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To the Graduate Council:

I am submitting herewith a thesis written by John Robert Jared entitled "Influence of Parent Material and Time on Properties of Some Hapludalfs from Loess in West Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

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INFLUENCE OF PARENT MATERIAL AND TIME ON PROPERTIES OF SOME
HAPLUDALFS FROM LOESS IN WEST TENNESSEE

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
John Robert Jared

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ABSTRACT

In the loess areas of West Tennessee, well-drained upland soils which formed under similar climate and organisms have been mapped extensively as members of the Memphis series. However, morphology of all the soils is not always the same. For example, soils in thin loess have redder B horizons, more strongly developed blocky structure, higher sand content, and more prominent clay films than do soils in thick loess near the bluff. With such differences in morphology, it is logical to assume that chemical, physical, and mineralogical properties differ also.

Therefore, the main objective of this study was to determine physical and chemical properties of these Hapludalfs at various distances from the bluff and relate any differences to one or more of the soil forming factors. A second objective was to classify these soils according to the seventh approximation.

Two transects, parallel and 20 miles apart, were extended from the bluff southeastward for 50 miles across thick, intermediate, and thin loess areas. On high gently sloping positions along each transect, pedons were selected in each of the three loess areas. Each pedon was described and sampled to a depth of at least 150 cm. Exchangeable bases, pH, exchangeable acidity, CEC, and free iron oxides were determined in the laboratory, along with particle size distribution, bulk density, and moisture retention.

Soils in thin loess had lower base saturation, lower CEC, less extractable P, lower Ca/Mg ratios, and a higher sand content than the

soils in thick loess. Soils in thin loess are polygenetic and formed from Wisconsin and Loveland loess. Soils in thick and intermediate loess have formed in Peorian.

Soils in Peorian loess were classified as Typic Hapludalfs belonging to the Memphis series. Soils in thin loess are definitely out of the Memphis series because content of sand coarser than very fine exceeds 5 percent at 62 cm in soil 5 and at 55 cm in soil 6. Soil 6 was classified as an Ultic Hapludalf belonging to the Lexington series. Although similar to soil 6 in most properties, soil 5 was barely too high in base saturation for an Ultic Hapludalf.

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CHAPTER I

INTRODUCTION

Many soils of West Tennessee have formed in a mantle of late Pleistocene loess varying in thickness from 15 m or more at the line of bluffs overlooking the flood plains of the Mississippi River to 1 m 60 miles to the southeast. According to Wascher (42) this loess was deposited in three distinct sheets with the bottom layer considerably older and more severely weathered than the upper two. Sufficient time elapsed between deposition of the loess sheets for soil formation to occur both between intervals and perhaps during deposition.

Well-drained upland soils of the loess region have formed under similar climate and organisms and have been mapped extensively as members of the Memphis series. However, the morphology of these soils is not always the same. That is, soils in thin loess have redder B horizons, more strongly developed blocky structure, higher sand content, and more prominent clay films than do soils in thick loess near the bluff. Although such differences have been known for some-time, few steps have been taken to analyze the soils quantitatively. Little is known about relation of CEC, base saturation, exchangeable bases, and other properties to distance of the soils from the source area. Therefore, the main objective of this study was to determine physical and chemical properties of some well-drained soils at various distances from the bluff and relate any differences to one or more of

the soil forming factors. A second objective was to classify these soils according to the seventh approximation. With climate and organisms remaining uniform and by choosing similar topography, any differences found could be attributed to time and parent material.

Extensive field work preceded selection of pedons along two transects 20 miles apart, extending 50 miles southeast from the Mississippi Bluff. Horizons were sampled from each solum to 150 cm with auger samples being taken near 200 cm. Detailed profile and field descriptions were written at each site. Exchangeable bases, pH, exchangeable acidity, CEC, free iron oxides (Fe_2O_3), particle size distribution, bulk density, and moisture retention were determined in the laboratory. Differences in properties of the soils were then related to thick, intermediate, and thin loess.

CHAPTER II

LITERATURE REVIEW

I. West Tennessee Plateau Slope

The entire area of the slope of West Tennessee is a great plain or plateau sloping to the west. Average elevation above sea level is from 400 to 500 feet (30). The slope begins along the edges of the Tennessee River and extends westward for an average distance of approximately eighty miles, where it abruptly terminates at the line of bluffs that overlook the alluvial plains of the Mississippi River. This physiographic division of the state occupies an area of some 8,850 square miles.

The topography that constitutes the eastern margin of the plateau is at many points rough and high, ranging in general elevation from 350 to 400 feet above the Tennessee Valley. To the west, the plateau becomes less broken and more gently rolling until it is terminated by the western escarpment. The escarpment is cut by the river valleys into sections; however, these are considered as one and are termed the Mississippi Bluff. At various sites along the river bottoms the bluff rises from 50 to 180 feet, with the average being roughly 130.

II. Classification and Age of Loess

Loess deposition in West Tennessee and the southern Mississippi Valley as postulated by Wascher, Humbert, and Cady (42), occurred in

conjunction with the two major stages of Wisconsin and Illinoian glaciation. These stages, along with the earlier Nebraskan and Kansan, constitute the glacial stages within the Pleistocene Epoch of the Cenozoic Era (7). The glacial and interglacial stages as classified by Leighton (20) in order of increasing age are:

Wisconsin glacial stage

Sangamon interglacial stage

Illinoian glacial stage

Yarmouth interglacial stage

Kansan glacial stage

Aftonian interglacial stage

Nebraskan glacial stage

Later Leighton (21) classified the Wisconsin glacial stage on the basis of stratigraphy into the following six glacial substages as listed in decreasing age: Farmdale, Iowan, Tazewell, Cary, Mankato, and Valders.

From Wascher's study, loess in the southern Mississippi Valley was represented by three distinct sheets (42). The upper or surface sheet corresponds in position and appearance to the Peorian loess of Leighton (19) and his co-workers, the middle sheet to the late Sangamon or Farmdale loess of Leighton, and the third or bottom sheet to the Loveland loess of Smith. Based on radiocarbon dating, Ruhe (29) and Frye (7) have reported that Peorian loess is between 12 and 22,000 years old, late Loveland near 90,000 years old, and Farmdale is intermediate with late Farmdale being somewhere near 25,000 years

of age. The surface and middle sheets are associated with the Wisconsin stage of glaciation, while the bottom or oldest layer corresponds to the Illinoian stage.

III. Differentiation of the Loess Sheets

Laboratory and field analyses have indicated that the Loveland is the most severely weathered of the three loess mantles as shown by the presence of only the most resistant minerals. Farmdale and Peorian are less weathered and are differentiated on bases of color and leaching (42). According to Leighton (19), Farmdale, where thick and calcareous, has a distinctive pinkish-gray color, while with leaching it commonly is oxidized to a chocolate-brown color. Peorian is darker where thin and entirely leached than in deposits where it is thicker and less leached. However, Farmdale is darker than thin Peorian and frequently can be recognized in areas where Farmdale is only a few inches thick. From work in the southern Mississippi Valley, Wascher (42) found that the mineralogical make-up of the Farmdale loess is much like that of Peorian although most of the Farmdale appears to be weathered more than the calcareous Peorian material but less than the soil profiles developed in Peorian. Fehrenbacher (4) reported from a study in Illinois and Indiana that Farmdale loess is lower in illite, slightly higher in expandable minerals, and somewhat higher in kaolinite than overlying calcareous Peorian.

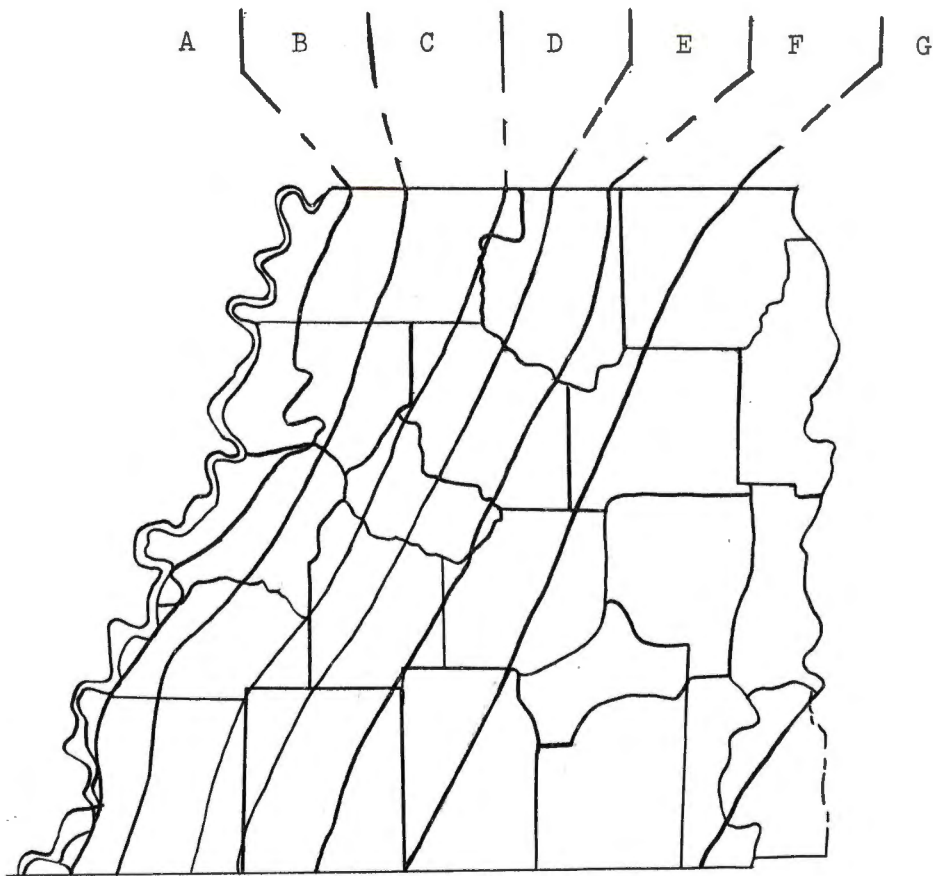
In West Tennessee, Peorian loess where thick and uneroded contains the present soils in its upper part with a few inches to several feet

of noncalcareous silt loam beneath the solum. As described by Wascher et al. (42), with good drainage this material is yellowish brown with Munsell notations (10YR 5/6 - 5/8) to (7.5YR 5/8), while near the bluff this leached noncalcareous layer is underlain by a nearly uniform calcareous silt of pale brown to yellowish brown color containing less than 10 percent clay. They also found that feldspar and hornblende minerals were less abundant in the soil developed in Peorian loess than in the calcareous material, but weight percentages of zircon, tourmaline, and other resistant minerals increased.

IV. Distribution of Loess

Distribution of loess in West Tennessee, as denoted by Wascher (42), is shown in Figure 1. Distribution here follows similar patterns that have been determined by other investigators. Waggoner and Bingham (40) stated, "As one travels away from the source of loess, the thickness of the blanket at first decreases precipitously, and then, after a few miles, the decrease becomes a slow attenuation."

In Illinois Smith (34) was able to establish a linear relationship between particle size and the logarithm of the distance from the bluff, with the finer fraction increasing and coarser decreasing with increased distance from the bluff. Also a similar relationship was established from the rate of thinning of loess with distance from its source. The soils of the thick and thin loess deposits were easily differentiated, the latter showing low base saturation and a higher degree of clay accumulation. Similar findings of loess distribution have been reported by Hutton (13).



Legend:

Loess Areas

A--Major bottomlands (probable source of loess).

B--Peorian loess mostly more than 15 feet thick (calcareous loess present).

C--Peorian loess mostly 10 to 15 feet thick.

D--Peorian loess mostly 7 to 10 feet thick.

E--Peorian loess mostly 5 to 7 feet thick.

F--Peorian loess mostly 4 to 5 feet thick.

G--Total loess mostly 3 to 4 feet thick.

Figure 1. Loess areas of the West Tennessee Plateau Slope (Wascher, 42).

Caldwell and White have shown that an increase in the quartz/feldspar ratio of soils derived from loess occurred with an increase in the distance from the Wabash River in southern Indiana (2). Feldspar minerals decreased in content with increasing distance from the loess source. Sodium appeared to decrease in direct proportion to distance from source, while the relationship of K was much less evident although a slight tendency was shown for the potassium feldspars to decrease with increasing distance from the source area. Calcium decreased rapidly for the first few miles with only a slight decrease for the remainder of the study area.

In Iowa, Hutton (14) found that the degree of weathering and soil development increased in the direction of decreasing loess thickness. Cation exchange capacity of the clay decreased towards thinner loess, while clay content increased and sand decreased in the same direction. Hutton explained that such differences in properties are due to effective time that soil formation has occurred along the sequence. Assuming the solum to be 30 inches deep along the sequence and loess deposition occurring concurrently throughout the entire depositing period, the solum of the thickest site would have been deposited during the last 30/600, or 1/20, of the total period of deposition where loess was 600 inches deep, and the solum, where the loess was 90 inches deep, would have been deposited during the last 30/90, or 1/3, of the period of deposition. If such a concept is true, each succeeding increment in distance from the source area would represent a progressive increase in time of weathering.

V. Factors of Soil Formation

As defined by Simonson (32), all soils are naturally occurring three-dimensional bodies occupying space and possessing distinct upper boundaries that meet the atmosphere and indefinite lower boundaries that grade into less weathered regolith or parent material. According to Jenny (16), such bodies are the result of the action of five soil forming factors: climate, topography, parent material, organisms, and time. These factors are interacting, and with variation in degree of expression of one or more in the soil forming scheme, soils with varying properties and characteristics are developed.

In a chrono-litho-sequence study of loess-derived prairie soils in Iowa, Hutton hypothesized that not only are exchangeable bases, CEC, and clay accumulation affected by climate but also by the length of time the soils have been exposed to the other four soil forming factors (14). He noticed fewer exchangeable bases, lower CEC per 100 g clay, and greater clay accumulations as the soils increased in maturity. Also from a study of geomorphic surfaces in the same state, Ruhe discovered the major cause of the differences in three groups of soils to be age (28). Thickness of the sola and B horizons, along with an increase in percent clay, increased from profiles on the youngest surface to profiles on the oldest surface. With an increase in age, ratios of heavy-mineral to light-mineral fractions also increased.

Ehrlich et al. (3) reported that parent material is the most direct soil forming factor influencing some soils in Manitoba. Inorganic

carbonates in the parent material were found to be highly significant in restricting profile development, while mineralogical composition of the parent material appeared to be the only factor leading to differences between the Grey Wooded, Brown Podzolic, and Podzol soils. In soils developed in Wisconsin drift in Illinois, Winters and Wascher found that parent material had a strong influence on the character of the soils developed (44).

VI. Steps and Processes of Soil Formation

Simonson (32) postulated that soil genesis be thought of as occurring in the two overlapping steps: accumulation of parent material and differentiation of horizons. The latter step is involved with four basic processes of additions, removals, transfers, and transformations, which in turn depend upon many specific and simpler processes such as oxidation, hydrolysis, leaching, solution, hydration, carbonation, and others. Both the simple and basic processes which proceed in the genesis of all soils are governed by the factors of formation.

VII. Major Upland Soils from Loess

Memphis soils are in most counties of West Tennessee. In the association occupying the western rim of the bluff, Memphis makes up about 80 percent of the area and is on both the top and sides of ridges with slopes up to 50 percent. These narrow, winding, and long ridges are separated by deep and narrow hollows. According to Wascher (42), this association corresponds to area B of Figure 1, page 7, which

is approximately 8 miles wide and where Peorian loess is greater than 4.5 m thick.

Moving eastward into intermediate loess, Memphis soils decrease, and Grenada and Loring soils increase along sideslopes and less frequently on ridgetops. These correspond to areas C, D, E, and F of Figure 1, page 7. According to Ray (26), soils of this region are less well-drained with a marked change in the character of the soil profile.

In areas where total loess is less than 1.2 m thick, Memphis is replaced by well-drained Lexington soils which have developed in thin loess over friable coastal plains sediments and contain more than 15 percent sand within 1.2 m of the surface (6). These soils closely resemble the Memphis; however, they are derived from thinner loess, have redder subsoils, and contain appreciable sand in the lower portion of the profile.

According to the established series description, Memphis is a member of the fine-silty, mixed, thermic family of Typic Hapludalfs. By sum of cations, base saturation is more than 60 percent at 125 cm below the top of the argillic horizon, and clay content of the upper 50 cm of the Bt horizon is between 18 and 35 percent. Sand content to a depth of 120 cm or more is less than 5 percent.

The A horizon is silt or silt loam with hues of 7.5YR or 10YR, values of 3 through 5, and chromas of 2 through 4. The Bt horizon has hues of 7.5YR or 10YR, values of 4 or 5, and chromas of 4 through 6 with a silt loam or silty clay loam texture.

VIII. Climate of Study Area

Climate of the counties involved is rather uniform throughout. As shown in Table 1, rainfall is well distributed throughout the year with total annual precipitation averaging approximately 45 inches. September and October are generally driest with October averaging less than 2 inches per month. February, March, and April receive the heaviest rainfall of about 4.5 inches each. The hottest month of the year is July which averages about 79° F. The coolest is January which averages about 36° F. Based on a 39-year average, the growing season at Jackson is 202 days. It is 211 days at Dyersburg from 22 years of records (43).

January and July soil temperatures from 1962-1966, recorded at 4-inch depths below sod, were calculated from weekly readings collected at the West Tennessee Agricultural Experiment Station at Jackson on Memphis silt loam and averaged 43.8° F. and 78.3° F., respectively.¹ Also soil temperatures at 20 inches below sod for the same location and months averaged 47.4° F. and 76.2° F., respectively, from weekly readings during a two-year period. The annual soil temperature was 61.1° F.

Water balances by the Thornthwaite method (39), shown in Figures 2 and 3, indicate that soil moisture loss, soil moisture recharge, water surplus, water deficit, and potential and actual evapotranspiration

¹Calculated from unpublished data collected by H. A. Fribourg, Associate Professor of Agronomy, University of Tennessee.

Table 1. Mean monthly and annual temperatures (°F.) and precipitation (inches) from 1958-1967
for four locations in West Tennessee

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Brownsville													
Temp.	39.0	42.2	50.7	62.8	71.2	76.9	79.8	78.8	73.1	62.6	52.1	41.7	60.9
Precip.	3.3	5.0	5.3	5.7	4.4	2.9	5.3	3.2	3.6	2.0	3.4	4.4	48.6
Dyersburg													
Temp.	37.3	40.0	48.9	61.3	70.4	77.2	79.8	78.3	72.2	61.8	50.5	39.8	59.8
Precip.	3.1	4.5	4.9	3.8	4.4	2.5	4.8	2.8	4.3	1.5	4.1	3.9	45.6
Jackson													
Temp.	36.4	39.6	47.8	60.6	68.9	75.3	78.3	77.0	71.4	60.4	49.8	39.2	58.7
Precip.	3.3	4.5	4.8	4.7	4.1	3.2	4.2	2.6	2.8	1.7	3.1	4.3	43.4
Milan													
Temp.	32.3	39.2	48.3	60.5	68.9	75.2	78.0	76.8	70.8	60.0	49.6	38.9	58.6
Precip.	3.3	4.5	5.2	4.6	5.0	3.5	4.7	4.3	3.2	2.1	3.7	4.3	48.3

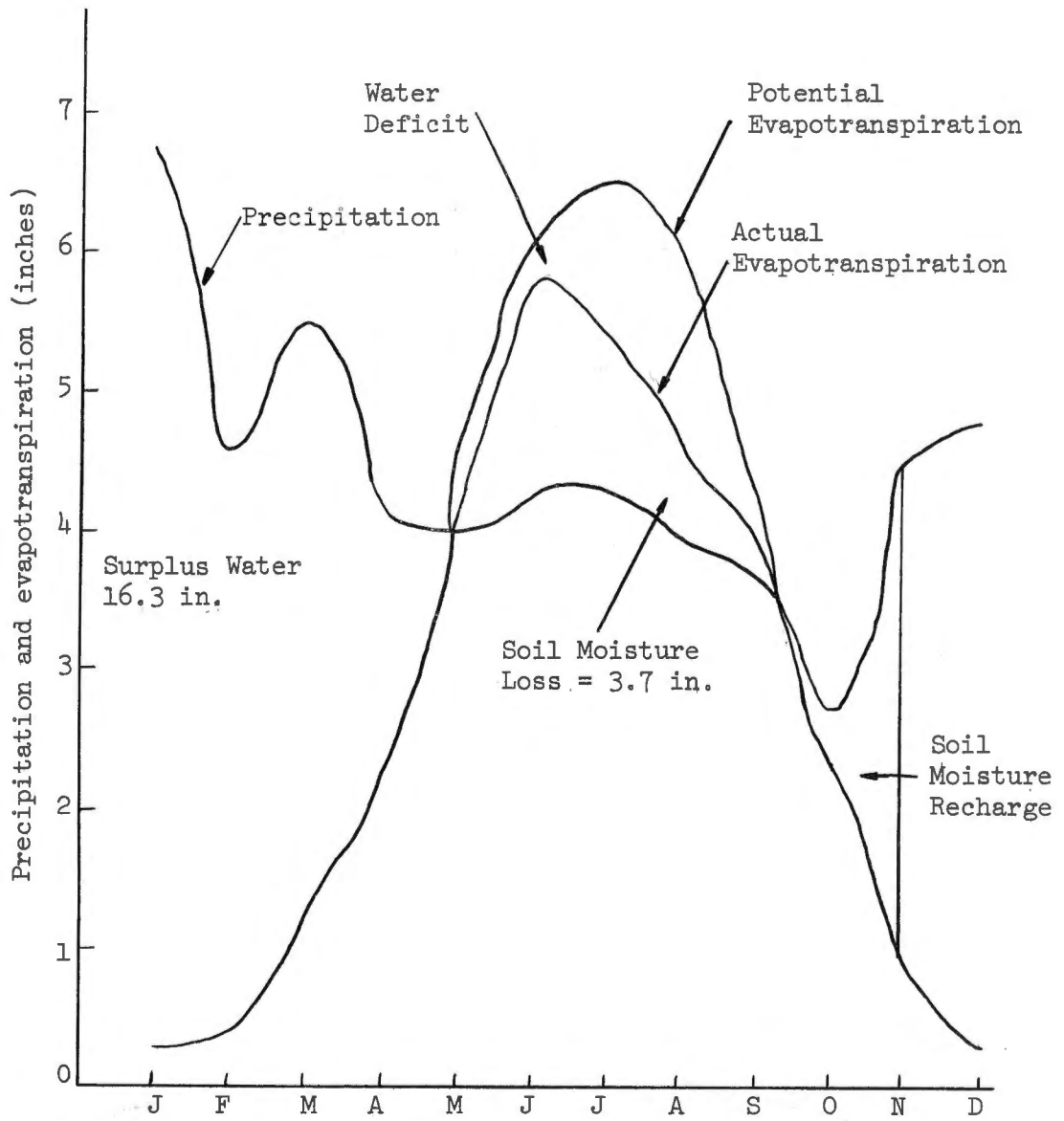


Figure 2. Average water balance at Jackson, Madison County, Tennessee, computed from data recorded from 1931-1960.

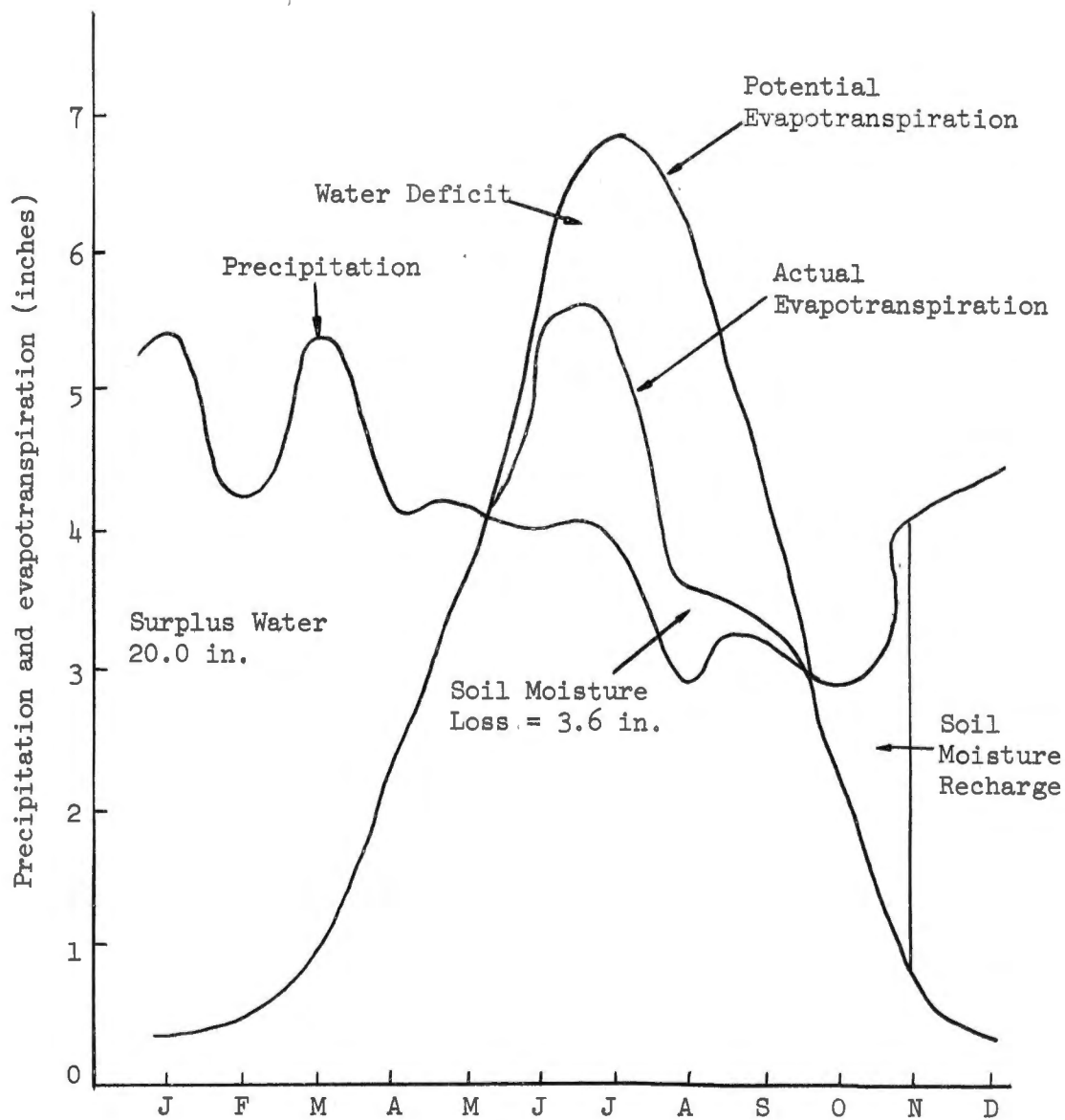


Figure 3. Average water balance at Newbern, Dyer County, Tennessee, computed from data recorded from 1931-1960.

are uniform at locations in Madison and Dyer Counties. Thus, the relationship between soil formation and water balance at the two locations is similar. The soils are moist most of the year with surplus water occurring during periods of heaviest precipitation. The soils are not dry for as much as 90 cumulative days in some horizon between 18 and 50 cm.

CHAPTER III

METHODS AND PROCEDURES

I. Field Methods

A preliminary field study of loess distribution and the morphological properties of some well-drained upland soils derived from loess was made to determine the sampling area. Morphological differences were looked at in relation to distance of the soils from the edge of the bluff. Also, topography and associated soils were investigated.

Sampling sites shown in Figure 4 were chosen along two parallel transects roughly perpendicular to the line of bluffs. The transects were 20 miles apart, extended from the bluff's edge 50 miles to the southeast, and dissected the thick, intermediate, and thin loess areas. From each of the three areas a pedon was sampled and described along each transect. Sites 1, 3, and 5 were located along the northern transect in Dyer, Gibson, and Carroll County, respectively, while sites 2, 4, and 6 of the southern transect were in the counties of Lauderdale, Crockett, and Madison. The six sites were selected on similar topographical positions which showed no evidence of colluvial or local alluvial deposition and only slight erosion.

Pits were dug to a depth of 150 cm. Prior to digging the pits numerous borings were made with a soil auger for determining some diagnostic properties. Profile descriptions were made from the face of the pit using Munsell color notations on moist soil. Samples were

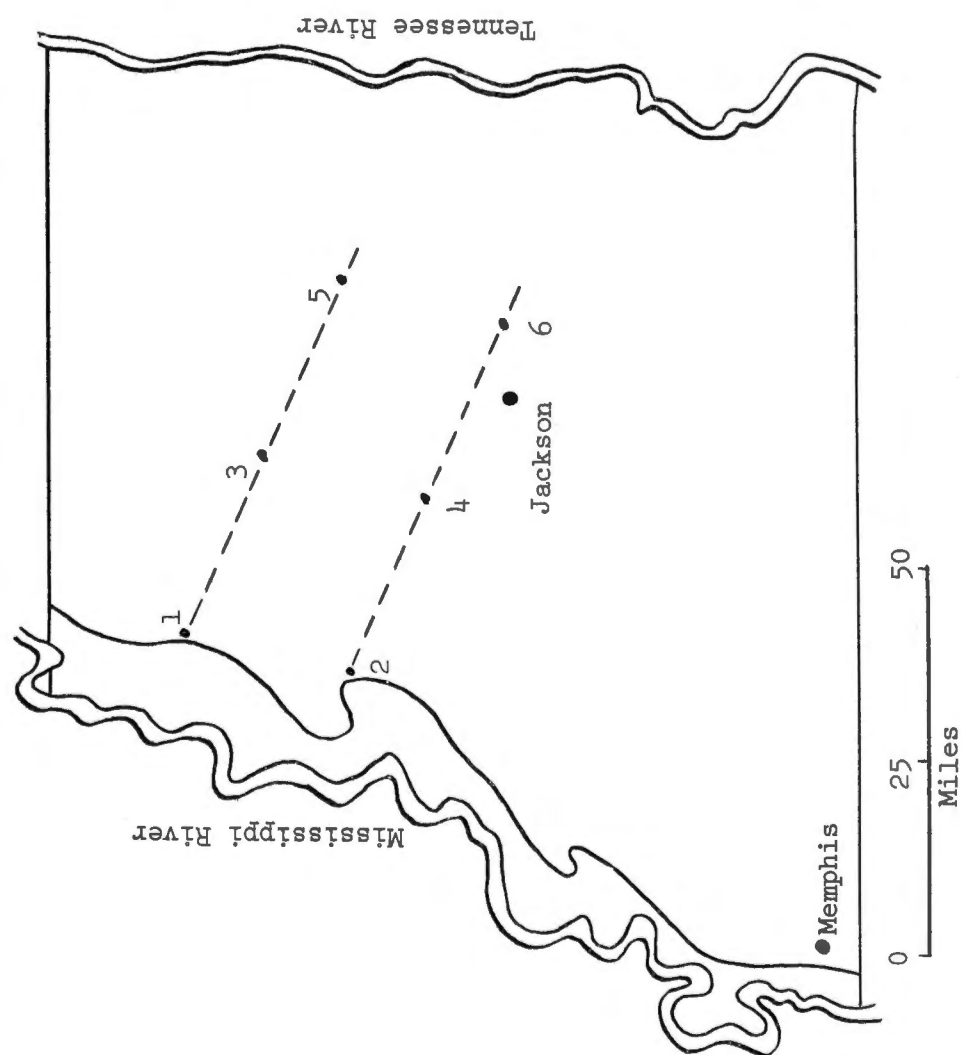


Figure 4. Location of six pedons along two transects across thick, intermediate, and thin loess in West Tennessee.

collected from each described horizon to the depth of the pit. If horizons were thicker than 20 cm, more than one sample was taken. Also, samples were taken with a bucket auger at depths between 175 and 200 cm at each site. Samples were collected from the bottom upward to avoid contaminating unsampled horizons. Each sample was placed in a plastic bag, labeled, and tightly sealed for transport to the laboratory. Clods were taken in triplicate at four depths from each profile, dipped in saran, air-dried, and packed in insulation.

II. Laboratory Procedures

After collecting and transporting the samples to the soil preparation room, pH was determined with a glass electrode on moist soil using 1:1 soil-water and 1:2.5 soil-normal KCl ratios. Samples were then air-dried and mixed thoroughly by rotating on a large piece of paper. Approximately one pint of the mixed sample was separated, ground with a rubber pestle, passed through a 2 mm sieve, and placed in pint ice cream cartons. The remainder of the unground samples were rebagged and stored.

Also pH was determined on air-dried samples using 1:1 soil-water ratio and a glass electrode. In addition, pH was determined on all samples at the State Testing Laboratory in Nashville.

Single determinations of particle size distribution were made on each sample by the pipette method as described by Kilmer and Alexander (17). During sedimentation, cylinders were kept in a constant temperature bath. Sedimentation times for this procedure, along with

separation of the coarse silt and fine silt fractions, were taken from the nomograph by Tanner and Jackson (38).

Cation exchange capacity was determined by sum of cations. Exchangeable bases were extracted by leaching with normal ammonium acetate as described by Jackson (15). The leachate was evaporated to dryness and taken up in normal HCl. Ferric chloride was then added and the solution neutralized with 1:1 NH_4OH . The solution was diluted to 500 ml, filtered, and the cations Ca, Mg, Na, and K were determined by atomic absorption with the Perkin-Elmer 303 Spectrophotometer. Exchangeable acidity was determined by the BaCl_2 -triethanolamine method described by Peech (24).

Free iron oxide was estimated in duplicate according to the procedure of Kilmer (18).

Moisture retention at 1/3 atmosphere was determined on undisturbed samples by the method described by Young (45). Fifteen-atmosphere water was determined in duplicate by the pressure membrane procedure of Richards (39).

Bulk density was determined on plastic-coated clods as described by Brasher et al.¹

Heavy minerals were separated from light minerals with tetrabromoethane (density 2.95) after the method of Marshall (12), with modifications by Gass (8).

¹Brasher et al., Volume Measurement of Saran Coated Soil-Fragments. Soil Survey Laboratory. S.C.S., U.S.D.A. Beltsville, Md., May, 1962.

CHAPTER IV

RESULTS

I. Description of the Soils

Some important differences in properties were revealed by descriptions of soils at each of the six sites.

Site 1: Memphis Silt Loam

Ap	0-17 cm	Brown (10YR4/3) silt loam; weak fine granular structure; very friable; abrupt smooth boundary.
Blt	17-33 cm	Dark brown (7.5YR4/4) silt loam; weak medium subangular blocky structure; friable; clear smooth boundary; few thin clay films mostly on verticle ped faces; common fine and medium pores.
B2lt	33-72 cm	Dark brown (7.5YR4/4) silt loam; moderate medium subangular blocky structure; friable; clear smooth boundary; common thin clay films; few black stains on ped faces; common very fine pores.
B22t	72-92 cm	Dark brown (7.5YR4/4) silt loam; moderate medium subangular blocky structure; friable; common thin clay films; common thin (10YR5/3) silt coatings on vertical ped faces; common very fine pores.

Location: The site was about 100 feet from a gravel road 1/2 mile west of the fire tower just north of Millsfield in Dyer County, Tennessee. The pit was approximately 3/4 of a mile east of the bluff's edge.

Vegetation: Most of the surrounding area was wooded with black oak (Quercus velutina), American beech (Fagus grandifolia), mockernut hickory (Carya tomentosa), and yellow-poplar (Liriodendron tulipifera). The site location was fallow with cotton nearby.

Ap 0-17 cm Dark brown (7.5YR4/4) silt loam; weak medium granular structure; friable; abrupt smooth boundary.

B21t	17-46 cm	Dark brown (7.5YR _{4/4}) silt loam; moderate medium subangular blocky structure; friable; gradual smooth boundary; continuous clay films; few Fe and Mn stains on ped surfaces.
B22t	46-63 cm	Dark brown (7.5YR _{4/4}) silt loam; moderate medium subangular blocky structure; friable; gradual smooth boundary; thin continuous clay films; few silt coatings of (10YR _{5/3}).
B23t	63-80 cm	Dark brown (7.5YR _{4/4}) silt loam; weak medium subangular blocky structure; friable; gradual smooth boundary; continuous clay films on vertical ped faces; common (10YR _{5/3}) silt coatings; common fine pores inside peds.
B24t	80-100 cm	Dark brown (7.5YR _{4/4}) silt loam; moderate medium subangular blocky structure; friable; gradual smooth boundary; continuous clay films on vertical ped faces; few (10YR _{5/3}) silt coatings.
B31t	100-115 cm	Dark brown (7.5 YR _{4/4}) silt loam; weak medium and coarse subangular blocky structure; friable; gradual smooth boundary; clay films on vertical ped faces only; few (10YR _{5/3}) silt coatings; common fine pores inside peds.
B32t	115-140 cm	Dark brown (7.5YR _{4/4}) silt loam; weak coarse subangular blocky structure; friable; thin clay films on vertical ped faces; few silt coatings.

Remarks: Weak coarse prismatic structure in the B21t continued to the bottom of the pit. The B23t and B24t horizons were slightly brittle. Medium and fine roots were common down through the B22t, while only a few fine roots were at greater depths.

Location: The pit was dug approximately 75 feet from a paved highway roughly 1 mile north of Double Bridges, Lauderdale County, Tennessee. The site was 3 miles east of the bluff's edge.

Topography: The highly dissected landscape was composed of winding ridges with steep slopes and good drainage. The pit was about 30 feet from the crest of the ridge on a north facing 3.5 percent slope.

Vegetation: Native vegetation was black oak (Quercus velutina) and American beech (Fagus grandifolia), with some yellow-poplar (Liriodendron tulipifera), black walnut (Juglans nigra), and sycamore (Plantanus occidentalis). Vegetation was cotton.

Site 3: Memphis Silt Loam

Ap	0-20 cm	Brown (10YR4/3) silt loam; weak fine granular structure; very friable; abrupt smooth boundary.
B21t	20-40 cm	Dark brown (7.5YR4/4) silty clay loam; moderate and strong medium subangular blocky structure; friable; clear smooth boundary; continuous clay films; common black stains on prism faces.
B22t	40-70 cm	Dark brown (7.5YR4/4) silt loam; moderate medium subangular blocky structure; friable, clear smooth boundary; common clay films on vertical and

horizontal ped faces; common black stains on prism faces; few fine pores inside peds.

- | | | |
|------|------------|--|
| B23t | 70-90 cm | Dark brown (7.5YR4/4) silt loam; moderate medium subangular blocky structure; friable; clear smooth boundary; common clay films; few fine pores inside peds. |
| B24t | 90-110 cm | Dark brown (7.5YR4/4) silt loam; moderate medium subangular blocky structure; friable; gradual smooth boundary; common clay films; common pale brown (10YR6/3) silt coatings on vertical prism faces; few fine pores inside peds. |
| B31t | 110-130 cm | Dark brown (7.5YR4/4) silt loam; weak medium subangular blocky structure; friable; gradual smooth boundary; common clay films on vertical ped faces only; common pale brown (10YR6/3) silt coatings on vertical prism faces; few fine pores inside peds. |
| B32t | 130-150 cm | Dark brown (7.5YR4/4) silt loam; weak medium subangular blocky structure; friable; common clay films on vertical ped faces only; common or many pale brown (10YR6/3) silt coatings on vertical prism faces. |

Remarks: Weak coarse prismatic structure occurred from the B21t to the bottom of the pit. It was noticeably stronger below 90 cm. The B23t was slightly darker than (7.5YR4/4). Common fine roots were in the top 60 cm.

Location: The location was about 100 feet east of a gravel road just west of Highway 45W and about two miles north of Trenton in Gibson County. The site was 25 miles from the Mississippi River Bluff.

Topography: The pit was located about 30 feet from the crest of the ridge on a north slope of 3 percent. Relief of the area was less dissected than the landscape near the bluff, and the slopes were more gentle.

Vegetation: Forest vegetation was predominantly black oak (Quercus velutina) and white oak (Quercus alba). Eastern redcedar (Juniperus virginiana) and sassafras (Sassafras albidum) were common along fence rows. Most of the area was in corn, cotton, soybeans, and pasture. Corn was growing at the pit location.

Site 4: Memphis Silt Loam

Ap	0-20 cm	Brown (10YR4/3) silt loam; weak medium and coarse granular structure; very friable; abrupt smooth boundary.
B2lt	20-38 cm	Dark brown (7.5YR4/4) silty clay loam; friable; weak medium subangular blocky structure; clear smooth boundary; clay films continuous or nearly so on ped faces; few black soft concretions and stains on ped faces.
B22t	38-90 cm	Dark brown (7.5YR4/4) silt loam; friable; weak medium subangular blocky structure; clear smooth boundary; clay films thinner and less common than in horizon above; few black soft concretions and stains on ped faces.

- B23t 90-125 cm Dark brown (7.5YR4/4) silt loam; friable; weak medium subangular blocky structure; clear smooth boundary; common thin clay films on vertical and horizontal ped faces.
- B31t 125-150 cm Dark brown (7.5YR4/4) silt loam; friable; weak medium subangular blocky structure; common clay films on vertical faces; few pale brown (10YR6/3) silt coatings on ped faces.

Remarks: Weak coarse prismatic structure began in the B21t and continued to bottom of pit. Few fine and medium roots were found throughout the profile. From the old pieces of flint and relict arrowheads around, it appeared that Indians had once used the area.

Location: The site was located on a high ridgetop about 200 yards west of a small gravel road that intersected Highway 88 one mile west of the junction with Highway 20 near Alamo in Crockett County. The pit was located about 25 miles from the bluff. Several other ridges were investigated, but all showed gray mottles.

Topography: The topography was gently rolling with a few scattered high ridges. The site was one of the highest points in the area, with the pit being located on a 1 percent slope breaking to 5 percent to the west and 3 percent to the east.

Vegetation: The surrounding trees were mostly black oak (Quercus velutina) and American elm (Ulmus americana). There were a few eastern redcedar (Juniperus virginiana) in fence rows. Soybeans had been grown the previous cropping season.

Site 5: Typic Hapludalf

Ap	0-16 cm	Brown (10YR ⁴ /3) silt loam; very friable; weak medium and coarse granular structure; abrupt smooth boundary; many fine roots.
Blt	16-23 cm	Dark brown (7.5YR ⁴ /4) to strong brown (7.5YR ⁵ /6) silt loam; friable; weak medium subangular blocky structure; few clay films on vertical ped faces; many fine and medium roots.
B2lt	23-62 cm	Dark brown (7.5YR ⁴ /4) silt/loam/silty clay loam; friable; moderate and strong medium subangular blocky structure; clear smooth boundary; nearly continuous clay films; many black stains on ped faces; common fine roots and pores.
B22t	62-97 cm	Dark brown (7.5YR ⁴ /4) silt loam; friable; moderate medium subangular blocky structure; clear smooth boundary; many clay films; many black stains on ped faces; few fine roots and pores.
B3lt	97-120 cm	Yellowish red (5YR ⁴ /6) silt loam; friable; moderate and weak medium subangular and angular blocky structure; clear smooth boundary; common clay films; few gray silt coatings; few fine roots.
B32t	120-150 cm	Red (2.5YR ⁴ /6) to reddish brown (5YR ⁴ /4) silt loam; friable; moderate and weak medium subangular blocky structure; common clay films; few gray silt coatings; few fine roots.

Remarks: Weak coarse prismatic structure began in the B3lt and continued to bottom of pit. There was a slight increase in sand at the bottom of the B22t, with a noticeable increase in the Cl.

Location: The site was located in Carroll County 12 miles northeast of Spring Creek and 100 feet from a gravel road 1 mile from Highway 70. The pit was located approximately 51 miles from the bluff.

Topography: The area was composed of broad ridges with deep hollows. Slopes were generally steep. The pit was located on a 3 percent slope to the west.

Vegetation: Most of the surrounding area was in small trees of black oak (Quercus velutina), white oak (Quercus alba), and mockernut hickory (Carya tomentosa). There were several scattered eastern redcedar (Juniperus virginiana) and sassafras (Sassafras albidum) as field invaders. The pit was dug in a small field of fescue and white clover.

Site 6: Lexington Silt Loam

Ap	0-18 cm	Brown (10YR4/4) silt loam; weak fine granular structure; very friable; abrupt smooth boundary.
B2lt	18-40 cm	Dark brown (7.5YR4/4) silty clay loam; moderate medium subangular blocky structure; friable; clear smooth boundary; common thin clay films; common dark stains on ped faces; many fine roots.
B22t	40-55 cm	Dark brown (7.5YR4/4) silt loam; moderate medium subangular blocky structure; friable; clear smooth boundary; common thin clay films; common dark stains on ped faces; common fine roots.

B23t	55-73 cm	Dark brown (7.5YR4/4) silt loam; weak and moderate medium subangular blocky structure; friable; clear smooth boundary; many clay films; black stains slightly less than common; few very fine pores.
B31t	73-100 cm	Reddish brown (5YR4/4) silt loam; weak and moderate medium subangular blocky structure; friable; clear smooth boundary; common clay films; few pale brown (10YR6/3) silt coatings.
B32t	100-150 cm	Reddish brown (5YR4/4) silt loam; weak medium subangular blocky structure; friable; clay films in medium and large pores; few tongues of pale brown (10YR6/3) 1.25 cm wide tonguing between some prism faces.

Remarks: Weak coarse prismatic structure began in the B31t and continued to the bottom of the pit; noticeable sand began in the B23t and increased with depth; there was a slightly brittle layer at 100 cm.

Location: The site was located about 1 mile south of Highway 20 about 150 feet west of Liberty-Claybrook Road in the Claybrook Community of eastern Madison County. The site was 52 miles from the bluff.

Topography: Relief of the area was gently rolling broad ridges with good drainage. Slopes were gentle in areas of cultivation but increased in wooded areas. The pit was on a 2 percent slope facing north.

Vegetation: White oak (Quercus alba), black oak (Quercus velutina),

and mockernut hickory (Carya tomentosa) were the most common trees. Eastern redcedar (Juniperus virginiana) were growing along fence rows. Vegetation at location of pit was seresia lespedeza and fescue.

II. Physical Properties of Horizon Samples

Further differences in physical properties among soils in thick, intermediate, and thin loess were brought out by laboratory results for the six soils. Particle size distribution, bulk density, and moisture retention are in Tables 2, 3, and 4.

Sand content in the 2.0 mm to 0.10 mm fraction was less than 1 percent throughout each solum at sites in thick and intermediate loess. At shallow loess sites, sand content of the same size range was greater and increased with depth below 45 cm. Very fine sand content was between 1 and 2 percent at thick loess sites 1 and 2, and less than 1 percent at intermediate sites 3 and 4. Very fine sand varied from 0.4 to 4.3 percent at shallow loess sites 5 and 6, increasing with depth from 55 cm at site 5 in Carroll County and from 80 cm at site 6 in Madison County. Total sand content at 150 cm ranged from 2.5 percent or less in thick and intermediate loess to 30 percent in shallow.

Total silt content averaged highest in thick loess and lowest in shallow. Coarse silt (0.05-0.02 mm) was greater than fine silt (0.02-0.002 mm) in thick and intermediate loess with the difference being less significant in intermediate. In shallow loess, differences in coarse and fine silt were slightly less than those in intermediate

Table 2. Some physical properties of Memphis silt loam in deep loess of West Tennessee

Site	County	Horizon	Depth (cm)	Bulk Density gr/cc	% Water Atmospheres 15 1/3*	Particle size distribution (mm)						Textural Class
						% Sand		% Silt		% Clay <0.002		
						2.0-	0.1-	0.05-	0.02-			
1	Dyer	Ap	0-17	---	---	0.6	1.8	58.1	27.2	12.3	sil	
		B1t	17-33	---	---	0.2	1.1	41.5	28.0	29.3	sicl	
		B21t	33-53	1.5	14.7	0.2	1.3	46.3	25.3	27.0	sil/sicl	
		B21t	53-72	---	---	0.3	1.7	46.0	30.0	22.0	sil	
		B22t	72-92	1.5	---	0.2	1.7	46.7	29.6	21.8	sil	
		B23t	92-105	1.5	12.5	0.2	1.8	47.9	30.9	19.3	sil	
		B23t	105-117	---	---	0.8	1.2	51.2	31.5	15.3	sil	
		B31t	117-135	---	---	0.3	2.1	52.2	28.6	16.9	sil	
		B31t	135-150	1.5	---	0.5	1.7	53.0	29.6	15.4	sil	
		C1	175-200	---	---	0.2	1.2	48.5	32.7	17.2	sil	
2	Lauder- dale	Ap	0-17	---	---	0.2	0.9	45.0	29.9	23.9	sil	
		B21t	17-46	1.5	---	0.1	1.2	43.1	28.7	26.9	sil/sicl	
		B22t	46-63	1.5	11.5	0.2	1.2	46.6	30.1	21.9	sil	
		B23t	63-80	---	---	0.1	1.1	47.0	31.2	20.6	sil	
		B24t	80-100	1.5	11.6	0.1	0.8	48.6	31.8	18.7	sil	
		B31t	100-115	---	---	0.1	0.7	57.4	28.2	13.6	sil	
		B32t	115-140	1.4	---	0.5	0.7	53.4	29.6	15.9	sil	
		C1	170-200	---	---	0.6	0.8	51.9	29.3	17.5	sil	
		C2	250-265	---	---	0.2	1.3	58.3	31.5	8.7	sil	

*Determinations were made on undisturbed clods.

Table 3. Some physical properties of Memphis silt loam in intermediate loess in West Tennessee

Site	County	Horizon	Depth (cm)	Bulk Density gr/cc	% Water Atmospheres 15 1/3*	Particle size distribution (mm)						Textural Class
						% Sand		% Silt		% Clay		
						2.0-	0.1-	0.05-	0.02-	0.02	<0.002	
3	Gibson	Ap	0-20	---	---	0.2	0.7	45.2	29.8	24.1	sil	
		B21t	20-40	1.4	---	0.1	0.5	37.2	27.1	35.1	sicl	
		B22t	40-70	1.4	14.1	26.9	0.1	0.5	42.8	36.0	20.6	sil
		B23t	70-90	---	---	---	0.2	0.5	43.9	33.3	22.1	sil
		B24t	90-110	1.4	10.5	25.5	0.1	0.4	47.2	38.1	14.2	sil
		B31t	110-130	---	---	---	0.4	0.4	38.1	31.8	29.3	sicl
		B32t	130-150	1.4	---	---	0.3	0.6	39.6	38.5	21.0	sil
		C1	150-160	---	---	---	0.8	0.8	45.2	36.0	17.2	sil
		C2	175-200	---	---	---	3.8	2.2	47.7	31.8	14.5	sil
4	Crockett	Ap	0-20	---	---	0.1	0.8	46.6	32.6	19.9	sil	
		B21t	20-38	1.4	---	---	0.1	0.5	37.4	33.9	28.1	sicl
		B22t	38-60	1.3	13.9	27.5	0.1	0.4	40.0	29.8	29.7	sicl
		B22t	60-75	---	---	---	0.3	0.4	43.4	33.2	22.7	sil
		B22t	75-90	---	---	---	0.1	0.5	42.3	34.4	22.7	sil
		B23t	90-105	1.4	---	---	0.1	0.5	42.6	41.4	15.4	sil
		B23t	105-125	---	10.6	24.9	0.2	0.3	41.8	35.2	22.5	sil
		B31t	125-150	1.4	---	---	0.3	0.5	42.0	39.6	17.6	sil
		C1	200-225	---	---	---	2.5	1.3	46.1	33.8	16.3	sil

*Determinations were made on undisturbed clods.

Table 4. Some physical properties of some Hapludalfs in shallow loess of West Tennessee

Site	County	Horizon	Depth (cm)	Bulk Density gr/cc	% Water Atmospheres 15	1/3*	Particle size distribution (mm)						Textural Class
							% Sand		% Silt		% Clay		
							2.0- 0.1	0.1- 0.05	0.05- 0.02	0.02- 0.002	0.002 <0.002		
5	Carroll	Ap	0-16	---	---	---	3.2	0.7	39.4	31.6	25.1	sil	
		B1t	16-23	1.3	---	---	2.0	0.5	36.6	34.5	26.4	sil/sicl	
		B21t	23-62	1.3	12.4	---	4.4	0.6	38.7	34.1	22.2	sil	
		B22t	62-80	---	---	---	8.3	0.7	33.6	41.2	16.2	sil	
		B22t	80-97	1.5	8.8	20.6	12.7	1.0	38.0	30.9	17.4	sil	
		II B31t	97-120	---	---	---	20.0	1.5	31.1	24.5	22.9	sil	
		II B32t	120-150	1.6	---	---	28.1	1.9	27.0	25.5	17.5	sil	
		III C1	175-200	---	---	---	46.3	2.1	16.7	18.7	16.2	1	
6	Madison	Ap	0-18	---	---	---	6.2	0.9	49.7	28.3	15.0	sil	
		B21t	18-40	1.3	---	---	2.4	0.6	35.9	32.7	28.5	sicl	
		B22t	40-55	---	---	---	4.3	0.7	35.0	38.0	21.9	sil	
		B23t	55-73	1.5	9.5	23.4	8.3	1.2	40.7	31.2	18.5	sil	
		B31t	73-100	1.5	8.8	22.0	13.7	1.7	34.8	29.3	20.6	sil	
		II B32t	100-125	1.5	---	---	20.9	2.7	28.7	30.6	17.1	sil	
		II B32t	125-150	---	---	---	24.4	2.7	27.4	32.5	13.1	sil	
		III C1	163-175	---	---	---	37.3	4.3	20.0	20.2	18.2	1	
III C2	200-250	---	---	---	29.1	3.7	17.9	16.5	32.9	cl			

*Determinations were made on undisturbed clods.

to a depth of 120 cm in Carroll County and 100 cm in Madison. Below these depths total silt decreased and the two silt fractions were approximately equal.

Evident breaks in coarse silt/fine silt occurred near 90 cm at site 3 and 130 cm at site 4. Breaks were even more obvious in shallow loess sites. A break was at 60 cm at site 5 and at 40 cm at site 6. Both silt fractions were rather uniform with depth in thick loess although a slight break was evident at 100 cm at the site in Lauderdale County.

Clay percentages were in the mid and upper twenties in the B1t and B21t horizons at all sites. Secondary clay bulges at sites in intermediate loess were at depths near 110 cm. In shallow loess in Carroll County a second clay increase was near 120 cm. Only one appreciable clay bulge was evident within the solum in Madison County although a second increase appeared at 200 cm.

Bulk density of clods at field moisture were 1.4 and 1.5 in soils from thick and intermediate loess. Density of the clods in soils from shallow loess increased with depth from 1.3 to 1.6.

Both 1/3-bar and 15-bar water were lower for soils in shallow loess than at sites in thick and intermediate. Moisture retention values depicted 1/3-bars tension to average about 13 percent by weight more water than 15-bars tension. Percent water for given tension levels was relatively uniform with depth.

III. Chemical Properties of Horizon Samples

Differences in chemical properties among the soils in thick, intermediate, and thin loess were revealed by laboratory results for the six soils. Some chemical properties of the six soils are in Tables 5, 6, and 7.

Cation exchange capacity per 100 g soil showed a general decrease from site 1 in thick loess to site 5 in shallow. Cation exchange capacity/percent clay at 50 cm averaged 1.5 in thick loess, 1.2 in intermediate, and 0.9 in shallow. Cation exchange capacity/percent clay between 50 and 100 cm averaged 2.0 in thick loess, 1.8 in intermediate, and 0.8 in shallow. Averages between 100 and 150 cm depths were 1.8, 1.3, and 0.8, respectively.

Exchangeable Na and K averaged less than 0.5 milliequivalents (meq) per 100 g soil at all sites. Sodium content was rather uniform throughout while K was slightly less at the two shallow loess sites. Exchangeable Ca showed a general decrease from thick loess to thin although site 4 in Crockett County gave the highest readings of the six sites. Exchangeable Ca in thin loess was about one-third that of thick loess. Exchangeable Mg ranged from 3 to 8 meq per 100 g soil, with no appreciable changes in relation to loess thickness. Calcium-magnesium ratios decreased from about 2.0 in thick loess to less than 1.0 in thin.

Exchangeable acidity showed considerable fluctuation among the six sites. Total average was highest at site 4 in Crockett County and lowest at site 2 in Lauderdale County.

Table 5. Some chemical properties of Memphis silt loam in deep loess of West Tennessee

Site	County	Horizon	Depth (cm)	Exchangeable cations					Base* sat. %	Fe ₂ O ₃ %	pHw	pHs	Ca/ Mg
				CEC*	Ca	Mg	K	Na					
					(Milliequivalents/100 g soil)				Exchange acidity				
1	Dyer	Ap	0-17	---	---	---	---	---	---	---	5.5	4.6	---
		B1t	17-33	---	---	---	---	---	---	---	5.9	4.9	---
		B21t	33-53	---	---	---	---	---	---	---	4.9	4.4	---
		B21t	53-72	33.8	12.9	7.3	0.5	0.3	12.7	1.8	4.9	4.0	1.8
		B22t	72-92	---	---	---	---	---	---	---	5.0	4.1	---
		B23t	92-105	---	---	---	---	---	---	---	5.0	4.2	---
		B23t	105-117	32.4	13.1	6.1	0.6	0.1	12.6	1.7	5.0	4.2	2.2
		B31t	117-135	---	---	---	---	---	---	---	5.0	4.3	---
		B31t	135-150	29.0	10.9	5.3	0.5	0.2	11.9	1.8	5.0	4.2	2.0
		Cl	175-200	---	---	---	---	---	---	---	5.2	4.3	---
				---	---	---	---	---	---	---	---	---	---
				---	---	---	---	---	---	---	---	---	---
2	Lauder- dale	Ap	0-17	---	---	---	---	---	---	---	5.1	3.9	---
		B21t	17-46	---	---	---	---	---	---	---	5.0	3.8	---
		B22t	46-63	24.4	12.4	5.5	0.7	0.3	5.5	---	5.0	3.8	2.3
		B23t	63-80	---	---	---	---	---	---	---	5.1	3.9	---
		B24t	80-100	---	---	---	---	---	---	---	5.3	4.0	---
		B31t	100-115	25.4	12.7	5.8	0.7	0.2	6.0	76	5.3	4.2	2.2
		B32t	115-140	27.9	14.5	6.5	0.7	0.1	6.1	78	5.3	4.1	2.2
		Cl	170-200	---	---	---	---	---	---	---	5.4	4.2	---
		C ₂	250-265	---	---	---	---	---	---	---	5.4	4.1	---
				---	---	---	---	---	---	---	---	---	---
				---	---	---	---	---	---	---	---	---	---
				---	---	---	---	---	---	---	---	---	---

*By sum of cations.

Table 6. Some chemical properties of Memphis silt loam in intermediate loess in West Tennessee

Site	County	Horizon	Depth (cm)	Exchangeable cations							pHw	pHs	Ca/ Mg
				CEC*	Ca	Mg	K	Na	Exchange	Base*			
									acidity				
(Milliequivalents/100 g soil)													
3	Gibson	Ap	0-20	---	---	---	---	---	---	---	---	---	
		B21t	20-40	---	---	---	---	---	---	---	---	---	
		B22t	40-70	28.7	7.2	6.8	0.4	0.2	14.1	51	2.1	1.1	
		B23t	70-90	---	---	---	---	---	---	---	---	---	
		B24t	90-110	19.4	5.6	3.9	0.4	0.2	9.2	53	2.0	1.4	
		B31t	110-130	---	---	---	---	---	---	---	---	---	
		B32t	130-150	17.4	6.6	3.4	0.4	0.2	6.9	60	1.9	1.9	
		C1	150-160	---	---	---	---	---	---	---	---	---	
		C2	175-200	---	---	---	---	---	---	---	---	---	
4	Crockett	Ap	0-20	---	---	---	---	---	---	---	---	---	
		B21t	20-38	---	---	---	---	---	---	---	---	---	
		B22t	38-60	32.0	15.8	4.9	0.7	0.1	10.4	67	---	3.2	
		B22t	60-75	---	---	---	---	---	---	---	---	---	
		B22t	75-90	---	---	---	---	---	---	---	---	---	
		B23t	90-105	34.3	17.4	4.9	0.8	0.2	11.1	68	---	3.6	
		B23t	105-125	40.8	17.0	6.0	0.8	0.2	16.8	59	---	2.8	
		B31t	125-150	---	---	---	---	---	---	---	---	---	
		C1	200-225	---	---	---	---	---	---	---	---	---	

*By sum of cations.

Table 7. Some chemical properties of two Hapludalfs in shallow loess of West Tennessee

Site	County	Horizon	Depth (cm)	Exchangeable cations						Base* sat. %	Fe ₂ O ₃ %	pHw	pHs	Ca/ Mg
				CEC*	Ca	Mg	K	Na	Exchange acidity (Milliequivalents/100 g soil)					
5	Carroll	Ap	0-16	---	---	---	---	---	---	---	2.0	5.3	4.2	---
		B1t	16-45	---	---	---	---	---	---	---	2.5	5.1	4.1	---
		B21t	45-62	26.4	4.6	8.1	0.5	0.5	12.7	52	2.2	5.3	4.0	0.6
		B22t	62-80	---	---	---	---	---	---	---	2.0	5.1	4.1	---
		B22t	80-97	---	---	---	---	---	---	---	1.7	4.9	4.0	---
		IIB31t	97-120	18.5	3.8	6.8	0.4	0.4	7.1	62	1.6	5.0	3.9	0.6
		IIB32t	120-150	13.4	2.0	6.2	0.3	0.3	4.6	65	1.5	5.1	4.0	0.3
		IIIC1	175-200	---	---	---	---	---	---	---	---	5.0	3.9	---
6	Madison	Ap	0-18	---	---	---	---	---	---	---	1.5	6.4	5.4	---
		B21t	18-40	---	---	---	---	---	---	---	2.6	5.2	4.3	---
		B22t	40-55	17.5	5.2	3.4	0.4	0.1	8.1	53	2.4	5.0	4.1	1.5
		B23t	55-73	---	---	---	---	---	---	---	2.0	5.1	4.0	---
		B31t	73-100	---	---	---	---	---	---	---	1.8	5.1	4.1	---
		IIB32t	100-125	11.7	2.0	3.0	0.3	0.2	6.3	47	1.6	5.0	4.0	0.7
		IIB32t	125-150	12.3	1.6	2.7	0.3	0.2	7.5	39	1.6	4.9	4.0	0.6
		IIIC1	163-175	---	---	---	---	---	---	---	---	5.1	4.0	---
		IIIC2	200-250	---	---	---	---	---	---	---	---	5.4	4.1	---

*By sum of cations.

Base saturation ranged from a low in the B33t horizon of the thin loess site in Madison County to a high in the B32t in Lauderdale County in thick loess. In general, base saturation was greater than 50 percent with a slight decrease in the direction of thinning loess.

Free iron oxides showed greatest accumulation in the horizons of highest clay content. Highest accumulations were in B2lt horizons and lowest amounts in B3t horizons. Free Fe_2O_3 /clay ratios were roughly uniform throughout the solums, ranging from 0.09 to 0.12.

Soil reaction with a 1:1 water ratio ran from strongly to medium acid throughout the B2t and B3t horizons at all sites. Readings of 1 part soil to 2.5 parts normal KCl suspension were 3.6 to 4.8. Additional pH readings, along with extractable P and K, determined in the Soil Testing Laboratory at Nashville are in Table 8. Averaged pH values were about 0.4 units lower than the water pH's determined in Knoxville. Extractable P in soils from thin loess is less than one-fifth that in soils from thick loess. In intermediate loess it is about one-half. Potassium was lowest in Madison County and highest in Crockett County with readings near 55 and 135 ppm, respectively. There was a general decrease in K from soils in thick to those in thin loess.

Percent light and heavy minerals are presented in Table 9. Heavy minerals averaged less than 2 percent at all sites. The greatest amounts of heavy minerals were at site 6 in Madison County.

Table 8. Some chemical properties of six Hapludalfs in the
Loess region of West Tennessee

Thickness of loess	Site	County	Horizon	Depth (cm)	pHw	Extractable (ppm)	
						P	K
Thick	1	Dyer	Ap	0-17	5.5	25	125
			B1t	17-33	5.4	25	75
			B21t	33-53	4.8	27	115
			B21t	53-72	4.8	25	85
			B22t	72-92	4.7	27	85
			B23t	92-105	5.0	27	85
			B23t	105-117	4.8	30	90
			B31t	117-135	4.7	25	75
			B31t	135-150	5.0	30	85
			C1	175-200	4.8	37	75
Thick	2	Lauder- dale	Ap	0-17	4.8	27	115
			B21t	17-46	4.8	25	70
			B22t	46-63	4.8	20	70
			B23t	63-80	5.1	20	95
			B24t	80-100	5.3	27	100
			B31t	100-115	5.2	37	95
			B32t	115-140	5.3	35	100
			C1	170-200	5.2	47	65
			C2	250-265	5.2	47	60
Intermed.	3	Gibson	Ap	0-20	5.8	15	150
			B21t	20-40	4.5	15	90
			B22t	40-70	4.8	15	75
			B23t	70-90	4.8	15	75
			B24t	90-110	4.8	15	65
			B31t	110-130	4.8	17	55
			B32t	130-150	5.0	17	55
			C1	150-160	5.0	22	50
			C2	175-200	5.2	25	35

Table 8 (continued)

Thickness of loess	Site	County	Horizon	Depth (cm)	pHw	Extractable (ppm)	
						P	K
Intermed.	4	Crockett	Ap	0-20	5.0	15	100
			B21t	20-38	5.0	15	105
			B22t	38-60	5.0	14	125
			B22t	60-75	5.4	13	150
			B22t	75-90	5.4	13	170
			B23t	90-105	5.4	13	135
			B23t	105-125	5.2	14	150
			B31t	125-150	5.2	15	150
			C1	200-225	5.4	25	70
Thin	5	Carroll	Ap	0-16	5.2	2.5	105
			B1t	16-45	4.8	2.0	80
			B21t	45-62	5.1	3.5	65
			B22t	62-80	5.0	5.5	75
			B22t	80-97	5.0	4.0	60
			IIB31t	97-120	5.0	3.5	60
			IIB32t	120-150	5.0	3.0	60
			IIIC1	175-200	4.9	2.5	75
Thin	6	Madison	Ap	0-18	6.2	3.5	55
			B21t	18-40	5.0	2.5	65
			B22t	40-55	4.8	3.5	60
			B23t	55-73	5.0	4.5	55
			B31t	73-100	5.0	5.5	70
			IIB32t	100-125	5.0	3.5	55
			IIB32t	125-150	5.0	3.5	50
			IIIC1	163-175	5.1	4.5	50
			IIIC2	200-250	5.0	2.5	35

Table 9. Percent by weight of light and heavy minerals in the
0.05-0.02 mm fraction of some Hapludalfs in the loess
region of West Tennessee

Loess Area	Site	County	Horizon	Depth (cm)	Minerals	
					Light <2.95	Heavy >2.95
Thick	2	Lauder- dale	Ap	0-17	99.3	0.7
			B22t	46-63	99.0	1.0
			B31t	100-115	97.7	2.3
Intermed.	3	Gibson	Ap	0-20	98.8	1.2
			B22t	40-70	99.3	0.7
			B24t	90-110	99.3	0.7
Thin	5	Carroll	Ap	0-16	99.1	0.9
			B21t	45-62	98.2	1.8
			IIB31t	97-120	99.1	0.9
			IIIC1	175-200	99.1	0.9
Thin	6	Madison	Ap	0-18	98.5	1.5
			B22t	40-55	99.0	1.0
			IIB32t	100-125	97.8	2.2
			IIIC2	200-250	98.1	1.9

CHAPTER V

DISCUSSION

Results of laboratory and field analyses of some soils from thick, intermediate, and thin loess indicate that well-drained upland soils of the loess region in West Tennessee increase in weathering in the direction of thinning loess. Such evidence is in agreement with Wascher (42) that soils developed in Peorian loess greater than 15 feet thick are less weathered than those formed in loess of thicknesses less than 15 feet. Caldwell (2) has also reported from x-ray diffraction studies in southern Indiana that degree of weathering, indicated by the quartz/feldspar ratio of A2 horizons, is more pronounced with distance from the Wabash River.

Memphis and other well-drained Hapludalfs were sampled on gently rolling positions where neither erosion nor accumulation was great. Oak and hickory had been the native vegetation. Thus, with climate, vegetation, and topography relatively uniform, differences in the soils can be related to time and parent material.

I. Color

Some differences in the Hapludalfs are apparent from observations of the solums in place. One of the most detectable distinguishing characteristics is color. The four Memphis profiles located in thick and intermediate loess have moist colors of uniform dark brown (7.5YR4/4) throughout the B horizons. The two Hapludalfs in thin loess

increased in redness with depth from dark brown (7.5YR4/4) in the B2t to red (2.5YR4/6) in the B3t layer. Such differences in colors were at first believed by the author to be related to the amount of iron; however, color changes perhaps relate more to the chemical state than quantity of iron because content of free iron oxides decreased with depth.

Red (2.5YR4/6) color in the B3t horizons of the thin loess soils relates to colors described by Wascher (42). He reported that B horizons of soils developed in Loveland loess are from a yellowish red (5YR5/8) or strong brown (7.5YR5/8) to red (2.5YR4/8). Color of samples from coastal plains material was also red (2.5YR4/8). Wascher reported B horizons in coastal plains to be red (10YR4/6).

II. Physical Properties

Difference in total sand content between soils in thick and thin loess (Figures 5 through 10) is a second property that was easily distinguished in the field. The sharp increase in sand with depth in the shallow loess profiles is due to influence of coastal plains material. Also, similar influences were shown in intermediate loess near 200 cm. According to Wascher (42), where total loess is less than 3 feet in thickness, mixing with coastal plains material has occurred to the extent that differentiation of the loess sheets is impossible. Evidence from the current study suggests that in shallow loess mixing has occurred well into Peorian.

Very fine sand (0.10-0.05) was greater at thick than at

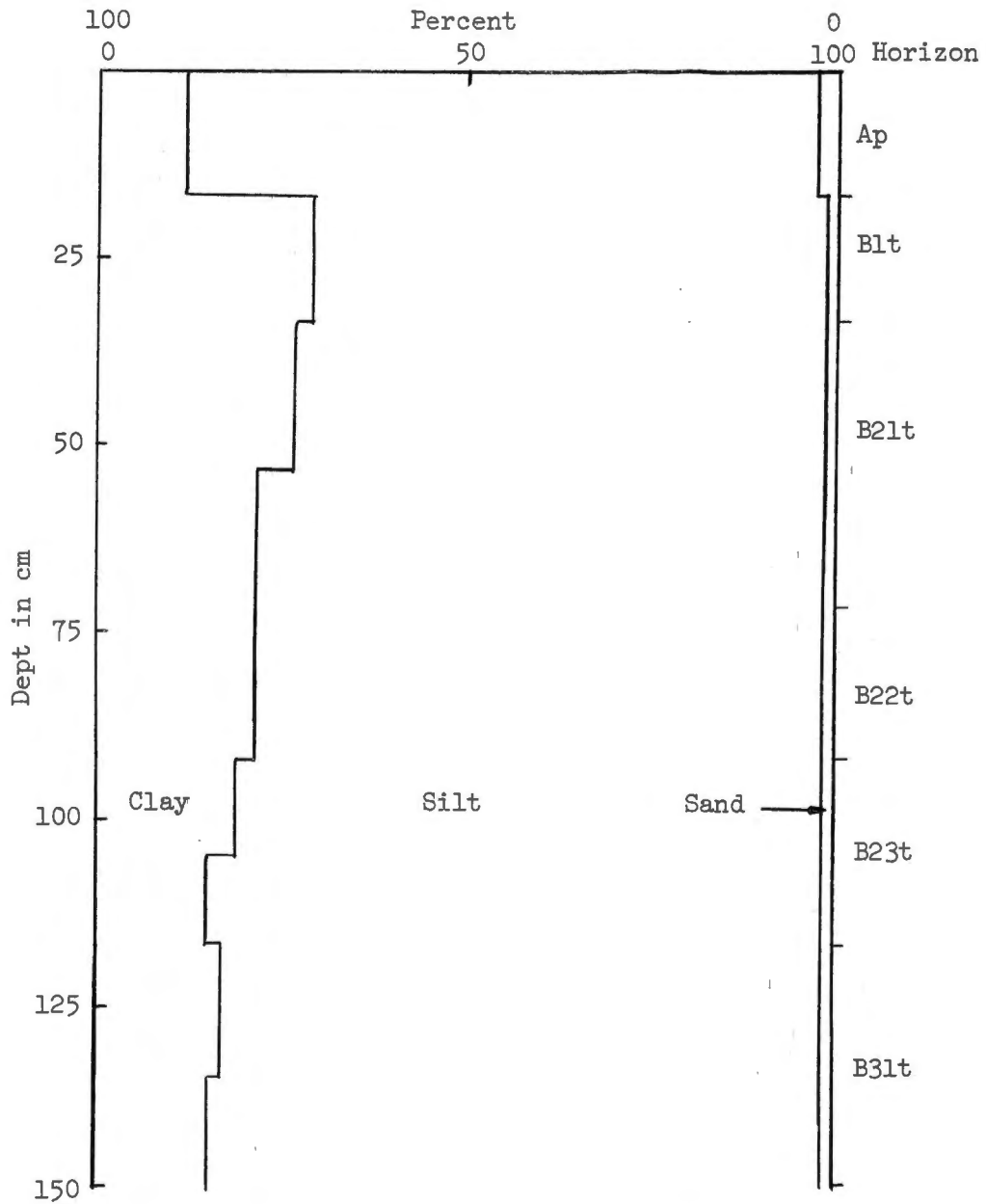


Figure 5. Particle size distribution for site 1 in thick loess in Dyer County, Tennessee.

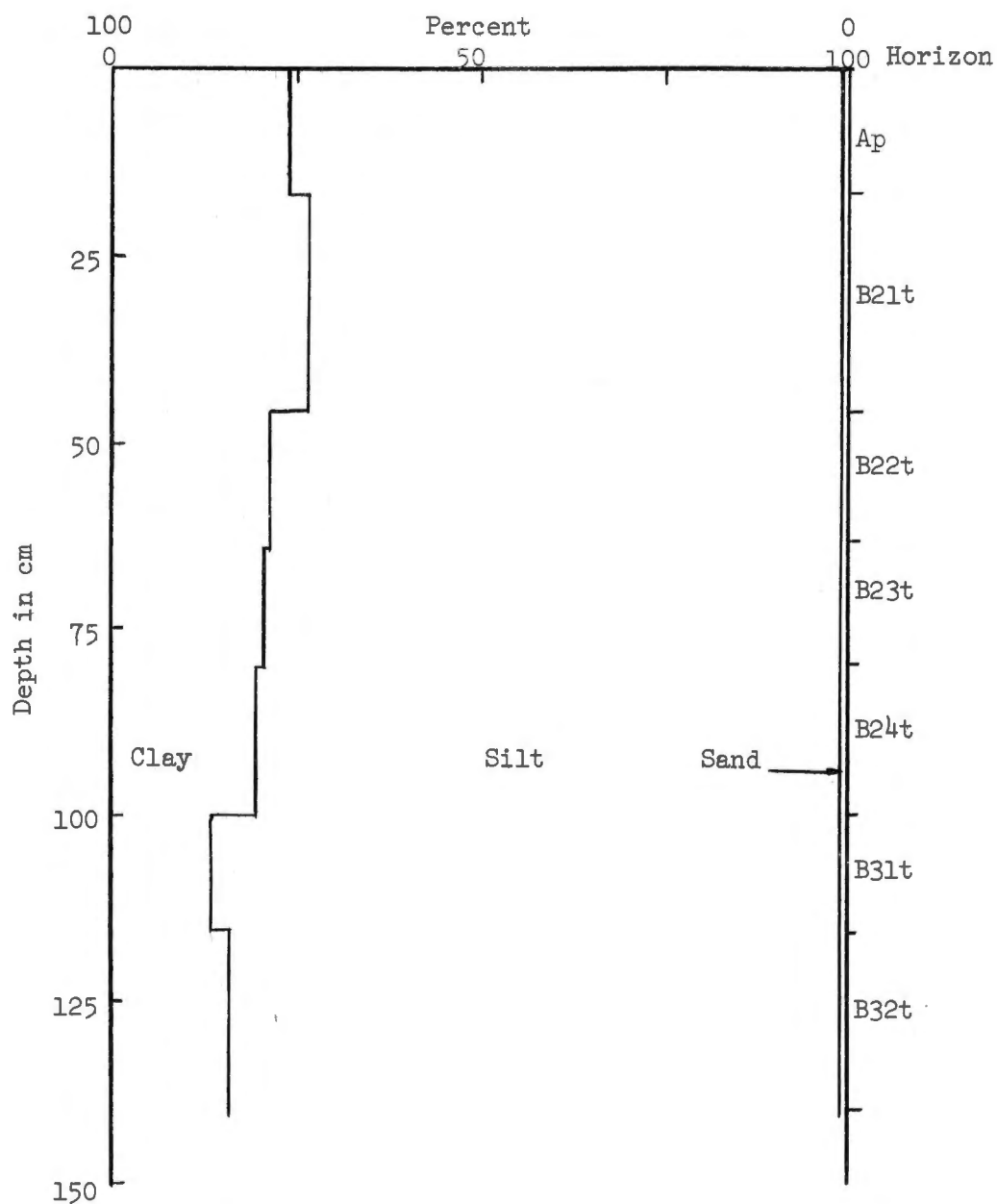


Figure 6. Particle size distribution for site 2 in thick loess in Lauderdale County, Tennessee.

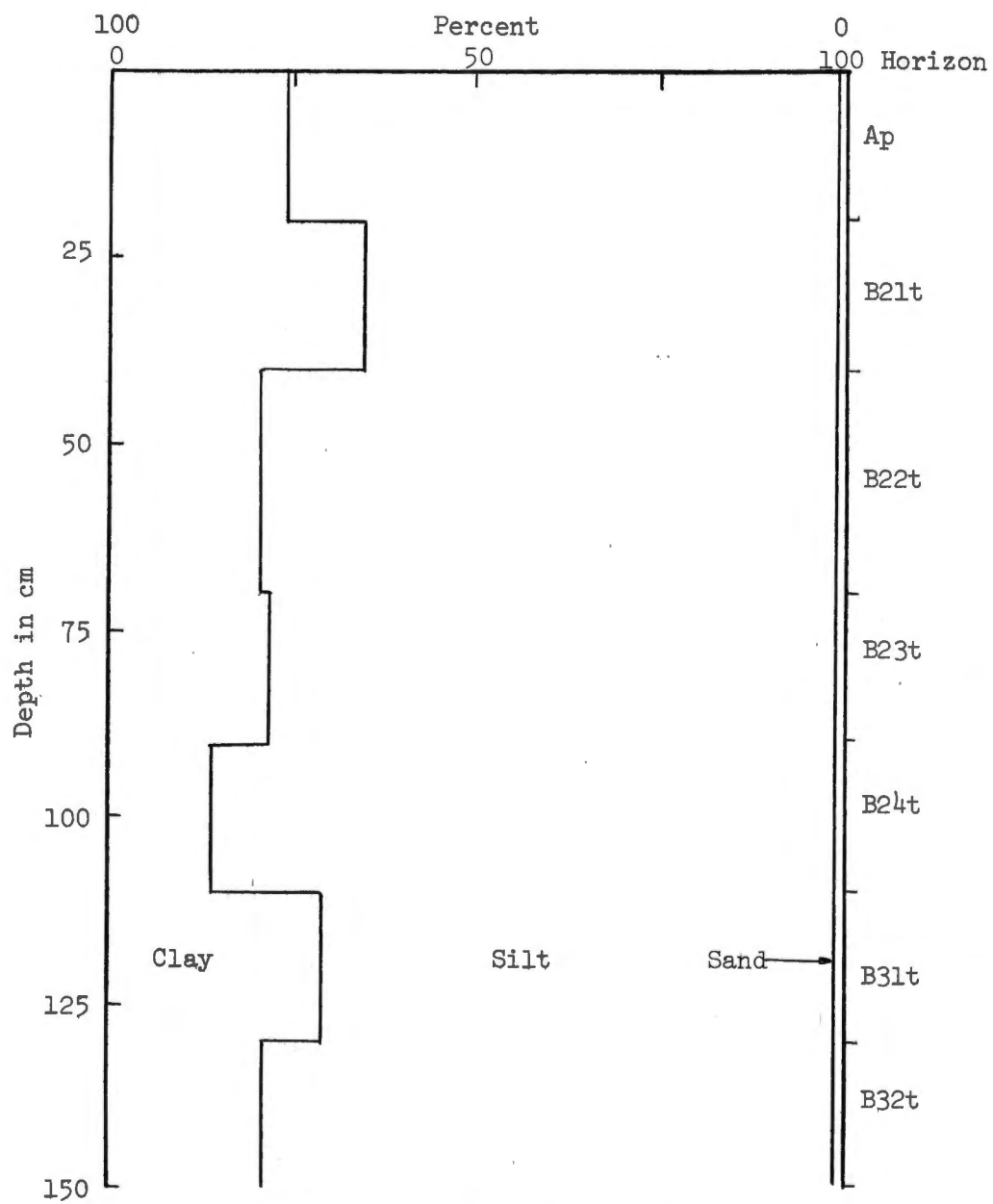


Figure 7. Particle size distribution for site 3 in intermediate loess in Gibson County, Tennessee.

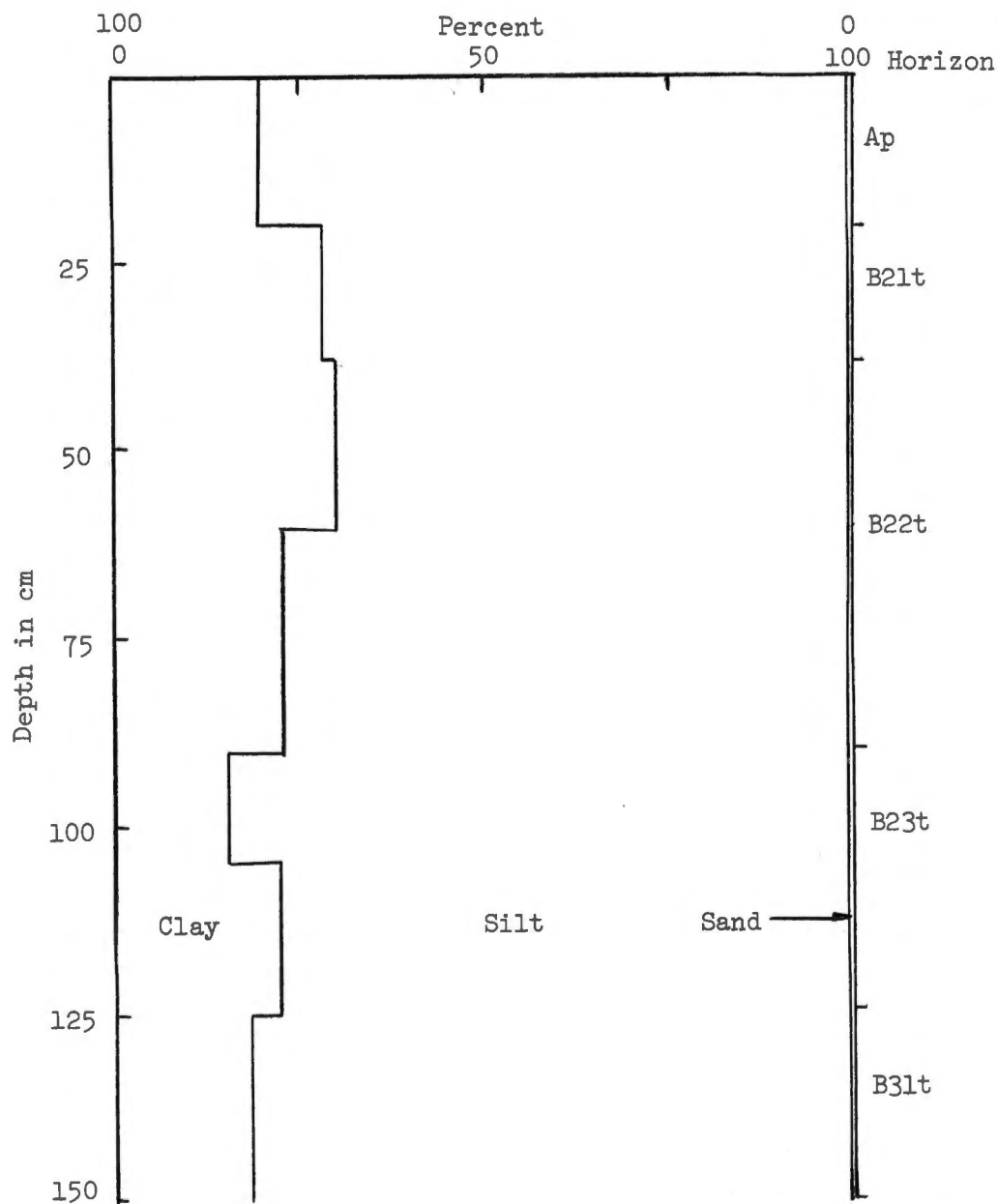


Figure 8. Particle size distribution for site 4 in intermediate loess in Crockett County, Tennessee.

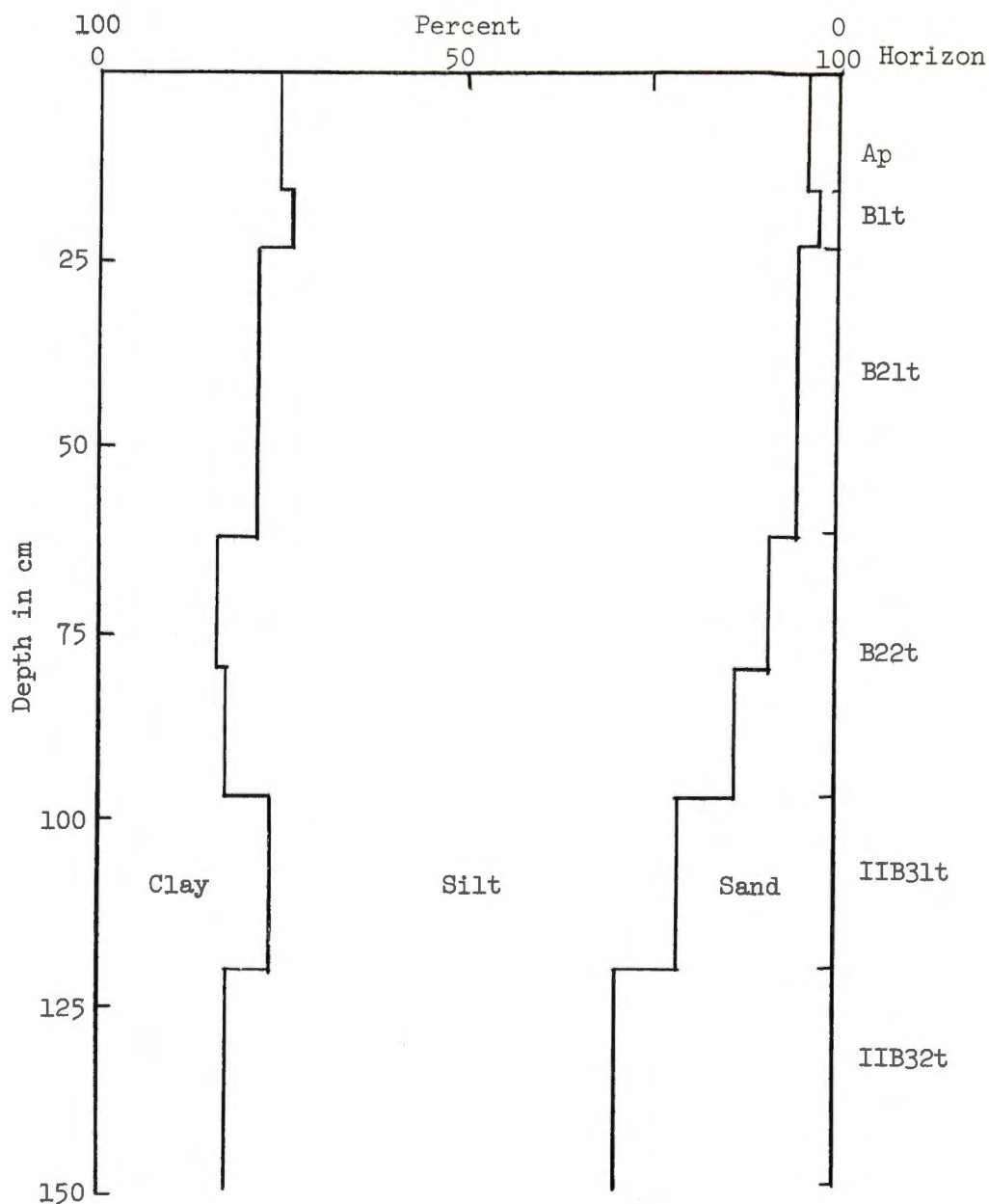


Figure 9. Particle size distribution for site 5 in thin loess in Carroll County, Tennessee.

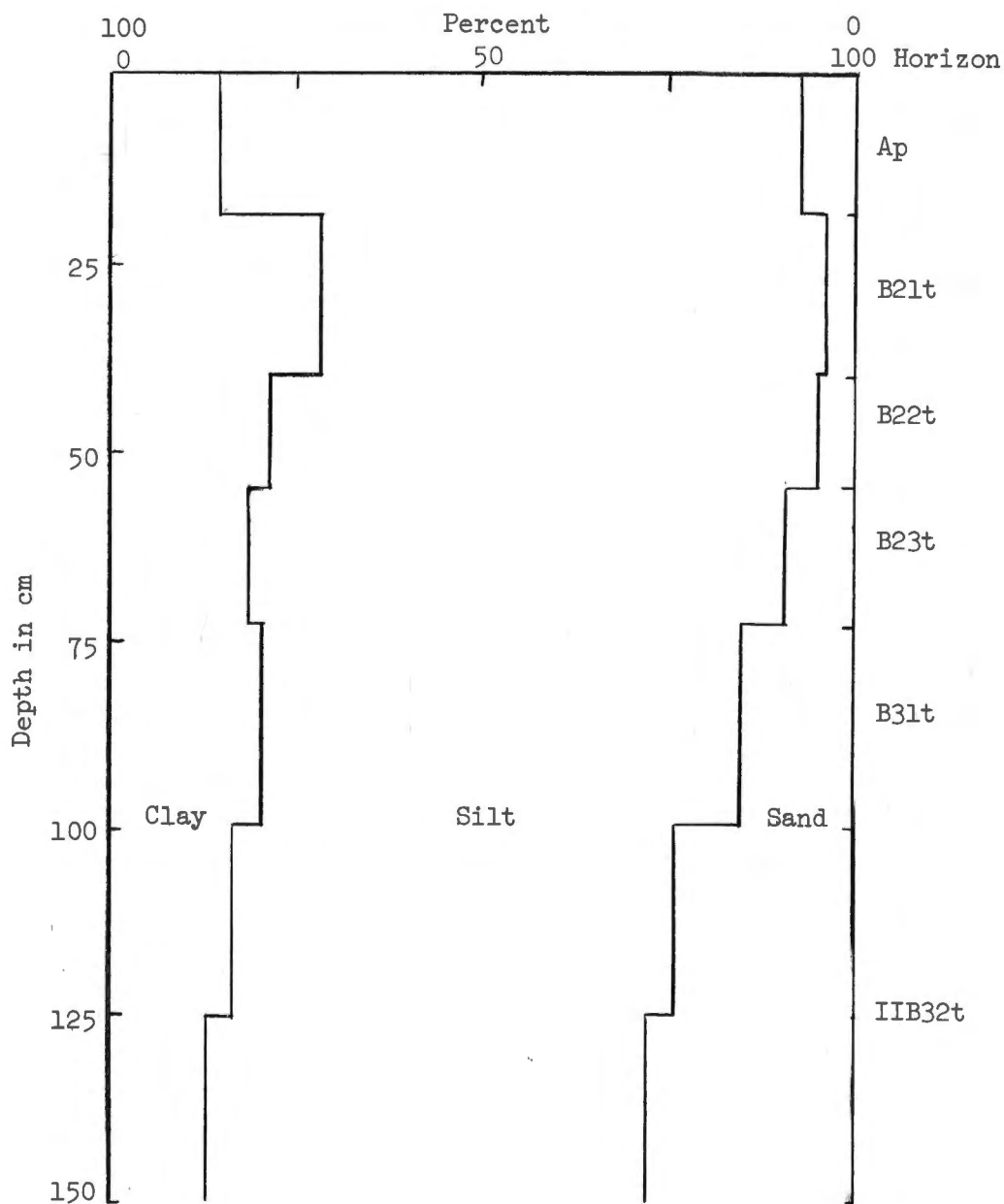


Figure 10. Particle size distribution for site 6 in thin loess in Madison County, Tennessee.

intermediate loess sites. This may be due to deposition of coarser particles, including sand near the bluff. Also, very fine sand was greater than content of coarser sands at intermediate loess sites which further indicates that the finer sand was transported by wind and deposited. There was little coarse (1.0-0.5 mm) and very coarse (2.0-1.0) sand in thick loess sites.

Total sand content showed a steady increase with depth in shallow loess beginning about 40 cm. Medium and coarse fractions accounted for the major increase. Since coarser material is less likely to have been transported by wind this further indicates that sand content is due to mixing of coastal plains material with shallow loess.

Coarse silt/fine silt ratios (Figures 11 through 12) for soils of the three loess regions decreased with an increase in distance from the source area. Average ratios to 50 cm were 1.7 in thick, 1.3 in intermediate, and 1.2 in shallow. Decreases in ratios were more attributable to a decrease in coarse silt than an increase in fine. Thus, it appears that coarse silt decreased rapidly near the bluff, then more slowly after a few miles to the east. Similar findings were reported by Smith (34) in Illinois where he established a linear relationship between particle size and the logarithm of the distance in miles from the bluff.

A decrease in clay content and a simultaneous increase in silt as depicted in Figures 7 and 8, pages 48 and 49, were prominent near 90 cm in intermediate loess. A less noticeable break occurred near 100 cm at site 2 in thick loess. Subsequent clay increases occurred

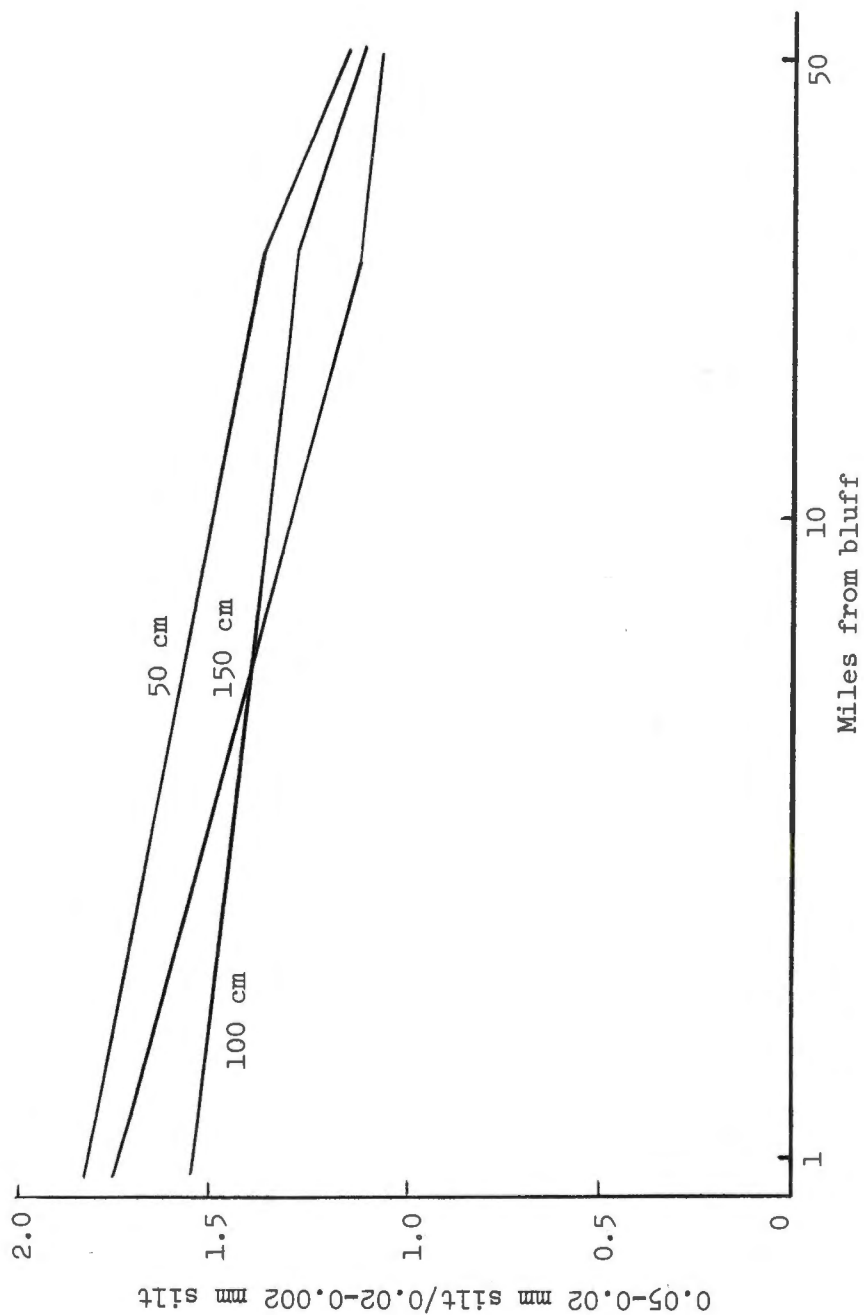


Figure 11. Relationship of silt size to distance from the bluff of the 0-50, 50-100, and 100-150 cm layers of soils of West Tennessee (north transect).

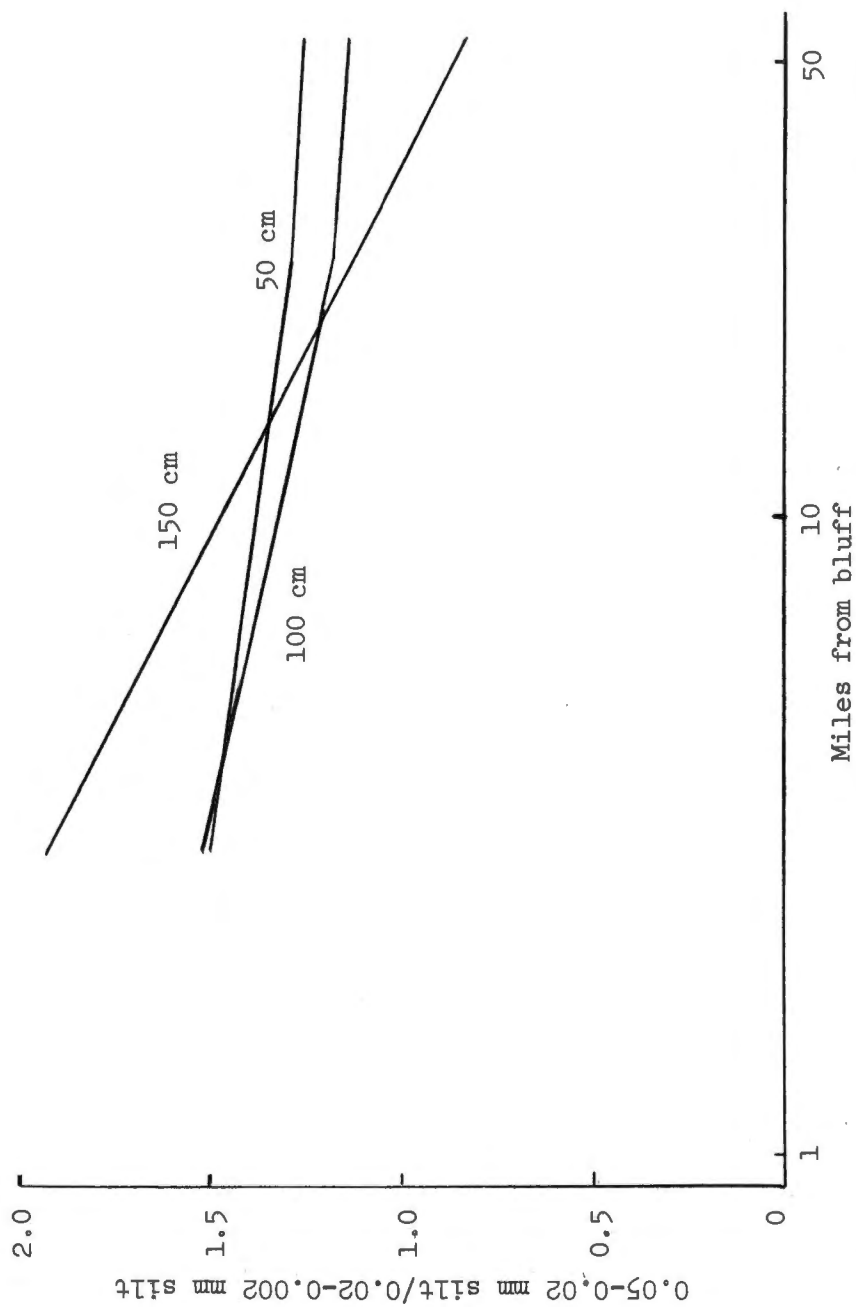


Figure 12. Relationship of silt size to distance from the bluff of the 0-50, 50-100, and 100-150 cm layers of soils of West Tennessee (south transect).

near 105 cm at sites in intermediate loess and at 115 cm at site 2 in thick loess. Such breaks probably occurred in conjunction with one of the intervals between Peorian loess deposition postulated by Simonson and Hutton (32). They reported that the Peorian formation consists of more than one loess sheet.

Percent moisture retention at 1/3 and 15-bars tension followed percent clay and fine silt at all sites. Where a decrease in only fine silt or clay was shown, weight percent water remained fairly constant; however, where both fine silt and clay decreased, a proportional decrease in weight percent water was evident. A slight decrease in weight percent moisture retention at both 1/3 and 15-bars tension occurred at thin loess sites as well as with depth in each of the six profiles. Moisture values agreed in general with those of Longwell, Parks, and Springer (22).

Bulk density values were similar in the thick and intermediate loess areas. Nevertheless, an expected increase was detectable at lower depths of profiles in thin loess which contained significantly more sand. Similar findings reported by Grossman et al. (11) have been associated with increases in sand content.

III. Chemical Properties

In general, CEC per 100 g soil decreased with decreasing loess thickness. Ratios of CEC/percent clay were calculated at 50, 100, and 150 cm depths at the two sites in each of the three loess regions (Figure 13). Thus, the capacity for a gram of clay to exchange cations

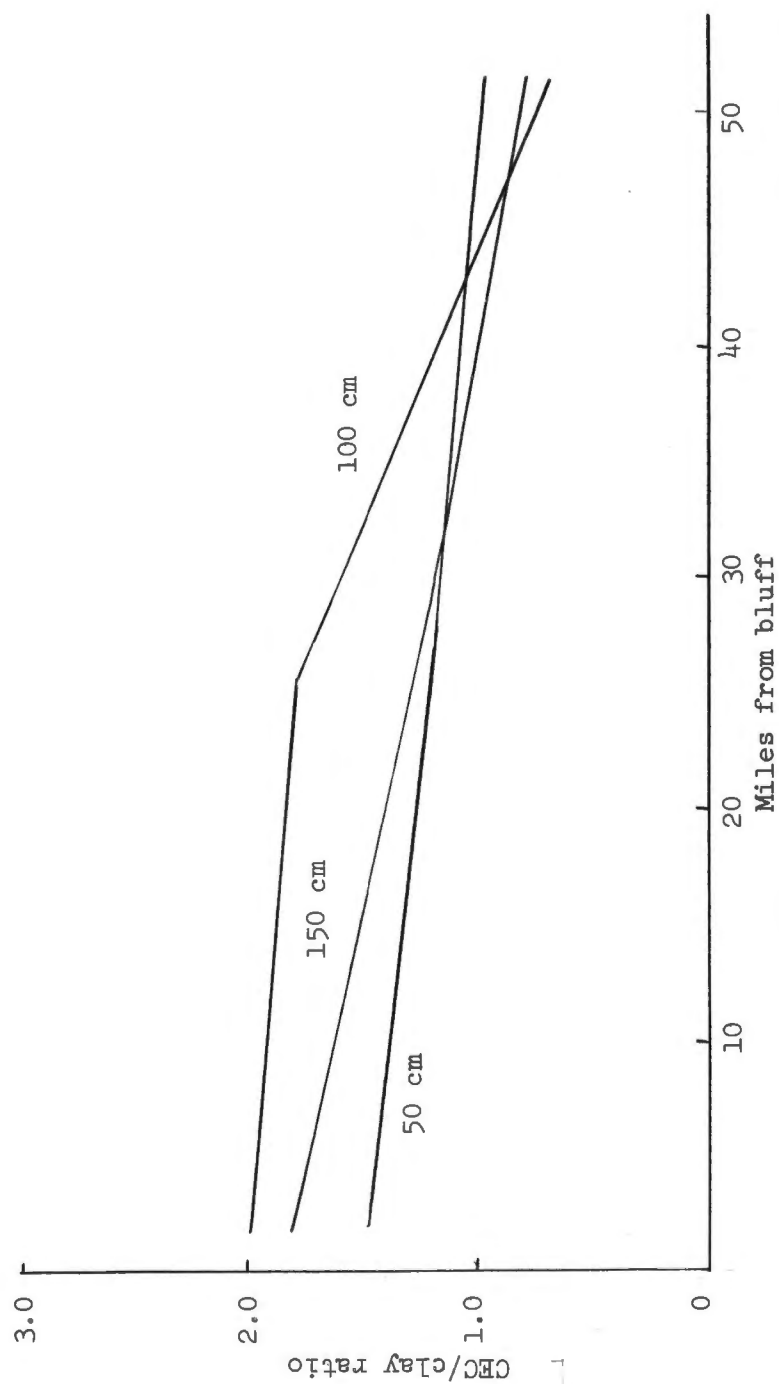


Figure 13. Relation of CEC in meq per g of clay at depths of 50, 100, and 150 cm to distance from the bluff (north transect).

decreased in the same direction. These ratios indicate that clays with low exchange capacities such as kaolinite are more prevalent in soils in thin loess than soils in thick. This is due to mixing of parent materials which has incorporated low exchange capacity clays from old coastal plains and Loveland B horizons.

Hutton (14) reported from Iowa that soils farthest from the loess source were most weathered. Such results indicate that clays of lower exchange capacities, e.g., kaolinite, are more prevalent in soils from thin loess than in thick. From a study in Illinois and Indiana Fehrenbacher (4) reported that Farmdale and Loveland loess were lower in illite, equal to or slightly higher in expandable minerals, and somewhat higher in chlorite and kaolinite than overlying calcareous Peorian. This, plus the mixing of underlying material that has occurred in thin loess, is evidence that the clays at sites in shallow loess are probably more weathered than those of sites in thicker loess.

Although there were no appreciable differences in Na and exchangeable acidity at the six sites, K, P, and Ca did show significant variations. Calcium ranged from roughly 12 meq per 100 g soil in thick loess to about 3 meq in thin. While there was only a slight decrease of exchangeable K towards thinner loess, a more noticeable decrease occurred in extractable K. Caldwell and White (2) reported a decrease in total Ca and K with an increase in distance from the source area of loess in southern Indiana. Magnesium was relatively uniform at sites 1, 2, 4, and 5, but was about one-half as much at sites 3 and 6.

Calcium/magnesium decreased from slightly more than 2.0 at thick

loess sites to less than 1.0 at sites in thin (Figure 14). At both thin loess sites, ratios were smaller below 100 cm than in the upper layers. Calcium/magnesium in thick loess solums were rather uniform throughout. Ratios in intermediate loess soils showed a general increase with depth in Gibson County but a decrease near 105 cm in Crockett County. According to Grossman et al. (11) such decreases are indicative of the relative amount of weathering that soils have undergone, with smaller ratios representing greater amounts of weathering.

Extractable P decreased southeastward across the transects. Values for the north transect are presented in Figure 15. This agrees with Rice (27) who found from 39 Memphis profiles that extractable P decreased as loess thickness decreased. Godfrey and Riecken (9) reported similar results. According to Rice such findings indicate that all Memphis soils were formed in loess of similar properties when first deposited, but due to differences in thickness of loess and weathering rates, Memphis developed in loess at greater distances from the source area appears to be more weathered.

Percent base saturation of soils along the south transect showed some decrease with decrease in loess thickness (Figure 16). Base saturation of soils along the north transect were about constant across all loess thicknesses (Figure 17). Since exchangeable acidity was rather uniform at all sites, a lower base saturation was due primarily to the decline of the exchangeable bases. The fewest bases were in Madison County in thin loess where a marked decrease occurred

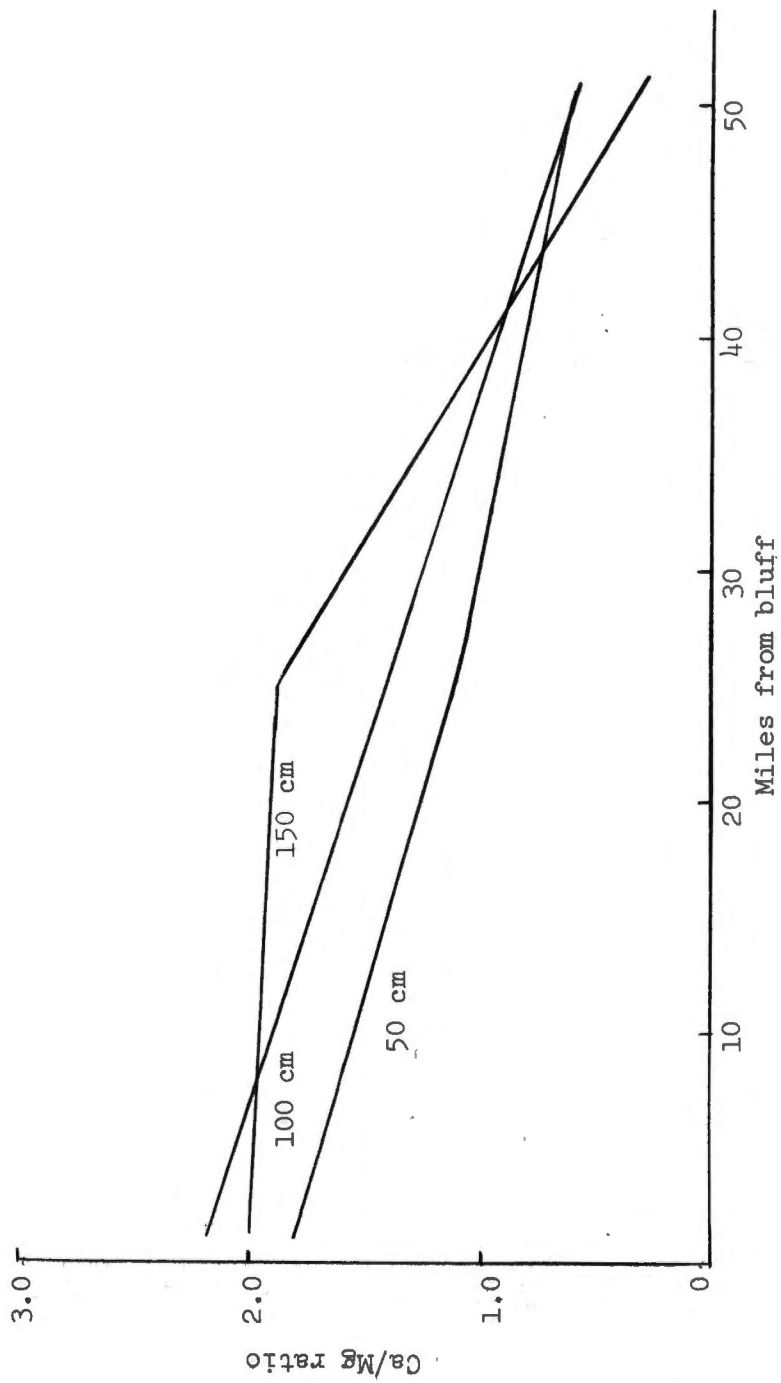


Figure 14. Relation of exchangeable Ca/Mg at depths of 50, 100, and 150 cm to distance from the bluff (north transect).

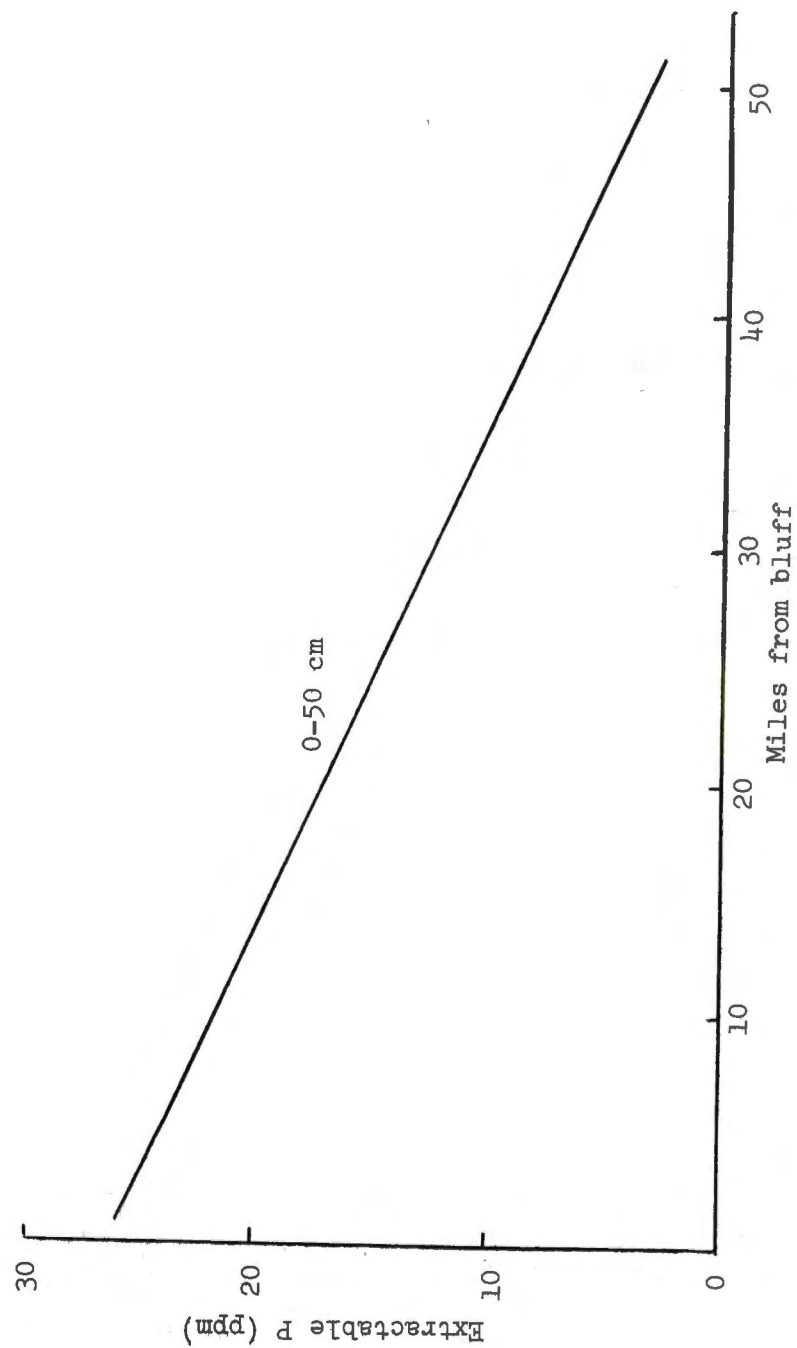


Figure 15. Relationship of extractable phosphorus in the upper 50 cm to distance from bluff (north transect).

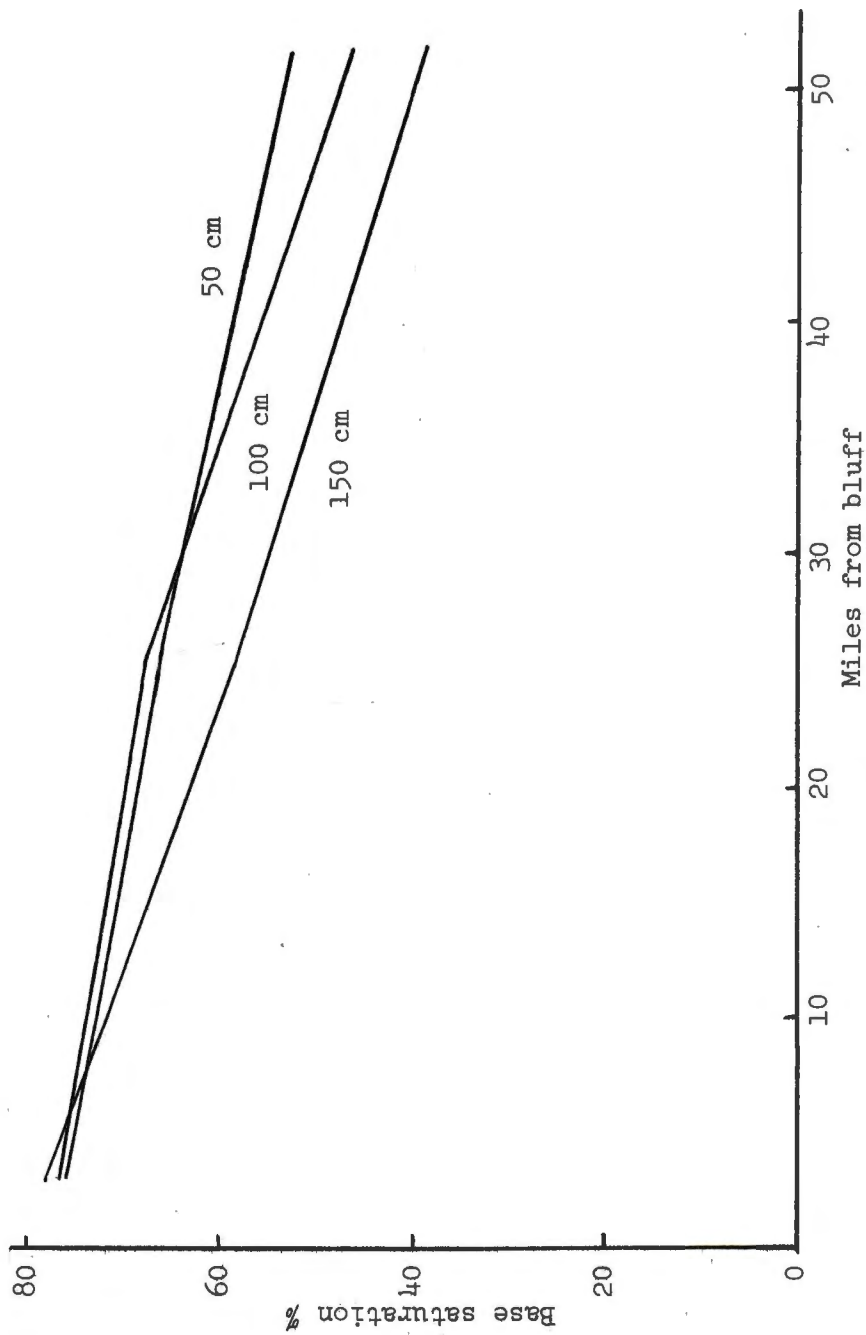


Figure 16. Relation of base saturation at depths of 50, 100, and 150 cm to distance from the bluff (south transect).

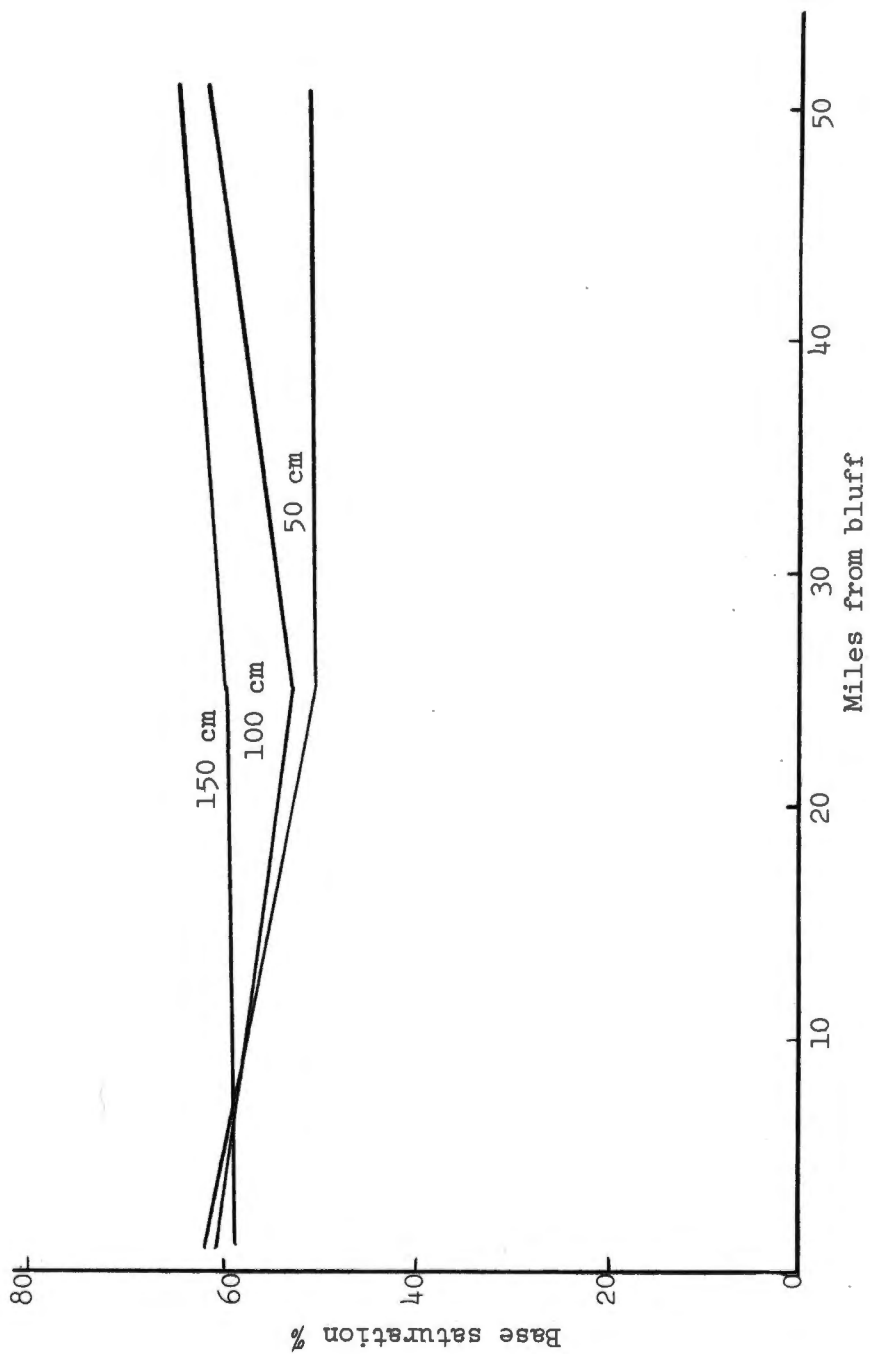


Figure 17. Relation of base saturation at depths of 50, 100, and 150 cm to distance from the bluff (north transect).

at 100 cm. Decreases in base saturation with increases in distance from the source area have also been reported by Smith (34) in Illinois and Hutton (13) in Iowa.

Free iron oxides followed percent clay rather than color. Maximum accumulations were in horizons of highest clay concentrations. Sutton (37) also noted that free iron occurred in conjunction with clay content. Relationship between free iron and clay content was not so close in thick and intermediate as in shallow loess. However, only limited determinations were made from the two thicker areas and no apparent explanation of the differences can be offered.

Four pH readings were determined on each of the 54 samples although only three have been reported. Readings made on moist soils were discarded because of apparent mechanical error. The determinations on 1:1 ratios of water to air-dried samples indicated the soils to be strongly to medium acid with readings from 5.0 to 6.0. Readings in normal KCl at a 1:2.5 ratio averaged from 1.0 to 1.5 pH units lower. According to Puri (25), a decrease in pH by the addition of a salt is expected although the magnitude of the decrease is not always predictable. Difference in readings on a 1:1 water suspension of dry soil at the Soil Testing Laboratory in Nashville averaged about 0.4 of a unit lower than those determined in Knoxville. Why such differences occurred is not evident. In general there were no large differences in pH at any of the six sites although considerably higher readings in the Ap layers at sites 3 and 6 were due perhaps to past liming.

Determinations of soil pH in normal KCl were made to give some indication as to the relative types of clay minerals present. Usually, pH values rise with an increase in base saturation. However, at site 6 in thin loess, base saturation decreased with no apparent decrease in pH. Since dilution was held constant and a salt solution was used to eliminate interference of soluble salts, lack of a difference in pH values indicated a difference in type of clay minerals. Given two soils with the same pH and different base saturation, the soil with the lower base saturation might be expected to have a smaller CEC in order to supply approximate quantities of hydrogen ions. Determinations on soil 6 supported this hypothesis. Thus the smaller CEC might indicate an admixture of some clay such as kaolinite.

IV. Mineralogy

Only limited data were collected on mineralogy, and no statement can be made. However, with the exception of the B3lt horizon at site 2 in thick loess, the two thin loess sites possessed the lowest light mineral/heavy mineral ratios at 50 and 100 cm. According to Wascher (42), heavy minerals include zircon, tourmaline, garnet, hornblende, rutile, epidote, and others. Light minerals include the feldspars, quartz, and all micas with specific gravities less than 2.95.

Wascher et al. (42) presented evidence to show that Peorian loess contains more weatherable feldspars, micas, and heavy minerals than the older loess sheets. Since, in soils from shallow loess, mixing

has occurred to a considerable extent, easily weatherable feldspar minerals might be expected to be less than in thick due to the dilution effect by more weathered material from below. Although the presence and distribution of bases in a soil give some indication of the minerals present, such relations are only approximate and actual mineral determinations are needed.

V. Morphology

One of the interesting morphological properties of the soils was difference in structure from thick loess to thin. Profiles in thick loess had weak coarse prismatic structure beginning about 20 cm and continuing to the bottom of the pit. In intermediate loess, medium size prisms began immediately below the Ap and continued to near 100 cm before giving way to prisms of coarse size. In thin loess prismatic structure was absent to near 100 cm where coarse prisms began and continued to 150 cm. In general such differences in structure are indicative of the relative amount of weathering that has occurred; however, such generalizations must be made with caution. In thin loess sites, prismatic structure is only at depths that correspond to what is believed to be soils from Loveland loess. This is considered the most highly weathered of the three loess layers, and no relevant explanation of prismatic structure in this material is presented. Absence of prisms in the tops of the profiles in shallow loess is perhaps the result of a longer period of weathering or soil formation than in the top 100 cm of soils in thick and intermediate

loess, combined with the destructive effects on structure by mixing.

Pale brown to gray silt coatings and black manganese stains were prevalent in all profiles at various depths. Black stains generally appeared near 20 cm, while silt coatings ranged from 46 to 125 cm. Clay films in the B horizons ranged from few to common at all sites; however, they were less common below 120 cm at thick loess sites than at the remaining four where they were still common at 150 cm.

In light of field and laboratory analyses, soils in intermediate loess appeared more like the neighboring soils in thick than in thin. Too, intermediate soils were not uniform in properties. Site 3 in Carroll County appeared to be more weathered than site 4 in Crockett County as shown by lower CEC, base saturation, and Ca/Mg ratios.

VI. Time and Parent Material

To conclude that the soils in thin loess are more weathered than those in thick implies that soil forming factors differed from one area to another. Considering climatic and vegetational data and that all sites were located on similar convex slopes, the three soil forming factors--climate, organisms, and topography--remained uniform throughout the six sites. Thus time and parent material are the two factors to consider in evaluating differences in properties related to loess thickness.

Although a break was evident at 90 cm in intermediate soils, parent material was relatively uniform, except for particle size and

thickness, throughout the intermediate and thick loess sites (Figure 18). However, soils in intermediate loess have formed in finer textured parent material than those in thick loess as indicated by smaller coarse silt/fine silt ratios.

Parent material at thin loess sites varies with depth (Figures 19-20). Sand content increases with distance from the surface. This increase in sand is due to apparent mixing of the loess layers with underlying coastal plains sediments. These mixed conditions have resulted through the action of tree-fall, burrowing animals, freezing and thawing, wind, and other factors. Mixing and contamination has occurred throughout formation of the soils. Initially Loveland loess was deposited on soils formed in coastal plains. After thousands of years of mixing and soil formation, Farmdale loess was deposited. After slight soil formation in Farmdale, Peorian loess was deposited and mixing then occurred between it and the underlying soils. Thus, the combination of these mixed layers constitutes the parent material from which the present soils formed.

Thickness of loess sheets as calculated from mixed and unmixed loess are shown in Figure 21. Determinations for actual loess thickness of each loess layer were made by calculating cumulative volume percentages. Values representing only total Wisconsin loess, which includes Peorian and Farmdale, were about 50 cm. Loveland loess was calculated to be near 70 cm. Thus, the parent material for soils formed in 150 cm of mixed loess was by volume about 50 cm Wisconsin loess, 70 cm Loveland loess, and the remaining 30 cm was coastal plain material that had been mixed with the loess sheets.

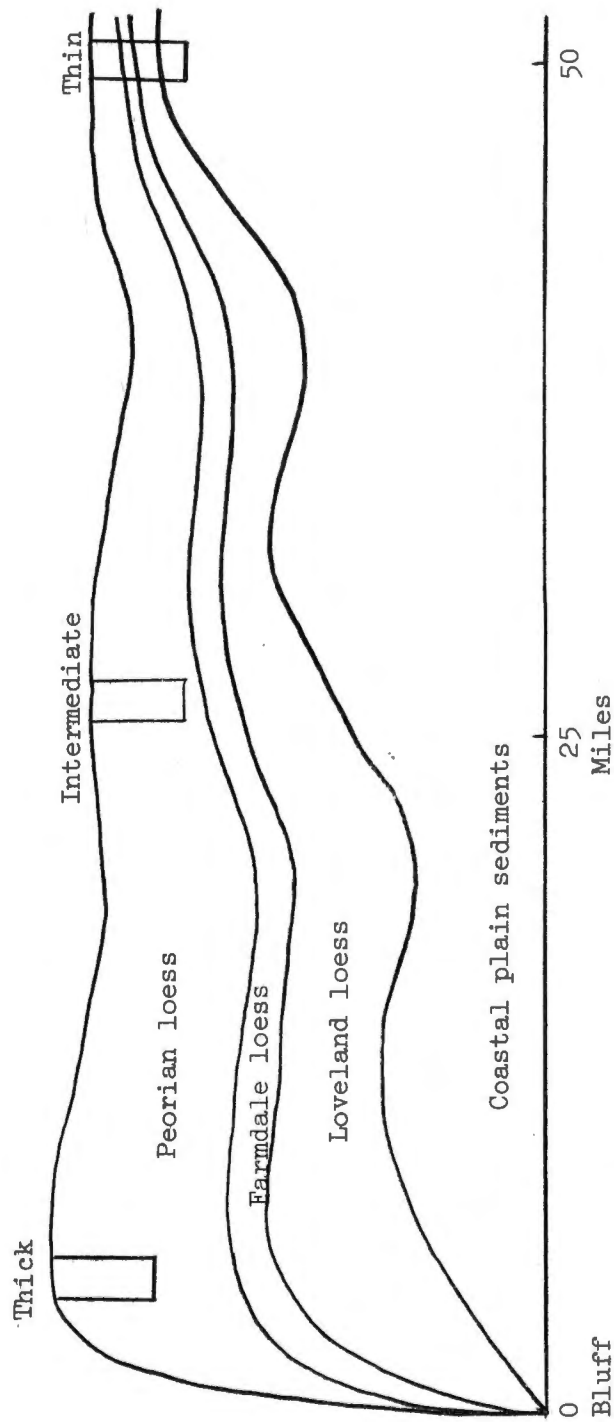


Figure 18. Sketch of sites and hypothetical parent material in thick, intermediate, and thin loess in West Tennessee.

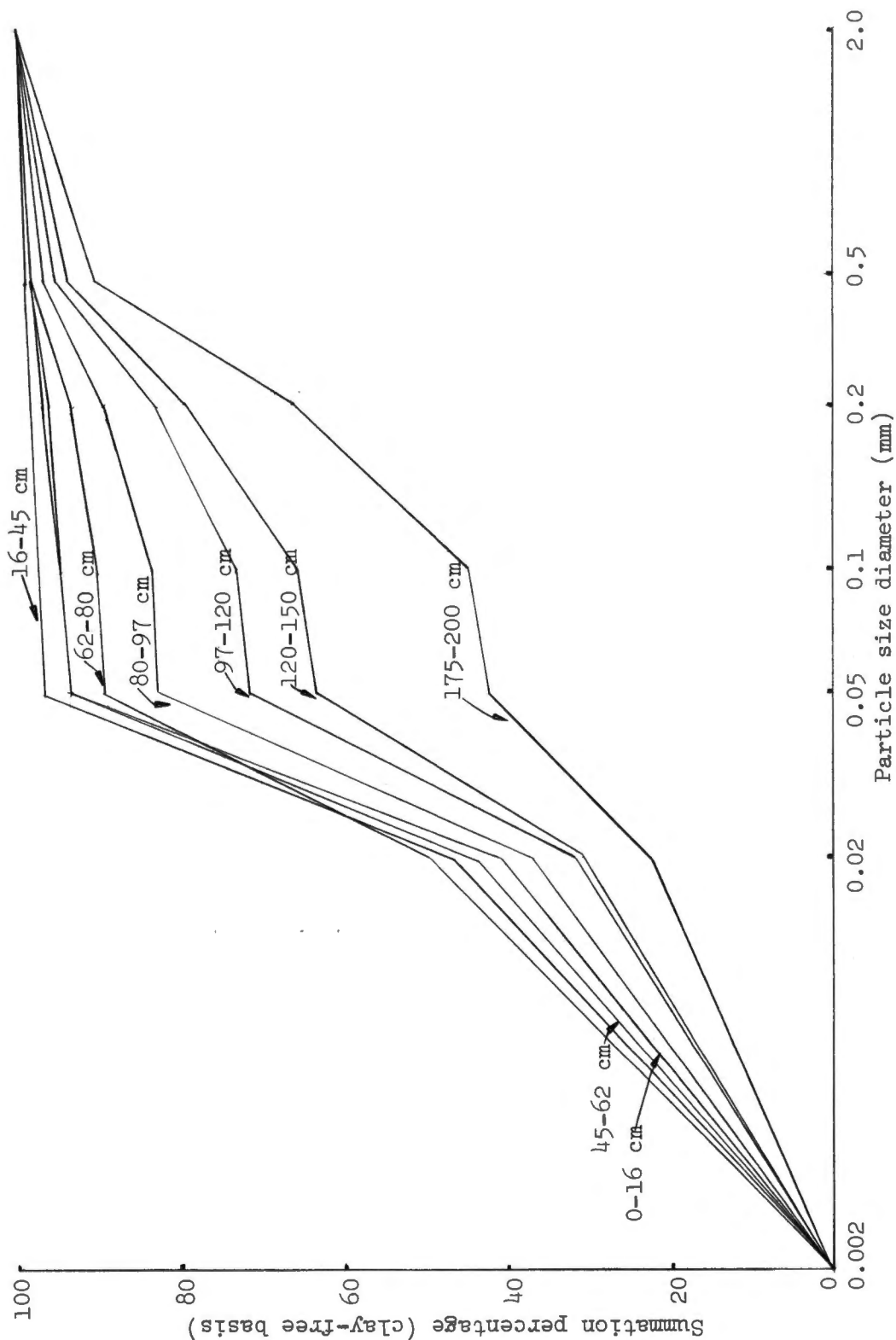


Figure 19. Summation percentages of silt and sand sized particles in horizons of a Typic Hapludalf in Carroll County, Tennessee (soil 5).

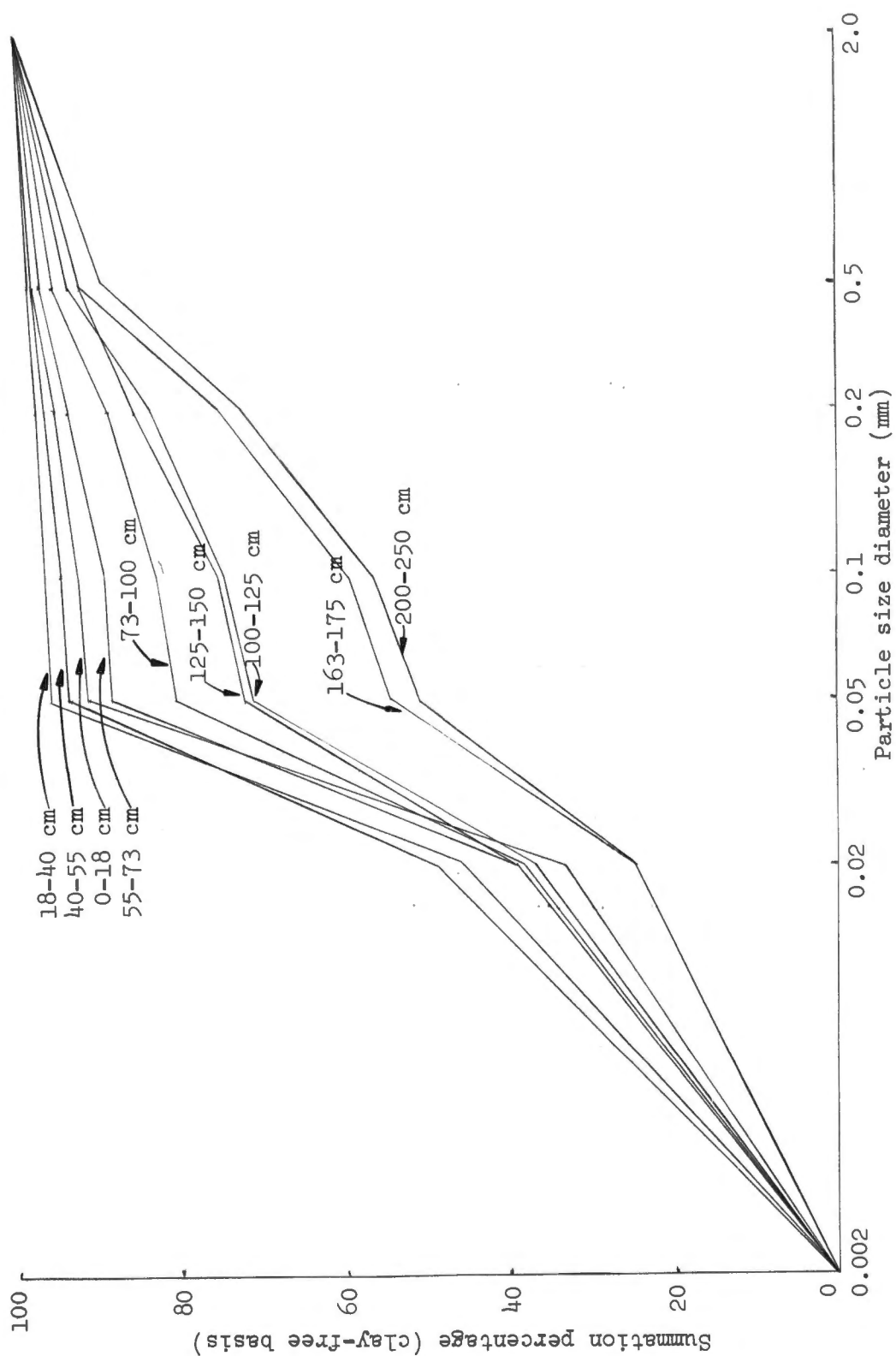


Figure 20. Summation percentages of silt and sand sized particles in horizons of a Lexington silt loam in Madison County, Tennessee (soil 6).

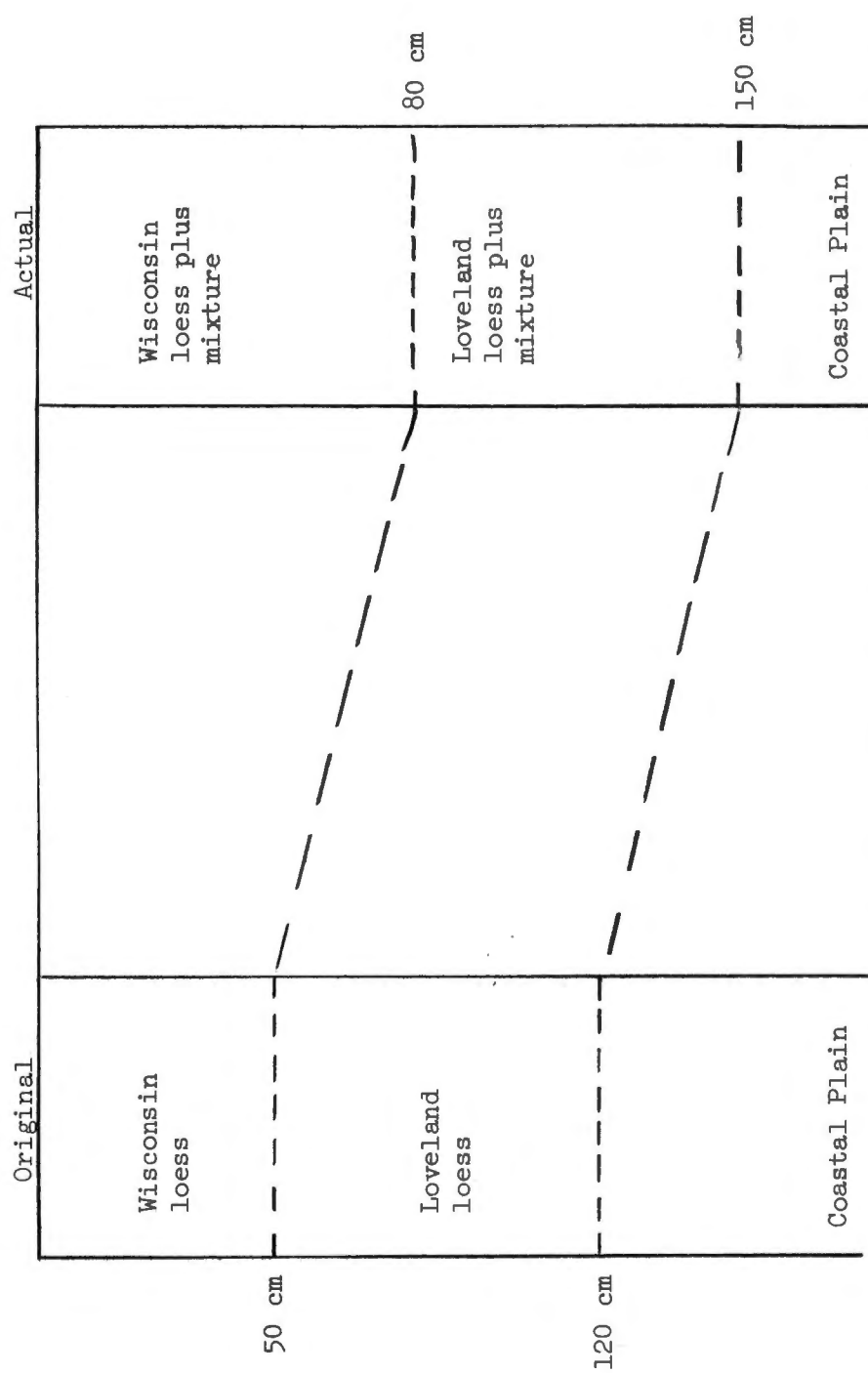


Figure 21. Hypothetical diagram of parent material of soils in the thin loess area of West Tennessee.

In Illinois (34), coarser material decreased and finer material increased with distance from the source. Thus, with other things equal, weathering would progress faster in the finer material because greater surface area permitted more exposure to weathering elements.

VII. Classification

Although classification and correlation was relatively simple for five of the soils, the sixth presented some difficulty. All six soils had ochric epipedons and argillic B horizons. Sites 1, 2, 3, 4, and 5 are classified as Typic Hapludalfs. These soils have base saturation by sum of cations greater than 60 percent at a depth of 125 cm below the top of the argillic (see Appendix). Site 6 is an Ultic Hapludalf which is like Typic except base saturation is less than 60 percent at a depth of 125 cm below the top of the argillic. All six soils are members of fine-silty, mixed, thermic families.

Soils 1 through 4 belong to the Memphis series which has a sand content of less than 5 percent within 120 cm of the surface. The soil at site 6 is a member of the Lexington series and has a sand content greater than 15 percent within 120 cm of the surface. Soil 5 does not fit into the Memphis series because sand is greater than 5 percent within 120 cm of the surface and could not be placed in Lexington because base saturation was barely greater than 60 percent at a depth of 125 cm below the top of the argillic. Therefore, the soil could be classified as a fine-silty, mixed, thermic Typic Hapludalf, but a series of classification is lacking. The soil is more

like Lexington than Memphis. Not only was sand content similar to Lexington, but the Ca/Mg ratio was less than 1. Also, soils 5 and 6 were quite similar in Ca, P, pH, and free iron oxides although site 5 was somewhat higher in K, Na, and Mg as well as base saturation. There was no appreciable difference in exchangeable acidity, and physical and morphological properties. If further work establishes that most soils in thin loess have base saturations greater than 60 percent at 125 cm below the top of the argillic horizon, then site 5 may be considered a taxadjunct of Lexington.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Field and laboratory studies were conducted on six Hapludalfs from the loess region of West Tennessee to determine some properties of the soils at various distances from the source area. Pedons were described and sampled along two transects with each transect containing a pedon from the thick, intermediate, and thin loess areas. Differences in soil properties were related to the soil forming factors, time and parent material.

Soils differed with increasing distance from the source as shown by physical, chemical, and morphological properties. Soils in thin loess were redder in color below 100 cm; contained less exchangeable Ca, K and extractable P; were lower in CEC; had small Ca/Mg and coarse silt/fine silt ratios; and contained more sand. While percent base saturation along the south transect decreased from the upper seventies at site 2 in thick loess to below 50 at site 6 in thin loess, there was no significant change in base saturation of the soils along the north transect.

Soils in thick and intermediate loess have formed from Peorian. However, noticeable breaks in the coarse silt/fine silt ratios of profiles in intermediate loess indicate that Peorian deposition was not one continuous and uniform process but was interrupted by some stage of geological activity. Soils in thin loess are polygenetic and formed

from Wisconsin loess, which is composed of both Farmdale and Peorian, and an old underlying soil developed in Loveland loess. Parent material of approximately the top 80 cm of the soils in thin loess is mainly Wisconsin. From 80 to 100 cm is a blend of Wisconsin loess and an underlying soil in Loveland loess. Between 100 and 150 cm parent material was mainly Loveland loess with some admixture of an underlying old coastal plain soil. Original thickness of Wisconsin and Loveland loess were approximately 50 and 70 cm. Thus, soils in thin loess have formed during a longer period of time and from different parent material than the soils in thick and intermediate loess. While formation of exposed soils has been occurring in the thick and intermediate loess only since the Peorian deposits, formation in thin loess soils has been proceeding between loess intervals, and perhaps during deposition, since deposition of Loveland loess. Therefore, soils in thin loess have been influenced by more than one stage of weathering.

Particle size distribution revealed that sand content increased rather rapidly with depth in the soils of thin loess. Such increases are due to mixing of loess with sandy coastal plains soils by tree-fall, burrowing animals, freezing and thawing, wind, and other factors. It is postulated that initial mixing occurred between an old soil from coastal plains and Loveland loess, with subsequent mixing occurring between the soil in Loveland and Wisconsin loess.

All of the six soils are Hapludalfs possessing ochric epipedons, argillic B horizons, and base saturation greater than 35 percent. The four soils in Peorian loess are Typic Hapludalfs belonging to the

Memphis series. The Madison County soil in thin loess is an Ultic Hapludalf and is a member of the Lexington series. The second soil in thin loess in Carroll County is a Typic Hapludalf; however, it does not belong in the Memphis series because sand content is greater than 5 percent within 125 cm. It cannot be placed in the Lexington series because base saturation is 60 percent at 125 cm below the top of the argillic. Therefore, if further work in thin loess establishes that at 125 cm below the top of the argillic most base saturations are less than 60 percent, this pedon can be considered a taxadjunt of Lexington. With the exception of base saturation, the two soils in thin loess are similar.

LITERATURE CITED

LITERATURE CITED

1. Brown, William T. and others. 1965. Soil survey of Dyer County, Tennessee. U.S. Government Printing Office, Washington, D.C.
2. Caldwell, R. E. and J. L. White. 1956. A study of the origin and distribution of loess in Southern Indiana. Soil Sci. Soc. Amer. Proc. 20:258-263.
3. Ehrlich, W. A., H. M. Rice, and J. H. Ellis. 1967. Influence of the composition of parent materials on soil formation in Manitoba. Selected papers in soil formation and classification. SSA, Inc. Pp. 228-244.
4. Fehrenbacher, J. B. 1965. Loess composition in Southeastern Illinois and Southwestern Indiana. Soil Sci. Soc. Amer. Proc. 29:572-579.
5. Flint, R. F. 1963. Status of the Pleistocene Wisconsin stage in Central North America. Science 139:402-404.
6. Flowers, Robbie L. and others. 1960. Soil survey of Henderson County, Tennessee. U.S. Government Printing Office, Washington, D.C.
7. Frye, J. C., H. B. William, and R. G. Black. 1966. Outline of glacial geology of Illinois and Wisconsin: The Quaternary of the United States. Princeton University Press. Princeton.
8. Gass, C. R. 1961. The influence of parent materials upon the formation and morphology of some soils of the Highland Rim and Brotherton Bench in Putnam County, Tennessee. Unpublished Master's thesis. The University of Tennessee, Knoxville.
9. Godfrey, C. L. and F. F. Riecken. 1954. Distribution of phosphorus in some genetically related loess-derived soils. Soil Sci. Soc. Amer. Proc. 18:80-84.
10. Graham, E. R. 1949. The plagioclase feldspars as an index to soil weathering. Soil Sci. Soc. Amer. Proc. 13:300-302.
11. Grossman, R. B., J. B. Fehrenbacher, and A. H. Beavers. 1959. Fragipan soils of Illinois: I. General characteristics and field relationships of Hosmer silt loam. Soil Sci. Soc. Amer. Proc. 23:55-59.

12. Haseman, J. F. and C. E. Marshall. 1954. The use of heavy minerals in the studies of the origin and development of soils. University of Missouri Agr. Exp. Sta. Research Bulletin 387.
13. Hutton, Curtis E. 1947. Studies of loess-derived soils in Southwestern Iowa. Soil Sci. Soc. Amer. Proc. 12:425-431.
14. Hutton, Curtis E. 1950. Studies of the chemical and physical characteristics of a chrono-litho-sequence of loess-derived prairie soils of Southwestern Iowa. Soil Sci. Soc. Amer. Proc. 15:318-324.
15. Jackson, M. L. 1958. Soil chemical analysis. Prentice-Hall. Englewood Cliffs, New Jersey. Pp. 85-86.
16. Jenny, H. 1941. Factors of soil formation. McGraw-Hill. New York.
17. Kilmer, V. J. and L. T. Alexander. 1949. Methods of making analyses. Soil Sci. 68:15-24.
18. Kilmer, V. J. 1960. The estimation of free iron oxides in soils. Soil Sci. Soc. Amer. Proc. 24:420-421.
19. Leighton, M. M. and H. B. Willman. 1950. Loess formations of the Mississippi Valley. Jour. Geology 58:599-623.
20. Leighton, M. M. 1931. The Peorian loess and the classification of the glacial drift sheets of the Mississippi Valley. Jour. Geology 39:45-53.
21. Leighton, Morris M. The classification of the Wisconsin glacial stage of North Central United States. Jour. Geology 68:529-552.
22. Longwell, T. J., W. L. Parks, and M. E. Springer. 1963. Moisture characteristics of Tennessee soils. Tennessee Agr. Expt. Sta. Bulletin 367.
23. Palmer, W. C. and A. V. Havens. 1958. A graphical technique for determining evapotranspiration by the Thornthwaite method. Monthly Weather Review 86:123-128.
24. Peech, Michael, R. L. Cowan, and J. H. Baker. 1962. A critical study of the BaCl_2 -triethanolamine and the ammonium acetate methods for determining the exchangeable hydrogen content of soils. Soil Sci. Soc. Amer. Proc. 26:37-40.
25. Puri, A. N. and A. G. Asghar. 1938. Influence of salts and soil-water ratio on pH value of soils. Soil Sci. 46:249-257.

26. Ray, L. L. 1963. Silt-clay ratios of weathering profiles of Peorian loess along the Ohio Valley. *Jour. Geology* 71:38-47.
27. Rice, O. W. 1965. Relationship of pH, phosphorus, and potassium of soil layers among fifty soil series in Tennessee. Unpublished Master's thesis. The University of Tennessee, Knoxville.
28. Ruhe, R. V. 1956. Geomorphic surfaces and the nature of soils. *Soil Sci.* 82:441-455.
29. Ruhe, R. V. and W. H. Scholtes. 1958. Radiocarbon dates in Central Iowa. *Jour. Geology* 63:82-92.
30. Safford, J. M. 1869. The Geology of Tennessee. Nashville: S. C. Mercer, Printer to the State. Pp. 110-118.
31. Simonson, R. W. 1949. Genesis and classification of redyellow Podzolic soils. *Soil Sci. Soc. Amer. Proc.* 14:316-319.
32. Simonson, R. W. 1959. Outline of a generalized theory of soil genesis. *Soil Sci. Soc. Amer. Proc.* 23:52-156.
33. Simonson, R. W. and C. E. Hutton. 1954. Distribution curves for loess. *Amer. Jour. Sci.* 252:101.
34. Smith, G. D. 1942. Illinois loess. Variations in its properties and distribution: a pedologic interpretation. *Illinois Agr. Exp. Sta. Bulletin* 490.
35. Soil Survey Staff. 1951. Soil survey manual. Agriculture Handbook 18. U.S.D.A.
36. Soil Survey Staff. 1967. Supplement to soil classification system. 7th Approximation. S.C.S., U.S.D.A.
37. Sutton, J. P., Jr. 1964. The influence of loess on the formation and morphology of Mountview and Dickson soils in Robertson County, Tennessee. Unpublished Master's thesis. The University of Tennessee, Knoxville.
38. Tanner, C. B. and M. L. Jackson. 1947. Nonographs of sedimentation times for soil particles under gravity or centrifugal acceleration. *Soil Sci. Soc. Amer. Proc.* 12:60-65.
39. Thornthwaite, C. W. and J. R. Mather. 1955. The water balance. *Drexel Inst. Tech., Lab. Climatology.* Vol. 8, No. 1.
40. U.S.D.A. Agriculture Handbook. 1954. No. 60. Pp. 109-110.

41. Waggoner, P. E. and Christopher Bingham. 1961. Depth of loess and distance from source. *Soil Sci.* 92:396-401.
42. Wascher, R. P., R. P. Humbert, and J. C. Cady. 1947. Loess in the Southern Mississippi Valley: identification and distribution of the loess sheets. *Soil Sci. Soc. Amer. Proc.* 12:389-399.
43. Williamson, R. M. 1941. Climate of Tennessee. *U.S.D.A. Yearbook of Agriculture.* Pp. 1119-1128.
44. Winters, E. and H. Wascher. 1935. Local variability in the physical composition of Wisconsin drift. *Jour. Am. Soc. Agron.* 27:617-622.
45. Young, Keith K. 1962. A method of making moisture desorption measurements on undisturbed soil samples. *Soil Sci. Soc. Amer. Proc.* 26:301.

APPENDIX

Placement of six Hapludalfs according to Seventh Approximation Criteria
of March, 1967

Alfisols: Order 7

Alfisols are mineral soils that have no spodic or oxic horizon overlying an argillic horizon; that have no mollic epipedon; that have no surface horizon and an upper subhorizon of an argillic or natric horizon that are separated by an albic horizon but that together meet all requirements for a mollic epipedon; and that have one of the following combinations of properties;

1. Have no fragipan but have an argillic or natric horizon; are usually moist in some part of the soil between 25 cm and 1 m (10 and 40 inches) unless the epipedon is both hard and massive when dry; and either have mean annual soil temperature less than 8° C (47° F), or have base saturation (by sum of cations) of 35 percent or more at a depth of 1.25 m (50 inches) below the top of the argillic horizon or at 1.8 m (72 inches) below the soil surface, or immediately above a lithic or a paralithic contact, whichever is shallower;
2.

Udalfs (7.3) Suborder

Alfisols that--

1. Have a mean summer soil temperature at 50 cm (20 inches) or above a lithic or paralithic contact, whichever is shallower, or 15° C (59° F) or more if cultivated or lacking an O horizon, or 8° C (47° F) or more if with an O horizon;
2. Are usually moist, and are not dry in most years for as much as 60 consecutive days in all parts or 90 cumulative days in some horizons between 18 and 50 cm (7 and 20 inches) and lack a calcic horizon or a horizon with soft powdery secondary lime in or within 50 cm (20 inches) below the base of the argillic horizon;
3. Are not saturated with water at any period or lack the characteristics associated with wetness defined for Aqualfs;
4. Lack an albic horizon that is continuous, that has dominant moist and dry chromas of 2 or less in the matrix of some

subhorizon, and that tongues or interfingers into an argillic or natric horizon, or have a mean annual soil temperature of 8° C (47° F) or more.

Typic Hapludalfs (7.35 -1) Subgroup

Hapludalfs that--

- a. Have no abrupt textural change if there are mottles in the upper 25 cm (10 inches) of the argillic horizon;
- b.
- c. Have an argillic horizon that is free of mottles with chromas of 2 or less in the upper 25 cm (10 inches), or if the upper boundary of the argillic horizon is deeper than 50 cm (20 inches) have no mottles with chromas of 2 or less within 75 cm (30 inches) of the surface;
- d. Have within 50 cm (20 inches) of the surface textures finer than loamy fine sand in some subhorizons;
- e.
- f.
- g. Have an Ap horizon with a moist color value of 4 or more or with a dry color value of 6 or more (crushed and smoothed), or the A1 horizon is less than 15 cm (6 inches) thick if its moist value is lower than 3.5;
- h.
- i. Have an argillic that is continuous horizontally, that is continuous vertically for at least the upper 20 cm (8 inches), and has a texture finer than loamy fine sand;
- j. Have base saturation (by sum of cations) of more than 60 percent at a depth of 1.25 m (50 inches) below the top of the argillic horizon;
- k.

Ultic Hapludalfs (7.35-21) Subgroup

- a. Hapludalfs like the Typic except for j.

VITA

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