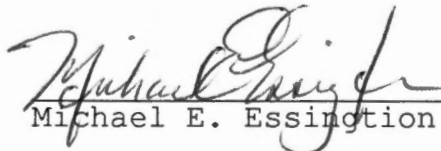


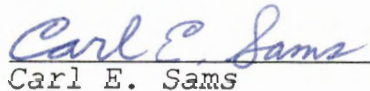
To the Graduate Council:

I am submitting herewith a thesis written by D.E. Smith entitled "A Geomorphological Investigation of Soils Forming on the Humboldt Terrace in Western Tennessee". I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Sciences.


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Associate Vice Chancellor and
Dean of The Graduate School

**A Geomorphological Investigation
of Soils Forming on the Humboldt
Terrace in Western Tennessee**

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

David Edward Smith

May 1998

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Thesis
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DEDICATION

This work is dedicated to my wife, Jennifer, without whose support it would not have been possible.

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ABSTRACT

Soils forming on the Humboldt terrace in western Tennessee were investigated for their genesis and classification. Diatoms within the profiles were used to determine whether the Humboldt terrace originated in a fluvial environment, which is the accepted theory, or a tidal environment.

A total of seven sites were chosen on the Milan Agricultural Experiment Station. Five of the sites were located in an upland position on the Humboldt terrace, while two other sites were located on a lower lying flood plain. The five terrace sites were sampled to a depth ranging from 3.5 to 5 meters. The flood plain sites were sampled to a depth of no more than 2 meters. Standard soil survey field and laboratory techniques were performed on the sites for particle size, cation exchange capacity, base saturation, pH, total elemental concentrations, free iron oxides, dithionite extractable iron, hydroxylamine manganese, and KCl exchangeable aluminum. Diatom identification was completed using standard separation techniques, a 950X microscope, and scanning electron microscopy. The soils were subsequently classified according to Soil Taxonomy.

A sequence of loess over alluvium was found on the five terrace sites. Separate depositions of Peoria, Roxana, and

Loveland loess were found on all of the five Humboldt terrace sites. A paleosol of the Loveland loess deposition was present on all five sites located on the Humboldt terrace. Total loess thickness ranged from 312 to 370 centimeters. Diatoms were not found at the loess/alluvium interface, thus the fluvial depositional environment theory remains the standard. The soils classified at the Great Group level as Udifluvents, Eutrochrepts, HapludalFs, and FragiudalFs.

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CHAPTER I

Introduction

The geology of western Tennessee is comprised of tertiary and quaternary coastal plain sands and alluvium covered by a loess veneer. The coastal plain geology is also defined by several terraces that decrease in elevation from east to west. The coastal plain region extends from the Western Tennessee River Valley westward to the Mississippi River.

A series of stream terraces were identified and delineated on the Obion, Forked Deer, Hatchie, Loosahatchie, and Wolf Rivers in western Tennessee. From lowest and youngest (closest to the Mississippi River) to highest and oldest, they are designated the Finley, Hatchie, Humboldt, and Henderson terraces (Saucier, 1987). According to Saucier (1987), these terraces originated by deposition from the Mississippi River during the late Quaternary period. Unfortunately, little field work was performed and no effort was made to collect subsurface information to substantiate these findings.

Another explanation, introduced by Geyl (1996), suggested that these terraces were relict tidal landforms or tidal paleomorphs. Using topographic sheets of the region

and classical geomorphology, Geyl concluded that the underfit streams observed throughout the region were due to sea regression and the terraces were the result. Again, no field work or subsurface information was collected to support the explanation.

Diatom assemblages were used to address the origin and formation of west Tennessee terraces. Comparisons between terrace diatom communities and the overlying alluvium diatom communities were performed to evaluate changes within the two deposits. Diatom salinity tolerance data from many sources were used to evaluate the salinity tolerances of species found in the terraces. These data will provide information on the west Tennessee diatom communities and assist in determining the geologic history of the terraces.

The study area lies in the Southern Mississippi Valley Silty Uplands Major Land Resource Area (MLRA) within the Milan Agricultural Experiment Station (USDA Soil Conservation Service, 1969) (Fig. 1). The soils of this study area are derived from a moderately deep to deep layer (approx. 1 - 4 meters) of loess over alluvium and coastal plain material. The western portion of the area is occupied by deep well drained soils on rolling to hilly relief. A majority of the soils in this region are characterized by fragipans with varying depths and thickness (Bell, 1977).

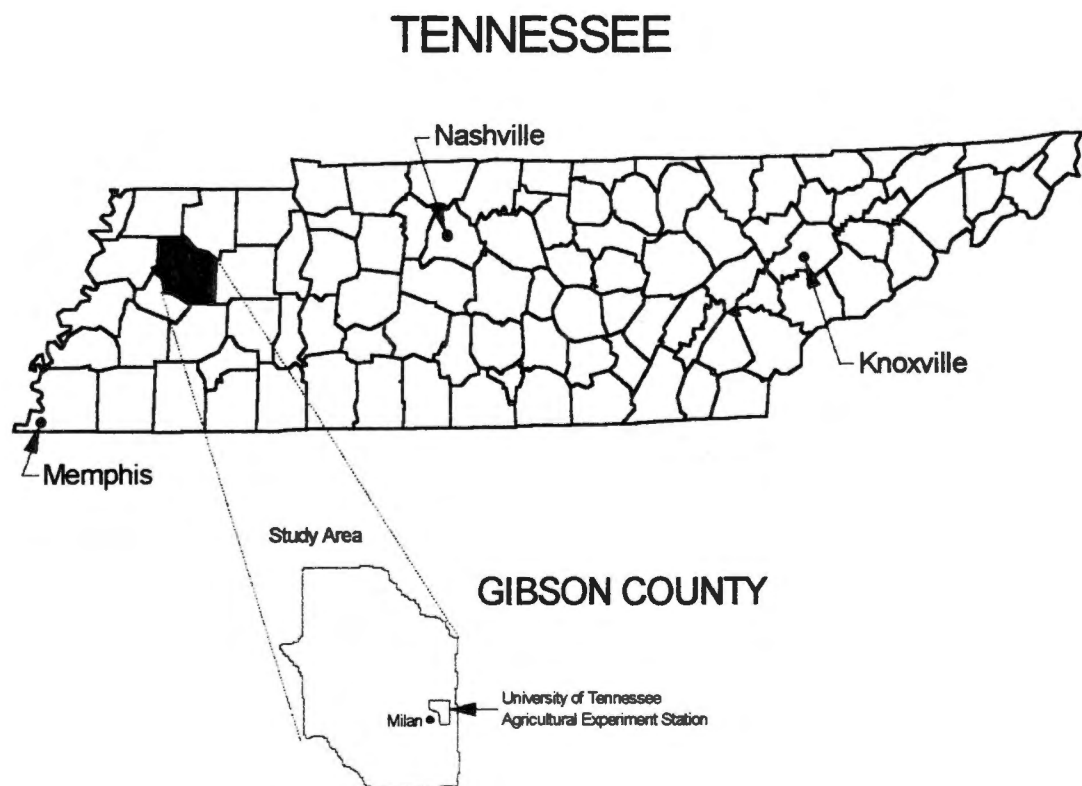


Figure 1. Location map of sample sites in Gibson County, Tennessee

The objectives of this research were to 1) fully describe and classify seven soil profiles with differing landscape positions on the Humboldt terrace in Gibson County, Tennessee, 2) study the soil geomorphological relationships between the different profiles in relation to their landscape position and use, 3) determine if there is a diatom fossil record present in the west Tennessee terraces, 4) fully classify the diatoms present using known sources, and 5) use the information obtained to draw conclusions on the terrace origin.

CHAPTER II

Literature Review

West Tennessee Geology and Soils

The geologic formations of west Tennessee began approximately 450 million years ago during the Silurian and Devonian periods of the Paleozoic era (Table 1). These periods were representative of shallow seas in west Tennessee. The Brownsport Formation (Silurian period), composed of shaly limestone, holds many excellent invertebrate fossils, including, brachiopods, cephalopods, corals, crinoids, gastropods, sponges, and trilobites (Moore, 1994). The Devonian period is also known as the Fish Age because of the abundant fish fossil record in Devonian type rocks. A few Devonian rock sites in west Tennessee mark the first occurrence of vertebrate remains in Tennessee (Miller, 1974).

The next major geologic formation sequence began approximately 150 million years with the start of the Cretaceous period of the Mesozoic era (fig. 2). The Tuscaloosa and, to a lesser extent, Eutaw formations are a collection of cherty gravel and pebbles that were deposited from highland area erosion (Roberts, 1928; Stearns, 1957). Soon after the deposition of the Tuscaloosa formation, a

Table 1. Geologic Time Scale (Geological Society of America, 1983).

Era	Period	Epoch	Approx. Age in Millions of Years Before Present
Cenozoic	Quaternary	Holocene (recent)	.01
		Pleistocene	1.6
	Tertiary	Pliocene	5.3
		Miocene	23.7
		Oligocene	36.6
		Eocene	57.8
		Paleocene	66.4
Mesozoic	Cretaceous		144
	Jurassic		208
	Triassic		245
Paleozoic	Permian		286
	Pennsylvanian		320
	Mississippian		360
	Devonian		408
	Silurian		438
	Ordovician		505
	Cambrian		570

Quaternary	Loess	
	Alluvium	
	Lafayette formation	
Tertiary	Jackson formation	
	Wilcox group	Grenada formation
		Holly Springs formation
	Midway group	Porters Creek clay
		Clayton formation
Cretaceous	Ripley formation	
	Selma formation	
	Eutaw formation	
	Tuscaloosa formation	

Figure 2. Geologic section of the embayment region of west Tennessee adapted from Stearns, 1957.

shallow sea, referred to as the Mississippi Embayment, began to encroach on the landmass (Moore, 1994). The Selma and Ripley formations are the result of sands and calcareous clays deposition during the Mississippi Embayment period. The McNairy sand inclusions near the end of the Cretaceous period are a product of the shallow sea oscillation period where the Embayment transgressed and regressed over the land surface (Roberts, 1928; Stearns, 1957; Moore, 1994).

The Tertiary stratigraphy and younger formations of west Tennessee were first described in detail by J. K. Roberts (1928) (Fig. 2). In Tennessee, the Tertiary deposits comprise lower and upper Eocene, with middle Eocene (Claiborne) being absent according to Roberts (1928). The Lower Eocene is comprised of two groups, Midway and Wilcox, and two formations within each group. The Upper Eocene period is observed in the Jackson formation and the Pliocene period is seen through the Lafayette formation. The formations consist of impure limestone, clay, sand, lignite, greensands, gravel, clay conglomerate, and numerous thin layers of ferruginous clay, sand, and gravel (Roberts, 1928). Each formation is differentiated by clear unconformities between each layer.

Stearns (1957) research indicates that the Paleocene and Eocene epochs during the Tertiary period of the Cenozoic

era record five advances and regressions of the Tertiary sea in Tennessee. The Midway group represents the Paleocene epoch, which extends from the present back to about 60 million years. The Clayton and Potters Creek formations from the Midway group are a continuation of deposition from shallow seas. The Eocene epoch contains the Wilcox, the Jackson, and the Claiborne groups. Each of these groups and formations give excellent plant and animal fossils representative of the period.

The Quaternary period is the next important time in Tennessee geologic history and the period most important to this research. The period is divided into two epochs. The Pleistocene, the older epoch, is commonly referred to as the Ice Age. It began approximately 1.6 million years ago. The Holocene, the younger epoch, represents the last 10,000 years.

During the Quaternary period, the planet experienced changes in climate from extreme cold during the Ice Age to temperature similar to present day. There is no evidence of glacial activity in Tennessee, but the recession of two major glacial stages left its mark on the west Tennessee landscape.

The Illinoian and Wisconsin glacial stages were a major influence on west Tennessee soils. As the glaciers moved,

the ice sheets cut into the earth's surface, pushing rock debris in front of the ice. As the glaciers began to melt, huge volumes of silt and tiny rock debris were washed out in the melt water. These silt particles, called loess, were then picked up by the wind and deposited onto the west Tennessee landscape. Loess layers can be several meters thick, unstratified or very finely stratified, with loess-like deposits and alternating with layers of paleosols and sand or gravel (Pesci, 1968). The main mineralogical constituents are quartz, feldspars, and calcium and magnesium carbonates with quartz being the most abundant (Pesci, 1968).

Three loess layers, the Loveland, the Late Sangamon, and the Peorian, were identified and sampled in Obion County, TN, northwest of the Milan study area, in 1947 by Wascher et al. (Table 2). The first layer deposited was called the "Loveland" loess. It was dated as pro-Illinoian age and was not present on all sites due to pre-Peorian erosion (Leighton and Willman, 1950). The buried surface layer, if present, of the Loveland loess was a light brownish yellow very compact silt loam, while the subsurface texture was always a silty clay loam and the color ranged from dark red to strong brown depending on drainage conditions (Washer et al., 1947) (Table 2).

Table 2. Data from a soil profile in Obion County, Tennessee
(Wascher et al. 1947).

Loess	Soil horizon	Depth (cm)	Munsell color notations	pH	% Sand 2-0.05 mm	% Silt 50-2 microns	% Clay <2 microns
Peorian	A	15-20	10YR 4/4	5.5	1.5	88.4	10.1
Peorian	B	63-69	7.5YR 5/6-5/8	4.8	1.4	71.3	27.3
Peorian	B (gray)	100-120	10YR 7/2-5/6	5.1	2.1	76.2	21.7
Peorian	C	200-230	7.5YR 5/6 to 10YR 7/2	5.4	1.0	81.9	17.1
Trans. to Sangamon		300-340	7.5YR 4/4 to 7.5YR 6/2	5.8	1.0	85.0	14.0
Sangamon		370-460	5YR 4/4	6.1	2.7	77.6	19.7
Loveland	A	488-533	7.5YR 6/4	6.4	7.7	70.6	21.7
Loveland	B	549-580	5YR 5/8 to 7.5YR 5/8	6.0	2.3	62.7	35.0
Loveland	C	609-640		6.2	3.0	76	21.0
Trans. to C.P.		670-700		6.3	14.4	64.8	20.8
Trans. to C.P.		730-762		6.2	53.2	37.1	9.1
Coastal Plain	A	762-790		6.7	53.8	29.8	16.4
Coastal Plain	B	800-832	10R 4/6	6.0	51.5	18.7	29.6

The second layer, dated pro-Wisconsin age, was referred to as the "Late Sangamon or Farmdale" loess. This layer may or may not be present due to variable erosion before the Peorian was deposited. It was nearly always a dark brown or redder brown and gray if poorly oxidized. The surface or uppermost layer, dated as Wisconsin age, was named the "Peorian" loess. This material contained well defined soil profiles, especially when thick and uneroded (Washer et al., 1947). The color tended to be yellowish brown, but was redder or grayer depending on drainage.

In a study of loess thickness in Illinois, Frye and Willman (1960) made some minor changes to the Washer et al. observations. The Peorian name was changed to Peoria and the Late Sangamon or Farmdale layer was referred to as Roxana loess. The Farmdale name was kept and used to name a weakly developed soil that formed in the top of the Roxana loess (Fehrenbacher et al., 1986) (Fig. 3).

Pye and Johnson (1988) identified four periods of loess deposition in Mississippi using thermoluminescence dating, geochemical and mineralogical criteria, and radiocarbon dating. The four layers coincided with the Peoria, Farmdale, Roxana, and Loveland loess previously recognized. Carbon 14 dating indicated that the carbonate rich Peoria layer was deposited between 9,000 and 20,000 years B.P. The

Peoria	9,000 - 20,000 years B.P. 70% of the total thickness yellowish brown
Farmdale	20,000 - 25,000 years B.P. yellowish brown (if present)
Roxana	76,000 - 85,000 years B.P. dark brown/dark reddish brown
Loveland	119,000 - 132,000 years B.P. red/reddish brown

Figure 3. Loess layers and ages of the Mississippi Valley adapted from Wascher et al., 1947; Frye and Willman, 1960; and Pye and Johnson, 1988.

Farmdale layer was thin and somewhat decalcified and was deposited slowly between 20,000 and 25,000 years B.P. The Roxana layer was highly weathered and was deposited between 76,000 and 85,000 years B.P. The Loveland layer was also highly weathered and deposited between 119,000 and 132,000 years B.P.

The majority of soils in this region are gently rolling uplands with bottom lands and flats along the streams (Springer et al., 1980). These soils are very productive due to the high base holding capacity of the silty parent material. The main crops grown in the region are cotton, corn, and soybeans (Springer et al., 1980). As will be shown in this research, a majority of these soils have fragipans which can lead to poor drainage and prolonged wetness in some lower lying areas.

Although the fragipans can cause problems in these soils, the biggest problem in the region is erosion. The three deposits of silt, talked about previously, initially masked the underling terrace topography of the west Tennessee region. Within the past 10,000 years, the silts have slowly been eroding away due to wind, water, and agricultural practices, resulting in a dissected landscape. The erosion process is slowly allowing the loess surface to conform to the original landscape of the underlying geology,

revealing relict stream terraces.

Saucier's Terraces

Saucier (1987) identified and delineated a series of stream terraces on the Obion, Forked Deer, Hatchie, Loosahatchie, and Wolf Rivers in western Tennessee using only large-scale topographic maps and traditional geomorphological techniques. From lowest and youngest to highest and oldest, they are designated the Finley, Hatchie, Humboldt, and Henderson terraces (Fig. 4). These terraces were identified as being formed from Mississippi River alluvial deposits during the beginning of the Quaternary period as the river regressed to its present state. The following data on terrace morphology is paraphrased from Saucier (1987),

The Finley terrace is the easiest to recognize and delineate on all the rivers. The terrace surface is presently covered by Holocene flood-plain alluvium. Lacustrine sediments do not occur at the present terrace land surface except where the loess has been eroded. The Hatchie terrace is the best preserved and is similar to the Finley terrace in most morphologic aspects. The Humboldt terrace is more difficult to map than the Hatchie and Finley terraces because the exposures are smaller and less

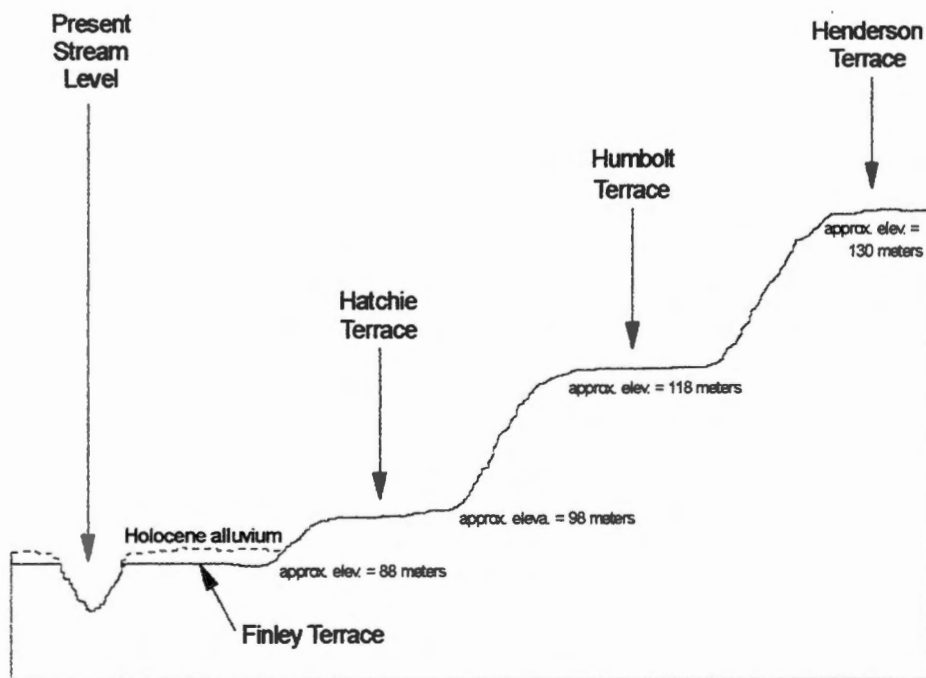


Figure 4. Cross-section of terraces in west Tennessee (Saucier, 1987).

continuous and the surface is more dissected. It has been identified on all the rivers except for the Loosahatchie and Wolf Rivers. Morphologically, this terrace lacks any clues as to its mode of origin. The Henderson terrace is only found on the upstream parts of the three forks of Forked Deer River. Since this is the oldest terrace, much of its original distribution may have been destroyed during subsequent cycles of valley degradation and aggradation and flood-plain formation.

Regional Soil Geomorphology

Geomorphology may be defined as the science which studies the nature and history of landforms and the processes of weathering, erosion, and deposition which created them (Selby, 1985). Soil Geomorphology or pedogeomorphology is an assessment of the genetic relationships of soils and landforms (Gerrard, 1992). A study of the coastal plain region encompasses three main events: the shallow seas that were present at the end of the Tertiary, the glacial movements of the Quaternary period, and the changes in river load and discharge.

The shallow seas, which originated from the Gulf of Mexico, were the first to influence the geology and landforms of western Tennessee. The brackish waters

deposited large amounts of sand, gravel, shells, and other material on the surface. This period lasted through the Tertiary period and into the beginning of the Quaternary period.

The Quaternary period ushered in a new geomorphic presence with the Ice Age. During the glacial period, sea-levels in western Tennessee and around the world began to rise and fall with each ensuing glacial movement (Dury, 1969). As mentioned in chapter one, two major glacial stages played an important role in the development of the west Tennessee landscape. It was during this time that Saucier's terraces were formed.

There are two schools of thought as to how the terraces and the general landscape of west Tennessee was developed. The first and most excepted states that the different terraces observed are due to changes in temperature and in precipitation during the glacial period. These drastic changes that occurred resulted in changes in runoff causing a profound effect on the behavior of rivers, especially channel form and pattern (Dury, 1969). As the glaciers began to melt, runoff from the glaciers would have overloaded the already present rivers and streams in the west Tennessee valley. This could account for the wide alluvial valleys in comparison to stream water levels or

underfit streams that are present today (Fig. 5). The underfit streams are then a result of a reduction in precipitation and runoff (Summerfield, 1991). Leading to the conclusion that the present day terraces were formed as stream water levels receded due to reductions in precipitation and runoff.

The second explanation for the landscape introduces the concept of tidal paleomorphs (Geyl, 1996, 1985, 1976, 1968). A tidal paleomorph is a relict tidal landform, the result of higher sea levels in the past (Geyl, 1996). As a sea retreats, it tends to leave wide valleys with underfit streams behind, similar to present day estuaries. This process does exist on the west Tennessee landscape as the majority of tributaries leading to the Mississippi River are underfit streams. Leading to a conclusion that the terraces may have been formed as the sea level decreased.

Diatoms

Diatoms are single-celled microscopic plants belonging to the algal class *Bacillariophyceae*. They are a class of plants contained in a shell, or frustule, composed of opaline silica ($\text{SiO}_2 \cdot n\text{H}_2\text{O}$) (Thurman, 1990). Because of the extreme resistance to decay of these diatom frustules, they remain intact for long periods of time and constitute some

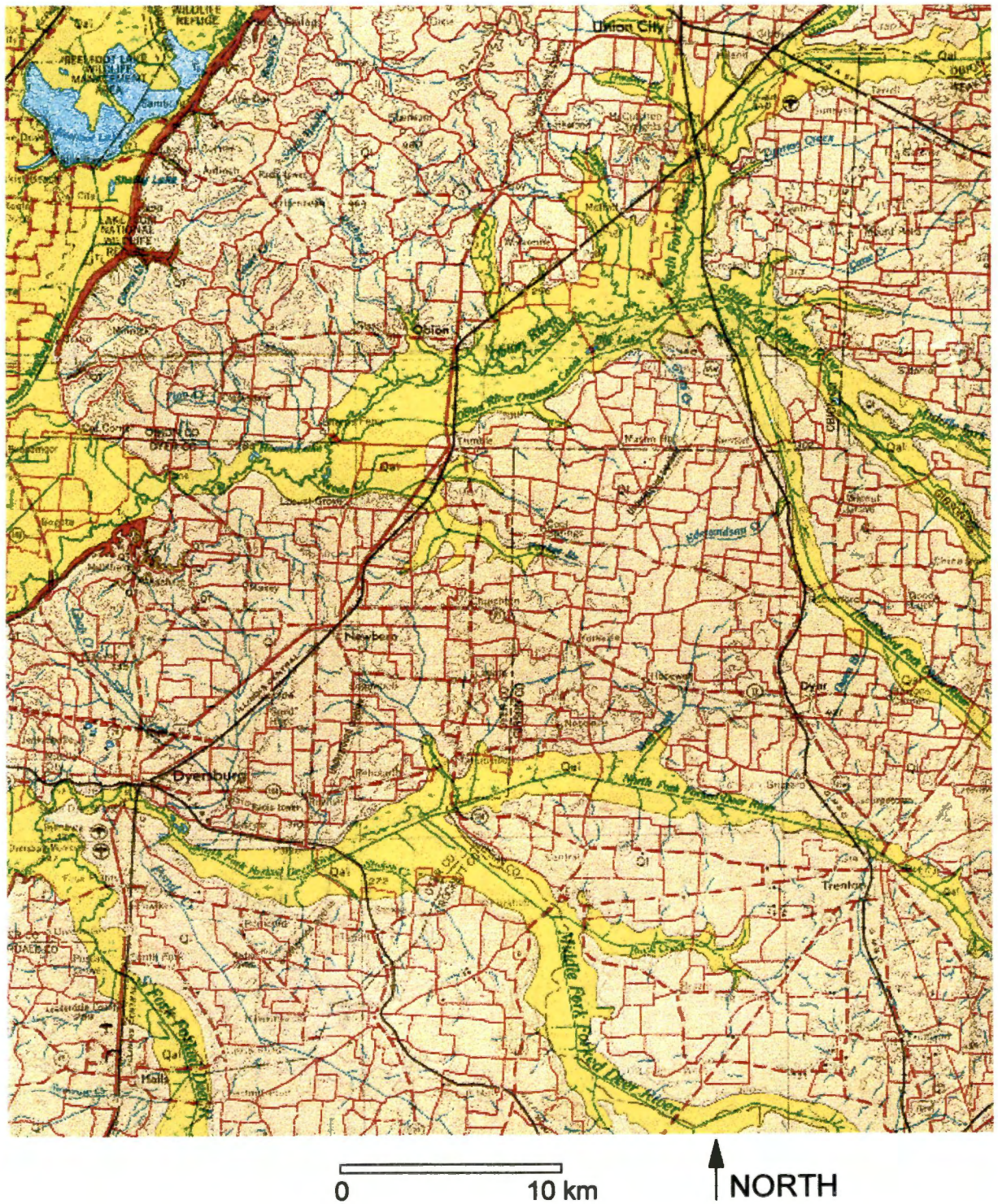


Figure 5. Illustration of the wide alluvial valleys and underfit streams present in west Tennessee (USGS Geologic Map, West Sheet, 1966).

of the best algal fossils ever found (Brock & Madigan, 1991). Each cell wall is made up of two main pieces, called valves, and belt-like elements that hold the valves together, called girdle bands. The taxonomy of diatoms is based on the unique, ornamented structure of the valves, and it is the valves that are measured and counted in ecological studies of diatom communities (Dixit et al., 1992; Patrick & Reimer, 1966).

It has long been recognized that many diatom taxa have distinct ecological requirements and tolerances in regard to a variety of water quality parameters (Reid et al., 1995). Before the 1980's, it was difficult to relate the diatom tolerances to specific environmental change because of all the variables that could be related to their habitation in a certain environment. However, with the development of applicable multivariate statistical techniques (Prentice, 1986; Smol, 1990), the potential of diatoms as water quality indicators has been realized. These techniques have assisted in relating both past and present environmental change to diatom assemblages.

Biological indicators are extremely valuable in assessing water quality. Diatoms possess a number of attributes which contribute to their suitability as biological indicators. These attributes include: (1) they

occur in almost all aquatic environments and are abundant (Round, 1993). (2) their taxonomy is well established and documented (Patrick & Reimer, 1966). (3) they are sensitive to changes in water chemistry (Fritz et al., 1993; Yang & Dickman, 1993). (4) microscope slides are permanent (Round, 1993). (5) they are well preserved in lake sediments (Hall & Smol, 1992).

The assemblages of diatoms preserved in marine sediments can directly reflect the floristic composition and productivity of diatom communities, and can indirectly reflect water quality, especially pH and alkalinity, nutrient status, and salinity (Battarbee, 1986).

Diatoms and Salinity

Diatoms were identified and enumerated from the surface sediments of 65 lakes located on the Cariboo and Chilcotin Plateau (British Columbia, Canada) in a 1993 paper by Cumming & Smol (Fig. 6). The project objectives were to document the diatom communities in 65 lakes that span a broad range in salinity values (freshwater to $>50 \text{ g l}^{-1}$), examine and model the response of individual diatom taxa to salinity and ionic composition, and develop quantitative inference models based on the relationship between diatom composition and salinity. Sample were taken and

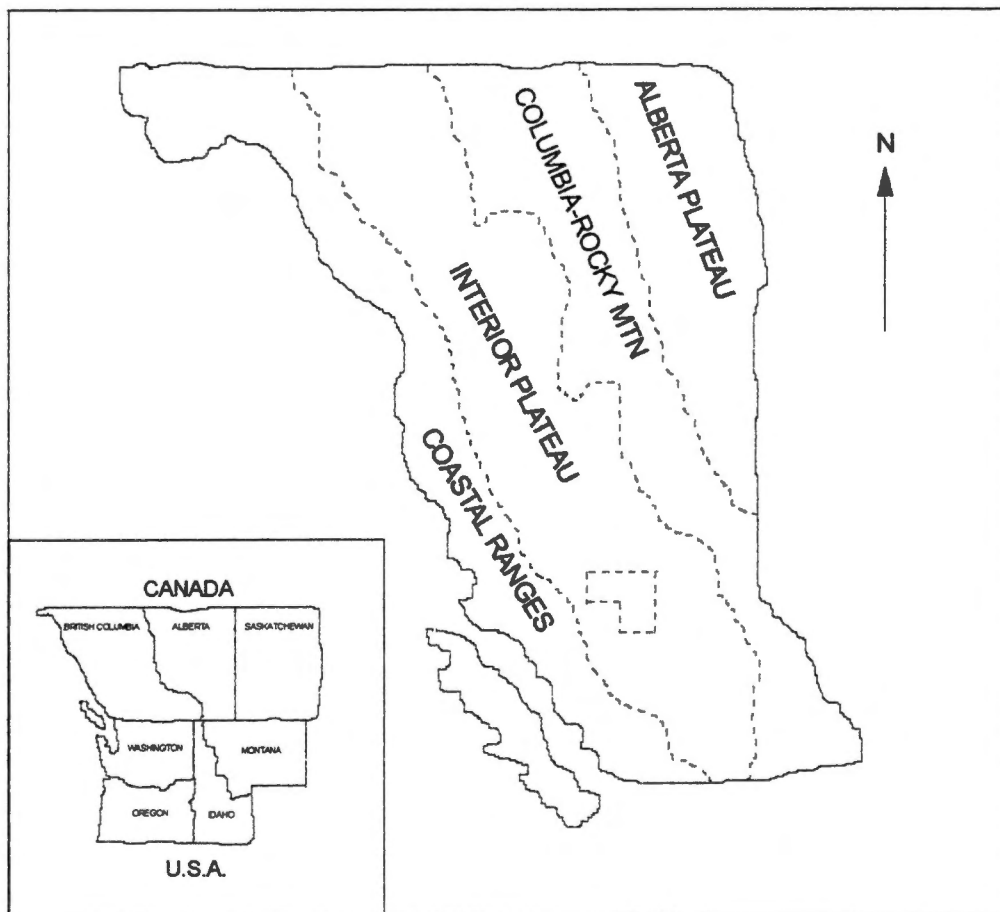


Figure 6. Location of the 65 calibration lakes located in British Columbia used in Cummins and Smol (1993).

environmental variables were measured from each lake.

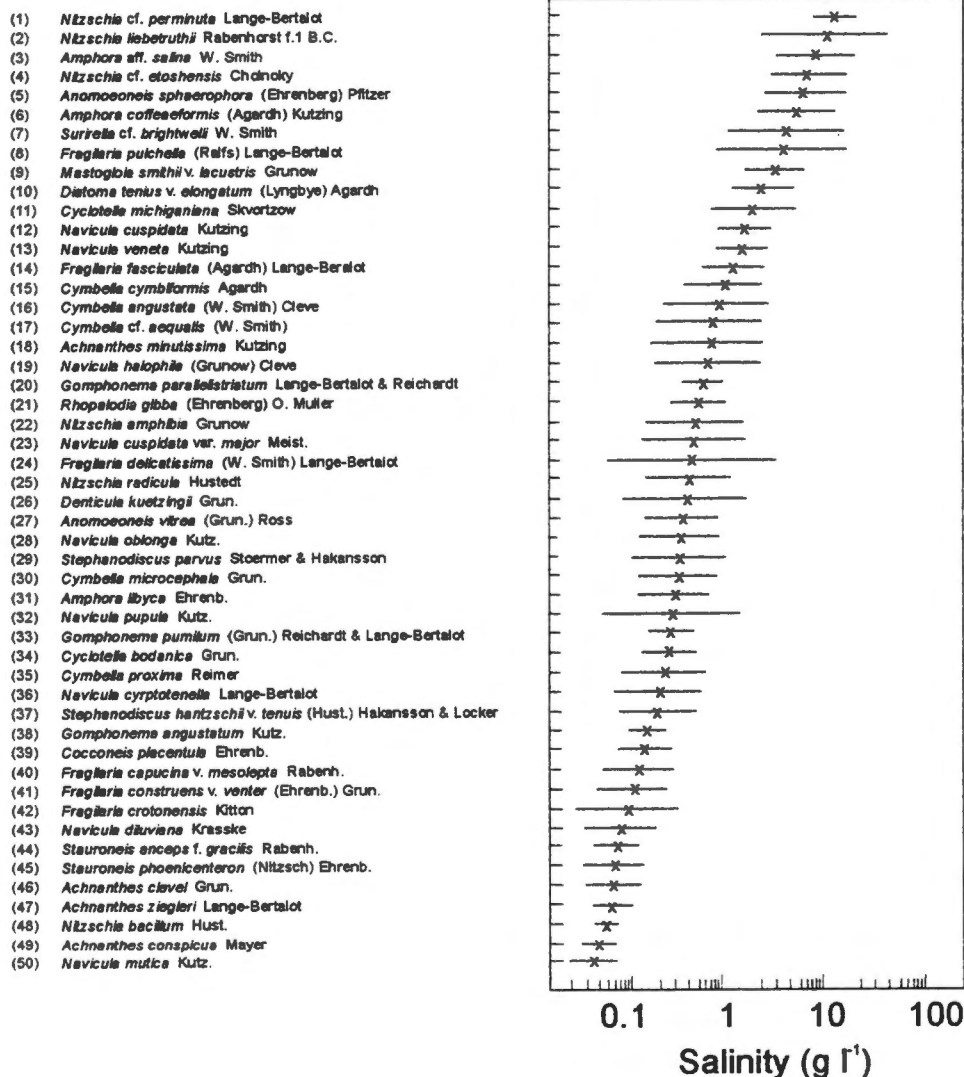
Canonical correspondence analysis (CCA), a constrained ordination technique, was used to identify which environmental variables could directly account for variations observed in the diatom data (Ter Braak, 1986, 1987). From the CCA biplot, it was shown that salinity was the most important environmental variable in terms of diatom communities. The optima and tolerances of the diatom taxa to lakewater salinity were estimated by a weighted-average and weighted standard deviation (Table 3). The "weight" was the relative abundance of a taxon in a particular lake.

Fritz et al. (1993) performed a similar experiment in the lakes of the northern Great Plains, North America (Fig. 7). The distribution of diatoms with respect to salinity was studied in lakes with a range from freshwater to 270 g l⁻¹. Canonical correspondence analysis of diatoms in the surface sediments of 66 lakes and associated water chemistry data indicated that diatom distributions are highly correlated with salinity (Table 4).

History of Soil Classification

Before the mid-1800's, soils were seldom thought of as much more than the top layer of rock on the earth's mantle and a medium for plant growth (Simonson, 1968). Little time

Table 3. Estimated salinity optima and tolerances of diatom taxa (Cumming and Smol, 1993).



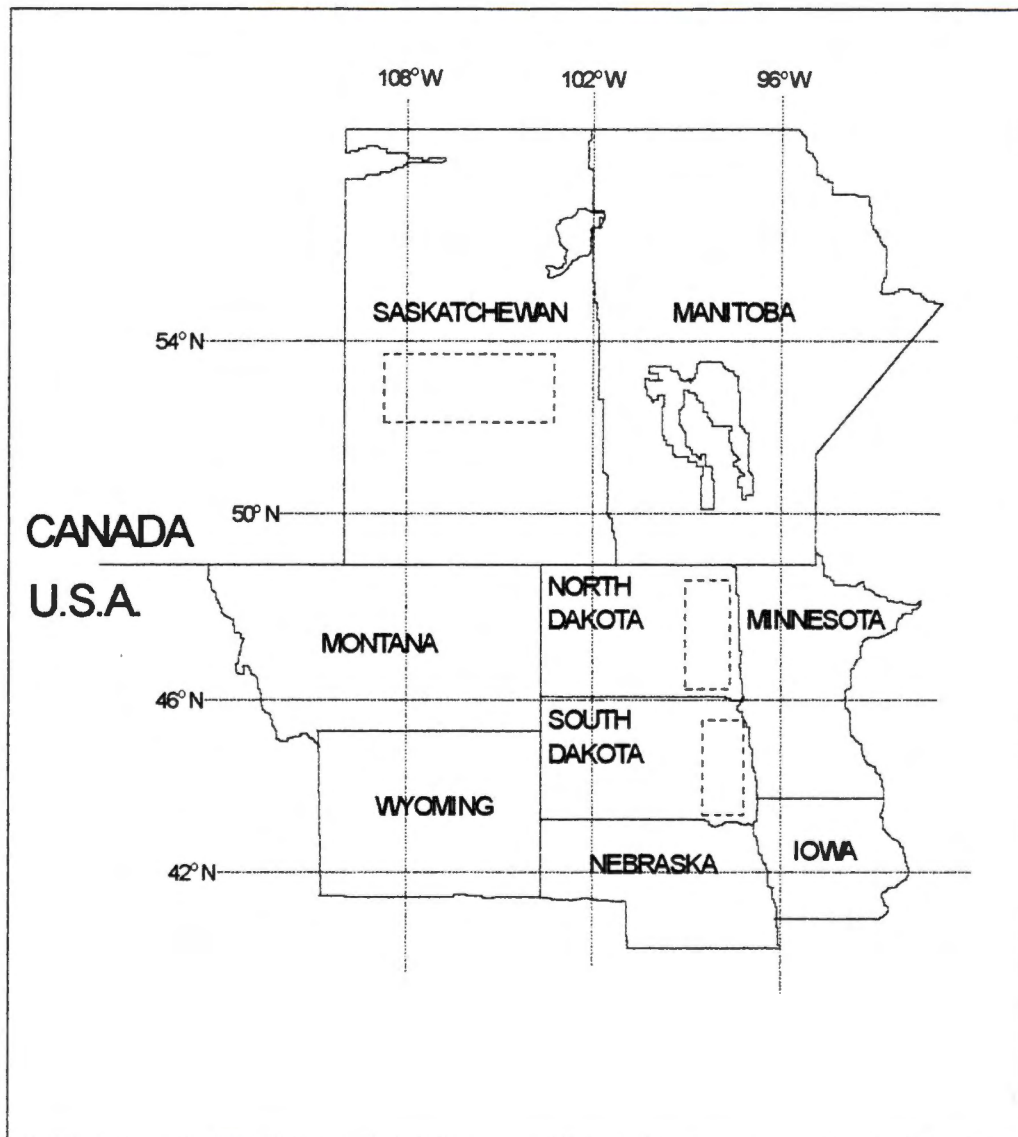


Figure 7. Location of study area for Fritz et al. (1993).

Table 4. List of all taxa in the calibration set for Fritz et al. (1993). Maximum abundance (%) and salinity units ($g\ l^{-1}$).

TAXON NAME	SITES	MAXIMUM ABUNDANCE	SALINITY OPTIMUM	LOWER LIMIT	UPPER LIMIT
<i>Achnanthes clevei</i>	3	1.54	23.87	17.40	32.73
<i>Achnanthes linearis</i>	2	2.21	2.81	2.08	3.81
<i>Achnanthes microcephala</i>	3	3.78	2.58	1.68	3.95
<i>Achnanthes microcephala</i>	12	3.78	2.83	1.71	4.67
<i>Amphipleura cf. rubilis</i>	4	3.44	20.80	18.45	23.44
<i>Amphipleura acutiuscula</i>	5	2.79	13.21	4.87	35.82
<i>Amphipleura coffeaeformis</i>	19	11.58	8.46	2.84	25.21
<i>Amphipleura ovalis</i>	5	4.90	4.20	1.59	11.08
<i>Amphipleura ovalis</i> var. <i>affinis</i>	24	28.44	2.95	1.06	8.08
<i>Amphipleura ovalis</i> var. <i>affinis</i>	15	4.28	4.23	1.42	12.63
<i>Amphipleura perpusilla</i>	3	3.08	2.34	1.19	4.60
<i>Amphipleura veneta</i>	15	5.88	7.32	3.29	16.25
<i>Amphora cf. coffeaeformis</i>	1	1.23	18.75	16.45	18.05
<i>Amphora</i> sp. 3	2	3.91	9.88	2.61	35.80
<i>Amphora micrometra</i>	1	1.45	18.75	18.45	18.05
<i>Anomoeoneis costata</i>	29	22.00	3.76	1.96	7.22
<i>Anomoeoneis sp. 2.</i>	6	38.10	5.97	3.97	8.88
<i>Asterionella formosa</i>	5	4.35	1.64	1.06	2.53
<i>Aulacoseira ambigua</i>	8	9.05	0.76	0.63	0.86
<i>Aulacoseira granulata</i>	11	35.50	1.03	0.49	2.18
<i>Aulacoseira granulata</i> var. <i>angustissima</i>	1	2.03	0.87	0.66	0.66
<i>Caloneis beccium</i>	1	2.77	18.92	18.62	19.22
<i>Campylodiscus clypeus</i>	22	28.67	4.75	2.21	10.18
<i>Chaetoceros eimrozmuelleri</i> cysts	38	60.15	12.03	4.75	30.49
<i>Cocconeis dimidiata</i>	7	12.38	5.26	3.30	8.39
<i>Cocconeis pediculus</i>	11	14.08	46.77	8.16	34.46
<i>Cocconeis plecentula</i>	21	41.98	2.31	1.00	5.37
<i>Cocconeis plecentula</i> var. <i>euglypta</i>	12	5.39	8.87	4.20	18.69
<i>Cocconeis plecentula</i> var. <i>linealis</i>	22	5.80	5.02	1.58	9.75
<i>Cyclotella bodanica</i>	7	41.29	2.07	1.03	4.19
<i>Cyclotella caspie</i>	5	1.87	1.80	0.85	3.82
<i>Cyclotella meneghiniana</i>	15	37.88	21.32	14.51	31.30
<i>Cyclotella meneghiniana</i>	40	45.83	3.36	1.16	9.86
<i>Cyclotella meneghiniana</i>	4	2.38	1.55	0.66	3.65
<i>Cyclotella quilenensis</i>	28	95.00	20.56	4.76	88.74
<i>Gymbella gymbiiformis</i> var. <i>nonpunctata</i>	5	2.21	2.00	1.25	3.21
<i>Gymbella microcephala</i>	3	1.53	2.16	1.33	3.56
<i>Gymbella minuta</i>	3	1.69	2.34	0.88	8.23
<i>Gymbella muelleri</i>	3	1.11	1.17	0.68	2.01
<i>Gymbella muelleri</i> forma <i>ventricosa</i>	5	2.04	2.31	1.46	3.67
<i>Gymbella pusilla</i>	22	48.71	8.54	3.16	23.11
<i>Denticula elegans</i>	1	1.88	8.92	8.78	9.06
<i>Diatoma tenue</i> var. <i>elongatum</i>	16	5.08	7.86	3.13	20.27
<i>Diploneis smithii</i>	1	1.39	18.92	18.62	19.22
<i>Epithemia pallidosa</i>	2	1.37	4.32	2.40	7.78
<i>Epithemia argus</i>	5	1.28	2.17	1.33	3.52
<i>Epithemia adriata</i>	5	1.14	2.72	1.43	5.16
<i>Epithemia turpida</i>	5	2.00	2.82	1.83	4.65
<i>Fragilaria brevistriata</i>	9	13.95	1.72	0.48	6.19
<i>Fragilaria brevis</i> var. <i>inflata</i>	8	35.02	1.49	0.74	2.99
<i>Fragilaria capucina</i> var. <i>masculipa</i>	8	54.43	1.08	0.70	1.62
<i>Fragilaria constans</i>	6	3.25	1.00	0.72	1.38
<i>Fragilaria constans</i> var. <i>veneta</i>	9	5.50	2.44	0.61	9.74
<i>Fragilaria craticulata</i>	2	31.71	1.86	1.27	8.74
<i>Fragilaria inflata</i>	1	25.25	0.88	0.67	0.89
<i>Fragilaria pinata</i>	12	1.81	2.95	0.83	10.54
<i>Fragilaria vaucheriae</i>	10	24.12	2.50	1.89	3.30
<i>Gomphonema olivaceum</i>	5	18.81	2.95	2.41	3.81
<i>Gomphonema angustatum</i>	4	2.19	2.39	1.83	5.93
<i>Gomphonema dichotomum</i>	8	16.81	2.75	2.08	3.64
<i>Gomphonema intusatum</i>	3	2.76	0.87	0.82	0.93
<i>Gomphonema parvulum</i>	3	2.47	2.49	1.36	4.47
<i>Gomphonema subclevatum</i> var. <i>commutatum</i>	1	1.14	5.81	5.72	5.90
<i>Navicula arenaria</i>	2	2.76	0.92	0.58	1.46
<i>Navicula bulnheimii</i>	8	15.93	28.43	17.90	38.02
<i>Navicula capitata</i>	15	20.05	1.28	2.74	2.74
<i>Navicula capitata</i> var. <i>hungarica</i>	18	41.87	3.98	2.55	6.14

Table 4. continued

TAXON NAME	SITES	MAXIMUM ABUNDANCE	SALINITY OPTIMUM	LOWER LIMIT	UPPER LIMIT
<i>Navicula car</i>	2	1.25	0.93	0.40	2.14
<i>Navicula cincta</i>	23	64.73	9.30	4.69	18.45
<i>Navicula crucicula</i>	3	1.79	22.03	10.15	47.84
<i>Navicula cryptocophale</i>	9	5.00	2.71	0.86	8.57
<i>Navicula gracilis</i>	16	2.85	2.20	1.19	4.07
<i>Navicula gracilis</i>	7	1.09	2.77	1.47	5.20
<i>Navicula halophila</i>	18	5.82	5.33	1.65	17.24
<i>Navicula halophila forma subcapitata</i>	2	12.19	6.55	1.50	26.56
<i>Navicula incerta</i>	5	2.30	21.10	18.03	24.68
<i>Navicula incerta</i>	18	32.34	2.48	1.50	4.10
<i>Navicula oblonga</i>	3	2.25	0.65	0.44	1.63
<i>Navicula pupula</i> var. <i>rectangularis</i>	4	4.28	5.24	2.97	9.23
<i>Navicula radiosa</i> var. <i>tenella</i>	1	1.25	0.65	0.84	0.86
<i>Navicula reinhardtii</i>	2	2.27	2.16	0.58	8.01
<i>Navicula salinarum</i>	9	11.99	4.94	1.05	23.23
<i>Navicula veneta</i>	10	9.36	11.33	4.73	27.15
<i>Navicula viridula</i>	5	9.34	1.09	0.56	2.14
<i>Navicula viridibilis</i>	1	26.33	1.77	1.74	1.80
<i>Navicula cf. cryptocophale</i>	2	5.72	2.46	2.25	2.89
<i>Navicula cf. rhyzocophale</i> var. <i>amphiceros</i>	1	5.32	9.90	9.74	10.06
<i>Navicula cf. seminulum</i>	4	2.86	33.16	24.09	45.64
<i>Navicula cf. spicula</i>	2	2.67	1.76	1.74	1.79
<i>Nedum erdis</i>	24	12.33	1.67	1.17	3.01
<i>Nitzschia amphibia</i>	1	1.02	2.06	2.03	2.09
<i>Nitzschia angustata</i>	13	14.94	11.07	5.23	23.44
<i>Nitzschia compressa forma minor</i>	4	20.11	4.25	3.09	5.84
<i>Nitzschia conscripta</i>	6	2.03	2.84	1.07	7.53
<i>Nitzschia denticula</i>	2	1.25	0.86	0.82	0.93
<i>Nitzschia dissipata</i>	16	17.82	2.17	1.21	3.89
<i>Nitzschia frutulum</i>	27	11.81	9.55	3.03	30.11
<i>Nitzschia hungarica</i>	15	47.17	18.45	6.28	43.09
<i>Nitzschia inornata</i>	6	1.05	2.72	1.86	3.77
<i>Nitzschia linearis</i>	5	1.56	11.11	4.54	27.18
<i>Nitzschia obtusa</i>	15	5.81	2.89	1.32	6.32
<i>Nitzschia paleacea</i>	5	2.38	2.17	0.87	0.57
<i>Nitzschia superciliosa</i>	1	30.17	18.75	18.45	19.05
<i>Nitzschia subtilis</i>	13	1.26	0.71	0.70	0.72
<i>Nitzschia bythionella</i>	2	7.84	3.43	3.30	3.55
<i>Nitzschia cf. bythionella</i>	24	67.99	13.91	5.61	34.48
<i>Nitzschia cf. fonticola</i>	3	1.63	3.29	1.52	7.14
<i>Nitzschia cf. palea</i>	13	12.75	7.91	5.29	11.63
<i>Opaphora cf. ostenii</i>	5	4.56	6.89	4.15	10.80
<i>Pleuropterus arzonica</i>	27	25.36	4.36	2.02	8.55
<i>Rhizocaphene curvata</i>	21	9.91	3.57	2.02	6.29
<i>Rhopilechia gibba</i>	2	2.51	0.85	0.83	0.86
<i>Stephanodiscus alpinus</i>	16	86.53	2.06	1.07	3.97
<i>Stephanodiscus hantzschii</i>	21	13.00	1.29	0.55	3.04
<i>Stephanodiscus niagarae</i>	23	68.65	2.25	1.08	4.76
<i>Stephanodiscus parvus</i>	4	11.75	1.55	1.12	2.14
<i>Stephanodiscus cf. medius</i>	2	1.00	1.44	0.22	9.25
<i>Surrella linearis</i>	20	5.75	2.54	0.73	8.62
<i>Surrella ovalis</i>	9	32.84	7.13	4.17	12.18
<i>Surrella ovalis</i> var. <i>crumena</i>	20	36.84	3.27	1.92	5.56
<i>Surrella striatula</i>	12	4.30	7.03	3.64	13.56
<i>Synedra acuta</i>	4	2.21	1.33	1.15	2.74
<i>Synedra acuta</i> var. <i>angustissima</i>	3	2.00	0.75	0.63	0.86
<i>Synedra bacilliformis</i>	29	13.07	6.70	2.89	15.54
<i>Synedra fasciculata</i>	1	3.07	2.06	2.03	2.09
<i>Synedra parasitica</i>	3	2.06	1.86	0.74	3.69
<i>Synedra parasitica</i>	29	7.69	10.32	4.44	23.99
<i>Synedra pulchella</i>	12	1.36	1.63	0.89	2.97
<i>Synedra ulna</i>	5	5.93	2.08	0.70	6.17
<i>Synedra cf. filiformis</i>	1	2.91	18.75	18.45	19.05
<i>Thalassiosira hantzschii</i>	1	1.71	3.84	3.76	3.90
<i>Thalassiosira latus</i>	4	4.63	1.64	1.02	2.65

was taken into studying the genesis and classification of soils. The majority of research during this period was concerned with ways of improving the physical and chemical properties for the enhancement of plant growth. It was not until the mid to late 1800's that soils began to be recognized as organized natural bodies worthy of scientific study (Simonson, 1968).

In 1883 V.V. Dokuchaev, the founder of pedology, published a report on a field study of Chernozems (Buol et al., 1989). *Russian Chernozem* was the first report to discuss principles of soil morphology, soil genesis, soil classification, and soil mapping methods (Boul et al., 1989). Although considering vegetation to be the most important factor in soil formation, Dokuchaev is commonly given credit for first noting the relationship of soil forming factors (parent material, climate, organisms, relief, and time) to soil genesis (Fanning et al. 1989).

A vast majority of Dokuchaev's work could have gone unnoticed if it were not for the work of two of his students, Sibertzev and Glinka. A textbook by Sibertzev, *First Course in Soil Science*, was completed in 1900. It discussed specific characteristics of Chernozems and Podzols and was the first full statement of the findings of the new school of pedology (Simonson, 1968). Glinka was

instrumental in making Dokuchaev's work available to Americans by translating many reports into German and publishing them in his own textbook in 1914 (Soil Survey Staff, 1993). These works were later translated into English by C.F. Marbut, while director of the U.S. Soil Survey Division, in 1927 (Buol et al., 1989) (Soil Survey Staff, 1993).

During this same period of time, soil genesis research was being conducted in the United States. In 1860, E.W. Hilgard, published the *Report on the Geology and Agriculture of the State of Mississippi*. The first half of the report focused on geology, while the second half dealt with soils, their nature and their management (Jenny, 1961). Before the report, Hilgard had studied geology and worked as the state geologist for Mississippi. Upon completion of the report, Hilgard became the first pedologist in the United States (Soil Survey Staff, 1993).

Near the end of the nineteenth century, the National Soil Survey Program was developed by Professor Milton Whitney (Jenny, 1961). Whitney surrounded himself with the best scientists available in order to take soil survey and classification to the next level. In 1909, Whitney published the first American soil classification system incorporating physiographic region, geologic parent

materials, and soil texture (Buol et al., 1989).

The period of greatest growth in soil classification came during C.F. Marbut's tenure as director of the USDA Soil Survey Division. Marbut took examples from both Russia and the United States in order to develop the first multi-categorical classification system (McDonald, 1994). In 1938, with help from Kellogg and Thorp, a revision of Marbut's classification was published as the 1938 *USDA Yearbook of Agriculture, Soils and Men*. This publication was a qualitative classification of all known soils in the United States (Soil Survey Staff, 1993).

With the publication of *Factors of Soil Formation* in 1941, Hans Jenny brilliantly illustrated and summarized many basic principles of modern soil science in a quantitative platform (Jenny, 1941). In the years preceding this masterful treatise, classification schemes were described solely on a qualitative basis resulting in inconsistent soil classifications. Jenny's introduction of the five soil forming factors along with scientific advances in soil physics, soil chemistry, soil biology, and soil mineralogy, paved the way for a quantitatively based classification system.

A new modern period in the history of soil classification began with a revision of the 1938 *Yearbook*,

Soils and Men. Soil classification began to pass through a series of approximations from lower categories to higher, detailed categories. This process reduced homogeneity and allowed for differing characteristics within each profile to predominate resulting in a detailed quantitative classification (Cline, 1949).

With the help of soil scientists and universities throughout the United States, Guy Smith, as the director of Soil Survey Investigations for the USDA-SCS, developed a definite series of approximations of soil taxonomy. This modern soil classification was published as *Soil Taxonomy* in 1975 and, with the exception of some minor changes, is the present standard for soil classification in the United States (McDonald, 1994).

CHAPTER III

Materials and Methods

Field Methods

Seven sites were chosen and sampled on the University of Tennessee Milan Agricultural Experiment Station (Fig. 8 & 9). Table 5 outlines the location of each site using elevation, latitude, and longitude data obtained from the Atwood, Tennessee 7.5 minutes series topographic quadrangle (1966). Sites 1-4 dissected the Northern tract of the station, while sites 5-7 dissected the Southern tract of the station. Sites 1 - 5 were located on the Humboldt terrace. Sites 6-7 were located on a lower lying flood plain. Core samples were taken to a depth of approximately 4 meters using a Giddings soil probe.

Each core was described morphologically. Each horizons' depth, color, texture, structure, and other prominent soil properties were noted. A representative sample from each morphologic horizon was obtained and approximately 3 kg were mixed and placed in plastic bags for use in further laboratory analysis (Soil Survey Division Staff, 1993).

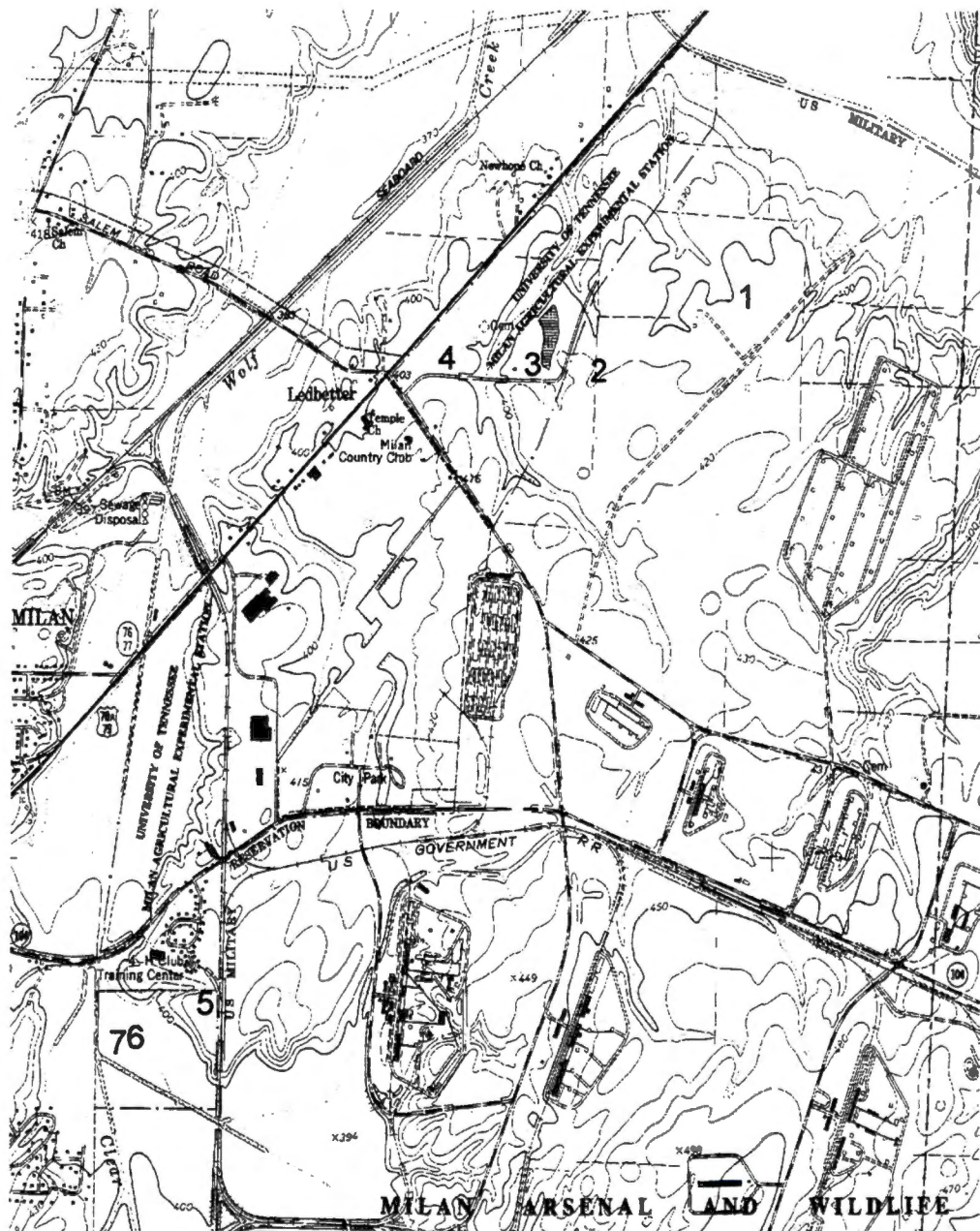


Figure 8. Location of sites on the Milan Experiment Station (USGS, 1966).

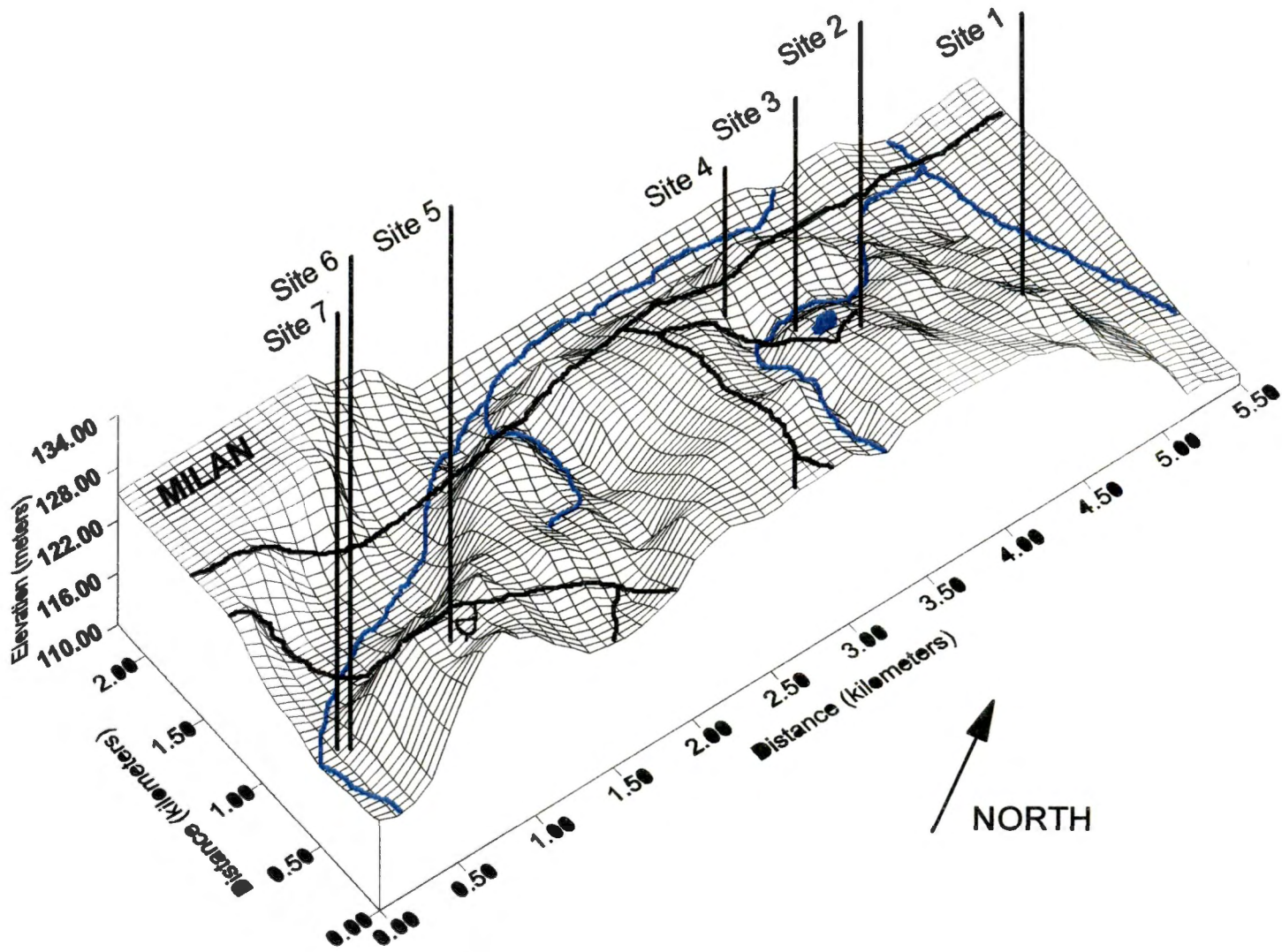


Figure 9. Three-dimensional view of Milan and the Humboldt terrace.

Table 5. Latitude, longitude, and elvation for
all seven sites.

Site	North Latitude	West Longitude	Elevation (m)
1	35 56 14 N	88 42 36 W	122.5
2	35 56 04 N	88 43 06 W	125
3	35 56 04 N	88 43 18 W	124
4	35 56 07 N	88 43 33 W	123
5	35 54 42 N	88 44 22 W	125
6	35 54 38 N	88 44 36 W	119
7	35 54 38 N	88 44 39 W	117

Laboratory Methods

Sample Preparation

All samples were air-dried and passed through a 2 mm diameter sieve. The < 2 mm fraction was thoroughly mixed and one fourth of each sample was finely ground and passed through a 60 mesh sieve for use in total elemental analysis (Soil Surv. Staff, 1984).

Physical Analysis

Particle size distribution of clay, silt, and sand size fractions was determined using a sand sieving and sedimentation-pipette method (Kilmer and Alexander, 1949). Sand fractions were sieved into very coarse, coarse, medium, fine, and very fine sand sizes (Gee and Bauder, 1986). Silt, fine silt, clay and fine clay fractions were determined gravimetrically by removing aliquots from the soil suspension at specified times.

Chemical Analysis

Cation exchange capacity was determined using a direct displacement method with 1 N ammonium acetate, extracted with an acidified NaCl solution, and analyzed using a LabConco distillation unit and titration with 0.01 N HCl

(Chapman, 1965). Exchangeable bases were extracted by saturation with 1 N ammonium acetate at pH 7 and analyzed using the Perkin-Elmer 5000 Atomic Absorption Spectrophotometer (Jackson, 1958; Hammer and Lewis, 1987; and Baker and Suhr, 1982).

Base saturation was mathematically determined by dividing the amount of all bases into CEC. Extractable acidity was determined by the BaCl_2 - TEA procedure and used to distinguish between Alfisols and Ultisols when necessary (Peech, 1965) (Soil Survey Staff, 1996). Exchangeable aluminum was determined by extraction with 1N potassium chloride and analyzed using atomic absorption (Thomas, 1982). Exchangeable aluminum was used to determine the effective cation exchange capacity of the soil. Exchangeable acidity was determined by extraction with 1 N potassium chloride and titration with a standard 0.01 N sodium hydroxide solution (Thomas, 1982).

Free iron, manganese, and aluminum oxides were determined using the dithionite extractable method as outlined by Olsen and Ellis (1982). Easily reducible manganese in solution was determined by using an hydroxylamine hydrochloride extraction outlined by Chao (1972).

Total elemental concentrations were determined using a

modified microwave dissolution technique and analyzed using an ICAP (Ammons et al., 1995).

A combination pH electrode and a 1:1 soil sample to water ratio was used to determine pH (McLean, 1982). A pH measurement in 0.01M CaCl₂ was also taken to evaluate the salt effect (Rowell, 1993).

Total carbon, nitrogen, and sulfur were analyzed on the Leco-CNS 2000. Percent organic mater and organic carbon were evaluated using the Walkley-Black method (Jackson, 1958). Because of the low pH and the small percentage of carbon in the system, total carbon data was assumed to be composed of all organic material.

Mineralogy in the silt fraction was determined on the control section using powder mounts and X-ray diffraction. This data was used for taxonomic classification of mineralogy at the family level.

Diatom Analysis

There are a number of ways of extracting diatoms from sediments for slide preparation. Care was taken at all stages not to lose or damage valves, and occasional checks for such events were made by examining treated material before, during, and after the various stages of preparation.

Three kinds of sedimentary material were removed in

order to obtain a satisfactory slide preparation, and the techniques used for these procedures are as follows

(Battarbee, 1986) (Fig. 11):

- (1) *Salts soluble in hydrochloric acid.* Carbonate and many metal salts and oxides were removed by treatment with dilute hydrochloric acid. A small quantity of sediment was placed into a beaker and covered with 10% HCl. This was agitated and heated gently for about 15 minutes, centrifuged, and washed in distilled water.
- (2) *Organic matter.* Organic matter was removed by oxidation with 30% H₂O₂ and gently heated on a hotplate until all organic matter was removed.
- (3) *Mineral matter.* Mineral matter was removed to have good slide preparation. This was accomplished by swilling in a beaker and decanting in the presence of ammonium hydroxide solution.

All diatom examination were carried out using oil immersion objectives and magnifications of 950X and scanning electron microscopy.

Data Analysis

Fine sand ratios (fine sand/(total sand+silt)*100) and fine clay percentages were determined and plotted against each other to locate possible lithologic discontinuities,

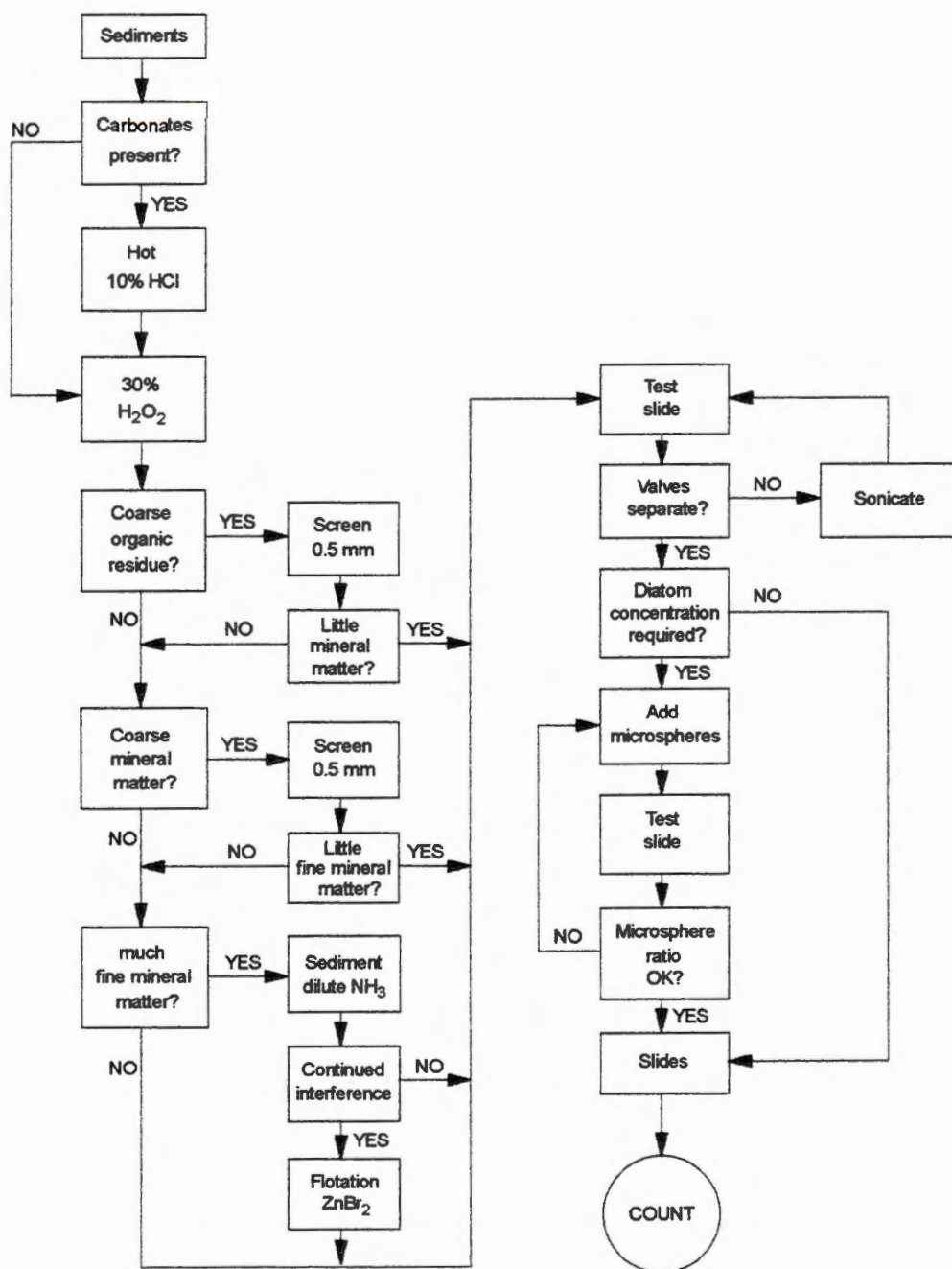


Figure 10. Flowchart for the laboratory preparation of diatoms from lake sediment (Batterbee, 1986).

especially between the loess and alluvium (Soil Survey Staff, 1995). Free iron and total iron have been used in soil profiles as indicators of soil age (Arduino et al., 1986). They were plotted against each other to evaluate changes in age between the loess layers.

Titanium on a silt basis and a titanium/zirconium ratio were used in the analysis of parent materials (Chapman and Horn, 1968). Titanium was chosen because of its relative stability over time compared to other elements. Titanium was analyzed on a silt basis because most of the titanium minerals are found in the silt fraction of soils (Chapman and Horn, 1968; Essington and Mattigod, 1990). Titanium was calculated on a silt basis by the following equation:

$$\frac{\text{Total soil titanium (mg kg}^{-1}\text{)}}{\text{Percent silt fraction (\%)}} \times 100$$

The titanium/zirconium ratio was determined using total elemental data from the ICAP and plotted to assist in identifying different depositions.

Total carbon content distribution curves were plotted to evaluate weathering patterns and check for buried surface horizons.

Morphological properties, such as soil structure and Munsell color, were also valuable identifiers of discontinuities.

CHAPTER IV

Results and Discussion

Site 1

This site is located on an upland position under a corn plot at an elevation of 122.5 meters above mean sea level (402 feet). The soil morphology of site 1 was described to a depth of 384 cm (Fig. 11). The parent material sequence for this site is loess over alluvium.

The Peoria loess layer as described by Wascher et al. (1947), extends from the surface to a depth of 134 cm (Fig. 11). A free iron oxide bulge occurs between 0 and 134 cm with the highest point being in the second, Bw1, horizon at 23 cm (Fig. 12). There is a slight increase in the fine clay percentage, which is to be expected. There is also a sharp increase in the titanium/zirconium ratio at the 23 cm depth (Fig. 13). The titanium on a silt basis remains constant throughout the first 134 cm, confirming the absence of a lithologic discontinuity (Fig. 13). The colors are 10YR 4/4 throughout most of the loess layer described as Peoria.

A second loess layer extends from 134 cm to 201 cm (Fig. 11). It has Roxana properties, but could be a

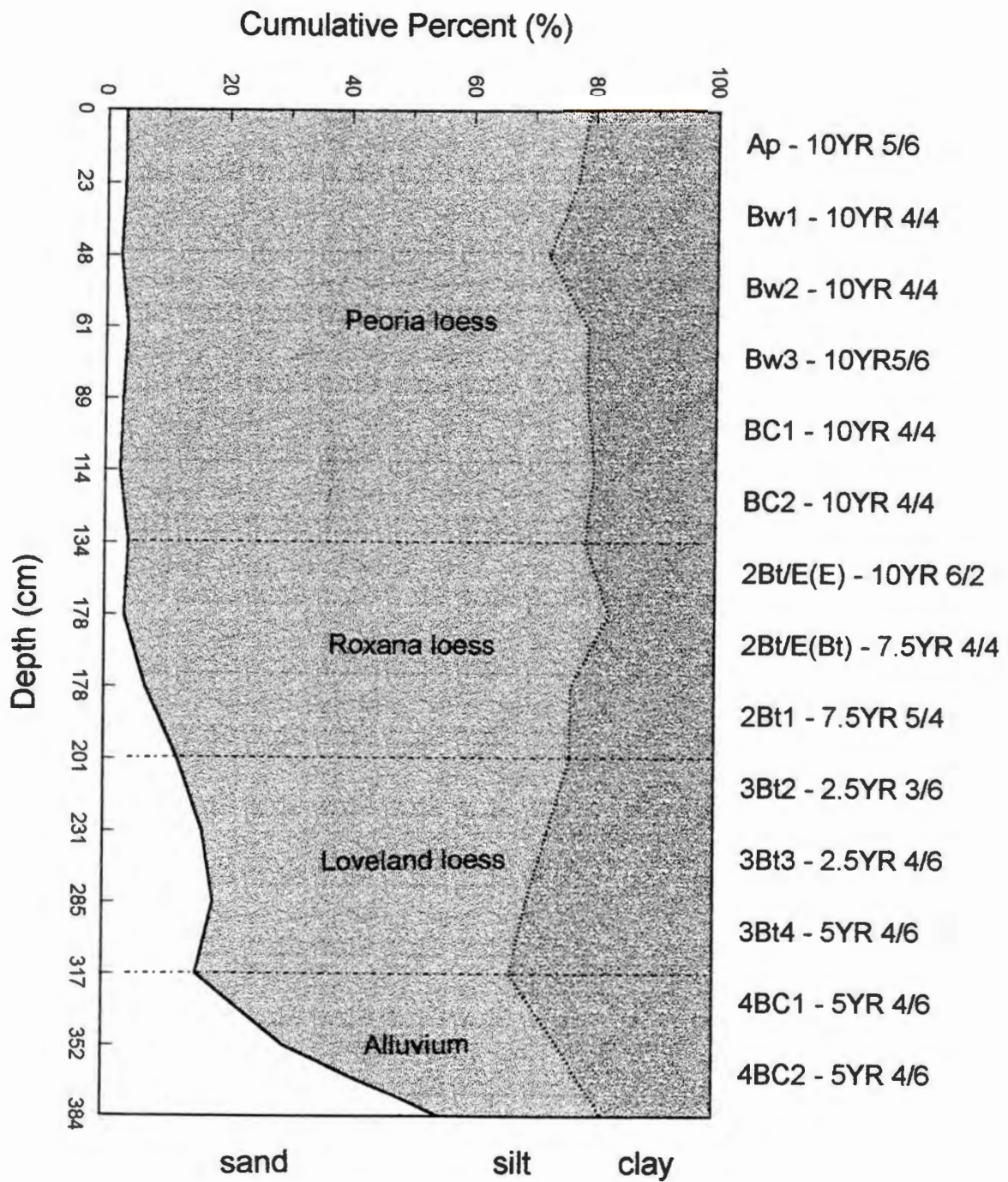


Figure 11. Particle size plot for Site 1.

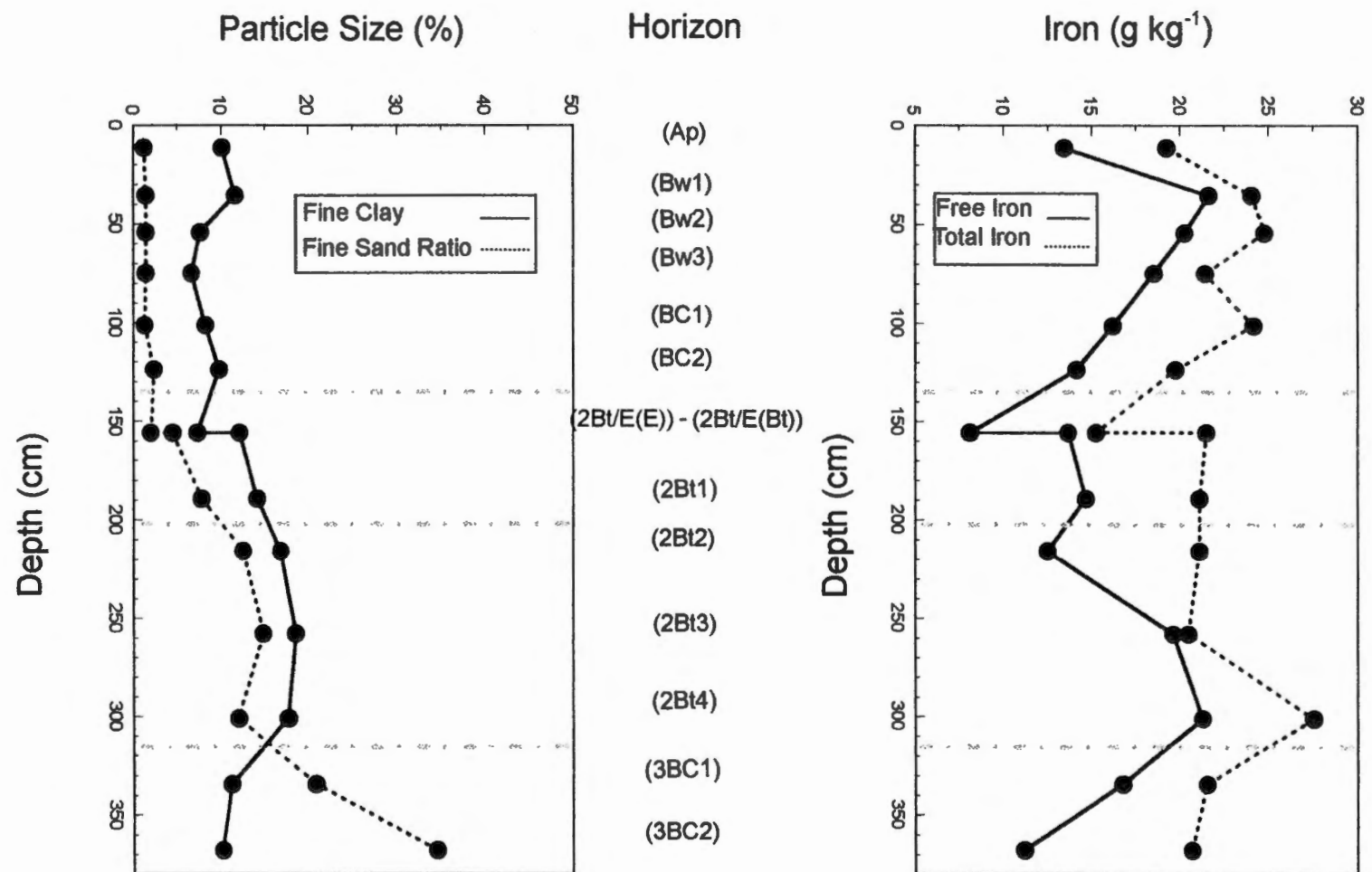


Figure 12. Plots of fine sand ratio, fine clay, free iron, and total iron for Site 1.

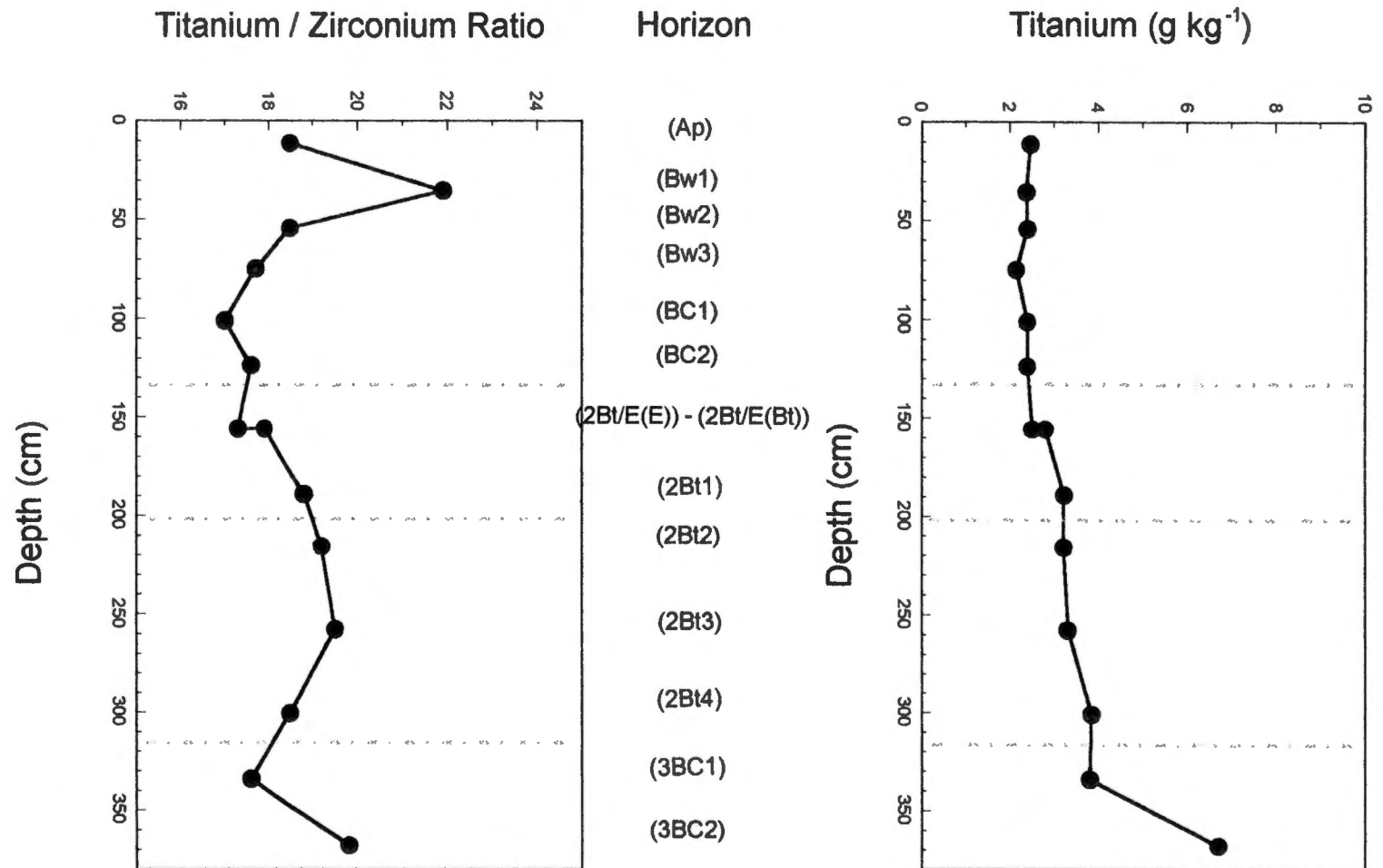


Figure 13. Plots of the titanium/zirconium ratio and titanium on a silt basis for Site 1.

Peoria/Roxana mix or a transitional layer into the Loveland loess. The first free iron oxide bulge either drops off considerably (E material), due to the removal of iron in this eluviated horizon, or remains approximately the same (Bt material) in the 2Bt/E depending on which material is analyzed (Fig. 12). The titanium on a silt basis and the titanium/zirconium ratio show subtle increases compared to the Peoria loess deposit (Fig. 13). There are small increases in the fine sand ratio and clay fraction (Fig. 12). And there is a change in hue from 10YR in the first loess layer, to 7.5YR in the present layer (Fig. 11).

A third distinct layer ranges between 201 cm and 317 cm (Fig. 11). This layer is a paleosol with Loveland loess characteristics. This loess layer was deposited between 119,000 - 132,000 years B.P. and was not covered by another loess deposit for another 30,000 years (Fig. 3). This allowed the deposit to weather and oxidize the iron present in the profile. This is exhibited by a free iron oxide inflection beginning at 215 cm below the surface (Fig. 12). This free iron oxide bulge is also consistent with the gradual increase in clay (Fig. 12). There are also small increases in the titanium and titanium/zirconium ratio (Fig. 13). The reddish-brown color is the most obvious change in the third layer. This color change, a process called

rubification, is due to the release, oxidation, and hydration of iron in the soil. The hue changes drastically from 7.5 YR to 2.5YR and 5YR (Fig. 11). This, along with an increase clay, is consistent with the Loveland loess layer described by Wascher et al. (1947) in Obion County, TN (Table 2).

The alluvium begins at a depth of 317 cm (Fig. 11). There is a rapid increase in sand with depth and a rapid decrease in silt (Fig. 11). The decrease in silt implies that this final layer is not of loess origin. The increase in sand denotes an alluvial environment and a transition into the Coastal Plain. This deposit is most likely the location of the Humboldt terrace.

The carbon distribution curve indicates a continuous weathering pattern throughout this profile (Fig. 14). The carbon content is greatest at the surface and decreases with depth. This indicates the absence of a buried surface horizon or any degree of melanization.

The 3Bt3, 3Bt4, 4BC1, and 4BC2 horizons were analyzed for the presence of diatoms using the techniques described in the Material and Methods section. There were no diatoms found in any of the sampled layers. There may not have been any diatoms present prior to the loess deposition. The loess/alluvium interface may have also been truncated prior

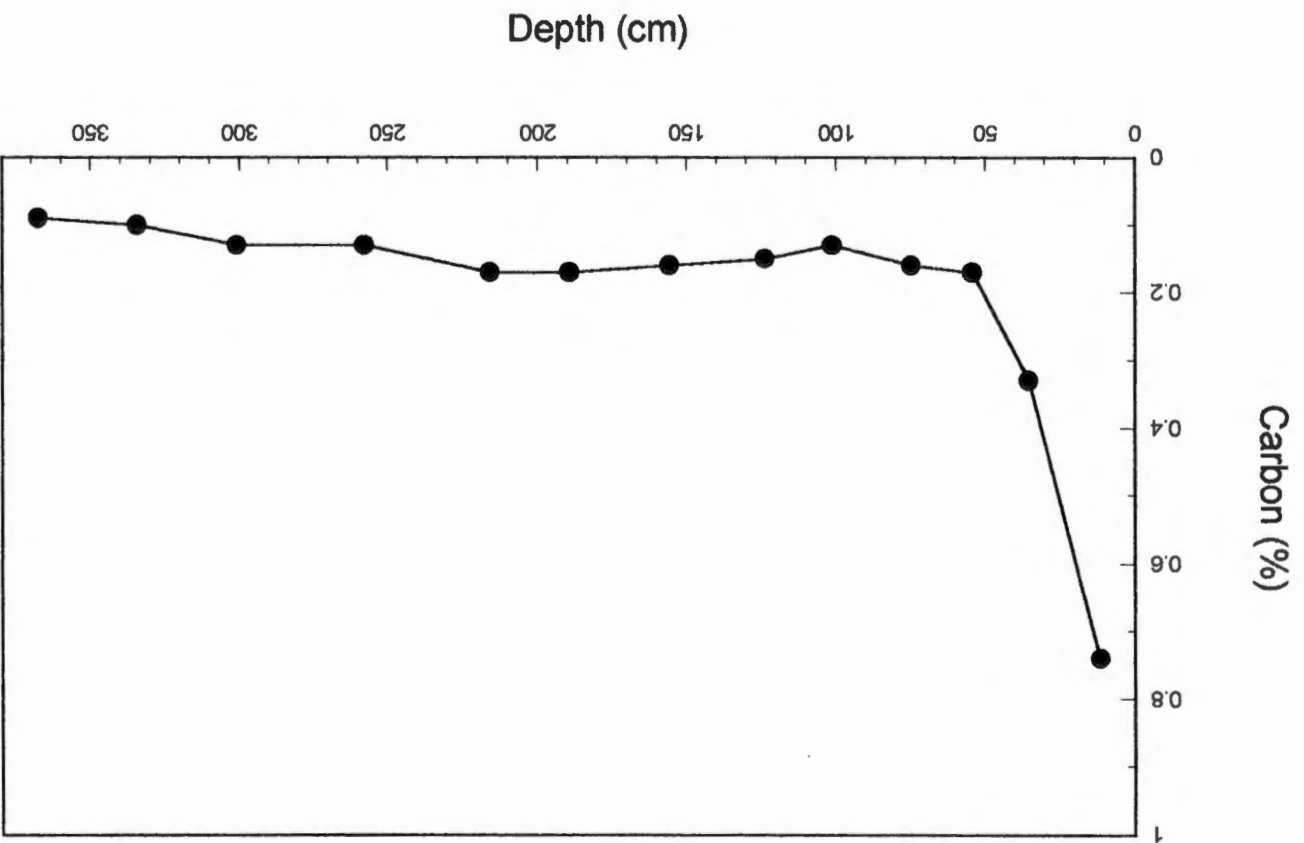


Figure 14. Total carbon distribution for Site 1.

to loess deposition, resulting in the destruction or movement of the fragile diatom valves.

From the particle size data in Table 6, the particle size class is fine-silty. The mineralogy in the silt fraction is composed primarily of quartz and two potassium-feldspars, low albite and microcline (Table 7). A mixed mineralogy occurs in the control section of the clay fraction based on the CEC/clay ratios (Table 7). The site has an ochric epipedon with a cambic diagnostic subsurface horizon, which would classify this soil as an Inceptisol. The clay percentage in the first B horizon is one-tenth of a percentage point away from being classified as an Alfisol (Table 6). One theory as to how this upland Inceptisol formed, is that this soil could have been a drainageway at one time, been eroded, and never allowed an argillic horizon to form. Since this soil is well-drained and lacks a fragipan, the clays may not have been able to collect in the B horizon or were continually flushed out of the horizon. The soil could also have been disturbed by agricultural practices and not allowed to fully develop. Based on the findings of this study, the classification of the soil on this site is fine-silty, mixed, active, thermic Typic Eutrochrept (Table 8).

Table 6. Particle size distribution for site 1.

horizon	depth cm	Particle Diameter (microns)		
		sand	silt	clay
		2000-50	50-2	< 2
		-----percent-----		
Ap	0 - 23	3.0	74.0	23.0
Bw1	23 - 48	2.4	70.1	27.5
Bw2	48 - 61	3.7	75.3	21.1
Bw3	61 - 89	2.9	76.0	21.1
BC1	89 - 114	2.5	77.6	19.9
BC2	114 - 134	3.9	74.8	21.3
2Bt/E (E)	134 - 178	3.3	79.4	17.3
2Bt/E (Bt)	134 - 178	6.8	69.7	23.5
2Bt1	178 - 201	12.1	64.3	23.6
3Bt2	201 - 231	16.2	56.6	27.2
3Bt3	231 - 285	18.1	51.3	30.6
3Bt4	285 - 317	15.3	51.4	33.3
4BC1	317 - 352	29.7	45.1	25.2
4BC2	352 - 384	55.3	26.6	18.1

Table 7. Silt and clay fraction mineralogy for
all seven sites in the control section.

Location	Silt fraction mineralogy (control section mineralogy)	CEC/clay ratios
Site 1	quartz, low albite, and microcline	0.5 (mixed)
Site 2	quartz, low albite, and microcline	0.5 (mixed)
Site 3	quartz, low albite, and microcline	0.5 (mixed)
Site 4	quartz, low albite, and microcline	0.5 (mixed)
Site 5	quartz, low albite, and microcline	0.5 (mixed)
Site 6	quartz, low albite, and microcline	0.5 (mixed)
Site 7	quartz, low albite, and microcline	0.4 (mixed)

Table 8. Soil Classification at each site sampled according to Soil Taxonomy.

Location	Soil Classification
Site 1	fine-silty, mixed, active, thermic Typic Eutrochrept
Site 2	fine-silty, mixed, active, thermic Aquic Fragiudalf
Site 3	fine-silty, mixed, active, thermic Typic Fragiudalf
Site 4	fine-silty, mixed, active, thermic Typic Hapludalf
Site 5	fine-silty, mixed, active, thermic Typic Hapludalf
Site 6	coarse-silty, mixed, thermic Oxyaquic Eutrochrept
Site 7	coarse-silty, mixed, nonacid, thermic Typic Udifluvent

Site 2

Site 2 is located on an upland position under a forested area of Oak, Cedar, and Ash trees at an elevation of 125 meters above mean sea level (410 feet). The soil morphology of this site was described to a depth of 358 cm (Fig. 15). The parent material sequence for this site is loess over alluvium.

A loess layer extends to a depth of 94 cm (Fig. 15). It is a Peoria loess deposit. The EA and E horizons, 10 to 38 cm, show a decrease in free iron due to the eluviation of iron from this horizon. The Bt horizons, 38 to 94 cm, demonstrate an increase of free iron oxides to a depth of 94 cm (Fig. 16). The data demonstrates that there is some degree of illuviation occurring.

At the point where the fragipan begins, the titanium zirconium ratio drastically decreases indicating a lithologic discontinuity between the Peoria and Roxana loess depositions. The free iron oxides tend to decrease through the fragipan to a depth of approximately 230 cm (Fig. 16).

The third depositional layer lies between 276 and 336 cm (Fig. 15). This is a Loveland loess deposit. A free iron oxide inflection occurs from 230 cm to 320 cm (Fig. 16). There is also an increase in the titanium on a silt basis (Fig. 17). The sand and clay increase is again

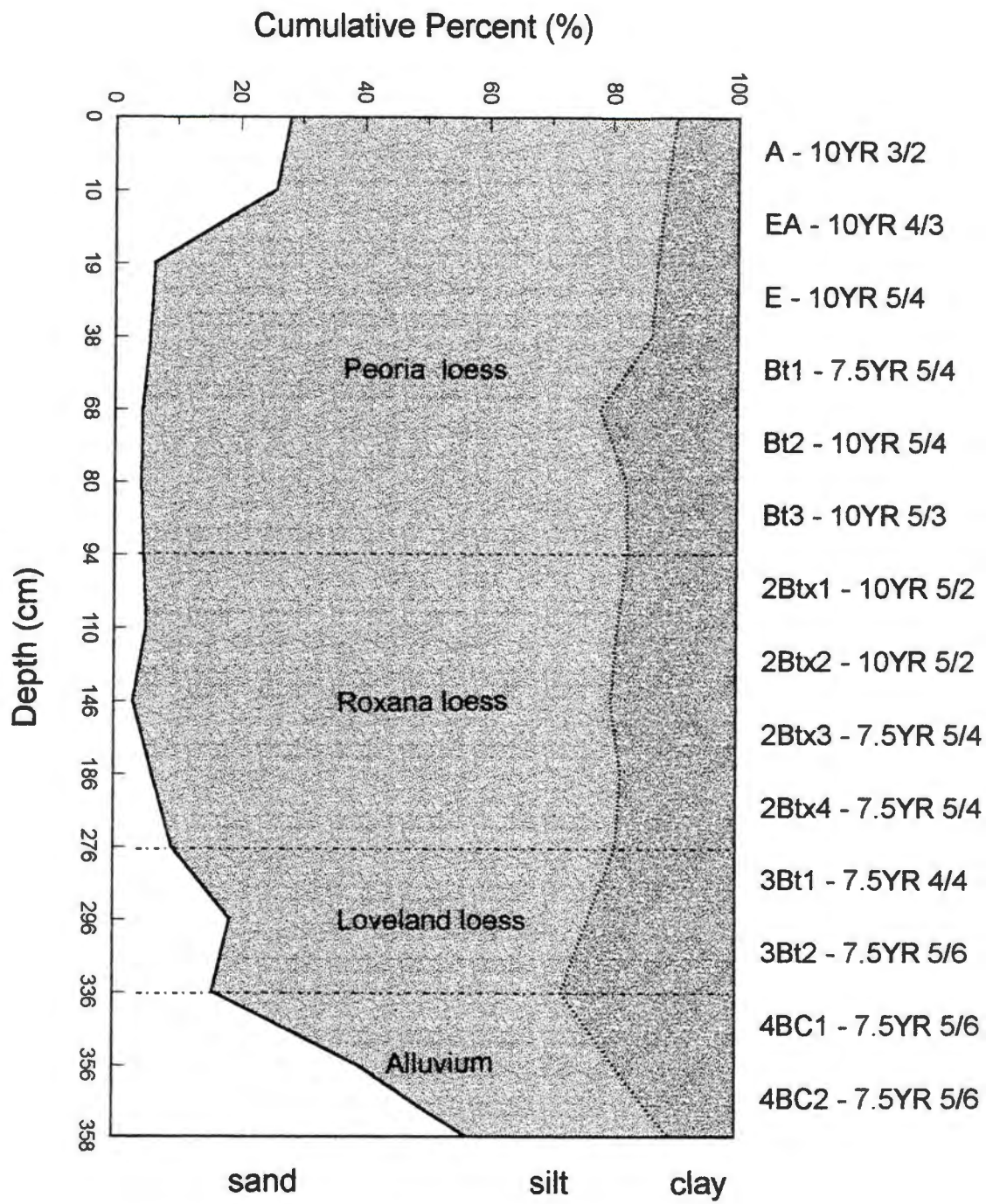


Figure 15. Particle size plot for Site 2.

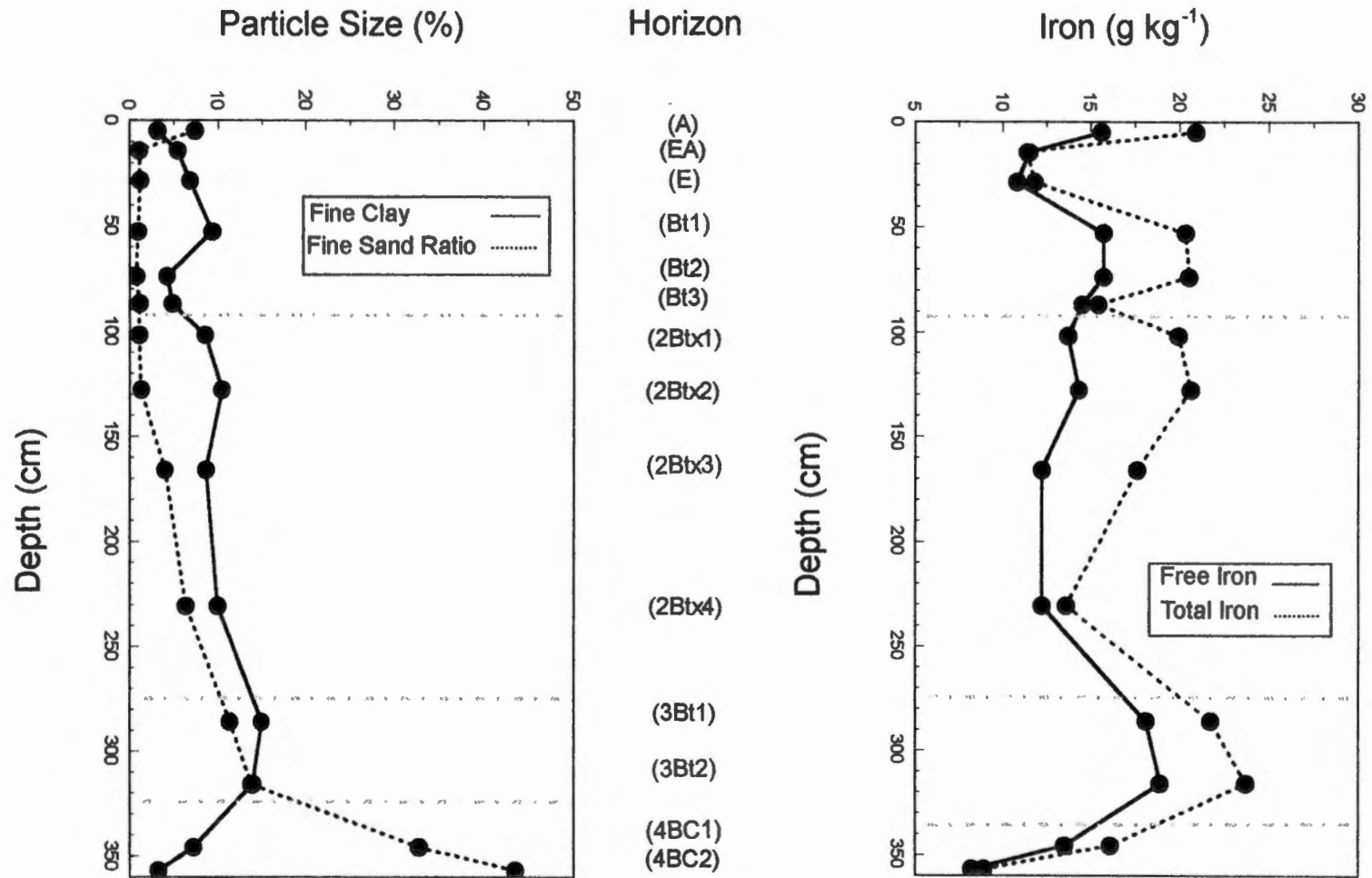


Figure 16. Plots of fine sand ratio, fine clay, free iron, and total iron for Site 2.

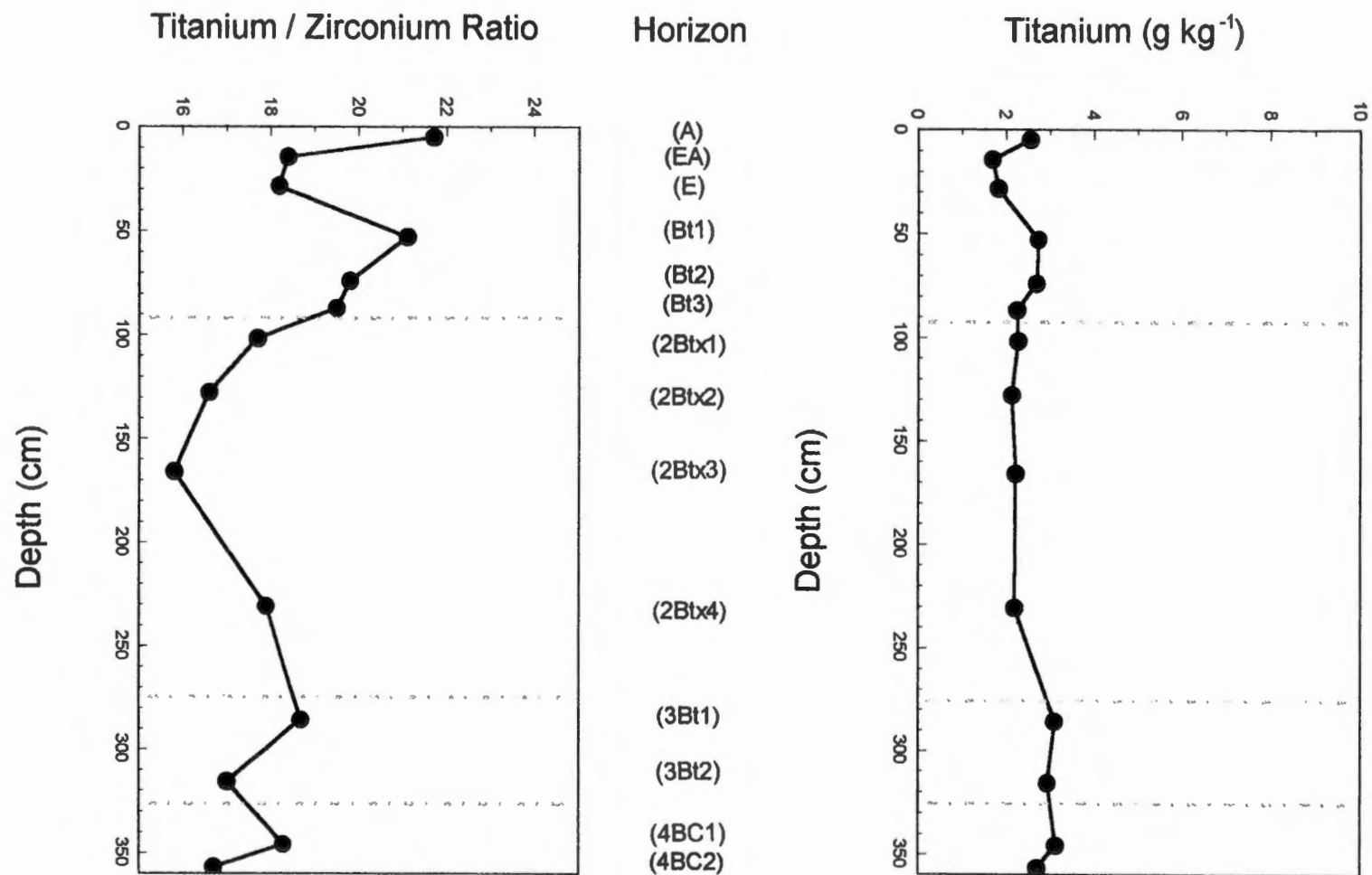


Figure 17. Plots of the titanium/zirconium ratio and titanium on a silt basis for Site 2.

consistent with the Loveland loess layer described by Wascher et al. (Fig. 15).

The alluvial layer was identified between 336 and 358 cm (Fig. 15). It is best indicated by a drop in free iron oxides, a sharp increase in the fine sand ratio, and a sharp decrease in the fine clay percentage (Fig. 16).

Again, the carbon distribution curve indicates a continuous weathering pattern throughout this profile (Fig. 18). The lack of any sharp increases in carbon with depth indicates the absence of a buried surface horizon.

The 3Bt1, 3Bt4, 4BC1, and 4BC2 horizons were analyzed for the presence of diatoms. Again, there were no diatoms found in the sampled areas.

Based on the particle size percentage in Table 9, the particle size class is fine-silty. Based on the CEC/clay ratios, a mixed mineralogy occurs in the clay fraction (Table 7). The mineralogy in the silt fraction is composed primarily of quartz, low albite, and microcline (Table 7). The site has an ochric epipedon and an argillic subsurface horizon. The base saturation data in Table 10 confirms that the soil is an Alfisol. The classification of this soil profile is fine-silty, mixed, active, thermic Aquic Fragiudalf (Table 8).

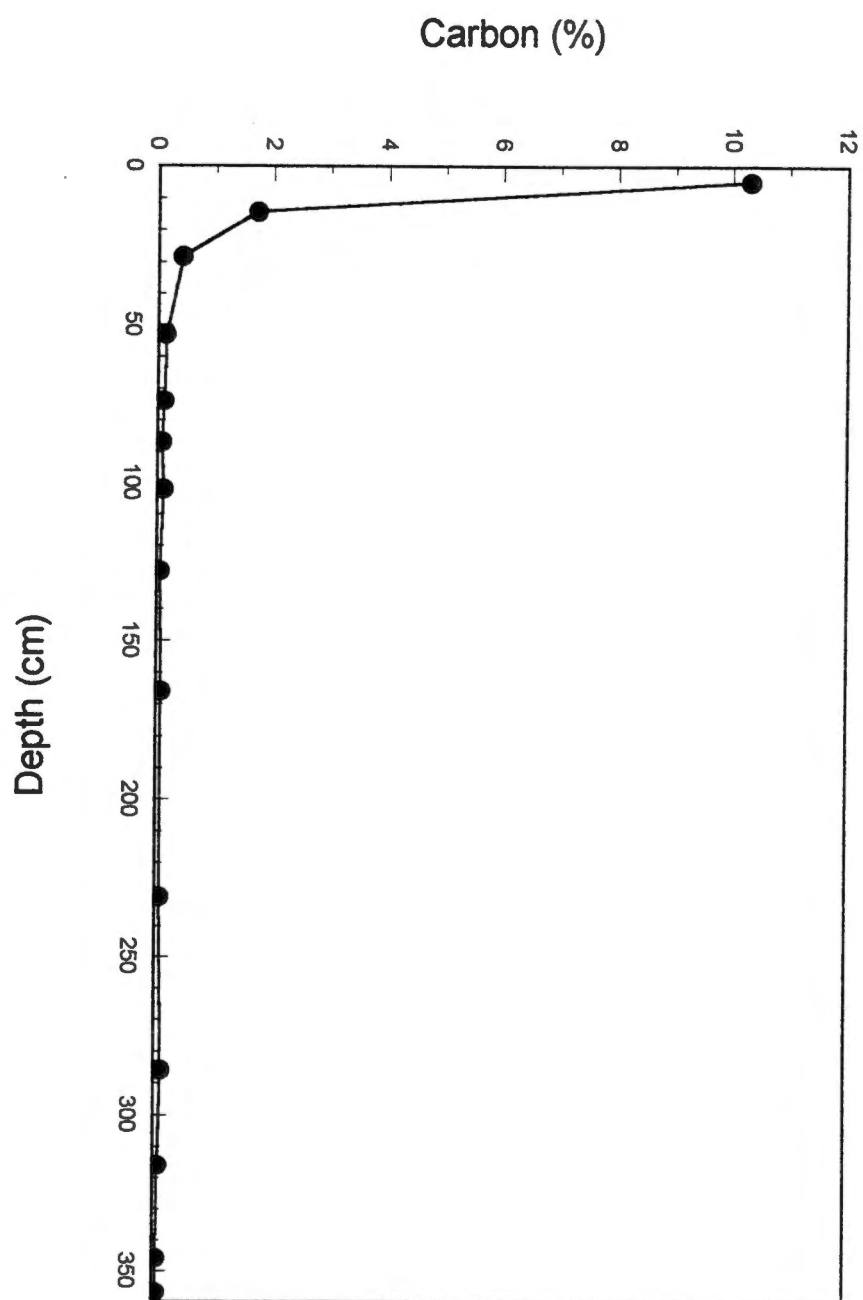


Figure 18. Total carbon distribution for Site 2.

Table 9. Particle size distribution for site 2.

horizon	depth cm	Particle Diameter (microns)		
		sand	silt	clay
		2000-50	50-2	< 2
		-----percent-----		
A	0 - 10	25.7	62.7	11.5
EA	10 - 19	6.3	80.8	12.9
E	19 -38	5.6	80.6	13.8
Bt1	38 - 68	4.4	73.5	22.0
Bt2	68 - 80	4.3	77.8	17.9
Bt3	80 - 94	4.7	77.7	17.6
2Btx1	94 - 110	5.2	75.6	19.3
2Btx2	110 - 146	3.1	76.7	20.2
2Btx3	146 - 186	6.1	75.2	18.7
2Btx4	186 - 276	9.4	71.2	19.4
3Bt1	276 - 296	18.7	57.5	23.8
3Bt2	296 - 336	15.9	56.1	28.0
4BC1	336 - 356	39.4	41.0	19.6
4BC2	356 - 358	56.7	32.6	10.7

Table 10. Cation exchange capacity, exchangeable bases, and base saturation for site 2.

horizon	CEC	exchangeable bases				Base
	(NH ₄ OAc)	Ca	Mg	Na	K	Saturation
	-----cmol (+) / kg-----					(NH ₄ OAc) pH 7 %
A	14.39	9.69	2.95	0.07	0.46	92
EA	8.35	3.79	0.84	0.06	0.37	61
E	7.05	3.16	1.67	0.07	0.27	73
Bt1	9.91	4.32	1.64	0.09	0.33	64
Bt2	8.48	3.47	2.01	0.12	0.33	70
Bt3	9.99	1.62	2.46	0.08	0.31	45
2Btx1	13.54	2.17	5.17	0.10	0.35	57
2Btx2	13.57	2.71	5.75	0.14	0.29	65
2Btx3	9.08	3.25	5.60	0.22	0.15	102
2Btx4	8.80	3.24	4.99	0.55	0.11	101
3Bt1	11.63	4.74	5.19	0.96	0.11	95
3Bt2	10.96	5.06	5.30	0.93	0.09	104
4BC1	7.16	3.20	3.00	0.71	0.67	106
4BC2	5.39	2.47	2.35	0.51	0.33	105

Site 3

This site is located on an upland position under grass sod and no-till cotton at an elevation of 124 meters above mean sea level (407 feet). The soil morphology of site 3 was described to a depth of 428 cm (Fig. 19). The parent material sequence for this site is loess over alluvium over coastal plain.

The Peoria loess deposit extends from the surface to a depth of 61 cm, while the Roxana loess encompasses the fragipan to a depth of 205 cm (Fig. 19). This deposit is similar to Site 2 in that the free iron oxides are high in the Bt horizon and decrease with depth through the fragipan (Fig. 20). One difference between Site 2 is that the titanium/ zirconium ratio remains constant throughout the first layer instead of decreasing drastically like in the previous data (Fig. 21). There is a color change from 10YR in the Peoria section to 7.5 YR in the Roxana deposition (Fig. 19).

The third layer is an excellent example of the Loveland loess deposition (Fig. 19). It extends from 205 to 312 cm. There is an extreme bulge in free iron oxides that is consistent with the increase in percent clay (Fig. 20). The titanium/zirconium ratio and the titanium on a silt basis do not exhibit strong inflections (Fig. 21). The hue

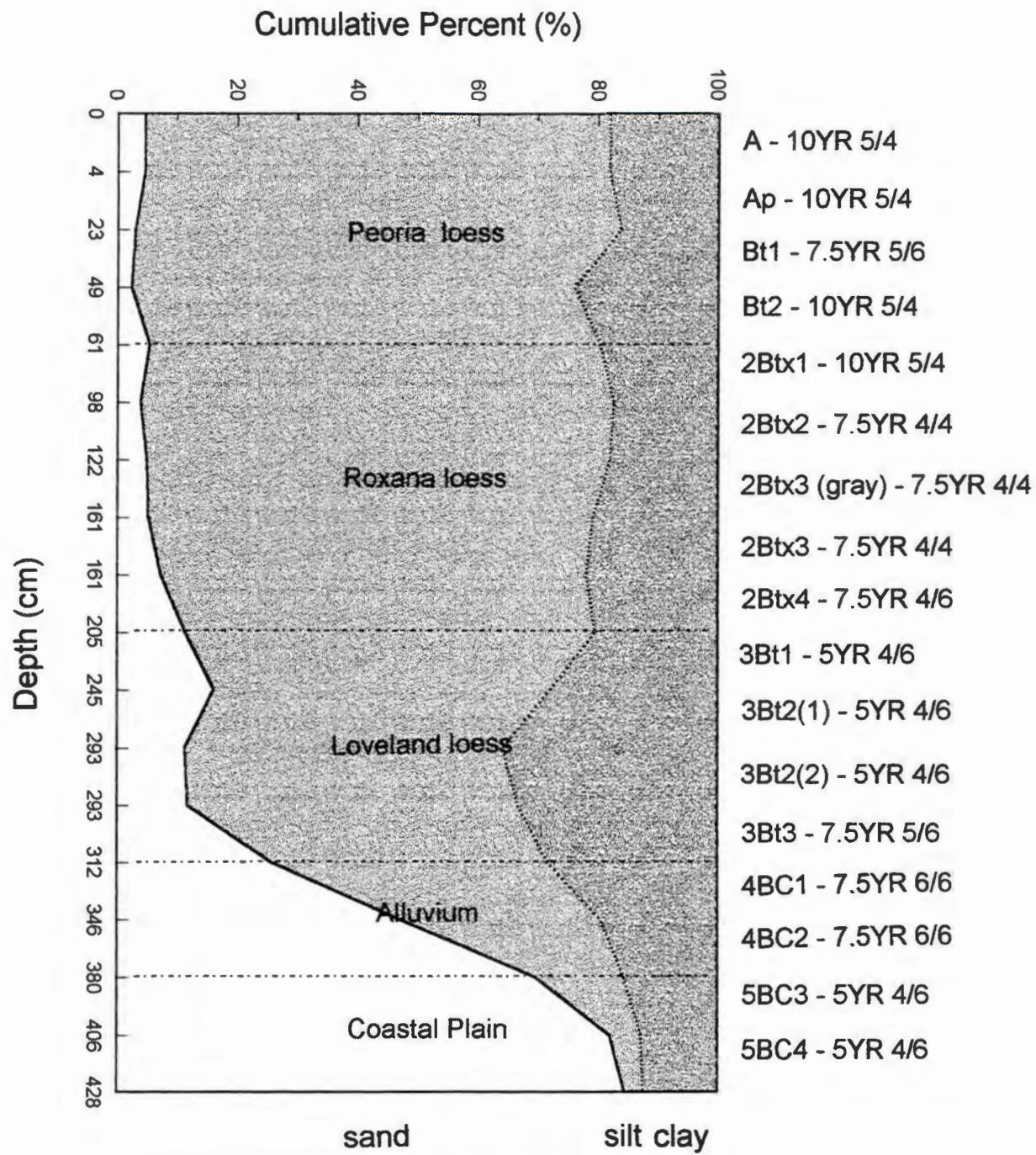


Figure 19. Particle size plot for Site 3.

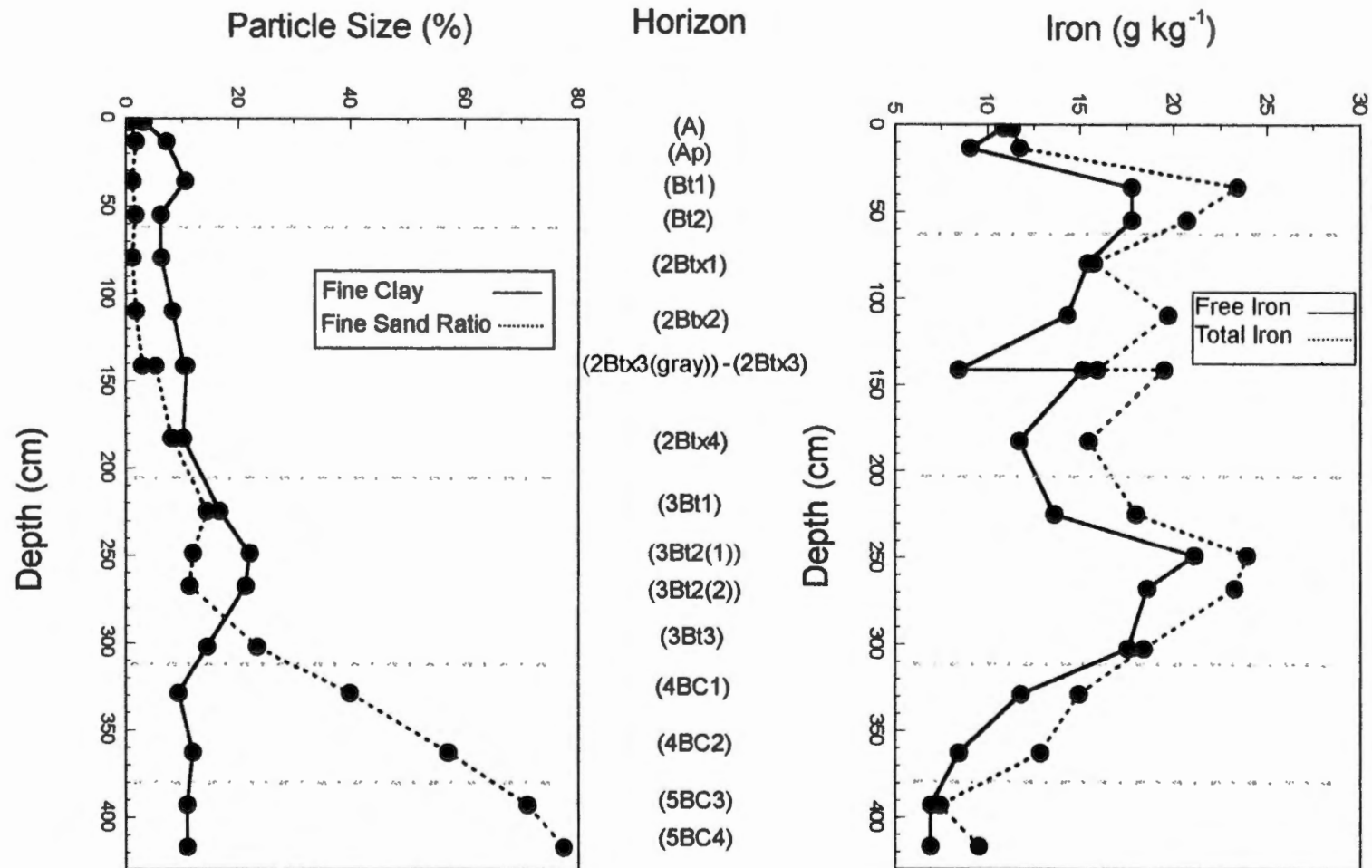


Figure 20. Plots of fine sand ratio, fine clay, free iron, and total iron for Site 3.

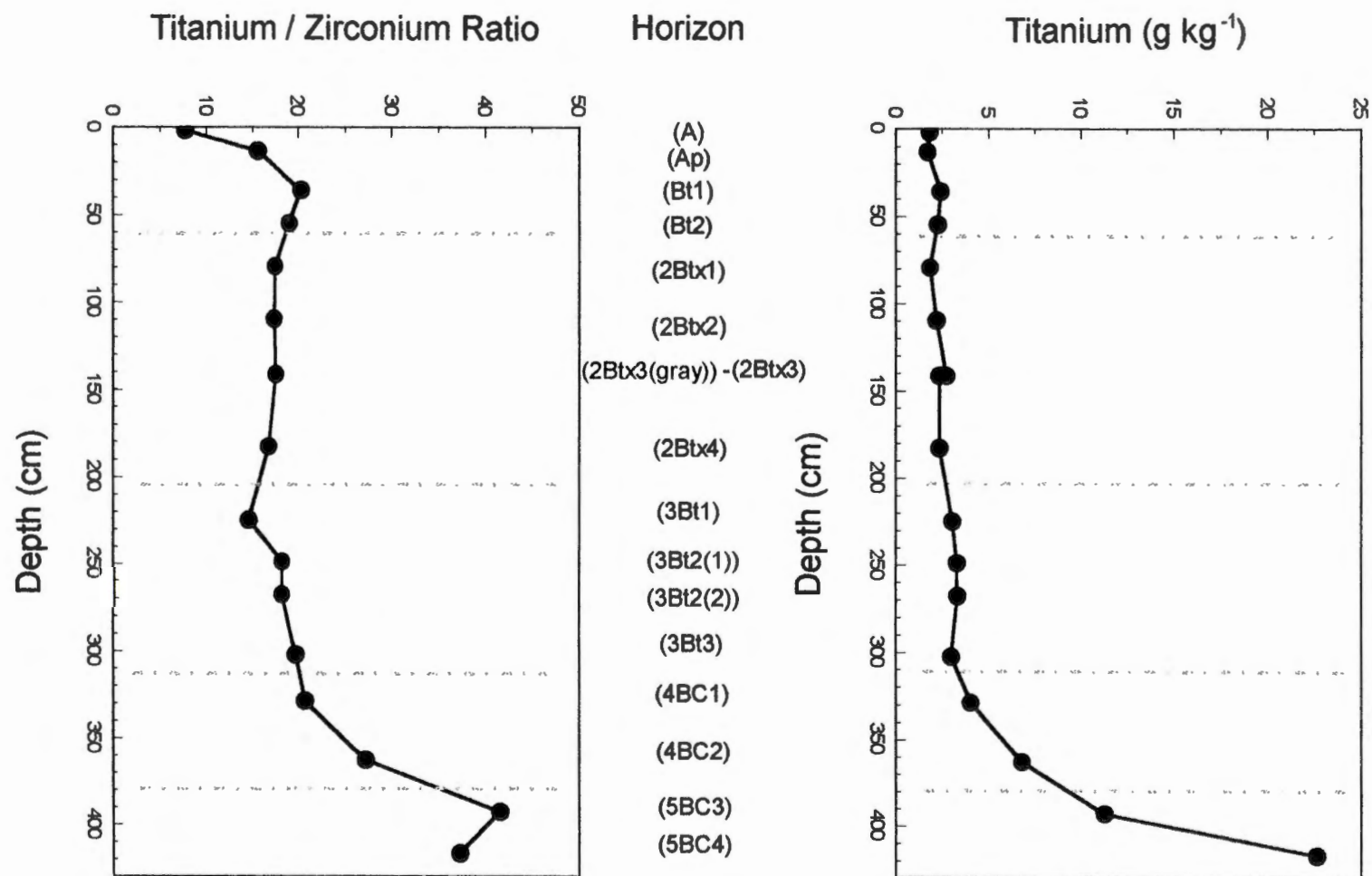


Figure 21. Plots of the titanium/zirconium ratio and titanium on a silt basis for Site 3.

changes from 7.5YR in the Roxana deposition to 5YR in the Loveland deposition due to rubification (Fig. 19). The 2Bt3 horizon, 293 to 312 cm, appears to be a mixing zone of sorts between the loess and alluvium (Fig. 19). There is a sharp increase in fine sand and the fine clay begins to decrease indicating a change in parent material (Fig. 20). There is also a change in hue from 5YR up to 7.5YR (Fig. 19).

The final two layers are the alluvium and coastal plain (Fig. 19). These are separated into two distinct zones based on the chemical and physical data. The alluvium lies between 312 and 380 cm, while the coastal plain lies between 380 and 428 cm (Fig. 19). This is most likely one large transition between the alluvium and coastal plain. The deposits were separated based on the gradual iron oxide decrease, the increase in titanium on a silt basis, and the change in color between the two horizons. The free iron oxides show a steady decrease to a depth of 390 cm and then they level out once in the coastal plain (Fig. 20). The titanium increase in the alluvial layer is gradual to a depth of 390 cm, while there is a sharp increase in the coastal plain deposit (Fig. 21). Finally, there is a change in the hue from 7.5YR in the alluvium to 5YR in the coastal plain (Fig. 19).

A continuous weathering pattern throughout this profile

is exhibited by the carbon distribution curve (Fig. 22). Based on the data, there is no evidence of melanization occurring in this profile.

Diatom analysis was conducted on the 2Bt3, 3BC1, 3BC2, and 4BC3 horizons. These horizons incorporated the loess, alluvium, and coastal plain transitions. There were no diatoms found in any of the sampled horizons.

A particle size class of fine-silty is confirmed by the particle size data in Table 11. Quartz and potassium feldspars are the primary mineralogical component in the control section of the silt fraction (Table 7). The mineralogy in the control section of the clay fraction is mixed based on the CEC/clay ratios (Table 7). The site has an ochric epipedon and an argillic horizon. The soil is an Alfisol according to the base saturation data (Table 12). Based on the findings of this study, the classification of this soil is fine-silty, mixed, active, thermic Typic Fragiudalf (Table 8).

Site 4

Site 4 is located on an upland position under cotton plots at an elevation of 123 meters above mean sea level (404 feet). The soil morphology of site 4 was described to a depth of 455 cm (Fig. 23). The parent material sequence

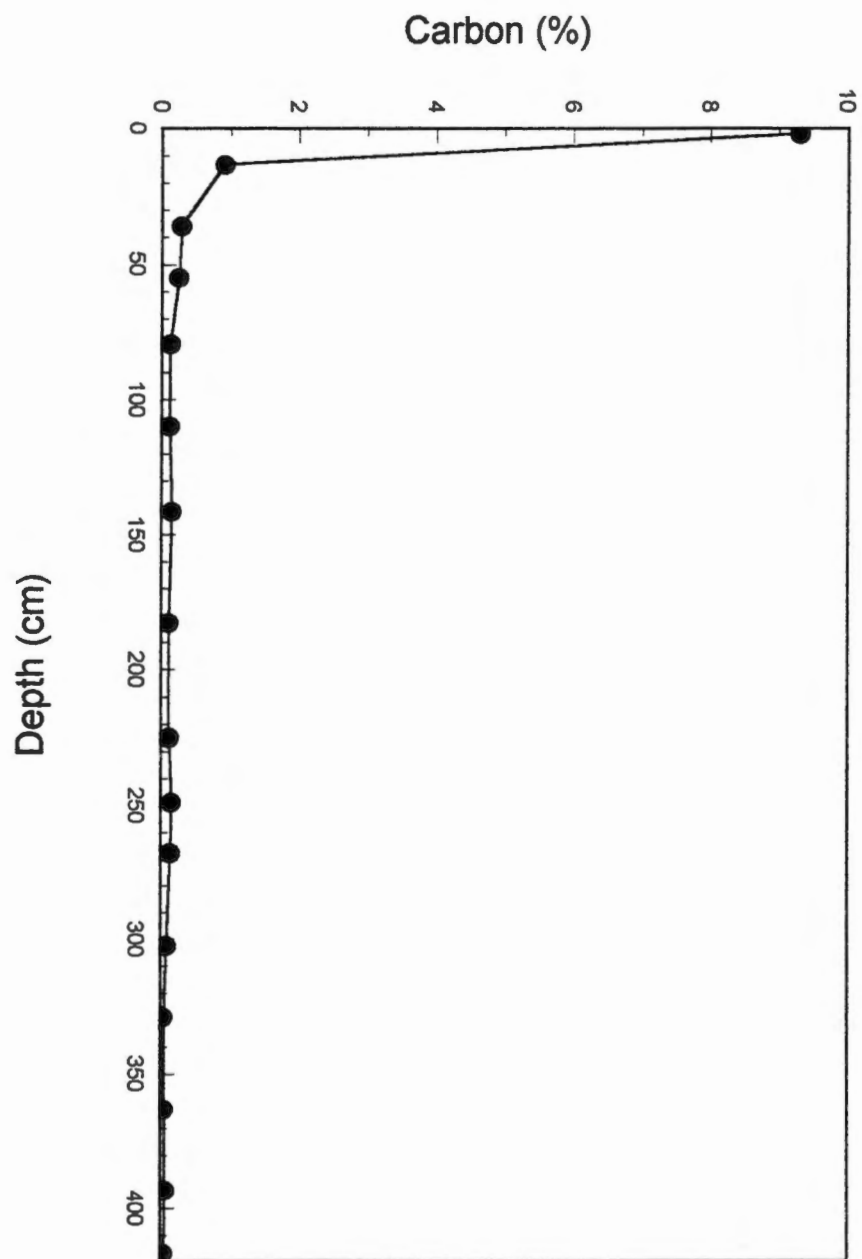


Figure 22. Total carbon distribution for Site 3.

Table 11. Particle size distribution for site 3.

horizon	depth cm	Particle Diameter (microns)		
		sand	silt	clay
		2000-50	50-2	< 2
-----percent-----				
A	0 - 4	4.6	77.3	18.1
Ap	4 - 23	3.0	80.9	16.1
Bt1	23 - 49	2.4	73.8	24.0
Bt2	49 - 61	5.4	75.0	19.6
2Btx1	61 - 98	3.9	78.7	17.4
2Btx2	98 - 122	5.0	77.0	18.0
2Btx3 (gray)	122 - 161	5.2	74.0	20.8
2Btx3	122 - 161	7.3	70.7	22.0
2Btx4	161 - 205	11.3	68.3	20.5
3Bt1	205 - 245	16.1	56.0	27.9
3Bt2 (1)	245 - 293	11.3	52.9	35.8
3Bt2 (2)	243 - 293	11.8	55.0	33.2
3Bt3	293 - 312	25.7	46.1	28.2
4BC1	312 - 346	47.0	33.5	19.5
4BC2	346 - 380	69.7	14.7	15.7
5BC3	380 - 406	82.0	5.3	12.7
5BC4	406 - 428	84.5	3.1	12.4

Table 12. Cation exchange capacity, exchangeable bases, and base saturation for site 3.

horizon	CEC	exchangeable bases				Base Saturation
	(NH ₄ OAc)	Ca	Mg	Na	K	(NH ₄ OAc) pH 7
	-----cmol (+) / kg-----					%
A	11.82	8.69	2.06	0.06	0.44	95
Ap	7.48	5.34	0.94	0.05	0.28	88
Bt1	11.48	6.28	2.62	0.09	0.25	80
Bt2	10.17	2.65	2.87	0.10	0.19	57
2Btx1	9.86	1.97	3.92	0.16	0.16	63
2Btx2	10.17	2.76	5.59	0.29	0.16	87
2Btx3 (gray)	10.36	3.27	5.72	0.31	0.16	91
2Btx3	9.89	3.23	5.10	0.33	0.12	89
2Btx4	8.79	2.51	4.59	0.26	0.11	85
3Bt1	8.77	2.79	3.90	0.22	0.16	81
3Bt2 (1)	11.23	2.94	4.19	0.25	0.19	67
3Bt2 (2)	11.90	2.90	4.32	0.25	0.20	65
3Bt3	9.85	2.40	3.92	0.23	0.15	68
4BC1	6.06	2.18	2.69	0.16	0.10	85
4BC2	4.41	1.62	1.79	0.15	0.08	83
5BC3	3.86	1.54	1.75	0.13	0.07	90
5BC4	4.83	1.25	1.63	0.12	0.07	63

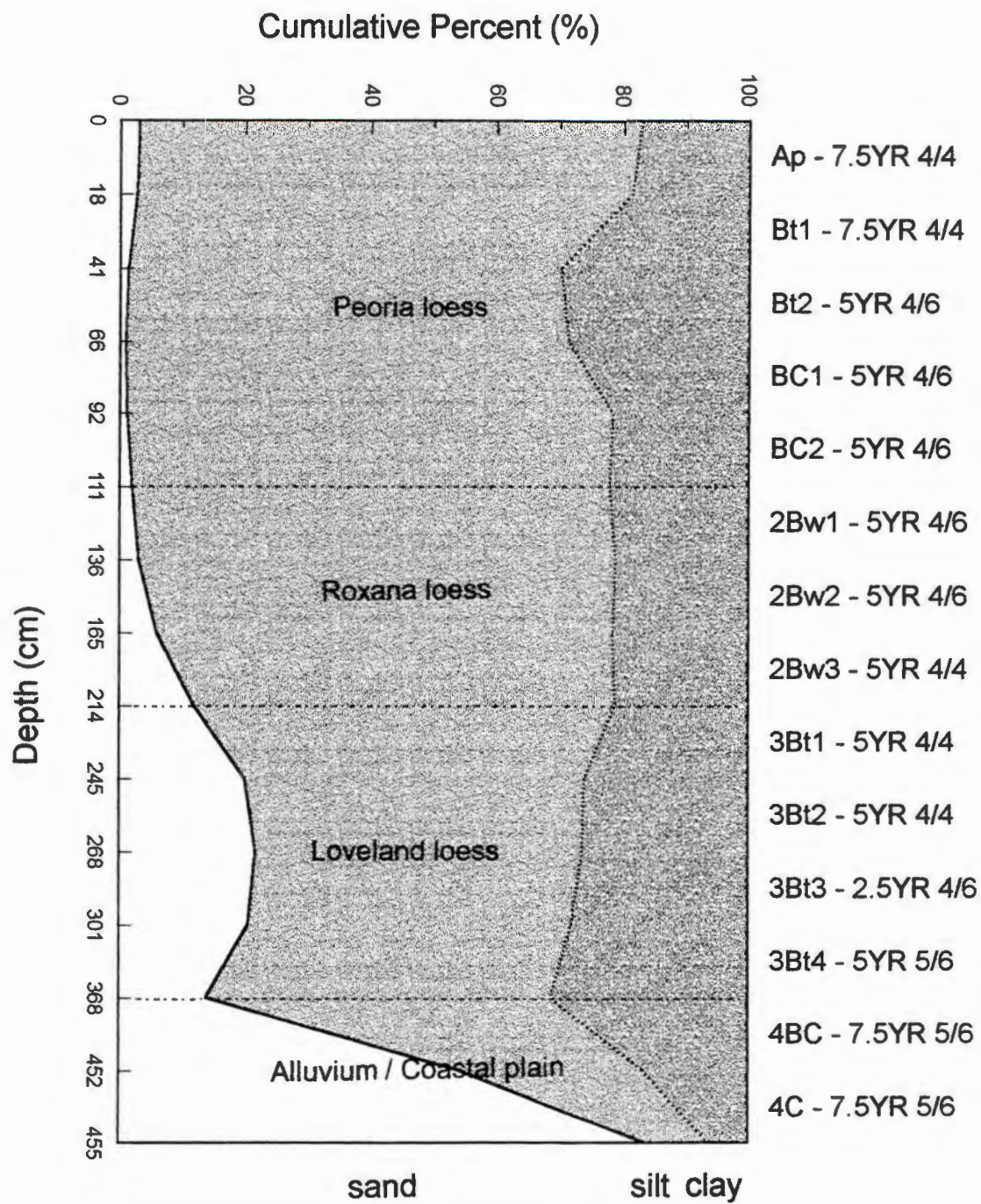


Figure 23. Particle size plot for Site 4.

for this site is loess over alluvium and coastal plain.

The Peoria loess deposition extends from the surface to a depth of 111 cm (Fig. 23). Free iron oxides change in relation to percent fine clay (Fig. 24). The titanium and titanium/zirconium ratio data best indicates the Peoria/Roxana break in this profile (Fig. 25). At approximately 100 cm, there is a sharp decrease in the titanium on a silt basis (Fig. 25). The titanium/zirconium ratio also decreases to a depth of 120 cm then begins to gradually increase (Fig. 25). There is enough of a decrease in the percent clay from 66 to 92 cm that the underlying horizon changes to a BC1 (Fig. 23).

The Roxana loess layer begins at a depth of 111 cm and ends at approximately 268 cm (Fig. 23). There is a slight increase in clay and a sharp increase in the fine sand ratio to a depth of 280 cm (Fig. 24). Titanium on a silt basis demonstrates a slight increase throughout this depositional layer (Fig. 25). The titanium/zirconium ratio increases to a depth of 260 cm before it drops off (Fig. 25).

The Loveland deposition extends from 214 to 368 cm (Fig. 23). The most notable indicator is the sharp increase in free iron oxides, especially since there is not a huge increase in the clay percentage (Fig. 24). There is also a noticeable decrease in the titanium/zirconium ratio

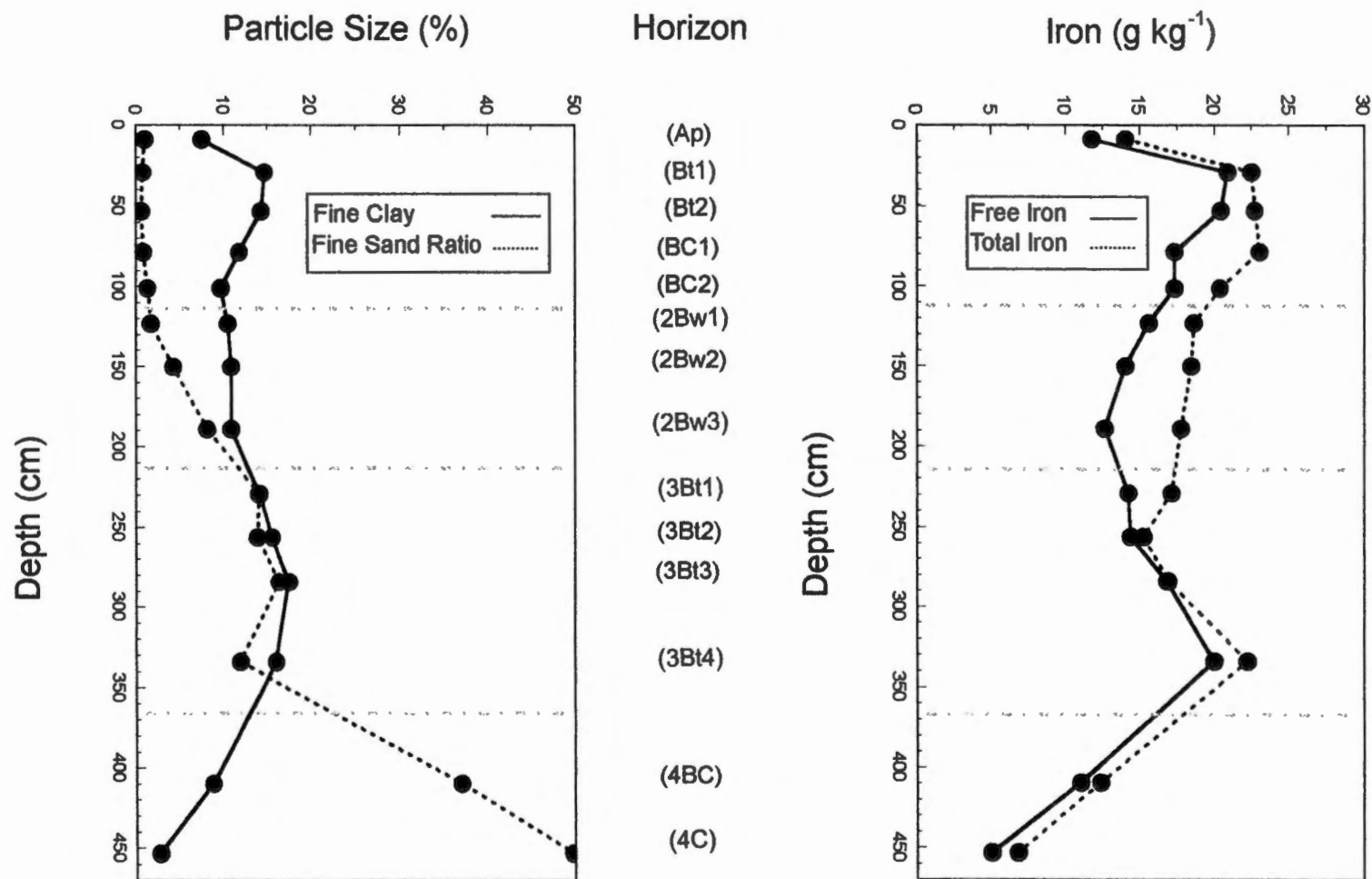


Figure 24. Plots of fine sand ratio, fine clay, free iron, and total iron for Site 4.

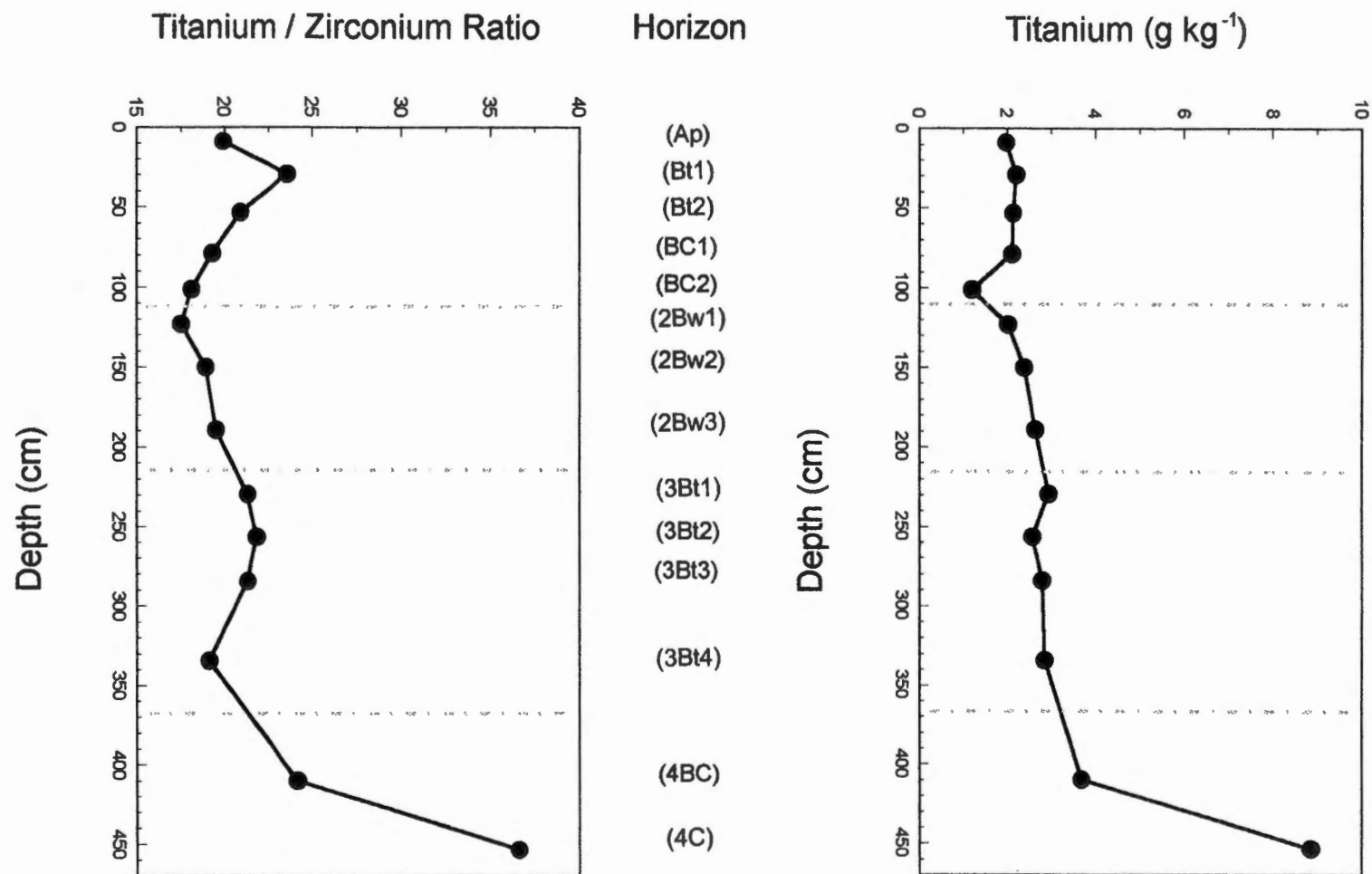


Figure 25. Plots of the titanium/zirconium ratio and titanium on a silt basis for Site 4.

throughout this layer (Fig. 25). A change in hue from 5YR to 2.5YR is also present in the layer (Fig. 23).

The alluvium and coastal plain layers are grouped as one large mixing zone (Fig. 23). From 368 to 455 cm, there is an increase in sand and a decrease in both silt and clay. There are no obvious indicators between the alluvium and coastal plain that would result in a separation of the two depositions.

The carbon distribution curve indicates an irregular weathering pattern throughout this profile (Fig. 26). As is expected, the surface data exhibits the highest carbon content. There is a gradual decrease to a depth of approx. 100 cm. At this point, there is an increase in carbon content to a depth of approx. 200 cm. This increase coincides with the determined location of the Roxana deposition. Although the field data does not exhibit any evidence of a buried surface horizon, the sharp increase in carbon indicates a possible organic material paleoenvironment for the Roxana deposit. There is a regular decrease through the remaining Loveland loess and alluvium/coastal plain depositions.

The 3Bt3, 3Bt4, 4BC, and 4C horizons were analyzed for the presence of diatoms. There were no diatoms found in the sampled horizons.

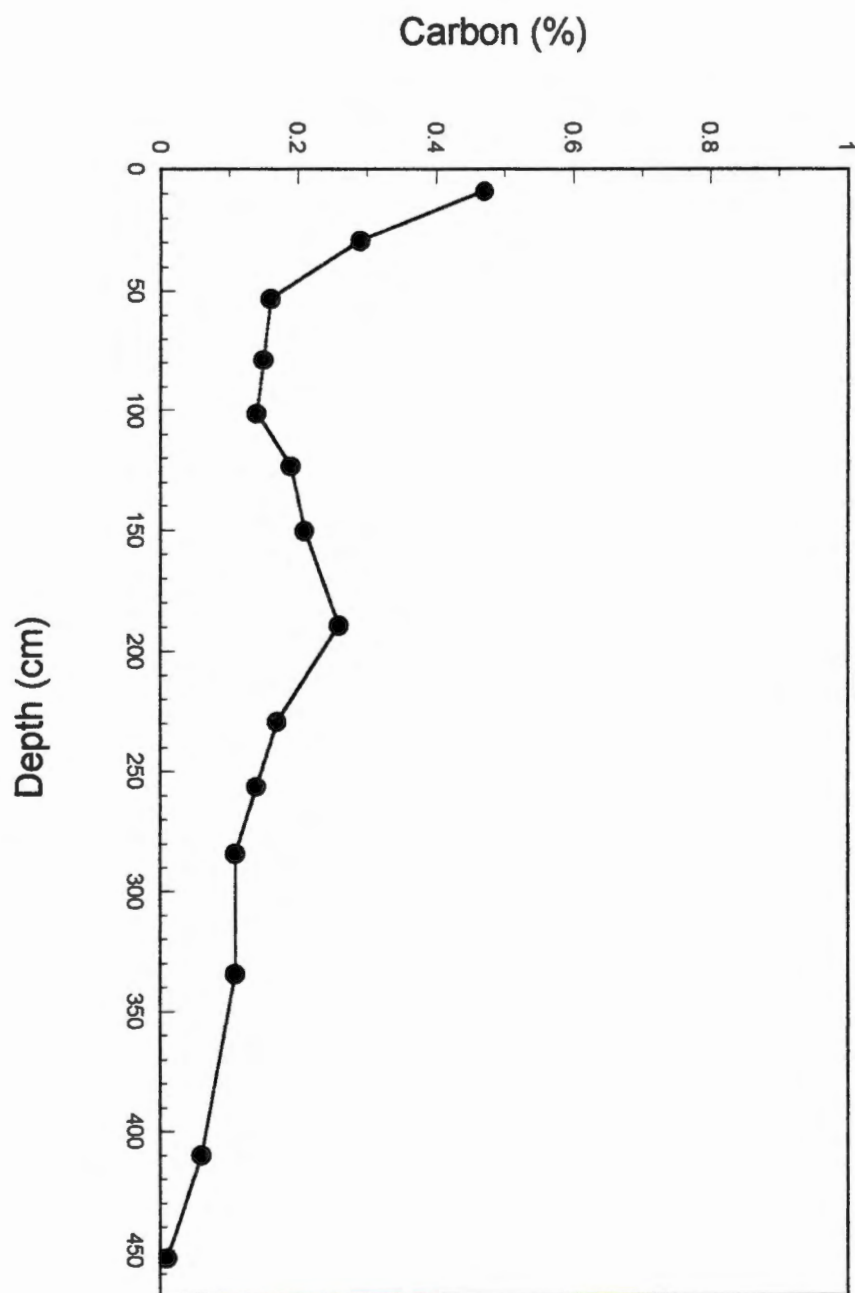


Figure 26. Total carbon distribution for Site 4.

From the particle size data in Table 13, the particle size class is fine-silty. The mineralogy in the silt fraction is composed primarily of quartz and two potassium-feldspars, low albite and microcline (Table 7). A mixed mineralogy occurs in the clay fraction based on the CEC/clay ratios (Table 7). The site has a ochric epipedon and an argillic subsurface horizon. The base saturation data (Table 14) confirms that the soil is an Alfisol. The classification of this soil profile is fine-silty, mixed, active, thermic Typic Hapludalf (Table 8).

Site 5

This site is located on the South tract on an upland position under soybeans at an elevation of 125 meters above sea level (410 feet). The soil morphology of site 5 was described to a depth of 449 cm (Fig. 27). The parent material sequence for this site is loess over alluvium and coastal plain.

The first loess layer, Peoria, extends from the surface to a depth of 147 cm (Fig. 27). The free iron oxides exhibit a gradual increase from the surface to about 100 cm (Fig. 28). Beyond 100 cm, free iron oxides decrease to a depth of 140 cm (Fig. 28). This trend is also seen in percent fine clay (Fig. 28). The clay drops enough to

Table 13. Particle size distribution for site 4.

horizon	depth cm	Particle Diameter (microns)		
		sand	silt	clay
		2000-50	50-2	< 2
		-----percent-----		
Ap	0 - 18	2.7	78.8	18.5
Bt1	18 - 41	1.3	68.8	29.9
Bt2	41 - 66	0.9	70.5	28.6
BC1	66 - 92	1.2	77.2	21.6
BC2	92 - 111	2.0	75.9	22.0
2Bw1	111 - 136	3.0	75.9	21.2
2Bw2	136 - 165	5.9	72.5	21.6
2Bw3	165 - 214	11.9	66.9	21.2
3Bt1	214 - 245	20.0	54.0	26.0
3Bt2	245 - 268	21.7	51.9	26.4
3Bt3	268 - 301	20.5	51.4	28.1
3Bt4	301 - 368	13.8	54.8	31.4
4BC	368 - 452	54.2	29.2	16.6
4C	452 - 455	83.6	10.0	6.4

Table 14. Cation exchange capacity, exchangeable bases, and base saturation for site 4.

horizon	CEC (NH ₄ OAc)	exchangeable bases				Base Saturation	
		Ca	Mg	Na	K	(NH ₄ OAc) pH 7	%
		-----cmol (+)/kg-----					
Ap	9.29	8.31	1.29	0.06	0.52	110	
Bt1	14.20	10.28	3.23	0.09	0.35	98	
Bt2	13.11	4.90	3.70	0.09	0.32	69	
BC1	11.27	2.95	3.20	0.10	0.26	58	
BC2	10.31	2.46	3.01	0.12	0.23	56	
2Bw1	8.50	3.04	3.00	0.11	0.23	75	
2Bw2	8.71	3.21	2.59	0.15	0.22	71	
2Bw3	8.57	3.66	2.96	0.15	0.19	81	
3Bt1	8.18	3.38	2.97	0.16	0.20	82	
3Bt2	6.94	3.33	2.56	0.15	0.19	90	
3Bt3	8.25	3.61	2.89	0.15	0.20	83	
3Bt4	11.11	4.66	3.40	0.19	0.22	76	
4BC	5.21	2.46	2.01	0.12	0.12	90	
4C	1.99	1.00	0.74	0.07	0.04	93	

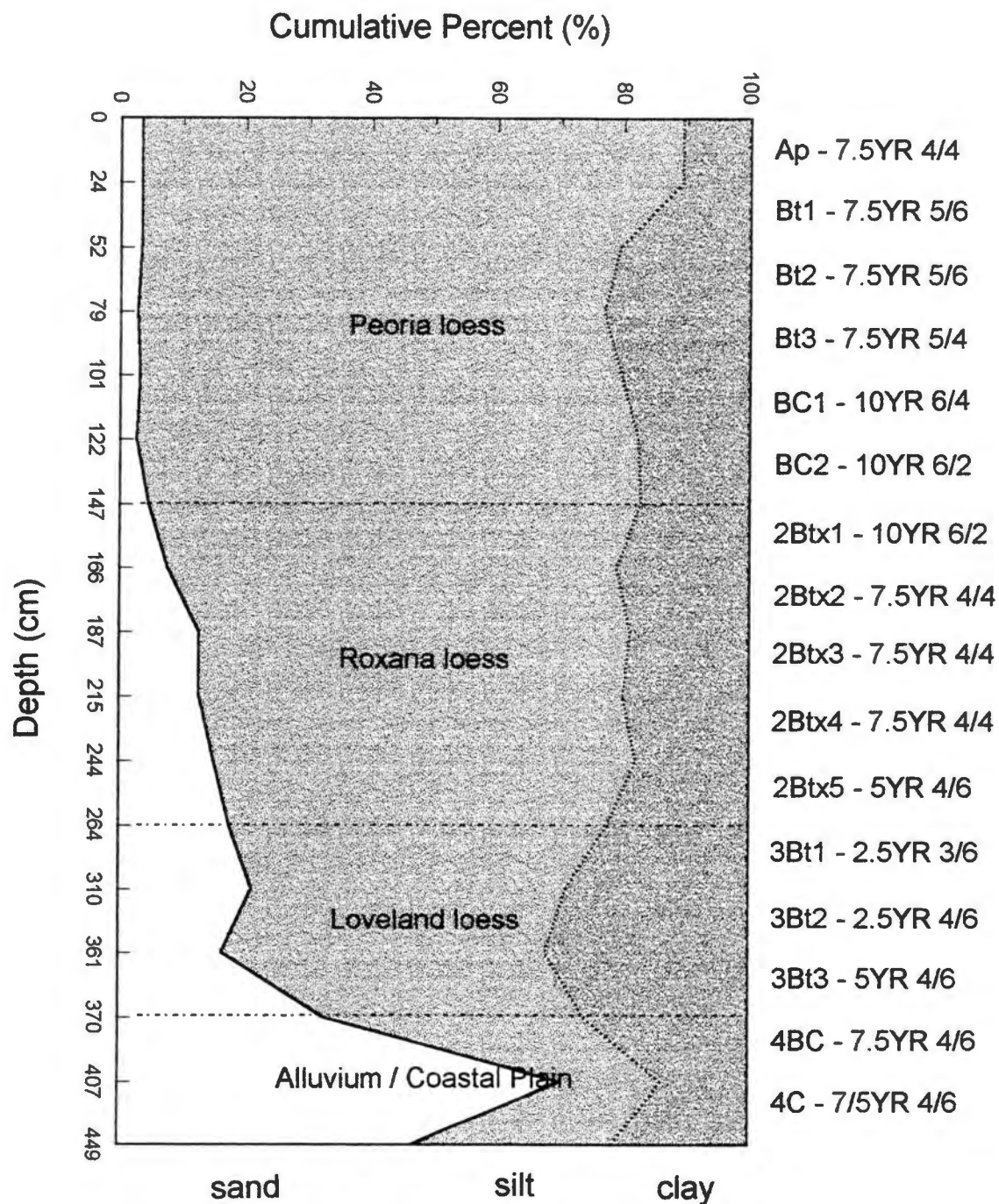


Figure 27. Particle size plot for Site 5.

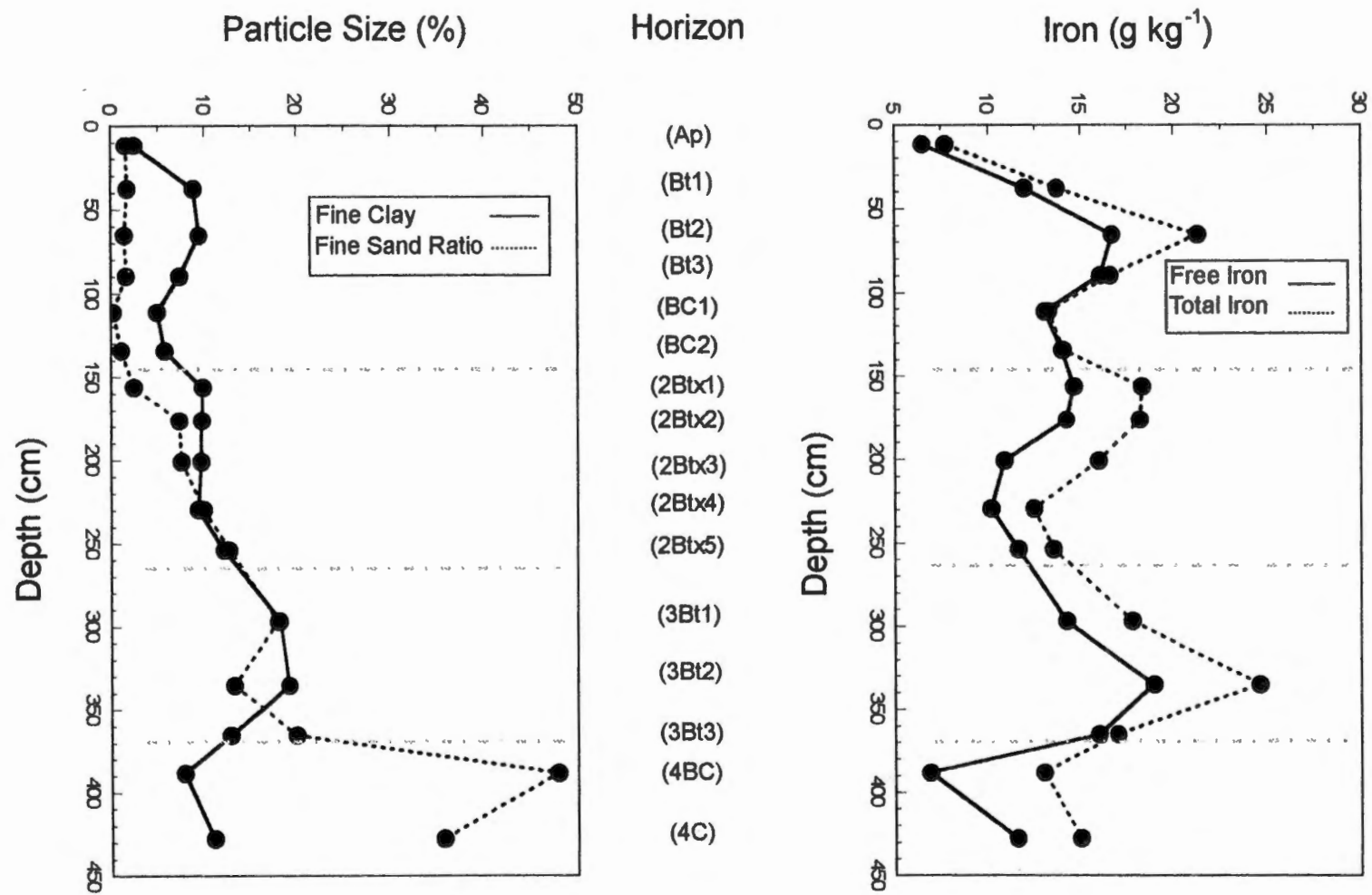


Figure 28. Plots of fine sand ratio, fine clay, free iron, and total iron for Site 5.

change the morphology to a transitional BC horizon (Fig. 27). Although the titanium on a silt basis demonstrates little change, the titanium/zirconium ratio illustrates an inflection at approximately 65 cm, then decreasing with depth (Fig. 29).

The Roxana loess deposition extends from 147 to 264 cm. There is a second inflection in the free iron oxides starting on the transitional line (Fig. 27). The titanium on a silt basis shows a slight increase from the Peoria deposition (Fig. 29). The most interesting feature is the decrease in the titanium/zirconium ration throughout this layer (Fig. 29). This is similar to a trend seen in the Roxana deposition in Site 2.

Probably the best example of the Loveland loess deposition is seen in this site. It extends from 264 to 370 cm (Fig. 27). There is a distinct increase in the free iron oxides, again consistent with an increase of clay in the paleosol (Fig. 28). There are increases in the titanium on a silt basis and the titanium/zirconium ratio throughout the deposition (Fig. 29). The most obvious sign lies in the color change due to rubification. The hue shifts from a 5YR in the Roxana deposition to a 2.5YR in the Loveland loess (Fig. 27). It then returns to a 5YR as the transition to the alluvium/coastal plain begins (Fig. 27).

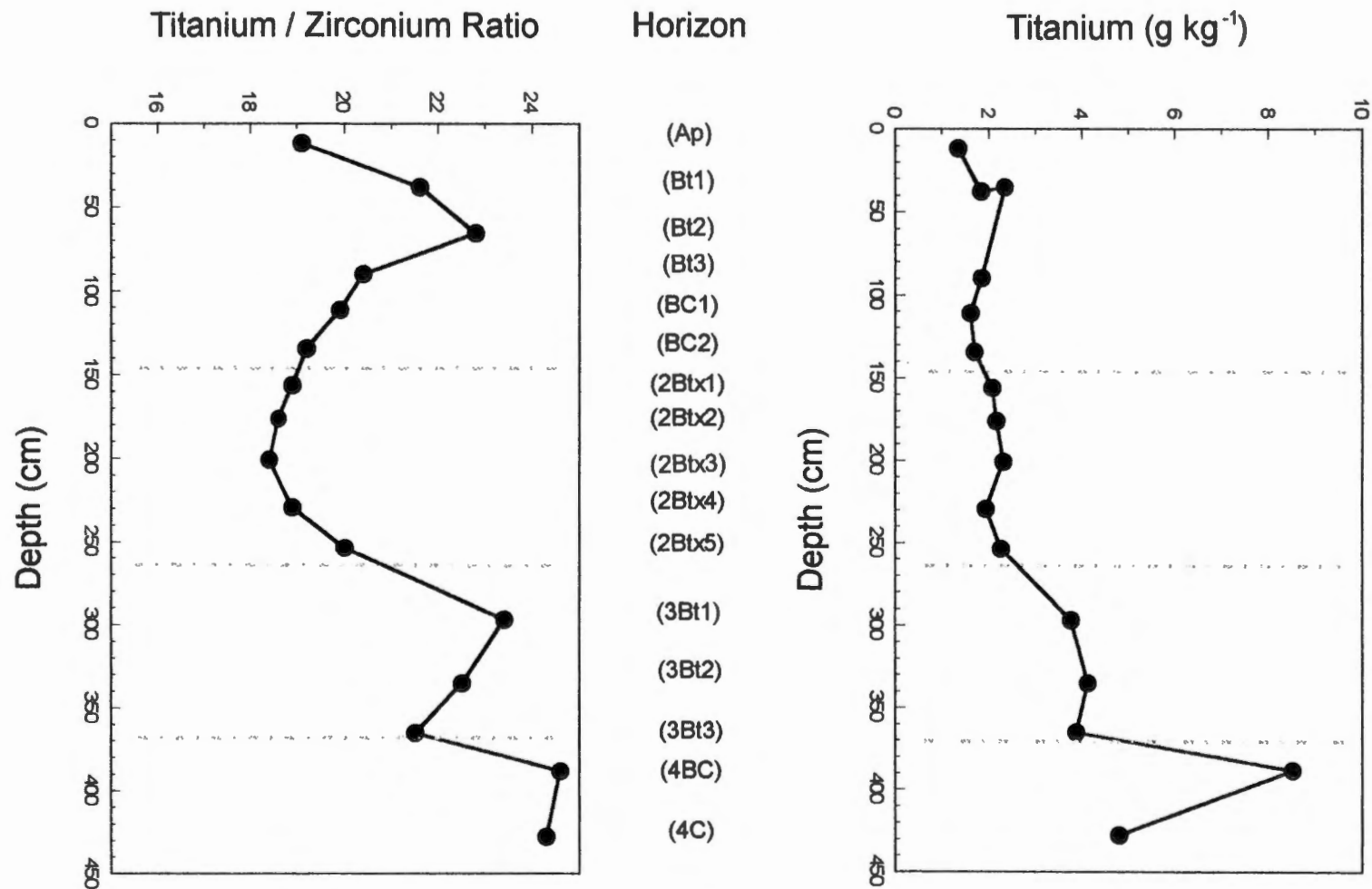


Figure 29. Plots of the titanium/zirconium ratio and titanium on a silt basis for Site 5.

A mixing zone of alluvium and coastal plain materials ranges from 370 to 449 cm (Fig. 27). The first data point shows a large increase in the fine sand ratio and decrease in fine clay, while the second point demonstrates the opposite (Fig. 28). The same is true with the titanium on a silt basis and the titanium/zirconium ratio (Fig. 29).

Again, the carbon distribution curve indicates an irregular weathering pattern throughout this profile, similar to site 4 (Fig. 30). Beginning at 147 cm there is an increase in carbon that eventually levels off at approx. 250 cm. This is the same location of the Roxana loess deposit. There is a regular decrease in carbon throughout the remainder of the profile.

The 3Bt2, 3Bt3, 4BC, and 4C horizons were analyzed for the presence of diatoms. There were no diatoms found in any of the horizons.

Based on the particle size percentage in Table 15, the particle size class is fine-silty. A mixed mineralogy is present in the clay fraction (Table 7). The mixed mineralogy in the silt fraction is composed primarily of quartz, low albite, and microcline (Table 7). The site has an ochric epipedon and an argillic subsurface horizon. The base saturation data in Table 16 confirms that the soil is and Alfisol. Although this soil does contain a fragipan,

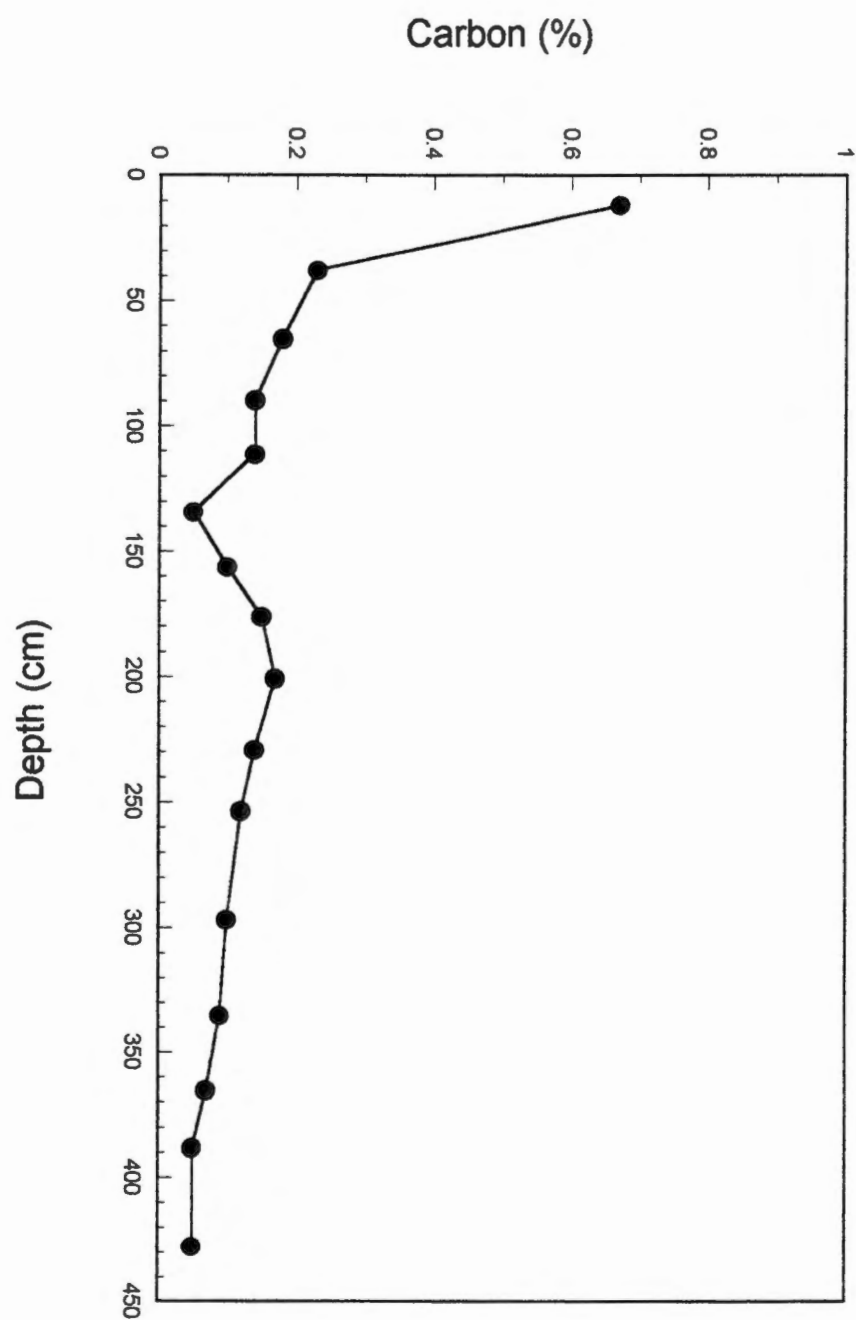


Figure 30. Total carbon distribution for Site 5.

Table 15. Particle size distribution for site 5.

horizon	depth cm	Particle Diameter (microns)		
		sand	silt	clay
		2000-50	50-2	< 2
		-----percent-----		
Ap	0 - 24	3.4	85.9	10.7
Bt1	24 - 52	3.3	76.1	20.6
Bt2	52 - 79	2.7	74.2	23.1
Bt3	79 - 101	3.1	76.6	20.3
BC1	101 - 122	2.6	79.7	15.9
BC2	122 - 147	4.6	78.1	19.3
2Btx1	147 - 166	7.6	71.4	21.0
2Btx2	166 - 187	12.6	68.5	18.9
2Btx3	187 - 215	12.7	67.3	20.0
2Btx4	215 - 244	15.0	67.1	17.9
2Btx5	244 - 264	17.5	60.1	22.4
3Bt1	264 - 310	21.1	49.9	29.0
3Bt2	310 - 361	16.4	51.4	32.2
3Bt3	361 - 370	32.5	41.5	26.0
4BC	370 - 407	70.0	16.2	13.8
4C	407 - 449	46.6	31.7	21.7

Table 16. Cation exchange capacity, exchangeable bases, and base saturation for site 5.

horizon	CEC (NH ₄ OAc)	exchangeable bases				Base Saturation	
		Ca	Mg	Na	K	(NH ₄ OAc) pH 7	%
		-----cmol (+)/kg-----					
Ap	4.79	4.02	0.50	0.05	0.35	103	
Bt1	6.53	5.67	1.18	0.07	0.19	109	
Bt2	10.32	4.98	2.62	0.10	0.20	77	
Bt3	9.70	3.31	3.36	0.10	0.20	72	
BC1	7.71	2.02	2.88	0.10	0.18	67	
BC2	8.29	2.10	3.75	0.12	0.17	74	
2Btx1	10.44	2.52	4.48	0.19	0.18	71	
2Btx2	9.86	2.56	4.04	0.22	0.14	71	
2Btx3	9.03	3.06	4.34	0.23	0.11	86	
2Btx4	7.97	2.80	4.06	0.19	0.12	90	
2Btx5	8.92	2.96	4.05	0.17	0.17	82	
3Bt1	8.29	2.66	3.71	0.15	0.22	81	
3Bt2	11.35	3.40	4.01	0.19	0.22	69	
3Bt3	9.52	3.29	3.43	0.19	0.16	74	
4BC	4.64	1.58	1.72	0.10	0.08	75	
4C	7.80	2.84	2.68	0.14	0.12	74	

the fragipans upper boundary does not occur within 100 cm of the mineral soil surface and is classified as a Hapludalf instead of a Fragiudalf (Soil Survey Staff, 1997). Based on the findings of this study, the classification of the soil is fine-silty, mixed, active, thermic Fragic Hapludalf (Table 8).

Site 6

This site is located on a flood plain position under soybeans at an elevation of 119 meters above sea level (390 feet). The soil morphology of site 6 was described to a depth of 184 cm (Fig. 31). The parent material is recent Holocene alluvium.

A deposition of alluvium is present from the surface to a depth of 90 cm (Fig. 31). There is a definite inflection in the free and total iron oxides compared to the second alluvium deposition (Fig. 32). There is a slight bulge differentiating the Ap2 and Bw1 horizons in the titanium/zirconium ratio (Fig. 33). The titanium on a silt basis is constant and does not give any indication as being similar to or eroded from the surface of site 5 (Fig. 33).

A second Holocene alluvium deposition begins at 90 cm and proceeds to the sampling depth of 184 cm (Fig. 31). There is evidence of reduced conditions and gleying in this

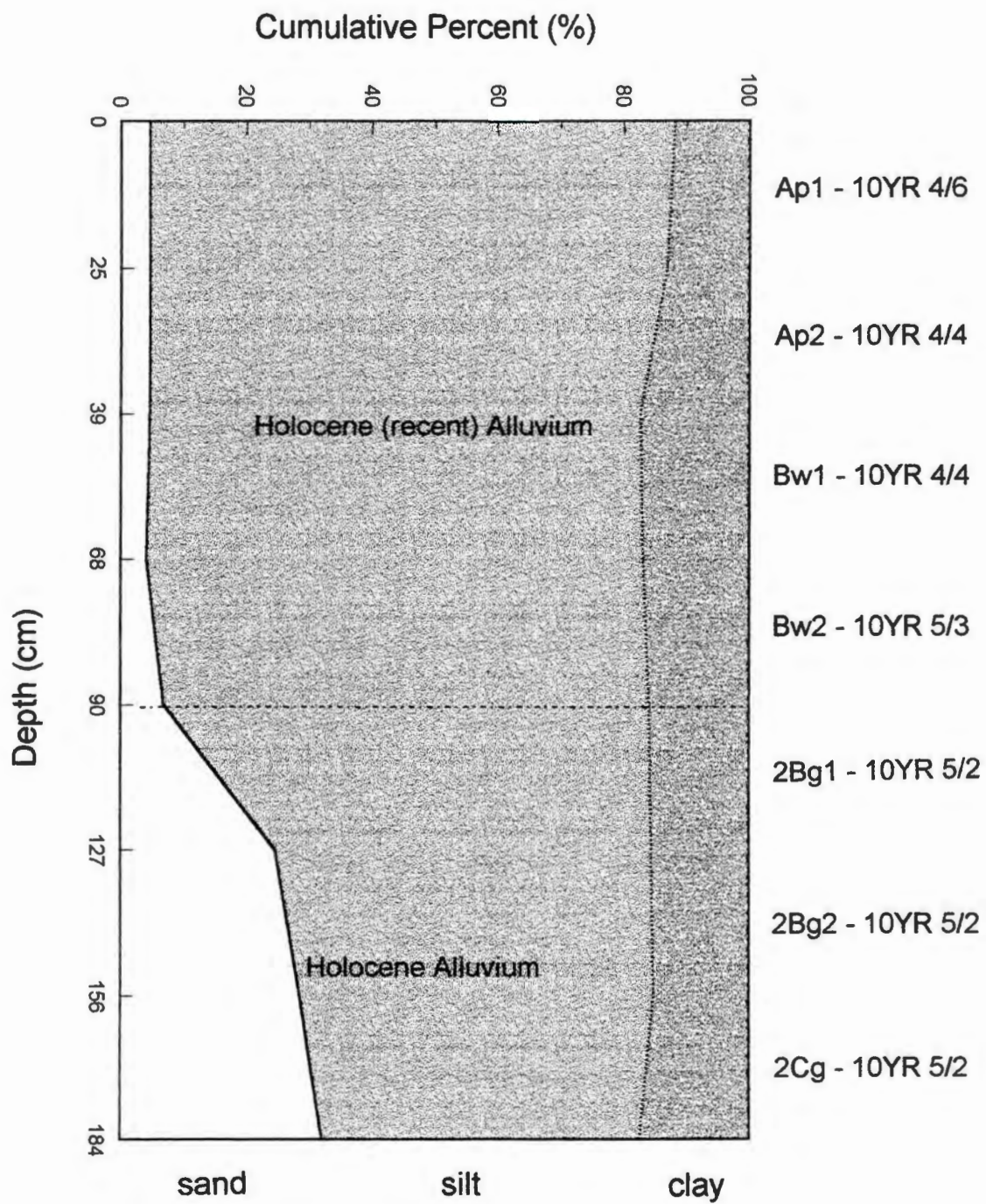


Figure 31. Particle size plot for Site 6.

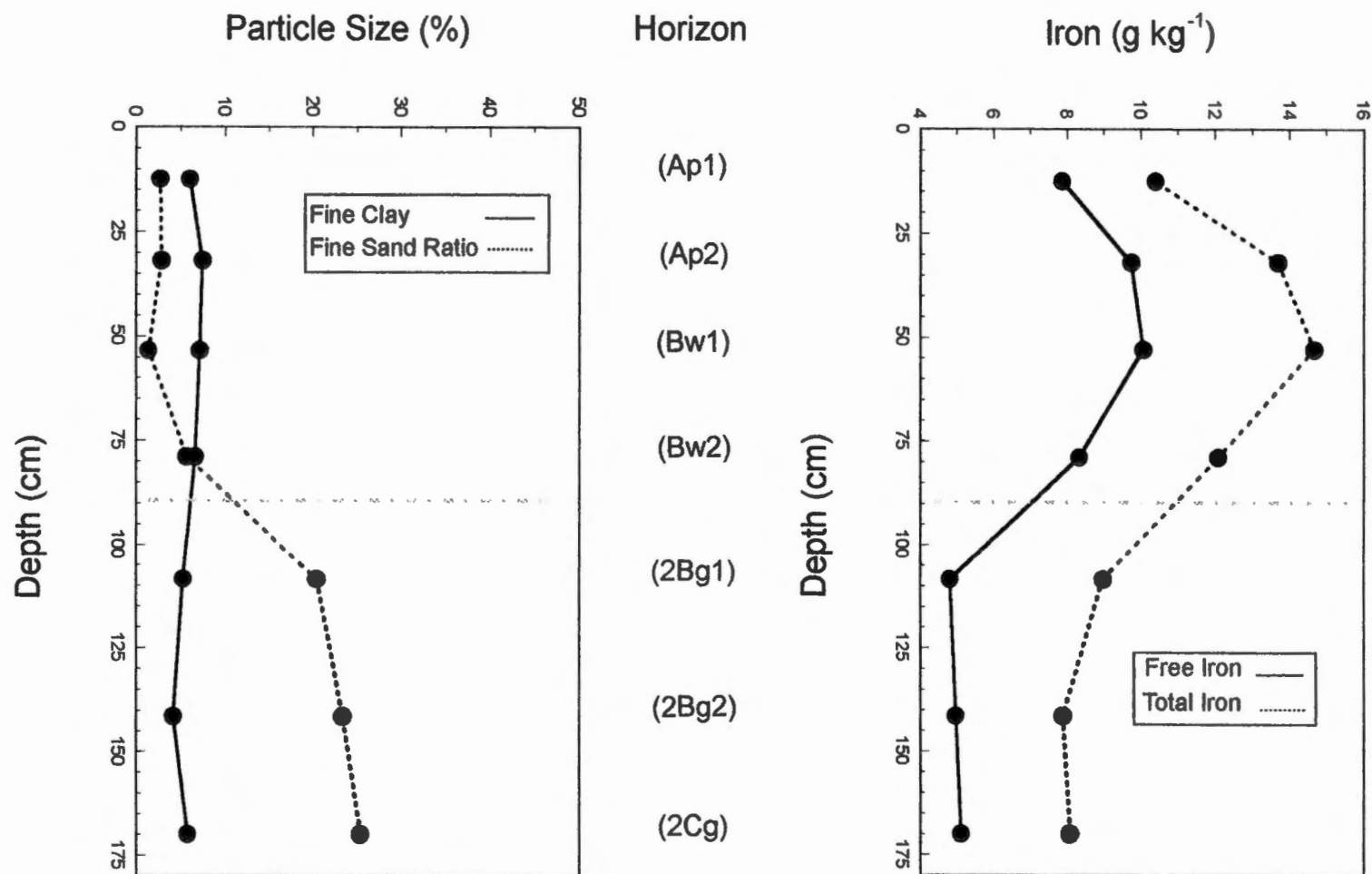


Figure 32. Plots of fine sand ratio, fine clay, free iron, and total iron for Site 6.

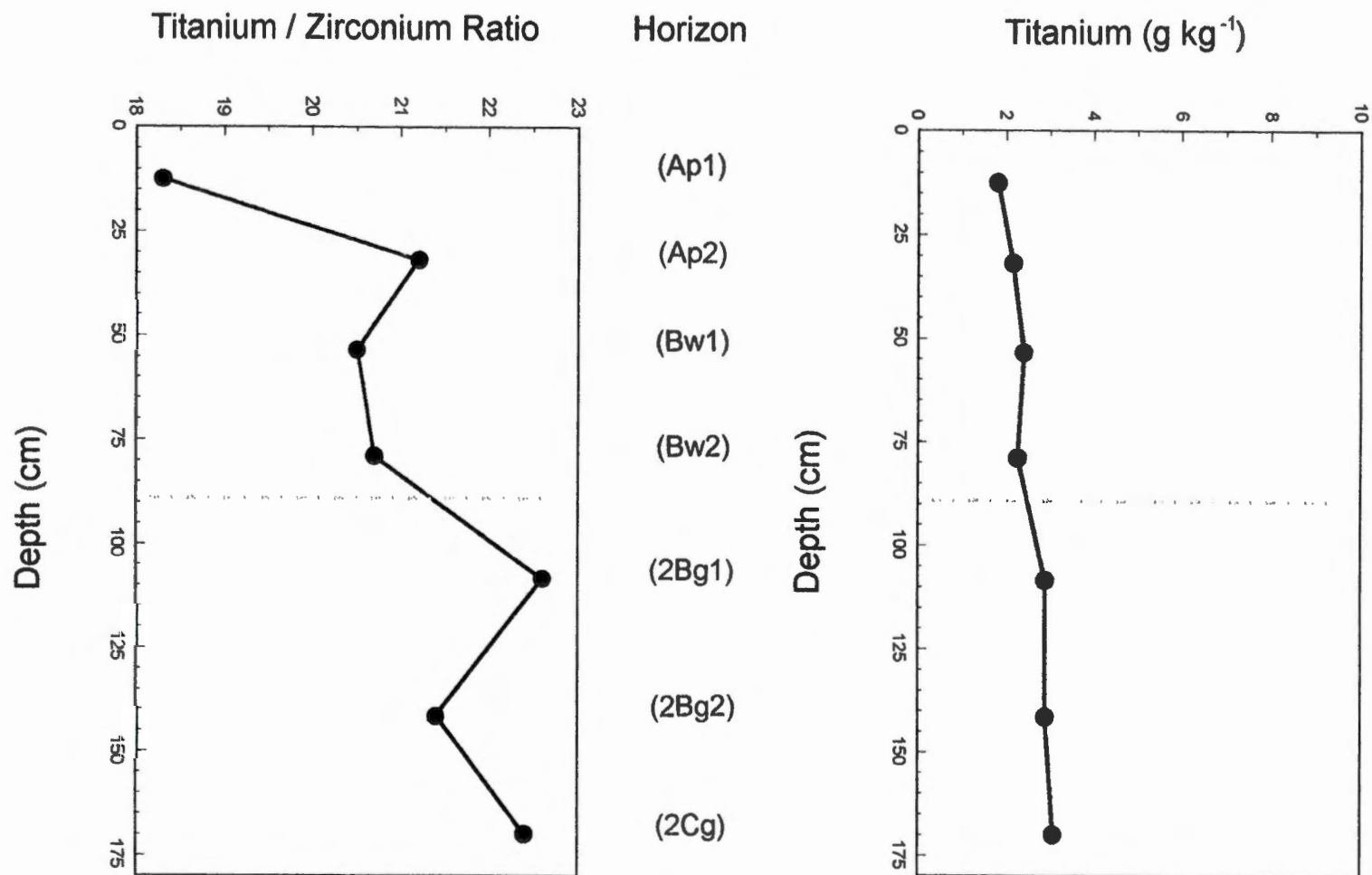


Figure 33. Plots of the titanium/zirconium ratio and titanium on a silt basis for Site 6.

layer of alluvium (Fig. 31). This deposition demonstrates a large enough increase in the fine sand ratio to indicate a discontinuity (Fig. 32). The free iron oxides decrease and eventually level off at a depth of 115 cm (Fig. 32). The titanium/zirconium ratio increases at the transition (Fig. 33). The titanium on a silt basis shows little change between the depositions (Fig. 33).

There appears to be a regular weathering pattern based on the carbon distribution curve (Fig. 34). There is a slight inflection at approx 80 cm below the surface, which could be an area that was exposed for a long enough period of time to have an organic matter influence. The remainder of the profile exhibits a uniform decrease in carbon.

A particle size class of coarse-silty is confirmed by the particle size data in Table 17. Quartz and potassium feldspars are the primary mineralogical component in the control section of the silt fraction (Table 7). This site has an ochric epipedon and a cambic subsurface horizon. The classification of this soil is coarse-silty, mixed, thermic Oxyaquic Eutrochrept (Table 8).

Site 7

The final site is located on a flood plain position under soybeans at an elevation of 117 meters above mean sea

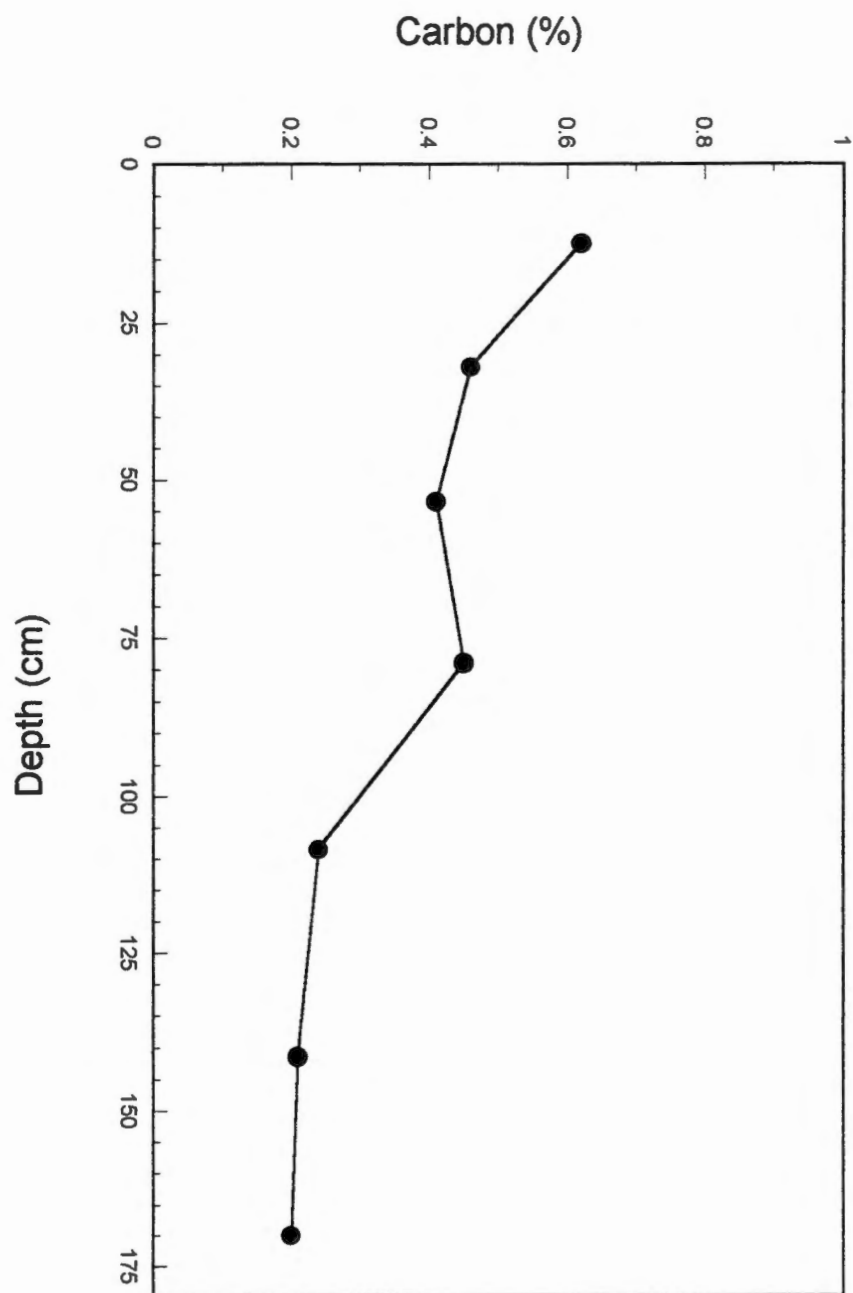


Figure 34. Total carbon distribution for Site 6.

Table 17. Particle size distribution for site 6.

horizon	depth cm	Particle Diameter (microns)		
		sand	silt	clay
		2000-50	50-2	< 2
		-----percent-----		
Ap1	0 - 25	4.6	82.3	13.1
Ap2	25 - 39	4.5	78.1	17.4
Bw1	39 - 68	4.0	79.1	17.0
Bw2	68 - 90	6.8	77.2	16.0
2Bg1	90 - 127	24.5	59.9	15.6
2Bg2	127 - 156	28.4	56.4	15.2
2Cg	156 - 184	32.0	50.5	17.5

level (385 feet). The soil morphology of site 7 was described to a depth of 181 cm (Fig. 35). The parent material is recent Holocene alluvium. A deposit of alluvium extends from the surface to 131 cm (Fig. 35). There is a slight increase and leveling off of the free iron oxides in the first deposition (Fig. 36). The titanium/zirconium ratio also demonstrates a bulge in this deposition (Fig. 37).

The remainder of the profile data exhibits four different depositions of alluvium (Fig. 35). The sand fluctuations between the four alluvial horizons is the most recognizable difference (Fig. 35). Similar fluctuations are present in the free iron oxide data (Fig. 36). The difference being that the iron is at its highest point when the sand is at its highest point (Fig. 36). The titanium/zirconium ratio has a large increase at the point of transition (Fig. 37). The titanium on a silt basis demonstrates a similar pattern to the fine sand ratio (Fig. 37).

The carbon distribution curve indicates a distinct irregular weathering pattern throughout the profile (Fig. 38). This irregular decrease in organic carbon content is important for distinguishing between Fluvents and Orthents for taxonomic classification. Fluvents exhibit an irregular

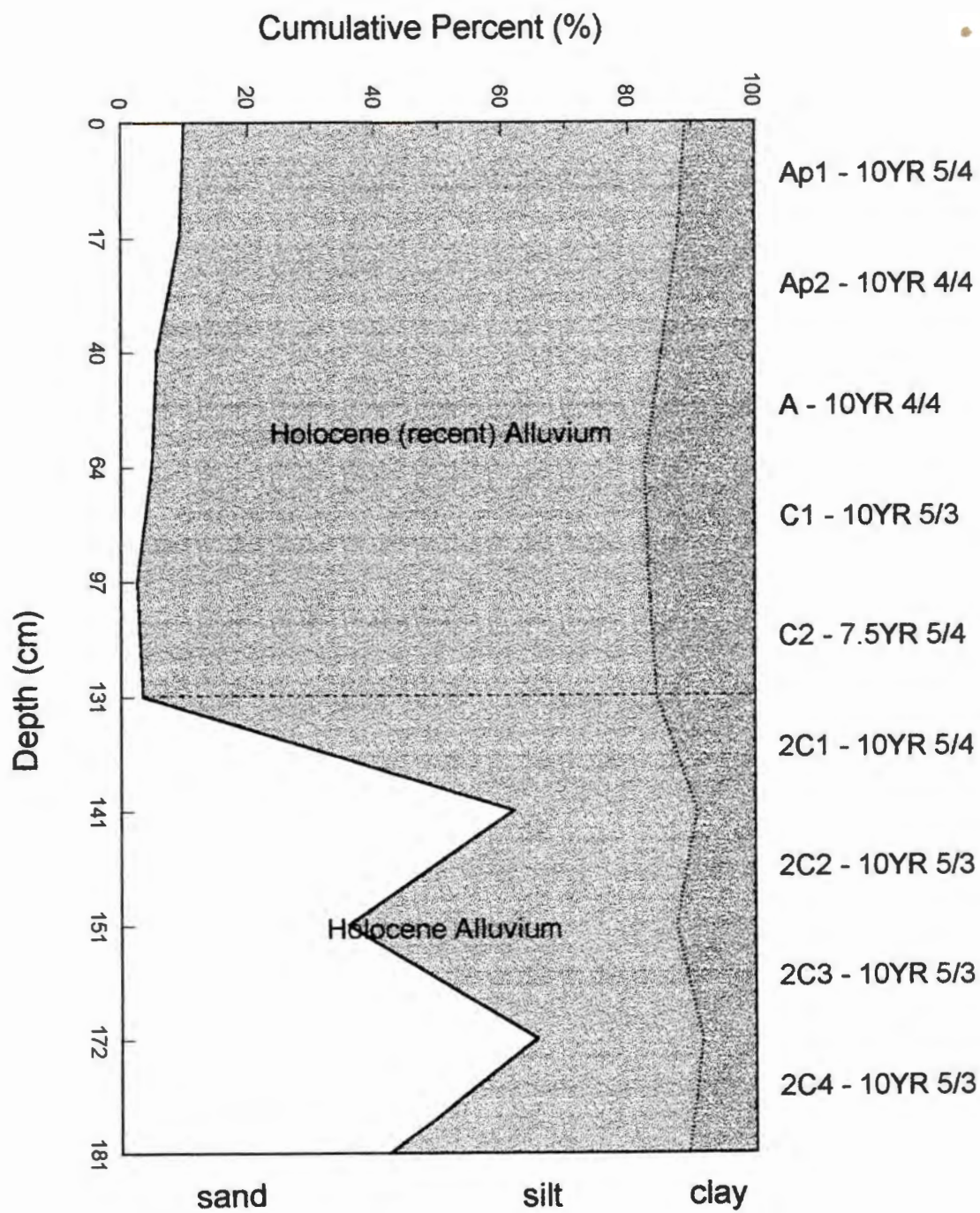


Figure 35. Particle size plot for Site 7.

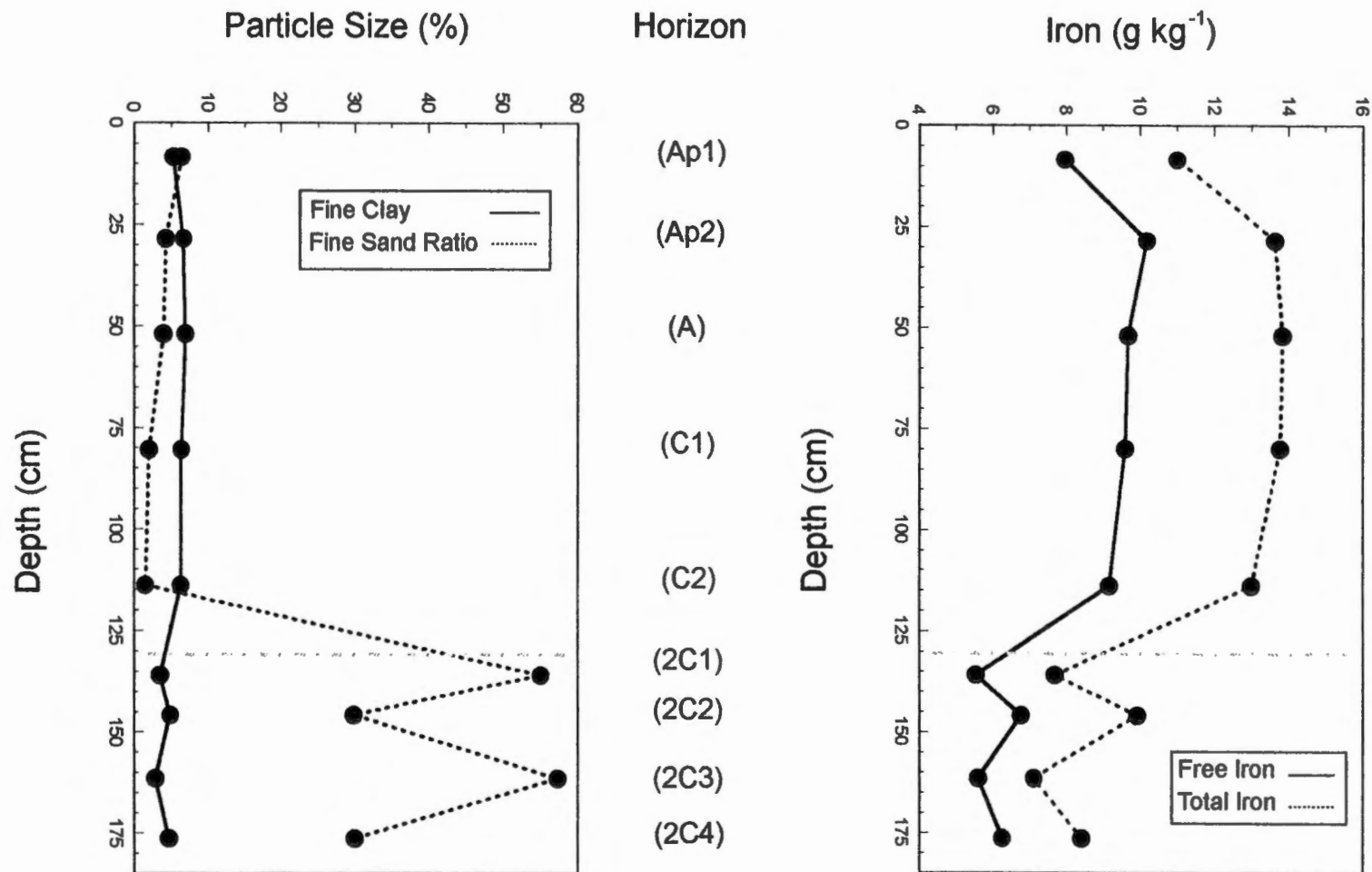


Figure 36. Plots of fine sand ratio, fine clay, free iron, and total iron for Site 7.

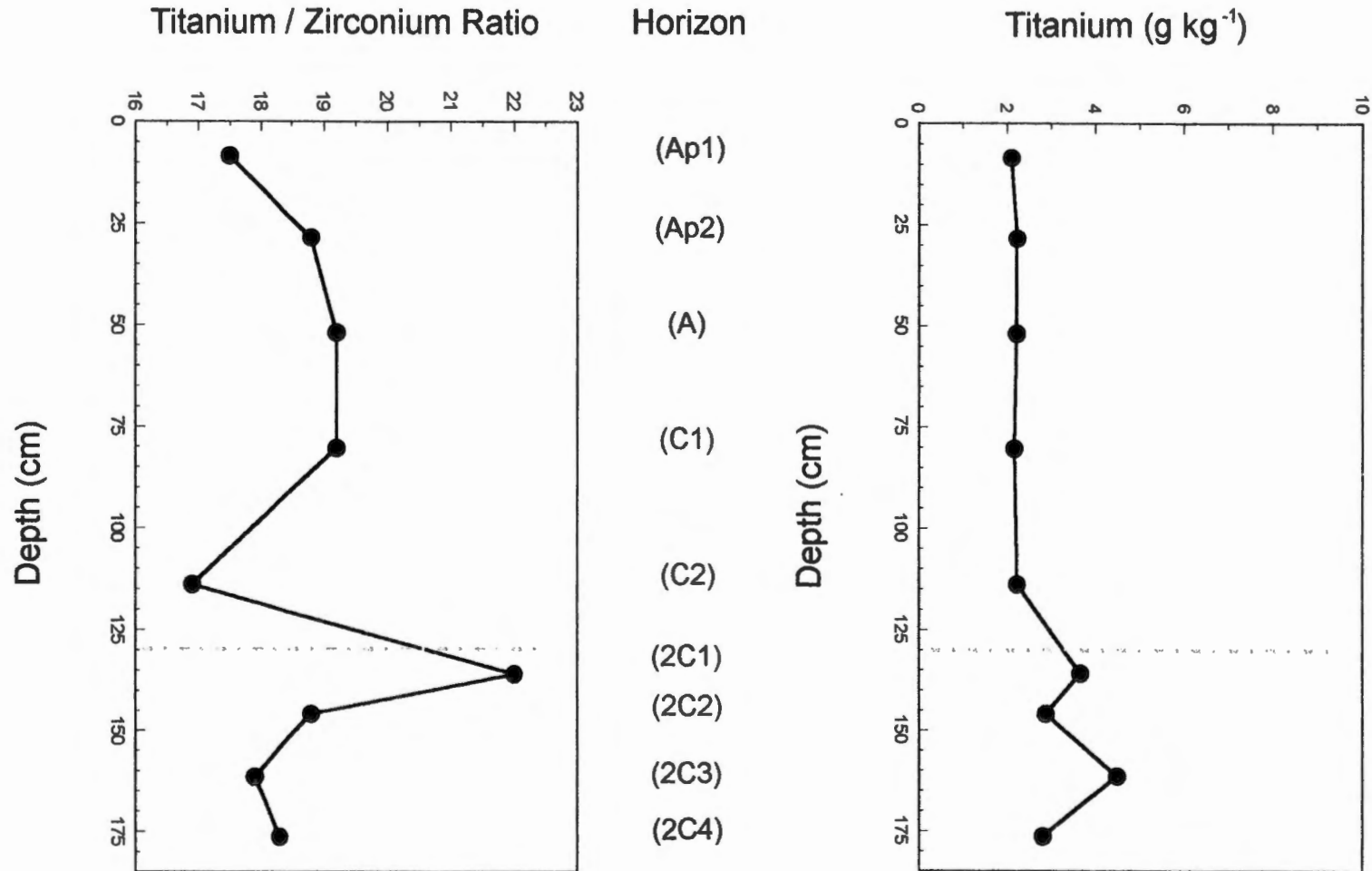


Figure 37. Plots of the titanium/zirconium ratio and titanium on a silt basis for Site 7.

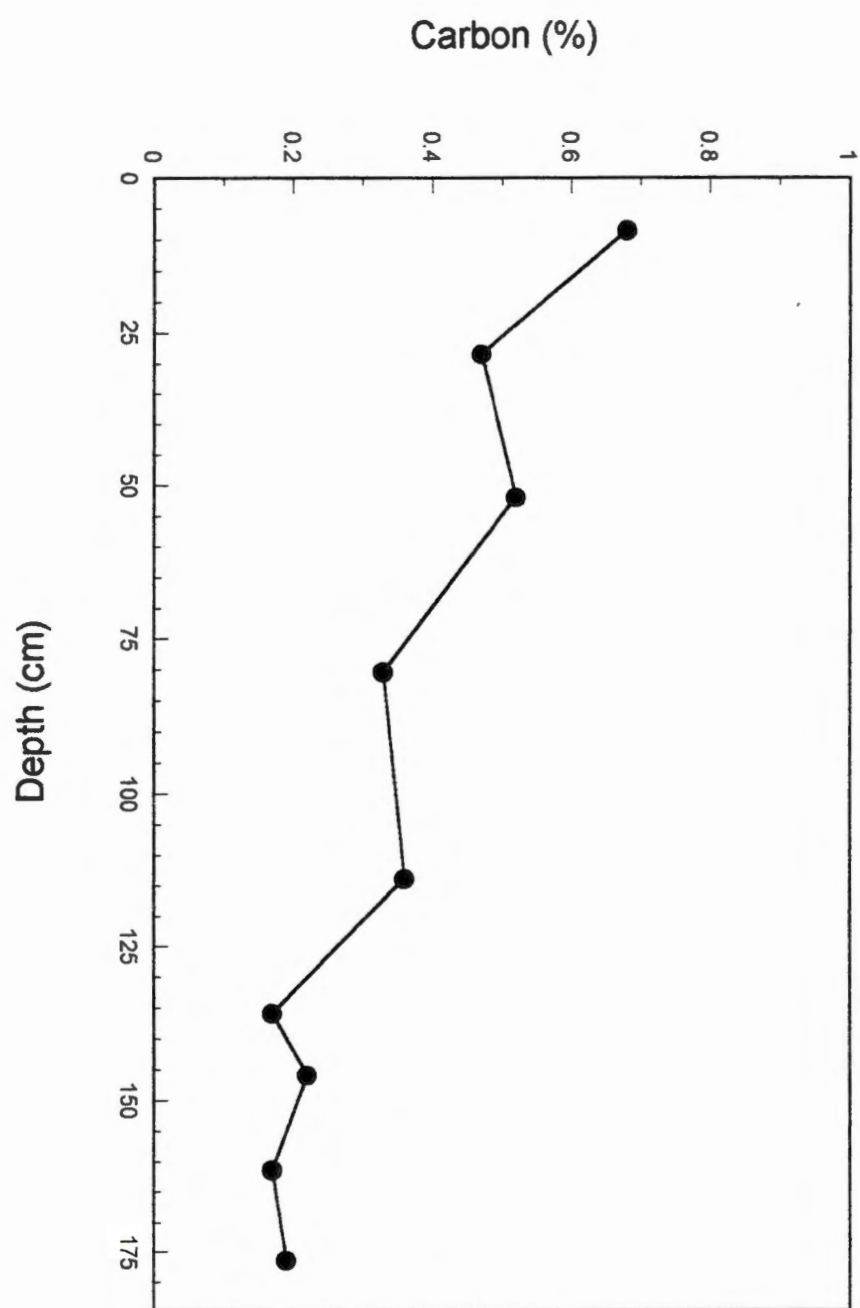


Figure 38. Total carbon distribution for Site 7.

decrease in organic carbon content from a depth of 25 to 125 cm (Soil Survey Staff, 1997).

From the particle-size data in Table 18, the particle size class is coarse-silty. The mineralogy in the silt fraction is composed of quartz, low albite, and microcline (Table 7). This site has an ochric epipedon and no diagnostic subsurface horizon. Based on the findings of this study, the classification of the soil is coarse-silty, mixed, nonacid, thermic Typic Udifluvent (Table 8).

Table 18. Particle size distribution for site 7.

horizon	depth cm	Particle Diameter (microns)		
		sand	silt	clay
		2000-50	50-2	< 2
		-----percent-----		
Ap1	0 -17	9.3	78.6	12.1
Ap2	17 - 40	5.7	79.6	14.7
A	40 - 64	4.9	77.7	17.4
C1	64 - 97	2.6	80.6	16.8
C2	97 - 131	3.5	80.9	15.6
2C1	131 - 141	61.8	29.0	9.2
2C2	141 - 151	35.7	51.8	12.5
2C3	151 - 172	65.4	26.2	8.4
2C4	172 - 181	42.3	47.1	10.6

CHAPTER V

Conclusions

1. Sites 1 - 5 were located on the Humboldt terrace as described by Saucier (1987). The parent material was loess over alluvium on sites 1, 2, 4, and 5. The parent material for site 4 was loess over alluvium over coastal plain. Sites 6 & 7 were on a lower lying flood plain. The parent material was Holocene alluvium.
2. Separate depositions of Peoria, Roxana, and Loveland loess were found on all five Humboldt terrace sites.
3. A fragipan was described on three of the five Humboldt terrace sites. All three occurred at the interface separating the Peoria and Roxana depositions.
4. The five terrace sites all had varying degrees of rubification occurring in the Loveland loess deposit. Three of the five Loveland loess deposits exhibited colors of 2.5 YR 4/6 or redder. The other two paleosols exhibited colors of 7.5 YR 5/6 or redder.

5. Sites 4 and 5 had total carbon distributions that revealed possible melanization with depth. Inflections occurred at a depth of approx. 200 cm on both sites within the Roxana loess deposit.
6. There were no buried A horizons, indicating that all former surfaces had been truncated.
7. An Inceptisol was classified on the upland position of site 1. This soil is still young due most likely to erosion and agricultural practices in the area, resulting in an unstable pedogenic environment.
8. There were no diatoms found in the Humboldt terrace soil profiles. This is most likely due to their absence during terrace formation or possibly physical destruction over time.
9. Sites 6 and 7 were classified as Inceptisol and Entisol, respectively. Site 7 had an irregular organic carbon distribution and was classified as a Udifluvent.

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APPENDICES

Appendix A. Morphology and Laboratory Data for Site 1

Soil Profile Description for Site 1

Landscape position: terrace

Slope: 1%

Parent material: loess / alluvium

Vegetation: complots

Drainage: moderately well drained

Classification: fine-silty, mixed, active, thermic Typic Eutrochrept

- Ap - 0 to 23 cm; yellowish brown (10YR 5/6) silt loam; weak fine subangular blocky and weak fine granular structure; friable; moderately acid; clear smooth boundary.
- Bw1 - 23 to 48 cm; dark yellowish brown (10YR 4/4) silt loam; moderate medium subangular blocky structure; friable; few continuous clay films; strongly acid; clear smooth boundary.
- Bw2 - 48 to 61 cm; dark yellowish brown (10YR 4/4) silt loam; moderate medium subangular blocky structure; friable; very few patchy clay films; very strongly acid; clear smooth boundary.
- Bw3 - 61 to 89 cm; yellowish brown (10YR 5/6) silt loam with few very fine distinct gray (10YR 6/1) mottles; weak medium subangular blocky structure; friable; few fine Fe/Mn concentrations; very strongly acid; clear wavy boundary.
- BC1 - 89 to 114 cm; dark yellowish brown (10YR 4/4) silt loam with many fine distinct grayish brown (10YR 5/2) and light brownish gray (10YR 6/2) mottles; weak medium subangular blocky structure; friable; few fine Fe/Mn stains; very strongly acid; gradual boundary.
- BC2 - 114 to 134 cm; brown (7.5YR 4/4) silt loam with many fine distinct grayish brown (10YR 5/2) and light brownish gray (10YR 6/2) mottles; weak medium subangular blocky structure; friable; few fine Fe/Mn stains; very strongly acid; gradual boundary.
- 2Bt/E - 134 to 178 cm; (Bt) brown (7.5YR 4/4) silt loam with few fine distinct pale brown (10YR 6/3) mottles, (E) light brownish gray (10YR 6/2) silt loam with few fine distinct pale brown (10YR 6/3) mottles; weak medium and fine subangular blocky structure; friable; very strongly acid; gradual boundary.
- 2Bt1 - 178 to 201 cm; brown (7.5YR 5/4) silt loam with few fine distinct pale brown (10YR 6/3) mottles; weak fine subangular blocky structure; friable; very few patchy clay films; very strongly acid; gradual boundary.
- 3Bt2 - 201 to 231 cm; dark red (2.5YR 3/6) silt loam with many fine prominent pale brown (10YR 6/3) mottles long and continuous along pores; weak fine subangular blocky structure; friable; very few patchy clay films; very strongly acid; gradual boundary.
- 3Bt3 - 231 to 285 cm; dark red (2.5YR 4/6) silty clay loam with many very fine prominent pale brown (10YR 6/3) mottles; weak fine subangular blocky structure; friable; very few patchy clay films; very strongly acid; gradual boundary.

- 3Bt4 - 285 to 317 cm; yellowish red (5YR 4/6) silty clay loam with few very fine faint pale brown (10YR 6/3) mottles; weak fine subangular blocky structure; friable; very few patchy clay films and few discontinuous clay films; few fine Fe/Mn concretions; very strongly acid; gradual boundary.
- 4BC1 - 317 to 352 cm; yellowish red (5YR 4/6) loam with many very fine distinct reddish yellow (7.5YR 6/8), few very fine distinct reddish yellow (7.5YR 6/6), and many very fine distinct dark red (2.5YR 3/6) mottles; weak fine subangular blocky structure; friable; few moderately thick discontinuous clay films in pores; few very fine Fe/Mn concentrations; very strongly acid; gradual boundary.
- 4BC2 - 352 to 384 cm; yellowish red (5YR 4/6) fine sandy loam with few very fine distinct dark brown (7.5YR 3/2), many very fine distinct reddish yellow (7.5YR 6/8), few very fine distinct reddish yellow (7.5YR 6/6), and many very fine distinct dark red (2.5YR 3/6) mottles; massive structure; friable; few thin to medium discontinuous clay films in pores; many very fine Fe/Mn stains; very strongly acid.

Sampling depth, pH, organic mater and carbon, total carbon, nitrogen, sulfur,
and carbon to nitrogen ratios for Site 1.

sample #	horizon	depth -----cm-----	midpoint	pH (1:1 H ₂ O)	pH (1:2 CaCl ₂)	O.M. (Walkley-Black)	O.C.	total Carbon ----- % -----	total Nitrogen	total Sulfur	C/N
89314	Ap	0 - 23	11.5	5.6	5.4	0.40	0.23	0.74	0.05	0.01	16.15
89315	Bw1	23 - 48	35.5	5.4	5.2	0.20	0.12	0.33	0.04	0.01	7.57
89316	Bw2	48 - 61	54.5	4.5	4.2	0.07	0.04	0.17	0.04	0.01	3.95
89317	Bw3	61 - 89	75.0	4.3	4.0	0.03	0.02	0.16	0.04	0.01	3.90
89318	BC1	89 - 114	101.5	4.4	3.8	0.03	0.02	0.13	0.04	0.01	3.17
89319	BC2	114 - 134	124.0	4.5	4.0	0.03	0.02	0.15	0.04	0.01	3.75
89320a	2Bt/E (E)	134 - 178	156.0	4.6	4.0	0.03	0.02	0.14	0.03	0.00	5.00
89320b	2Bt/E (Bt)	134 - 178	156.0	4.7	4.0	0.03	0.02	0.17	0.04	0.01	4.24
89321	2Bt1	178 - 201	189.5	5.0	4.2	0.07	0.04	0.17	0.03	0.00	5.25
89322	3Bt2	201 - 231	216.0	5.0	4.2	0.03	0.02	0.17	0.04	0.01	4.12
89323	3Bt3	231 - 285	258.0	5.0	4.2	0.03	0.02	0.13	0.03	0.00	5.28
89324	3Bt4	285 - 317	301.0	4.9	4.2	0.00	0.00	0.13	0.03	0.00	4.81
89325	4BC1	317 - 352	334.5	4.8	4.2	0.00	0.00	0.10	0.03	0.01	3.06
89326	4BC2	352 - 384	368.0	4.7	4.2	0.00	0.00	0.09	0.02	0.00	3.71

Particle size distribution for Site 1.

horizon	Size Class and Particle Diameter (microns)											
	vcos	cos	ms	fs	vfs	sand	cosi	fsi	silt	clay	clay	
	2000-1000	1000-500	500-250	250-100	100-50	2000-50	50-20	20-2	50-2	< 2	< 0.2	
	percent											
Ap	0.2	0.5	0.8	0.9	0.5	3.0	40.6	33.4	74.0	23.0	10.1	
Bw1	0.0	0.6	0.2	1.0	0.7	2.4	31.4	38.7	70.1	27.5	11.6	
Bw2	0.2	0.6	1.0	1.1	0.8	3.7	38.1	37.1	75.3	21.1	7.6	
Bw3	0.1	0.4	0.5	1.1	0.9	2.9	39.3	36.8	76.0	21.1	6.6	
BC1	0.0	0.4	0.3	1.0	0.9	2.5	40.6	37.0	77.6	19.9	8.2	
BC2	0.0	0.3	0.6	1.8	1.2	3.9	38.9	36.0	74.8	21.3	9.8	
2BtE (E)	0.2	0.3	0.4	1.6	0.9	3.3	42.1	37.3	79.4	17.3	7.3	
2BtE (Bt)	0.0	0.6	1.4	3.4	1.4	6.8	37.5	32.2	69.7	23.5	12.1	
2Bt1	0.2	1.3	2.9	5.9	1.8	12.1	31.1	33.1	64.3	23.6	14.1	
3Bt2	0.3	1.5	4.1	9.1	1.3	16.2	23.0	28.6	56.6	27.2	16.9	
3Bt3	0.2	1.4	5.1	10.3	1.2	18.1	25.0	26.2	51.3	30.6	18.6	
3Bt4	0.1	1.8	4.3	8.0	1.1	15.3	27.5	23.9	51.4	33.3	17.8	
4Bc1	0.0	3.6	8.3	15.6	2.2	29.7	22.7	22.5	45.1	25.2	11.2	
4Bc2	0.5	7.0	15.5	28.3	4.0	55.3	14.1	12.6	26.6	18.1	10.2	

Cation exchange capacity (pH 7), ammonium acetate extractable bases, potassium chloride extractable aluminium and acidity, barium chloride extractable acidity, and base saturation data for Site 1.

horizon	CEC (NH ₄ OAc)	Ca	exchangeable bases			K	(KCl) Al	acidity (KCl)	ext. acidity (BaCl ₂)	Base Saturation	
			Mg	Na	(NH ₄ OAc) pH 7					sum of cations	
											-----cmol(+)/kg-----
Ap	10.46	8.04	1.83	0.06	0.41	0.00	0.00			99	
Bw1	13.03	8.41	3.29	0.09	0.26	0.00	0.00			92	
Bw2	10.28	4.94	3.66	0.10	0.20	0.47	0.85			87	
Bw3	9.34	3.55	2.98	0.09	0.18	1.51	1.95			73	
BC1	11.63	2.96	3.24	0.11	0.23	2.10	2.15			56	
BC2	9.20	2.34	2.85	0.15	0.20	1.22	2.02			60	
2Bt/E (E)	9.56	2.11	2.58	0.13	0.17	0.79	1.21			52	
2Bt/E (Bt)	10.15	2.54	3.49	0.14	0.20	1.03	1.62	7.60		63	46
2Bt1	10.03	3.35	3.39	0.61	0.19	0.50	1.26	7.80		75	49
3Bt2	9.22	3.02	3.48	0.17	0.20	0.28	0.87			74	
3Bt3	9.68	2.56	3.06	0.14	0.19	0.51	0.94			61	
3Bt4	11.88	4.01	4.45	0.49	0.19	0.63	0.97			77	
4BC1	9.27	3.08	2.71	0.14	0.14	0.70	0.91			65	
4BC2	6.89	2.06	2.12	0.13	0.13	0.24	0.62			64	

Dithionite extractable iron, manganese, and aluminum;
hydroxylamine manganese, and CEC/clay ratios for
Site 1.

horizon	----- dithionite extractable -----						Ha - Mn ppm	CEC/Clay Ratio
	Fe	Mn	Al	Fe	Fe ₂ O ₃	Mn		
	----- ppm	----- ppm	----- ppm	----- %	----- %	----- ppm		
Ap	13426.6	730.8	1409.4	1.3	1.9	0.07	346.0	0.5
Bw1	21630.8	865.9	2251.7	2.2	3.1	0.09	199.0	0.5
Bw2	20250.8	579.5	1862.4	2.0	2.9	0.06	144.5	0.5
Bw3	18516.7	520.1	1862.4	1.9	2.7	0.05	135.0	0.4
BC1	16183.7	596.7	1543.6	1.6	2.3	0.06	194.0	0.6
BC2	14130.0	745.1	1423.8	1.4	2.0	0.07	361.5	0.4
2Bt/E (E)	8110.1	160.6	1026.5	0.8	1.1	0.02	70.0	0.6
2Bt/E (Bt)	13635.0	966.7	1350.0	1.4	2.0	0.10	431.5	0.4
2Bt1	14645.0	816.7	1266.7	1.5	2.1	0.08	364.5	0.4
3Bt2	12457.8	827.8	1341.1	1.2	1.7	0.08	520.0	0.3
3Bt3	19596.5	368.3	1476.5	2.0	2.9	0.04	213.5	0.3
3Bt4	21267.6	119.1	2147.7	2.1	3.0	0.01	22.0	0.4
4BC1	16749.2	120.0	1533.3	1.7	2.4	0.01	32.0	0.4
4BC2	11174.2	88.3	733.3	1.1	1.6	0.01	19.5	0.4

Concentration of selected elements for Site 1.

horizon	total elemental analysis										
	Al	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn
	ppm										
Ap	36955.0	482.3	2338.5	5.9	10.5	25.9	42.5	19245.0	13885.0	2844.5	681.0
Bw1	41400.0	383.5	1888.5	< 2.0	10.0	25.2	19.7	24060.0	11670.0	3644.5	647.5
Bw2	43760.0	420.7	1732.0	2.8	7.8	26.6	30.2	24755.0	9200.0	3804.0	539.0
Bw3	38785.0	387.4	1728.0	2.3	7.6	23.8	18.5	21420.0	9880.0	3372.5	426.1
BC1	45220.0	470.4	2384.5	2.1	9.3	28.9	20.6	24160.0	16440.0	3787.5	578.5
BC2	39645.0	452.9	2168.0	< 2.0	8.6	19.4	16.3	19735.0	15675.0	3060.5	654.5
2Bt/E (E)	38680.0	534.5	2386.5	< 2.0	4.7	27.6	16.0	15225.0	13290.0	2776.0	222.6
2Bt/E (Bt)	42665.0	489.7	2004.0	2.6	9.5	24.5	16.9	21485.0	13460.0	3090.0	816.0
2Bt1	42115.0	451.6	1546.5	< 2.0	8.2	21.1	19.9	21075.0	12945.0	2791.5	706.0
3Bt2	38810.0	366.3	938.5	< 2.0	8.9	21.1	19.9	21075.0	12945.0	2791.5	706.0
3Bt3	40530.0	306.7	691.0	4.4	12.3	28.3	20.3	20455.0	7495.0	2043.5	350.3
3Bt4	48090.0	317.1	798.0	< 2.0	5.9	41.5	20.0	27535.0	8350.0	2604.0	154.3
4BC1	37055.0	279.4	641.0	< 2.0	5.1	30.0	18.8	21525.0	7920.0	2141.5	161.6
4BC2	37340.0	278.9	695.0	2.3	5.0	23.8	20.0	20680.0	7750.0	2182.0	152.8

Concentration of selected elements for Site 1, continued.

horizon	total elemental analysis										
	Mo	Na	Ni	P	Pb	S	Si	Sr	Ti	Zn	Zr
	ppm										
Ap	7.3	4032.0	18.1	278.7	35.7	387.5	156100.0	67.8	1822.0	60.9	98.3
Bw1	6.6	3060.5	< 10.0	164.1	46.1	210.1	130750.0	57.1	1658.5	45.5	75.8
Bw2	< 5.0	4840.5	11.4	208.5	63.4	157.8	80950.0	72.4	1803.5	42.3	97.8
Bw3	< 5.0	5280.0	< 10.0	193.4	39.3	344.9	99350.0	73.6	1628.5	49.6	92.0
BC1	7.3	6785.0	10.2	192.0	34.3	230.6	138850.0	95.1	1852.5	43.3	109.0
BC2	< 5.0	6125.0	10.2	168.7	42.5	< 25.0	135300.0	86.3	1788.0	39.0	101.7
2Bt/E (E)	5.3	7130.0	< 10.0	61.9	50.1	61.0	220000.0	97.7	1982.5	29.2	114.8
2Bt/E (Bt)	11.9	5445.0	14.5	116.4	47.9	176.7	235200.0	79.9	1952.5	40.6	109.0
2Bt1	< 5.0	3652.0	22.8	86.4	66.4	57.8	217500.0	64.1	2069.5	38.6	110.3
3Bt2	< 5.0	1807.5	12.2	89.2	55.4	< 25.0	84850.0	43.5	1816.5	32.9	94.6
3Bt3	< 5.0	659.5	< 10.0	98.4	58.1	< 25.0	114850.0	36.1	1700.0	59.0	87.1
3Bt4	8.6	520.0	21.2	185.4	39.0	54.7	159250.0	34.8	1972.0	49.7	106.4
4BC1	< 5.0	510.0	20.0	189.0	56.4	< 25.0	75100.0	30.6	1717.0	28.0	97.8
4BC2	7.9	489.3	< 10.0	238.3	55.2	111.8	251400.0	29.6	1781.0	34.1	89.9

Appendix B. Morphology and Laboratory Data for Site 2

Soil Profile Description for Site 2

Landscape position: terrace

Slope: 1%

Parent material: loess / alluvium

Vegetation: oak and cedar forested area

Drainage: somewhat poorly drained

Classification: fine-silty, mixed, active, thermic Aquic Fragiudalf

- Oi - 2 to 0 cm; clear boundary.
- A - 0 to 10 cm; very dark grayish brown (10YR 3/2) silt loam; weak fine granular structure; very friable; moderately acid; abrupt smooth boundary.
- EA - 10 to 19 cm; brown (10YR 4/3) and yellowish brown (10YR 5/4) silt loam; weak fine subangular blocky structure; very friable; strongly acid; clear smooth boundary.
- E - 19 to 38 cm; yellowish brown (10YR 5/4) silt loam; weak fine subangular blocky structure; very friable; strongly acid; clear smooth boundary.
- Bt1 - 38 to 68 cm; brown (7.5YR 5/4) silt loam with few very fine faint strong brown (7.5YR 5/8) and pinkish gray (7.5YR 6/2) mottles; weak fine subangular blocky and weak prismatic structure; friable; very few patchy clay films in pores; very few fine Fe/Mn stains; very strongly acid; gradual boundary.
- Bt2 - 68 to 80 cm; yellowish brown (10YR 5/4) silt loam with common very fine faint light brownish gray (10YR 6/2), light gray (10YR 7/2), and few very fine distinct strong brown (7.5YR 5/6) mottles; weak fine subangular blocky and weak fine prismatic structure; friable; few fine to medium Fe/Mn stains; very strongly acid; clear to gradual boundary.
- Bt3 - 80 to 94 cm; brown (10YR 5/3) silt loam with many fine distinct light brownish gray (10YR 6/2) mottles; moderate medium prismatic and weak fine subangular blocky structure; friable; few fine Fe/Mn stains and concentrations; very strongly acid; clear smooth boundary.
- 2Btx1 - 94 to 110 cm; grayish brown (10YR 5/2) silt loam with common fine faint light brownish gray (10YR 6/2) and pinkish gray (7.5YR 6/2) mottles; moderate medium and coarse prismatic structure; firm; common fine Fe/Mn stains and concentrations; very strongly acid; clear smooth boundary.
- 2Btx2 - 110 to 146 cm; grayish brown (10YR 5/2) silt loam with common fine faint light gray (10YR 7/2) and pinkish gray (7.5YR 7/2) mottles; fine coarse prismatic and fine medium subangular structure; firm; few fine Fe/Mn stains and concentrations; very strongly acid; gradual boundary.
- 2Btx3 - 146 to 186 cm; brown (7.5YR 5/4) silt loam with common fine faint pale brown (10YR 6/3) and grayish brown (10YR 5/2) mottles; weak fine subangular blocky and weak fine prismatic structure; firm; few fine Fe/Mn stains and concentrations; strongly acid; gradual boundary.

- 2Btx4 - 186 to 276 cm; brown (7.5YR 5/4) silt loam with grayish brown (10YR 5/2) streaks; few coarse prismatic structure; firm; few fine and medium Fe/Mn concretions; few discontinuous clay films in pores; strongly acid; clear boundary.
- 3Bt1 - 276 to 296 cm; brown (7.5YR 4/4) silt loam with pinkish gray (7.5YR 6/2) mottles; massive structure; friable; common coarse and medium Fe/Mn concentrations; moderately acid; clear boundary.
- 3Bt2 - 296 to 336 cm; strong brown (7.5YR 5/6) silty clay loam with common fine distinct light brown (7.5YR 6/4) mottles; massive structure; friable; very fine thin clay films along macropore faces; moderately acid; clear boundary.
- 4BC1 - 336 to 356 cm; strong brown (7.5YR 5/6) loam with common fine distinct pinkish gray (7.5YR 6/2) mottles; massive structure; friable; very fine thin clay films along macropore faces; moderately acid; clear boundary.
- 4BC2 - 356+ cm; strong brown (7.5YR 5/6) sandy loam; massive structure; moderately acid.

Sampling depth, pH, organic mater and carbon, total carbon, nitrogen, sulfur,
and carbon to nitrogen ratios for Site 2.

sample #	horizon	depth	cm			pH (1:1 H ₂ O)	pH (1:2 CaCl ₂)	O.M. (Walkley-Black)	O.C.	%			C/N
			midpoint							total Carbon	total Nitrogen	total Sulfur	
89327	A	0 - 10	5.0	5.6	5.3	6.04	3.51	10.31	0.10	0.24	100.10		
89328	EA	10 - 19	14.5	5.3	4.6	0.88	0.51	1.72	0.04	0.04	39.02		
89329	E	19 - 38	28.5	5.1	4.4	0.27	0.16	0.42	0.04	0.01	10.50		
89330	Bt1	38 - 68	53.0	5.0	4.2	0.07	0.04	0.14	0.03	0.01	4.12		
89331	Bt2	68 - 80	74.0	5.0	4.3	0.03	0.02	0.11	0.03	0.01	3.93		
89332	Bt3	80 - 94	87.0	4.8	3.8	0.00	0.00	0.08	0.03	0.01	3.12		
89333	2Bt1	94 - 110	102.0	4.6	3.7	0.00	0.00	0.11	0.04	0.01	3.20		
89334	2Bt2	110 - 146	128.0	4.8	3.9	0.00	0.00	0.06	0.04	0.01	1.69		
89335	2Bt3	146 - 186	166.0	5.1	4.2	0.00	0.00	0.09	0.03	0.00	2.65		
89336	2Bt4	186 - 276	231.0	5.4	4.6	0.00	0.00	0.08	0.03	0.01	2.21		
89337	3Bt1	276 - 296	286.0	5.8	5.0	0.03	0.02	0.12	0.03	0.01	3.94		
89338	3Bt2	296 - 336	316.0	5.8	4.9	0.00	0.00	0.08	0.04	0.01	2.28		
89339	4BC1	336 - 356	346.0	5.9	4.8	0.00	0.00	0.06	0.02	0.01	2.90		
89340	4BC2	356 - 358	357.0	5.9	4.8	0.00	0.00	0.06	0.02	0.01	3.16		

Particle size distribution for Site 2.

horizon	Size Class and Particle Diameter (microns)										
	vcos	cos	ms	fs	vfs	sand	cosl	fsi	silt	clay	clay
	2000-1000	1000-500	500-250	250-100	100-50	2000-50	50-20	20-2	50-2	< 2	< 0.2
	percent										
A	7.2	5.8	3.8	6.5	2.5	25.7	34.3	28.4	62.7	11.5	3.1
EA	1.8	1.3	1.8	0.9	0.6	6.3	41.2	39.3	80.8	12.9	5.4
E	1.2	1.4	1.4	1.0	0.8	5.6	39.8	40.7	80.6	13.8	6.8
Bt1	1.0	1.6	0.6	0.7	0.5	4.4	37.2	36.3	73.5	22.0	9.3
Bt2	1.0	1.7	0.7	0.6	0.4	4.3	35.9	41.9	77.8	17.9	4.2
Bt3	1.0	1.5	0.9	0.9	0.5	4.7	39.0	38.7	77.7	17.6	4.8
Btx1	0.5	1.7	0.5	0.8	1.5	5.2	31.0	44.5	75.6	19.3	8.5
Btx2	0.1	0.9	0.6	1.0	0.5	3.1	40.8	35.9	76.7	20.2	10.4
Btx3	0.5	0.7	1.1	3.2	0.6	6.1	40.5	34.7	75.2	18.7	8.6
Btx4	0.6	0.7	2.4	5.1	0.6	9.4	40.6	30.5	71.2	19.4	9.9
2Bt1	2.6	1.9	3.6	8.6	2.0	18.7	28.0	19.5	57.5	23.8	14.9
2Bt2	0.9	0.9	2.7	9.9	1.5	15.9	26.7	19.4	56.1	28.0	13.9
3BC1	0.1	1.8	8.9	26.3	2.3	39.4	19.7	21.3	41.0	19.6	7.2
3BC2	0.3	2.1	11.2	38.8	4.3	56.7	14.3	18.2	32.6	10.7	3.2

Cation exchange capacity (pH 7), ammonium acetate extractable bases, potassium chloride extractable aluminum and acidity, and base saturation data for Site 2.

horizon	CEC		exchangeable bases					Base Saturation	
	(NH ₄ OAc)	Ca	Mg	Na	K	Al (KCl)	acidity (KCl)	ext. acidity (BaCl ₂)	sum of pH 7 cations
A	14.39	9.69	2.95	0.07	0.46	0.00	0.00	0.00	92
EA	8.35	3.79	0.84	0.06	0.37	0.03	0.43		61
E	7.05	3.16	1.67	0.07	0.27	0.27	0.99		73
B1	9.91	4.32	1.64	0.09	0.33	0.76	1.01		64
B2	8.48	3.47	2.01	0.12	0.33	0.43	1.62		70
B3	9.99	1.62	2.46	0.08	0.31	2.60	2.93		45
Btx1	13.54	2.17	5.17	0.10	0.35	2.29	2.51		57
Btx2	13.57	2.71	5.75	0.14	0.29	1.31	1.87	10.20	65
Btx3	9.08	3.25	5.60	0.22	0.15	0.33	0.70	8.00	102
Btx4	8.80	3.24	4.99	0.55	0.11	0.07	0.22		101
2Bt1	11.63	4.74	5.19	0.96	0.11	0.00	0.00		95
2Bt2	10.96	5.06	5.30	0.93	0.09	0.07	0.00		104
3BC1	7.16	3.20	3.00	0.71	0.67	0.00	0.00		106
3BC2	5.39	2.47	2.35	0.51	0.33	0.09	0.00		105

Dithionite extractable iron, manganese, and aluminum;
hydroxylamine manganese, and CEC/clay ratios for
Site 2.

horizon	----- dithionite extractable -----						Ha - Mn ppm	CEC/Clay Ratio
	Fe	Mn	Al	Fe	Fe ₂ O ₃	Mn		
	----- ppm	----- ppm	----- ppm	----- %	----- %	----- %		
A	15570.8	1253.3	1166.7	1.6	2.3	0.13	900.0	1.3
EA	11535.6	990.8	1556.3	1.2	1.7	0.10	570.5	0.6
E	10760.9	567.1	1375.8	1.1	1.6	0.06	310.0	0.5
Bt1	15675.3	370.8	1996.6	1.6	2.3	0.04	161.5	0.5
Bt2	15655.0	706.7	2066.7	1.6	2.3	0.07	417.5	0.5
Bt3	14476.7	523.3	1516.7	1.4	2.0	0.05	424.0	0.6
Btx1	13723.7	560.0	1550.0	1.4	2.0	0.06	356.0	0.7
Btx2	14297.2	503.3	1307.9	1.4	2.0	0.05	252.0	0.7
Btx3	12190.6	475.2	1026.5	1.2	1.7	0.05	288.0	0.5
Btx4	12201.3	551.7	1224.8	1.2	1.7	0.06	603.0	0.5
2Bt1	18095.8	2400.0	2216.7	1.8	2.6	0.24	1126.5	0.5
2Bt2	18937.5	102.0	1550.0	1.9	2.7	0.01	73.0	0.4
3BC1	13472.3	16.8	1208.1	1.3	1.9	0.00	0.5	0.4
3BC2	8248.3	20.0	600.0	0.8	1.1	0.00	1.5	0.5

Concentration of selected elements for Site 2.

horizon	total elemental analysis										
	Al	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn
	ppm										
A	28180.0	435.4	3050.0	< 2.0	6.5	18.4	17.9	20920.0	10220.0	1739.0	1290.0
EA	26305.0	389.2	1640.0	< 2.0	3.6	19.4	13.6	11430.0	10645.0	1535.0	709.5
E	28640.0	382.0	1695.0	< 2.0	3.5	21.8	12.1	11810.0	11415.0	1732.5	414.8
Bt1	43510.0	458.8	1825.0	2.1	7.1	32.7	20.0	20250.0	13375.0	3069.0	313.6
Bt2	45705.0	508.0	1953.0	2.8	12.2	42.6	21.8	20525.0	15505.0	3421.5	739.5
Bt3	38100.0	447.7	1641.5	4.9	10.7	28.9	21.2	15410.0	13885.0	2966.0	417.4
Btx1	41960.0	431.2	2003.0	< 2.0	8.7	27.9	22.2	19940.0	13885.0	3764.0	487.9
Btx2	40115.0	404.4	2611.5	< 2.0	7.6	31.7	16.3	20555.0	12690.0	3734.5	430.5
Btx3	36100.0	407.8	2952.0	< 2.0	7.2	28.3	13.2	17555.0	10305.0	2943.5	435.3
Btx4	29805.0	318.3	2013.0	< 2.0	3.3	22.5	10.2	13585.0	7835.0	2198.5	223.2
2Bt1	35870.0	301.6	1027.0	< 2.0	17.0	25.2	13.5	21735.0	7240.0	2108.5	2119.5
2Bt2	38800.0	238.4	854.0	2.6	4.0	27.2	11.4	23730.0	5790.0	2107.0	115.3
3BC1	28315.0	194.4	640.5	< 2.0	< 3.0	24.5	8.1	16125.0	5365.0	1555.0	46.5
3BC2	18375.0	145.1	434.3	< 2.0	< 3.0	13.6	5.4	8895.0	3748.0	972.0	35.3

Concentration of selected elements for Site 2, continued.

horizon	total elemental analysis										
	Mo	Na	Ni	P	Pb	S	Si	Sr	Ti	Zn	Zr
	ppm										
A	9.3	3869.5	11.0	394.2	41.3	791.5	135750.0	70.7	1592.5	97.2	73.5
EA	5.3	4289.0	< 10.0	215.6	31.4	230.8	59500.0	59.3	1359.5	35.7	74.0
E	< 5.0	4558.0	< 10.0	97.6	< 25.0	< 25.0	66500.0	62.6	1465.0	27.6	80.5
Bt1	8.6	4811.0	14.9	183.3	47.9	243.2	247300.0	68.9	1996.5	37.9	94.6
Bt2	7.9	6500.0	< 10.0	198.1	56.8	401.7	311100.0	82.5	2083.0	43.1	105.1
Bt3	11.2	6160.0	< 10.0	96.1	43.3	< 25.0	217300.0	81.5	1742.0	75.2	89.4
Btx1	< 5.0	7370.0	< 10.0	195.7	52.4	944.0	235400.0	85.1	1712.0	43.1	97.0
Btx2	5.3	7150.0	< 10.0	255.1	67.3	< 25.0	113000.0	94.5	1626.0	38.4	97.8
Btx3	< 5.0	6780.0	< 10.0	176.9	37.6	< 25.0	46520.0	95.1	1658.5	29.2	104.8
Btx4	5.3	4409.0	< 10.0	95.7	38.9	< 25.0	37095.0	64.3	1562.0	19.6	87.3
2Bt1	6.6	1475.5	20.8	136.5	41.1	< 25.0	53650.0	46.4	1784.5	30.2	95.7
2Bt2	7.3	1240.5	< 10.0	143.1	45.3	186.3	160700.0	31.0	1646.0	24.4	96.7
3BC1	< 5.0	865.0	< 10.0	51.6	< 25.0	88.3	49115.0	< 25.0	1279.0	10.7	70.1
3BC2	9.9	944.5	< 10.0	86.9	< 25.0	< 25.0	48460.0	< 25.0	881.5	4.0	52.8

Appendix C. Morphology and Laboratory Data for Site 3

Soil Profile Description for Site 3

Landscape position: terrace

Slope: 1%

Parent material: loess / alluvium

Vegetation: grass sod - near no-till cotton

Drainage: moderately well drained

Classification: fine-silty, mixed, active, thermic Typic Fragiudalf

- A - 0 to 4 cm; yellowish brown (10YR 5/4) silt loam; weak fine granular structure; friable; strongly acid; clear smooth boundary.
- Ap - 4 to 23 cm; yellowish brown (10YR 5/4) silt loam; weak fine subangular blocky structure; friable; moderately acid; abrupt boundary.
- Bt1 - 23 to 49 cm; strong brown (7.5YR 5/6) silt loam; moderate fine prismatic and weak fine subangular blocky structure; friable; few fine clay films on ped faces; moderately acid; clear boundary.
- Bt2 - 49 to 61 cm; yellowish brown (10YR 5/4) silt loam; weak fine subangular blocky structure; very friable; few fine and medium Fe/Mn stains and concretions; few fine clay films on ped faces; very strongly acid; clear boundary.
- 2Btx1- 61 to 98 cm; yellowish brown (10YR 5/4) and brown (7.5YR 4/4) silt loam; weak medium prismatic and weak fine subangular blocky structure; firm to brittle; few fine and medium Fe/Mn stains and concretions; strongly acid; gradual boundary.
- 2Btx2 - 98 to 122 cm; brown (7.5YR 4/4) silt loam with grayish brown (10YR 5/2) streaks; weak medium prismatic, weak coarse platy, and weak fine subangular blocky structure; firm to brittle; few medium Fe/Mn stains; few fine discontinuous clay films in pores; moderately acid; gradual boundary.
- 2Btx3 - 122 to 161 cm; brown (7.5YR 4/4) silt loam with grayish brown (10YR 5/2) streaks; weak coarse subangular blocky and weak coarse platy structure; firm; few fine and medium Fe/Mn stains and concretions; few fine discontinuous clay films in pores; moderately acid; gradual boundary.
- 2Btx4 - 161 to 205 cm; strong brown (7.5YR 4/6) silt loam with grayish brown (10YR 5/2) streaks; weak coarse subangular blocky structure and weak coarse platy structure; firm; few medium Fe/Mn stains; few fine discontinuous clay films in pores; moderately acid; gradual boundary.
- 3Bt1 - 205 to 245 cm; yellowish red (5YR 4/6) silty clay loam with light brownish gray (10YR 6/2) streaks; moderate fine subangular blocky structure; friable; few medium Fe/Mn stains; few fine discontinuous clay films in pores; strongly acid; gradual boundary.
- 3Bt2 - 245 to 293 cm; yellowish red (5YR 4/6) silty clay loam with light brownish gray (10YR 6/2) streaks; moderate fine and weak medium subangular blocky structure; friable; few fine discontinuous clay films in pores; strongly acid; gradual boundary.

- 3Bt3 - 293 to 312 cm; strong brown (7.5YR 5/6) clay loam with weak moderate subangular blocky structure; friable; few medium Fe/Mn stains; few fine discontinuous clay films in pores; very strongly acid; gradual boundary.
- 4BC1 - 312 to 346 cm; reddish yellow (7.5YR 6/6) loam with few fine faint yellowish brown (10YR 5/4) and strong brown (7.5 YR 4/6) mottles; massive structure; friable; few fine Fe/Mn stains; few fine discontinuous clay films in pores; very strongly acid; gradual boundary.
- 4BC2 - 346 to 380 cm; reddish yellow (7.5YR 6/6) sandy loam with few fine faint yellowish brown (10YR 5/4) and strong brown (7.5 YR 4/6) mottles; massive structure; friable; few very fine Fe/Mn stains; few very fine discontinuous clay films in pores; very strongly acid; gradual boundary.
- 5BC3 - 380 to 406 cm; yellowish red (5YR 4/6) sandy loam; massive structure; friable; few very fine Fe/Mn stains; very strongly acid; gradual boundary.
- 5BC4 - 406 to 428+ cm; yellowish red (5YR 4/6) loamy sand; massive sand grain structure; friable; very strongly acid; gradual boundary.

Sampling depth, pH, organic mater and carbon, total carbon, nitrogen, sulfur, and carbon to nitrogen ratios for Site 3.

sample #	horizon	depth	midpoint	pH (1:1 H ₂ O)	pH (1:2 CaCl ₂)	O.M. (Walkley-Black)	O.C.	total Carbon	total Nitrogen	total Sulfur	C/N
		-----cm-----						%			
89341	A	0 - 4	2.0	5.4	4.7	4.94	2.87	9.30	0.17	0.10	53.43
89342	Ap	4 - 23	13.5	6.0	5.3	0.28	0.16	0.91	0.04	0.02	21.09
89343	Bt1	23 - 49	36.0	5.6	5.0	0.00	0.00	0.29	0.04	0.01	7.50
89344	Bt2	49 - 61	55.0	4.8	4.0	0.00	0.00	0.25	0.03	0.01	8.79
89345	2Btx1	61 - 98	19.5	5.3	4.1	0.00	0.00	0.13	0.03	0.01	4.54
89346	2Btx2	98 - 122	110.0	5.7	4.3	0.00	0.00	0.12	0.02	0.00	5.13
89347	2Btx3 (gray)	122 - 161	141.5	5.6	4.3	0.00	0.00	0.09	0.03	0.00	3.21
89348	2Btx3	122 - 161	141.5	5.9	4.5	0.00	0.00	0.17	0.03	0.00	5.52
89349	2Btx4	161 - 205	183.0	5.8	4.5	0.00	0.00	0.11	0.03	0.00	3.96
89350	3Bt1	205 - 245	225.0	5.4	4.3	0.00	0.00	0.12	0.03	0.00	3.41
89351	3Bt2 (1)	245 - 293	249.0	5.2	4.1	0.00	0.00	0.15	0.03	0.00	4.83
89352	3Bt2 (2)	243 - 293	268.0	5.2	4.1	0.00	0.00	0.14	0.03	0.00	5.22
89353	3Bt3	293 - 312	302.5	4.9	4.0	0.00	0.00	0.08	0.03	0.00	3.11
89354	4BC1	312 - 346	329.0	5.0	4.0	0.00	0.00	0.04	0.03	0.00	1.72
89355	4BC2	346 - 380	363.0	5.0	4.0	0.00	0.00	0.05	0.02	0.00	2.22
89356	5BC3	380 - 406	393.0	4.9	4.0	0.00	0.00	0.06	0.02	0.00	2.42
89357	5BC4	406 - 428	417.0	5.0	4.1	0.00	0.00	0.04	0.03	0.00	1.41

Particle size distribution for Site 3.

horizon	Size Class and Particle Diameter (microns)									
	vcos	cos	ms	fs	vfs	sand	cosi	fsi	silt	clay
	2000-1000	1000-500	500-250	250-100	100-50	2000-50	50-20	20-2	50-2	< 2
	percent									
A	0.2	0.8	2.1	0.6	0.8	4.6	38.8	38.5	77.3	18.1
Ap	0.1	0.3	0.8	1.4	0.5	3.0	41.7	39.2	80.9	16.1
Bt1	0.0	0.5	0.5	0.8	0.7	2.4	36.6	37.2	73.8	24.0
Bt2	0.3	2.5	0.7	1.3	0.6	5.4	35.2	39.8	75.0	19.6
Bx1	0.3	0.8	0.8	0.9	1.1	3.9	39.4	39.3	78.7	17.4
Bx2	0.3	0.4	1.5	1.4	1.4	5.0	39.4	37.6	77.0	18.0
Bx3 (gray)	0.2	0.8	0.9	2.2	1.1	5.2	42.3	31.9	74.0	20.8
Bx3	0.0	0.6	1.0	4.0	1.7	7.3	37.8	32.9	70.7	22.0
Bx4	0.0	0.4	2.1	6.4	2.4	11.3	36.2	32.1	68.3	20.5
2Bt1	0.1	0.6	2.9	10.3	2.2	16.1	27.4	28.6	56.0	27.9
2Bt2 (1)	0.0	0.5	2.1	7.6	1.1	11.3	23.9	29.0	52.9	35.8
2Bt2 (2)	0.0	0.6	2.1	7.5	1.6	11.8	26.3	28.7	55.0	33.2
2Bt3	0.0	0.6	4.5	16.7	3.9	25.7	24.7	21.4	46.1	28.2
3Bc1	0.0	1.3	8.3	32.1	5.3	47.0	18.6	14.8	33.5	19.5
3Bc2	0.2	2.1	12.1	48.1	7.2	69.7	9.0	5.7	14.7	15.7
4Bc3	0.0	1.2	11.5	62.0	7.3	82.0	4.9	0.4	5.3	12.7
4Bc4	0.0	1.2	12.3	67.8	3.2	84.5	2.4	0.6	3.1	12.4
										10.8

Cation exchange capacity (pH 7), ammonium acetate extractable bases, potassium chloride extractable aluminium and acidity, barium chloride extractable acidity, and base saturation data for Site 3.

horizon	CEC (NH ₄ OAc)	Ca	exchangeable bases			K	(KCl) Al	acidity (KCl)	ext. acidity (BaCl ₂)	Base Saturation	
			Mg	Na	(NH ₄ OAc) pH 7					sum of cations	
											cmol(+)/kg
A	11.82	8.69	2.06	0.06	0.44	0.00	0.00			95	
Ap	7.48	5.34	0.94	0.05	0.28	0.00	0.00			88	
Bt1	11.48	6.28	2.62	0.09	0.25	0.00	0.00			80	
Bt2	10.17	2.65	2.87	0.10	0.19	1.80	1.74			57	
Bx1	9.86	1.97	3.92	0.16	0.16	1.25	1.53			63	
Bx2	10.17	2.76	5.59	0.29	0.16	0.55	0.84			87	
Bx3 (gray)	10.36	3.27	5.72	0.31	0.16	0.48	0.82			91	
Bx3	9.89	3.23	5.10	0.33	0.12	0.17	0.23	7.20		89	55
Bx4	8.79	2.51	4.59	0.26	0.11	0.28	0.66	7.00		85	52
2Bt1	8.77	2.79	3.90	0.22	0.16	0.49	0.61			81	
2Bt2 (1)	11.23	2.94	4.19	0.25	0.19	1.48	1.50			67	
2Bt2 (2)	11.90	2.90	4.32	0.25	0.20	1.45	1.52			65	
2Bt3	9.85	2.40	3.92	0.23	0.15	1.30	1.41			68	
3BC1	6.06	2.18	2.69	0.16	0.10	0.85	1.01			85	
3BC2	4.41	1.62	1.79	0.15	0.08	0.37	0.41			83	
4BC3	3.86	1.54	1.75	0.13	0.07	0.36	0.39			90	
4BC4	4.83	1.25	1.63	0.12	0.07	0.37	0.40			63	

Dithionite extractable iron, manganese, and aluminum;
hydroxylamine manganese, and CEC/clay ratios for
Site 3.

horizon	----- dithionite extractable -----						Ha - Mn ppm	CEC/Clay Ratio
	Fe	Mn	Al	Fe	Fe ₂ O ₃	Mn		
	----- ppm	----- ppm	----- ppm	----- %	----- %	----- ppm		
A	10852.3	497.5	1023.3	1.3	1.9	0.05	621.0	0.7
Ap	9053.5	531.7	1266.4	0.9	1.3	0.05	342.0	0.4
Bt1	17756.6	389.2	2069.5	1.8	2.6	0.04	115.0	0.7
Bt2	17759.2	663.3	1883.3	1.8	2.6	0.07	218.0	0.4
Bx1	15402.5	648.3	1400.0	1.5	2.1	0.06	261.0	0.5
Bx2	14308.3	738.3	1183.3	1.4	2.0	0.07	352.0	0.6
Bx3 (gray)	8444.5	82.8	728.5	0.8	1.1	0.01	6.5	0.6
Bx3	15158.4	732.8	1266.4	1.5	2.1	0.07	398.0	0.5
Bx4	11705.3	597.7	1151.3	1.2	1.7	0.06	325.0	0.4
2Bt1	13621.7	595.4	1200.7	1.4	2.0	0.06	474.5	0.4
2Bt2 (1)	21098.2	164.4	1778.5	2.1	3.0	0.02	41.0	0.4
2Bt2 (2)	18556.2	117.5	1828.9	1.9	2.7	0.01	26.5	0.3
2Bt3	17539.1	66.3	2000.0	1.8	2.6	0.01	7.0	0.3
3BC1	11783.3	61.7	1050.0	1.2	1.7	0.01	2.5	0.2
3BC2	8444.5	64.6	745.0	0.8	1.1	0.01	17.0	0.2
4BC3	6939.6	71.2	761.6	0.7	1.0	0.01	31.5	0.2
4BC4	6901.7	71.7	700.0	0.7	1.0	0.01	35.0	0.4

Concentration of selected elements for Site 3.

horizon	total elemental analysis										
	Al	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn
	ppm										
A	24910.0	385.6	2154.0	< 2.0	4.8	284.1	17.9	11350.0	10645.0	1621.0	484.9
Ap	26320.0	374.0	1674.5	7.7	10.8	53.1	15.5	11725.0	8090.0	1568.5	476.8
Bt1	41655.0	397.7	1799.5	2.6	10.2	27.2	16.6	23390.0	10220.0	3298.0	370.1
Bt2	40760.0	413.4	1376.0	< 2.0	6.7	30.3	17.9	20685.0	10475.0	3367.0	462.8
Bx1	33325.0	363.4	1563.5	3.1	7.1	29.6	11.4	15740.0	5365.0	2971.5	399.8
Bx2	40000.0	464.7	2644.0	< 2.0	7.9	30.6	15.4	19700.0	12180.0	3576.5	620.0
Bx3 (gray)	42710.0	530.0	3133.5	2.8	3.9	46.0	13.8	15930.0	11670.0	3395.0	142.8
Bx3	36010.0	452.9	2481.5	< 2.0	8.8	37.8	12.9	19490.0	11245.0	2955.0	650.0
Bx4	31640.0	372.0	1803.0	< 2.0	7.7	18.7	14.2	15450.0	9880.0	2351.5	495.0
2Bt1	35700.0	308.8	788.5	2.1	9.1	26.9	13.9	17965.0	8690.0	2066.0	490.8
2Bt2 (1)	42845.0	274.3	647.5	4.4	10.3	37.8	17.5	23910.0	6220.0	2407.0	182.7
2Bt2 (2)	42260.0	283.8	675.5	3.6	4.9	39.5	17.8	23235.0	7750.0	2393.0	154.4
2Bt3	31285.0	208.3	445.5	< 2.0	< 3.0	25.9	9.9	18390.0	3577.5	1785.0	81.4
3BC1	27085.0	200.8	417.1	< 2.0	< 3.0	19.1	9.3	14925.0	3833.0	1558.0	79.0
3BC2	24260.0	149.8	406.7	< 2.0	4.2	12.3	7.5	12830.0	3407.0	1308.0	98.3
4BC3	13020.0	66.0	267.5	< 2.0	< 3.0	8.5	6.1	7390.0	1277.5	773.0	72.7
4BC4	16195.0	71.4	323.3	< 2.0	3.8	10.9	5.7	9520.0	1363.0	914.0	83.2

Concentration of selected elements for Site 3, continued.

horizon	----- total elemental analysis -----										
	Mo	Na	Ni	P	Pb	S	Si	Sr	Ti	Zn	Zr
	----- ppm -----										
A	< 5.0	3706.5	15.7	713.0	93.1	720.5	66100.0	52.4	1393.0	95.1	180.1
Ap	12.6	4048.0	< 10.0	244.8	46.0	142.0	93400.0	55.0	1372.0	49.5	88.6
Bt1	< 5.0	4192.5	< 10.0	194.9	44.8	< 25.0	122600.0	56.5	1778.5	40.1	87.8
Bt2	< 5.0	5060.0	20.8	216.9	45.8	< 25.0	52250.0	64.9	1711.5	37.9	90.2
Bx1	11.9	5685.0	< 10.0	178.2	42.4	75.5	59600.0	69.6	1429.0	28.6	82.1
Bx2	< 5.0	7435.0	14.1	206.2	59.5	< 25.0	57850.0	96.8	1679.5	38.2	97.2
Bx3 (gray)	11.9	7625.0	10.2	90.2	66.8	46.7	242350.0	105.5	1998.0	36.9	114.2
Bx3	< 5.0	5550.0	33.7	110.1	59.3	< 25.0	50800.0	80.6	1649.5	34.0	94.4
Bx4	11.9	4480.0	< 10.0	118.6	< 25.0	< 25.0	128850.0	61.5	1604.0	23.5	96.2
2Bt1	11.2	2385.5	11.4	140.6	38.0	< 25.0	226850.0	36.4	1697.5	30.1	117.1
2Bt2 (1)	6.0	1351.5	19.2	164.3	58.0	< 25.0	78200.0	33.2	1735.5	41.0	95.4
2Bt2 (2)	9.3	1396.5	< 10.0	197.1	53.7	110.2	224700.0	32.8	1816.5	50.3	99.6
2Bt3	6.6	309.7	11.8	175.7	30.7	< 25.0	27750.0	< 25.0	1371.0	17.4	69.5
3BC1	< 5.0	339.4	< 10.0	132.2	< 25.0	164.3	49845.0	< 25.0	1342.0	33.5	64.8
3BC2	< 5.0	195.7	< 10.0	140.9	< 25.0	< 25.0	30530.0	< 25.0	996.0	102.2	36.6
4BC3	< 5.0	63.8	< 10.0	90.9	< 25.0	< 25.0	31885.0	< 25.0	597.0	10.9	14.4
4BC4	5.3	53.9	< 10.0	142.6	< 25.0	< 25.0	102700.0	< 25.0	701.5	10.8	18.8

Appendix D. Morphology and Laboratory Data for Site 4

Soil Profile Descriptions for Site 4

Landscape position: terrace

Slope: 1%

Parent material: loess / alluvium

Vegetation: cotton plots

Drainage: well drained

Classification: fine-silty, mixed, active, thermic Typic Hapludalf

- Ap - 0 to 18 cm; brown (7.5YR 4/4) silt loam; weak fine subangular blocky structure; friable; neutral; clear boundary.
- Bt1 - 18 to 41 cm; brown (7.5YR 4/4) silty clay loam; moderate fine subangular blocky structure; friable; few fine and medium Fe/Mn stains; few thin continuous clay films on ped faces; moderately acid; clear boundary.
- Bt2 - 41 to 66 cm; yellowish red (5YR 4/6) silty clay loam with few fine distinct light brown (7.5YR 6/4) mottles; weak medium prismatic structure; friable; few thin continuous clay films on ped faces; extremely acid; clear boundary.
- BC1 - 66 to 92 cm; yellowish red (5YR 4/6) silt loam with few fine distinct light brown (7.5YR 6/4) mottles; weak fine subangular blocky structure; friable; few thin continuous clay films on ped faces; extremely acid; clear boundary.
- BC2 - 92 to 111 cm; yellowish red (5YR 4/6) silt loam with few very fine distinct light brown (7.5YR 6/4) mottles; weak medium subangular blocky structure; friable; very few fine Fe/Mn stains; very few thin continuous clay films on ped faces; extremely acid; gradual boundary.
- 2Bw1 - 111 to 136 cm; yellowish red (5YR 4/6) silt loam with few very fine distinct light brown (7.5YR 6/4) mottles; weak coarse subangular blocky structure; friable; very few fine Fe/Mn stains; very few thin discontinuous clay films in pores; very strongly acid; gradual boundary.
- 2Bw2 - 136 to 165 cm; yellowish red (5YR 4/6) silt loam with few very fine distinct light brown (7.5YR 6/4) mottles; weak coarse subangular blocky structure; friable; very few fine Fe/Mn stains; very few thin discontinuous clay films in pores; very strongly acid; gradual boundary.
- 2Bw3 - 165 to 214 cm; reddish brown (5YR 4/4) silt loam; weak coarse subangular blocky structure; friable to firm; very few fine Fe/Mn stains; very few thin continuous clay films in pores; moderately acid; clear boundary.
- 3Bt1 - 214 to 245 cm; reddish brown (5YR 4/4) silt loam with few common distinct brown (7.5YR 5/4) and very few fine faint yellowish red (5YR 5/8) mottles; weak coarse subangular blocky and weak medium subangular blocky structure; friable to firm; few very fine Fe/Mn stains; few thin continuous clay films in pores; very strongly acid; clear boundary.

- 3Bt2 - 245 to 268 cm; reddish brown (5YR 4/4) silt loam with few common distinct light reddish brown (5YR 6/4) streaks and few common faint yellowish red (5YR 5/8) mottles; weak fine to medium subangular blocky structure; friable; few very fine Fe/Mn stains; few thin continuous clay films in pores; bleached sand grains in pores; very strongly acid; clear boundary.
- 3Bt3 - 268 to 301 cm; dark red (2.5YR 4/6) clay loam with distinct light reddish brown (5YR 6/4) mottles; moderate fine to medium subangular blocky structure; firm; few fine Fe/Mn stains; few common continuous clay films in pores; very strongly acid; gradual boundary.
- 3Bt4 - 301 to 368 cm; yellowish red (5YR 5/6) silty clay loam with fine medium distinct light brown (7.5YR 6/4) and strong brown (7.5YR 5/6) mottles; weak medium and moderate fine subangular blocky structure; friable; very few fine Fe/Mn stains; few thin continuous clay films in pores; very strongly acid; gradual boundary.
- 4BC - 368 to 452 cm; strong brown (7.5YR 5/6) sandy loam with many fine distinct light strong brown (7.5YR 5/8) and light brown (7.5YR 6/3) mottles; massive structure; friable; very fine continuous clay films in pores; strongly acid; clear boundary.
- 4C - 452+ cm; strong brown (7.5YR 5/6) loamy sand; massive sand grain structure; very friable; strongly acid.

Sampling depth, pH, organic mater and carbon, total carbon, nitrogen, sulfur, and carbon to nitrogen ratios for Site 4.

sample #	horizon	depth	midpoint	pH (1:1 H ₂ O)	pH (1:2 CaCl ₂)	O.M. (Walkley-Black)	O.C.	total Carbon	total Nitrogen	total Sulfur	C/N
		-----cm-----						%			
89358	Ap	0 - 18	9.0	6.6	6.2	0.30	0.17	0.47	0.04	0.01	12.70
89359	Bt1	18 - 41	29.5	5.9	5.4	0.17	0.10	0.29	0.04	0.01	7.55
89360	Bt2	41 - 66	53.5	4.4	3.9	0.03	0.02	0.16	0.04	0.02	4.47
89361	BC1	66 - 92	79.0	4.2	3.8	0.03	0.02	0.15	0.03	0.01	5.29
89362	BC2	92 - 111	101.5	4.4	3.9	0.03	0.02	0.14	0.04	0.00	3.94
89363	2Bw1	111 - 136	123.5	4.6	4.1	0.10	0.06	0.19	0.04	0.00	5.37
89364	2Bw2	136 - 165	150.5	4.9	4.2	0.13	0.08	0.21	0.03	0.01	8.23
89365	2Bw3	165 - 214	189.5	5.6	4.4	0.17	0.10	0.26	0.03	0.00	10.08
89366	3Bt1	214 - 245	229.5	5.0	4.4	0.10	0.06	0.17	0.03	0.00	6.76
89367	3Bt2	245 - 268	256.5	5.0	4.5	0.03	0.02	0.14	0.02	0.00	6.26
89368	3Bt3	268 - 301	284.5	5.0	4.4	0.00	0.00	0.11	0.03	0.00	3.21
89369	3Bt4	301 - 368	334.5	5.0	4.4	0.00	0.00	0.11	0.03	0.00	3.55
89370	4BC	368 - 452	410.0	5.1	4.4	0.00	0.00	0.06	0.03	0.00	2.15
89371	4C	452 - 455	453.5	5.2	4.6	0.00	0.00	0.01	0.03	0.00	0.23

Particle size distribution for Site 4.

horizon	Size Class and Particle Diameter (microns)										
	vcos	cos	ms	fs	vfs	sand	cosi	fsi	silt	clay	clay
	2000-1000	1000-500	500-250	250-100	100-50	2000-50	50-20	20-2	50-2	< 2	< 0.2
	percent										
Ap	0.2	0.5	0.7	0.8	0.5	2.7	46.1	32.7	78.8	18.5	7.5
Bt1	0.3	0.1	0.3	0.5	0.1	1.3	33.5	35.4	68.8	29.9	14.7
Bt2	0.2	0.2	0.1	0.4	0.0	0.9	34.6	35.9	70.5	28.6	14.3
BC1	0.1	0.2	0.3	0.6	0.0	1.2	36.5	40.7	77.2	21.6	11.8
BC2	0.0	0.3	0.3	1.0	0.6	2.0	38.8	34.1	75.9	22.0	9.7
2Bw1	0.0	0.3	0.9	1.3	0.5	3.0	40.9	34.9	75.9	21.2	10.5
2Bw2	0.0	0.2	1.8	3.3	0.6	5.9	39.5	33.0	72.5	21.6	10.9
2Bw3	0.3	0.8	3.0	6.4	1.4	11.9	35.1	31.9	66.9	21.2	10.9
2Bt1	0.2	1.6	5.6	10.4	2.2	20.0	28.9	25.1	54.0	26.0	14.1
2Bt2	0.2	1.7	6.0	10.2	3.6	21.7	26.7	25.2	51.9	26.4	15.6
3Bt3	0.2	1.4	5.8	11.8	1.4	20.5	24.5	26.9	51.4	28.1	17.5
3Bt4	0.2	1.1	3.6	8.2	0.7	13.8	28.7	26.1	54.8	31.4	16.1
4BC	0.1	3.6	16.4	30.9	3.2	54.2	16.9	12.2	29.2	16.6	8.8
5C	0.4	6.6	21.1	46.6	8.9	83.6	8.0	2.0	10.0	6.4	2.7

Cation exchange capacity (pH 7), ammonium acetate extractable bases, potassium chloride extractable aluminum and acidity, barium chloride extractable acidity, and base saturation data for Site 4.

horizon	CEC (NH ₄ OAc)	Ca	exchangeable bases				(KCl) Al	acidity (KCl)	ext. acidity (BaCl ₂)	Base Saturation	
			Mg	Na	K	cmol(+)/kg				pH 7	sum of cations
Ap	9.29	8.31	1.29	0.06	0.52	0.00	0.00	0.00		110	
Bt1	14.20	10.28	3.23	0.09	0.35	0.00	0.00	0.00		98	
Bt2	13.11	4.90	3.70	0.09	0.32	1.99	2.22			69	
BC1	11.27	2.95	3.20	0.10	0.26	2.65	2.72			58	
BC2	10.31	2.46	3.01	0.12	0.23	1.33	1.59			56	
2Bw1	8.50	3.04	3.00	0.11	0.23	0.88	0.99			75	
2Bw2	8.71	3.21	2.59	0.15	0.22	0.32	0.43		5.20	71	54
2Bw3	8.57	3.66	2.96	0.15	0.19	0.10	0.00		4.40	81	61
2Bt1	8.18	3.38	2.97	0.16	0.20	0.24	0.20			82	
2Bt2	6.94	3.33	2.56	0.15	0.19	0.11	0.00			90	
3Bt3	8.25	3.61	2.89	0.15	0.20	0.20	0.20			83	
3Bt4	11.11	4.66	3.40	0.19	0.22	0.26	0.25			76	
4BC	5.21	2.46	2.01	0.12	0.12	0.23	0.20			90	
5C	1.99	1.00	0.74	0.07	0.04	0.18	0.20			93	

Dithionite extractable iron, manganese, and aluminum;
hydroxylamine manganese, and CEC/clay ratios for
Site 4.

horizon	dithionite extractable						Ha - Mn ppm	CEC/Clay Ratio
	Fe	Mn	Al	Fe	Fe ₂ O ₃	Mn		
	ppm	ppm		%	%			
Ap	11777.1	743.3	1216.7	1.2	1.7	0.07	435.0	0.5
Bt1	20899.5	687.5	1610.7	2.1	3.0	0.07	198.0	0.5
Bt2	20420.3	619.1	1912.8	2.0	2.9	0.06	137.5	0.5
BC1	17338.3	436.7	1683.3	1.7	2.4	0.04	120.5	0.5
BC2	17307.1	551.3	1374.2	1.7	2.4	0.06	192.0	0.5
2Bw1	15613.0	600.0	1133.3	1.6	2.3	0.06	196.0	0.4
2Bw2	14037.0	725.3	1282.9	1.4	2.0	0.07	242.5	0.4
2Bw3	12625.0	691.3	1308.7	1.3	1.9	0.07	209.5	0.4
2Bt1	14234.9	904.4	939.6	1.4	2.0	0.09	368.0	0.3
2Bt2	14392.5	768.3	1083.3	1.4	2.0	0.08	400.5	0.3
3Bt3	16798.3	319.6	1307.9	1.9	2.7	0.03	168.5	0.3
3Bt4	19985.6	200.3	1456.9	2.0	2.9	0.02	52.0	0.4
4BC	11015.1	132.6	1023.5	1.1	1.6	0.01	28.5	0.3
5C	5016.6	74.5	629.1	0.5	0.7	0.01	17.5	0.3

Concentration of selected elements for Site 4.

horizon	total elemental analysis										
	Al	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn
	ppm										
Ap	30025.0	436.1	2332.5	2.3	7.3	24.5	12.0	14025.0	8175.0	2031.0	586.0
Bt1	37585.0	360.6	2017.0	< 2.0	8.6	25.9	15.7	22510.0	6985.0	3367.0	513.5
Bt2	37490.0	342.3	1423.5	< 2.0	6.6	30.6	16.1	22710.0	5965.0	3419.0	454.1
BC1	39015.0	388.7	1631.5	6.2	10.8	25.2	21.9	23025.0	8005.0	3505.5	402.8
BC2	36025.0	384.3	2054.0	< 2.0	7.8	30.0	16.4	20355.0	8005.0	3131.0	474.5
2Bw1	35645.0	408.3	2308.5	< 2.0	5.8	25.5	13.0	18630.0	6730.0	2943.5	511.5
2Bw2	36680.0	440.8	2344.5	< 2.0	7.9	26.9	13.2	18465.0	9200.0	2878.0	556.0
2Bw3	35885.0	431.5	2134.5	< 2.0	7.8	28.3	12.9	17755.0	8005.0	2640.5	550.0
2Bt1	33395.0	327.6	1139.5	< 2.0	4.6	26.2	12.6	17140.0	8260.0	2046.5	595.5
2Bt2	29420.0	267.3	826.5	< 2.0	4.5	22.5	11.2	15245.0	5195.0	1690.0	488.1
3Bt3	32380.0	259.6	749.0	< 2.0	7.1	32.0	9.6	16885.0	6220.0	1674.0	269.8
3Bt4	38060.0	289.0	847.5	< 2.0	5.3	32.7	11.7	22230.0	7070.0	2186.5	184.1
4BC	21235.0	183.3	536.0	5.9	6.0	16.4	10.6	12335.0	3918.0	1371.5	132.5
5C	11390.0	99.8	329.6	< 2.0	< 3.0	18.7	5.7	6785.0	2470.0	738.0	99.6

Concentration of selected elements for Site 4, continued.

horizon	total elemental analysis										
	Mo	Na	Ni	P	Pb	S	Si	Sr	Ti	Zn	Zr
	ppm										
Ap	< 5.0	3897.5	< 10.0	359.8	25.7	< 25.0	34240.0	62.3	1553.5	29.0	78.2
Bt1	< 5.0	2813.5	< 10.0	340.0	47.5	238.7	28095.0	54.2	1515.0	138.5	64.3
Bt2	< 5.0	3333.5	16.5	278.8	62.3	229.7	34120.0	54.1	1498.5	45.9	71.9
BC1	< 5.0	4406.5	< 10.0	258.2	64.0	< 25.0	38685.0	88.1	1626.5	76.8	84.2
BC2	< 5.0	5035.0	20.4	179.1	43.9	< 25.0	30830.0	77.1	1515.5	42.6	83.9
2Bw1	< 5.0	5440.0	24.7	256.6	38.2	32.7	32475.0	80.9	1536.0	31.7	87.6
2Bw2	6.0	5050.0	14.1	210.7	50.7	< 25.0	31315.0	81.1	1723.5	39.6	91.0
2Bw3	11.9	4304.0	< 10.0	119.9	48.9	< 25.0	97700.0	73.3	1758.0	29.8	90.2
2Bt1	< 5.0	1833.5	13.0	134.1	56.8	< 25.0	26475.0	43.5	1590.0	35.1	74.8
2Bt2	11.9	1003.5	< 10.0	172.1	< 25.0	< 25.0	25025.0	33.3	1333.5	25.2	61.2
3Bt3	< 5.0	586.5	19.2	102.0	48.5	< 25.0	32315.0	30.7	1436.0	26.4	67.5
3Bt4	6.6	481.7	11.8	239.8	44.4	< 25.0	25585.0	34.1	1558.5	34.0	81.8
4BC	5.3	224.1	< 10.0	151.9	32.6	< 25.0	27150.0	< 25.0	1074.5	48.3	44.5
5C	6.0	125.3	< 10.0	78.4	< 25.0	< 25.0	53100.0	< 25.0	889.5	8.0	24.3

Appendix E. Morphology and Laboratory Data for Site 5

Soil Profile Description for Site 5

Landscape position: terrace

Slope: 1-2%

Parent material: loess / alluvium

Vegetation: soybean research plot

Drainage: well drained

Classification: fine-silty, mixed, active, thermic Fragic Hapludalf

- Ap - 0 to 24 cm; brown (7.5YR 4/4) silt; very weak fine subangular blocky structure; very friable; moderately acid; clear boundary.
- Bt1 - 24 to 52 cm; strong brown (7.5YR 5/6) silt loam with few very fine faint light yellowish brown (10YR 6/4) and dark brown (10YR 3/4) mottles; weak fine subangular blocky structure; friable; very few fine Fe/Mn stains; few very fine discontinuous clay films in larger pores; moderately acid; clear boundary.
- Bt2 - 52 to 79 cm; strong brown (7.5YR 5/6) silt loam; weak fine and medium subangular blocky structure; friable; few fine Fe/Mn stains; few very fine discontinuous clay films in larger pores; strongly acid; clear boundary.
- Bt3 - 79 to 101 cm; brown (7.5YR 5/4) silt loam with few very fine faint strong brown (7.5YR 5/8) and dark brown (7.5YR 3/4) mottles; weak fine subangular blocky structure; friable; few fine and medium Fe/Mn stains and concretions; few fine clay films associated with worm activity; very strongly acid; clear boundary.
- BC1 - 101 to 122 cm; light yellowish brown (10YR 6/4) silt loam; very weak fine subangular blocky structure; friable; very strongly acid; clear boundary.
- BC2 - 122 to 147 cm; light brownish gray (10YR 6/2) silt loam with few fine faint light yellowish brown (10YR 6/4) and few common distinct strong brown (7.5YR 5/6) mottles; weak fine and medium subangular blocky and weak fine prismatic structure; friable; few fine and medium Fe/Mn stains and concretions; very strongly acid; clear boundary.
- 2Btx1 - 147 to 166 cm; light brownish gray (10YR 6/2) silt loam with many common distinct brownish yellow (10YR 6/6) and many common distinct strong brown (7.5YR 5/6) mottles; weak medium prismatic structure; (grays) friable, (browns) firm; common fine and medium Fe/Mn stains and concretions; very strongly acid; clear boundary.
- 2Btx2 - 166 to 187 cm; brown (7.5YR 4/4) silt loam with few common distinct light brownish gray (10YR 6/2) and light yellowish brown (10YR 6/4) mottles; weak medium prismatic structure; firm; common fine Mn stains; strongly acid; clear boundary.
- 2Btx3 - 187 to 215 cm; brown (7.5YR 4/4) silt loam with few common distinct light brownish gray (10YR 6/2) and light yellowish brown (10YR 6/4) mottles; moderate medium prismatic and weak medium platy structure; firm; few fine Mn stains; strongly acid; clear boundary.

- 2Btx4 - 215 to 244 cm; brown (7.5YR 4/4) silt loam with few common distinct light brownish gray (10YR 6/2) and light yellowish brown (10YR 6/4) mottles; moderate medium prismatic structure; firm; few fine Mn stains; very few fine discontinuous clay films in lower pores; some bleached ped faces; strongly acid; clear boundary.
- 2Btx5 - 244 to 264 cm; yellowish red (5YR 4/6) silt loam with light brown (7.5YR 6/4) seams and few very fine distinct (10YR 6/2) mottles in seams; weak fine and medium prismatic and weak medium subangular blocky structure; firm, friable in seams; few fine Mn stains; very few fine discontinuous clay films in upper part; strongly acid; clear boundary.
- 3Bt1 - 264 to 310 cm; dark red (2.5YR 3/6) clay loam with light brown (7.5YR 6/4) streaks; weak to moderate fine subangular blocky structure; friable; few fine and medium Fe/Mn stains; few fine continuous clay films in larger pores; strongly acid; gradual boundary.
- 3Bt2 - 310 to 361 cm; dark red (2.5YR 4/6) silty clay loam with pinkish gray (7.5YR 6/2) streaks; moderate fine to medium subangular blocky structure; friable; few fine Mn stains mostly in pores; few fine continuous clay films in larger pores; very strongly acid; clear boundary.
- 3Bt3 - 361 to 370 cm; yellowish red (5YR 4/6) loam; weak fine and medium subangular blocky structure; friable; few fine and medium Mn stains mostly in pores; few very fine discontinuous clay films in pores; very strongly acid; gradual boundary.
- 4BC - 370 to 407 cm; strong brown (7.5YR 4/6) sandy loam with few common distinct light brown (7.5YR 6/4) mottles; weak medium prismatic and weak fine subangular blocky structure; friable; few fine and medium Mn stains mostly in pores; few fine discontinuous clay films in pores; strongly acid; gradual boundary.
- 4C - 407 to 449 cm; strong brown (7.5YR 4/6) loam; massive sand grain structure; very friable; very strongly acid.

Sampling depth, pH, organic matter and carbon, total carbon, nitrogen, sulfur, and carbon to nitrogen ratios for Site 5.

sample #	horizon	depth	midpoint	pH (1:1 H ₂ O)	pH (1:2 CaCl ₂)	O.M. (Walkley-Black)	O.C.	total Carbon	total Nitrogen	total Sulfur	C/N
89372	Ap	0 - 24	12.0	5.8	5.4	0.33	0.19	0.67	0.03	0.00	24.93
89373	Bt1	24 - 52	38.0	6.0	5.5	0.13	0.08	0.23	0.03	0.00	7.63
89374	Bt2	52 - 79	65.5	5.1	4.5	0.13	0.08	0.18	0.02	0.01	7.70
89375	Bt3	79 - 101	90.0	4.9	4.2	0.03	0.02	0.14	0.03	0.01	4.76
89376	BC1	101 - 122	111.5	4.9	4.2	0.00	0.02	0.14	0.03	0.01	4.96
89377	BC2	122 - 147	134.5	5.0	4.1	0.00	0.00	0.05	0.03	0.00	1.63
89378	2Btx1	147 - 166	156.5	5.0	4.1	0.00	0.00	0.08	0.03	0.00	3.12
89379	2Btx2	166 - 187	176.5	5.3	4.4	0.03	0.02	0.15	0.03	0.00	5.46
89380	2Btx3	187 - 215	201.0	5.4	4.4	0.03	0.02	0.17	0.03	0.00	5.57
89381	2Btx4	215 - 244	229.5	5.4	4.4	0.03	0.02	0.14	0.03	0.00	4.36
89382	2Btx5	244 - 264	254.0	5.3	4.4	0.00	0.00	0.12	0.03	0.00	3.66
89383	3Bt1	264 - 310	297.0	5.1	4.3	0.00	0.00	0.10	0.03	0.00	3.16
89384	3Bt2	310 - 361	335.5	5.0	4.2	0.00	0.00	0.09	0.02	0.00	3.67
89385	3Bt3	361 - 370	365.5	5.0	4.2	0.00	0.00	0.07	0.02	0.00	3.70
89386	4BC	370 - 407	388.5	5.1	4.2	0.00	0.00	0.05	0.02	0.00	2.37
89387	4C	407 - 449	428.0	5.0	4.2	0.00	0.00	0.05	0.02	0.00	2.22

Particle size distribution for Site 5.

horizon	Size Class and Particle Diameter (microns)											
	percent											
	vcos	cos	ms	fs	vfs	sand	cosi	fsi	silt	clay	clay	
	2000-1000	1000-500	500-250	250-100	100-50	2000-50	50-20	20-2	50-2	< 2	< 0.2	
Ap	0.2	0.4	0.7	1.4	0.8	3.4	49.9	36.0	85.9	10.7	2.5	
Bt1	0.1	0.5	0.4	1.4	0.9	3.3	36.0	40.1	76.1	20.6	8.8	
Bt2	0.0	0.2	0.7	1.1	0.7	2.7	33.6	40.6	74.2	23.1	9.4	
Bt3	0.1	0.4	0.5	1.3	0.9	3.1	38.6	38.0	76.6	20.3	7.3	
BC1	0.1	0.4	0.8	0.2	1.1	2.6	36.3	43.4	79.7	15.9	4.9	
BC2	0.2	0.7	0.5	0.9	2.3	4.6	38.9	39.2	78.1	19.3	5.7	
2Bx1	0.3	0.7	1.3	1.9	3.4	7.6	41.3	30.0	71.4	21.0	9.8	
2Bx2	0.1	0.6	1.6	5.9	4.4	12.6	36.4	32.1	68.5	18.9	9.7	
2Bx3	0.0	0.3	1.2	6.0	5.2	12.7	36.7	30.6	67.3	20.0	9.6	
2Bw1	0.3	1.1	2.1	8.1	3.6	15.0	36.9	30.2	67.1	17.9	9.3	
2Bw2	0.5	0.5	2.8	9.8	3.9	17.5	31.6	28.5	60.1	22.4	12.1	
3Bt1	0.0	1.0	4.1	12.7	3.3	21.1	22.7	27.2	49.9	29.0	18.2	
3Bt2	0.0	0.8	3.4	8.9	3.3	16.4	22.6	28.8	51.4	32.2	19.2	
3Bt3	0.2	1.2	5.5	14.8	10.8	32.5	22.2	19.4	41.5	26.0	12.8	
4BC	0.0	3.4	15.6	41.3	9.7	70.0	8.5	7.7	16.2	13.8	7.8	
4C	0.0	1.8	8.1	28.0	8.8	46.6	18.2	13.5	31.7	21.7	11.0	

Cation exchange capacity (pH 7), ammonium acetate extractable bases, potassium chloride extractable aluminum and acidity, barium chloride extractable acidity, and base saturation data for Site 5.

horizon	CEC (NH ₄ OAc)	Ca	exchangeable bases				(KCl) Al	acidity (KCl)	ext. acidity (BaCl ₂)	Base Saturation	
			Mg	Na	K	cmol(+)/kg				pH 7	sum of cations
Ap	4.79	4.02	0.50	0.05	0.35	0.08	0.00			103	
Bt1	6.53	5.67	1.18	0.07	0.19	0.04	0.00			109	
Bt2	10.32	4.98	2.62	0.10	0.20	0.33	0.41			77	
Bt3	9.70	3.31	3.36	0.10	0.20	0.59	0.77			72	
BC1	7.71	2.02	2.88	0.10	0.18	0.63	0.71			67	
BC2	8.29	2.10	3.75	0.12	0.17	1.35	1.39			74	
2Bx1	10.44	2.52	4.48	0.19	0.18	0.79	0.91			71	
2Bx2	9.86	2.56	4.04	0.22	0.14	0.27	0.30			71	
2Bx3	9.03	3.06	4.34	0.23	0.11	0.22	0.20			86	
2Bw1	7.97	2.80	4.06	0.19	0.12	0.27	0.25		4.00	90	61
2Bw2	8.92	2.96	4.05	0.17	0.17	0.28	0.35		4.60	82	62
3Bt1	8.29	2.66	3.71	0.15	0.22	0.61	0.75			81	
3Bt2	11.35	3.40	4.01	0.19	0.22	0.95	1.04			69	
3Bt3	9.52	3.29	3.43	0.19	0.16	0.76	1.00			74	
4BC	4.64	1.58	1.72	0.10	0.08	0.39	0.62			75	
4C	7.80	2.84	2.68	0.14	0.12	0.68	0.88			74	

Dithionite extractable iron, manganese, and aluminum;
hydroxylamine manganese, and CEC/clay ratios for
Site 5.

horizon	----- dithionite extractable -----						Ha - Mn ppm	CEC/Clay Ratio
	Fe	Mn	Al	Fe	Fe ₂ O ₃	Mn		
	----- ppm -----			----- % -----				
Ap	6480.8	1293.3	850.0	0.6	0.9	0.13	947.0	0.4
Bt1	11954.5	732.6	1183.3	1.2	1.7	0.07	501.0	0.3
Bt2	16721.9	511.6	1423.8	1.7	2.4	0.05	213.0	0.4
Bt3	16075.8	761.7	816.7	1.6	2.3	0.08	410.0	0.5
BC1	13051.2	644.3	1191.3	1.5	2.1	0.06	284.5	0.5
BC2	13989.0	395.7	860.9	1.6	2.3	0.04	193.5	0.4
2Bx1	14645.0	864.2	1016.7	1.5	2.1	0.09	674.0	0.5
2Bx2	14224.2	1265.0	850.0	1.4	2.0	0.13	840.5	0.5
2Bx3	10857.5	601.7	500.0	1.1	1.6	0.06	280.0	0.5
2Bw1	10151.2	621.6	777.0	1.0	1.4	0.06	408.5	0.4
2Bw2	11608.2	726.5	620.8	1.2	1.7	0.07	321.5	0.4
3Bt1	14229.8	698.2	866.7	1.4	2.0	0.07	534.0	0.3
3Bt2	18937.5	170.0	1466.7	1.9	2.7	0.02	50.5	0.4
3Bt3	15991.7	143.3	1166.7	1.6	2.3	0.01	12.5	0.4
4BC	6863.3	99.0	654.4	0.7	1.0	0.01	50.5	0.3
4C	11538.1	97.7	711.9	1.2	1.7	0.01	17.5	0.4

Concentration of selected elements for Site 5.

horizon	total elemental analysis										
	Al	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn
	ppm										
Ap	21525.0	428.1	1751.5	2.1	3.5	16.0	7.2	7695.0	9540.0	1007.0	1045.0
Bt1	28960.0	383.8	1632.0	3.9	6.8	27.6	10.8	13720.0	5280.0	1877.5	605.0
Bt2	38530.0	400.6	1646.0	2.1	8.3	36.8	13.8	21290.0	7240.0	3205.0	419.2
Bt3	32855.0	371.7	1433.5	2.1	4.7	27.9	12.4	16600.0	7920.0	2762.0	520.0
BC1	27265.0	339.5	1315.0	3.9	3.7	25.2	9.0	13230.0	6305.0	2202.0	352.0
BC2	28255.0	333.5	1610.0	< 2.0	6.1	25.5	9.9	14055.0	5535.0	2397.0	259.5
2Bx1	33530.0	378.7	2399.5	< 2.0	11.5	31.7	12.1	18325.0	5025.0	2937.0	675.5
2Bx2	33645.0	404.4	2606.0	2.3	15.1	31.3	13.3	18200.0	6305.0	2845.5	1096.0
2Bx3	32635.0	409.3	2491.5	4.1	11.0	34.7	17.3	15980.0	9455.0	2626.0	552.5
2Bw1	26080.0	315.8	1691.0	< 2.0	4.1	17.0	12.1	12445.0	6730.0	1971.5	443.9
2Bw2	27510.0	301.3	1284.0	2.8	4.4	49.0	11.5	13520.0	5790.0	1933.5	414.2
3Bt1	35225.0	281.7	687.5	< 2.0	7.6	17.0	12.3	17775.0	8175.0	1918.0	616.5
3Bt2	45000.0	301.6	774.5	< 2.0	6.5	35.4	14.1	24555.0	8690.0	2412.5	209.5
3Bt3	28865.0	203.6	559.0	2.3	< 3.0	22.5	9.3	16985.0	6050.0	1725.0	138.4
4BC	22340.0	158.0	488.5	2.8	< 3.0	17.4	10.8	12980.0	4429.5	1388.5	151.6
4C	26125.0	186.6	534.5	< 2.0	3.4	16.7	7.7	14985.0	4855.0	1573.0	125.2

Concentration of selected elements for Site 5, continued.

horizon	total elemental analysis										
	Mo	Na	Ni	P	Pb	S	Si	Sr	Ti	Zn	Zr
	ppm										
Ap	< 5.0	4068.5	< 10.0	312.7	33.0	140.6	30765.0	58.3	1160.5	14.2	60.9
Bt1	11.9	3792.5	< 10.0	263.0	33.0	132.5	131350.0	55.0	1391.0	67.6	64.3
Bt2	9.3	4197.5	10.2	389.8	63.5	130.8	222000.0	63.7	1736.5	42.7	76.2
Bt3	19.2	4424.5	< 10.0	304.0	< 25.0	80.2	26845.0	60.9	1416.0	42.2	69.3
BC1	9.9	4375.5	< 10.0	215.3	26.2	83.5	24275.0	67.0	1280.0	25.5	64.3
BC2	13.2	5080.0	< 10.0	155.7	27.8	< 25.0	25235.0	65.5	1318.5	18.7	68.8
2Bx1	6.6	5720.0	11.0	187.1	46.4	< 25.0	31785.0	80.9	1476.5	35.1	78.2
2Bx2	7.3	5655.0	< 10.0	227.4	38.6	43.8	57100.0	83.1	1480.0	30.7	79.7
2Bx3	10.6	5065.0	< 10.0	152.6	26.6	< 25.0	93300.0	79.4	1552.0	32.7	84.4
2Bw1	9.3	3429.0	< 10.0	62.6	27.4	86.6	24865.0	53.8	1294.5	26.9	68.5
2Bw2	6.0	2586.5	16.9	168.3	< 25.0	< 25.0	25485.0	45.5	1358.0	23.3	68.0
3Bt1	6.0	750.5	< 10.0	1968.5	60.6	< 25.0	129750.0	31.2	1881.5	39.4	80.3
3Bt2	15.2	596.0	< 10.0	238.7	56.5	< 25.0	290450.0	33.3	2125.0	40.3	109.0
3Bt3	5.3	299.3	< 10.0	181.7	25.1	< 25.0	38290.0	< 25.0	1610.5	44.9	74.8
4BC	13.2	310.6	< 10.0	163.6	49.1	194.3	328950.0	< 25.0	1380.0	20.2	56.2
4C	5.3	279.4	10.2	178.9	34.0	< 25.0	78100.0	< 25.0	1522.0	22.1	62.7

Appendix F. Morphology and Laboratory Data for Site 6

Soil Profile Description for Site 6

Landscape position: flood plain

Slope: 1%

Parent material: recent alluvium

Vegetation: soybeans

Drainage: somewhat poorly drained

Classification: coarse-silty, mixed, thermic Oxyaquic Eutrochrept

- Ap1 - 0 to 25 cm; dark yellowish brown (10YR 4/6) silt loam; weak medium granular structure; friable; slightly acid; clear boundary.
- Ap2 - 25 to 39 cm; dark yellowish brown (10YR 4/4) silt loam with few very fine distinct light yellowish brown (10YR 6/4) mottles; weak medium granular structure; friable; few fine Fe/Mn stains; slightly acid; abrupt boundary.
- Bw1 - 39 to 68 cm; dark yellowish brown (10YR 4/4) silt loam with few very fine distinct light yellowish brown (10YR 6/4) and strong brown (7.5YR 5/6) mottles; weak medium prismatic and weak medium subangular blocky structure; friable; few fine Fe/Mn stains; strongly acid; clear boundary.
- Bw2 - 68 to 90 cm; brown (10YR 5/3) silt loam with few fine distinct light yellowish brown (10YR 6/4) and strong brown (7.5YR 5/6) mottles; weak medium prismatic and weak medium subangular blocky structure; friable; few fine Fe/Mn stains and concretions; strongly acid; gradual boundary.
- 2Bg1- 90 to 127 cm; grayish brown (10YR 5/2) silt loam with few fine yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/6) mottles; weak medium subangular blocky structure; very friable; few fine and medium Fe/Mn concretions; very strongly acid; clear boundary.
- 2Bg2- 127 to 156 cm; grayish brown (10YR 5/2) silt loam with few fine yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; very friable; common medium Fe/ Mn concretions; very strongly acid; gradual boundary.
- 2Cg - 156 to 184 cm; grayish brown (10YR 5/2) silt loam with few fine yellowish brown (10YR 5/6) mottles; massive structure; very friable; common medium Fe/ Mn concretions; strongly acid.

Sampling depth, pH, organic mater and carbon, total carbon, nitrogen, sulfur,
and carbon to nitrogen ratios for Site 6.

sample #	horizon	depth	midpoint	pH (1:1 H ₂ O)	pH (1:2 CaCl ₂)	O.M. (Walkley-Black)	O.C.	total Carbon	total Nitrogen	total Sulfur	C/N
		-----cm-----						----- % -----			
89388	Ap1	0 - 25	12.5	6.4	6.2	0.36	0.21	0.62	0.04	0.00	17.11
89389	Ap2	25 - 39	32.0	6.1	6.7	0.23	0.13	0.46	0.04	0.01	12.38
89390	Bw1	39 - 68	53.5	5.4	5.0	0.23	0.13	0.41	0.03	0.01	12.55
89391	Bw2	68 - 90	79.0	5.1	4.6	0.23	0.13	0.45	0.04	0.01	12.27
89392	2Bg1	90 - 127	108.5	4.9	4.3	0.17	0.10	0.24	0.02	0.00	10.00
89393	2Bg2	127 - 156	141.5	5.0	4.3	0.13	0.08	0.21	0.03	0.01	7.14
89394	2Cg	156 - 184	170.0	5.1	4.3	0.13	0.08	0.20	0.03	0.01	5.94

Particle size distribution for Site 6.

horizon	Size Class and Particle Diameter (microns)											
	vcos	cos	ms	fs	vfs	sand	cosi	fsi	silt	clay	clay	
	2000-1000	1000-500	500-250	250-100	100-50	2000-50	50-20	20-2	50-2	< 2	< 0.2	
percent												
Ap1	0.0	0.4	0.3	2.3	1.7	4.6	38.2	44.1	82.3	13.1	6.0	
Ap2	0.1	0.9	0.5	2.3	0.9	4.5	23.0	55.0	78.1	17.4	7.4	
Bw1	0.1	0.2	0.5	1.1	2.1	4.0	26.5	52.6	79.1	17.0	7.1	
Bw2	0.3	0.2	0.9	4.7	0.7	6.8	26.7	50.5	77.2	16.0	6.6	
2Bg1	1.0	0.7	2.9	17.2	2.7	24.5	22.0	37.9	59.9	15.6	5.2	
2Bg2	1.1	1.5	2.6	19.8	3.4	28.4	7.8	48.6	56.4	15.2	4.1	
2Cg	3.1	1.8	2.2	20.9	4.0	32.0	21.3	29.2	50.5	17.5	5.7	

Cation exchange capacity (pH 7), ammonium acetate extractable bases, potassium chloride extractable aluminium and acidity, and base saturation data for Site 6.

horizon	CEC	Ca	exchangeable bases			(KCl)	acidity	Base Saturation %
	(NH ₄ OAc)		Mg	Na	K	Al	(KCl)	
			-----cmol(+)/kg-----					
Ap1	7.22	6.33	0.95	0.07	0.41	0.04	0.00	108
Ap2	8.40	4.91	1.23	0.06	0.24	0.06	0.00	77
Bw1	7.30	4.15	1.57	0.07	0.17	0.00	0.00	82
Bw2	7.18	3.09	1.46	0.09	0.12	0.27	0.20	66
2Bg1	5.42	2.25	1.03	0.11	0.12	0.60	0.75	65
2Bg2	5.30	2.01	1.01	0.09	0.12	0.33	0.30	61
2Cg	6.38	2.19	1.23	0.10	0.14	0.55	0.50	57

Dithionite extractable iron, manganese, and aluminum;
hydroxylamine manganese, and CEC/clay ratios for
Site 6.

horizon	dithionite extractable						CEC/Clay	
	Fe	Mn	Al	Fe	Fe ₂ O ₃	Mn	Ha - Mn	Ratio
	ppm	ppm		%	%		ppm	
Ap1	7858.0	537.2	650.0	0.8	1.1	0.05	412.0	0.6
Ap2	9744.1	679.5	822.1	1.0	1.4	0.07	500.5	0.5
Bw1	10083.1	716.4	687.9	1.0	1.4	0.07	532.5	0.4
Bw2	8332.5	751.7	833.3	0.8	1.1	0.08	567.0	0.4
2Bg1	4797.5	415.0	666.7	0.5	0.7	0.04	250.5	0.3
2Bg2	4958.4	688.0	483.3	0.5	0.7	0.07	491.0	0.3
2Cg	5100.2	998.3	579.5	0.5	0.7	0.10	779.5	0.4

Concentration of selected elements for Site 6.

horizon	total elemental analysis										
	Al	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn
	ppm										
Ap1	24315.0	348.8	2027.5	< 2.0	3.4	16.4	8.0	10395.0	8605.0	1418.0	438.8
Ap2	30865.0	433.5	2015.5	6.2	12.0	16.5	16.6	13690.0	12010.0	1925.0	633.0
Bw1	33495.0	462.2	192.6	2.3	6.4	17.4	14.4	14665.0	13800.0	2059.0	730.0
Bw2	30300.0	459.1	1685.0	< 2.0	3.8	17.7	14.2	12090.0	11925.0	1802.0	696.0
2Bg1	28425.0	389.2	1406.5	< 2.0	< 3.0	16.4	11.7	8975.0	10645.0	1614.0	413.8
2Bg2	26900.0	378.7	1294.0	< 2.0	3.2	14.7	11.1	7880.0	10050.0	1514.5	492.3
2Cg	26535.0	348.0	1079.0	< 2.0	< 3.0	15.3	10.5	8080.0	8260.0	1497.5	796.5

Concentration of selected elements for Site 6, continued.

horizon	total elemental analysis										
	Mo	Na	Ni	P	Pb	S	Si	Sr	Ti	Zn	Zr
	ppm										
Ap1	5.3	3937.0	< 10.0	305.0	31.5	132.5	35320.0	57.0	1484.5	50.6	81.0
Ap2	9.3	4246.5	< 10.0	310.9	60.9	92.8	90250.0	68.4	1679.5	33.1	79.2
Bw1	9.9	4612.0	< 10.0	260.0	45.9	311.4	218350.0	70.6	1894.0	33.5	92.3
Bw2	< 5.0	4598.5	< 10.0	246.1	39.0	161.0	95350.0	66.4	1736.5	53.3	83.9
2Bg1	5.3	3808.5	11.8	182.9	33.1	56.4	82350.0	56.5	1730.5	27.9	76.6
2Bg2	< 5.0	3545.5	< 10.0	145.6	27.0	< 25.0	127650.0	53.8	1622.5	26.1	75.8
2Cg	< 5.0	2895.0	< 10.0	102.4	< 25.0	< 25.0	55150.0	44.9	1544.5	30.3	69.0

Appendix G. Morphology and Laboratory Data for Site 7

Soil Profile Description for Site 7

Landscape position: flood plain

Slope: 1%

Parent material: recent alluvium

Vegetation: soybeans

Drainage: moderately well drained

Classification: coarse-silty, mixed, non acid, thermic Typic Udifluent

- Ap1 - 0 to 17 cm; yellowish brown (10YR 5/4) silt loam with few fine faint light yellowish brown (10YR 6/4) mottles; massive structure; very friable; neutral; clear boundary.
- Ap2 - 17 to 40 cm; dark yellowish brown (10YR 4/4) silt loam with few fine faint light yellowish brown (10YR 6/4) mottles; weak medium subangular blocky structure; friable; few fine Fe/Mn stains; neutral; clear boundary.
- A - 40 to 64 cm; dark yellowish brown (10YR 4/4) silt loam with few fine faint light yellowish brown (10YR 6/4) mottles; weak medium subangular blocky structure; friable; few fine Fe/Mn stains; strongly acid; gradual boundary.
- C1 - 64 to 97 cm; brown (10YR 5/3) silt loam with few fine distinct strong brown (7.5YR 4/6) and few fine faint light yellowish brown (10YR 6/4) mottles; stratified massive structure; very friable; few fine and medium Fe/Mn stains and concretions; strongly acid; clear boundary.
- C2 - 97 to 131 cm; brown (7.5YR 5/4) silt loam with few fine distinct strong brown (7.5YR 4/6) and pale brown (10YR 6/3) mottles; stratified massive structure; very friable; few fine and medium Fe/Mn stains and concretions; strongly acid; gradual boundary.
- 2C1 - 131 to 141 cm; yellowish brown (10YR 5/4) sandy loam with few fine and medium distinct brown (7.5YR 4/6) mottles; stratified massive sand grain structure; very friable; few fine and medium Fe/Mn stains and concretions; strongly acid; gradual boundary.
- 2C2 - 141 to 151 cm; brown (10YR 5/3) silt loam with few fine distinct strong brown (7.5YR 4/6) mottles; stratified massive structure; very friable; few fine and medium Fe/Mn stains and concretions; very strongly acid; gradual boundary.
- 2C3 - 151 to 172 cm; brown (10YR 5/3) sandy loam with few fine distinct strong brown (7.5YR 4/6) mottles; stratified massive sand grain structure; large sand grains; few fine and medium Fe/Mn stains and concretions; very strongly acid; gradual boundary.
- 2C4 - 172 to 181 cm; brown (10YR 5/3) loam with few fine distinct brown (7.5YR 5/2) mottles; stratified massive structure; very friable; few fine and medium Fe/Mn stains and concretions; very strongly acid.

Sampling depth, pH, organic mater and carbon, total carbon, nitrogen, sulfur,
and carbon to nitrogen ratios for Site 7.

sample #	horizon	depth	midpoint	pH (1:1 H ₂ O)	pH (1:2 CaCl ₂)	O.M. (Walkley-Black)	O.C.	total Carbon	total Nitrogen	total Sulfur	C/N
		-----cm-----						-----%-----			
89395	Ap1	0 - 17	8.5	6.7	6.3	0.36	0.21	0.68	0.03	0.01	21.77
89396	Ap2	17 - 40	28.5	6.7	6.1	0.23	0.13	0.47	0.03	0.00	14.56
89397	A	40 - 64	52.0	5.4	4.9	0.30	0.17	0.52	0.03	0.01	15.35
89398	C1	64 - 97	80.5	5.2	4.7	0.17	0.10	0.33	0.03	0.00	9.97
89399	C2	97 - 131	114.0	5.1	4.5	0.20	0.12	0.36	0.03	0.01	12.13
89400	2C1	131 - 141	136.0	5.1	4.5	0.10	0.06	0.17	0.02	0.01	8.95
89401	2C2	141 - 151	146.0	5.0	4.3	0.13	0.08	0.22	0.04	0.00	6.29
89402	2C3	151 - 172	161.5	5.0	4.3	0.10	0.06	0.17	0.03	0.00	5.69
89403	2C4	172 - 181	176.5	4.8	4.3	0.10	0.06	0.19	0.03	0.00	6.68

Particle size distribution for Site 7.

horizon	Size Class and Particle Diameter (microns)										
	vcos	cos	ms	fs	vfs	sand	cosi	fsi	silt	clay	clay
	2000-1000	1000-500	500-250	250-100	100-50	2000-50	50-20	20-2	50-2	< 2	< 0.2
	percent										
Ap1	0.0	0.3	0.9	5.6	2.5	9.3	33.4	45.2	78.6	12.1	5.2
Ap2	0.0	0.0	0.6	3.6	1.5	5.7	31.4	48.2	79.6	14.7	6.6
A	0.0	0.2	0.6	3.2	1.0	4.9	27.4	50.2	77.7	17.4	6.9
C1	0.0	0.0	0.3	1.6	0.7	2.6	31.8	48.8	80.6	16.8	6.3
C2	0.0	0.0	0.2	1.2	2.1	3.5	45.4	35.5	80.9	15.6	6.2
2C1	0.0	0.3	4.3	50.0	7.2	61.8	15.8	13.2	29.0	9.2	3.4
2C2	0.0	0.1	1.6	26.1	7.9	35.7	30.4	21.4	51.8	12.5	4.8
2C3	0.0	0.4	7.7	52.5	5.0	65.4	15.9	10.3	26.2	8.4	2.8
2C4	0.0	0.1	2.8	26.8	12.6	42.3	30.2	16.9	47.1	10.6	4.6

Cation exchange capacity (pH 7), ammonium acetate extractable bases, potassium chloride extractable aluminium and acidity, and base saturation data for Site 7.

horizon	CEC (NH ₄ OAc)	Ca	exchangeable bases			K	(KCl) Al	acidity (KCl)	Base Saturation %
			Mg	Na					
			-----cmol(+)/kg-----						
Ap1	6.32	5.77	0.90	0.05	0.56	0.12	0.00	115	
Ap2	6.59	6.13	1.02	0.05	0.31	0.10	0.00	114	
A	7.44	3.80	1.15	0.07	0.25	0.20	0.20	71	
C1	6.66	3.20	1.31	0.05	0.19	0.34	0.40	71	
C2	5.50	2.52	1.47	0.07	0.17	0.27	0.30	77	
2C1	3.73	1.04	0.73	0.05	0.08	0.30	0.30	51	
2C2	5.16	1.77	0.96	0.06	0.11	0.52	0.65	56	
2C3	3.52	1.00	0.68	0.05	0.07	0.22	0.25	51	
2C4	3.19	1.64	0.83	0.05	0.10	0.38	0.40	82	

Dithionite extractable iron, manganese, and aluminum;
hydroxylamine manganese, and CEC/clay ratios for
Site 7.

horizon	dithionite extractable						Ha - Mn ppm	CEC/Clay Ratio
	Fe	Mn	Al	Fe	Fe ₂ O ₃	Mn		
	ppm			%				
Ap1	7973.7	516.4	921.1	0.8	1.1	0.05	393.0	0.5
Ap2	10184.2	553.3	950.0	1.0	1.4	0.06	499.0	0.4
A	9679.2	625.0	950.0	1.0	1.4	0.06	513.5	0.4
C1	9595.0	655.9	1050.0	1.0	1.4	0.07	549.0	0.4
C2	9174.2	575.0	616.7	0.9	1.3	0.06	425.0	0.4
2C1	5544.8	332.8	574.3	0.6	0.9	0.03	206.0	0.4
2C2	6772.4	336.1	811.3	0.7	1.0	0.03	201.5	0.4
2C3	5601.8	251.7	496.7	0.6	0.9	0.03	167.5	0.4
2C4	6247.9	362.9	700.0	0.6	0.9	0.04	264.5	0.3

Concentration of selected elements for Site 7.

horizon	total elemental analysis										
	Al	Ba	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn
	ppm										
Ap1	26880.0	394.4	2238.5	< 2.0	< 3.0	19.8	9.6	11000.0	11330.0	1545.5	493.5
Ap2	31365.0	438.7	2323.0	2.8	6.6	20.4	13.2	13630.0	13030.0	1888.5	643.5
A	30855.0	432.5	1794.0	< 2.0	6.3	20.1	12.3	13830.0	12435.0	1860.5	653.5
C1	30970.0	456.5	1743.0	< 2.0	6.3	22.5	12.9	13755.0	12860.0	1851.5	648.0
C2	29750.0	430.7	1683.0	6.2	10.6	20.8	14.1	12985.0	12605.0	1706.0	633.0
2C1	15360.0	203.1	754.0	< 2.0	3.3	16.4	7.8	7685.0	5450.0	908.5	315.9
2C2	21160.0	282.0	1095.5	2.6	< 3.0	16.7	7.1	9940.0	7835.0	1215.5	360.5
2C3	13890.0	183.0	670.0	< 2.0	4.3	17.7	6.9	7115.0	4429.5	820.5	261.9
2C4	18060.0	241.8	971.5	< 2.0	< 3.0	18.7	7.5	8420.0	6900.0	1028.5	331.6

Concentration of selected elements for Site 7, continued.

horizon	total elemental analysis										
	Mo	Na	Ni	P	Pb	S	Si	Sr	Ti	Zn	Zr
	ppm										
Ap1	6.6	4567.0	< 10.0	344.0	31.3	< 25.0	72150.0	63.2	1653.5	30.0	94.4
Ap2	7.9	4836.0	< 10.0	344.9	38.8	99.1	124100.0	67.7	1771.0	28.8	94.1
A	< 5.0	4465.0	11.8	295.2	27.3	< 25.0	51150.0	64.1	1719.0	32.8	89.4
C1	9.3	4765.5	< 10.0	275.8	57.3	313.1	171350.0	68.7	1739.5	28.1	90.4
C2	< 5.0	4527.5	11.0	188.6	37.7	< 25.0	195400.0	70.9	1799.0	28.3	106.7
2C1	8.6	1916.0	< 10.0	196.2	< 25.0	< 25.0	103850.0	30.1	1060.0	13.5	48.1
2C2	7.3	2899.0	< 10.0	229.9	< 25.0	< 25.0	96250.0	47.0	1464.5	14.9	77.9
2C3	< 5.0	1596.0	< 10.0	159.3	29.4	58.2	140900.0	26.4	1177.0	12.3	65.9
2C4	< 5.0	2304.0	13.4	155.5	< 25.0	< 25.0	73650.0	37.7	1321.0	45.4	72.2

VITA

David Edward Smith was born in Murfreesboro, Tennessee on September 2, 1973. In June 1991, he graduated from Virginia High School in Bristol, Virginia. In May 1995, he received his Bachelor of Sciences degree from Virginia Polytechnic Institute and State University, Blacksburg, Virginia with a major in Crop & Soil Environmental Sciences. In August 1995, he enrolled in The University of Tennessee, to pursue a Master's of Science degree in Plant and Soil Science, which was awarded to him in May of 1998.

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