to a fresh tube in zinc bromide solution and reevaluated for fraction purity. Once the phytolith fraction is deemed to be pure, the phytolith solution density is lowered below 1.5 g/cm^3 by adding of water which causes the phytoliths to sink. The phytoliths are then centrifuged and recovered as a pellet in the centrifuge tube. The phytolith pellet is then resuspended and washed repeatedly with pure water to remove the zinc bromide until the sequential water rinses have a density of 1.0 g/cm^3.

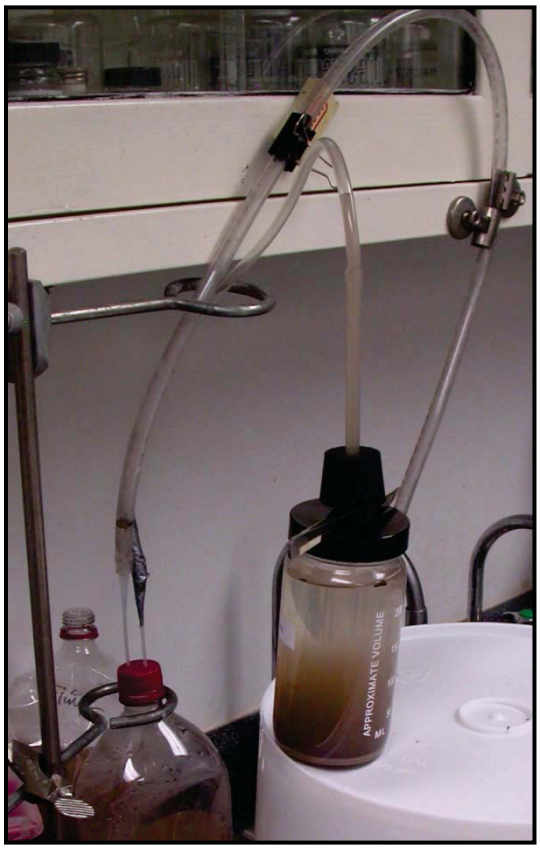

Figure E-12. Recovery Procedure

[The pooled diluted solvent rinses are later concentrated to recover the zinc bromide which is both expensive (> $1.00/ml) and hazardous (the residual silt ~2.65 g/cm^3 fraction is also repeatedly water-rinsed to recover the reagent).] The clean phytoliths are quantitatively transferred to pre-weighed labeled storage vials, oven dried, cooled, and weighed. The weight percent of phytoliths in the soil is determined (Table E-3). After gently mixing, a small fraction of each pure phytolith/biogenic silica fraction (~1 to 2 mg) is placed on a microscope slide and mounted in Canada Balsam with a cover slip (Figure E-13, 200x). After curing, the slide mounts are scanned at 500x using a polarized light microscope, and the various phytolith morphologies tabulated until at least 200 short cell phytoliths have been counted for each sample. A digital camera mounted on the microscope is used to document the observed forms. After the formal counting scan, the entire slide is scanned and examined for additional particles of interest.

E.5 RESULTS

During quantitative phytolith extractions, the weights of the sand and silt fractions were obtained (clay, the third textural component of soil, was not weighed.) This weight data enables determination of the soil textural class for all samples (Table E-2). Due to the presence of observed non-siliceous debris (Figure E-4), the sand fractions were returned to the project manager for further characterization.

A hole was drilled in a lid for the 250 ml jars and a Pasteur pipette connected to Tygon® tubing was used to withdraw the suspended clay fraction from above the silt layer. The 250 ml jar was elevated above the receiving container to enhance siphoning once the liquid phase flow started. The two plastic micro-pipette tips are visible perforating the two-liter receiving jar lid (duct tape was used to seal a problem air leak with the tubing). A ring stand and ring were used to keep the receiving bottle from tipping over (see also Figure E-9). The rubber stopper was used to hold the Pasteur pipette tip the correct distance off of the bottom of the 250 ml jar above the sediment layer. In this photograph, a pair of forceps is under the stopper to keep the stopper level, and to also give an added degree of distance during removal of most of the clay solution so as to be certain not to disturb the sediment bed. Once the bulk of the solution is removed, the pipette is lowered another ~5 mm to complete the clay removal by gently removing the forceps and holding the stopper steady. In this photograph, the vacuum has pulled the suspended clay solution nearly 90 percent of the way up the tubing. Once the solution passes the peak, siphoning action begins and solution removal accelerates. Magnets and binder clips were used to hold the tubing in a stable arched configuration.

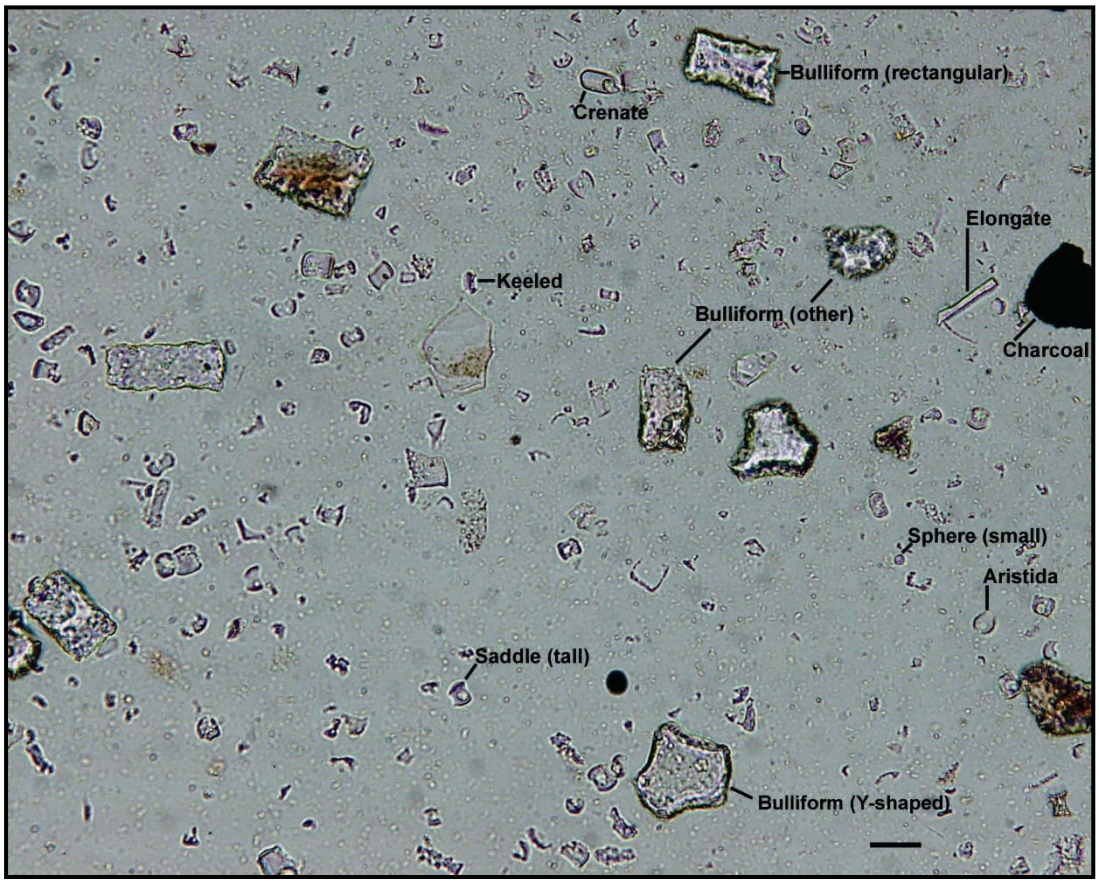

Figure E-13. Image of isolated biogenic silica fraction mounted on a microscope slide in Canada Balsam taken at 200x (the bar scale at the lower right is 20 microns long). Actual slide scans for particle counting are performed at 500x.

Table E-2. Soil Sample Texture Information (41YN452).

Sample Name and Source Detail		Sand Wt (g)	Silt Wt (g)	Sand %	Silt %	Soil Type Designation
2Akb	**820-4-1b**	7.55	12.545	**31.0%**	**51.5%**	**Silt Loam**
F1	**128-004-1a F1**	2.13	4.725	**29.5%**	**65.5%**	**Silt Loam**
F2	**144-004-1a F 2**	2.20	9.175	**12.0%**	**50.2%**	**Silty Clay Loam**
F7	**491-004-1b F 7**	6.62	9.945	**28.1%**	**42.2%**	**Clay Loam**
F10	**699-004-1a F10**	4.46	6.865	**27.7%**	**42.7%**	**Clay Loam**
F15	**742-004-1b F15**	3.44	1.945	**26.6%**	**15.0%**	**Clay**
F17	**748-004-3b F17**	3.08	1.645	**23.7%**	**12.7%**	**Clay**

Using the dry soil sample and the recovered phytolith weights, the actual weight percent phytolith concentration of the soil samples was determined (Table E-3). The average concentration in the six feature samples (1.27 percent) is similar to that of the contemporaneous buried soil (2Akb) surface sample used as a control. These feature sample phytolith concentrations are just outside the range of normal variation for replicate samples from a given site (see the Manning Tallgrass Prairie replicate sample data and discussion (Sudbury 2010:162-184)).

A portion of each phytolith sample was mounted on a slide and the slide was scanned while tabulating the various phytolith morphologic forms present in each field of view. The summary phytolith count data is in Table E-4. The first twelve forms listed in Table E-4 (i.e., the diagnostic Poaceae short cell phytoliths; see Table E-1 and Figures E-1 through E-3) are the categories used to evaluate seasonality in the following discussion. Specimens of basic short cell phytolith forms are illustrated in Figures E-1 through E-3.

The total short cell category counts observed during each sample scan are tabulated in Table E-5; the forms in each seasonality grouping are also tabulated (top portion of Table E-5) and normalized (bottom half of Table E-5). The Pooid, or cool moist morphologic forms (C_3), are keeled, conical, pyramidal, and crenate (Figure E-1). The Panicoid, or hot moist climate forms (C_4), are the lobates and crosses (Figure E-2; the Stipa, a minor intermediate group containing both C_3 and C_4 members are also included in the Panicoid fraction count). The Chloridoid (hot dry weather C_4 plant phytoliths; Figure E-3) forms tabulated are the two saddle forms which differ in their relative height to width ratio (i.e., tall vs. squat). The *Aristida* lobate form, which (when broken) can sometimes be confused with saddles (Figure E-10, and Sudbury 2010:122-126) were not included in these particle counts or the seasonality data.

A plot of the normalized data from the lower part of Table E-5 appears in Figure E-15 showing that the C_4 Panicoids—most often associated with tallgrass prairies—are a minor component. Except for the two samples from Features 1 and 2, the hot/dry weather C_4 Chloridoid fraction predominates whereas the cool season Pooids (i.e., spring and fall C_3 grasses) also make a significant contribution to the total phytolith count in the 41YN452 soil samples.

Table E-3. Phytolith Concentration in Soil Samples (41YN452)

Sample Name	Sample Name and Source Detail	Phytolith Wt (g)	Soil Sample Wt (g)	Soil Phytolith Concentration (wt/wt %)
2Akb	820-4-1b	0.3147	24.370	**1.29%**
F1	128-004-1a F1	0.1045	7.210	**1.45%**
F2	144-004-1a F 2	0.2821	18.280	**1.54%**
F7	491-004-1b F 7	0.2554	23.570	**1.08%**
F10	699-004-1a F10	0.1519	16.080	**0.94%**
F15	742-004-1b F15	0.1290	12.930	**1.00%**
F17	748-004-3b F17	0.2083	12.980	**1.60%**

Table E-4. Phytolith Morphologic Form Soil Sample Counts (41YN452)

Morphologic Form	41YN452 Soil Sample Source						
	2Akb	F1	F2	F7	F10	F15[1]	F17
Keeled	53	43	45	44	81	54	53
Conical	64	38	36	35	32	35	29
Pyramidal	24	45	38	23	27	38	52
Crenate	2	9	8	6	2	10	7
Saddle, squat	68	35	24	43	55	38	39
Saddle, tall	138	68	97	120	155	171	128
Stipa	5	5	6	0	4	9	5
Lobate, Simple	2	9.5	6	6	4	2	2
Lobate, Panicoid	11	10	13	12	10.5	8	4
Lobate, Panicoid (compound)	0	1	0	0	0	4	0
Cross, Panicoid (<10 um)	2	4	0	1	1	1	0
Cross, Panicoid (>10 um)	1	0	2	0	1	1	0
Large Disc	1	2	1	0	2	11	6
Maize Rondel	0	0	0	0	0	0	0
Dicot, knobby	3	6	5	1	7	2	0
Spiny spheroid	0	0	0	0	0	0	1
Diatom	1	1	1	0	0	0	1
Sponge spicule	3	10	5	1	4	2	2
Sponge gemmule	0	0	0	1	0	0	1
Trichome, Hair Cells	7	3	8	4	2	0	4
Bulliform, square	15	30	9	17	16	15	12
Bulliform, rectangular	30	64	38	24	39	32	12
Bulliform, keystone	3	16	7	4	12	9	5
Bulliform, Y-shaped	12	11	6	0	0	7	3
Bulliform, other	20	45	53	21	31	37	34
Elongate, smooth	4	8	10	4	4	5	3
Elongate, sinuous	2	1	0	0	1	1	0
Elongate, castillate	2	1	2	2	2	0	1
Elongate, spiny	2	9	3	4	4	5	4
Charcoal	49	50	19	19	6	6	8
Parallelopiped	0	3	3	0	0	0	1
Aristida Lobate	1	3.5	3	8	2	5	1
Sedge	0	1	2	0	0	0	0

[1] Feature 15 produced an articulated epidermal phytolith skeleton that may have been cut at one end (Figure E-14).

While scanning and counting phytoliths forms, the number of burned phytoliths (i.e., darkened in color from thermal alteration) was also noted; the data for the burned short cell forms of interest is in Table E-6 (no other burned phytolith forms were observed during the counts other than the categories listed). Whereas actual specimen counts are given in Table E-6, the burned specimens of each category divided by the total number specimens in of that category observed are presented in Table E-7 (values from Table E-6 divided by values in Table E-4). Some background level of burned phytoliths is expected due to normal environmental processes such as prairie fires and eolian introduction. The "natural" background level of burned Panicoid phytoliths at Manning Tallgrass Prairie was reported as 3.2 percent (0 to 5 cm sample, n=21) with Panicoids representing 80 percent of the burned short cell phytolith types (Sudbury 2010:160, 179). Boyd (2002:478) reported a baseline incidence of burned phytoliths at about 8 percent in a modern prairie soil, although the value in one charcoal dense buried soil was noted to be 73 percent.

Several other particle types recovered—sponge spicules and bulliform phytoliths—are also reported as per cent relative to the total number of short cell phytoliths observed in the same fields of view during the counting procedure (Table E-8). Examples of recovered bulliform phytoliths, sponge spicules, and sponge gemmules are illustrated in Figures E-16 through E-19. In the sponge spicule discussion, "weathering" refers to having an abraded and/or pitted surface (vs. pristine) rather than being complete or fragmentary. Sedge phytoliths were also noted in some soil samples (Table E-4 and Figure E-20).

E.6 DISCUSSION

In a recent experiment, twenty-one five cm deep surface A horizon soil samples were collected from within a twenty meter diameter circle at a virgin tallgrass prairie; the soil phytolith concentration in that small level area varied from 0.77 to 1.20 weight percent (Sudbury 2010:165-166).

Table E-5. Seasonality Interpretation--Phytolith Count Totals and Normalized Short Cell Values

Morphologic Form	41YN452 Soil Sample Source						
	2Akb	F1	F2	F7	F10	F15	F17
Total Short Cell Count	371	269.5	276	290	374.5	382	325
Pooid (Cool and Moist)	143	135	127	108	142	137	141
Panicoid (Warm and Moist)	22	31.5	28	19	22.5	36	17
Chloridoid (Hot and Dry)	206	103	121	163	210	209	167
Pooid (Cool and Moist)	0.386	0.501	0.460	0.372	0.379	0.359	0.434
Panicoid (Warm and Moist)	0.059	0.117	0.101	0.066	0.060	0.094	0.052
Chloridoid (Hot and Dry)	0.555	0.382	0.438	0.562	0.561	0.547	0.514

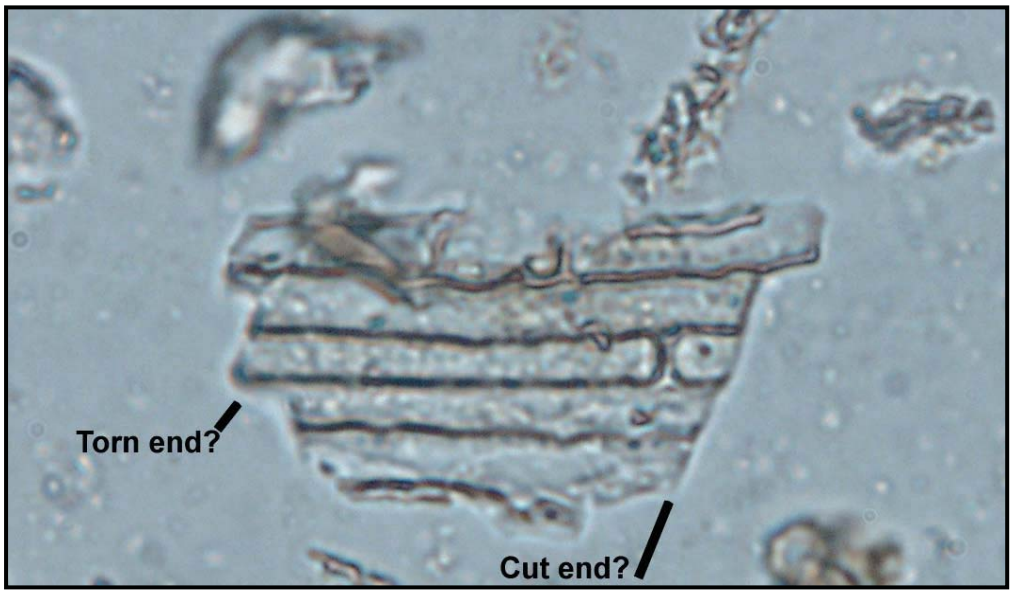

Figure E-14. Spodogram or Silica Skeleton (articulated phytolith pavement) of Epidermal Elongate Cells with One End which Appears to Have Possibly Been Cut. This specimen was found in the Feature 15 soil sample; Feature 15 also had the highest per cent incidence and variety of burned phytoliths (see Table E-7). Combined, these two observations tentatively support an interpretation of plant resource acquisition for processing in conjunction with activity occurring at Feature 15. This type of physical observation (i.e., a cut phytolith skeleton) was recently summarized by a researcher looking at evidence of early agriculture and use of the threshing sledge who stated that diagnostic cuts did not occur with other types of processing (Cummings 2007). The original studies by Anderson (1999, 2003) concentrated on tool use and wear, but also illustrated cut phytoliths. Although the threshing process in these papers was clearly an Old World phenomenon, this specimen from 41YN452 does show one end that that has a fairly straight edge that truncates the cells which raises the question of how this may have occurred.

Based on this data, the variation in soil phytolith concentration among the 41YN425 feature samples cannot be positively attributed to human activity as the total phytolith concentration was "relatively constant" ranging from 0.94 to 1.60 percent (Table E-3).

The soil types from the six feature samples range from clay to silt loam (Table E-2). The phytolith signature for the two features with clay loam soils—Features 7 and 10--are virtually identical (Figure E-15). The phytolith signature of Feature 15 is also very similar, although the soil is significantly higher in clay content. If the phytolith signature represents unaltered background contribution of the local vegetation, this would suggest that Features 7, 10, and 15 were in use at approximately the same time. These three features also have an essentially identical phytolith distribution to the 2Akb control sample (Figure E-15).

The other three features (1, 2, and 17) have a larger cool season phytolith component than the other features; this could indicate that these three features were in use during a different season than the three features discussed previously and/or that they are not contemporaneous with the first three features. Alternatively, if the concentration difference is because the occupants were actively gathering plant material, it is not clear whether they were gathering dry biomass for use as fuel (i.e., dry C_4

vegetation during the fall through spring) and/or gathering green biomass for other purposes (i.e., C_4 vegetation during the summer for processing), and vice-versa for the other cluster of features. The majority of the burned phytoliths observed in all features (except Feature 2) were Panicoid (Table E-6).

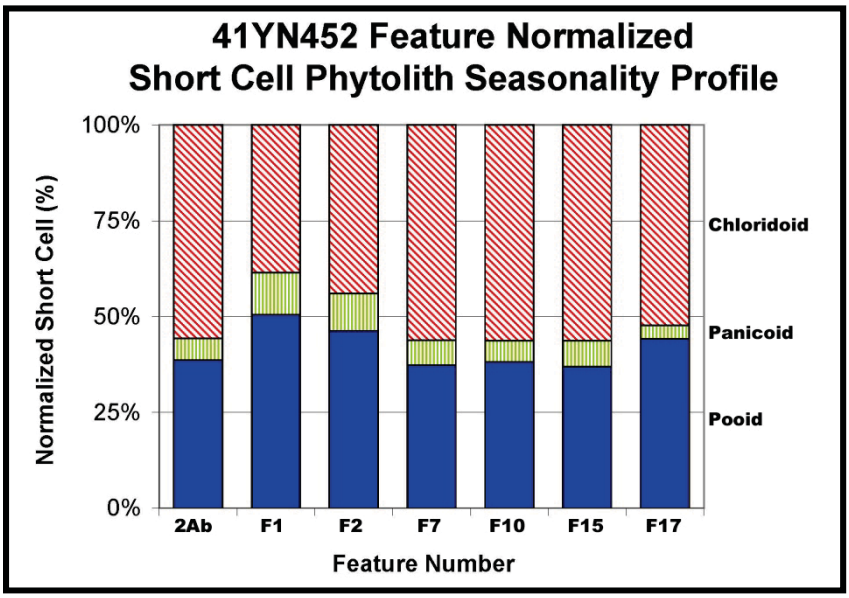

Figure E-15. Normalized Short Cell Phytolith Morphologic Form Counts, Grouped by Seasonality Type (data from Table E-5).

Table E-6. Count of Burned Phytoliths Observed in Counted Fields (41YN452).

Burned Phytoliths	2Akb	F1	F2	F7	F10	F15	F17
Keeled	-	-	1	-	-	-	-
Conical	-	-	-	-	-	-	-
Pyramidal	-	-	-	-	-	-	1
Crenate	-	-	-	-	-	-	-
Saddle, squat	-	-	-	-	1	1	-
Saddle, tall	-	1	4	3	-	-	2
Stipa	1	-	-	-	1	-	1
Lobate, Simple	-	1	-	1	-	-	-
Lobate, Panicoid	-	-	2	3	0.5	1.5	2
Lobate, Panicoid (compound)	-	-	-	-	-	2	-
Cross, Panicoid (<10 um)	-	1	-	-	-	1	-
Cross, Panicoid (>10 um)	-	-	-	-	-	1	-
Aristida lobate						1	

Table E-7. Percent of Burned Phytoliths Observed in Counted Fields (41YN452).

Burned Phytoliths, %	2Akb	F1	F2	F7	F10	F15	F17
Keeled	-	-	2%	-	-	-	-
Conical	-	-	-	-	-	-	-
Pyramidal	-	-	-	-	-	-	2%
Crenate	-	-	-	-	-	-	-
Saddle, squat	-	-	-	-	2%	3%	-
Saddle, tall	-	1%	4%	3%	-	-	2%
Stipa	20%	-	-	-	25%	-	20%
Lobate, Simple	-	11%	-	17%	-	-	-
Lobate, Panicoid	-	-	15%	25%	5%	19%	50%
Lobate, Panicoid (compound)	-	-	-	-	-	50%	-
Cross, Panicoid (<10 um)	-	25%	-	-	-	100%	-
Cross, Panicoid (>10 um)	-	-	-	-	-	100%	-
Aristida lobate	-	-	-	-	-	20%	-

The relative sponge spicule concentration was highest in samples from Features 1 and 2 (Table E-8). This may indicate that site conditions were wetter at that time and/or that these two features show more evidence of water use than the other features. The higher bulliform phytolith concentration in these same two features (Table E-8) supports the notion of plants from a cooler/moister environment contributing to the feature phytolith composition. Sedge phytoliths, indicating wet conditions, also were only noted in the formal slide particle counts for these two features. The short cell phytolith signature, sponge spicule data, bulliform phytolith data, and sedge phytolith data all agree in their support that the biogenic silica composition and seasonal/climatic information for Features 1 and 2 are different than observed for the other four features analyzed, and from the 2Akb control soil sample.

In order to assess the regional climate at the time development of the 41YN452 2Akb buried soil ended, it is of interest to compare the Root-Be-Gone site buried soil phytolith signature to that of the similarly dated Caddo buried soil located on a short drainage about 215 km to the north. This Oklahoma location, known as the Carnegie Canyon site (34CD76), was studied intensively in the 1980s (Lintz and Hall 1983; Hall and Lintz 1984); however, only in the past few years has phytolith analysis been performed on the entire stratigraphic soil column at the site—including the buried Caddo soil which was radiocarbon dated at 1050±50 years (Carter et al. 2009, Sudbury 2010).

Table E-8. Bulliform Phytolith and Sponge Spicule Counts Relative to the Total Number of Short Cell Phytoliths Present (41YN452).

Sample	Bulliforms: Short Cells (%)	Spicules: Short Cells (%)
2Akb	21.6 %	0.8 %
F1	62.1 %	3.7 %
F2	41.1 %	1.8 %
F7	22.8 %	0.3 %
F10	26.3 %	1.1 %
F15	27.0 %	0.5 %
F17	20.7 %	0.6 %

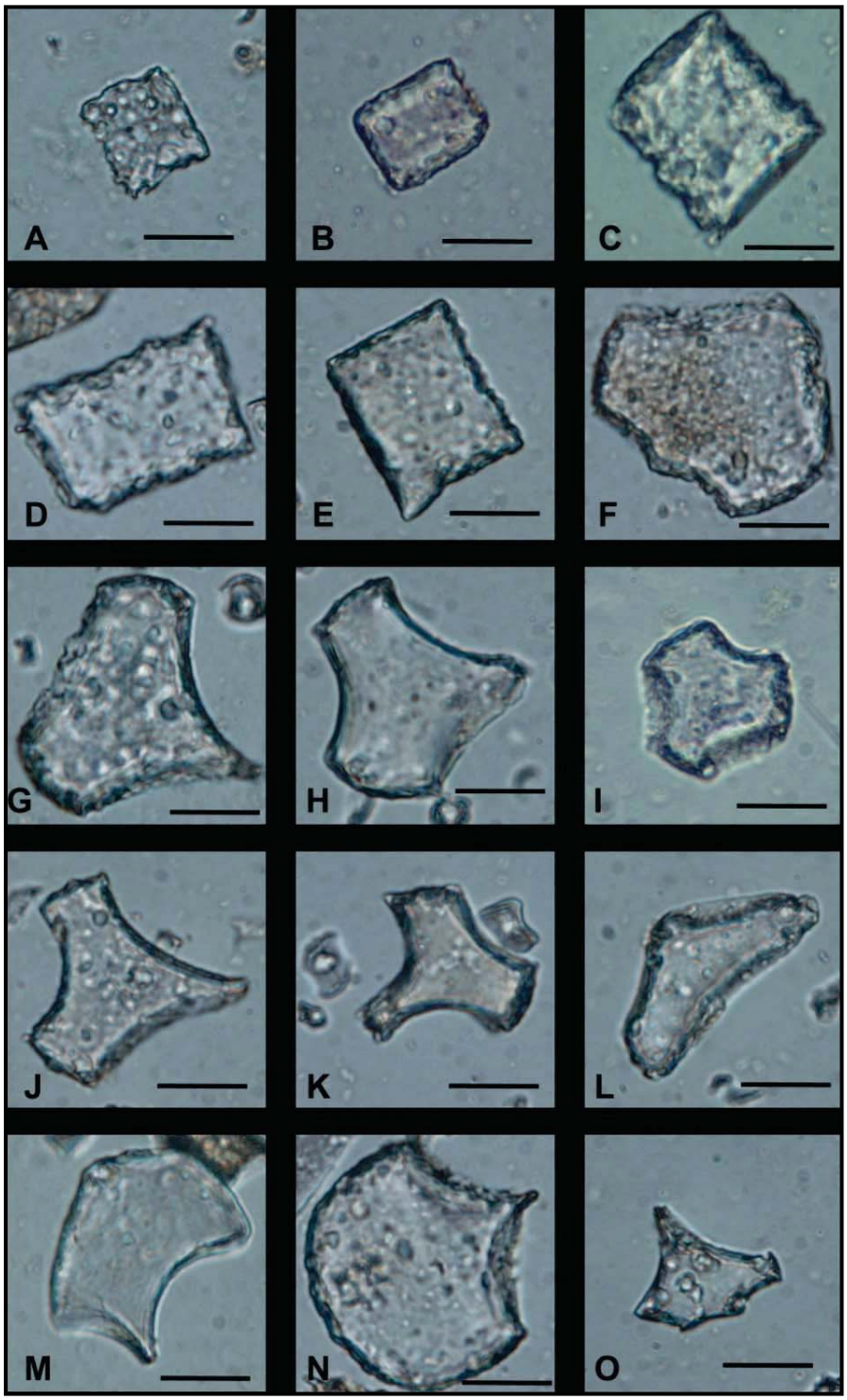

Figure E-16. Representative Bulliform Phytoliths
Specimens A-E, Rectangular; specimens F-G and M-N, Keystone; specimens H-K, Y-shaped; and specimens L and O, Other forms. (Specimen provenience: specimens B, C, F, I - Buried 2Akb; specimens A, E, G, M, O, - Feature 1; specimen L - Feature 7; specimens H and K - Feature 10; and specimens D, J, and N - Feature 15). The bar scales are 20 microns.

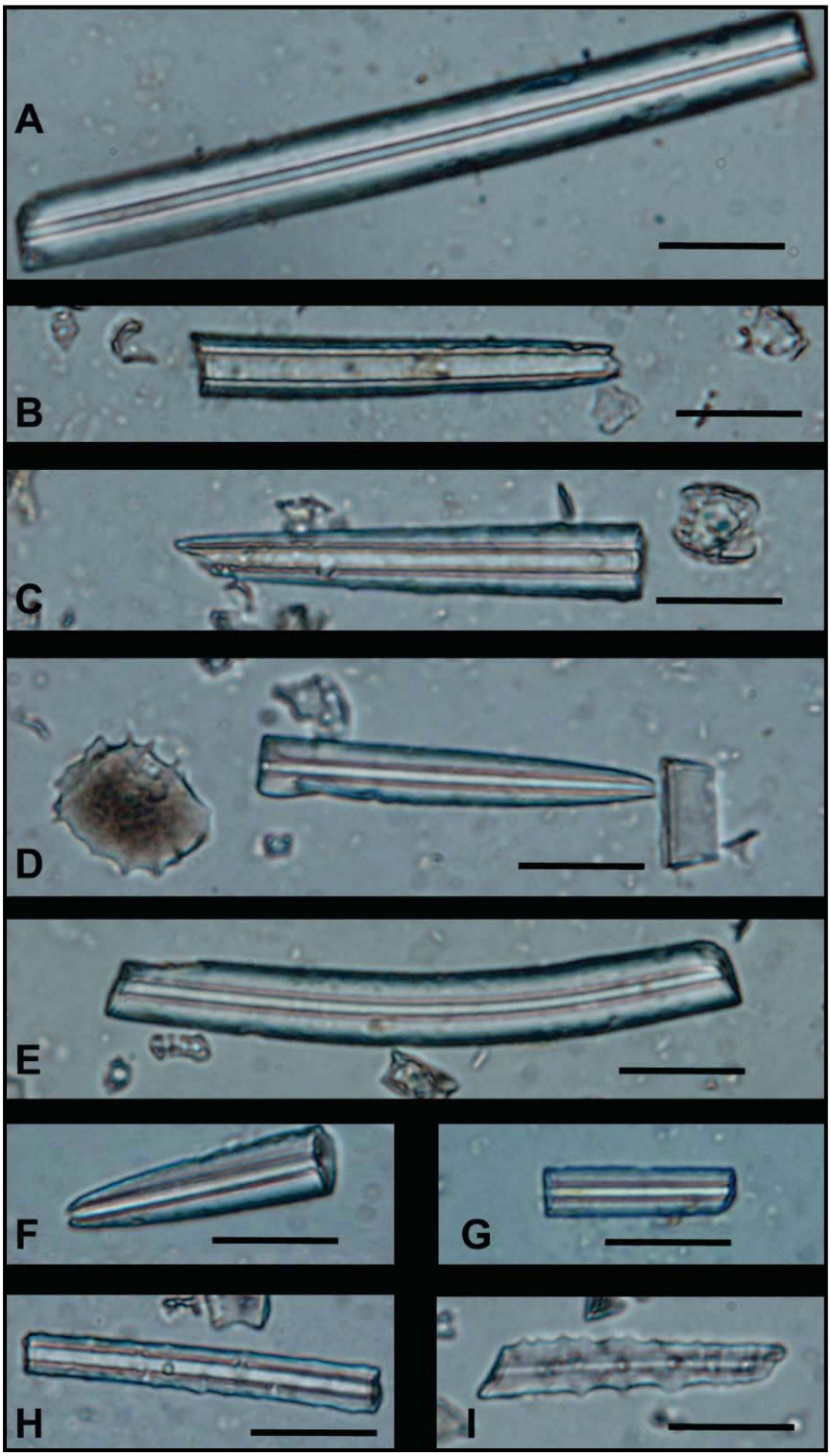

Figure E-17. Weathered Sponge Spicule Sections (A-G) and spiny spicule sections (H-I). Specimen A - buried soil Ab; specimen B - Feature 1; specimen C - Feature 7; specimen D - Feature 17; specimen E - Feature 7; specimen F - Feature 2; specimen G - buried soil Ab; specimen H - Feature 15; and specimen I - Feature 10. The bar scales are 20 microns.

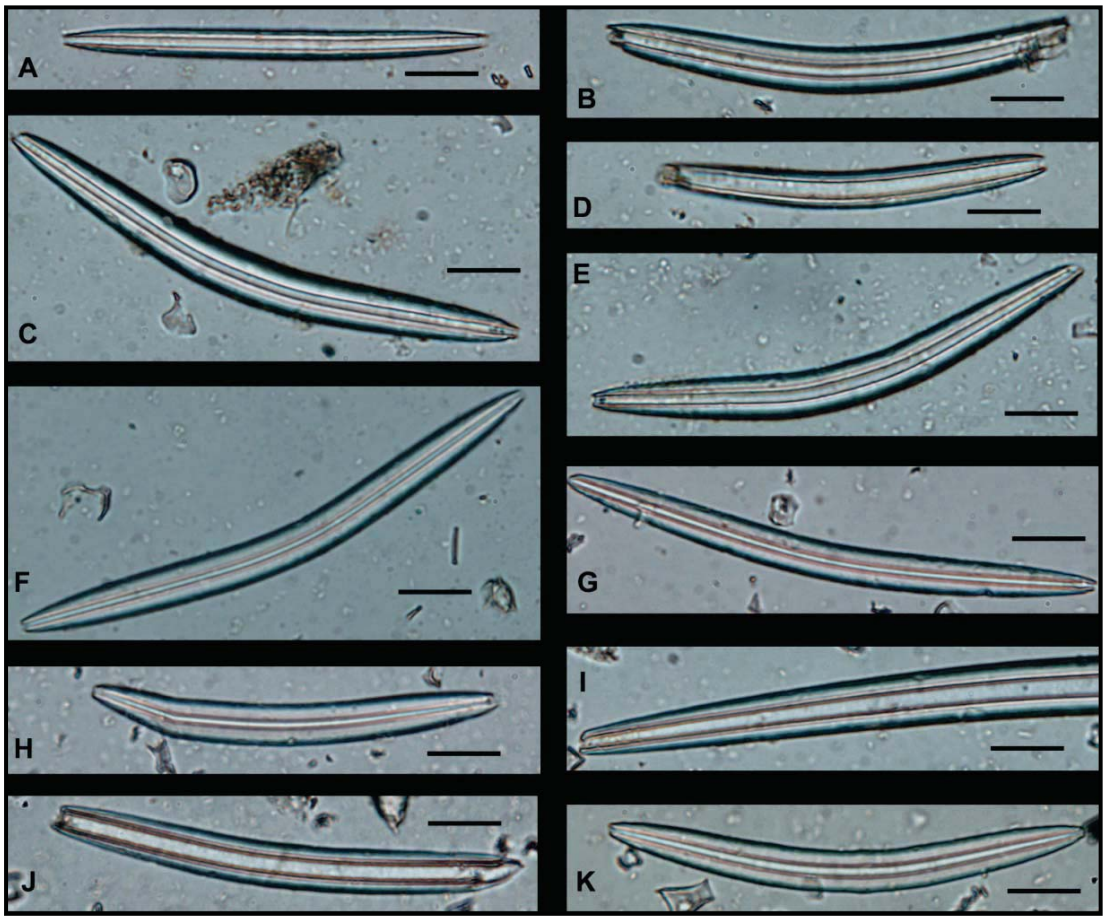

Figure E-18. Unweathered Sponge Spicules. Specimens A-E, Feature 1; specimen F, Feature 2; specimens G-I, Feature 7; specimen J, Feature 15; and specimen K, Feature 17. Average length of these specimens (excluding specimen I), is 132 microns. The bar scales are 20 microns.

Figure E-19. Sponge Gemmules (broken). Specimen A/A' (two views after particle rolling), Feature 7; and specimen B, Feature 17. The bar scales are 20 microns.

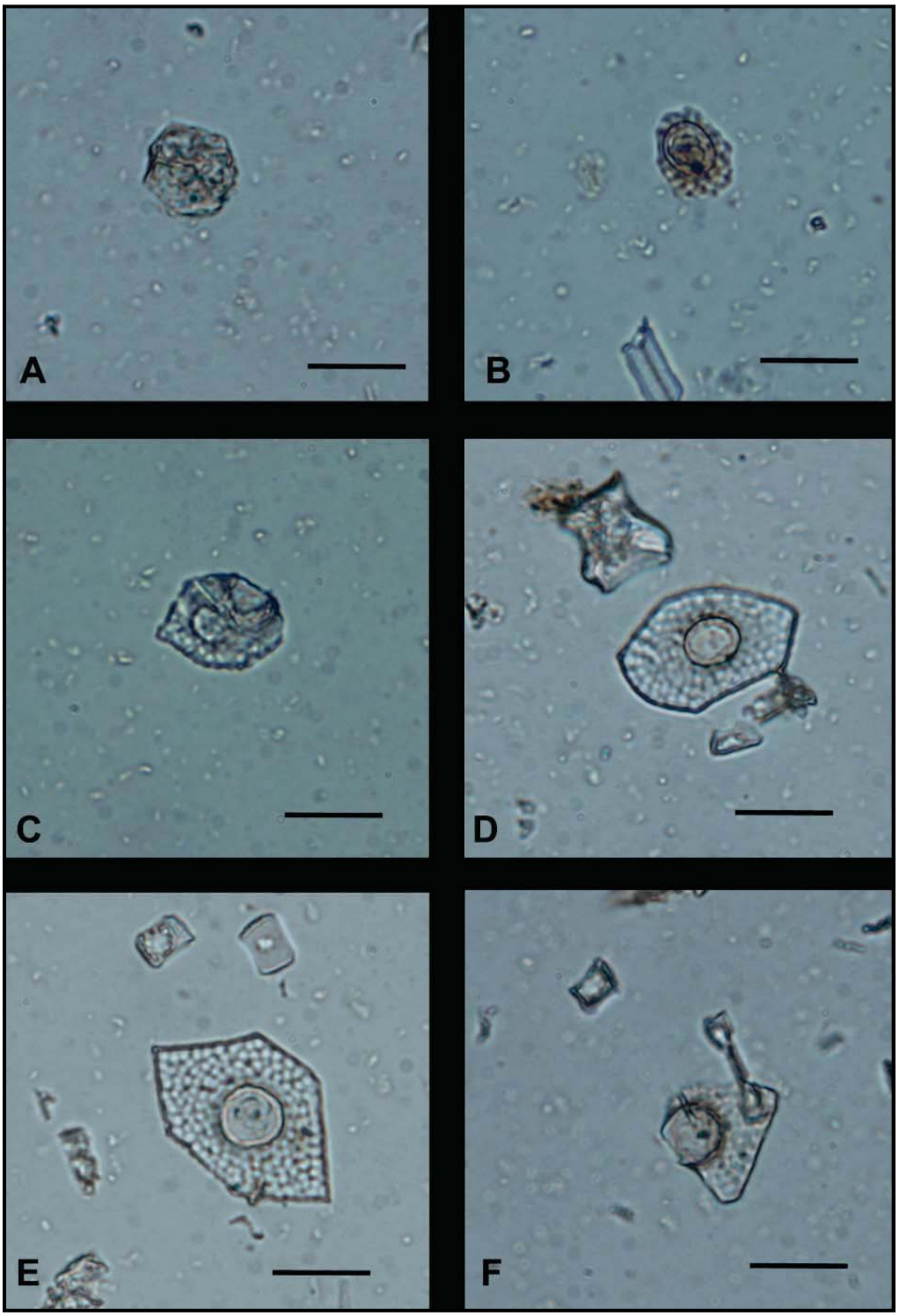

Figure E-20. Sedge Phytoliths
Specimens A-C, buried 2Akb soil; specimen D, Feature 1; specimen E, Feature 7; and specimen F, Feature 15. Identify of Specimen A is uncertain (appears to be upside down). The fragmentary specimen in F has what appears to be an Aristida bilobate superimposed on top (the bilobate is distorted as is not in a planar position). The bar scales are 20 microns.

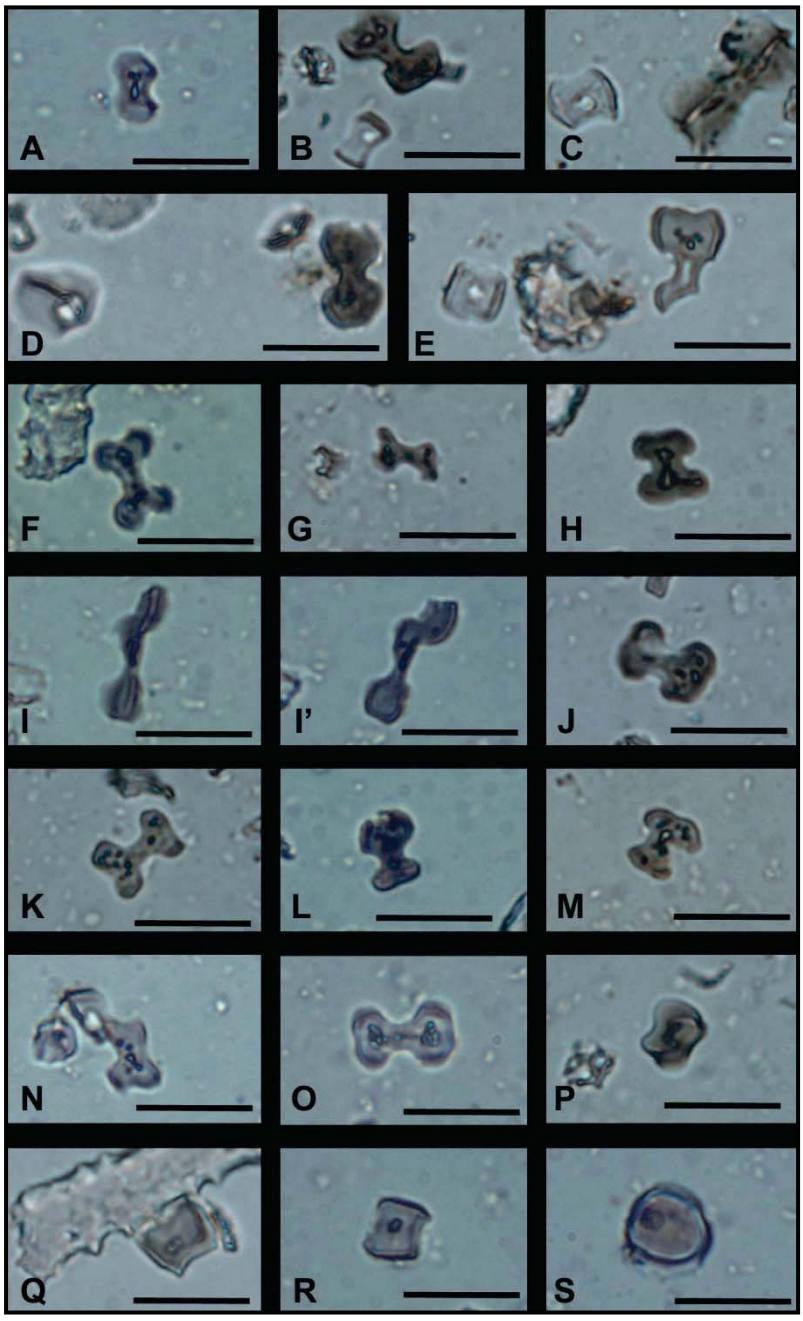

Figure E-21. Representative Burned Phytoliths. Specimen A, Simple Lobate; specimens B-O, other Panicoids2, specimens P-R, Saddle-shaped; and specimen S, large Disc. (Specimen provenience: specimens O and S - buried 2Akb control soil; specimens A, C and N - Feature 1; specimens L and R - Feature 2; specimens D, E, J, and K - Feature 7; specimens B, H, and Q - Feature 10, and specimens F, G, and I [I and I' show the benefit of particle rolling], - Feature 15; specimens M and P – Feature 17.) The bar scales are 20 microns.

[2] For comparison of the coloration caused by burning, images B, C, and E show burned Panicoids with unburned tall saddle phytoliths, and image D shows a burned Panicoid Lobate compared to a keeled phytolith. [The Panicoid Lobate phytolith in C is turned about 45° on it's side.]

In a recent thorough review of Oklahoma radiocarbon dates, the authors suggest a date of 1100 to 1400 rcybp for the Caddo soil (Wyckoff et al. 2009:97-98). In the same volume Bollans and Jennings (2009) briefly review Texas buried paleosols.

The phytolith counts from the 2Akb control sample from 41YN452 and from four of the thirty-two soil samples processed from 34CD76 are presented in Table E-9. For the Carnegie Canyon site, the modern ground surface (sample 1) is reported as is the upper portion of the Caddo soil (sample 19). At this Oklahoma exposure, the buried Caddo soil—1.4 meters thick—was found to actually consist of four welded A horizons (Carter et al. 2009). The three subsamples from the top welded A horizon—at the end of the period of stability and soil development [samples 19-21] that proceeded an extensive period of alluvial fill—are reported here for comparison to the similarly dated 41YN452 2Akb site samples. Originally, sample 19 (227-234 cmbs, CAb2) was thought to be a later buried soil with evidence of disruption; however, subsequent phytolith and diatom results suggested that sample 19 is actually the upper portion of the Caddo soil at the time A horizon formation abruptly ended. If the two buried soil sites under discussion are contemporaneous, the data in Figure E-22 indicates that the local climate at 41YN452 was significantly hotter and drier than the climate at the Carnegie Canyon site (34CD76). The phytolith signature change at 34CD76 from the 234 to 245 cmbs sample to the 227 to 234 cmbs sample shows a significant increase in the Chloridoid component during that interval (Figure E-22); as this change occurred near the end of the period of Caddo soil formation, this indicates that transitional period was accompanied by a marked change in the environmental conditions conducive to expansion of the mixed and/or short grass prairie region (i.e., warmer temperatures with less summer moisture). The sample from the beginning interval of the upper buried A horizon (245 to 256 cmbs) shows a climate similar to modern day (0 to 11 cmbs sample) with perhaps slightly more summer moisture in modern times. The major change that occurred during the Caddo soil development period appears to be a much wetter cooler interval (234 to 245 cmbs); subsequently, when the conditions reverted to warmer, A horizon formation ended and a prolonged alluvial fill episode ensued at the site. The Oklahoma rate of fill in this very short minor drainage was nearly three times that which occurred 215 km to the south at the Root-Be-Gone site (227 to 234 cm vs. 87 to 88 cm). Another interesting outcome of the Oklahoma research is that several of the four welded soils that ended up contributing to the Caddo buried soil were determined to have formed by melanization rather than a cumulic process (Carter et al. 2009); this discovery directly conflicts with past assumptions that thick buried A horizons are cumulic in nature. At the end of the period of Caddo soil formation in Oklahoma, the Chloridoid phytolith content effectively doubled, with offsetting decreases in the Pooid and Panicoid phytolith fraction concentrations—the climate was becoming hotter and drier.

It is apparent from looking at the 87 to 88 cmbs 41YN452 2Akb control sample compared to the control Oklahoma Poaceae sample (Figure E-22) as well as the entire suite of 41YN452 samples (Figure E-15) that this Texas sit location was not dominated by tallgrass prairie during the time the site was occupied. The dearth of Panicoid phytoliths suggests that the prairie vegetation at the 41YN452 site locale was more likely a mixed grass or even shortgrass prairie (see also Figure E-23). Overall the feature samples mirror the local lack of Panicoid grasses and a hot dry summer climate as reflected in sample 2Akb.

Table E-9. Comparison of Phytolith Signatures from ca. 1000-1100 B.P. Buried Soils at Two Sites

Site	41YN452	34CD76	34CD76	34CD76	34CD76
Sample Designation	820-4-1b	19	20	21	1
Horizon Designation	2Akb	CAb2	A1b3 (t)	A1b3 (b)	AC
Depth below ground surface (cmbs)	87-88	227-234	234-245	245-256	0-11
Keeled	53	32	36	35	38
Conical	64	50	49	37	39
Pyramidal	24	7	4	3	0
Crenate	2	8	13	12	2
Saddle, Squat	68	53	17	39	44
Saddle, Tall	138	17	10	27	16
Stipa	5	12	17	10	19
Lobate, Simple	2	8	6	7	8.5
Lobate, Panicoid	11	31.5	36.5	47.5	34.5
Lobate, Panicoid (Compound)	0	0	0	0	0
Panicoid Cross (<10 µ)	2	5	4	4	5
Panicoid Cross (>10 µ)	1	4	0	2	6
Large Disc	1				
Maize Rondel	0	1	3	1	3
Rondel, other		1	6	7	0
Dicot, knobby	3	0	1	0	0
Spiny spheroid	0	2	0	0	4
Diatom	1	69	28	34	45.5
Sponge spicule	3	7	5	3	5
Trichome, Hair Cells	7	6	3	5	6
Bulliform, square	15	9	1	4	5
Bulliform, rectangular	30	7	2	9	4
Bulliform, keystone	3	1	1	4	0
Bulliform, Y-shaped	12	0	0	0	1
Bulliform, other	20	13	12	20	6
Elongate, smooth	4	23	11	9	5
Elongate, sinuous	2	4	1	4	3
Elongate, castillate	2	3		7	2
Elongate, spiny	2	1	3	0	9
Charcoal	49				
Parallelopiped	0				
Aristida Lobate	1				
Sedge	0	2	1	4	3.5
Total Short Cell Phytoliths Count	370	227.5	192.5	223.5	212
Total Cool and Moist	143	97	102	87	79
Total Warm and Moist	21	60.5	63.5	70.5	73
Total Hot and Dry	206	70	27	66	60
Normalized % Short Cell Phytoliths					
Cool and Moist	38.65%	42.64%	52.99%	38.93%	37.26%
Warm & Moist	5.68%	26.59%	32.99%	31.54%	34.43%
Hot and Dry	55.68%	30.77%	14.03%	29.53%	28.30%

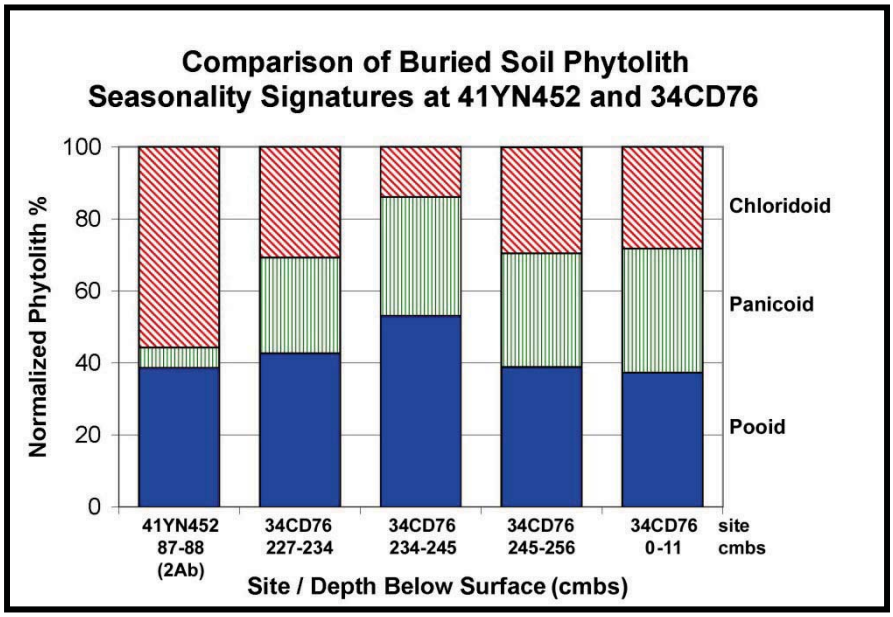

Figure E-22. Comparison of Normalized Phytolith Seasonality Data from Two Different Sites with Similarly Dated Buried A Horizons (41YN452 is the Root-Be-Gone site in Young County, Texas, and 34CD76 is the Carnegie Canyon site in Caddo County, Oklahoma).

In further evaluating the soil phytolith signature, the ratio of two shapes of saddle phytoliths can be studied as a reflection of botanical species variation at the site among different features. The ratio of tall saddles verses short (squat) saddles—i.e., squat meaning wider than tall—is plotted verses the normalized percent of saddles to total short cell phytoliths in the same soil samples (Figure E-23). The diamonds with open white circles are samples from 41YN452 whereas the solid diamonds (alluvial A horizon soil phytolith signatures) and squares (control prairie soil phytolith signatures) are data from prior Oklahoma research (Sudbury 2010). The vertical placement on the plot is a measure of the total saddle concentration (i.e., relative temperature), and the relative displacement along the x-axis is felt to be a reflection of the contribution of different botanical species. Again, we see that Features 7 and 10 appear to be virtually identical, with much more apparent species variation occurring among the other four feature samples. At the Manning Tallgrass Prairie control site, study of twenty-one identical replicate samples (varying only in horizontal displacement from each other), even more x-axis variation was observed than in the Root-Be-Gone samples (Sudbury 2010:290). This variation was interpreted to indicate a change in vegetation due to varying moisture and/or soil conditions (Sudbury 2010); significantly, less y-axis variation was noted at Manning Prairie than in the Root-Be-Gone site samples.

At Manning Prairie, there was even variation in the mean phytolith saddle ratios provided by two replicate 20 meter circles placed close to each other (which explains the two Manning control squares in Figure E-23). Thus, the x-axis deviation is felt to represent change in species diversity rather than climatic variation, although the diversity could result from climate change. The broader y-axis range observed at 41YN452 may not be simple seasonal variation (i.e., the features may not all be contemporaneous).

Interpreting the burned phytolith data is even more problematic. Some incidental burned phytoliths would be expected due to

natural prairie fires, eolian contribution, etc. Most of the burned phytoliths are Panicoid. However, the high variation in association with morphology of burned phytoliths and the high percentage of burned specimens (100 percent in several categories), makes it appear that some intentional use or processing activity may have been occurring associated with Feature 15. This feature also included one articulated epidermal phytolith specimen that may possibly have been cut on one end (Figure E-14).

If the grasses represented in the burned phytolith data were collected as fuel, then the grasses would have been gathered dry; i.e., the biomass of Panicoid grasses which flourish in the summer would have been gathered sometime from fall to spring.

Alternatively, if the Panicoid grasses were gathered for use for processing while growing and/or green, they would represent a summer/later summer activity. In addition to fuel, there many alternate reasons for gather miscellaneous grasses, possibly including food, fiber, seeds, making brushes, insulation, and construction. As a final note—no definitive phytolith evidence of maize ("ruffled rondels") or cucurbits were observed in any of the 41YN452 soil samples.

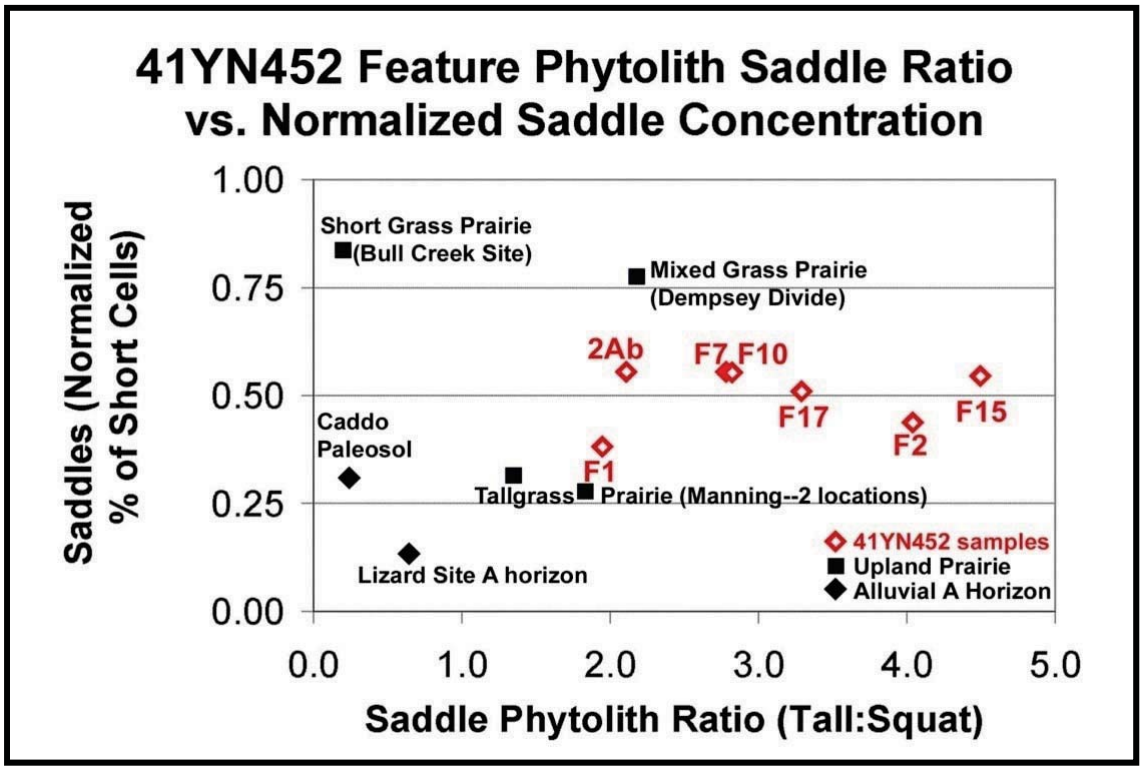

Figure E-23. The Caddo Paleosol Was Sampled at 34CD76[sample 19], Whereas the Surface A Horizon Sample from the Lizard Site (34WN107) is from an Alluvial Setting that Drains a Tallgrass Prairie Region in Northeastern Oklahoma. The black squares are based on phytolith samples isolated from modern control prairie soil samples collected in Oklahoma (Sudbury 2010). The open diamonds represent soils from the buried 2Akb soil and occupation features at 41YN452.

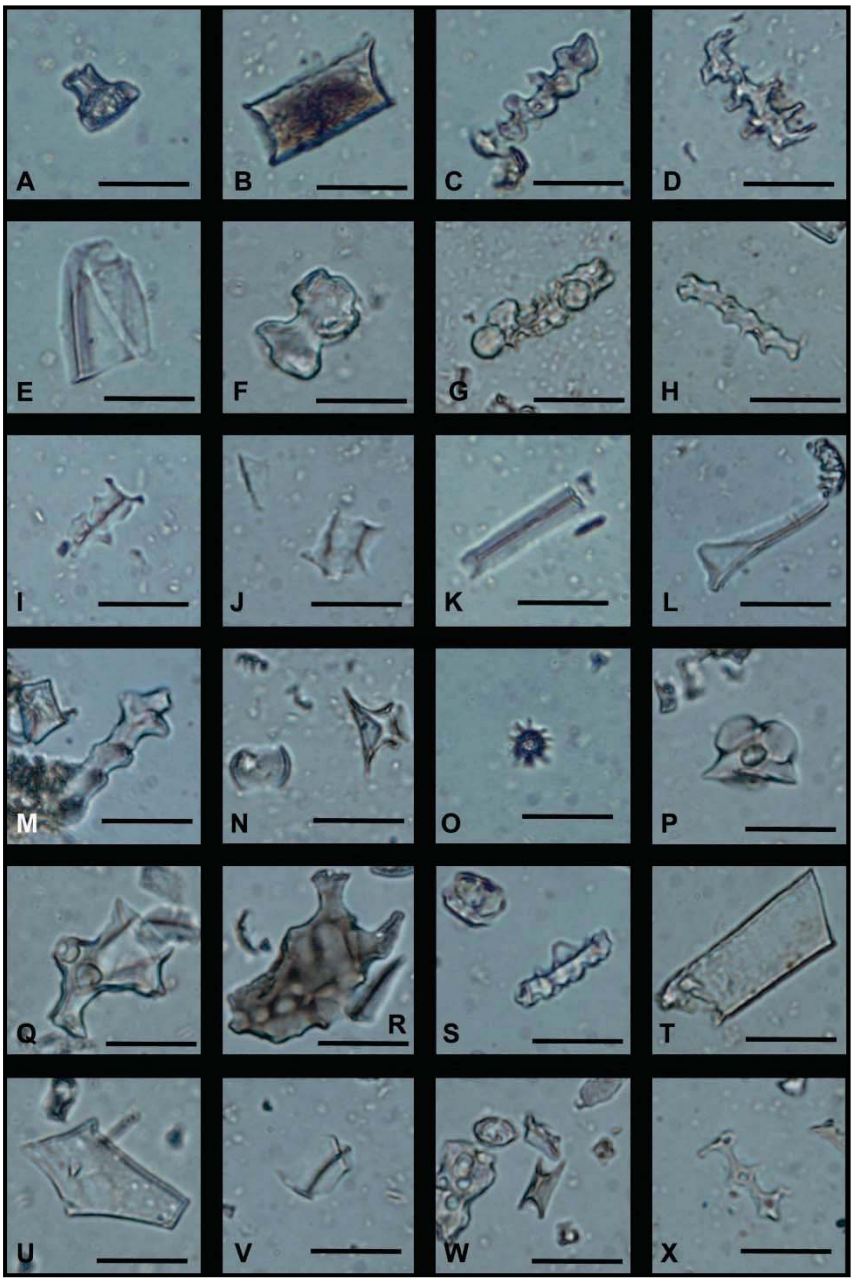

Figure E-24. Unidentified Phytoliths (1). Specimens A-E, buried soil sample 2Akb; specimens F-O, Feature 1; and specimens P-X, Feature 2. The bar scales are 24 microns.

E.7 SUMMARY

Based on the phytolith evidence, the Root-Be-Gone site (41YN452) occupation was not located in a tallgrass prairie region, nor was the immediate upstream area feeding the drainage a tallgrass prairie. The phytolith evidence points to a short grass and/or mixed grass prairie at the time of buried A horizon formation.

The phytolith concentration (averaging 1.27 weight percent of the soil for the six features tested) does not show a significant increased phytolith concentration in the features. The broad variation in the phytolith

concentration range observed (0.94 to 1.60 percent) is near the replicate variation range reported within a confined surface A horizon control area.

No maize phytoliths (i.e. "ruffeled rondels") were observed in the Root-Be-Gone samples (they were observed in the presumed contemporaneous Caddo soil at 34CD76). Also, cucurbit phytoliths were not observed in these samples. Both of these phytolith morphologic categories are readily recognizable and identifiable when present.

Evidence of plant collection (possible cut edge on a section of articulated phytolith epidermal sheet) was observed in one specimen from Feature 15; possibly suggesting actively harvesting a plant resource. The extensive variety and high percent of burned phytoliths in Feature 15 potentially indicates intentional plant processing (an alternate explanation for the broad phytolith variety present and burned may be that this feature was in active use over a longer interval than the other features).

The lower Chloridoid component in Features 1 and 2 could be explained by one of several scenarios including:

- these are slightly earlier features that were present during a cooler climatic interval at the site location, or
- cool season Poaceae were selectively collected and added to the feature during the course of site occupational activity.

The higher concentration of bulliform phytoliths recovered in Features 1 and 2 relative to the other five samples corroborates the observation of more cool season grasses present in those features.

The higher sponge concentration in the same two features (1 and 2) may indicate more water use associated with those particular features, or a wetter time interval (and thus also a cooler interval as noted above). Interestingly, no complete sponge spicules were observed in the prepared slide mount for sample 2Akb which may mean that the complete spicules are evidence of active water use associated with the features rather than a simple passive contribution. During the formal particle counts, sedge phytoliths were only observed in the soil samples from Features 1 and 2 (Table E-4) again supporting these features being in use during a wetter climatic interval.

The tall:squat saddle phytolith ratio data also support Features 1, 2, and 17 (in that order of relative intensity) as having somewhat cooler season phytolith signatures. The 34CD76 site stratigraphic phytolith evidence suggests that there was a cool interval immediately prior to the termination of the period of buried soil formation at about 1000 BP.

The siliceous sponge spicules observed in all seven soil samples suggest clear flowing water present at or near the site. The spicules in pristine (unweathered) condition suggest they are contemporaneous with the site.

The weathered spicules (surface pitting and/or abrasion) may be eolian or could have traveled down stream as sediment and thus may or may not be concurrent with site occupation. Although some spicules may have been introduced by alluvial or eolian processes, they may have also been introduced into the features from carrying water for cooking and food processing, or could potentially be passed through the gut via imbibing water (mussels, animals, and/or humans).

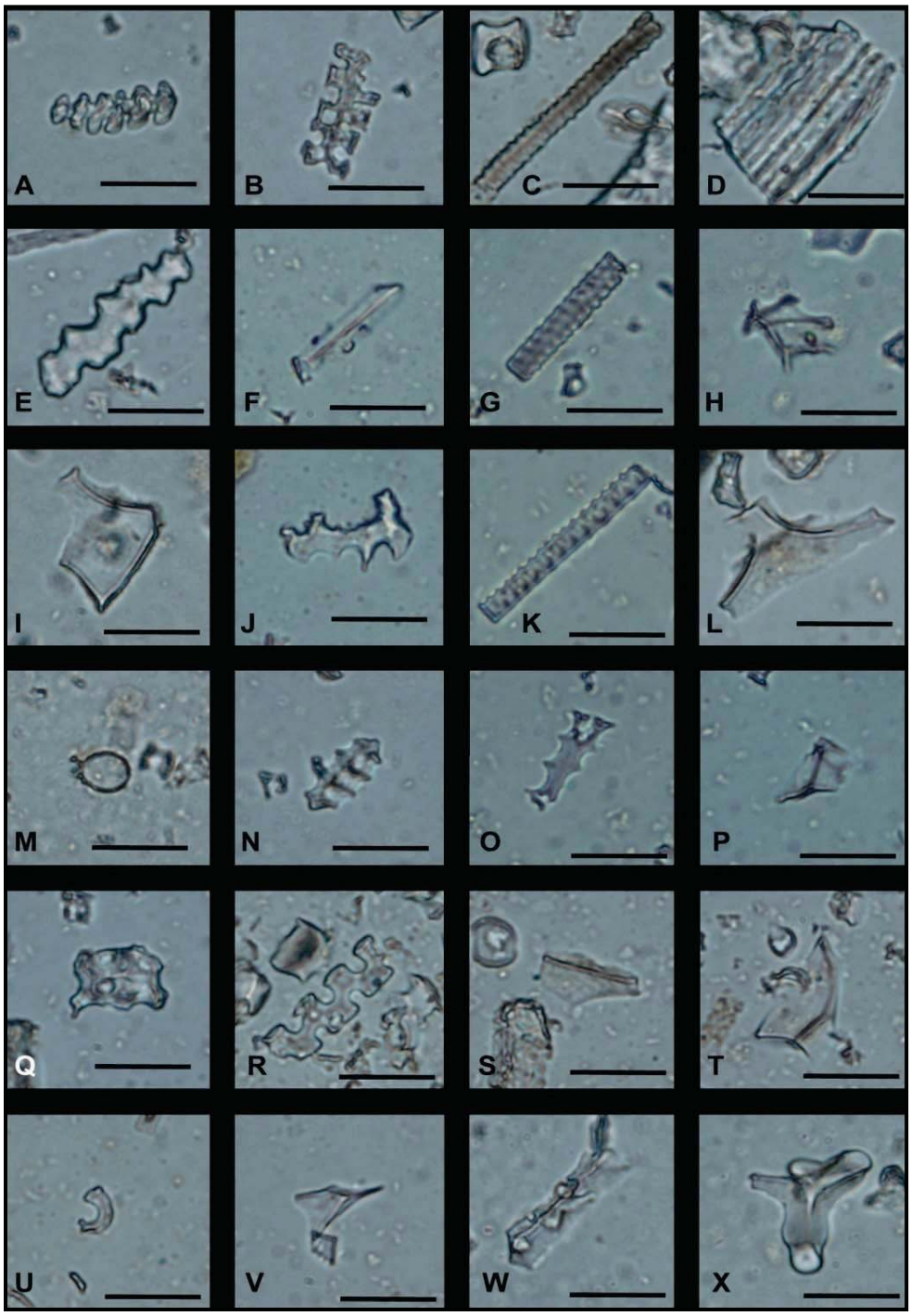

Figure E-25. Unidentified Phytoliths (2)
Specimens A-D, Feature 10; specimens E-Q, Feature 15, and specimens R-X, Feature 17.
The bar scales are 24 microns.

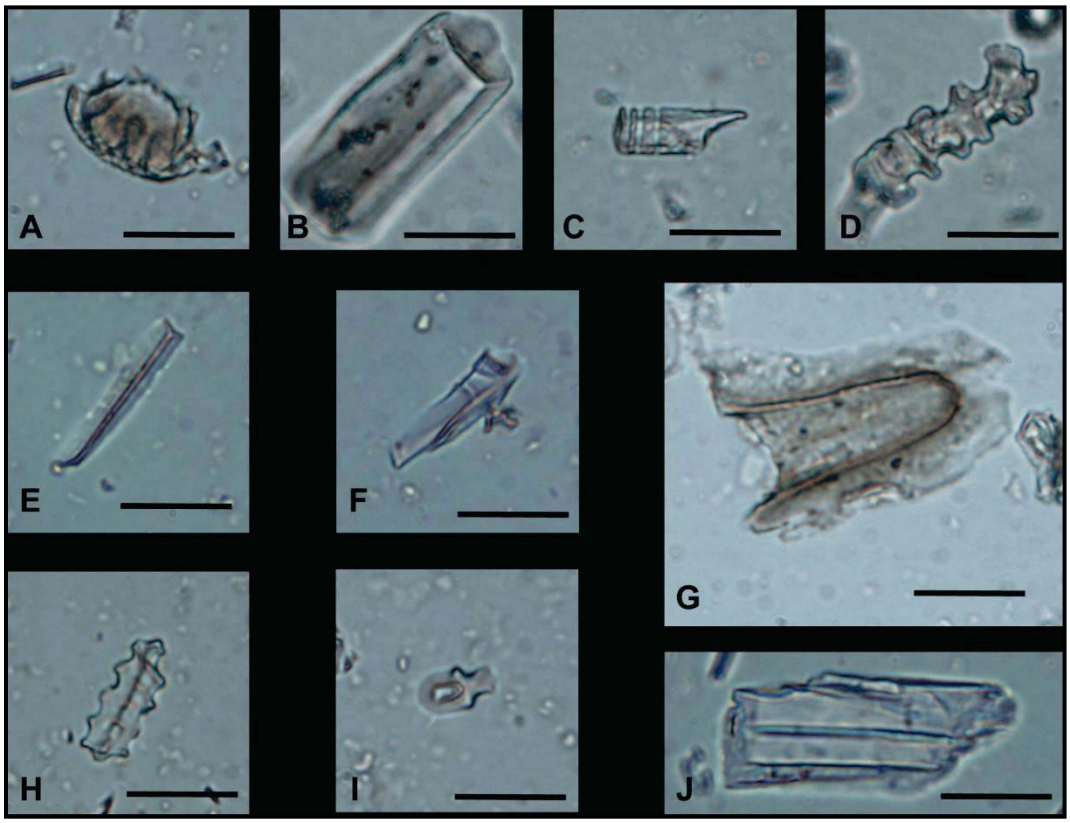

Figure E-26. Unidentified Phytoliths (3). Specimens A-F and H-I, Feature 17; specimen G, Feature 2; and specimen J, Feature 7. The bar scales are 24 microns.

The two broken sponge gemmules observed potentially represent spring season water and feature usage. This observation is difficult to interpret as gemmules remain in the environment for millennia once produced. However, sponge reproduction (gemmule formation) tends to be a spring phenomena. Sponge gemmules, always uncommon in soils, were observed in Features 7 and 17. [3]

Although the JSE lab has an abundance of glassware, sample preparation equipment, extraction equipment, vacuum pumps, etc., the laboratory isolation procedure presented in this report is safer, quicker as far as hands-on processing time [not lag time], produces very complete clean phytolith fractions, and can be performed by anyone with a minimal amount of equipment. This modified procedure was developed for this project due to the small sample size and the limited time available for sample processing and analysis. This report is part of an ongoing concerted effort to adapt existing methods—such as the basic phytolith isolation procedure via heavy liquid flotation—to be performed with simple, inexpensive, readily available equipment and supplies thus enabling others without extensive laboratory facilities to successfully isolate clean phytolith fractions for analysis. As a side benefit, this effort also enables

[3] The two alluvial setting sites reported previously (Carter et al. 2009 [see also Sudbury (2010)]), 34CD76 and 34WN107 (both exposed by stream cuts and located at the stream edge), did not produce any gemmules throughout their entire stratigraphic columns. Gemmules were previously observed in the biogenic silica fraction of soil samples at another site where water was carried uphill to the occupation site from an adjacent stream (Sudbury 2006:156, Figure 17C-E).

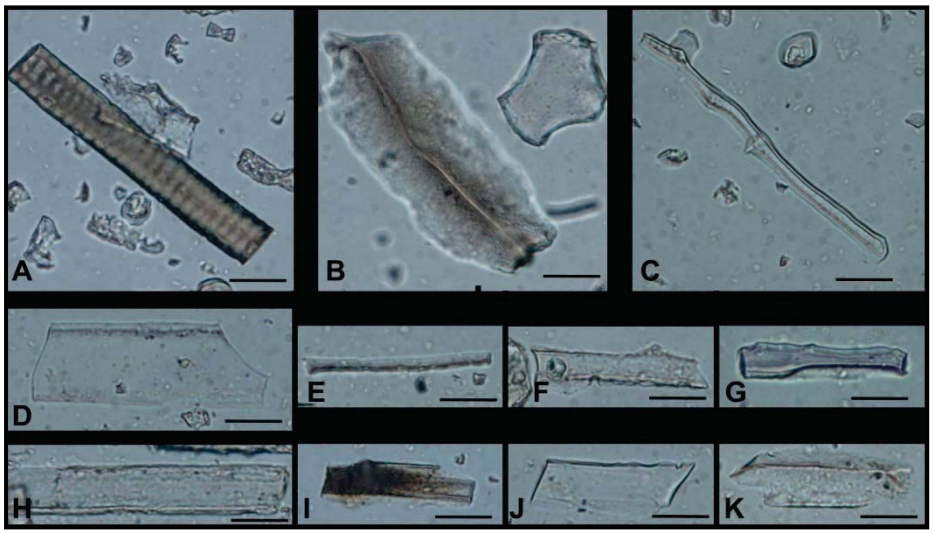

Figure E-27. Unidentified Phytoliths (4).
Specimen A, Feature 10; specimen B, Feature 15; specimen C, Feature 17; specimen D, Feature 7; specimen E, Feature 17; specimen F, Feature 15; specimen G, Feature 15; specimen H, Feature 17; specimen I, Feature 15; specimen J, Feature 7; and specimen K, Feature 1. The bar scales are 24 microns.

some prolonged preparative steps to be adapted to processing in the field thus potentially shortening the amount of actual laboratory work needed after the field season. For instance, the month-plus long settling process to remove clay from the silt fractions—using pure water and all plastic disposable glassware—is readily amenable to field camp processing.

E.8 CONCLUSIONS

Based on the phytolith evidence, the Root-Be-Gone site occupation was not located in a tallgrass prairie, nor was the immediate upstream area draining a tallgrass prairie. The Poaceae phytolith evidence points to a short grass and/or mixed grass prairie providing the primary short cell phytolith signature at the site. Comparative phytolith evidence also suggests that Features 1, 2, and possibly 17 may be slightly earlier than the other features, or that they were used seasonally when cool season plants were dominant. Features 1 and 2 contain more bulliform phytoliths, more sedge phytoliths, more spicules, and more cool season Poaceae short cell phytoliths. Plant processing was implied for Feature 15 by the presence of more burned types of phytoliths at higher concentration than in the other features, and the presence of a plant epidermal sheet that appears to possibly have been cut. No phytolith evidence supporting actual agricultural activity was observed.

E.9 ADDITIONAL RESEARCH POTENTIAL

There are several options for further research on this site (and/or in future research at subsequent sites). These would all contribute to the information generated by this study and the interpretive power of the tools being used.

A collection of identified modern indigenous reference botanical specimens would be helpful for assessing phytoliths recovered from soil; a number of distinctive but unidentifiable phytolith forms were observed during this study. A survey and study of local species phytoliths would help to fill in some of the data gaps encountered. This would not be expected to substantially alter the seasonality interpretation, but it

would potentially generate specific new information from the samples about the site, features, activities, and environment. Some of the apparently distinctive phytoliths from 41YN452 that remain to be identified due the lack of suitable area reference specimens for comparative analysis are illustrated in Figures E-24 through E-28. Some of these probably represent trees (such as the apparent tracheal elements (Figures E-25 C, G, and E-27 A) and the two spiny spheroids observed (Figure E-18), both forms present in limited quantity at the site). However, quantitation of the degree of forest encroachment in this area is not known from this limited data. Some tree growth would be expected along a stream bank, and the charcoal present in the features does indicate that trees were present.

Subsampling the entire stratigraphic column at a site is an excellent way to see seasonal and plant community changes over time. It is difficult to interpret the occupation zone climate and climatic change based on one solitary sample.

The very useful delta 13 analysis is a relatively inexpensive technique for assessing botanical community changes over time that are recorded in the soil, and can compliment soil phytolith data.

Starch analysis from soil samples is another potentially useful investigation for sites of this age (c.f. Balme and Beck 2002, Horrocks 2005, Horrocks and Barber 2005, Kubiak-Martens 2002, Lentfer et al. 2002, Loy 1994, Parr and Carter 2003, Pearsall 2003, Piperno et al. 2004, Therin et al. 1999, Torrence and Barton 2006, and Zarrillo and Kooyman 2006.)

E.10 ACKNOWLEDGEMENTS

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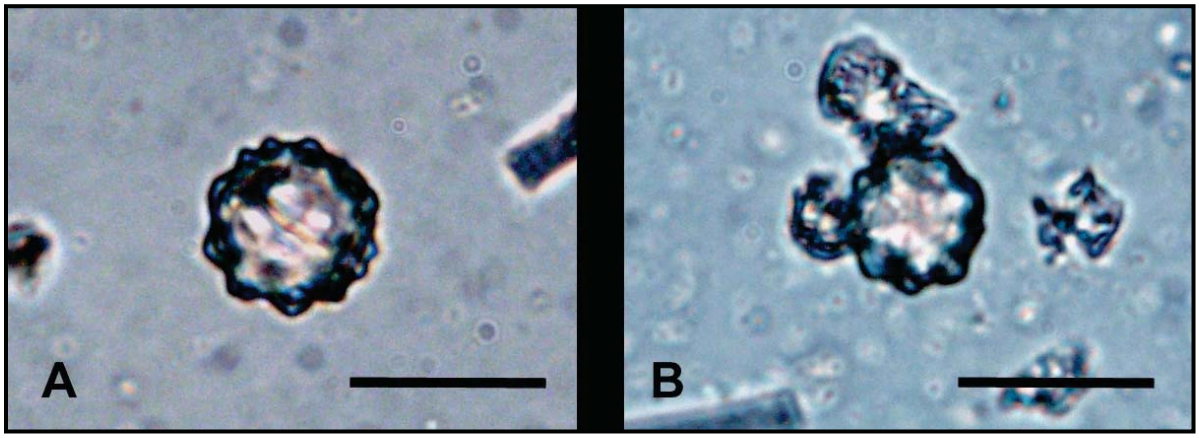

Figure E-28. The Two Rugulose Spheres (spiny spheriods) Observed in the Seven Soil Samples Processed from 41YN452. Specimen A is from Feature 2 and specimen B is from Feature 17. The bar scales are 24 microns.

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