SECTION 9.0 GEOARCHAEOLOGICAL ANALYSIS OF FEATURES AND DEPOSITS

Previous sections described Hickory Bluff's landform history, stratigraphic deposits, and the types of features occurring on site (Sections 4.0, 6.0 and 7.0). The goal of the current section is to present the results of the physical and geochemical studies performed on features and across depositional surfaces. Geoarchaeological analysis of features and surfaces were conducted to provide detailed information about the cultural and natural agencies operating on site and the relative influence of postdepositional processes.

ARCHAEOLOGICAL FEATURES

Features discovered across Hickory Bluff included several forms. Each feature consisted of an anomaly or a distinct variation in the general character of the site matrix or the archaeological component. Matrix features included intrusive basins while component features included distinct concentrations of weather-resistant archaeological materials, such as thermally altered stone (TAS), debitage or ceramics. Definition of features was contingent upon the general morphology of each feature, the determination of feature origin, and resolution of any postdepositional influences.

Matrix Features--Basins

Basins of various sizes and shapes were defined by changes in the overall matrix. During controlled excavations they usually became evident within and below remnant E- soil horizons in distinct contrast to surrounding B-horizon soils (Figure 9.1). Generally these features were lighter in color maintaining a 10YR hue, in contrast to the redder 7.5YR hue of the surrounding, weathered matrices, and were far more friable (or "softer") than contrasting B-horizon strata. Occasionally they were noted to contain a higher moisture content. Fill remained friable to depth, and appeared more porous than surrounding B-horizons. Sedimentary bedding was rarely noted within these matrices, and pedogenic structure within the fill retained E-horizon-like characteristics (platy structure) in contrast to better-defined peds characteristic of prismatic and blocky B-horizons. In several deep basins, pedogenic lamellae were noted with depth and were indicative of incipient B-horizon formation. Formation and preservation of these lamellae indicated vertical mobility of water, elements (such as iron [Fe]) and clay-sized particles. Lateral boundaries, or contacts, with adjacent B-horizon strata were usually clear but rarely sharp or abrupt, suggesting some blurring of this contact by post-construction pedogenesis. Basin sidewalls tended to slope inward; originally, these may have been more straight-sided but advanced pedogenesis has blurred definition of the uppermost extent. Deep basins often extended to basal, minimally weathered, Columbia Formation (Fm.) sands. This sandy basal stratum affected drainage of basin sediments.

Basin features were susceptible to post-formation, biogenetic modification by plant and animal activity. Relative to surrounding weathered (B-horizon) Columbia Fm. sediments, basin matrices were generally more friable, moist, and possibly rich in both organic matter (OM) and plant nutrients following initial field observations. Large-basin features often extended to basal sands that facilitated percolation of moisture through the feature matrices; occasionally tree roots may have tapped sand strata for additional sustenance. Root and animal activity–while minor components–were occasionally noted within and between matrix features (Figure 9.2). However, the affects of such biogenetic modifications appeared to be location specific, time transgressive, and not necessarily characteristic of feature matrices as a whole. For example, the preservation of incipient pedogenic lamellae within several deep basin features argues against a strong bioturbation influence.

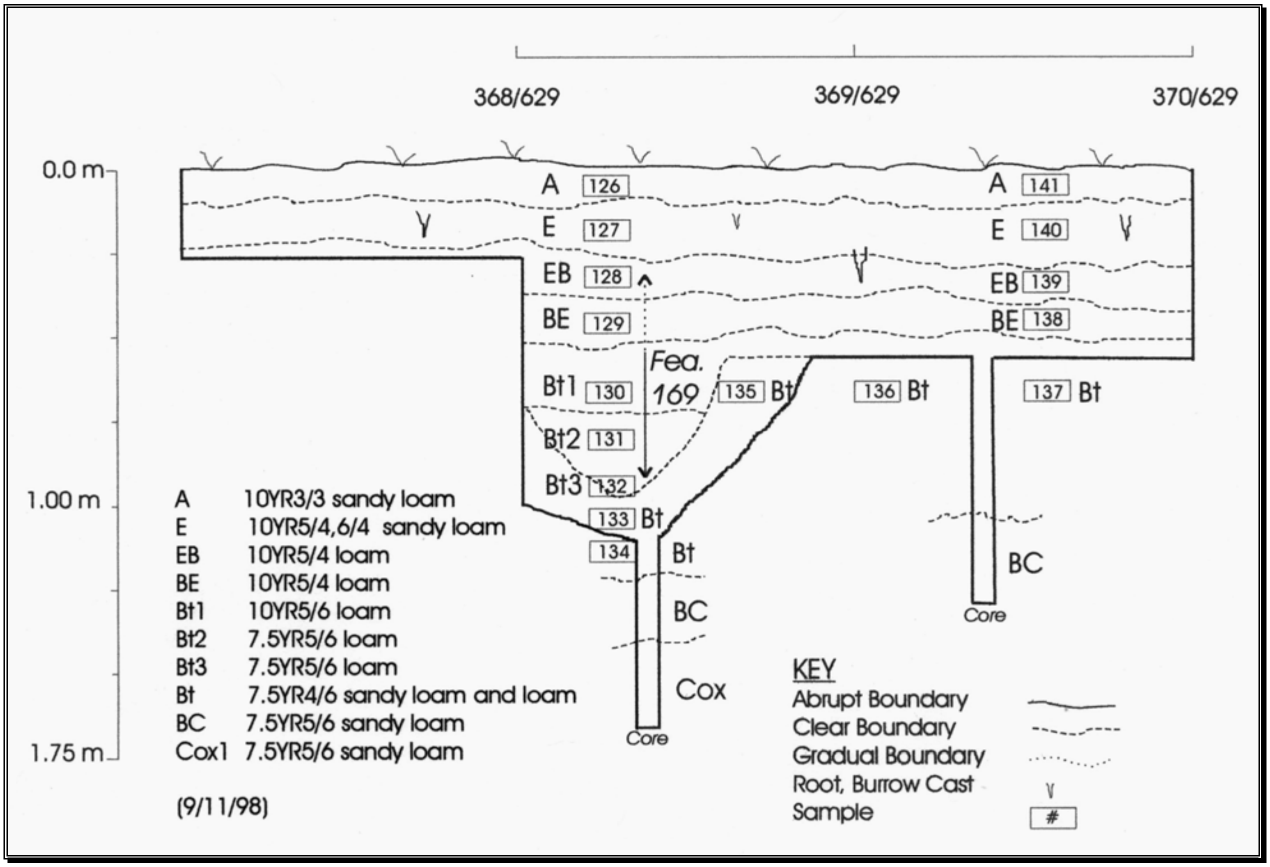


Figure 9.1 Drawings of Feature 169 and Offset Sediment Column

Artifact organic materials generally demonstrated a degree of temporal variability consistent with adjacent non-feature matrices, with a prehistoric date range spanning 320-4,210 years B.P. (Table 6.1).

Altogether, the archaeological, sedimentological, and pedogenic characteristics of matrix features provided some insights into initial feature formation and post-formation history. Although variations (such as volume) exist within the range of features investigated, several shared characteristics point to commonalities in feature formation. Matrix feature fills appeared to originate as mixed sediments derived from a single-event excavation. Fills appear to have been excavated in content of matrix features usually exhibited a modest increase in contrast with adjacent B-horizons. Artifacts from features were generally similar to artifacts from adjacent non-feature E-horizons in type and temporal variability. However, relative concentrations of artifacts within matrix features appear low. For example, relatively small quantities of heated stone were noted, despite the frequency of TAS features within E-horizon contexts elsewhere.

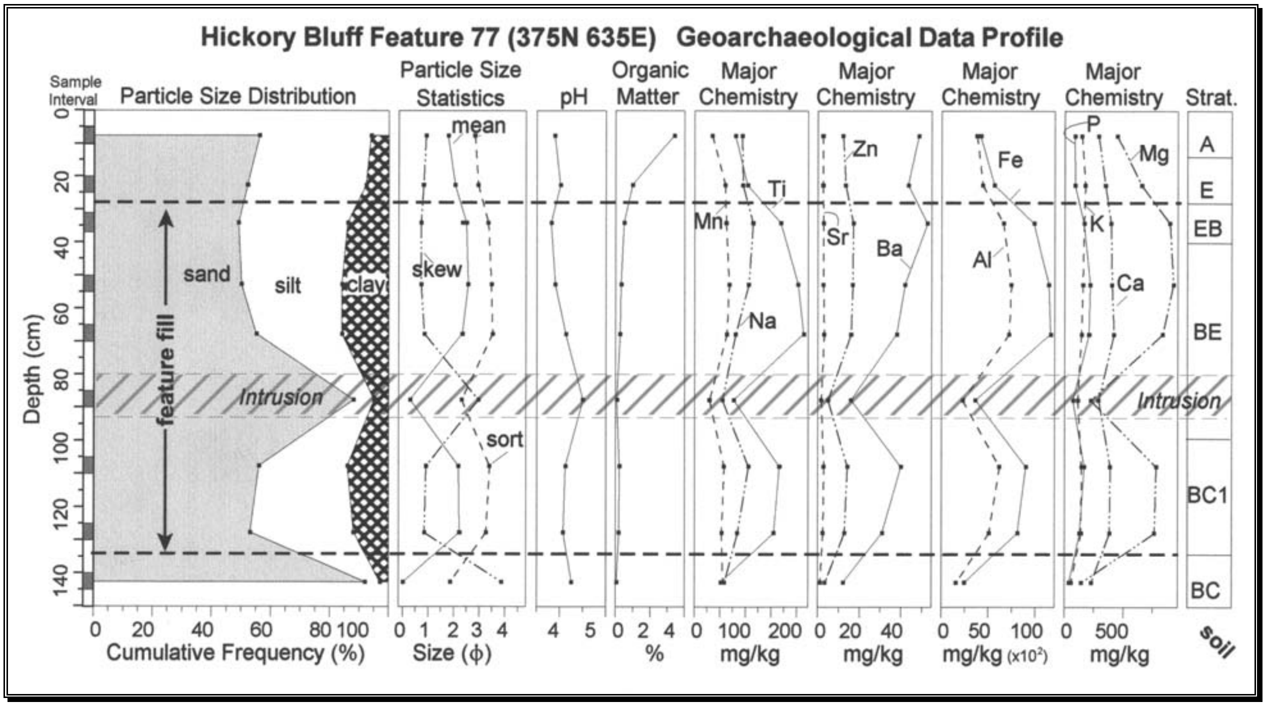


Figure 9.2 Geoarchaeology Data Profile of Feature 77

Inclusions of charred organic materials provided another contrast to surrounding B-horizons that were nearly devoid of macro-organic materials. Charcoal aggregates within matrix features appeared small (<5 mm) and generally dispersed. Radiocarbon age-estimates of feature small increments over a short-term interval, and mixed. The original clasts of exhumed soil, such as complete peds of argillic B-horizons, were not preserved. This suggested excavation of basins by the scraping of relatively compact and dense argillic horizons. Incorporated within feature back-dirt were preexisting archaeological materials derived from near-surface (A- and E-horizon) contexts. Intrusive basins were dug to a particular dimension, and then backfilled. Included within basin fill were possible additions of feature-specific cultural materials including artifacts and organics. Analyses of the archaeological data did not indicate a marked increase of the former, although geochemical analyses did indicate a probable increase in the latter (as discussed below). Backfilling apparently took place over a short period of time, and was not facilitated by wash events. No evidence was noted within feature fill of particle-size sorting or bedding (such as mud drapes). Additionally, no slump, scour or rilling of basin sides was in evidence. Post-fill pedogenic processes dominated by acid leaching and eluviation, imparted E-horizon-like characteristics to much of this fill. These processes blurred sidewall definition closer to the ground surface. Incipient B-horizon formation was noted within the basal segments of several deep basins, as evidenced by lamellae formation. Although some biogenetic disturbances such as tree roots were in evidence, feature fill did not exhibit extensive, postdepositional bioturbation.

Component Features—Artifact Concentrations

These features were primarily identified by distinct concentrations of weather-resistant archaeological materials, such as TAS, debitage or ceramics. Feature dimensions varied in planview. They routinely occurred in sub-A-horizon context, primarily in E- and BE-horizons

(Figure 9.3 and Figure 9.4). Fine-grained matrix generally exhibited similar characteristics (texture, color, and consistency) as surround E-horizons. Feature boundaries were marked by limits of artifact distribution. No distinct matrix boundaries that suggested cut-and-fill, or basin excavation, were noted. However, continued pedogenic alterations of these sediments have likely obscured any such boundaries, if they existed.

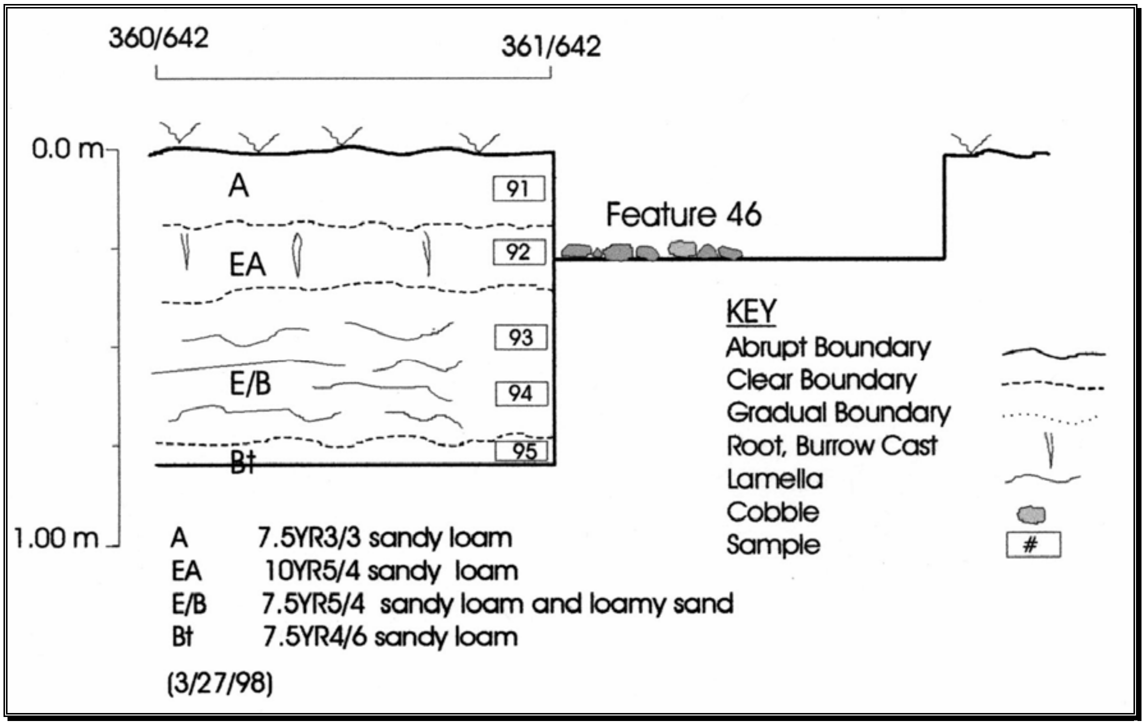


Figure 9.3 Drawing of Feature 46 Profiles

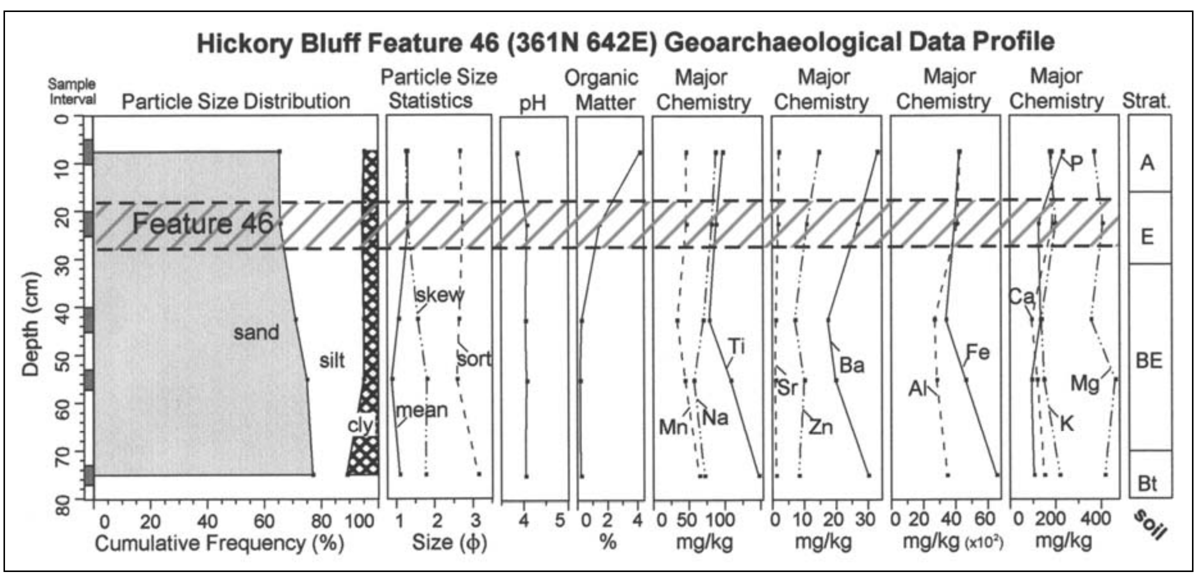


Figure 9.4 Geoarchaeology Data Profile of Feature 46

Component features, such as TAS clusters, were susceptible to post-formation, biogenetic modification by plant and animal activity due to close proximity to the ground surface. It was difficult to quantify the extent of these disturbances relative to surrounding non-feature matrices, although they were more easily recognized by the occasional displacement of artifacts, especially TAS. For example, root voids running laterally through Feature 46 left relatively distinct traces by displacement of the TAS cluster.

Artifact content of component features, by definition, was unusually high in contrast with surrounding E- and B-horizons. Artifacts clustered along a horizontal plane. Refits of TAS within individual features provided some measure of spatial integrity and artifact displacement. Refits of TAS between different, distinctive features suggested scavenging and reuse of TAS. Diagnostic artifacts located within TAS features indicated a strong Early to Middle Woodland Period component at Hickory Bluff.

Charcoal content of component features, while higher than adjacent E-horizons, was not particularly high considering the preponderance of TAS. Charcoal aggregates appeared small (<4 mm), were generally dispersed, and often included relatively hard specimens of charred nutshell. Inclusion of these organic materials within eluviated E-horizons, in close proximity to oxygen-rich surface horizons, undoubtedly contributed to their physical and chemical deterioration by degradation and oxidation. It is likely that the organic material, charred or otherwise, represents a very small percentage of original deposits, and may be weighted towards preservation of relatively young specimens. Radiocarbon age-estimates of component features generally demonstrated less temporal variability than matrix features, and spanned 570-2660 years B.P. (Table 9.1).

Altogether, the archaeological, sedimentological, and pedogenic characteristics of component features provided some insights into initial feature formation and post-formation history. Although variations exist within the range of features investigated, several shared characteristics pointed to commonalities in feature formation. Component features consisted of distinct concentrations of erosion-resistant artifacts, dominated by TAS. Generally, these features were concentrated within E- and EB-horizons, below surface A-horizons. Disposition of these artifacts (whole and broken) occurred through a generally horizontal plane. Radiocarbon assays noted no component feature older than 2660 years B.P. No evidence was noted of associated basin formation. Feature fine-grained matrices were chemically and physically similar to surrounding E- and EB-horizons, and exhibited evidence of pedogenic leaching and eluviation. Similar characteristics were noted for fine-grained sediments that overlay these component features, suggesting a common source of origin for near-surface sediments. Common traits of feature disposition, overburden, and pedogenic weathering suggest that many of these features (especially large features) may have originated as surface manifestations subsequently buried by additions of natural (non-cultural) sediment.

SEDIMENT ANALYSES

Macro-organic materials, such as shell, bone, nutshell and charcoal are important indicators of site function. The well-drained and coarse-grained nature of the Hickory Bluff sediments resulted in poor preservation of macro-organic materials. Since initial occupation the site was leached and oxidized to such an extent that most organic material has degraded.

Moreover, what few identifiable macro-organic artifacts remain may be skewed toward more recent occupations, due to less weathering. This was particularly true for charcoal and bone and, thus, application of the analytical results from these data must be carefully applied to the site in general.

Table 9.1 Descriptive Statistics and Component Matrix from the Principal Component Analysis for all Geoarchaeology Samples

	Mean	Standard Deviation	Component			
			F1	F2	F3	F4
Al	5301.28	1396.27	0.87	-0.17	0.03	-0.23
Ba	45.55	13.60	0.52	0.39	-0.35	-0.19
Ca	190.15	191.90	0.29	0.76	0.26	0.34
Fe	6838.40	2846.72	0.86	-0.44	0.14	0.11
K	285.53	91.51	0.45	0.00	0.77	-0.37
Mg	662.24	194.89	0.93	-0.11	0.13	-0.09
Mn	85.90	48.50	0.41	0.54	-0.38	0.25
Na	78.97	34.57	0.26	0.16	0.79	-0.29
P	151.78	70.32	0.72	0.04	-0.05	0.31
Sr	2.51	1.47	0.33	0.72	0.39	0.15
Ti	131.93	53.01	0.83	-0.41	0.08	0.30
Zn	20.01	29.82	0.14	0.19	-0.03	-0.21
pH	4.18	0.41	0.13	0.30	0.10	0.76
OM	1.27	1.57	-0.05	0.83	0.07	-0.12
Sand	57.37	10.40	-0.69	-0.20	0.50	0.30
Silt	32.40	8.88	0.43	0.48	-0.48	-0.43
clay	10.26	4.48	0.76	-0.47	-0.22	0.19
		% Variation Explained	33.65	19.16	13.40	9.74
		Cumulative % Explained	33.65	52.82	66.21	75.95

One goal of the geoarchaeological investigation was to recover some of the non-visible subsistence and activity information associated with archaeologically enriched sediments, and reconstruct feature use and formation. Pertaining to site geochemistry, this work was designed to test what, if any, residual portions of animal and plant residue, or other evidence of human occupation, remained at the site as elevated elements in the extractable portion of the soil chemistry.

To this end, characteristics of texture, geochemistry, pedology, and sedimentology of 286 samples collected from profiles, features, and regularly spaced grid nodes within two excavation blocks (Loci A and I) were identified. Sediment and soil samples were submitted to lab facilities for analyses that included particle-size determinations and geochemical assays (n=286). All sediment and soil samples were subjected to various levels of particle-size analyses that included pipette and hydrometer analyses, as well as sieve analysis of sand and gravel fractions, conducted by the University of Wisconsin-Milwaukee, Soils and Physical Geography Laboratory. Geochemical analyses that included OM (percent by digestion) and pH determinations were conducted by the same facility. The University of Wisconsin-Madison, Laboratory for Archaeological Chemistry conducted additional geochemical analyses, where following acid digestion, the relative percentages of 12 elements were determined semi quantitatively (aluminum [Al], barium [Ba], calcium [Ca], Fe, potassium [K], magnesium [Mg], manganese [Mn], sodium [Na], phosphorus [P], strontium [Sr], titanium [Ti] and zinc [Zn]) using the simultaneous multi-elemental analysis capability of inductively coupled plasma-atomic emission spectroscopy (ICP/AES). Results of these analyses, together with their sample provenience and feature association, are provided in Appendix D (Tables D-1 through D-3).

General Graphical and Statistical Analysis

Sample data were subjected to factor (principle component) and cluster analyses using an SPSS V9.0 software package in an effort to investigate any overall structure, pattern or groupings within the geoarchaeological data (Appendix D). All quantified physical and chemical data (measurements of sand, silt, clay, and Al, Ba, Fe, Ca, K, Mg, Na, P, Sr, Mn, Zn, pH and OM) were included in the review. Results that depict the correlation matrix and component (factor) matrix are listed in Tables 9.1 and 9.2.

Four main factors (F1-F4) were extracted and together accounted for 76 percent of the total variation (several other minor factors were extracted by SPSS that explained only a few percent more of the total variation). Of the four main factors, factors 1 (F1) and 2 (F2) were apparently the most important and explained about 53 percent of the total variation (33.7 percent and 19.2 percent, respectively). Factors 3 (F3) and 4 (F4) accounted for only an additional 23 percent (13.4 and 9.7 percent, respectively). Inspection of Tables 9.1 and 9.2 shows that elements with similar chemical properties strongly and positively cross correlate with each other. Additionally, high abundances of certain elements positively correlate with either high organic-matter content (Ca, Sr), or relatively higher amounts of silt and/or clay (nearly all other elements). Conversely, all elements show varying degrees of negative correlation with sand abundance, and a few negatively correlate with OM (Fe, Al, Mg). With the notable exception of Factor 4, the distribution and relationships of these elements with the physical characteristics of the host sediments were consistent with pedogenic weathering processes that occur within a typical A-E-B soil profile. Comparison of the cross-correlations with typical profiles (Section 6.0) graphically depicts these relationships between elevated element abundances, soil texture, and soil horizonation.

These general soil relationships were more clearly seen by inspection of the loading of the component matrix for each variable (Table 9.2). For example, Factor 1 (F1) showed generally positive relationships for all elements, but was controlled mainly by Al, Fe, Mg, P, Ti and to a lesser extent by Ba, K, Sr, and Mn. In addition, F1 was associated with relatively high percentages of clay and to a lesser extent, silt. F1 was associated with a low sand content. OM and pH apparently had little importance in controlling this factor.

Table 9.2 Correlation Matrix for Variable Used in the Factor Analysis of Geoarchaeological Samples

	Al	Ba	Ca	Fe	K	Mg	Mn	Na	P	Sr	Ti	Zn	pH	O.M.	Sand	Silt	Clay
Al	1.000	.499	.038	.817	.525	.808	.280	.219	.514	.124	.701	.110	-.131	-.109	-.532	.291	.654
Ba	.499	1.000	.238	.176	.066	.372	.577	-.028	.326	.283	.154	.114	-.022	.216	-.505	.487	.206
Ca	.038	.238	1.000	-.003	.180	.189	.416	.229	.326	.842	.052	.112	.442	.569	-.155	.229	-.080
Fe	.817	.176	-.003	1.000	.445	.822	.067	.181	.605	.065	.958	.049	.026	-.339	-.388	.017	.860
K	.525	.066	.180	.445	1.000	.555	-.134	.799	.126	.371	.298	.057	-.110	.060	-.024	-.020	.089
Mg	.808	.372	.189	.822	.555	1.000	.258	.379	.548	.256	.784	.090	.116	-.191	-.622	.392	.665
Mn	.280	.577	.416	.067	-.134	.258	1.000	-.086	.392	.298	.133	.122	.369	.300	-.399	.426	.101
Na	.219	-.028	.229	.181	.799	.379	-.086	1.000	.116	.331	.108	.072	.050	.134	.061	.002	-.144
P	.514	.326	.326	.605	.126	.548	.392	.116	1.000	.230	.641	.124	.188	.025	-.385	.179	.548
Sr	.124	.283	.842	.065	.371	.256	.298	.331	.230	1.000	.079	.083	.294	.569	-.158	.226	-.081
Ti	.701	.154	.052	.958	.298	.784	.133	.108	.641	.079	1.000	.009	.196	-.350	-.376	.000	.869
Zn	.110	.114	.112	.049	.057	.090	.122	.072	.124	.083	.009	1.000	-.049	.141	-.133	.165	-.019
pH	-.131	-.022	.442	.026	-.110	.116	.369	.050	.188	.294	.196	-.049	1.000	.073	.051	-.057	.026
OM	-.109	.216	.569	-.339	.060	-.191	.300	.134	.025	.569	-.350	.141	.073	1.000	-.115	.338	-.402
Sand	-.532	-.505	-.155	-.388	-.024	-.622	-.399	.061	-.385	-.158	-.376	-.133	.051	-.115	1.000	-.901	-.529
Silt	.291	.487	.229	.017	-.020	.392	.426	.002	.179	.226	.000	.165	-.057	.338	-.901	1.000	.113
Clay	.654	.206	-.080	.860	.089	.665	.101	-.144	.548	-.081	.869	-.019	.026	-.402	-.529	.113	1.000

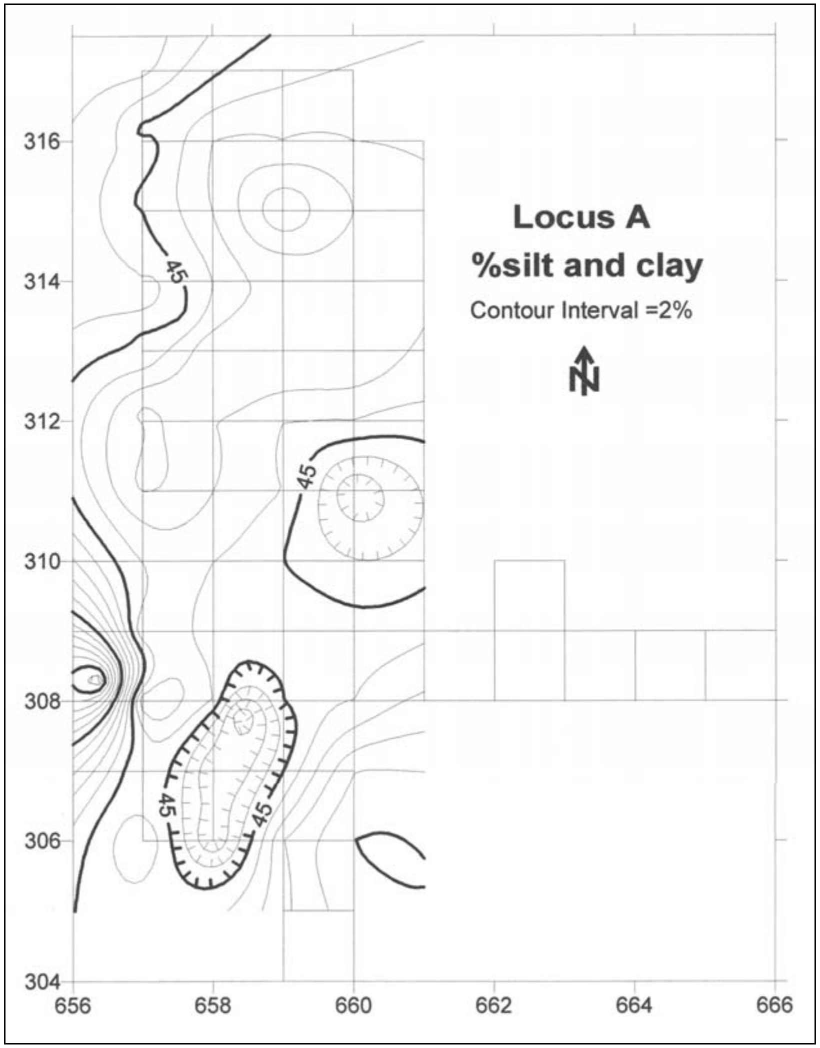
Clearly, F1 described a group of B-horizon samples where authigenic clays and translocated finer-textured materials accumulated along with most of the major soil elements (particularly metals). In fact, the accumulation of such materials was the main criterion for defining B-horizon formation.

Factor 2 (F2), on the other hand, described a sample grouping with relatively high pH and OM content along with abundant Ca Sr, Mn and lesser amounts of Ba and Na (Table 9.2). The F2 grouping also included low amounts of Al, Fe, and Mg and was deficient in clay but positively related to silt content. Given the strong positive correlation with OM content, F2 described typical A-horizon soil samples.

Factor 3 (F3) was controlled primarily by K, Na and to a lesser extent by Sr (Table 9.2). It also included high sand and low silt and clay content and was not affected by OM content or pH. Given the high sand content, F3 may represent a grouping of E-horizon samples. If so, the strong loading of K and Na in this grouping was somewhat anomalous. Because K and Na exhibited similar chemical properties, however, this cross-association was not surprising (Table 9.1). In addition, such anomalies in the E-horizon may reflect inputs of now-decayed wood and charcoal across the archaeological site. Further indication that these samples were atypical for an E-horizon was the lack of a strong negative correlation with OM content. This may indicate that OM (typically very low in the E-horizon) was actually somewhat variable because a relatively large number of these “E-horizon” samples represent a possible “buried” cultural horizon in the A- and I-blocks. These samples, as discussed below, exhibited variations in organic-matter content possibly attributable to a cultural overprint within the present E-horizon (Figure 9.5 and Figure 9.6).

In conjunction with the relationships described above for Factors 1-3, these data suggested that most of the variation in chemical components was controlled by soil weathering processes (i.e., soil horizonation), that included the chemical affinity of certain elements to be associated with organic-rich environments and/or fine-grained silt- and clay-size minerals. Values for each variable attributable to principal soil horizons are listed in Table 9.3 and illustrated in Figure 9.7. The relationships of individual elements to soil horizonation, OM, and texture are depicted in Appendix D. Appendix D (Figures D.1 through D.12) shows a series of scatterplots illustrating the relationships of element abundances between fine-grained components (silt and clay), OM content, and pH. Appendix D (Figures D.13 through D.23) also includes a series of frequency histograms that depict the variability of element abundances within different soil horizon and feature sediments.

Figure 9.8 is a compilation that illustrates the typical elemental relationships between soil weathering and archaeological site formation defined by the factors (F1-F3) discussed above. It depicts three elements considered representative of the diagenic relationships typical of archaeological site formation within a soil-weathering environment. Iron (Fe) was a principal, primarily non-cultural component of the natural sediment, and its distribution within weathered site sediment was typical of the properties controlling F1. Calcium (Ca) was a principal component of much of the natural and cultural biotic components common to this landform, including plant matter, bone and possibly shell. However, Ca was very mobile within a sediment weathering and biogenetic environment, and its distribution illustrates properties of both F1 and F2.



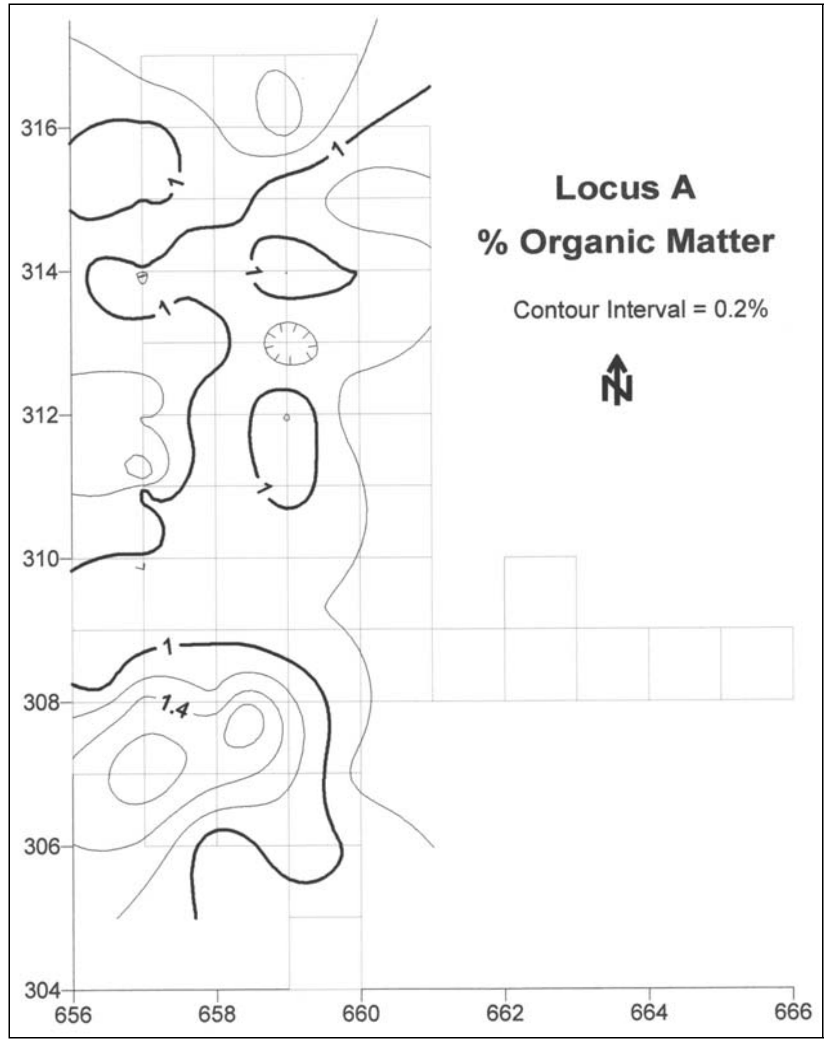


Figure 9.5 Contour Maps Showing the Distribution of Organic Matter in the E-Horizon of the A-Block

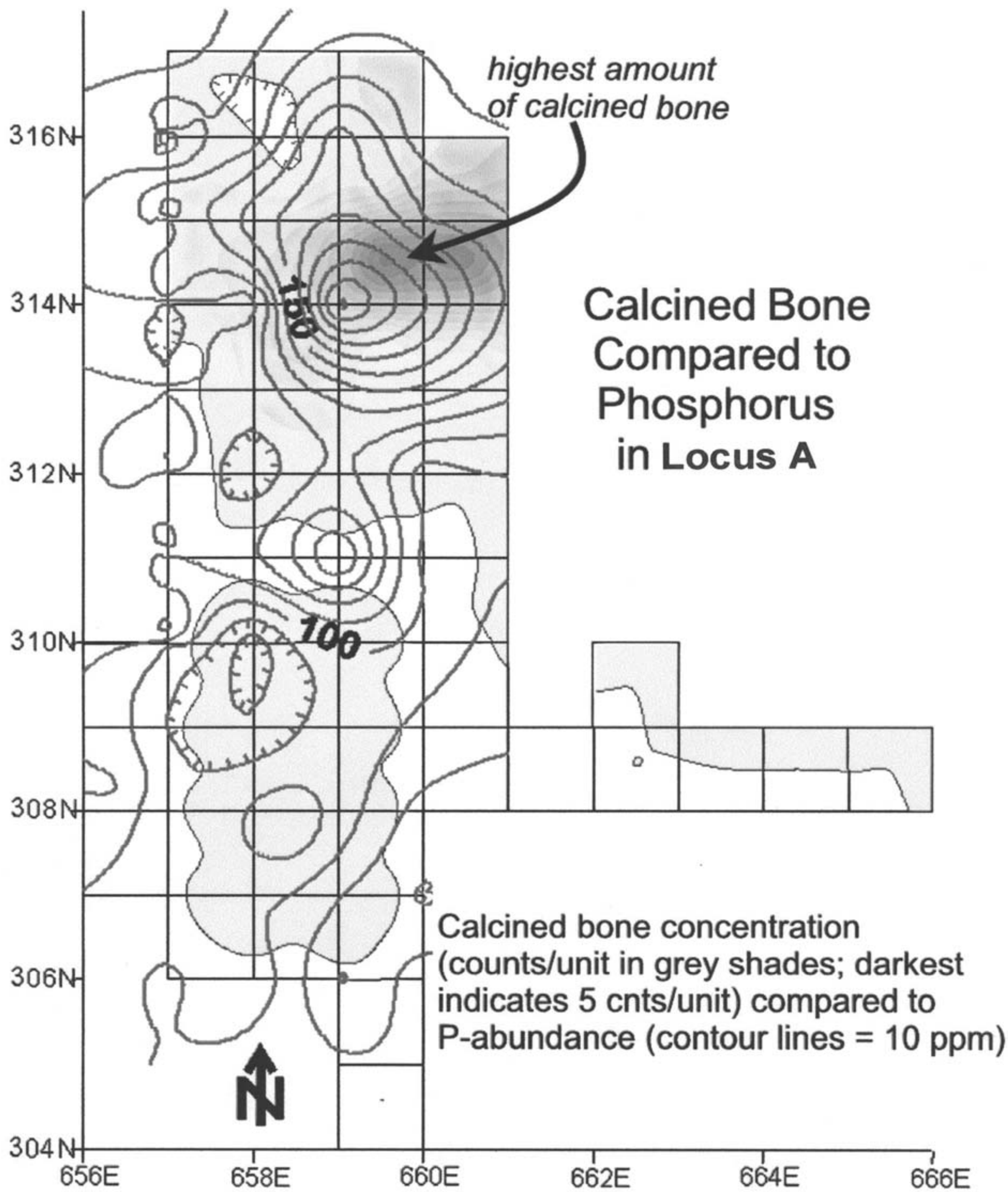


Figure 9.6 Contour Map Comparing the Distribution of Calcined Bone to P Concentrations in the A-Block

Table 9.3 Statistical Data of Texture and OM Content of Soil Horizons Compared with Cultural Features.

	Cultural Features				A-Horizon				E-Horizon				B-Horizon			
	%Clay	**%Silt**	**%Silt +Clay**	**%OM**	**%Clay**	**%Silt**	**%Silt +Clay**	**%OM**	**%Clay**	**%Silt**	**%Silt +Clay**	**%OM**	**%Clay**	**%Silt**	**%Silt +Clay**	**%OM**
MEAN	12.63	31.71	44.34	0.57	7.09	38.36	45.44	4.04	8.92	33.82	42.74	0.93	15.16	24.38	39.53	0.26
Std Error	0.54	0.83	1.05	0.05	0.32	0.98	1.13	0.29	0.17	0.56	0.69	0.04	1.05	1.90	2.74	0.03
Median	12.00	33.00	46.00	0.40	7.00	37.00	44.79	3.84	9.00	36.00	45.40	0.82	16.50	26.00	43.50	0.26
Mode	9.00	32.00	50.00	0.40	9.00	37.00	47.00	2.70	10.00	37.00	46.00	0.81	19.00	29.00	29.00	0.10
Std Dev	4.73	7.35	9.26	0.48	2.26	6.89	7.91	2.00	1.89	6.09	7.45	0.40	5.93	10.74	15.52	0.15
Variance	22.33	53.99	85.66	0.23	5.11	47.45	62.52	4.00	3.56	37.07	55.54	0.16	35.17	115.40	240.77	0.02
Kurtosis	0.22	2.59	2.22	2.89	-1.04	-1.06	-1.11	0.01	0.31	0.51	0.68	13.05	-0.37	-1.04	-0.84	0.98
Skewness	0.81	-1.53	-1.19	1.69	0.39	0.31	0.13	0.31	0.33	-0.67	-0.51	2.83	-0.55	-0.21	-0.35	0.77
Range	20.00	35.00	48.00	2.36	8.08	23.90	27.18	9.31	9.77	34.00	43.00	3.00	23.00	38.00	55.00	0.67
Minimum	5.00	7.00	12.00	0.00	3.92	27.30	31.92	0.20	5.23	17.00	23.00	0.30	3.00	4.00	7.00	0.04
Maximum	25.00	42.00	60.00	2.36	12.00	51.20	59.10	9.51	15.00	51.00	66.00	3.30	26.00	42.00	62.00	0.71
Count	78.00	78.00	78.00	78.00	49.00	49.00	49.00	49.00	117.00	117.00	117.00	117.00	32.00	32.00	32.00	32.00

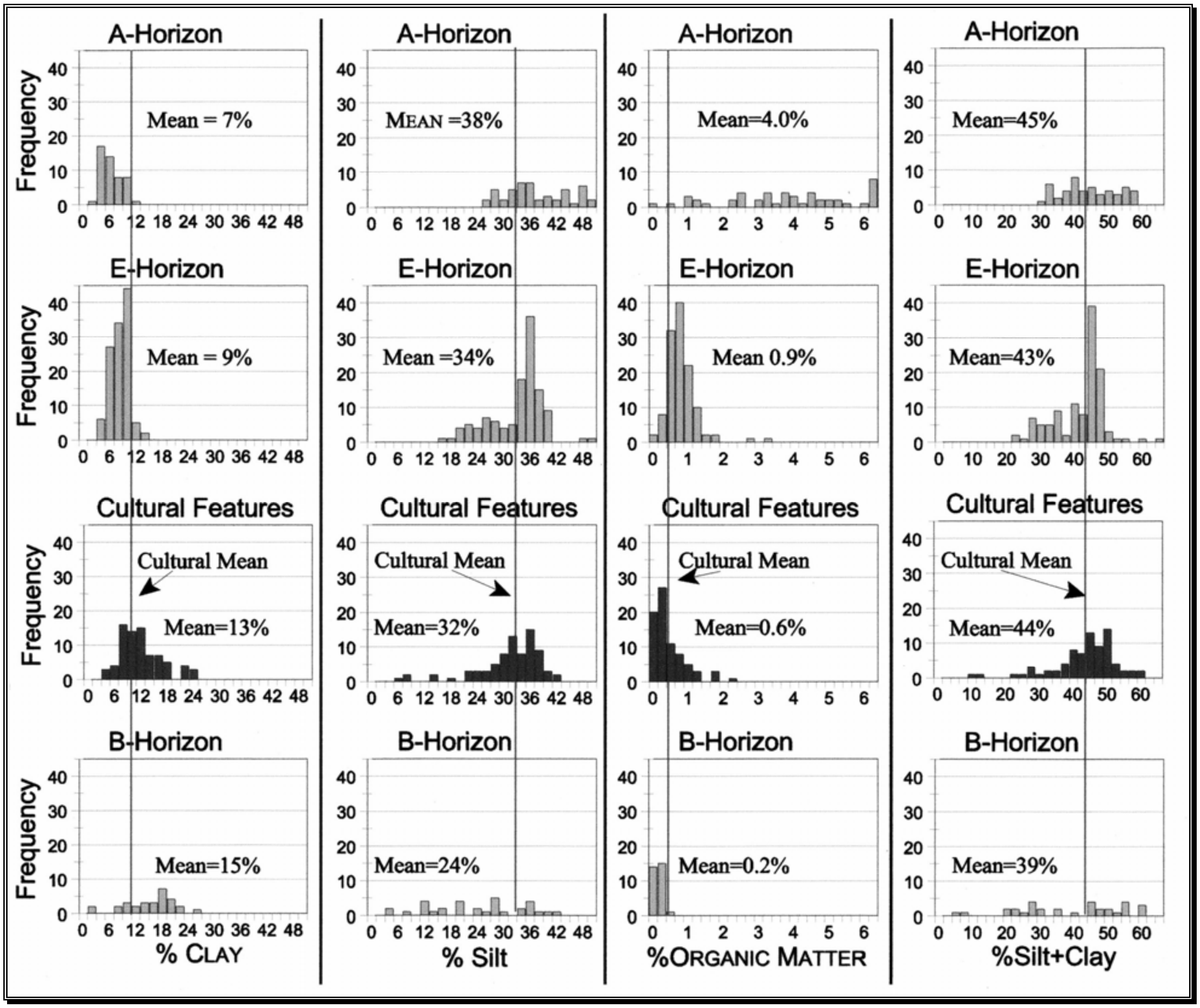
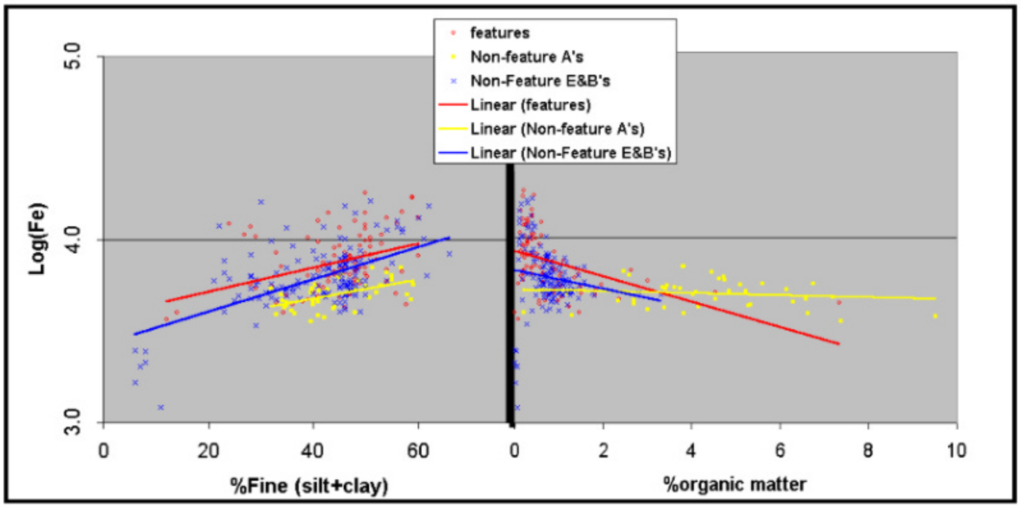


Figure 9.7 Histograms Showing the Relationships Between Organic Matter and Texture

Phosphorous (P) was also a common, although far less mobile, component of plant and animal chemistry considered emblematic of distinct cultural inputs within archaeological sites and its distribution illustrates properties of several different factors.

The systematics of Fe was typical of B-horizonation. Fe abundance in the B-horizon was usually high, but variable because it accumulates in association with fine-grained sediment and authigenic clay. Variability results from the relative ease with which Fe exchanges in interlayered clay minerals, adsorbed surface grain sites, or as oxide grain-coatings. This B-horizon variability results primarily because Fe has various states and potentials depending of the presence of free oxygen (redox) as well as soil and groundwater pH. On the other hand, available-Fe was generally less abundant in A-horizons because of its tendency to chelate with organic oxides. The abundance of OM (organic oxides) was generally low in the B-horizon (Figure 9.7).



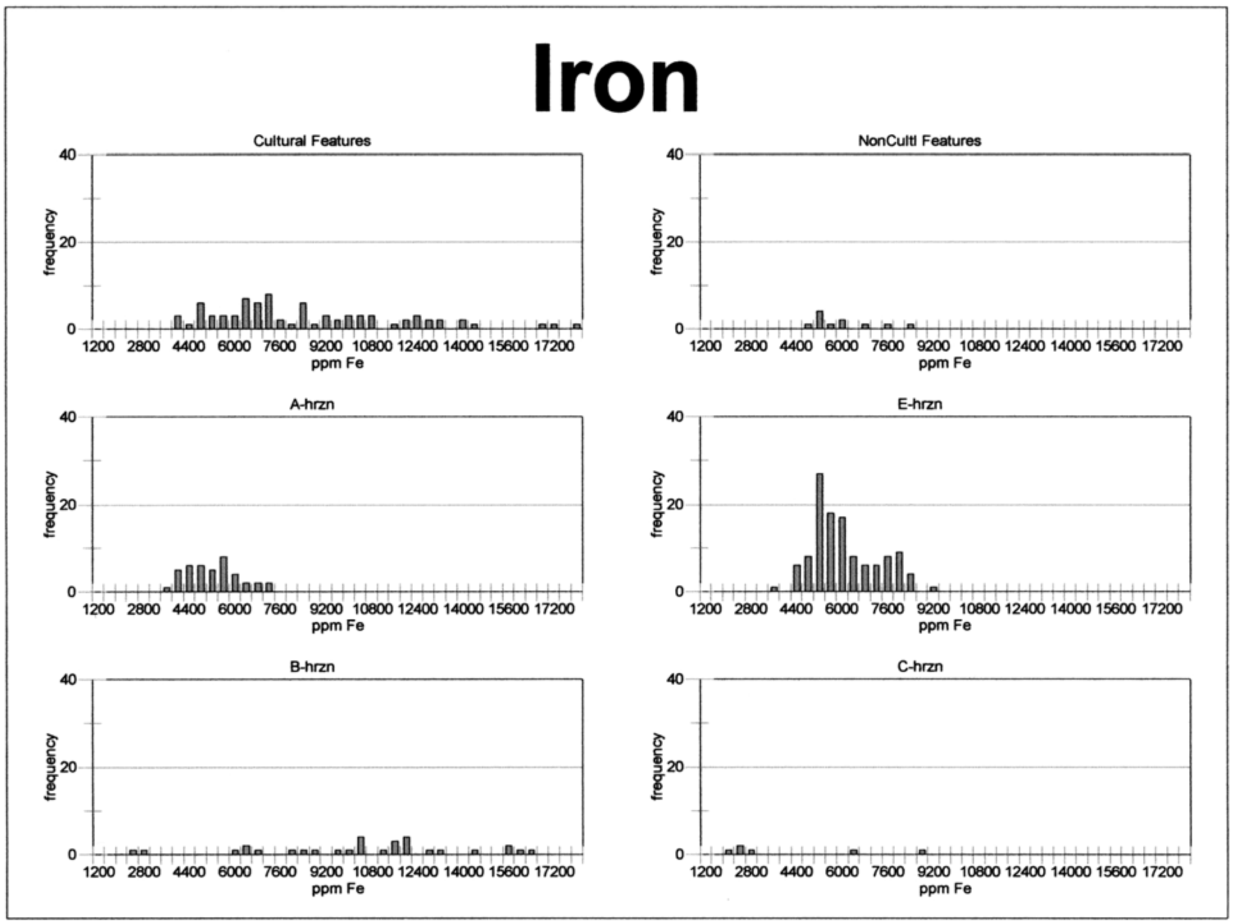
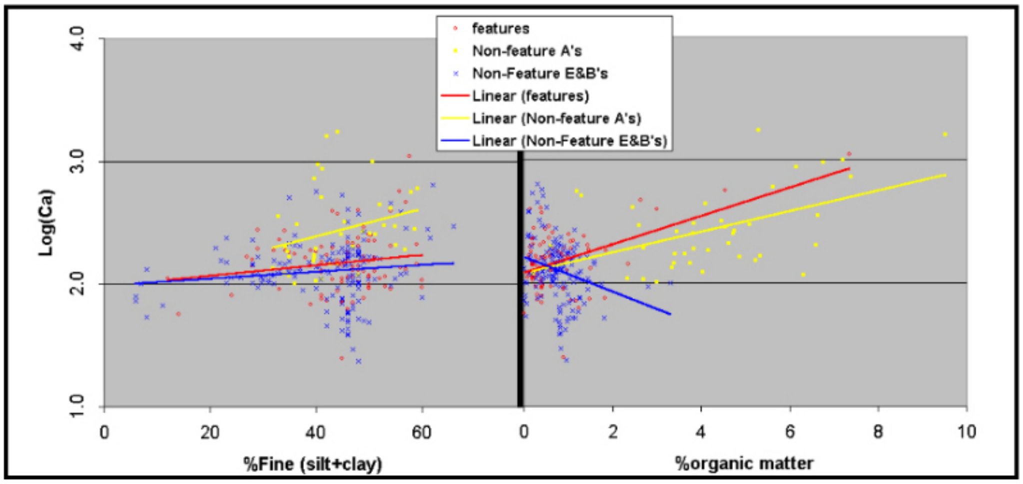


Figure 9.8 Scatter Diagrams and Histograms Showing the Relationships of Fe, Ca and P



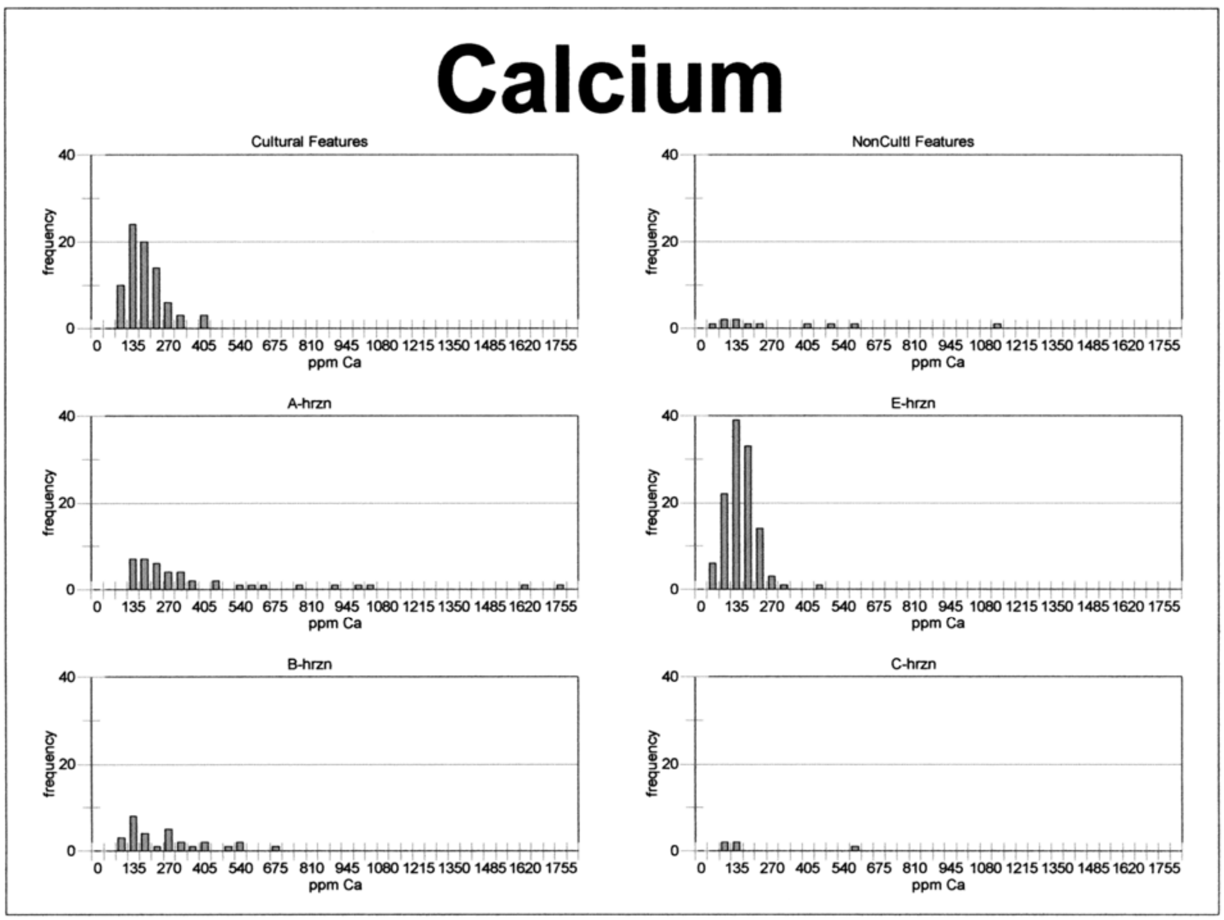
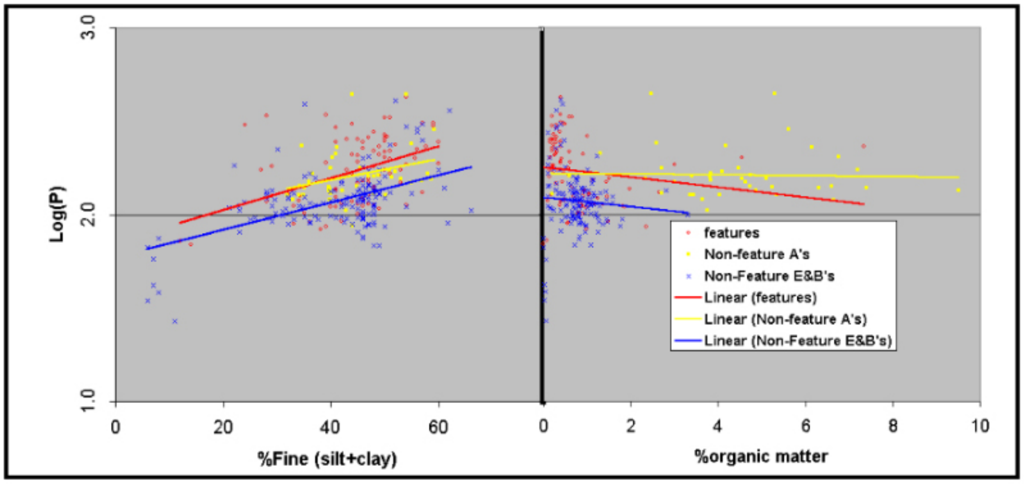


Figure 9.8 Scatter Diagrams and Histograms Showing the Relationships of Fe, Ca and P (Continued)



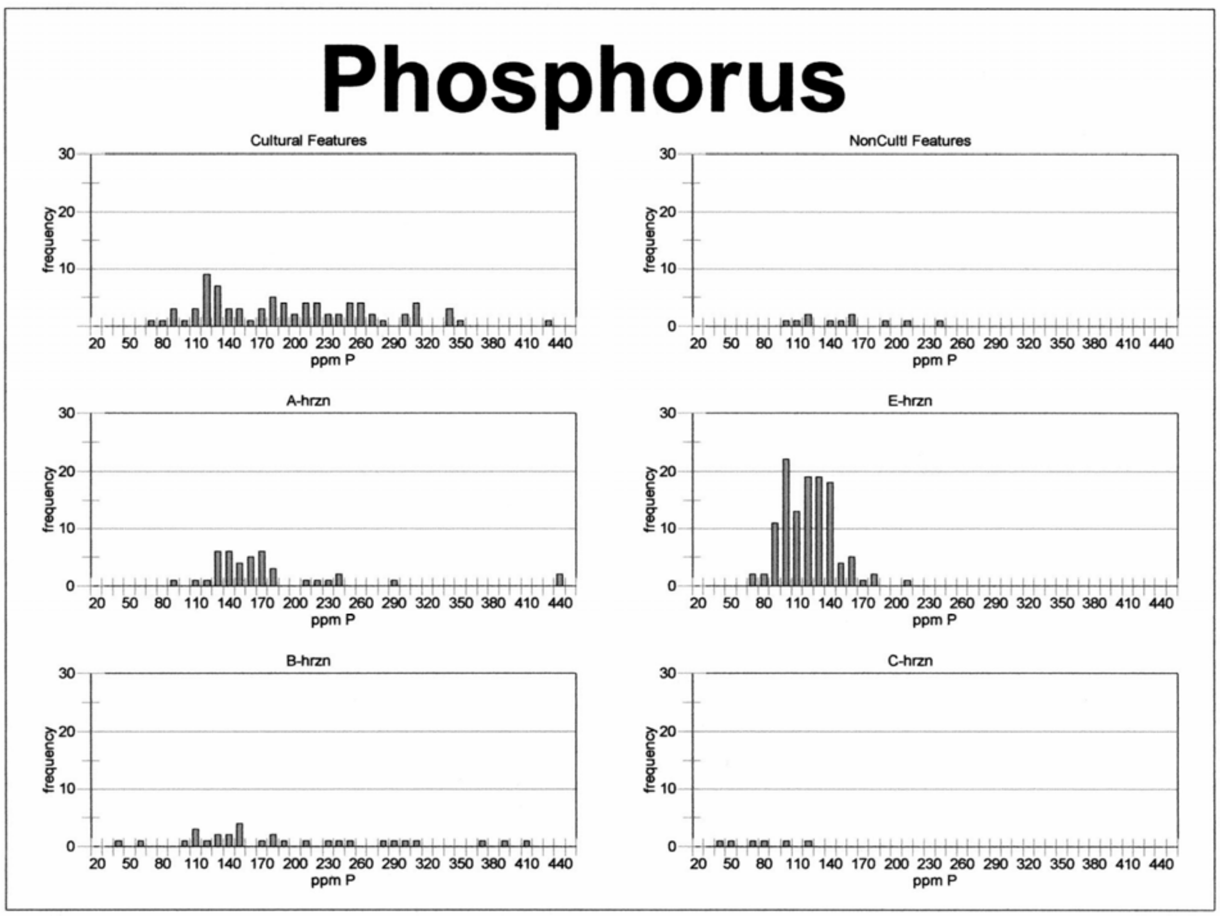


Figure 9.8 Scatter Diagrams and Histograms Showing the Relationships of Fe, Ca and P (Continued)

These typical B-horizon relationship were shown by both scatter plots and frequency histograms of Fe (Figure 9.8) and can be further seen by noting those elements with high cross-correlations with each other and a positive relationship with clay and/or silt (Table 9.1). These include Al, Mg, Ti, and P (Appendix D). Fe samples, regardless of soil horizon or cultural affinity show a general positive relationship with percent fine and a negative relationship with OM. Importantly, the general distribution of Fe from "cultural" samples was quite variable but generally overlaps that of the "non-cultural" samples. This suggests that Fe was generally not a sensitive archaeological indicator.

Calcium was also associated with B-horizonation but, unlike Fe, was also a common constituent of the A-horizon. This dichotomous relationship is shown in Figure 9.8. It depicts a negative relationship between OM and Ca for B- and E-horizons, and a positive relationship between Ca and OM for A-horizon and Feature samples. Additionally, Ca was generally only weakly related to grain size. Like Fe, the abundance and distribution of Ca in cultural samples generally overlaps that of the non-cultural soil samples. However, unlike Fe, a strong positive relationship exists between OM, Ca abundance, and cultural samples. This may reflect that calcium-rich OM was somewhat higher in features than the surrounding matrix.

Phosphorous (P), like Ca, was often associated with both clay-enriched B-horizons and OM-enriched A-horizons (Figure 9.7). However, this was only weakly reflected in the scatter diagrams from Hickory Bluff (Figure 9.8). For example, a weak negative relationship exists between P-abundance and OM while the opposite was true for P and percent fine. P-abundance histograms for A-horizon samples show less variability and generally lower values than for both soil B- and feature-horizon samples. This implies that accumulation of clays (such as was characteristic of B-horizon formation), rather than additions of OM (characteristic of A-horizon formation), were a dominating process controlling P-distribution and eventual accumulation. In fact, the distribution of P was more similar to Fe than Ca where a clear, relatively strong, positive relationship exists between all samples and percent fine (Figure 9.8). Again, frequency histograms of these elements also show that both cultural-feature and B-horizon samples have extremely variable P- and Fe-abundance while the Ca-distribution was more uniform. These similar relationships in Fe- and P-distribution for cultural-feature and B-horizon samples with percent fine may reflect incipient B-horizon formation within several of the relatively old, basin-shaped features due to ongoing pedogenesis. This was supported by field examinations that observed pedogenic lamellae formation within deep basin feature fill as thin lateral accumulations of oxidized, reddish-brown fines.

Importantly, although P abundance in cultural-feature and B-horizon samples may show similar trends, it was generally high in cultural features, (as was Ca) despite the fact that these samples exhibit slightly lower clay content (Figure 9.7). The relatively high P-concentrations in feature fills may reflect anomalous sources or rates of additions of P-enriched materials to feature fills at some time in the past. These sources likely were of organic origin. However, as previously noted, a weak negative relationship exists between P-abundance and measured OM. Within B-horizons this may reflect relatively low inputs of OM (because they were never surfaces, for example), while within cultural features (with expected, relatively intense additions of archaeological debris and detritus) this may reflect time-transgressive degradation of inclusive organic substances. The eventual, net loss of carbon-rich organic compounds by oxidation leads to low measurements of OM content.

Carbon-based compounds in oxygenated environments degrade relatively quickly into constituent compounds and elements, such as carbon dioxide and non-carbon compounds that may include P. Within these conditions an inverse relationship exists between OM preservation and time. High OM quantifications for A-horizon samples (Figure 9.7) were primarily attributable to the constant biological recycling of OM and constituent elements in these near-surface environments. Low OM quantifications for sub-A horizon samples (including features) in part reflect the net loss by degradation of any included or transferred OM, and less intensive biological activity. However, the accumulation of organic-derived P in feature fills (beyond that attributable to percent fines, and despite low OM readings) was intriguing. These data suggest that relatively large quantities of P-enriched organic materials (and possibly Ca) were concentrated within these fills at a particular point in time, well enough removed from the present to allow for degradation of much of the OM. If these accumulations were attributable to "natural," ongoing biological activity, such as root and rodent intrusions, relatively higher OM readings would be expected. The elevated readings of P in feature fills may relate to degraded bone, which was at least marginally suggested from Factor 4.

Factor 4 (F4) accounts for less than 10 percent of the total variation (Table 9.2). It was strongly related to a "high" pH grouping (compared to other samples) that was also relatively high in P, sand, and contains somewhat elevated Mn and clay contents. Additionally, this sample group was deficient in silt and negatively correlated with OM content. F3 (which probably defines soil E-horizon samples) and F4 were similar in that each was relatively high in sand, low in silt, and OM content was of little apparent significance. However, F4 differs from F3 in pH, P, and Mn, each of which was discriminate for F4 and either not important or negatively related to F3. Moreover, minor, positive affinity in F4 exists for Ca and P. The cross-correlation of these elements in F4 was different than most of the rest of the factors (Table 9.2) as well as for the general matrix of these samples (Table 9.1).

The "high" sand and "low" OM groupings suggest an E-horizon origin for the F4 grouping, although the association with higher clay content contradicts such a relationship. Although contradictory, the relatively high P content was intriguing given the affinity of P to mark areas of intense cultural activity. At archaeological sites, P-enrichment in soil was often attributed to accumulation of animal material (i.e., bone, waste) and OM enrichment by additions of any and all types of organic materials (i.e., plant and animal residues and wastes). Anomalously high amounts of P, particularly in association with Ca and Sr (all of which are primary components of bone) may indicate additions of weathered bone. Bone origin was suggested for the P because of the low-to-negative relationship of F4 to OM, and the strong, positive relationship to pH (bone degradation raises soil pH). Moreover, the cross-relationships between Ca and, to a lesser extent Sr with P, were at least weakly related to F4, and further support bone as the source of these elements (Table 9.2). As such, F4 may represent bone-enrichment of archaeologically modified sediments that include both identified feature fills, and other discreet locations within the artifact-enriched E-horizon.

Most of the statistical variation in elemental abundance at Hickory Bluff may be attributed to pedogenic processes and relationships. However, variations within these groupings may be significant and reflect minor, discrete overprinting by selective cultural activities. The archaeological component of this site was recovered from an E-horizon context, or from feature fills that exhibited common E-horizon characteristics (deep-basin features also exhibited incipient B-horizonation). Although soil E-horizon samples generally retained relatively low abundances of elements, spatial variations in the distribution of relative high and low values may relate to specific anomalies of cultural or natural origin. As described below, the systematic sampling and mapping of excavation blocks at specific levels indicated areas of possible archaeological interest suggested by anomalous distributions of specific elements. Additionally, comparison with identified feature fills also provides additional insights pertaining to feature formation and distribution.

Excavation Block Analyses

The presence of "intact" artifact concentrations and features stratigraphically situated below the surface A-horizon suggested that portions of Hickory Bluff might have been buried. As discussed in Section 4.0, several lines of evidence suggested that thin sheets of eolian-derived sand and silt might have covered the site during the late Holocene. If so, Early Woodland activity areas or strata may have been isolated from extensive surface disturbances and overprinting by additions of non-cultural OM. To examine whether some areas of the site were actually buried by eolian sediment, and to study the general distribution of soil chemical and physical parameters, a suite of regularly spaced samples were collected and analyzed from Loci A and I. Results are depicted on a series of maps that contour the chemistry, texture, and OM content for the two excavation blocks (Appendix D: Figures D.24 through D.31). These maps indicate that variations in most elements and other data exist across the two areas. Non-definitive relationships to cultural activities were suggested through comparison with archaeological data.

Characteristic of all site sediment analyses, textural data again proved less ambiguous than geochemical data. Mapped distributions of percent fine across Locus I indicated a distinctive deficit in the vicinity of Feature 90, a relatively large and deep basin feature. Bisecting the block along a northwest-southeast axis was a linear "ridge" of relatively high percent fines. These contrasting "textural features" apparently represent probable cultural and natural variations within the host Columbia Fm. sediments. The Feature 90 locus may include additions of exhumed and mixed basal sediment that impart a coarser overall texture to the uppermost limit of feature fill. The northwest-southeast-trending "ridge" of increased fines represents a pattern in sediment distribution that may relate to original deposition or postdeposition alterations by either cultural or natural means; the northwest-southeast orientation was reminiscent of wind direction previously considered characteristic of possible late Holocene deposition of eolian sediment derived from valley mudflats (Section 4.0).

The comparison of Locus A textural and chemical distributions with contour maps of artifactual content was intriguing (Appendix D: Figures D.28 through D.31). In general, a south/southwest-north/northeast-trending "ridge" of archaeological material can be discerned in the center of the block that was particularly evident for TAS distribution. TAS may better reflect areas of intensive OM accumulation associated with hearths than do distributions of ceramic and lithic tool-debris. Moreover, the distribution of OM and percent-fine (silt and clay) parallels the TAS pattern. Although OM content was quite low along the artifactual "ridge" it was nevertheless high in contrast with the surrounding area (Figure 9.5). This relatively higher OM content may also be associated with more intensive cultural activities. The textural anomalies, which follow a similar pattern, may be causally related to cultural uses of the area (Figure 9.5).

Alternatively, these fine-grained distributions may simply exist in contrast to the coarse-grained concentrations related to Features 49, 110 and 70 (non-cultural, or “geomorphic” features) and cultural Feature 120. As such, the overall distribution of most elements within Locus A may correspond with variable factors of percent-fine and OM content that may or may not reflect cultural inputs, despite artifact content. However, the continued retention of relatively high values of K, Mg, and Ca, which were all easily leached, were further suggestive of a cultural source. Unfortunately, most direct association between element abundance, organic source and cultural activity in this regard would be speculative. The one major exception includes calcined bone, a recoverable “macro-organic,” and its constituent elements.

The distribution of P, Ca, and Sr in Locus A shows the most apparent correspondence between chemistry and possible human activity (Figure 9.6). Comparison of the concentrations (counts) of calcined bone (the only bone of any consequence recovered at the site) to P abundance was intriguing (although direct cultural association with these bone fragments was also speculative, despite the similar abundance of artifacts with similar proveniences). Within Locus A, relatively high P values were associated with abundant calcined bone. Similar relationships also exist between Ca, Sr, and bone (Figure 9.9). These results suggest that as the bone component weathered, its major constitute minerals (Ca, P, and Sr) remained as residual indicators. Although far from definitive, this example suggests that similar loci with above average Ca, P and Sr accumulations may also indicate the presence of degraded bone components. Similar loci investigated include basin features.

Feature Analyses

A suite of samples from the large basin features was analyzed to determine if physical and chemical properties could indicate specific aspects of feature construction, function, and backfilling, as well as distinguish “natural” from “cultural” processes. These samples were collected from vertical columns within Features 2, 38, 60, 77, 90 and 169 (Figure 9.2, Figure 9.10, Figure 9.14). Columns were located near the center (or deepest portion) of each feature. Individual feature-fill samples from an additional 16 basin features were also analyzed. For comparison, 10 “non-feature” sample columns, (Figure 9.10 Figure 9.13, Figure 9.14, Section 6.0), and 15 samples from component TAS features (Figure 9.4), were collected and analyzed (Appendix D: Tables D.1 through D.3).

Matrix properties of features provided evidence as to the construction, abandonment, and final filling of the basin features. They also indicate taphonomic aspects for Hickory Bluff in general. As previously noted, basin fills were physically (texturally) similar to surrounding E- and EB-horizons (Figure 9.10-Figure 9.11 and Figure 9.13-Figure 9.14). Pedogenic characteristics also indicate that following deposition feature fills have undergone variable-stage soil formation. Incipient B-horizon formation was supported by relative highs within the fills for the “suite” of B-horizon-associated elements (i.e., Fe, Mg, P). This fact was illustrated in Feature 2 where these elements “spike” near the top to the “fill” just below the E-). Minor increases in clay and silt were also associated with these “spike” samples and may reflect initial formation of argillic B-horizons (sometimes noted as Feature EB- and Bt-horizons). Additionally, ephemeral soil lamellae were also commonly observed within basin fills, which again indicated the onset of B-horizonation.

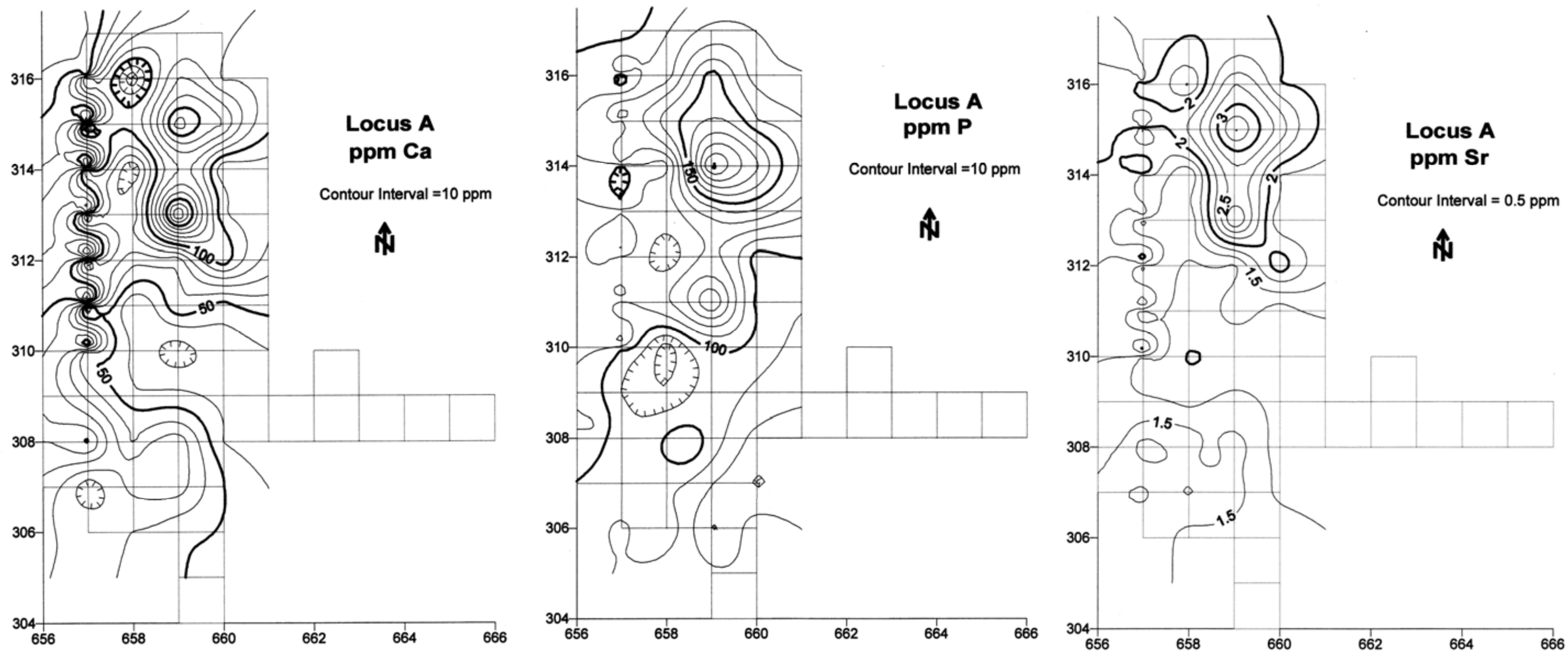


Figure 9.9 Contour Map Showing the Distribution of Ca in the E-Horizon of the A-Block

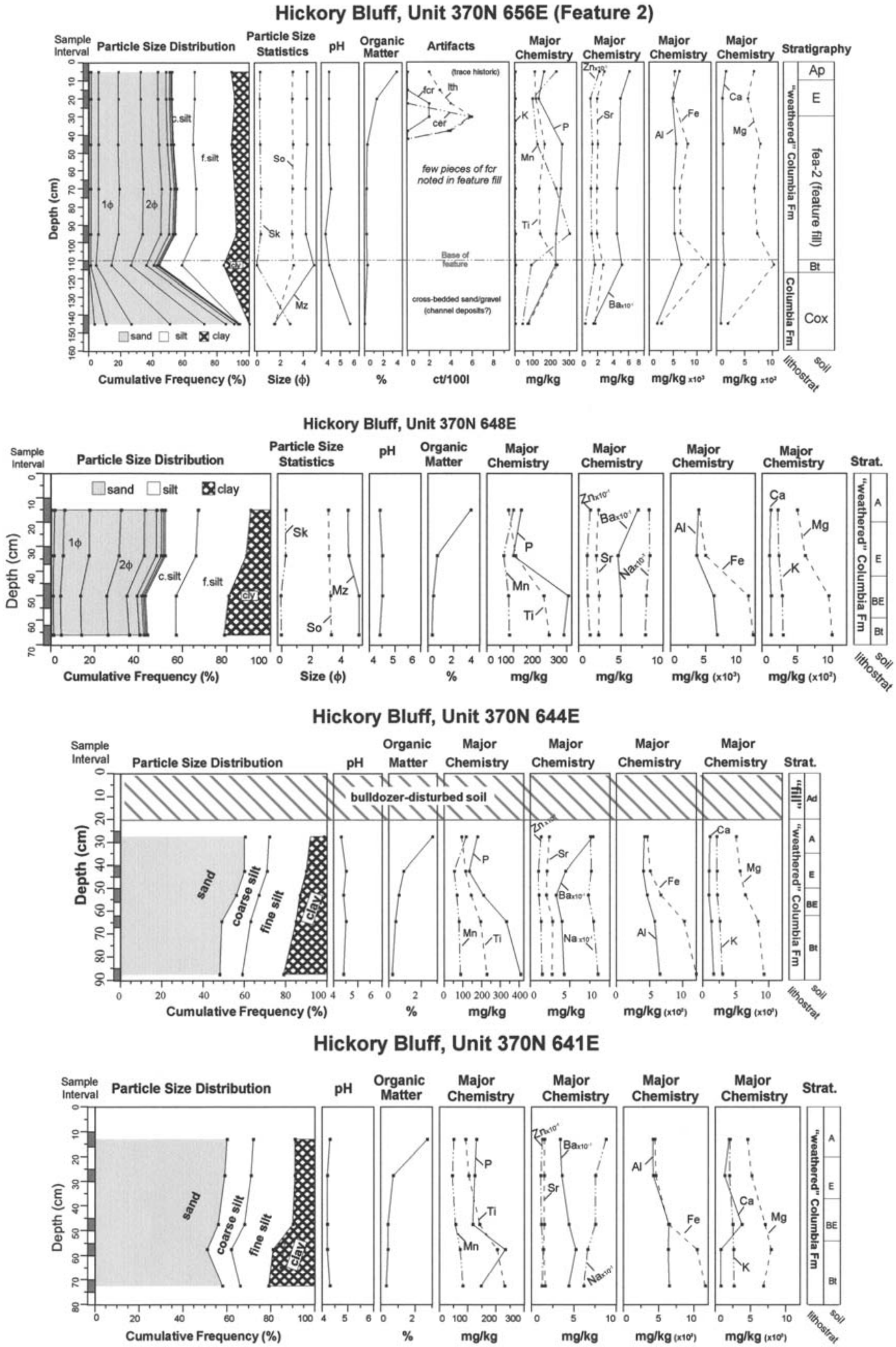


Figure 9.10 Geoarchaeology Profile of Feature 2 and Three Other Nearby Columns along the N370 Grid Line

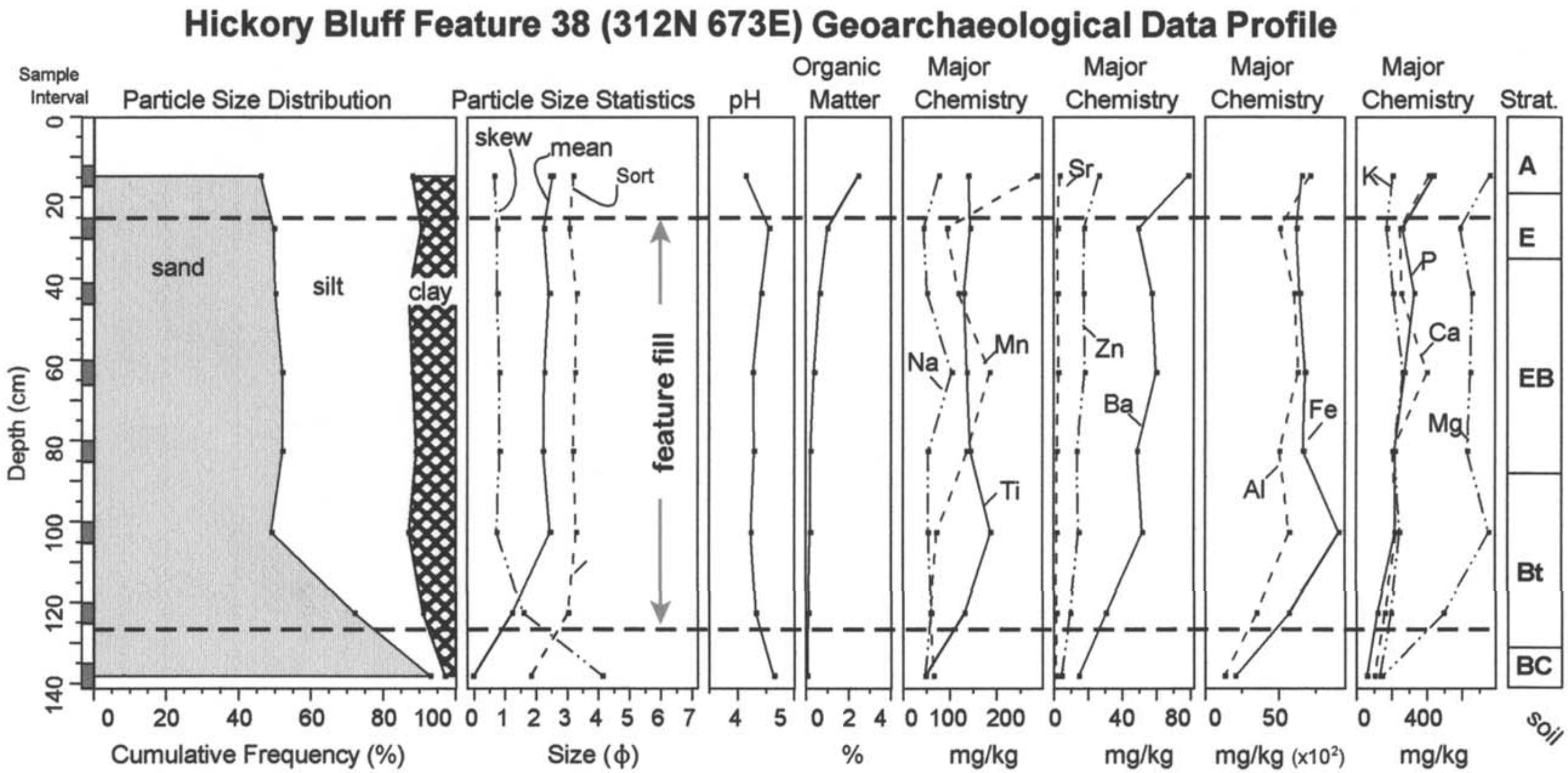


Figure 9.11 Geoarchaeology Data Profile of Feature 38

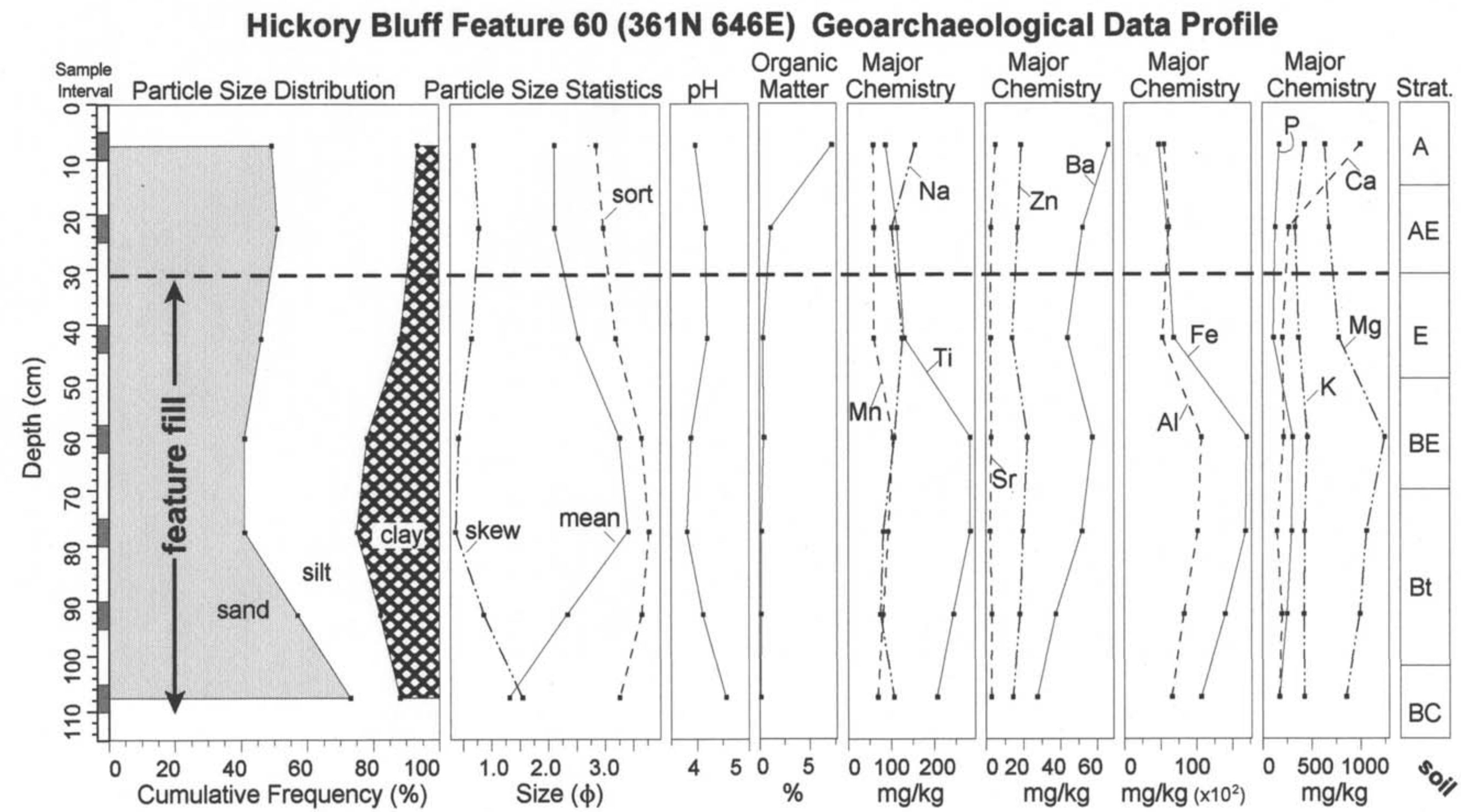


Figure 9.12 Geoarchaeology Data Profile of Feature 60

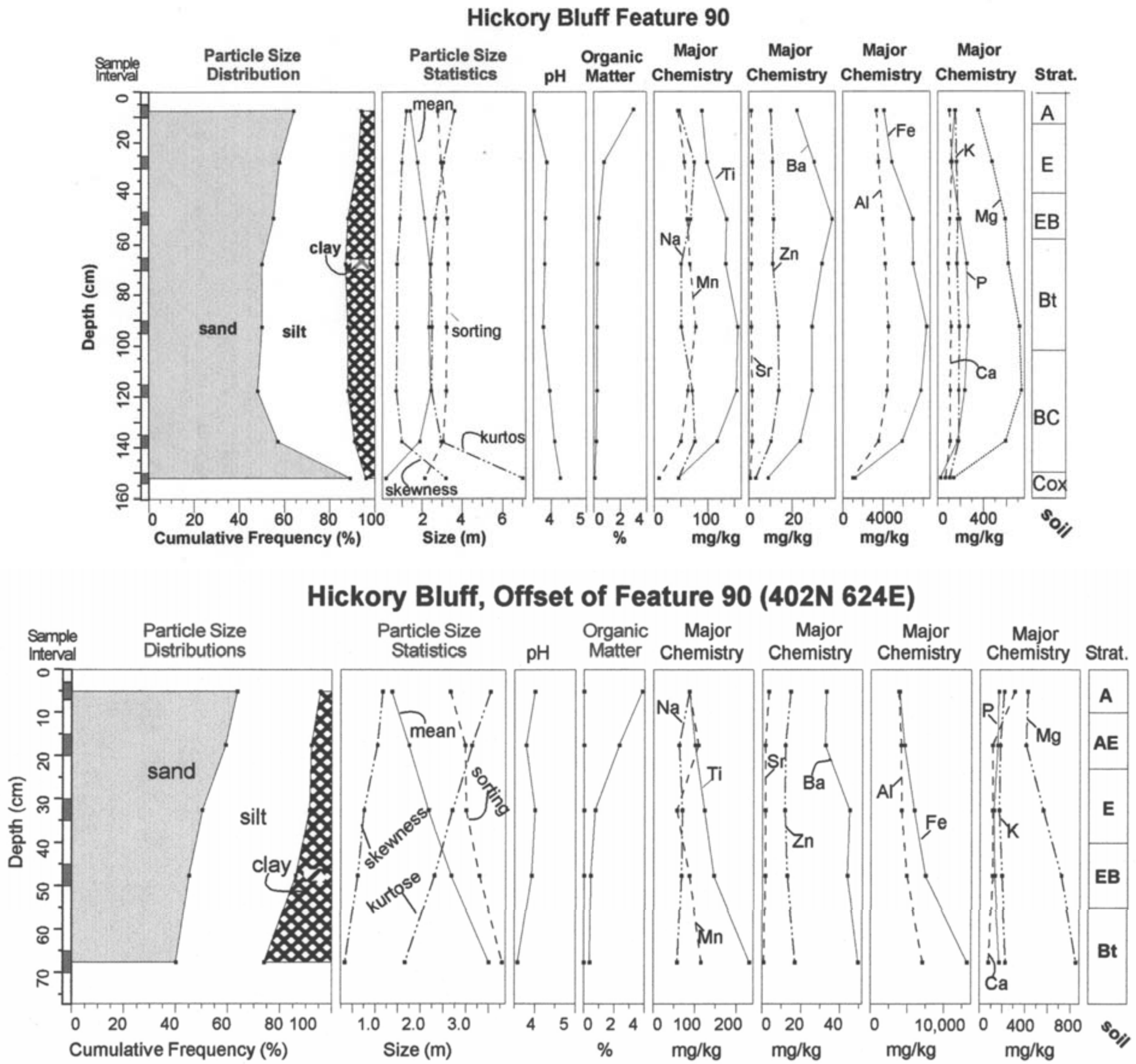
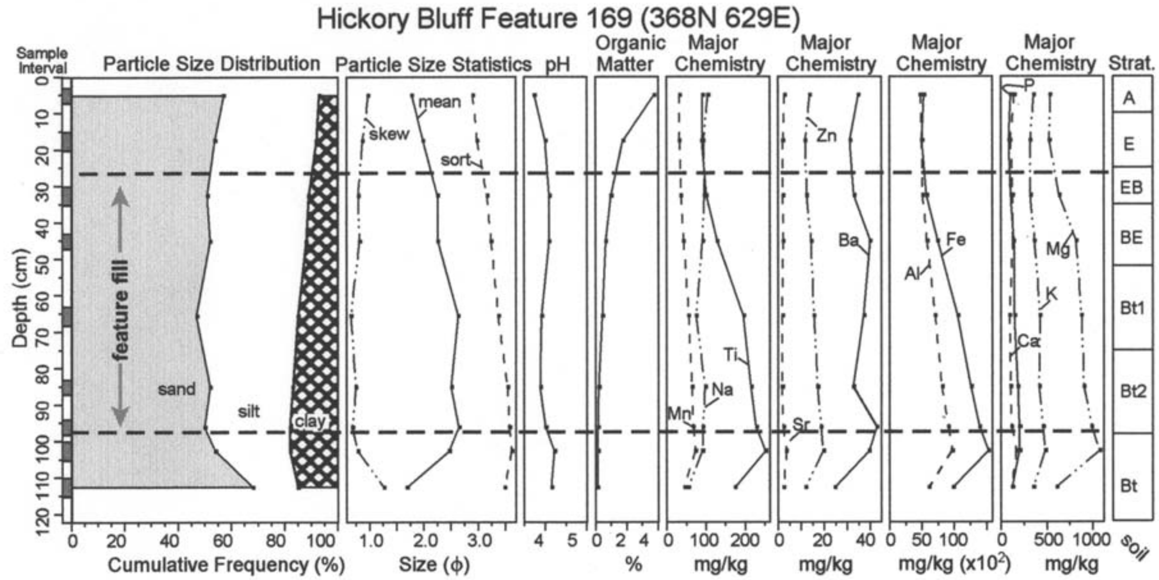


Figure 9.13 Geoarchaeology Profile of Feature 90 and an Adjacent Offset Column



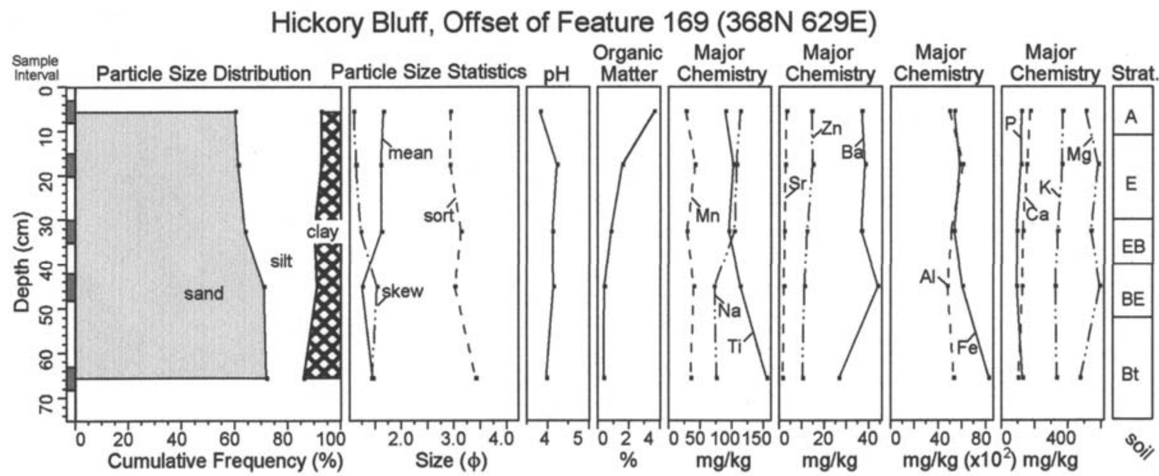


Figure 9.14 Geoarchaeology Data Profiles of Feature 169 and Offset Sediment Column

Sedimentary characteristics of feature fills indicate that backfilling of large-basin features occurred rapidly and was probably intentional. No depositional bedding or "drapes" and/or "layers" of silt and clay sediment were noted in the feature fills, as would be expected if filling occurred gradually by natural processes that include sheet wash, slump and puddling (Section 10.0). The general similarities in fill texture (i.e., Figure 9.10 and Figure 9.13-Figure 9.14) may indicate that original backfilling of each basin occurred by replacing original exhumed and subsequently mixed A-E- and B-horizon sediments into the basins. These feature fills–derived from both near-surface sediments that contained preexisting archaeological materials and culturally "sterile" subsoil–may contain significant amounts of cultural materials (lithic, ceramic and organic) that have no relationship to the original feature function, in addition to feature-related additions of cultural materials. This mixing of artifact-deficient and artifact enriched sediments may account for variable cultural-material densities in feature fills.

These data provided good evidence for the processes of construction and abandonment of deep basin features. However, the physical and chemical analyses provided very little direct indication of feature function. This was not surprising given that many of these features have undergone many years of weathering. In fact, as noted above, their configuration (i.e., penetration through the less permeable B-horizon into the C-horizon) has facilitated drainage and enhanced both the oxidation of OM and transfer of chemical constituents. Acidic conditions of the feature fills (low pH, commonly <4) contributed to the degradation of OM.

Although several elements measured showed a tendency to be more concentrated within cultural features, statistical applications do not support these observations. This was apparent in the elemental frequency histograms that compare element abundances for different types of features and soil horizons, and the series of scatter diagrams that compare elemental abundances for soil and feature grouping with textural, OM content, and pH. For example, elements such as P, Fe, and Ba were generally more abundant in feature fills than in the surrounding soil matrix. In part this may be the result of the inception of B-horizon formation within the basin fills, which tend to concentrate these elements. This observation may also indicate that these features were originally higher in OM containing greater amounts of these elements (i.e., bone) that have since degraded, leaving only the residual chemistry. As noted above, given the proposed attributes of feature formation, these chemical characteristics may reflect feature function, preexisting matrix attributes, and post formation feature pedogenesis (or soil formation). Indeed, the results of the chemical analyses for these feature data sets–much like that discussed above for Loci A and I data–provide intriguing, but ultimately ambiguous, indicators concerning the feature function.

However, the potential for fill chemistry to reflect increased culturally derived OM was potentially important for the element P (Figure 9.15). Comparisons of the abundance of P in all features with other "soil" (non-feature) samples from throughout the site indicate that although a great variability exists, cultural features generally contain higher and more variable concentrations of P (this was evident in the means and standard deviations). Moreover, these variations in feature data suggest that some differentiation may exist for different types of features. Large basins were particularly high in P; this may indicate the original presence of abundant quantities of degraded P-rich organic materials. TAS features were relatively low in P; this may be attributable to relative stratigraphic position within soil E-horizons. It was apparent that several millennia of variably intensive weathering have exerted strong controls upon feature preservation.

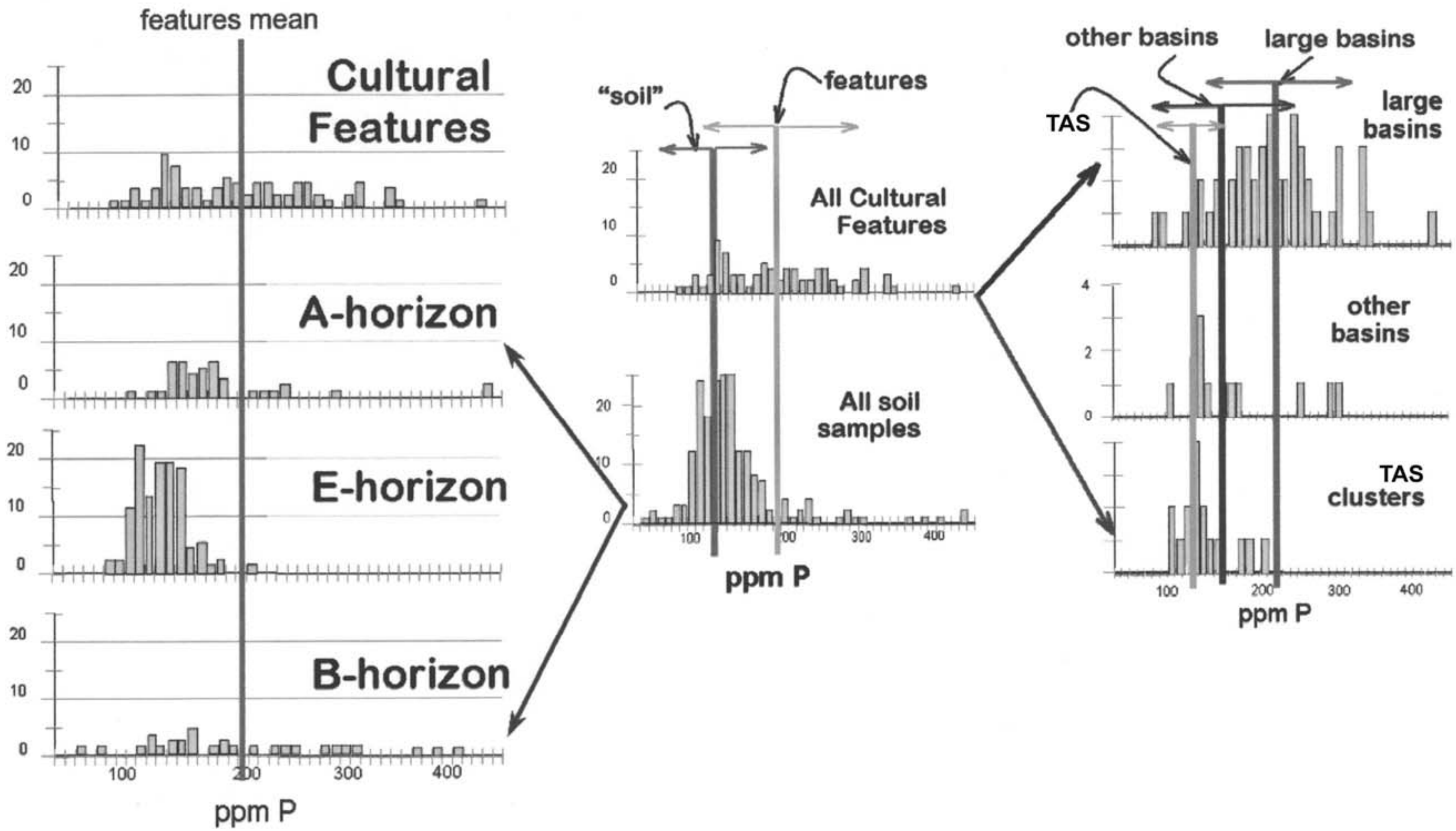


Figure 9.15 Series of Frequency Histograms that Depict the Variability in Abundances of P within Various Grouping of Data Types

Regardless of actual feature use, the cultural significance and importance of relatively high P abundance, when compared to A-E-B soil horizons, was interesting (Figure 9.15). These data indicate the distribution of P in cultural features to reflect that of B-horizon samples. Closer examination of sample provenience data reveal that many high values of P abundance were derived from B-horizon samples that lined basin features. In this case, high abundance of P again correlates to relatively high values of percent fines (as previously noted). As such, within this environment of active sediment weathering, clay-enriched B-horizon sediments that lined cultural features apparently accumulated feature-derived P as secondary deposits. If accurate, this interpretation infers that original feature fill contained relatively higher, but non-quantifiable, values of P. Such a process, redistribution of anthrogenically derived elements through ongoing weathering of cultural features, points out the complexity of understanding soil chemistry systematics from a 4000- to 2000-year-old archaeological site. So many factors influence the distribution of elements that confidently isolating natural from archaeologically significant distributions was difficult.

These factors of basin-feature sedimentology and pedology are significant from a taphonomic standpoint as indicators that bioturbation was not as dominant a postdepositional process within basin features as within soil-horizon formation. Extensive, vertical, physical mixing of deep-basin feature matrices by bioturbation would expectedly limit physical and chemical development of soil horizons. A “biomantle” model (Johnson 1990, 1993) of archaeological material disposition in subsurface contexts appears minimally applicable at Hickory Bluff. This suggests that disposition of artifacts within feature fills--and within subsurface contexts elsewhere across the site--resulted primarily from cultural activities and burial processes possibly related to eolian processes, and secondarily from bioturbation processes.