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The influence of loess on the formation and morphology of Mountview and Dickson soils in Robertson County, Tennessee

J. Paul Sutton

To the Graduate Council:

I am submitting herewith a thesis written by J. Paul Sutton entitled "The influence of loess on the formation and morphology of Mountview and Dickson soils in Robertson County, Tennessee." I have examined the final electronic 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 Agronomy.

M.E. Springer, Major Professor

We have read this thesis and recommend its acceptance:

Russell J. Lewis, O.H. Long

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

December 10, 1964

To the Graduate Council:

I am submitting herewith a thesis written by J. Paul Sutton, Jr. entitled "The Influence of Loess on the Formation and Morphology of Mountview and Dickson Soils in Robertson County, 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.

M. E. Springer
Major Professor

We have read this thesis and recommend its acceptance:

R. J. Lewis

O H Long

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

THE INFLUENCE OF LOESS ON THE FORMATION AND MORPHOLOGY OF MOUNTVIEW AND DICKSON SOILS IN ROBERTSON COUNTY, 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

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by

J. Paul Sutton, Jr.

December 1964

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CHAPTER I

INTRODUCTION

The upland soils in the northwestern region of the Highland Rim are quite similar in properties and behavior to those soils of the eastern Rim, yet the Mountview and Dickson soils as observed in Robertson County are generally more productive than their counterparts on the eastern section of the Rim. Also, the productivity varies considerably within Robertson County. Can the increased productivity be attributed to differences in the silty mantle, geologic substrata, or a combination of these components?

Wascher *et al*. (29) traced loess deposits from the bluffs to the western side of the Highland Rim, so there is evidence that these soils formed in a thin loess blanket. Gass (6) concluded from his studies of Mountview and Holston series that the sola of these upland soils on the eastern side of the Rim were formed in parent materials of aeolian origin, i.e., loess. However, this evidence needs further substantiation for the northern portion of the Highland Rim.

The nature of the material below the solum is questionable in certain areas. Is the substratum of residual, alluvial, or aeolian origin, and what is its effect on the solum? It is generally known that the substrata vary according to geologic formation, amount of erosion, and past stream influence. An attempt will be made in this study to ascertain some of the properties of the substrata and relate them to the sola.

It is generally apparent that the Montview and Dickson soils developed in silty parent materials over fine textured residual substrata in the southern part of the county, where the soils are isolated on narrow ridge crests. However, this distinction becomes obscure toward the northern part of the county, where the silty layer thickens over purer limestone formation on more level topography. The Crider soil is more common than Mountview in this section of the county.

The situation is complicated in northern areas by previous stream influence on the landscape. There is speculation that parent materials of the substrata in Crider, and possibly some Mountview soils, may have been transported by water, just as it is believed that parent materials of the solum were transported by wind before these soils developed _in situ_. However, there is some evidence that the substrata were developed in advance of loess deposition, as may be surmised from this investigation of the Mountview, Crider, and Dickson soils.

CHAPTER II

REVIEW OF LITERATURE

Location

The largest natural division of Tennessee is the Highland Rim. It covers approximately 9,300 square miles or nearly 2/9 of the state. The tableland has an average elevation of 900 to 1,000 feet above sea level. The portion west of the Basin is twice as wide as that on the eastern side of the Rim (19).

Robertson County lies entirely within the Highland Rim region and contains 477 square miles (1) (see Figure 1). Springfield, the county seat, is located centrally in the county. The Highland Rim Experiment Station is located SE of Springfield. Both are at an elevation of approximately 700 feet.

Topography

The general elevation of the northwestern side of the Rim, in the counties of Dickson, Robertson, Montgomery, and others through which the Cumberland River flows, is considerably lower than the opposite side in Franklin, Coffee, Warren, and Putnam Counties. It may be said that the whole area, Rim and Basin together, dips (or the great dish is tilted) to the northwest, as described by Safford (19). These dips or waves generally conform to the geological structure of the region.

Practically the entire county is well drained. Red River with its principal tributary, Sulfur Fork, drains approximately 3/4 of the county,

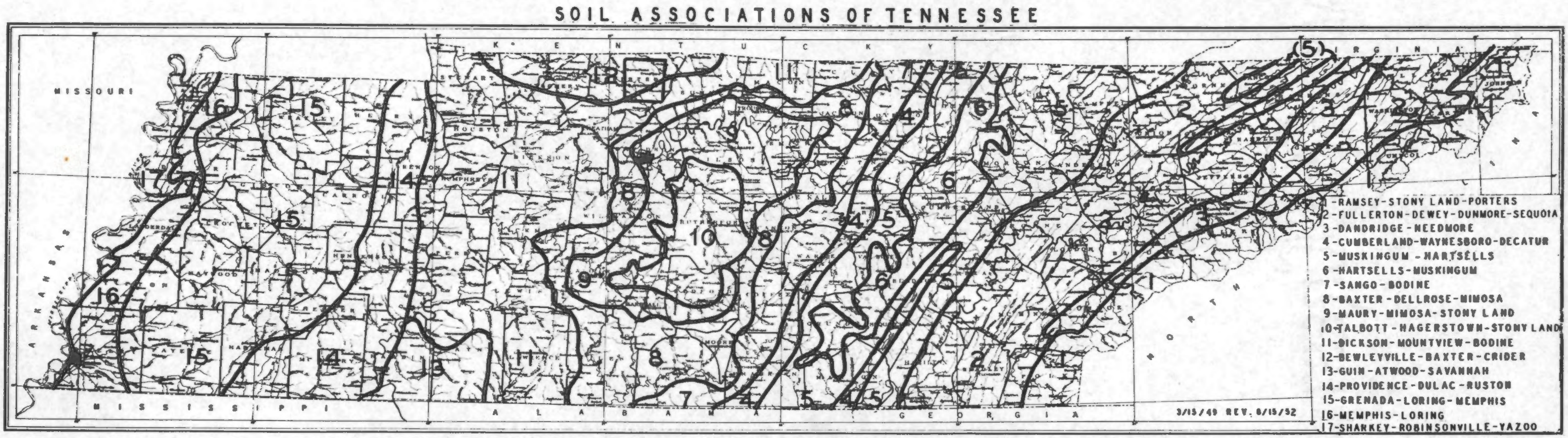

Figure 1--Map of Tennessee showing study area in Robertson County.

while Sycamore Creek drains much of the southern part. The streams in the southern part of Robertson County have dissected the plateau to such an extent that numerous ridges with intervening (V-shaped) valleys have formed as depicted in Figure 2. The northern part of the county is smoother with considerable rolling to almost level uplands. However, there are steep, irregular slopes in the vicinity of streams. Also, there are localized areas of karst topography (1).

Geology

The geologic formations of the Highland Rim are of the latter Paleozoic Era. Of the Lower Carboniferous Age, the Mississippian System with distinctive features of crinoids and lacybroyozoan is characteristic of the area (12).

Geologic formations characteristic of the Mississippi System as listed by Bassler (2) are:

St. Louis limestone--characterized by fossil corals, Lithostrotion canadense and L. proliferum.

Warsaw formation--distinguished by conglomeratic cherts filled with comminuted fossils to vesiculosed and solid cherts.

Fort Payne formation--a massive siliceous to argillaceous limestone which weathers into yellow, bulky chert.

The St. Louis limestone is rarely exposed and is chiefly known from its features after weathering, as are the underlying Warsaw and Fort Payne formations. The contact between each of these formations is

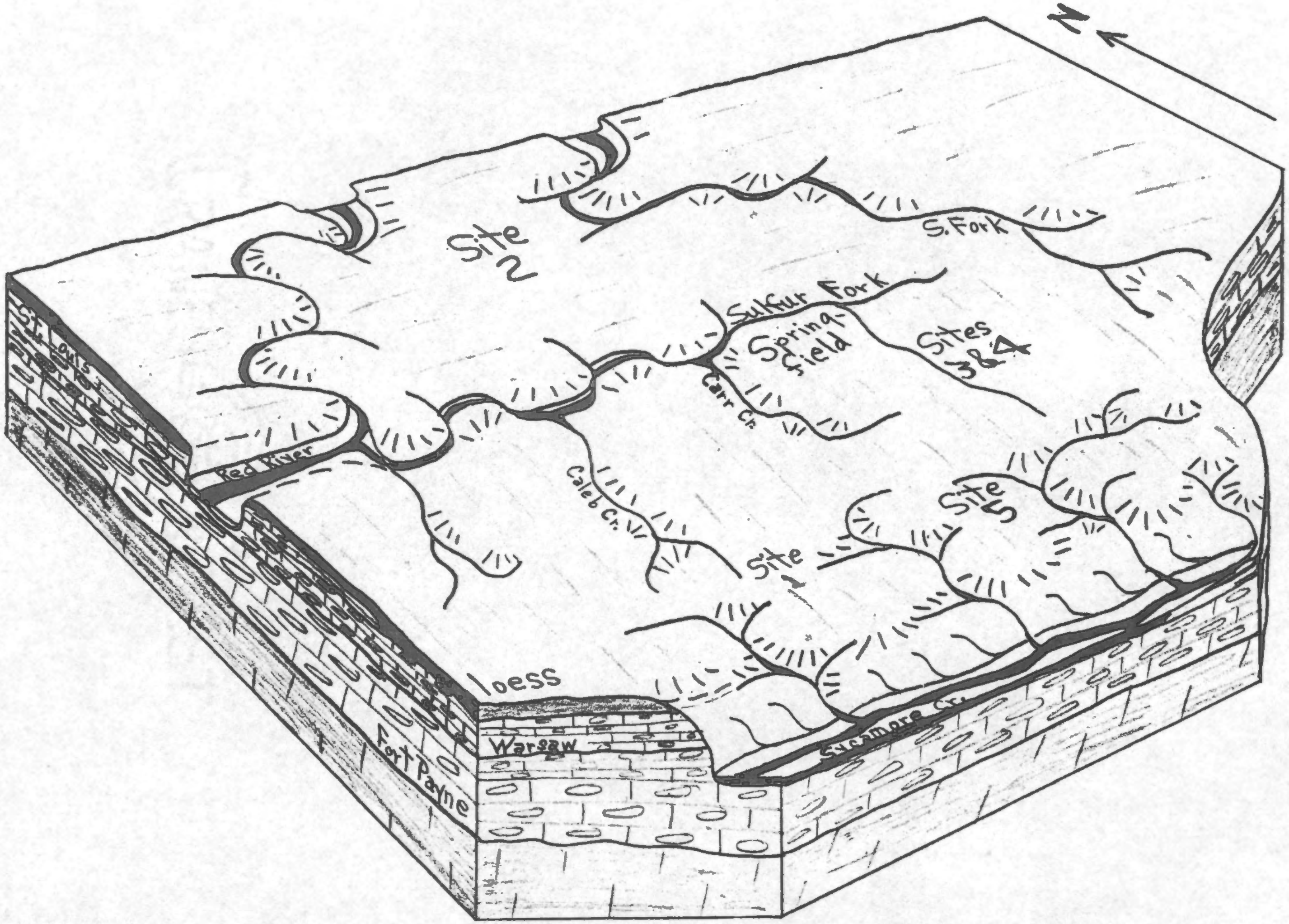

Figure 2--Block diagram showing relationship of Mountview, Crider, Dickson sites within Robertson County.

seldom observed and must be located by differences in chert, fossils, and soil, as well as by topography.

Early Soil Survey

Silty soils were recognized as being derived from residual limestone parent materials and are described in the Soil Survey of 1912 (1).

In the southern part of the county, Clarksville silt loam was described as being a pale yellow to grayish-yellow silt loam, underlain at about 10 to 15 inches by a friable silty clay loam of a pronounced yellow color, often present as a narrow band on the divides. (This description fits the current Mountview and Dickson Series.) The yellow subsoil was described as reaching a depth of 3 feet or more, with substrata beginning at about 40 to 50 inches, of a light red color that darkened with depth. On the slopes to stream courses, a large percentage of chert material was observed.

In the northern portion of the county, Decatur silt loam was characterized. It consisted of a brown to reddish-brown friable or mellow silt loam, underlain at about 8 to 12 inches by a red silty clay loam (the description covers Pembroke and Decatur Series) which changed at 18 to 24 inches into deep red silty clay of moderate, crumbly structure. These redder soils were attributed to weathering from the St. Louis limestone while the yellow soils were from the Fort Payne chert.

Climate

The climate of Robertson County is rather uniform over the area.

Rainfall is well distributed throughout the year, as shown in Table I, with total precipitation of about 50 inches. September and October are generally the driest months with an average of less than 3 inches per month. As compared to the hot mid-summer months, cooler temperatures coincide with the drier months. The heaviest rainfall comes during the winter months. The growing season lasts over 200 days (30). The average date of the last killing frost is April 8 in the spring, while the average first killing frost in the fall is on October 26. Clear skies prevail on about 130 days, partly cloudy in 115 days, and cloudy on about 120 days per year. Relative humidity averages 72 percent. Occasional droughts of 20 to 30 days duration may occur in the late summer and early fall.

The water balance according to the Thornthwaite method (15, 27) is depicted in Figure 3.

Red-Yellow Podzolics

Simonson has proposed, "That soil genesis be considered as two overlapping steps; viz, the accumulation of parent material and the differentiation of horizons in the profile." (22). He ascribes horizon differentiation to additions, removals, transfers, and transformations within the soil system and postulated that these kinds of changes proceed simultaneously in all soils. Simonson suggested that the balance within the combination of changes governs the ultimate nature of the soil profile. However, he added that these processes may be retarded or may offset horizon differentiation.

Table 1.--Mean monthly and annual temperature, precipitation, and evaporation on western side of the Highland Rim.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
HR Exp. Sta.[a] Temp. (°F.)	40.1	42.1	49.3	58.3	66.6	67.2	77.7	76.8	70.2	61.1	48.1	39.8	58.9
HR Exp. Sta. Precip.[b] (in.)	5.56	4.57	4.98	3.64	3.73	3.27	4.26	3.58	2.60	2.64	4.14	4.40	47.36
Cedar Hill[c] Precip. (in.)	5.83	3.92	5.40	4.76	4.69	4.59	4.37	3.85	3.35	3.32	3.69	5.07	52.83
Neptune[d] Evap.	1.03 (est'd)	2.31	3.31	4.70	5.59	6.44	6.77	5.94	4.78	3.26	2.01	1.29	47.23 (est'd)

[a]Supplement to Climatic Summary of the U.S. (Bulletin W. 1930 ed.) Climatography of U.S. No. 11-35. U.S. Dept. of Commerce.

[b]This data was gathered for 15 years following the data gathered for 39 years at Cedar Hill.

[c]"Climate and Man", U.S.D.A. Yearbook, 1941.

[d]Personal communication with M. H. Bailey, Weather Bureau State Climatologist.

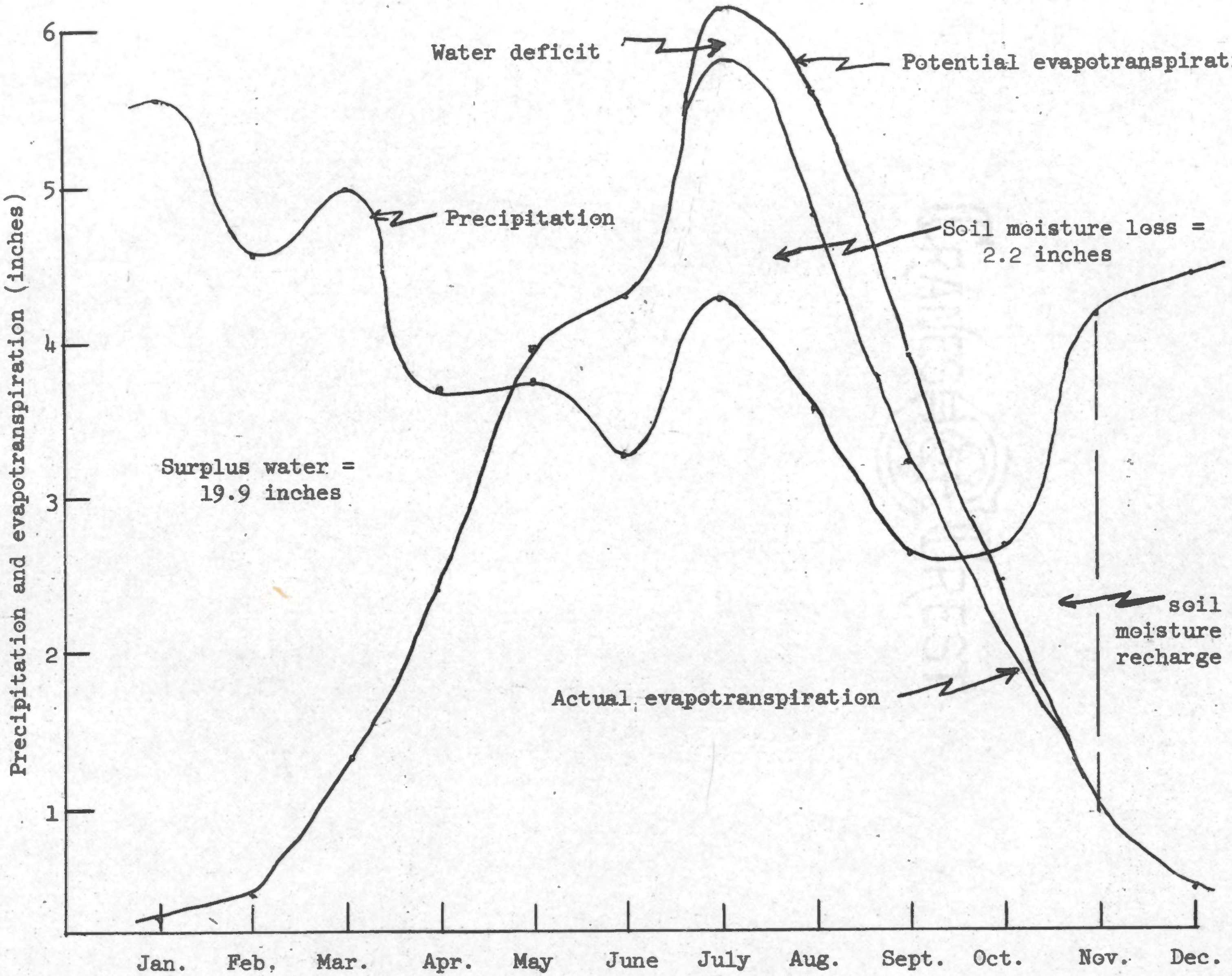

Figure 3--Average potential evapotranspiration and precipitat
Robertson County for the period 1931-1952

The four processes, as listed by Simonson, which operate in horizon differentiation are quite evident in the formation of the Red-Yellow Podzolic soils. These soils are found characteristically under humid, warm, temperate climate, as exists in the southeastern part of the U.S. Red-Yellow Podzolic soils are defined as: "A group of well-developed, well-drained acid soils having thin organic (A0) and organic-mineral (A1) horizons over a light colored bleached (A2) horizon, over a red, yellowish-red, or yellow more clayey (B) horizon. Parent materials are all more or less siliceous. Coarse reticulate streaks or mottles of red, yellow, brown, and light gray are characteristic of deep horizons of Red-Yellow Podzolic soils where parent materials are thick." (28).

Modified concepts of genetic processes in the genesis of Red-Yellow Podzolic soils added by Simonson are:

1. The formation of silicate clay minerals in the deeper horizons.

2. The destruction of these minerals in the upper horizons. Maximum clay concentration frequently occurs below the B horizon, giving evidence of formation of clay at depths followed by its destruction within the solum (21).

In the genesis of Red-Yellow Podzolic soils, McCaleb (14) places emphasis on movement of clay-size minerals into the B horizon and alteration _in situ_. With time, the B2 horizon becomes largely filled with clay-size minerals and pore space is decreased to a minimum as the lower areas are sealed off from effective movement. Thus the thickness and continuity of clay-skin development proceeds upward into the profile. He postulates that movement of materials from higher horizons to lower ones in the profile are initially responsible for mottling in the lower solum and C horizon.

Loess Mantle

The Highland Rim lies on the eastern fringe of the "loess area", according to Wascher et al. (29), who studied distribution of the loess sheets. They traced the outer fringe of loess to a depth of 2 to 3 feet overlying coastal plains or residual bedrock. Little or no loess was found on slopes greater than 4 to 5 percent, though the ridge tops were mostly loess covered. He surmised that the total loess in these areas tended to be made up mainly of Peorian loess. These depositions were due to prevailing Westerlies blowing from the Iowan till sheet. As a result of these winds, greater deposits of loess occur east of the Mississippi than west of the river. Bluffs greater than 40 feet in thickness are present from Hickman, Kentucky to Memphis, Tennessee and deposits of less than 15 feet are across the river. Progressively farther from the bluffs, the soils are more highly weathered and show more strongly developed profiles.

Peorian loess dates to the Wisconsin glacial stage of the Pleistocene Era. Through carbon-14 dating techniques, Flint (4) generalized that "The oldest Wisconsin drift recognized prior to 1950 is not much more than 25,000 years old." He assembled dates from studying wood buried in glacial drift, peat interbedded in drift, snail shells in loess, and other materials in stratigraphic relation to glacial sediments.

Smith studied particle size as related to the distribution of loess in Illinois (23). With increased distance from the bluff, the coarser fraction decreases and the finer fraction increases. He established a linear relationship between particle size and the logarithm of the distance from the bluff. The rate of thinning of the loess with distance from its source was also established as a linear function of the logarithm of the distance. Smith differentiated between soils formed in thick loess and those formed in thin loess deposits. The latter show low base saturation and a high degree of clay eluviation.

Fragipans

Fragipans are common in soils formed from loess, especially in thin deposits overlying substrata of a different nature. They are generally at a depth of 20 to 30 inches below the surface, on slopes of less than 10 percent. Fragipans are predominantly of the silt loam textural class (brittle like a cracker when dry but friable when moist) and usually siliceous in composition (32).

In Illinois, according to Grossman et al. (7), the fragipan is found within the lower sequum of a bisequal solum and there occurs in the lower sequum a polygonal network of gray silt loam that extends downward from the A'2 horizon and delineates prismatic structural units. Some morphological features listed in the Soil Survey Manual (24) are:

1. Compact horizons rich in silt, sand, or both, and relatively low in clay.

2. May or may not underlie or overlie a horizon of clay accumulation. (They commonly interfere with root and water penetration.)

3. Material appears indurated when dry but induration disappears upon being moistened.

4. Found in soils developed in both residual and transported materials.

Winters (31) listed the following conditions as affecting pan development: a definite period of time seems necessary but after a certain stage is reached, hardness does not seem to increase; parent material seems of less consequence than its physical properties; all soils with hardpans show evidence of restricted drainage as judged by color; usually the more restricted it is the harder the pan and closer it is to the surface.

Post-glacial Vegetation

Radio-carbon dating on the fossil occurrence of hemlock, spruce, and pine in the Middle West has made it possible to study climatic changes dating to late Sangamon time, estimated at 38,000 years, according to Ruhe and Scholtes (18). Cooler humid climate as determined by the presence of coniferous forest, larch and hemlock, was probably indicative of advent of the Wisconsin glacial period.

Lane is cited as reporting a pollen sequence from a peat bog in North Central Iowa that shows systematic vegetational change from the Upper Wisconsin Age toward warm, subhumid conditions that exist in Iowa today: (1) spruce forest; (2) mixed fir, birch, and spruce; (3) birch with fir and oak; (4) oak with birch and grasslands. He concluded that his pollen sequence showed a warming trend accompanying the change from coniferous to deciduous forms of vegetation.

CHAPTER III

METHODS AND PROCEDURES

Field Methods

Transects were made in areas of the selected soils to determine associated soils. Five individual sites were selected for the study. These were widely separated in the county except for two sites located on the Highland Rim Experiment Station. A Mountview in the southern part and a Crider in the north-central part of the county were both located within farm woodlots. Mountview and Dickson sites were selected on the eastern boundary of the experiment station; the former in a pasture field, the latter in a cultivated field. The remaining site, a Dickson silt loam was selected in the SE part of the county. The five sites were selected in areas that showed no recent influence by colluvial or stream deposition. Topography typical to the sites selected is shown in Figure 4.

Excavations were made after preliminary boring with a soil auger to help locate representative spots. The soil profile was described from the face of the pit, using Munsell color notations on moist soil. Clods were selected from main horizons, dipped in plastic, and dried for bulk density determinations. The profiles were sampled from the bottom upward to avoid contaminating unsampled horizons. Samples were placed in clean cloth bags for transport to the laboratory.

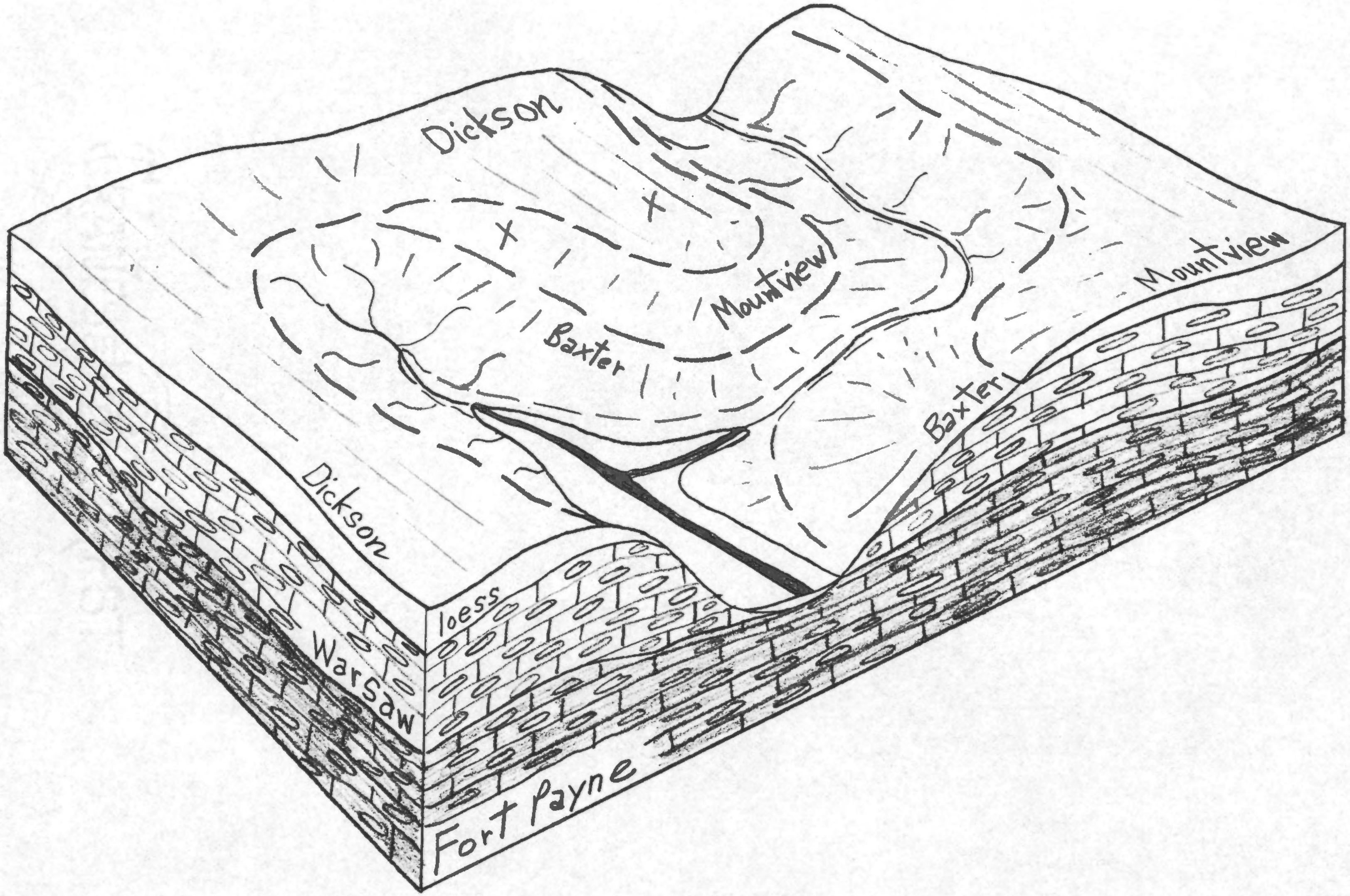

Figure 4--Block diagram depicting relationship of parent materials and soils to topography.

Laboratory Procedures

All soil samples were air-dried, ground with a rubber pestle, sieved through a 2-mm. sieve, mixed thoroughly, and stored in quart cartons. A subsample was later passed through an 80 mesh sieve for organic matter and nitrogen determinations.

All the determinations were made in duplicate except mechanical analysis of certain horizons, slide counts of the coarse silt (0.05-0.02 mm.) fraction, and quartz-chert counts of the fine sand (0.10-0.25 mm.) fraction.

Coarse fragments, > 2 mm. were washed, weighed air-dry, and calculated on a weight percentage basis. Mechanical analyses were made by the pipette method as described by Kilmer and Alexander (11). Sedimentation times for this determination and for retrieving the coarse silt fraction were taken from the nomograph by Tanner and Jackson (26). Bulk density was determined on plastic-coated clods as described by Brasher *et al*.[1]

pH was determined with a Beckman zeromatic pH meter on moist soil, using 1:1 water-soil ratio. Also, the pH was determined in a normal KCl solution.

C.E.C. was determined by the distillation of adsorbed ammonia after leaching the soil with normal ammonium acetate as described by Peech *et al*. (16), with the modification: 0.01 normal NH_4OAc was

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[1]Brasher, *et al*. Volume Measurement of Saran coated soil fragments. Soil Survey Laboratory. S.C.S., U.S.D.A. Beltsville, Md., May, 1962.

leached last through the soil before washing with alcohol. Exchangeable cations were estimated in two ways: potassium with a Beckman Model DU flame spectrophotometer as outlined by Shaw and Veal (20) and calcium and magnesium with a Perkin-Elmer 303 Atomic Absorption Spectrophotometer. These determinations were made in extract that had been evaporated down, organic matter destroyed, and taken up in HCl. The solution was made to be approximately 0.25 percent strontium for the latter determinations. The magnesium was determined in solution diluted 1:10.

Organic matter was determined by a modification of the Walkley-Black method as described by Peech et al. (16). Total nitrogen was determined by using the Kjeldahl process, following the procedure as outlined by Jackson (9). Available phosphorus was extracted with 0.05 normal H_2SO_4 + 1% $(NH_4)_2SO_4$ and determined on a Bausch & Lomb "Spectronic 20" colorimeter.

Free iron oxide was estimated according to the method of Kilmer (10).

The heavy minerals were separated from the light minerals after the method of Haseman and Marshall (8), with modification by Gass (6). The light minerals were stained by following the method of Gabriel and Cox (5) to determine the percentages of potassium feldspar and quartz. The percentages of opaque cherts were determined with the aid of a polarizing microscope with the fine sand particles immersed in oil.

CHAPTER IV

RESULTS AND DISCUSSION

Description of two Mountview, one Crider, and two Dickson profiles show some characteristics which were observed in situ.

Site 1

Soil Profile: Mountview silt loam

02,01	½-0 inches	Loose leaf litter from hardwoods with partly decomposed organic residues; pH 6.7.
A1	0-2 inches	Dark grayish-brown (10YR 4/2) silt loam; moderate fine granular structure; very friable; pH 5.1; clear wavy boundary.
A2	2-7 inches	Brown (10YR 5/3) silt; weak fine granular structure; very friable; pH 4.8; clear wavy boundary.
B1t	7-11 inches	Yellowish-brown (10YR 5/6-5/4) silt loam; weak fine subangular blocky structure; friable; pH 4.8; clear wavy boundary.
B21t	11-19 inches	Yellowish-brown (10YR 5/6) and strong brown (7.5YR 5/6) silty clay loam; moderate medium subangular blocky structure; friable; pH 4.7; diffuse smooth boundary; thin discontinuous clay films.
B22t	19-27 inches	Yellowish-brown (10YR 5/6) silty clay loam; moderate medium subangular blocky structure;

		friable; pH 4.7; gradual smooth boundary; discontinuous clay films.
B3t	27-34 inches	Variegations - Yellowish-brown (10YR 5/6) dominant, strong brown (7.5YR 5/6), red and reddish-brown (2.5YR 4/8 and 5/4) silty clay loam; moderate medium subangular blocky structure; friable to firm; pH 5.0; gradual wavy boundary; common continuous clay films.
IIB21tb	34-44 inches	Variegations - Red (2.5YR 4/6) dominant, reddish-yellow (7.5YR 6/6), yellowish-brown (10YR 5/4) silty clay loam; strong medium and fine sub-angular blocky structure; pH 4.9; gradual wavy boundary.
IIB22tb	44-55 inches+	Variegations - Red (2.5YR 4/6) dominant, strong brown (7.5YR 5/6), light grayish-brown (10YR 6/2) silty clay; moderate medium and fine angular blocky structure; firm; pH 5.0.
Location:		One mile east of Coopertown, 200 yards north of Betts Road, near the divide between the water-sheds of Sycamore and Sulfur Fork creeks.
Remarks:		A few chert fragments were distributed through the profile, later evidenced by $>$ 2mm. fragments. Plentiful fine roots were in the A1, lower B, and extending into the upper IIB horizon, while large and common roots were

		prevalent in the A2 and upper B horizon. Water was seeping out the top of the IIB21tb horizon at sampling time or early spring.
Topography:		The landscape was rolling to gently sloping and dissected by drainage ways in dendritic pattern. The site was located on a 6% slope, 50 yards from the crest of a ridge and 50 yards from nearest drainage way.
Vegetation:		A cut-over farm woodlot, composed mainly of: White oak (<u>Quercus alba</u>) Northern red oak (<u>Q. rubra</u>) Black oak (<u>Q. velutina</u>) Post oak (<u>Q. stellata</u>) Red maple (<u>Acer rubrum</u>) Hickory (<u>Carya Spp.</u>) Green ash (Fraxinus pennsylvania); with an understory of: Dogwood (<u>Cornus florida</u>) Persimmon (<u>Diospyros virginiana</u>) Black cherry (<u>Prunus serotina</u>)

Site 2

<u>Soil Profile</u>: <u>Crider silt loam</u>

02,01	2-0 inches	Loose leaf litter from hardwoods with partly decomposed organic residues; pH 6.5.
A1	0-2 inches	Dark grayish-brown (10YR 4/2) silt loam; weak fine granular structure; very friable; pH 5.4; clear wavy boundary; many pores and wormholes.
A2	2-6 inches	Yellowish-brown (10YR 5/4) silt; weak granular

		and weak fine subangular blocky structure; very friable; pH 5.1; gradual smooth boundary.
B1t	6-11 inches	Yellowish-brown (10YR 5/4) and dark brown (7.5YR 4/4) silt loam; weak medium subangular blocky structure; friable; pH 4.6; gradual smooth boundary.
B21t	11-22 inches	Dark brown (7.5YR 4/4) silt loam; moderate medium subangular blocky structure; friable; pH 4.6; gradual wavy boundary.
B22t	22-25 inches	Dark brown (7.5YR 4/4) dominant and dark red (2.5YR 3/6) silt loam; moderate medium subangular blocky structure; friable; pH 4.7; gradual irregular boundary; thin clay films.
B3t	25-32 inches	Dark red (2.5YR 3/6) dominant and dark brown (7.5YR 4/4) silty clay loam; strong medium subangular and angular blocky structure; firm; pH 4.7; thick continuous clay films.
IIB21tb	32-44 inches	Dark red (2.5YR 3/6) dominant and dark brown (7.5YR 4/4) silty clay; strong medium subangular and angular blocky structure; firm; pH 4.8; thick continuous clay films.
IIB22tb	44-56 inches	Dark red (2.5YR 3/6) and reddish-brown (5YR 4/4) silty clay; strong medium angular and subangular blocky structure; firm to very firm; pH 4.9; diffuse boundary; thick continuous clay films.

IIB23tb	56-74+ inches	Dark red (10YR 3/6) clay; strong angular and subangular blocky structure; very firm to firm; pH 5.0; thick continuous clay films.

Location: One mile west of Rt. 431, about 8 miles north of Springfield in the watershed of Red River.

Remarks: Roots were many and common throughout the solum. Yellowish-brown (10YR 5/6) and pale brown (10YR 6/3) silt loam tongues, 1/4-1/2 inch wide and 8-15 inches in length, extended from the B3 horizon into the IIB horizon. A few fine chert fragments were at the lowest depth sampled.

Topography: A gently sloping and rolling landscape slightly dissected by drainage ways in dendritic pattern. The site was located on a 4-5% slope 100 yards from nearest major drain and bounded on each side by minor drains at 50 yards.

Vegetation: A farm woodland that was composed mainly of: White Oak (*Quercus alba*) Southern Red Oak (*Q. falcata*) American Beech (*Fagus grandifolia*) Post Oak (*Q. stellata*) Black Walnut (*Juglans nigra*) Red Maple (*Acer rubrum*) Yellow Poplar (*Liriodendron tulipifera*) Shagbark Hickory (*Carya ovata*). The canopy was estimated to consist of 25% Beech, 25% Post Oak, White

Oak and 20% Yellow Poplar, Hickory, and Black Walnut:

The understory consisted mainly of:

Dogwood (Cornus florida) Sassafras (Sassafras albidum) Red cedar (Juniperus virginiana) Winged elm (Ulmus alata)

Site 3

Soil Profile: Mountview silt loam

A1	0-2 inches	Brown (10YR 5/3) silt loam; weak medium fine granular structure; very friable; pH 7.0.
A2	2-8 inches	Brown (10YR 5/3) silt; weak medium fine granular structure; very friable; pH 6.1; clear wavy boundary.
B1t	8-11 inches	Strong brown (7.5YR 5/6) and yellowish-brown (10YR 5/4) silt loam; weak medium subangular blocky structure and weak medium granular structure; friable; pH 5.8; gradual wavy boundary.
B21t	11-17 inches	Strong brown (7.5YR 5/6) cherty silty clay loam; weak moderate subangular blocky structure; friable; pH 4.6; gradual wavy boundary; few thin discontinuous clay films.
B22t	17-23 inches	Strong brown (7.5YR 5/6) and yellowish-brown (10YR 5/4) cherty silt loam; weak medium

		subangular blocky structure; friable; pH 4.7; gradual smooth boundary; few thin discontinuous clay films.
B23t	23-28 inches	Yellowish-brown (10YR 5/4) and strong brown (7.5YR 5/6) silty clay loam; moderate medium subangular blocky structure; friable; pH 4.7; clear wavy boundary; common thin continuous clay films.
IIB21tb	28-38 inches	Dark brown (7.5YR 4/4) and strong brown (7.5YR 5/6), few red (2.5YR 4/8) variegations, silty clay loam; strong medium angular and subangular blocky structure; firm; pH 4.8; gradual smooth boundary; common continuous clay films and many thick clay films.
IIB22tb	38-54+ inches	Variegations - strong brown (7.5YR 5/6) dominant and red (2.5YR 4/8) silty clay loam; moderate medium angular blocky structure; pH 4.9; firm; common thin clay films.
Location:		The site was located near the eastern boundary of the Highland Rim Experiment Station.
Remarks:		Roots were many and fine in the A and common in the B horizon. Chert was estimated to occupy 10 to 15% of the lower B horizons and 15 to 20% in the lowest layer sampled. The percentages of chert $>$2mm were quite significant

in these layers.

Topography: The landscape was gently sloping to rolling and the site was situated on a convex slope, 10 yards from the crest of the divide and 30 yards from the nearest drainageways.

Vegetation: Fescue pasture land.

Site 4

Soil Profile: Dickson silt loam

Ap	0-9 inches	Brown and yellowish-brown (10YR 5/3 and 5/4) silt loam; weak medium granular structure; friable; pH 4.9; clear smooth boundary.
B2t	9-18 inches	Yellowish-brown (10YR 5/6) silty clay loam; moderate medium and fine subangular blocky structure; friable; pH 4.9; clear smooth boundary.
A'2x	18-24 inches	Yellowish-brown (10YR 5/6) and light gray to gray (10YR 6/1 and 5/1) mottled silt loam; moderate medium subangular blocky structure, friable; pH 4.4; clear smooth boundary; thin clay films.
B'21tx	24-32 inches	Yellowish-brown (10YR 5/6) with light reddish-brown (2.5YR 6/4) and gray to dark gray (2.5YR 5/0 - 4/0) mottled silty clay loam; moderate medium angular and subangular blocky structure; friable (brittle when dry); pH 4.5;

clear smooth boundary.

IIB'22tx	32-40 inches	Red and dark red (10R 4/3 and 3/6) with dark brown to strong brown (7.5YR 4/4 to 5/6) and yellowish-brown (10YR 5/6) dominant mottles with light gray to dark gray (10YR 6/1 to 4/1) silty clay loam; moderate medium angular and subangular blocky structure; firm; pH 4.5 clear wavy boundary; thick continuous clay films.
IIB3t	40-54+ inches	Red (2.5YR 4/8) variegated with strong brown (7.5YR 5/8) and gray (10YR 6/1) silty clay loam; strong medium angular and subangular blocky structure; firm; pH 4.7; thick continuous clay films.
Location:		The site was located near the eastern boundary of the Highland Rim Experiment Station, about 200 yards from site 3.
Remarks:		Roots were few and fine in the A and ranged to common in the B horizon. A few fine chert fragments were distributed throughout the profile except for the lowest layer sampled which was estimated to contain 15-18% chert. A gray tongue (10YR 5/1) 5 inches wide extended down 10 inches through the predominantly red (10R 4/8) layer. Water was seeping from the face

	of the profile at 20 inches or just above the fragipan layers, when the site was sampled.
Topography:	The site was located on gently sloping to level upland of 2-3% slope; between two minor drainage ways at an approximate distance of 35 yards from each drain. The site was situated in the watershed of Sulfur Fork Creek.
Vegetation:	Weeds in the fencerow on the edge of a plowed field.

Site 5

<u>Soil</u> <u>Profile</u>: <u>Dickson</u> <u>silt</u> <u>loam</u>

Ap	0-8 inches	Brown (10YR 5/3) silt loam; granular structure; very friable; pH 6.4; abrupt smooth boundary.
B1t	8-10 inches	Yellowish-brown (10YR 5/6) silt loam; fine subangular blocky structure; friable; pH 4.6; clear smooth boundary.
B21t	10-16 inches	Yellowish-brown (10YR 5/6) silty clay loam; weak fine subangular blocky structure; friable; pH 4.5: gradual smooth boundary.
B22t	16-21 inches	Yellowish-brown (10YR 5/6) silty clay loam; moderate fine subangular blocky structure; pH 4.4; clear smooth boundary; few thin discontinuous clay films.
A'2x	21-26 inches	Yellowish-brown (10YR 5/6) strong brown (7.5YR

5/6) with light reddish-brown (2.5YR 4/6) and gray (10YR 6/1) mottled silt loam; moderate medium subangular blocky structure; friable to firm (brittle when dry); pH 4.4; clear wavy boundary; few thin clay films.

B'21tx	26-35 inches	Yellowish-brown (10YR 5/6), strong brown (7.5YR 5/6) with light reddish-brown (2.5YR 6/4) and gray (10YR 5/1) silty clay loam; moderate medium angular and subangular blocky structure; friable to firm; pH 4.5; clear irregular boundary; thin continuous clay films.
IIB'22tx	35-42 inches	Red (2.5YR 4/8) yellowish-red (5YR 4/8) with strong brown (7.5YR 5/6) and gray (10YR 5/1) mottled silty clay; moderate fine angular and subangular blocky structure; firm; pH 4.6; clear irregular boundary; thin continuous clay films.
IIB31t	42-52 inches	Dark red (2.5YR 3/6) variegated with yellowish-brown (10YR 5/8) and gray (10YR 6/1) silty clay; angular and subangular blocky structure; firm; pH 4.6; gradual irregular boundary; common continuous clay films.
IIB32t	52-60+ inches	Dark red (10R 3/6) clay; moderate angular blocky structure; firm; pH 4.5.
Location:		The site was located 200 yards north of Betts

	Road, about 2 miles southwest of Greenbrier.
Remarks:	A few fine chert were observed in the lower parts of the profile. Gray coatings were on the peds in the A'2x horizon. A gray silty polygonal-shaped structure, 8 inches in diameter extended through the pan horizon.
Topography:	The site was located on a "finger" of one of the numerous ridges, dissected by streams in the southern part of the county on a 2-3% slope, at a distance of 60 yards from the nearest drainageway.
Vegetation:	None but weeds on a stubble field.

Laboratory Results

Particle size distribution is presented in Tables 2, 3, and 4. The solum and bisequal solum grade from silt loam to silty clay loam in textural classification. The buried horizons increase in finer-sized particles to silty clay and clay textures.

Greater percentages of sand are in the A and buried B horizons than in the mid-profile horizons. The fine and very fine sand fractions (0.25 to 0.05 mm.) are about twice the amount of the coarse and medium-sized sand fractions (2.0 to 0.25 mm.), and average 2 to 3 percent. The total sand content ranges from 5 to 10 percent/horizon.

The silt content ranges from 35 percent in the buried soil to 80 in the A horizons. Both coarse and fine silt (0.05 to 0.002 mm.)

Table 2.--Some physical properties of Crider silt loam in Robertson County, Tennessee.

Site no.	Horizon	Depth (in.)	Bulk density gr/cc	% Fragments+ >2mm.	Particle size distribution: % Sand 2-0.5 mm	% Sand 0.5-0.25 mm	% Sand 0.25-0.1 mm	% Sand 0.1-0.05 mm	% Silt 0.05-0.02 mm	% Silt 0.02-0.002 mm	% Clay <0.002 mm	Textural class
2	A1*	0-2	--	<0.1	1.0	0.7	2.4	1.7	26.6	54.5	13.0	sil
	A2	2-6	1.3	<0.1	1.1	0.6	1.8	1.4	25.4	57.5	12.2	sil/si
	B1t*	6-11	--	<0.1	0.7	0.6	1.7	1.3	22.6	54.6	18.5	sil
	B21t	11-22	1.5	<0.1	0.4	0.4	1.8	1.5	20.1	49.0	26.8	sil
	B22t	22-25	--	0.2	0.6	0.4	2.5	2.1	20.4	46.4	27.6	sil
	B3t	25-32	1.7	0.3	0.6	0.4	2.8	2.3	20.0	42.4	31.5	sicl
	IIB21tb	32-44	1.7	0.4	0.4	0.5	3.3	2.7	15.0	37.4	40.7	sic
	IIB22tb*	44-56	--	0.5	0.4	0.8	4.8	3.6	14.1	33.5	42.8	sic
	IIB23tb	56-74+	--	1.1	1.3	1.2	5.9	3.5	9.8	24.9	53.4	c

+Based on total soil sample.

*Simple determinations were made on these horizons.

Table 3.--Some physical properties of Mountview silt loam in Robertson County, Tennessee.

Site no.	Horizon	Depth (in.)	Bulk density gr/cc	% Fragments 2mm.+	Particle size distribution: % Sand 2-0.5 mm	% Sand 0.5-0.25 mm	% Sand 0.25-0.1 mm	% Sand 0.1-0.05 mm	% Silt 0.05-0.02 mm	% Silt 0.02-0.002 mm	% Clay <0.002 mm	Textural class
1	A1*	0-2	--	0.6	1.9	1.5	3.0	2.4	26.4	54.2	10.6	sil
	A2	2-7	1.4	2.0	1.8	1.4	2.6	2.2	27.0	54.5	10.5	si
	B1t*	7-11	--	1.5	1.0	0.9	2.0	1.8	20.3	52.2	21.9	sil
	B21t	11-19	1.5	3.3	1.1	0.8	1.6	1.5	16.7	47.1	31.2	sicl
	B22t	19-27	1.6	2.7	1.4	0.8	1.8	1.9	16.9	45.2	32.0	sicl
	B3t	27-34	1.6	4.4	1.0	0.7	2.0	2.1	16.5	43.3	34.4	sicl
	IIB21tb*	34-44	1.7	4.0	1.8	1.2	2.7	2.7	14.5	40.5	36.6	sicl
	IIB22tb	44-55+	--	0.7	1.0	1.3	2.8	3.0	14.6	35.5	41.8	sic
3	A1*	0-2	--	2.5	2.0	1.4	3.2	3.1	31.6	48.1	10.6	sil
	A2	2-8	1.4	1.4	1.3	1.1	2.4	2.3	27.3	53.8	11.9	si
	B1t*	8-11	--	0.6	0.8	0.8	1.8	1.8	22.2	51.3	21.3	sil
	B21t	11-17	1.4	22.1	1.6	0.8	1.8	1.9	18.9	45.5	29.5	ch sicl
	B22t	17-23	1.6	22.2	1.9	0.9	2.1	2.2	20.7	44.9	27.3	ch sil
	B23t	23-28	--	11.7	1.8	1.1	2.5	2.6	18.3	43.5	30.2	sicl
	IIB21tb*	28-38	1.6	13.9	1.1	1.0	2.3	2.3	20.7	37.7	34.9	ch sicl
	IIB22tb*	38-54+	--	6.1	2.0	1.5	3.2	3.1	16.2	36.1	37.9	sicl

+Based on total soil sample.

*Single determinations were made on these horizons.

Table 4.--Some physical properties of Dickson silt loam in Robertson County, Tennessee.

Site no.	Horizon	Depth (in.)	Bulk density gr/cc	% Fragments >2mm.+	Particle size distribution: % Sand 2-0.5 mm	0.5-0.25 mm	0.25-0.1 mm	0.1-0.05 mm	% Silt 0.05-0.02 mm	0.02-0.002 mm	% Clay <0.002 mm	Textural class
4	Ap*	0-9	-	0.7	1.2	0.9	2.0	2.1	30.1	50.7	13.0	sil
	B2t	9-18	1.4	0.5	0.9	0.6	1.3	1.4	19.3	48.5	28.0	sicl
	A'2x	18-24	-	3.9	1.6	0.8	1.8	2.2	20.1	47.0	26.5	sil
	B'21tx	24-32	1.7	3.3	1.1	0.7	1.7	2.0	15.7	43.4	35.4	sicl
	*IIB'22tx	32-40	1.6	6.7	1.0	1.0	2.4	2.8	14.7	38.3	39.8	sicl
	IIB3t	40-54+	1.7	10.3	3.3	2.8	5.4	4.8	15.5	35.5	32.7	sicl
5	Ap	0-8	-	0.7	1.6	1.1	1.5	1.8	25.6	53.0	15.4	sil
	B1t*	8-10	-	0.4	1.6	0.7	1.0	1.2	19.3	50.4	25.8	sil
	B21t	10-16	1.4	1.5	1.5	0.8	1.2	1.4	19.0	48.4	27.7	sicl
	B22t*	16-21	1.4	2.0	2.2	0.9	1.5	1.7	20.4	45.4	27.9	sicl
	A'2x	21-26	1.6	1.5	2.2	1.0	1.7	2.1	21.2	45.4	26.4	sil
	B'21tx	26-35	1.6	1.3	1.5	0.8	1.8	2.1	18.4	41.4	34.0	sicl
	IIB'22tx	35-42	1.4	1.7	1.2	0.8	1.5	1.9	13.7	34.7	46.2	sic
	IIB31t	42-52	-	1.0	1.5	1.4	2.6	3.4	12.9	30.1	48.1	sic
	IIB32t	52-60+	-	4.1	3.7	2.8	4.2	4.7	12.0	26.5	46.1	c

+Based on total soil sample.

*Single determinations were made on these horizons.

progressively decrease with depth, the coarse silt generally being about one-half the quantity of the fine silt (0.02 to 0.002 mm.).

Clay content increases with depth, from 10 to 15 percent in the surface soil to 40 to 50 percent in the buried soil.

Chert fragments greater than 2 mm. are significant mainly in the soil at site 3, amounting to more than 20 percent by weight of the total sample in the B2 and IIB horizons.

Bulk density measurements of moist fragments (assumed to be at field capacity) are shown in Tables 2, 3, and 4. The values increase with depth--from about 1.5 in the surface soil to 1.7 grams per cc. in the lower horizons. A slight decrease in B.D. is depicted in the site 5 profile at the lowest depth sampled. B.D. values on the fragments oven-dry were 0.05 to 0.1 units higher.

Some chemical properties of the five soils sampled are presented in Tables 5, 6, and 7. The active acidity ranges from strongly acid in the surface soils to very strongly acid in the B horizons. There was a decrease in pH values to the lower part of the solum but a slight increase (0.2 to 0.4 pH unit) in the buried horizons. Values were below 4.5 when pH was determined in a salt solution. The leaf litter layer of sites 1, 2, and the A horizon of site 3 (a recently limed pasture field), were slightly acid to neutral in reaction.

The cation exchange capacity of the various layers was low or less than 15 in most cases. The C.E.C. values ranged from 7.0 me. per 100 grams of soil in the A horizons to 10 in the B horizons and 12 to 14 in the lower layers, generally below a depth of 30 inches.

Table 5.--Some chemical properties of Crider silt loam in Robertson County, Tennessee.

Site no.	Horizon	Depth (in.)	pHw	pHs	Organic matter (%)	Total nitrogen (%)	C.E.C. me./100 g.	Exch. cations Ca (me./100 g. soil)	Mg	K	Base sat. (%)	Fe_2O_3 (%)	P (ppm)
2	02,1	2-0	6.5	-	-	--	-	--	--	--	--	-	-
	A1	0-2	5.4	4.4	2.4	0.104	7.6	2.00	0.47	0.39	37.6	-	<1
	A2	2-6	5.1	3.6	1.2	0.063	5.5	0.63	0.03	0.22	16.0	1.2	tr.
	B1t	6-11	4.6	3.4	0.8	--	5.9	0.22	0.02	0.23	8.0	-	tr.
	B21t	11-22	4.6	3.4	0.6	0.039	9.3	0.53	1.30	0.30	22.9	2.3	tr.
	B22t	22-25	4.7	3.4	0.3	0.028	9.2	0.62	1.19	0.23	22.2	2.4	tr.
	B3t	25-32	4.7	3.3	0.2	--	9.7	0.51	0.86	0.22	16.4	-	tr.
	IIB21tb	32-44	4.8	3.2	0.2	--	10.6	0.53	1.16	0.21	17.9	3.5	tr.
	IIB22tb	44-56	4.9	3.2	-	--	9.6	0.58	1.13	0.19	19.8	-	tr.
	IIB23tb	56-74+	5.0	3.3	-	--	10.2	0.66	0.61	0.26	15.0	6.3	tr.

Table 6.--Some chemical properties of Mountview silt loam in Robertson County, Tennessee.

Site no.	Horizon	Depth (in.)	pHw	pHs	Organic matter (%)	Total nitrogen (%)	C.E.C. me./100 g.	Exch. cations Ca (me./100 g. soil)	Exch. cations Mg (me./100 g. soil)	Exch. cations K (me./100 g. soil)	Base sat. (%)	Fe_2O_3 (%)	P (ppm)
1	02,1	½-0	6.7	–	-	--	-	--	--	--	--	--	-
	A1	0-2	5.1	3.5	4.3	0.124	7.8	0.42	0.38	0.26	13.6	--	<1
	A2	2-7	4.8	3.5	2.0	0.056	4.6	0.01	0.14	0.14	6.3	1.0	tr.
	B1t	7-11	4.8	3.4	1.1	--	7.3	0.32	0.04	0.14	6.8	--	tr.
	B21t	11-19	4.7	3.2	0.7	0.038	10.5	0.37	0.86	0.17	13.3	--	tr.
	B22t	19-27	4.7	3.2	0.3	0.028	11.0	0.26	0.88	0.15	11.7	2.5	tr.
	B3t	27-34	5.0	3.1	0.3	--	12.0	0.22	0.90	0.14	10.5	3.2	tr.
	IIB21tb	34-44	4.9	3.1	-	--	10.2	0.20	0.52	0.10	8.0	3.5	tr.
	IIB22tb	44-55+	5.0	3.1	-	--	12.4	0.10	0.66	0.06	6.6	4.9	tr.
3	A1	0-2	7.0	6.0	3.1	0.129	7.6	4.64	0.42	0.46	72.6	--	3
	A2	2-8	6.1	4.9	1.4	0.055	4.5	1.62	0.01	0.32	43.3	1.1	<1
	B1t	8-11	5.8	4.2	1.2	--	6.7	1.83	0.42	0.40	39.6	--	tr.
	B21t	11-17	4.6	3.3	0.6	0.040	9.8	0.63	0.51	0.41	15.8	--	tr.
	B22t	17-23	4.7	3.3	0.5	0.035	9.4	0.49	0.65	0.35	15.9	2.4	tr.
	B23t	23-28	4.7	3.1	0.2	--	10.3	0.17	0.90	0.20	12.3	2.7	tr.
	IIB21tb	28-38	4.8	3.2	0.2	--	12.8	0.14	0.54	0.14	6.4	3.4	tr.
	IIB22tb	38-54+	4.9	3.1	-	--	12.2	0.09	0.86	0.10	8.6	3.9	tr.

Table 7.--Some chemical properties of Dickson silt loam in Robertson County, Tennessee.

Site no.	Horizon	Depth (in.)	pHw	pHs	Organic matter (%)	Total nitrogen (%)	C.E.C. me./100 g.	Exch. cations Ca (me./100 g. soil)	Mg	K	Base sat. (%)	Fe_2O_3 (%)	P (ppm)
4	Ap	0-9	4.9	3.6	1.4	0.070	5.1	0.66	0.01	0.28	18.6	1.3	3.0
	B2t	9-18	4.9	3.3	0.4	0.033	10.3	0.66	0.21	0.12	9.6	2.4	tr.
	A'2x	18-24	4.4	3.3	0.2	0.022	10.1	0.17	0.82	0.08	10.6	2.5	tr.
	B'21tx	24-32	4.5	3.2	0.2	--	12.1	0.09	1.08	0.08	10.7	-	tr.
	IIB'22tx	32-40	4.5	3.3	0.2	--	12.9	0.14	1.16	0.06	10.5	4.9	tr.
	IIB3t	40-54+	4.7	3.2	-	--	7.8	0.07	0.73	0.04	10.8	4.0	tr.
5	Ap	0-8	6.4	5.1	1.6	0.083	6.2	2.95	0.01	0.10	49.4	1.5	2
	B1t	8-10	4.6	3.5	0.6	0.043	8.8	1.87	0.02	0.12	22.8	-	<1
	B21t	10-16	4.5	3.4	0.4	0.029	10.1	1.43	0.04	0.13	15.8	-	tr.
	B22t	16-21	4.4	3.1	0.3	0.025	10.1	0.97	0.62	0.14	17.1	2.5	tr.
	A'2x	21-26	4.4	3.2	0.3	--	9.1	0.71	0.63	0.11	15.9	2.5	tr.
	B'21tx	26-35	4.5	3.1	0.2	--	12.2	0.41	0.78	0.15	11.0	-	tr.
	IIB'22tx	35-42	4.6	3.0	0.2	--	14.8	0.24	1.04	0.13	9.5	4.1	tr.
	IIB31t	42-52	4.6	3.1	-	--	14.6	0.28	1.06	0.10	9.9	6.6	tr.
	IIB32t	52-60+	4.5	3.1	-	--	12.2	0.35	0.44	0.09	7.2	5.5	tr.

The exchangeable cations were generally less than one me. per 100 grams of soil. However, calcium ranged from more than 1.0 me. in the A horizons at sites 2, 3, and 5 to less than 0.1 me. in the lowest horizons sampled. The general range for exchangeable magnesium was 0.5 to 1.0 me. However, Mg did range above 1.0 me. in the B and IIB horizons at site 2, and B'2 and IIB's at sites 4 and 5. Of the exchangeable cations determined, potassium was lowest, being in all cases less than 0.5 me. per 100 grams of soil.

Base saturation was somewhat lower in the surface soil at the farm woodland sites (1 and 2) than those located in open fields. The percent base saturation ranged in value from 40 to less than 20; generally, content of bases decreased with depth.

Available phosphorus content was very low at all sites, ranging from 3 to less than 1 ppm, or only a trace in most lower horizons.

Percent easily-oxidizable organic matter ranged from 4.0 in the surface soil to about 0.5 percent in the lower parts of the solum. The percent organic matter decreased rapidly below the solum to values of less than 0.25 percent.

Total nitrogen values were all less than 0.2 percent in the A horizons and less than 0.05 percent in the B horizons. The C/N ratios varied from more than 15 in the A horizons to less than 10.0 in the B horizons.

Free iron oxides showed greatest accumulation in the horizons below 40 inches at sites 1, 2, and 3. At sites 4 and 5, accumulation increased to the 40-inch depth and decreased below. The range in values was from 2 percent in the sola to 6 percent Fe_2O_3 in the layers below the sola. The ratio of free iron oxide to clay was roughly uniform throughout the various layers, ranging from 0.09 to 0.10.

Of the light minerals studied (specific gravity of less than 2.95) quartz was predominant, with potassium feldspar ranging up to 6 and 7 percent. The percent K feldspar decreased with depth to less than 1 percent or only a trace at the lowest sampled layers. The B horizons contained a slightly larger amount of K feldspar than did the A horizons.

Results of the light mineral count are presented in Table 8. Heavy minerals retained after centrifuging the coarse silt fraction in a heavy liquid of density 2.95 varied from 1.0 to 1.5 percent. The B2, A'2, and IIB'2 horizons contained less heavy minerals than did the A horizons or the bottom layers.

Cherts in the fine sand fraction varied from 10 percent in the solum to 20 in the buried soil at sites 1 and 2. There were more chert fragments in the fine sands of soils at sites 3, 4, and 5; the contents ranging from less than 20 percent in the solum to more than 40 percent in the substratum.

Table 8.--Some minerals in the coarse silt and fine sand fractions of Mountview, Crider, and Dickson soils.

			0.02-0.05 mm silt		0.10-0.25 mm fine sand
Site no.	Horizon	Depth in inches	% heavy minerals (spec. grav. > 2.95)[a]	% potassium feldspar[b] in light minerals	% opaque chert[c]
1	A2	2-7	1.1	6.3	9
Mount-	B21t	11-19	1.4	7.6	--
view	B22t	19-27	1.4	5.4	15
	B3t	27-34	1.0	2.3	--
	IIB22tb	44-55+	1.1	<1.0	20
2	A2	2-6	1.3	6.1	7
Crider	B21t	11-22	1.1	10.4	--
	B22t	22-25	1.1	6.8	8
	B3t	25-32	1.2	2.8	--
	IIB22tb	44-56	1.5	<1.0	10
3	A2	2-8	-	4.3	16
Mount-	B21t	11-17	1.5	3.8	--
view	IIB22tb	38-54	1.4	1.9	43
4	B2t	9-18	-	3.7	18
Dick-	A'2x	18-24	1.4	2.0	--
son	IIB'22tx	32-40	1.2	<1.0	37
5	Ap	0-8	1.1	6.1	31
Dick-	B21t	10-16	-	5.1	--
son	B22t	16-21	1.6	4.4	--
	B'21tx	26-35	1.1	3.1	43
	IIB31t	42-52	1.8	1.9	--
	IIB32t	52-60	-	<1.0	46

[a]Percent of 2 g. sample.

[b]Percent of 500 grain count, remaining percent predominantly clear quartz crystals.

[c]Percent of 200 grain count; of the count --7-10% of the particles at sites 1 and 2, and 20-30% of the particles at sites 3, 4, & 5 were coated with Fe_2O_3 or were concretionary. The remaining percent was quartz.

Discussion

The well-drained Mountview and Crider soils are on gently sloping and rolling topography which is dissected by dendritic shaped drainage ways. They lie on ridge crests and convex slopes that are inclined from 3 to 10 percent. Wascher et al. (29), in tracing loess thickness from western to middle Tennessee, did not detect much loess on slopes greater than 4 to 6 per cent on the western side of the Highland Rim. On slopes of 10 to 12 percent and greater, erosion is generally so severe that little or no loess remains and much cherty, fine textured soil (classified as Baxter) is exposed.

The moderately well drained Dickson soils are on more level parts of the landscape in relation to the well-drained members, generally on slopes of less than 5 or 6 percent. However, they may be on steeper slopes, at the head of drainage ways, or near the base of slopes. Dickson soils normally lie on more level parts of a ridge with Mountview on the sloping fringes. Frequently they lie lengthwise or parallel on finger-ridges. Cherty Baxter and Bodine soils occupy the side slopes below the Mountview and Dickson soils.

Profiles of sampled Mountview, Crider, and Dickson soils are similar. However, the colors of the well-drained soils are redder in hue than are the moderately well drained soils. Crider is lower in chroma than Mountview and Dickson. Variegations of strong brown, dark brown, yellowish-red, and red colors are common in the B3 and IIB horizons of the well-drained soils. These variegations may be attributed to contact mottling of the silty over the clayey materials. Mottling of yellowish-brown, strong browns, and grays are common in the moderately well drained Dickson soils. The mottles result from drainage restrictions. The upper part of the solum (A & B horizons) is medium-textured at all sites. The soils are medium to high in available water-holding capacity and have 6 to 9 inches of available water (13). Friable consistence ratings correlate with 1.45 bulk density values and firm with 1.65. Aeration and permeability to a depth of 24 to 30 inches are sufficient for root penetration and growth of most plants.

The Crider soil at site 2 was nearly free of fragments greater than 2 mm. Most horizons contained less than 1 percent. However, the soils at sites 1, 4, and 5 ranged up to 5 percent coarse fragments. Only at site 3 were chert fragments prominent. In the lower parts of the solum, some horizons had more than 20 percent.

Sand content is rather uniform to a 40 inch depth in the soils, and is indicative of thorough mixing by tree fall, animals, mechanical manipulation, etc. Particle size composition for the five soils is presented in Figure 5. Sand-sized separates consist mainly of quartz, opaque cherts, and concretionary materials. The chert particles and resistance quartz minerals are presumably impurities from weathered limestone or are of alluvial origin. Concretions in the Dickson soils are evidence of drainage impedance.

The silt fraction, major component of upper sola and bisequal

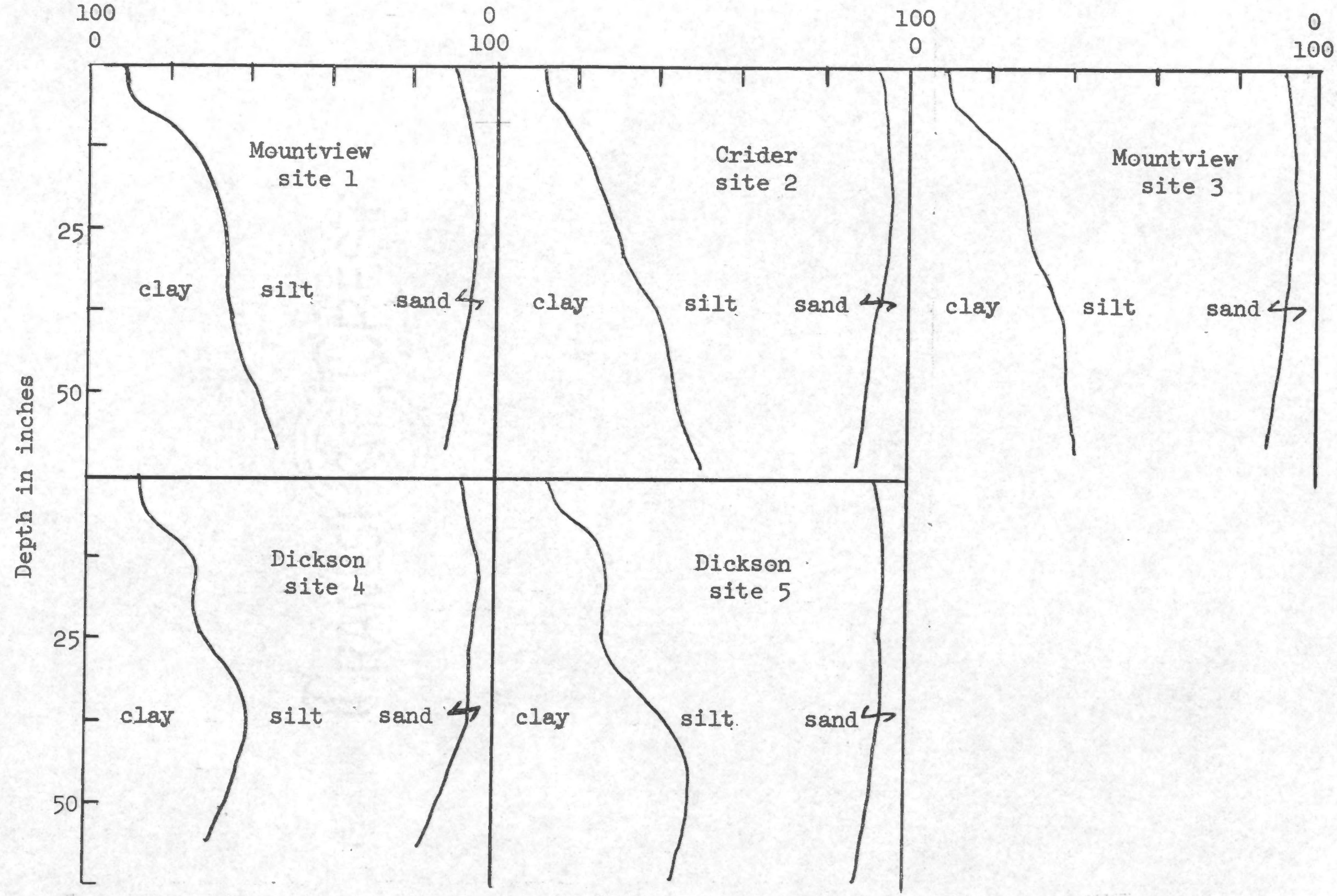

Figure 5--Particle size composition in percent for five soils in Robertson County, Tennessee.

sola, decreases uniformly from 80 percent in the A horizons to 50 percent at depths of 55 inches. The ratio of fine silt to coarse silt remains fairly constant to depths of about 40 inches, indicating uniform mixing of these two constituents that are apparently from a common source.

Smith, in Illinois (23), found a decreasing coarse silt/fine silt ratio with increasing distance from the bluffs. Coarse silt/fine silt ratios of 1.0 for Dyer in the western part of the state, 0.45 for Robertson and Lawrence, and 0.35 for Putnam and Coffee Counties were obtained.[1] This information as presented in Figure 6 agrees with Smith's demonstration (23) of a linear relationship between particle size decrease of the silt fraction and log of the distance from the source of loess.

The time of loess deposition for the late Wisconsin glacial stage of the Pleistocene is set at less than 15,000 years (4), through radio carbon dating technique, in Mid-western states. Since this period, the upper layers of the silt blanket have undergone intensive weathering. A warming trend to 6,500 years ago was cited by Ruhe and Scholtes (18), through study of the forest-prairie transition region. It might be expected that weathering has slowed down due to cooler temperatures some since that time.

The amount of loess deposited before much weathering occurred

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[1]Calculated from published Soil Survey reports for the respective counties, except for Dyer, Robertson and Putnam which are from unpublished data.

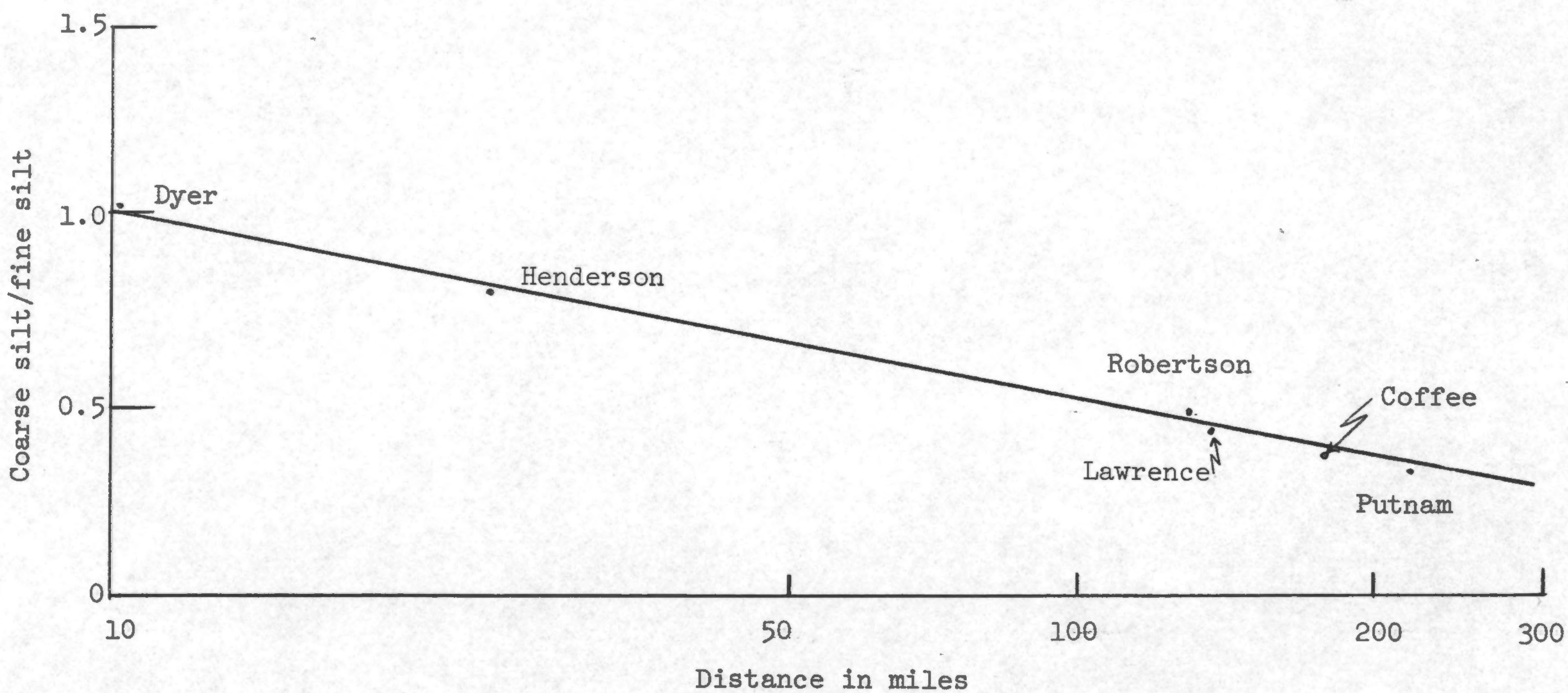

Figure 6--Particle size relationship to distance from the Bluffs.

is a matter of speculation. Wascher, et al. (29) in marking approximate depths of 10, 7, 5, and 4 feet of Peorian loess east of the Mississippi River, found them roughly parallel but the 3 and 2 feet depth lines did not parallel the others. Although they found the 3 and 2 foot depth loess layers more highly weathered than the 10 to 4 foot layers, they did not find as much erosion in the fringe area in which lies the Highland Rim. So, there is reason to believe that the existing loess blanket on level topography is little thinner than when deposited during the latter Wisconsin Period of the Pleistocene Era.

A lithologic discontinuity is indicated in particle size accumulation in Figures 7 and 8. There is uniformity of the silty textural component of the A to IIB21 horizons in Crider and Ap to B'2 in Dickson. The homogeneous textural composition of these upper solum horizons is indicative of inheritance from a common source of parent materials. The aeolian origin of the parent material has been demonstrated by the coarse silt/fine silt pattern extending from the bluffs to the Highland Rim. A different textural makeup for the buried soil is expressed by less uniform composition of the silt and sand constituents, represented by curves for the lower IIB2 and IIB3 horizons. These horizons include more sand than the upper solum or layers above approximately 44 inches.

The fairly constant ratios of fine sand with depths suggests that the sands came from the substratum. In relation to these sands, silt increases rapidly to about 10 inches, then decreases progressively to about 40 inches where it is fairly constant with greater depths. The

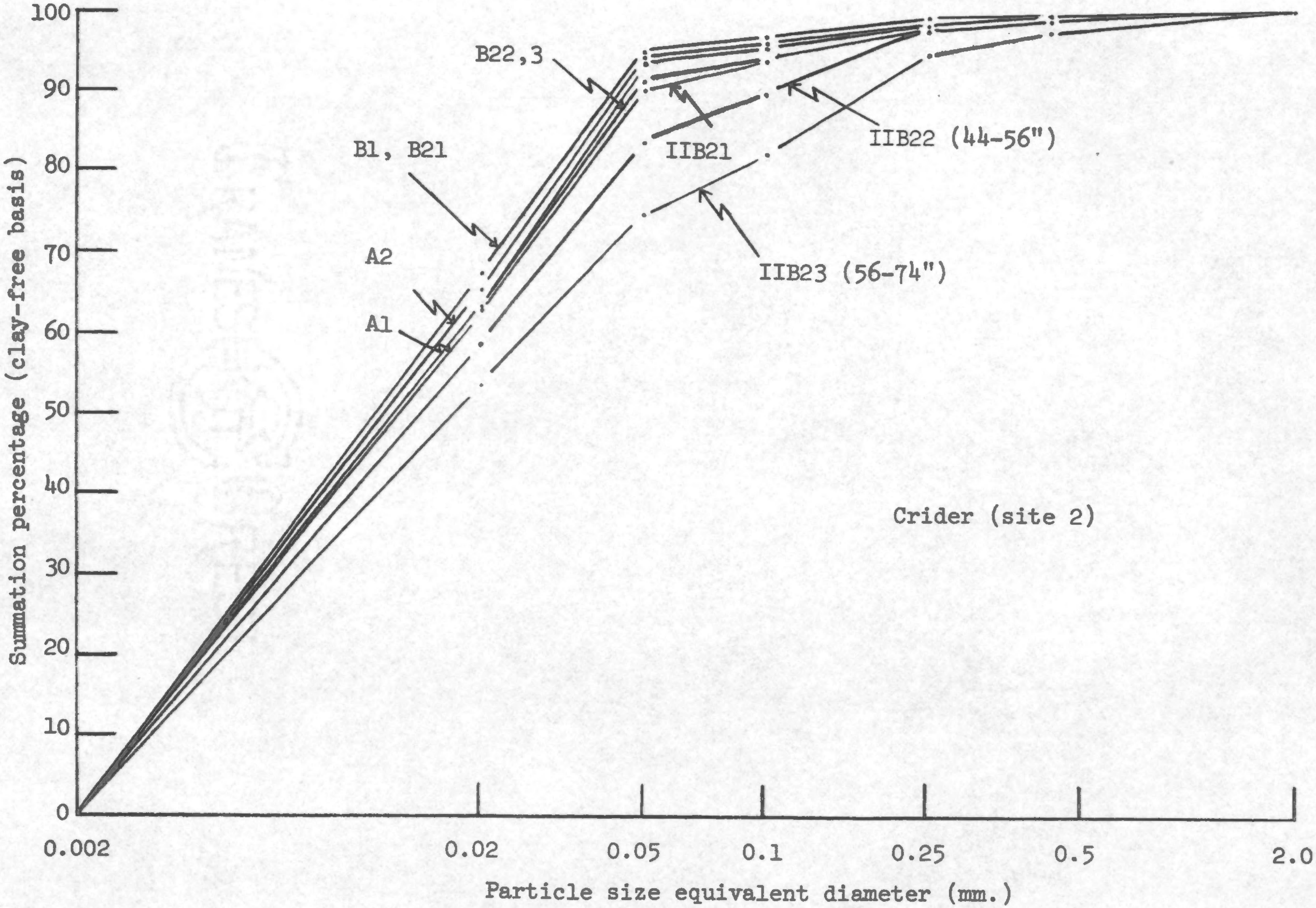

Figure 7--Accumulation of silt and sand sized particles in horizons of Crider silt loam.

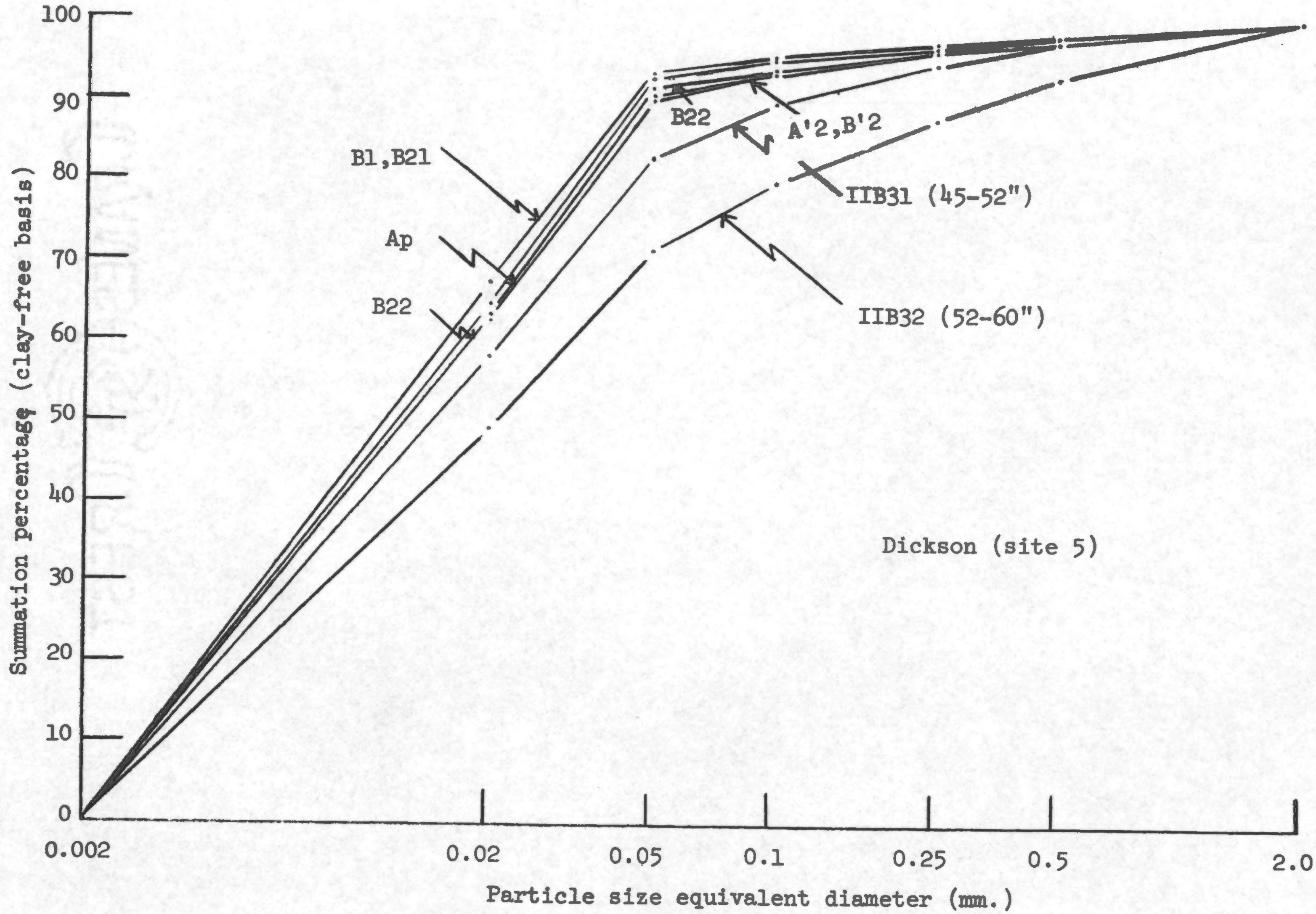

Figure 8--Accumulation of silt and sand sized particles in horizons of Dickson silt loam.

influence of the silty mantle on the solum is depicted in Figure 9. Loess influences the genetic makeup of the Mountview, Crider, and Dickson soils in Robertson County to approximately 40 inches. On similar soils in Putnam County, Gass (6) found loess influence to about 30 inches.

The average thickness of loess *per se* involved in formation of these soils is estimated to have been about 25 inches. A comparison was made of silt/fine sand ratio in the substratum to that in the upper part of the soil. It has been demonstrated that the sand came from the substratum and it is assumed that the sand admixture to silt of the solum was in the same proportion as in the substratum. The removal of this silt/fine sand ratio component from the upper 40 inches of solum leaves about 25 inches of silt. The silt blanket could have been thicker since erosion may have removed some of the surface soil.

That the soils are of a polygenetic nature is further supported by greater amounts of weatherable potassium feldspar minerals in the solum than in the buried B horizons. That the minerals were not inherited from the lower layers is verified by an inverse relationship with depth. A count of potassium feldspars revealed an increased content in B over A horizons, then a progressive decrease with depth. The mineralogical composition of the coarse silt fraction consists predominantly of clear quartz crystals with some opaque chert fragments. The decrease in content of K feldspars with depth is similar to results obtained by Gass (6) on Mountview and Holston soils on the eastern side of the Rim. The stained areas on the K feldspar decreased in size and distinctness with depth.

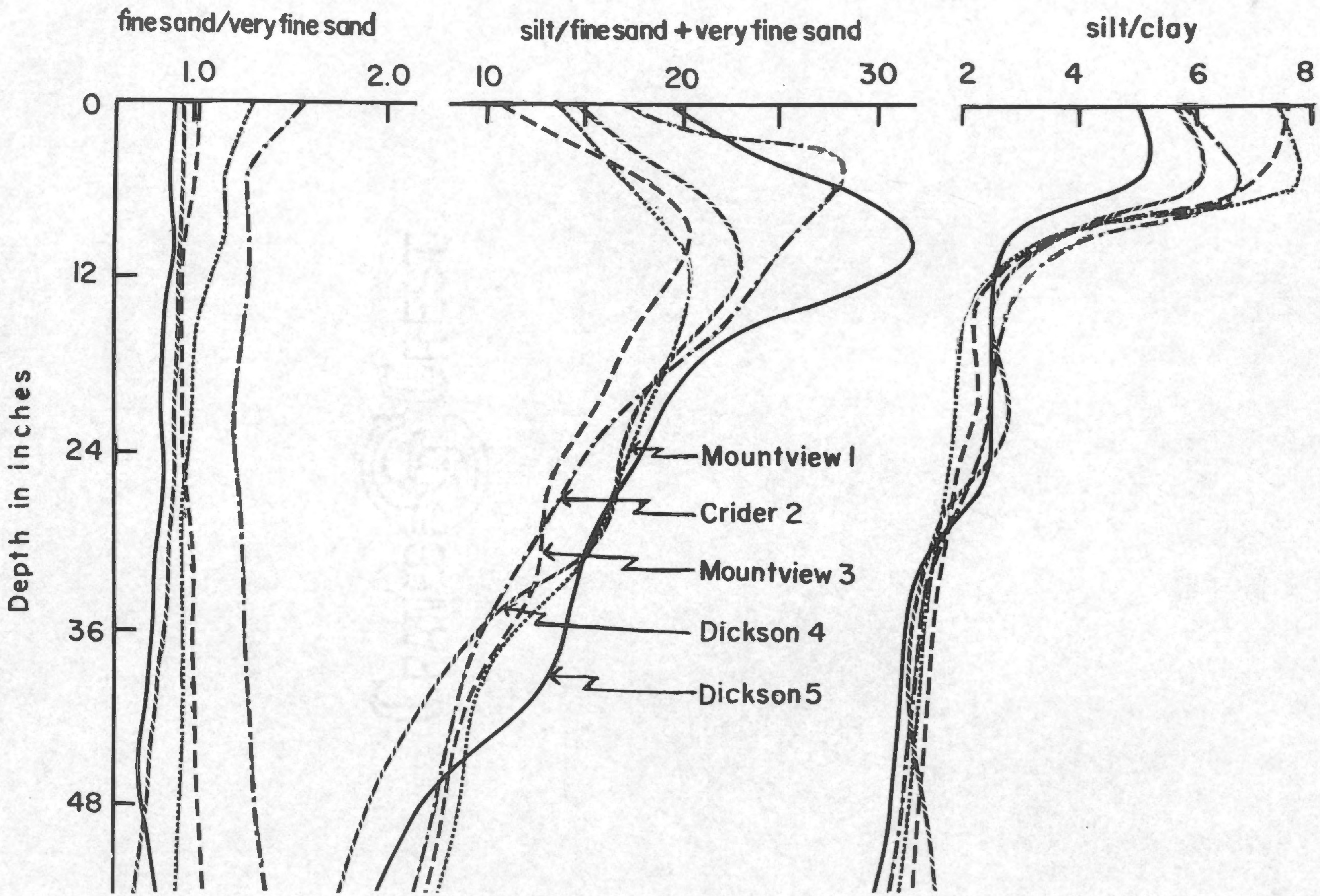

Figure 9--Ratios of certain sized particles in 5 soils of Robertson County, Tennessee.

The ratio of silt to clay decreases rapidly at 8 to 10 inch depths as depicted in Figure 9. Silt remains in the surface as clay moves into the B horizon. Sand is rather uniform through these two horizons, although some greater in the A than in the B horizon. This may be due to upward movement of coarse particles by mechanical manipulation, i.e., freezing and thawing, rodents, cultivation, etc. Silt is less in upper A and lower B in relation to sands than in the B1 and B21 horizons. Some weathering of fine silt in the A horizon may contribute to this difference. Also, this feature may be attributed to more sand in A than in B horizon. Some downward movement of the fine silt component may contribute to a greater amount of silt in B1 and B21 than above or below. However, it is to be expected that considerable amounts of fine silts have weathered into clays in the zone of illuviation, so this would offset any fine silt that has moved into the B horizon.

The bisequal nature of the Dickson soil is observable in the field but does not lend itself to verification by laboratory measurements of bulk density. The Mountview layers equivalent to the fragipan zone appear just as dense and compact as those in Dickson. There was evidence of some fragipan development in the Dickson soils sampled, although not as much as in most moderately well-drained soils. Seepage of water out of the face of the pit over A'2 and B'21 horizons at sampling time indicated movement of water over a dense compact layer, which apparently restricts drainage. It might be added that the fine sand/very fine sand ratio was less in the Dickson than in the other soils. The finer sands plus usual silt content may restrict drainage and favor pan development in Dickson more so than in Mountview soils.

In the Dickson soil at site 5, polygonal-shaped gray silty seams were observed to extend downward through the pan zone. Grossman, et al. (7), in Illinois, added such morphological features to the definition of fragipans: a polygonal network of gray silt loam extends downward from the A'2 horizon and delineates prismatic structural units in the lower sequum of a bisequal solum.

Clay accumulation is evident at about 12 to 18 inches and at depths of 40 inches or more. The first concentration of clay may be attributed to eluviation from the A horizon and illuviation in the B horizon. Movement of clay into the B2 and buried B horizons is evident by clay films increasing in thickness and coverage with depth of the three well-drained soils. However, clay content in the two moderately well drained soils remains fairly constant in the B2, and A'2 horizons. There is a slight decrease in the latter zone.

The greater amount of clay in the lower sola, below 40 inches, is believed to have been well developed before the Wisconsin stage or before fresh silty materials were laid down on the present buried soil. Some mineralogical studies on the clay fraction might contribute further toward understanding of the polygenetic nature of these soils. The buried soils are presumed to have been formed long before the deposition of loess. It is reasonable to assume that much more weathering has taken place in the buried soil, even if it is of alluvial deposition, because of longer exposure to weathering than the loess. The properties of high clay content, extremely leached condition of basic cations, and accumulation of iron oxides--all much greater than in the upper part of the solum are evidence of much older layers in the buried soils.

Although there is significant variation within the physical properties of these soils, differences in chemical properties are of less significance, e.g., active acidity is high in all horizons (where not influenced by recent liming and/or fertilization), exchangeable cations and exchange capacities are low and similar at all sites, except for the Crider. In horizons below the B1, cation exchange capacity increased with depth and was directly correlated with clay content. Higher CEC values in the A1 than in the A2 and B1 horizons may be attributed to a higher content of organic matter in the surface horizons.

Exchangeable calcium varied inversely with depth in the profile and magnesium varied directly with depth. Calcium decreased from 4 to less than 0.10 and magnesium increased from about 0.10 to more than 1 me. per 100 grams of soil. Low Ca/Mg ratios in the B22 and buried B horizon, due to leaching of the basic cations, indicate rather advanced stages of weathering in these horizons.

The Ca/Mg ratio was somewhat higher for the Crider soil than for the Mountview or Dickson soils. It did not drop below a ratio of 0.5; the others dropped to values of 0.1 and 0.2. This would indicate less weathering in the Crider than in the other soils. The Ca/Mg ratios for similar soils in the B22 and buried soils as found in the Pennyroyal region of Kentucky are considerably higher, generally above one, and base saturation is more than 30 percent for these same horizons.[2] There was some increase in Ca/Mg ratio in the deepest layers at sites 2 and 5. This is due to lower content of Mg than Ca in the lower buried soil.

Exchangeable potassium was rather uniform with depth at all sites. However, it decreased slightly from 0.5 to less than 0.25 me. per 100 grams of soil. Magnesium apparently accumulates in the lower B horizon and upper buried soil. Base saturation decreased appreciably with depth, to less than 10 percent at most sites. However, at site 2, it remained above 20 percent in the B2 and did not decrease below 15 percent in the buried B.

Free iron oxide increased with depth and was well correlated with clay content. The ratio of iron oxide to clay was rather uniform through the profiles. It is assumed that the oxides moved down with the clay and accumulated in the lower horizons, as well as forming in place. The ratios obtained from this study were quite similar to those obtained for like soils in Coffee County[3] on the eastern portion of the Rim.

Heavy concretaionary materials in the coarse silt and fine sand fractions of the Dickson soils, resulted from drainage impedance in

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[2]Personal correspondence with H. H. Bailey, Assoc. Prof. of Agronomy, University of Kentucky.

[3]Soil Survey Laboratory. Characterization report of selected soils from Coffee County, Tennessee, S.C.S., U.S.D.A., Beltsville, Md., 1959.

these soils. Also notably conspicuous were heavy amorphous coatings and iron stains in the fragipan as well as in the fine textured substratum.

An increase of opaque chert particles at the expense of clear quartz crystals signals the influence of impurities from residual substrata on the sola. The percentage of chert to quartz was insignificant in the fine sand fraction at sites 1 and 2 but was considerably larger at the other locations, up to almost 50 percent of the fine sand in the lower solum. Also, the total sand content below 40 inches was greater at sites 3, 4, and 5 than at 1 and 2. There was some correlation of fine sand chert fraction with percent of fragments greater than 2 mm. The increase of chert to quartz suggests influence of residual limestone impurities on the lower B, B' and buried B of Mountview and Dickson soils at sites 3, 4, and 5. However, the derivation of substrata of Mountview 1 and Crider from the weathering of limestone formations is not evident from these studies.

The heavy mineral fraction shows no pattern of distribution with depth. Identification of the heavy mineral suite would add further information to the origin and nature of these polygenetic soils.

The placement of these soils in a classification system hinges on how well they meet the criteria set up for the respective series. Soil series differentiae are expected to meet two requirements as set forth in the Seventh Approximation (25). First, the properties used as differentiae are observable or can be inferred with reasonable assurance. Second, the properties used have at least limited significance to soil genesis. For soils with evident genetic horizons, the properties of the solum below plow depth are given most weight. In this case, the diagnostic horizon would be the argillic horizon and is given considerable attention. The upper part of the solum is attributed to development in silty parent materials of aeolian origin. Bisequal profiles are observed to have fragipan development in the second sequum. Buried soils are recognized through study of lithologic discontinuities. So the polygenetic makeup of the soils is partially accounted for, in addition to the formation and nature of the upper part of the solum.

A Soil Series is defined as, "A group of soils having horizons similar as to differentiating characteristics and arrangement in the soil profile, except for the texture of the surface soil, and developed from a particular type of parent material" (3). The described profiles and sampled horizons of the soils under study are quite similar as to differentiating properties in relation to the respective series, especially in the upper parts of the sola. For the Mountviews, the colors range from yellowish-brown to strong brown in the B horizon of silt loam to silty clay loam textures. Variegated bright colors are not reached at depths of less than 26 inches. The Crider soils are redder in hue and lower in chroma than the Mountview. Also, the B horizon is darker brown and more silty to a greater depth in Crider than Mountview. The Dickson, similar to Mountview in the upper solum, is yellowish-brown in the B horizon and silty to at least 26 inches. However, a mottled fragipan is below 24 inches and extends down about 20 inches into the buried soil.

With chemical properties being similar, it might be questionable as to whether the differences in physical properties warrant separating the Crider and Mountview soils at the series level. However, it is suggested that because of a larger silt component to mid-B horizons and relatively chert-free substrata, in Crider compared to Mountview, the separation is important. Also, slightly higher base saturation and Ca/Mg ratios in Crider than Mountview lends support to separating the two series.

The differentiating characteristics for series range from practical usage to pedogenic processes (17). The difference is greater when the potential or use of Crider is compared to Mountview because of greater available moisture holding capacity for crops and deeper permeable, relatively chert-free medium for engineering uses.

The question of the Mountview-Dickson soils is one pertaining to a drainage problem. Mountview is the well-drained member of a catena that may range in drainage down to the poorly drained Guthrie. The fragipan in Dickson may affect the use of this soil for certain crops, e.g., alfalfa. However, it is believed that the incipient fragipan as observed in the Dickson under study, will not affect significantly the use of this soil for most crops or for engineering purposes. So the separation narrows down to one of a pedogenetic nature, based on the morphological characteristics peculiar to each soil. In this case, the beginning of a fragipan is evident in the Dickson sites and must be recognized. It is believed that these characteristics are sufficiently different to justify separation at the series level. These soils meet the criteria of their respective series when profiel descriptions are compared to the official series descriptions.

However, placing these soils according to the Seventh Approximation (25) is more exacting and quantitative in nature. Laboratory data, e.g., percent base saturation, clay mineralogy, and percent organic matter, are more useful in terms of the new soil classification scheme. The questionable soil in this study was Crider. Would the colors qualify--surface less than value of 4 and argillic horizon redder than 5 YR for Typic Rhodudults (8.220) or base saturation above 35 percent to qualify for Alfisols-Order 7? The Crider soil, as observed in Robertson County, does not qualify for either classification but falls within Typic Normudults (8.230), the same category as does Mountview (see Appendix). However, Crider may be placed more properly in Alfic Normudults, since base saturation is about 20 percent and color of the A horizon is darker (often found with value of less than 4) than normal for most Typic Normudults on the Highland Rim.

CHAPTER V

SUMMARY AND CONCLUSIONS

Field and laboratory studies were conducted on three well-drained and two moderately well drained soils. Transects were made across soil associations, individual sites selected, five profiles described, and horizons sampled in Robertson County. Physical properties were determined from the face of pits. Mountview 1 and Crider were near modal for the series. The Mountview at site 3 was more cherty in the B2 horizon than normal for the series. Fragipan development was minimal for Dickson at sites 4 and 5. Also, the pan was shallow at site 4 for modal Dickson soil.

Some physical, chemical, and mineralogical determinations were made on collected soil samples to supplement and confirm field studies. Particle size distribution studies revealed several significant factors contributing toward the polygenetic nature of these soils and the influence of a silty (loess) mantle. A lithologic discontinuity in the soils at about 40 inches is evident by the uniformity of silt-sized particles of the A and B horizons, and mixture of the buried B which contains definitely more sand and clay sized particles. The ratio of silt to fine sand plus very fine sand increases rapidly to 10 inches, then decreases with depth to about 40 inches, where it is fairly constant with greater depths. The ratio of fine sand to very fine sand is relatively uniform with depth, indicating derivation from a common source. Silt related to the fine sands shows loess influence on the solum to about a depth of 40 inches.

That the solum is of loessial origin is substantiated by the ratio of coarse silt to fine silt, which fits into the pattern of decreasing silt-sized particles from West Tennessee bluffs to the eastern side of the Highland Rim--a linear relationship between decreasing particle size and log of the distance from the source of loess (23). Mineralogical determinations on light minerals of the coarse silt fraction reveal a large percent of resistant quartz minerals. A count of potassium feldspars showed a decrease in content with depth. The presence of greater amounts of these weatherable minerals in the A and B horizons than in the lower sola or buried soil confirms the theory of loess or fresher parent materials.

That the buried soils are older, more highly weathered and leached than the upper solum is verified by much higher clay content, leached of basic cations with lower base saturation, and a higher accumulation of iron oxide. The increase with depth of chert fragments in relation to quartz minerals, up to 50:50 in the fine sand fraction, suggests development in residual limestone formations of the buried soils at sites 3, 4, and 5. However, further investigation of a mineralogical nature on the fine-textured substratum would provide more substantial evidence as to the nature and influence of these materials on the solum.

Chemical determinations gave similar results among these soils. All show much evidence of leaching and weathering, especially the buried B horizons, which is to be expected under existing climatic conditions favorable for formation of Red-Yellow Podzolic soils. However, Crider proved to be less weathered than Mountview and Dickson soils with slightly higher Ca/Mg ratios and base saturation. Below the A horizon all soils were very acid, low in CEC, exchangeable cations, and base saturation. Some A horizons showed evidence of liming and/or fertilization.

Characterization of these soils shows that they meet the differentiating criteria for their respective series. The properties observable in the field were further supplemented by laboratory measurements. Although these profiles show similarities in morphology, chemical properties and genesis, differences in their physical properties justify separation at the series level. A slightly higher Ca/Mg ratio and base saturation in Crider compared to the Mountview Series favors separation of these soils. Evidence of fragipan development in the Dickson justifies separation from the Mountview Series.

It is anticipated that this investigation will aid in proper placement of two most extensive soils (Mountview and Dickson) and one less extensive but more agriculturally important soil (Crider) on the Highland Rim in the classification system. Also, the aim is to provide information about the characteristics of these soils so that more accurate predictions may be made regarding the behavior and response of Mountview, Crider, and Dickson to various land uses.

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APPENDIX

Placement of Mountview, Crider and Dickson soils according to Seventh Approximation Criteria of December, 1964.

Ultisols: Order 8

Ultisols are mineral soils that lack oxic or spodic horizons. These soils do not have plinthite that is not indurated and that forms a continuous phase, or that constitutes more than half of the matrix, within 125 cm. (50 inches) of the surface if the dominant chroma in all horizons overlying the plinthite is 2 or less. These soils - -

1. Have a fragipan that (a) has clay skins more than 1 mm. thick in some part or (b) is in or below an argillic horizon; and has base saturation of less than 35 percent at a depth of 75 cm. (30 inches) below the upper boundary of the pan; or,

2. Do not have a fragipan, are never dry, or are dry less than 90 days in some horizon in most years; have an argillic horizon possessing dominant chroma of 6 or more or have an argillic horizon with chromas of less than 6, if base saturation is less than 35 percent (by sum of cations) at a depth of 125 cm. (50 inches) below the top of this horizon or,

3. ....

Udults (8.2) Suborder

Ultisols that - -

1. Are always moist or that have in most years no horizon that is dry for as much as 60 consecutive days if not irrigated;

2. Have less than 1.5 percent organic matter (0.87 percent carbon) in the upper 15 (6 inches) cm. of the argillic horizon, exclusive of any plow layer;

3. Have less than 20 kg. of organic matter in a unit volume of 1 square meter to a depth of 1 meter, excluding any 0 horizon; and

4. Have chromas higher than those of Aquults (2 or less).

Typic Normudults (8.230) Great Group

Normudults that - -

a. Have no mottles with chromas of 2 or less in the upper 50 cm. (20 inches) of the argillic horizon;

b. Have textures finer than loamy in some part of the argillic horizon, and have an argillic horizon that, in at least its upper 25 cm. (10 inches) has no lamellae;

c. Have no interruption--of the argillic horizon by ledges of bedrock within each pedon;

d. Have a moist value of 4 or more in all parts of the argillic horizon;

e. Lack a lithic contact within 50 cm. (20 inches) of the surface of the mineral soil;

f. Have a argillic horizon thicker than 25 cm. (10 in.);

g. Lack an epipedon thicker than 50 cm. (20 inches) if coarser textured than loamy fine sand;

h. Have one of the following:

   1.) a pattern of coarse mottling (called reticulate mottling) that includes at least some coarse mottles of dark red or red accompanied by strong brown, or light gray, or both.

i. ....

j. Have an Ap horizon with moist values of 4 or more, or an A1 horizon thinner than 15 cm. (6 inches) if its moist value is darker than 4.

Fine silty, mixed, thermic (family)

Mountview Series

Crider Series

<u>Fragiudults</u> (8.24) Great Group

Fragiudults that - -

a. Have an argillic horizon above the fragipan;

b. Have no mottles with chroma of 2 or less in the upper 25 cm. (10 inches) of the argillic horizon;

c. Have an Ap with a moist color value of more than 3 or an A1 horizon with a moist color value of more than 3.5 if thicker than 15 cm. (6 inches);

d. ....

e. Have a fragipan that has a brittle matrix in at least 90 percent of the cross section of the most strongly cemented subhorizon.

<u>Ochreptic</u> <u>Fragiudults</u> (8.24-3.4)

Fragiudults like the typic except for <u>a</u> and between the fragipan and the surface there is a horizon that - -

a. Is 25 cm or more thick;

b. Has chromas of 3 or more in the matrix;

c. Has not mottles with chromas of 2 or less in the upper 25 cm. (10 inches);

d. Has very few clay skins.

Fine silty, mixed, thermic (family)

Dickson Series