CHARACTERIZATION AND CLASSIFICATION OF SELECTED FORESTED SOILS OF CENTRAL AND EASTERN OKLAHOMA

By

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CHAPTER I

INTRODUCTION

Forested soils of similar morphology occur extensively throughout central and eastern Oklahoma. These soils have developed from acid sandstones of the Permian and Pennsylvanian geological system, and have been previously classified as Red-Yellow Podzolic soils. Pedological data is limited on these soils, and it is needed for better characterization and classification. The object of this study is to provide and compile data for three major soils of the area.

These forested soils were chosen because of the lack of previous research and because of their wide and extensive occurrence. Also, a classification problem is involved in this area. The soils in the western part of the area are being classified as Alfisols, whereas, the soils in the eastern part are being classified as Ultisols. It is hoped that this study will reveal some systematic criteria for soil scientists to use in the demarcation of these two Orders.

Four modal pedons of the Stephenville series, eight modal pedons of the Hartsells series, and two modal pedons of the Linker series were selected for the morphological, chemical and physical study[1].

These soils are extensive, and contribute significantly to the soil resources of central and eastern Oklahoma. It is hoped that this study will provide needed data for better characterization and classification.

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[1]Soil names refer to field names at time of sampling.

CHAPTER II

REVIEW OF LITERATURE

History

The Hartsells, Linker and Stephenville series are widespread in the southern and southeastern part of the United States and have been recognized for many years. Stephenville, the oldest, was first recognized in Eastland County, Texas, in 1916. Hartsells was established in Cherokee County, Alabama, in 1924, and Linker was established in Pope County, Arkansas, in 1938.

Presently, soil scientists are mapping all three series in Oklahoma. Linker and Stephenville soils have been mapped in Oklahoma since the late 1930's, but Hartsells soils were not recognized until the early 1960's. Prior to these dates, these soils were mapped with the Hanceville, Conway or Cleburne series. However, Hanceville and Conway have been revised to exclude these soils, and the Cleburne series has been inactivated. The general occurrence of the Hartsells, Linker and Stephenville soils in Oklahoma is outlined in Figure 1.

Prior to the initiation of the 7th Approximation (17)[1] much of the differentiation of the Stephenville, Linker and Hartsells series was physiographical rather than pedological. Stephenville was limited to central Oklahoma, and Linker and Hartsells were limited to eastern Oklahoma with no definite differentiate other than physiography.

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[1]Numbers in parentheses refer to literature cited.

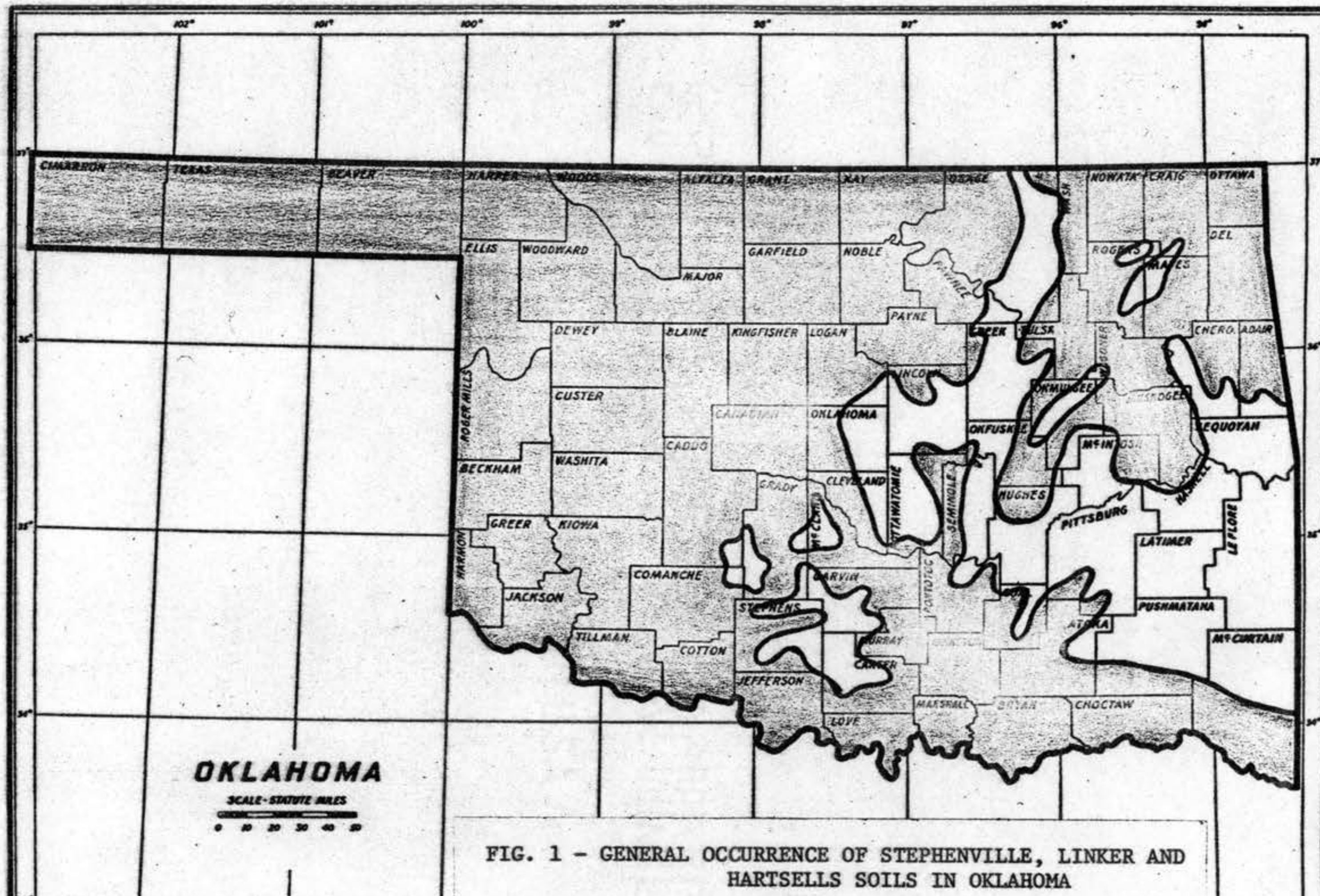

FIG. 1 - GENERAL OCCURRENCE OF STEPHENVILLE, LINKER AND HARTSELLS SOILS IN OKLAHOMA

At present, the classification of these soils according to the 7th Approximation is:

Hartsells series - Typic Hapludults - Fine-loamy, siliceous, thermic

Linker series - Typic Hapludults - Fine-loamy, siliceous, thermic

Stephenville series - Ultic Haplustalfs - Fine-loamy, siliceous, thermic

Soil Formation Factors

The concept of soils as organized natural bodies with systematically arranged characteristics can be more fully understood and studied when all soil forming factors are considered. Soils are dynamic systems of which the functional analysis is not based on physical, chemical or biological theories (8). Rather the genesis and morphology of a selected soil is based on one hypothesis. This hypothesis assumes that the variables - climate, vegetation, topography, parent material and time - suffice to define any soil. Although the factors of soil formation are studied separately, it should be understood that they are always interrelated in nature (6).

Climate

The soils selected for this study have developed under intense weathering conditions in a warm-temperature, moist subhumid or humid, continental climate (19). Within the area, there are notable variations in precipitation, temperature, P-E index and evapotranspiration. The average monthly precipitation and monthly temperature of three selected locations - Lincoln, Pittsburg, and McCurtain Counties - are given in Figures 2 and 3 (21). The mean annual temperature ranges from 61.5^{o} F. in the northwestern part (Lincoln County) to 63.5^{o} F. in the southeastern part (McCurtain County). The most

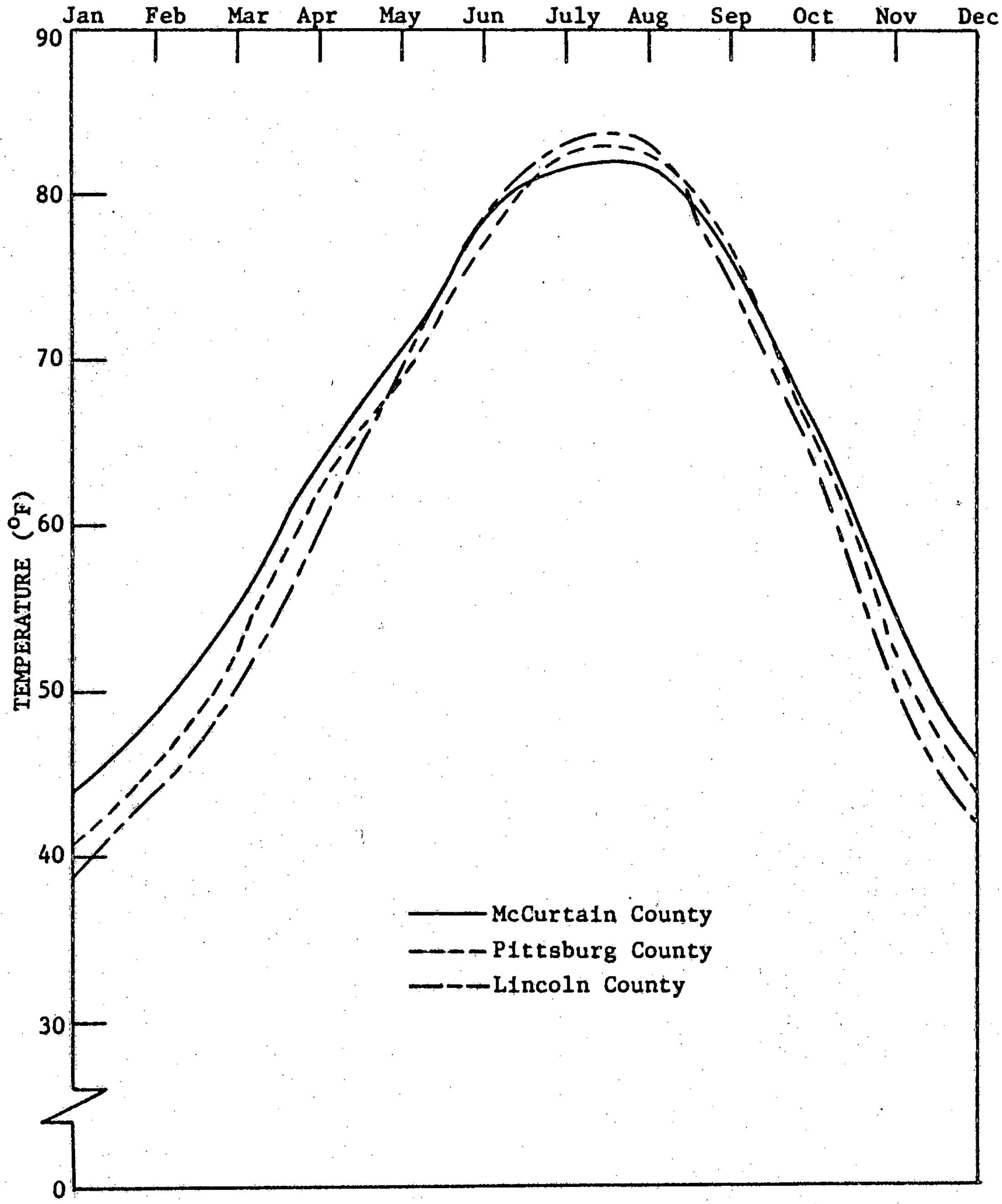

FIG. 2 - MEAN MONTHLY TEMPERATURE OF McCURTAIN PITTSBURG AND LINCOLN COUNTIES

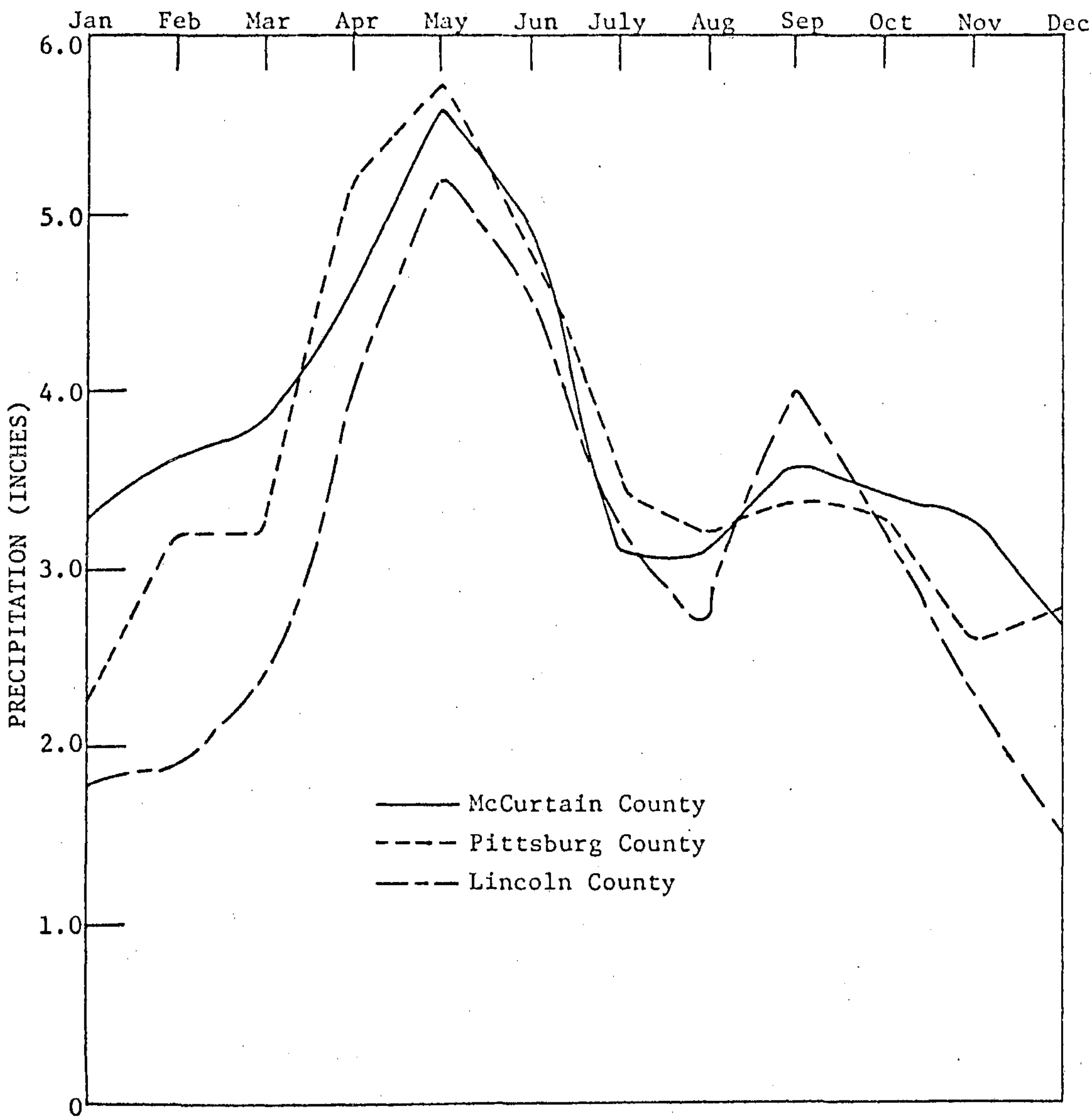

FIG. 3 - MEAN MONTHLY PRECIPITATION OF McCURTAIN, PITTSBURG AND LINCOLN COUNTIES

notable variation occurs during the winter months with only slight variations during the other parts of the season (Fig. 2). The total annual precipitation is 33.9 inches for Lincoln County; 42.0 inches for Pittsburg County, and 46.5 inches for McCurtain County (Fig. 4). Again, as with temperature, the most notable variations occur during the winter months (Fig. 3).

The annual precipitation is by no means a measurement of precipitation available for soil formation (8, 10, 22). Precipitation effectiveness (P-E index) and potential evapotranspiration are measurements where conditions such as temperature, air humidities, evaporation and transpiration are considered in measuring effective precipitation. Annual P-E index and potential evapotranspiration isograms by Thornthwaite (19) are shown in Figure 5. The P-E index varies from about 50 in the northwestern part of the area to 77 in the extreme southeastern part. The evapotranspiration is about 37 for the southern part or about 2 inches higher than the northern part.

Vegetation

The native vegetation of the study area consists primarily of savannah and forest types. The climax vegetation is shown in Figure 6 as determined by Harlan (7) from field studies and a review of historical writings. The savannah type consists primarily of post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) with an understory of tall native grasses - little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon gerardi*), switchgrass (*Panicum virgatum*), and Indiangrass (*Sorghastrum nutans*) as climax species. Hickory (*Carya texana*) becomes a major species in the eastern part

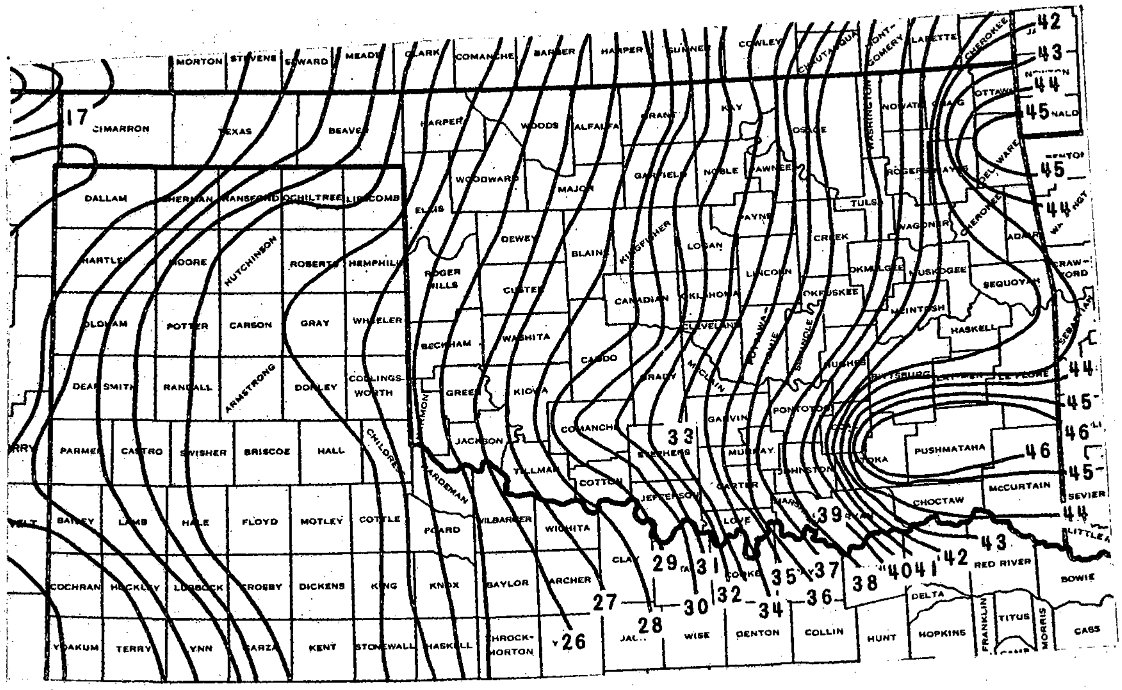

FIG. 4 - MEAN ANNUAL PRECIPITATION

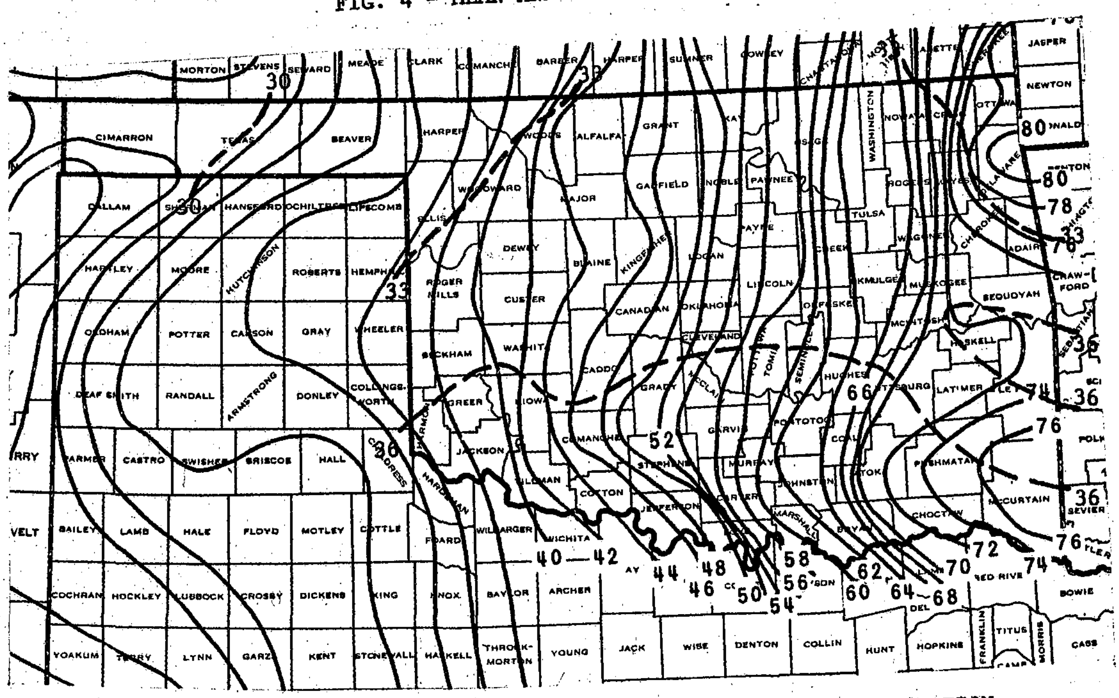

FIG. 5 - ANNUAL P-E INDEX AND POTENTIAL EVAPOTRANSPIRATION

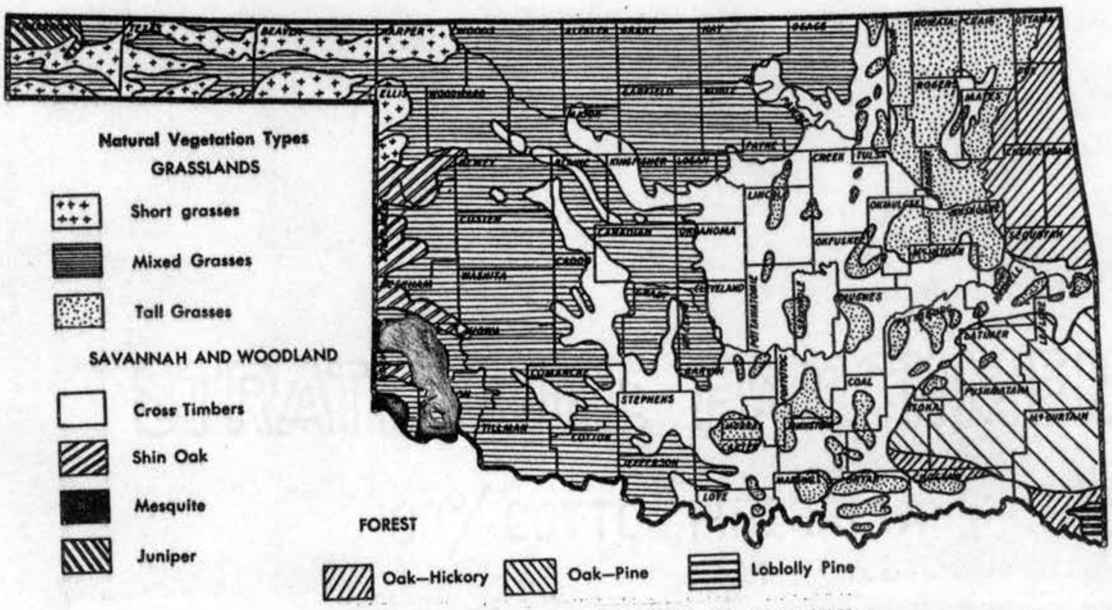

FIG. 6 - CLIMAX VEGETATION OF OKLAHOMA

From: Soils of Oklahoma, Gray, F., and Galloway, H. M., Dept. of Agronomy, Oklahoma State University, 1959.

of this area. The climax species of the forest area consist primarily of the blackjack oak, post oak, and hickory species, white oak (*Quercus alba*) and shortleaf pine (*Pinus echinata*). At present the Stephenville series is recognized in the savannah area and the Hartsells and Linker series are recognized in both the savannah and forest areas.

Topography

These forested soils occupy rolling, hilly and mountainous topography and occur on the ridgetops and smoother slopes within the area. The general landscape of the Stephenville soils and the Hartsells and Linker soils with respect to other related soils is shown in Figures 7 and 8. These soils are well drained and have medium runoff. Shape, gradient, length and exposure of slopes are comparable.

Parent Material

The parent material of the soils studied consists primarily of acid sandstone of the Permian and Pennsylvanian geologic systems (Fig. 9). The Permian system occupies the extreme western portion of the study area, and is characterized by thick beds of reddish colored sandstone interbedded with reddish colored shale, claybeds and siltstone. The Pennsylvanian system is by far the most extensive and is characterized by reddish and yellowish colored sandstone that is stratified with shale and siltstone. However, all the soils studied have developed primarily from the sandstones of these geologic ages.

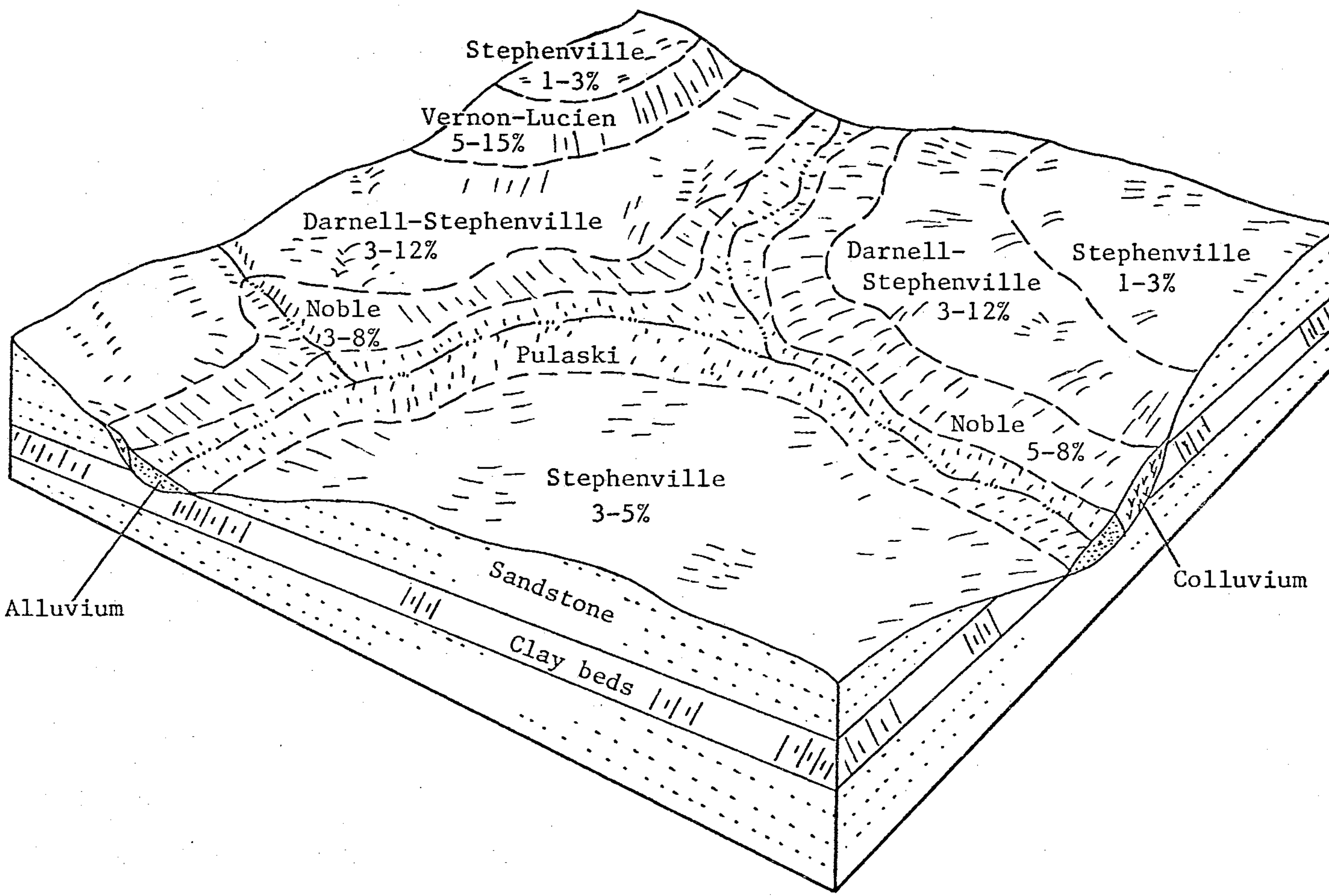

FIG. 7 - GENERAL LANDSCAPE OF STEPHENVILLE AND ASSOCIATED SOILS

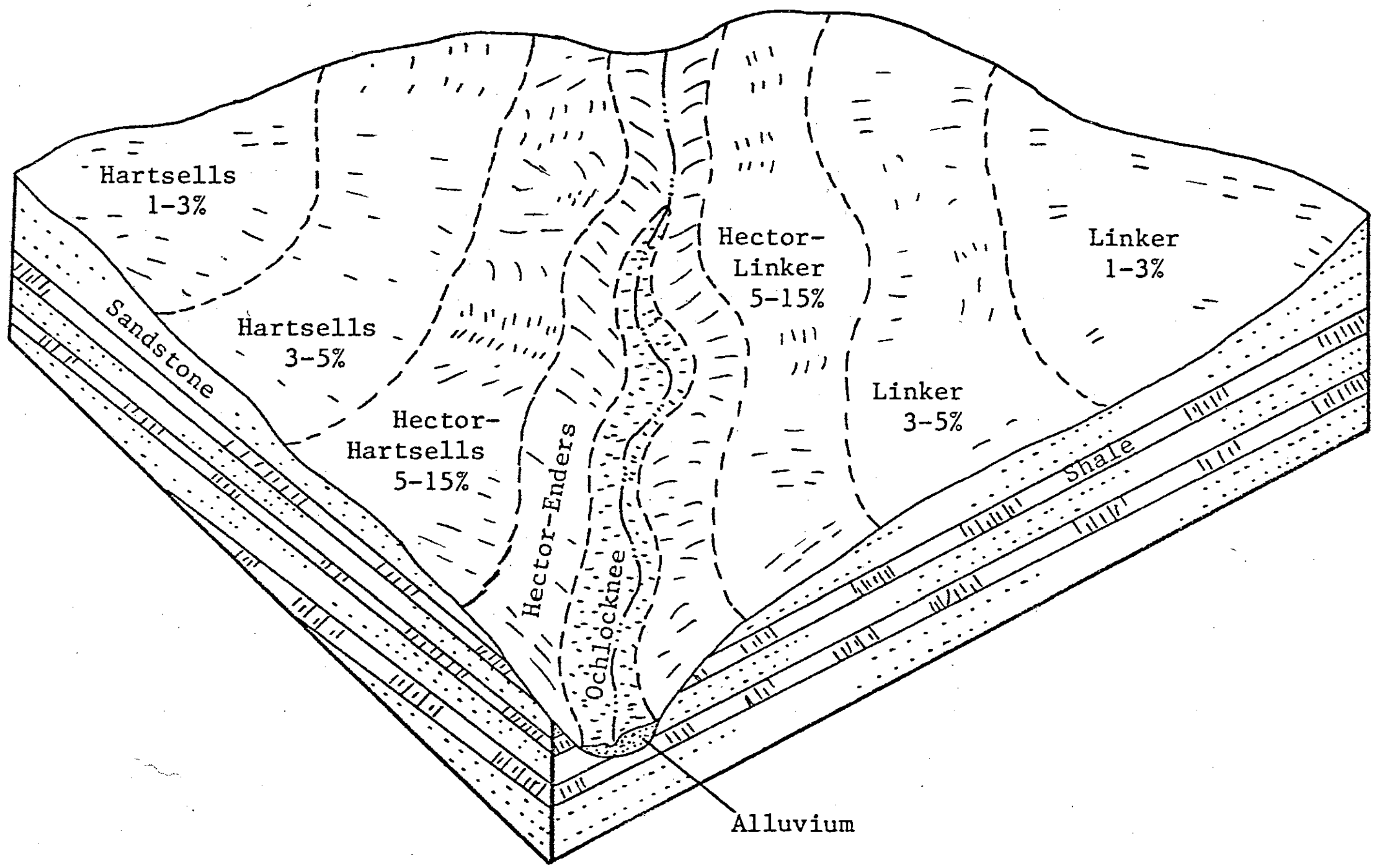

FIG. 8 - GENERAL LANDSCAPE OF LINKER AND HARTSELLS AND ASSOCIATED SOILS

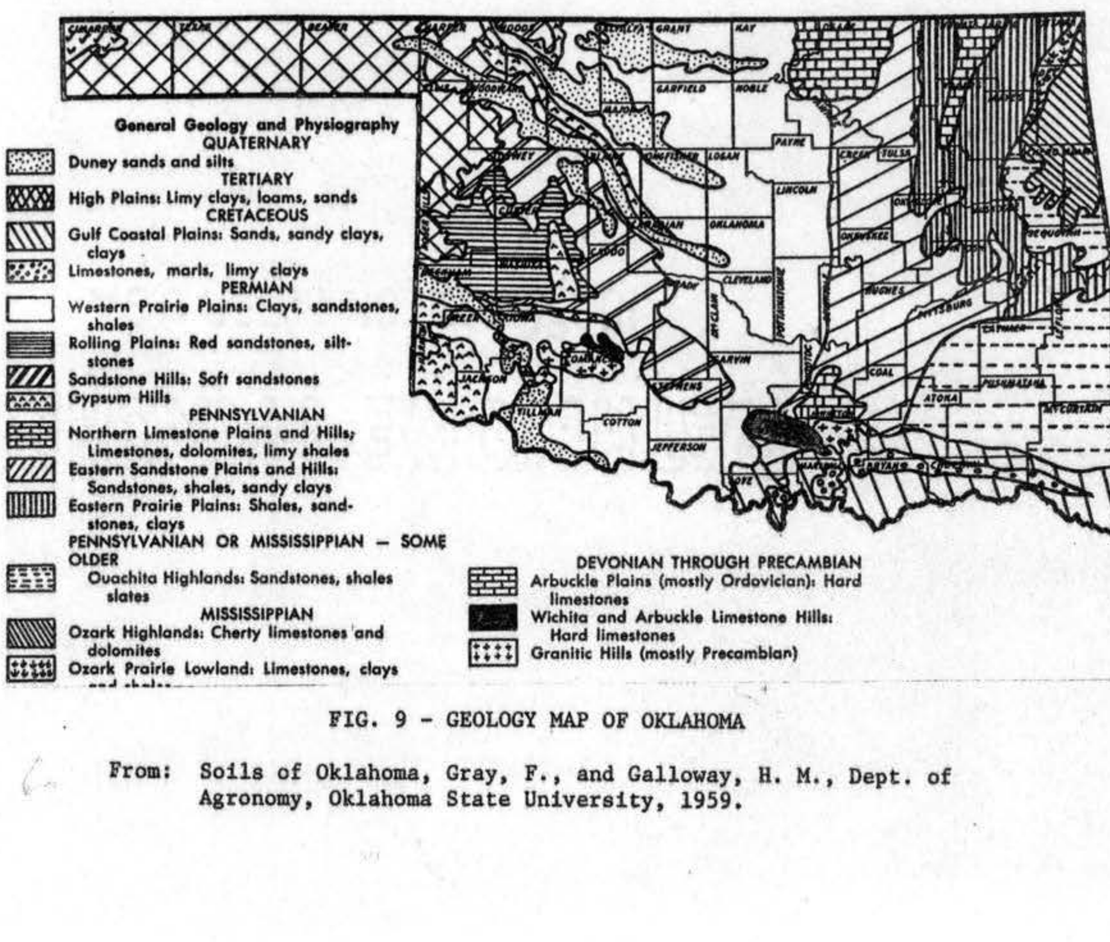

FIG. 9 - GEOLOGY MAP OF OKLAHOMA

From: Soils of Oklahoma, Gray, F., and Galloway, H. M., Dept. of Agronomy, Oklahoma State University, 1959.

Time

The estimation of relative age or degree of maturity of soils is universally based on horizon differentiation (8). Red-Yellow Podzolic soils have developed in the soil forming process of laterization modified by podzolization (3, 13, 22). These soils are considered genetically old. The degree of maturity is expressed in terms of primary mineral alteration, dominant clay minerals present, amount of clay and its distribution, profile development and the acid conditions resulting from base depletion (12). The pedons selected for this study have been previously classified with the Red-Yellow Podzolic great soil group (22), and their processes of soil formation are related to this great soil group.

Classification

The purpose of soil classification is to organize our knowledge so that the properties of soils may be remembered and their relationship may be understood most easily for a specific purpose (4). It must be remembered, however, that the validity of classification can be no better than the knowledge of the soil.

Alfisols Versus Ultisols

Sufficient studies have been made to determine that the soils of this study area generally have characteristics of either Alfisols or Ultisols. One of the criterion, and the most significant, for differentiation is the base saturation (by sum of cations) at 1.25m (50 inches) below the upper boundary of the argillic horizon or 1.8m (72 inches) below the soil surface or above a lithic or paralithic contact, whichever is shallower (17). Alfisols have base saturation of 35 percent or more, whereas, Ultisols have base saturation of less than 35 percent. Although both Alfisols and Ultisols are known to occur in this study area, no specific criteria have been developed for soil scientists to use in the field to separate these two Orders.

CHAPTER III

METHODS AND PROCEDURES

Field Study

The general location of the sampling sites is shown in Figure 10. The morphology of each pedon was studied in detail at each site. These pedons were then described according to standard procedure (18) and samples for laboratory analysis were collected from each horizon.

Physical Analysis

The soil samples were air dried under laboratory conditions and processed to pass a 2mm. screen. Particle size distribution was then determined. The samples were treated with H_2O_2 for organic matter removal, and then dispersed with sodium hexametaphosphate. The particle size distribution of Stephenville, Nos. 1 and 2 - Lincoln County, and Hartsells, Nos. 1 and 2 - Pittsburg County, was determined by the pipet method (15). On all other samples the sand was wet sieved and the total and the very fine sand was determined by weighing the sand remaining on the respective sieve. The silt and clay was determined by a Bouyoucous hydrometer using the Day (5) procedure.

Chemical Analysis

The soil pH was determined by using a Beckman pH meter on a 1:1 soil-water mixture and a 1:1 soil-KCl mixture. Soil organic matter was determined by the potassium dichromate wet oxidation method (15).

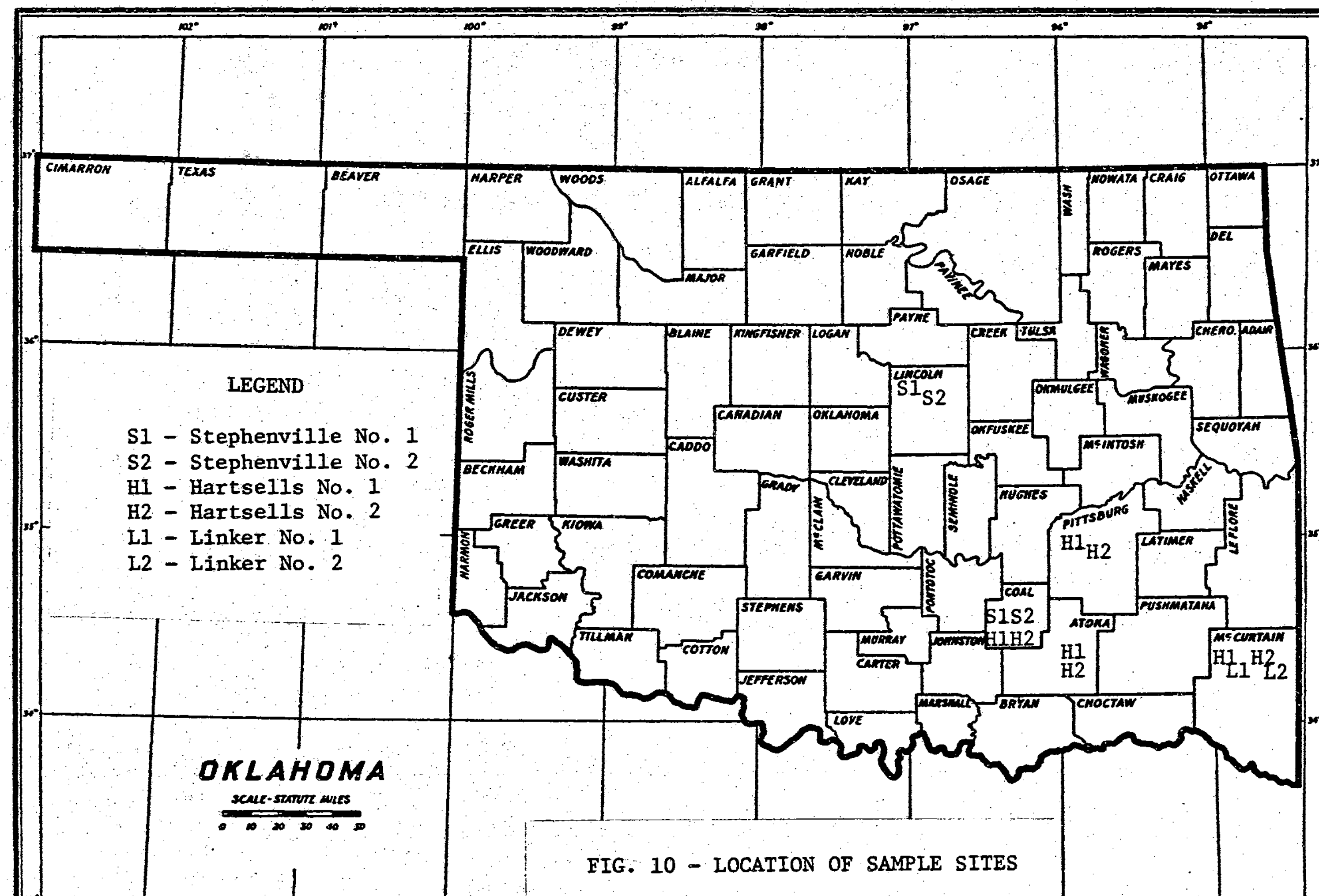

FIG. 10 - LOCATION OF SAMPLE SITES

Cation exchange capacity was determined by saturating the samples with ammonium acetate and then determining the amount of absorbed ammonia by Kjeldahl distillation (15). The ammonium acetate leachate was retained for determination of extractable bases. Extractable sodium and potassium were determined on the ammonium acetate leachate with the Beckman Model DU flame spectrophotometer. Calcium and magnesium were determined by the Versene titration method (15). The exchange acidity or extractable H^+ was determined by a modified barium chloride-triethanolamine method of Peech et al (15). The extractable aluminum was determined by the aluminon colorimetric method using a potassium chloride extraction (15).

Alfisols - Ultisols Demarcation

In order to determine a demarcation between the Orders - Alfisols and Ultisols - linear regressions were plotted with base saturation (sum of cations) on the X-axis and the variables - precipitation, P-E index, evapotranspiration, clay content, pH and temperature - on the Y-axis. Correlation coefficients were calculated to determine the significance of each variable.

CHAPTER IV

RESULTS AND DISCUSSIONS

Morphology

The pedons selected for this study were considered modal for the county in which they were sampled. Morphologically, most of the pedons are within the range of the Established Series[1]. However, some will need to be considered taxadjunct to the series. The soils selected all have an ochric epipedon, albic horizon, argillic horizon and a lithic contact within 20 to 50 inches.

The differentia in the Hartsells and Linker soils is the color of the argillic horizon. Linker has hues of 2.5YR or 5YR, whereas Hartsells has hues of 7.5YR and 10YR. Both these soils have base saturation of less than 35 percent above the lithic contact. The Stephenville soils have argillic horizons with colors that range in hues of 2.5YR through 7.5YR, however, these soils have a base saturation of 35 percent or more above the lithic contact.

The morphology of the fourteen pedons sampled is presented in Table I.

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[1]Established Series, National Cooperative Soil Survey, U.S.A.

TABLE I

MORPHOLOGY OF STEPHENVILLE, HARTSELLS, AND LINKER SOILS

Horizon	Depth(in.)	Color	Texture	Structure	Consistence	Boundary	Precip-itation	P-E Index
			Stephenville No. 1 - Lincoln County					
A1	0-6	10YR 4/2; 2/2m	lfs	lfgr	mvfr	c	34	56
A2	6-14	7.5YR 6/3; 4/4m	lfs	lvfgr-m	mvfr	a		
B21t	14-18	5YR 5/6; 4/6m	scl	1m&fsbk	mfr, dsh	gw		
B22t	18-27	5YR 5/6; 4/6m	scl	2msbk	mfr, dh	g		
B3	27-31	5YR 5/8; 4/8m	scl	1fsbk	mfr, dsh	cw		
R	31-40+	2.5YR 3/6m	weathered	sandstone				
			Stephenville No. 2 - Lincoln County					
A1	0-7	10YR 4/2; 2/2m	lfs	lfgr	mvfr	c	33	55
A2	7-14	10YR 7/4; 5/4m	lfs	m	-	a		
B21t	14-17	5YR 6/6; 5/6m	scl	lmsbk	-	c		
B22t	17-28	5YR 5/6; 4/6m	scl	2msbk	mfr, dh	gw		
B3	28-35	2.5YR 5/6; 3/6m	scl	lmsbk	mfr, dh	g		
R	35-40+	2.5YR 4/6m	weathered	sandstone				
			Stephenville No. 1 - Coal County					
A1	0-7	10YR 4/3m	fsl	-	-	c	45	70
A2	7-12	7.5YR 6/4m	lfs	-	-	a		
B2t	12-24	5YR 5/8m	scl	-	-	g		
B3	24-33	10YR 5/8m	scl	-	-	c		
R	33+	-	weathered	sandstone				

TABLE I--Continued

Horizon	Depth(in.)	Color	Texture	Structure	Consistence	Boundary	Precip-itation	P-E Index
			Stephenville No. 2 - Coal County					
A1	0-4	10YR 4/3m	fsl	1fgr	mvfr	c	45	70
A2	4-9	7.5YR 6/4m	fsl	1fgr	mvfr	c		
B1	9-14	7.5YR 6/6m	fsl	1mgr	mfr	c		
B2t	14-20	5YR 5/8m	cl	2msbk	mfr	g		
B3	20-25	5YR 5/8m	cl	1msbk	mfr	c		
R	25+	-	weathered sandstone					
			Hartsells No. 1 - Pittsburg County					
A1	0-4	10YR 5/2; 3/2m	fsl	1mgr	mvfr, dsh	c	41	68
A2	4-16	10YR 7/3; 6/4m	fsl	1gr	mvfr; dsh	d		
B21t	16-21	10YR 7/6; 6/6m	1	1msbk	mfr; dh	c		
B22t	21-26	10YR 7/3; 6/3m	lt. cl	2msbk	mfr; dh	c		
B23t	26-32	10YR 6/1; 10YR 5/6; 2.5YR 4/6	cl	2msbk	mfi; dvh	c		
B3	32-50	10YR 5/6; 10YR 6/2; 5YR 5/6	cl	2msbk	mfi; dvh	a		
R	50-58+		stratified sandstone					
			Hartsells No. 2 - Pittsburg County					
A1	0-3	10YR 5/2; 4/2m	fsl	1fgr	mvfr; dsh	c	43	70
A2	3-17	10YR 7/2; 5/2m	fsl	1fgr-sg	mvfr; dsh	c		
B21t	17-27	10YR 6/4; 5/6m	hfsl	2msbk	mfr; dh	d		
B22t	27-36	10YR 7/6; 6/6m	hfsl	2msbk	mfr; dh	g		
B3	36-48	10YR 7/6; 6/6m	hfsl	2msbk	mfr; dh			
R	48-66+	10YR 5/6	stratified cemented sandstone					

TABLE I--Continued

Horizon	Depth(in.)	Color	Texture	Structure	Consistence	Boundary	Precip-itation	P-E Index
			Hartsells No. 1 - McCurtain County					
A1	0-6	10YR 4/2m	l	lfgr	mfr	c	46	77
A2	6-16	10YR 6/4m	l	lfgr	mfr	a		
B2t	16-26	10YR 5/6m	cl	2msbk	mfr	g		
B3	26-34	10YR 5/6m	scl	2msbk	mfr	c		
R	34+		Sandstone					
			Hartsells No. 2 - McCurtain County					
A1	0-4	10YR 5/2m	l	lfgr	mfr	c	46	77
A2	4-14	10YR 6/3m	l	lfgr	mfr	a		
B2t	14-28	10YR 5/6m	cl	2msbk	mfr	g		
B3	28-37	10YR 6/4m	scl	lmsbk	mfr	c		
R	37-45+		Sandstone					
			Hartsells No. 1 - Coal County					
A1	0-8	10YR 4/3m	lfs	lfgr	-	c	42	65
A2	8-15	10YR 5/3m	fsl	lfgr	-	a		
B21t	15-22	10YR 5/6m	scl	lmsbk	-	g		
B22t	22-28	10YR 5/6m	scl	2msbk	-	g		
B3	28-32	10YR 5/6m	scl	lmgr	-	a		
R	32+		Sandstone					
			Hartsells No. 2 - Coal County					
Ap	0-9	10YR 4/3m	fsl	lfgr	-	a	42	65
B21t	9-21	10YR 4/4m	hfsl	lmsbk	-	g		
B22t	21-29	10YR 5/6m	scl	2msbk	-	g		
B3	29-35	10YR 5/6m	scl	lmsbk	-	a		
R	35+		Sandstone					

TABLE I--Continued

Horizon	Depth(in.)	Color	Texture	Structure	Consistence	Boundary	Precip- itation	P-E Index
			Hartsells No. 1 - Atoka County					
A1	0-5	10YR 4/2m	fsl	1fgr	mfr	c	41	70
A2	5-14	10YR 6/4m	fsl	1fgr	mfr	a		
B2t	14-26	10YR 5/6m	cl	2msbk	mfr	g		
B3	26-38	10YR 5/6m	sc	2msbk	mfr	a		
R	38+		Sandstone					
			Hartsells No. 2 - Atoka County					
A1	0-4	10YR 5/2m	fsl	1fgr	mfr	c	43	71
A2	4-10	10YR 6/2m	fsl	1fgr	mfr	a		
B2t	10-24	10YR 5/2m	scl	2msbk	mfr	g		
B3	24-32	10YR 5/2m	scl	2msbk	mfr	a		
R	32+		Sandstone					
			Linker No. 1 - McCurtain County					
A1	0-5	10YR 4/2m	sil	1fgr	mvfr	c	46	77
A2	5-12	10YR 6/3m	1	1msbk	mfr	a		
B2t	12-30	5YR 5/6m	cl	2msbk	mfr	g		
B3	30-38	7.5YR 6/6m	cl	2msbk	mfr	a		
R	38+		Weathered sandstone					
			Linker No. 2 - McCurtain County					
A1	0-4	10YR 5/2m	1	1fgr	mvfr	c	46	77
A2	4-12	10YR 6/3m	1	1fgr	mvfr	a		
B21t	12-18	5YR 5/6m	cl	2msbk	mfr	g		
B22t	18-28	2.5YR 4/6m	c	2msbk	mfr	g		
B3	28-38	5YR 5/6m	cl	2msbk	mfr	c		
R	38-46+		Sandstone					

Particle Size Distribution

The particle size distribution for the fourteen pedons sampled is shown in Table II. Surface texture of all the pedons is fine sandy loam or loamy fine sand except for the four pedons from McCurtain County which have loam or silt loam textures. All pedons have an argillic horizon with clay content ranging from 18.2 to 37.6 percent. The silt content varies considerably between pedons but all exhibit a regular decrease with depth. The soils developed from the Permian sandstone - Stephenville Nos. 1 and 2, Lincoln County - contain more sand and less silt than the soils developed from the Pennsylvanian sandstone. Also, the amount of very fine sand is less in the Permian sandstone derived soils.

The particle size - depth distribution curves of four representative pedons as presented in Figures 11, 12, 13 and 14 clearly show that translocation of clays has contributed significantly to losses in the A horizons and subsequent gains in the B2t horizons. The clay content of the A horizon ranges from about 4 to 14 percent. Very little variation is noted in the particle size distribution of the A1 and A2 horizons. Maximal clay accumulation is exhibited in the B2t horizon of all pedons. The upper boundary of the B2t horizon is 10 to 17 inches from the surface. The asymmetry of the clay distribution curve with depth for all pedons sampled, except Hartsells No. 2 - Pittsburg County (Figure 12) is characteristic of maximal profile development as suggested by Thorp and Smith (20). Hartsells No. 2 - Pittsburg County is indicative of a somewhat younger profile and would be considered medial development. Also, as noted in the morphology of this pedon, the R horizon is stratified and may account for the increased clay content of this horizon.

TABLE II

PARTICLE SIZE DISTRIBUTION OF STEPHENVILLE, HARTSELLS AND LINKER SOILS*

Horizon	Depth In.	Sand 2-.05mm %	Silt .05-.002mm %	Clay <.002mm %	Very Fine Sand .1-.05mm %
		Stephenville No. 1 - Lincoln County			
A1	0-6	82.2	14.1	3.7	9.4
A2	6-14	85.4	10.1	4.5	8.5
B21t	14-18	68.4	6.1	25.5	5.8
B22t	18-27	61.1	4.3	34.6	4.5
B3	27-31	70.7	3.7	25.6	3.0
R	31-40+	79.0	5.3	15.7	8.6
		Stephenville No. 2 - Lincoln County			
A1	0-7	82.4	12.1	5.5	10.2
A2	7-14	83.8	9.4	6.8	10.4
B21t	14-17	62.6	8.0	29.4	10.7
B22t	17-28	60.2	8.1	31.7	14.5
B3	28-35	64.0	5.0	31.0	11.4
R	35-40+	87.8	2.4	9.8	2.9
		Stephenville No. 1 - Coal County			
A1	0-7	72.4	21.3	6.3	22.8
A2	7-12	74.9	17.6	7.5	17.5
B2t	12-24	54.3	15.2	30.5	15.5
B3	24-33	58.2	16.5	25.3	14.3
R	33+	-	-	-	-
		Stephenville No. 2 - Coal County			
A1	0-4	57.3	33.9	8.8	37.8
A2	4-9	61.1	31.4	7.5	37.4
B1	9-14	61.1	28.9	10.0	37.6
B2t	14-20	40.4	29.1	30.5	26.6
B3	20-25	42.8	28.0	29.2	23.9
R	25+	-	-	-	-
		Hartsells No. 1 - Pittsburg County			
A1	0-4	61.1	33.7	5.2	19.9
A2	4-16	63.5	31.4	5.1	21.6
B21t	16-21	46.6	29.3	24.1	16.2
B22t	21-26	42.7	30.6	26.7	14.8
B23t	26-32	39.6	25.2	35.2	14.1
B3	32-50	41.1	24.3	34.6	13.2
R	50-58+	-	-	-	-

*Mechanical Analysis by Oklahoma Agricultural Experiment Station, Project H-1383.

TABLE II--Continued

Horizon	Depth In.	Sand 2-.05mm %	Silt .05-.002mm %	Clay <.002mm %	Very Fine Sand .1-.05mm %
		Hartsells No. 2 - Pittsburg County			
A1	0-3	59.6	35.4	5.0	21.7
A2	3-17	61.9	33.4	4.7	21.8
B21t	17-27	54.9	29.0	16.1	19.6
B22t	27-36	51.6	29.4	19.0	17.5
B3	36-48	51.1	29.4	19.5	16.6
R	48-66+	47.6	29.7	22.7	14.0
		Hartsells No. 1 - McCurtain County			
A1	0-6	47.0	39.1	13.9	17.5
A2	6-16	48.5	37.7	13.8	19.8
B2t	16-26	33.8	31.8	34.4	12.7
B3	26-34	53.1	26.6	20.3	15.3
R	34+	52.0	31.6	16.4	20.8
		Hartsells No. 2 - McCurtain County			
A1	0-4	49.8	42.7	7.5	28.9
A2	4-14	49.8	40.2	10.0	29.1
B2t	14-28	41.8	29.1	29.1	18.5
B3	28-37	55.8	20.2	24.0	16.9
R	37-45+	73.6	13.8	12.6	16.8
		Hartsells No. 1 - Coal County			
A1	0-8	74.8	21.4	3.8	14.4
A2	8-15	72.4	18.8	8.8	12.9
B21t	15-22	60.9	15.1	24.0	12.4
B22t	22-28	59.6	16.4	24.0	11.2
B3	28-32	64.6	13.9	21.5	8.6
R	32+	-	-	-	-
		Hartsells No. 2 - Coal County			
Ap	0-9	69.9	18.8	11.3	11.1
B21t	9-21	58.3	22.8	18.9	9.2
B22t	21-29	58.3	20.2	21.5	7.5
B3	29-35	60.8	17.7	21.5	7.1
R	35+	-	-	-	-

TABLE II--Continued

Horizon	Depth In.	Sand 2-.05mm %	Silt .05-.002mm %	Clay <.002mm %	Very Fine Sand .1-.05mm %
		Hartsells No. 1 - Atoka County			
A1	0-5	62.4	30.1	7.5	11.3
A2	5-14	63.3	28.1	8.6	12.5
B2t	14-26	41.9	19.3	38.8	7.9
B3	26-38	46.6	17.8	35.6	10.2
R	38+	-	-	-	-
		Hartsells No. 2 - Atoka County			
A1	0-4	58.5	34.0	7.5	8.7
A2	4-10	61.2	30.0	8.8	9.3
B2t	10-24	53.2	25.3	21.5	7.0
B3	24-32	45.4	25.4	29.2	5.9
R	32+	-	-	-	-
		Linker No. 1 - McCurtain County			
A1	0-5	29.8	56.4	13.8	16.6
A2	5-12	37.2	49.0	13.8	20.8
B2t	12-30	30.6	32.8	36.6	20.8
B3	30-38	33.8	34.4	31.8	25.8
R	38+	46.7	35.5	17.8	34.0
		Linker No. 2 - McCurtain County			
A1	0-4	48.4	41.6	10.0	24.3
A2	4-12	47.4	43.8	8.8	22.4
B21t	12-18	35.6	36.6	27.8	18.1
B22t	18-28	28.5	26.8	44.7	15.2
B3	28-38	36.1	29.4	34.5	21.2
R	38-46+	56.3	32.4	11.3	33.6

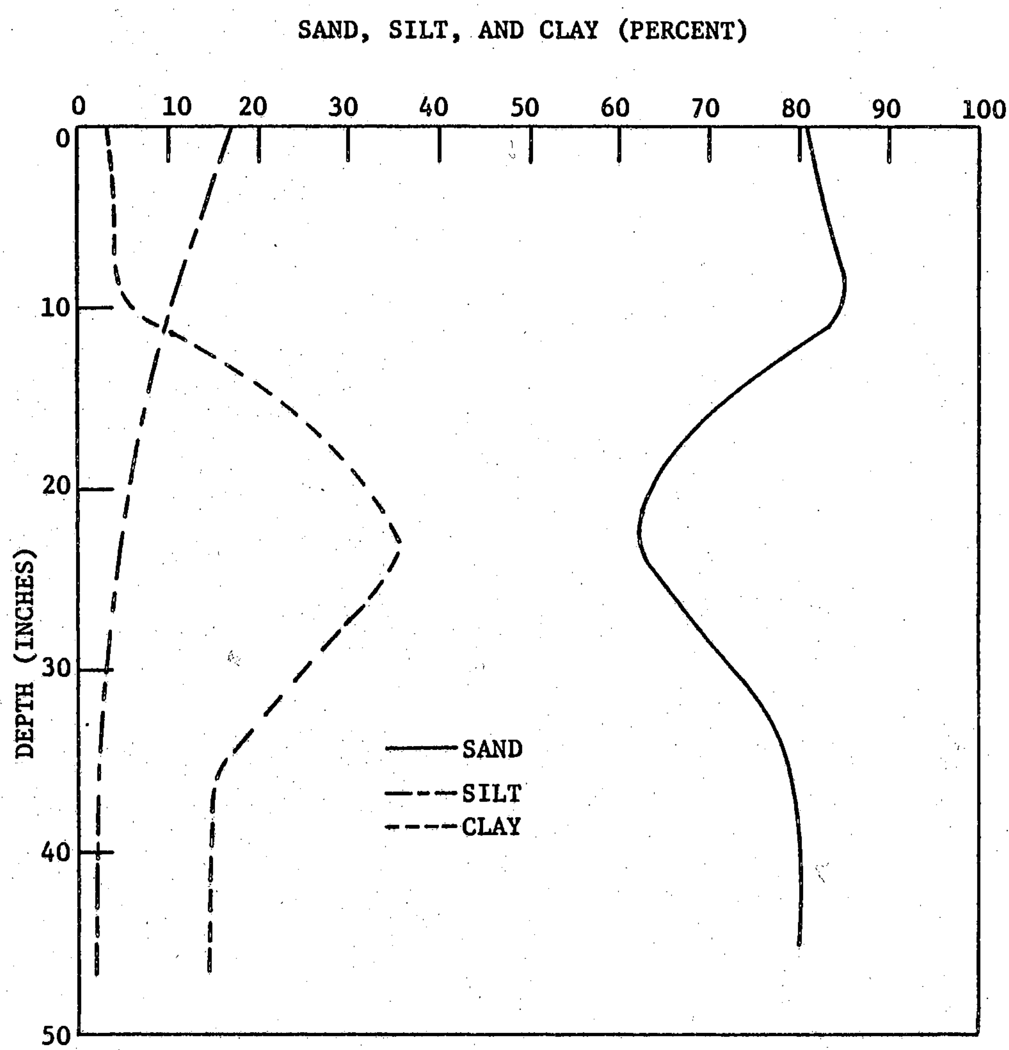

FIG. 11 - PARTICLE SIZE - DEPTH DISTRIBUTION CURVE FOR STEPHENVILLE NO. 1 - LINCOLN COUNTY

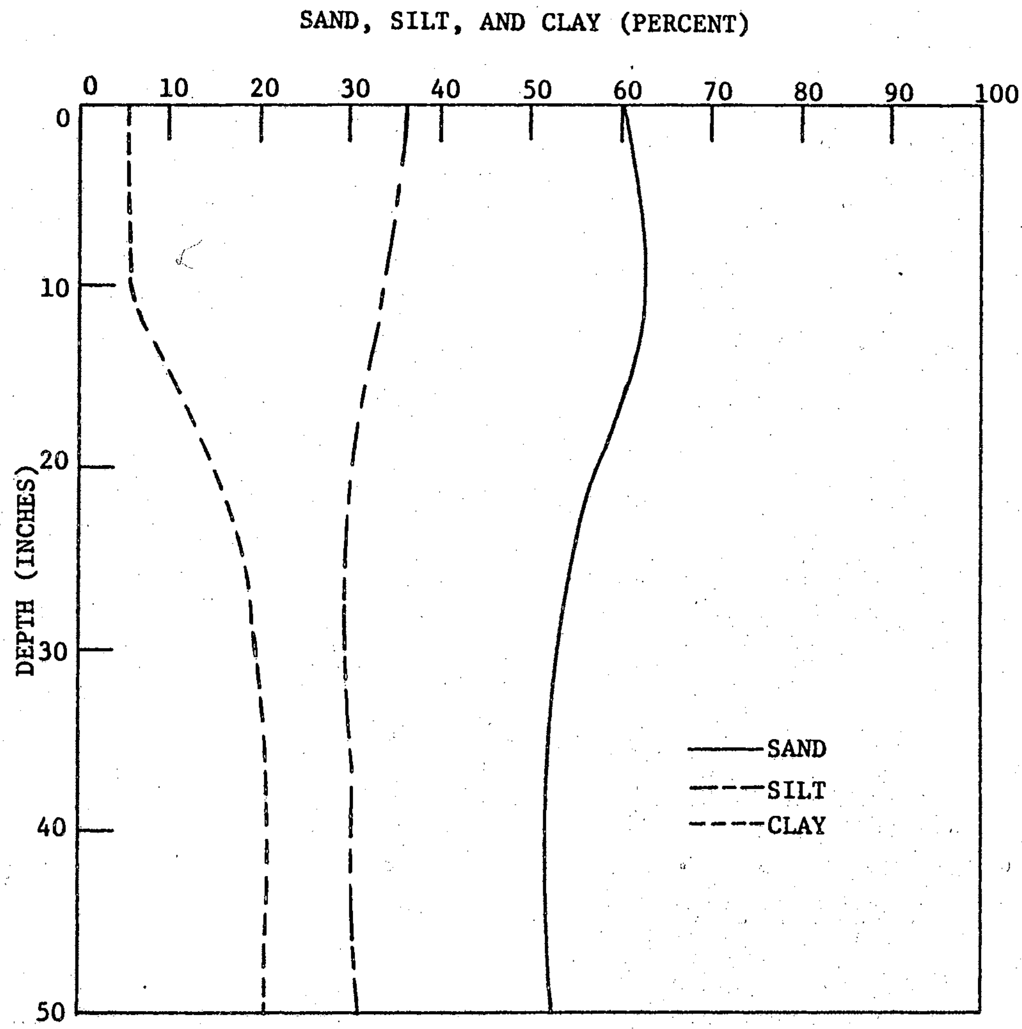

FIG. 12 - PARTICLE SIZE - DEPTH DISTRIBUTION CURVE FOR HARTSELLS NO. 2 - PITTSBURG COUNTY

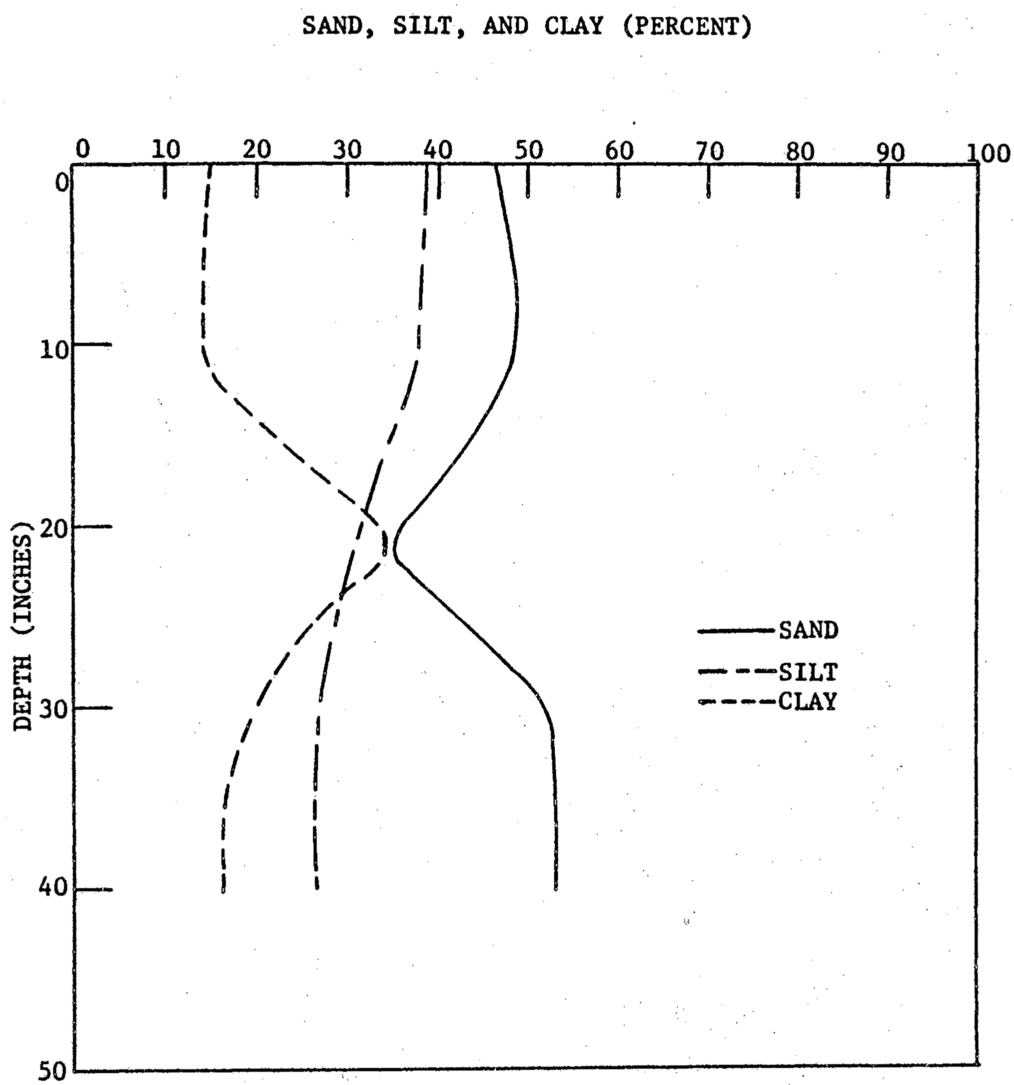

FIG. 13 - PARTICLE SIZE - DEPTH DISTRIBUTION CURVE FOR HARTSELLS NO. 1 - McCURTAIN COUNTY

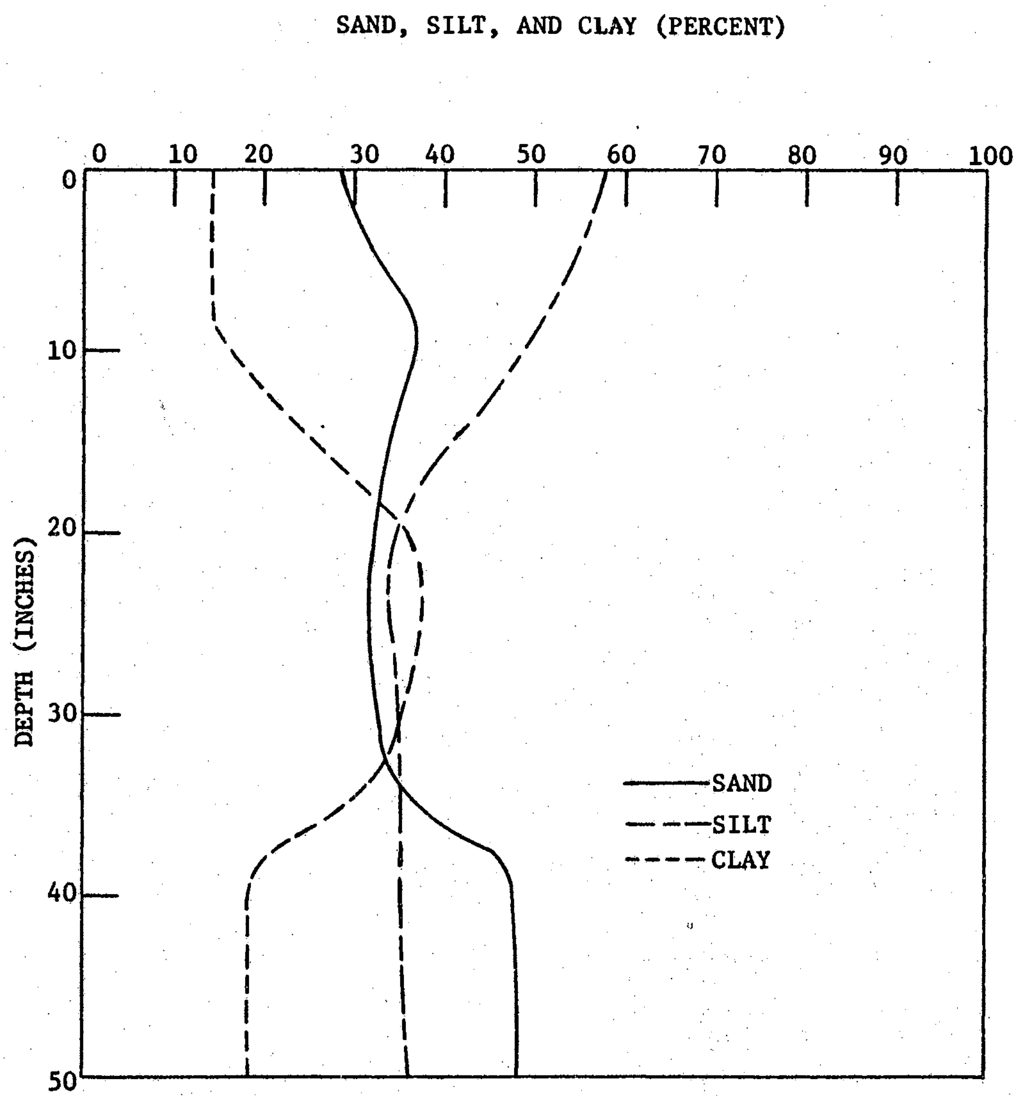

FIG. 14 - PARTICLE SIZE - DEPTH DISTRIBUTION CURVE FOR LINKER NO. 1 - McCURTAIN COUNTY

In order to determine if any discontinuity or stratification has occurred in these pedons, the particle size distribution was recalculated to a clay-free basis as suggested by Kellogg (11). The distribution of the silt and sand shows no contrasting difference within pedons which is suggestive of continuity. The difference among sand and silt content of the horizons of the pedons is caused by soil-forming processes that have changed the total soil mass through loss and addition of clay.

Cation Exchange Capacity, Extractable Cations and Base Saturation

The cation exchange capacity (CEC), extractable cations and base saturation of the Hartsells, Linker and Stephenville pedons are presented in Table III. The CEC is less than 23 meq/100g in all horizons. The B2t horizons have the highest CEC with values ranging from 8 to 23 meq/100g, however, most are about 13 meq/100g. These values are comparable with the findings of McCaleb (12) in his work with Red-Yellow Podzolic soils derived from sandstone. The effect of organic matter on CEC can be readily seen in these pedons. The CEC is 1 to 9 meq/100g higher in the A1 horizon than in the A2 horizon with minimal difference in clay content. This is apparently due to organic matter of which one percent organic matter is accountable for about 2.5 meq/100g exchange capacity.

H is the dominant cation of all pedons studied. Ca is the dominant basic cation in Stephenville Nos. 1 and 2 - Lincoln County, and Mg is the dominant basic cation in all other pedons. Although Mg dominates as the basic cation in most of the pedons, Ca generally dominates the A horizon. This condition was postulated by Joffe (10) to be due to the larger quantity of Ca returned to the surface layer by

TABLE III

CHEMICAL PROPERTIES OF STEPHENVILLE, HARTSELLS AND LINKER SOILS*

Horizon	Depth (In.)	pH 1:1 H_2O	pH 1:1 KCl	CEC meq/100g	Extractable Cations meq/100g H	Ca	Mg	K	Na	Al	Base Saturation NH_4OAc %	Sum of cation - %	Organic Matter %
					Stephenville No. 1 - Lincoln County								
A1	0-6	5.8	-	5.2	3.3	3.1	0.9	0.2	Tr	0.0	81	56	1.6
A2	6-14	5.2	-	1.9	1.5	0.4	0.4	0.1	Tr	0.1	47	38	0.2
B21t	14-18	4.9	-	9.9	6.0	3.9	2.6	0.2	Tr	0.8	68	53	0.5
B22t	18-27	4.9	-	12.1	7.9	4.9	3.1	0.3	Tr	1.0	68	51	0.5
B3	27-31	5.1	-	9.7	6.2	3.8	2.8	0.2	Tr	0.5	70	52	0.3
R	31-40+	5.4	-	5.7	2.9	2.2	2.3	0.2	Tr	Tr	80	62	0.1
					Stephenville No. 2 - Lincoln County								
A1	0-7	6.3	-	5.5	2.9	4.2	0.5	0.2	Tr	0.0	89	63	1.5
A2	7-14	6.3	-	3.4	1.6	2.1	0.5	0.1	Tr	0.0	79	63	0.3
B21t	14-17	5.8	-	13.2	5.0	6.8	4.4	0.3	Tr	0.0	87	70	0.7
B22t	17-28	5.6	-	13.4	5.9	5.9	5.0	0.3	Tr	Tr	84	65	0.5
B3	28-35	5.0	-	12.5	7.0	4.2	4.6	0.2	Tr	1.3	72	56	0.3
R	35-40+	5.0	-	3.5	2.1	1.0	1.2	0.1	Tr	0.4	66	52	0.1
					Stephenville No. 1 - Coal County								
A1	0-7	6.6	5.8	4.0	1.3	1.7	4.4	0.2	0.1	0.0	159	83	1.0
A2	7-12	6.4	5.1	3.1	4.2	1.9	3.2	0.2	0.1	0.6	175	56	0.3
B2t	12-24	5.1	3.7	13.4	9.3	1.3	1.8	0.4	0.1	3.9	27	28	-
B3	24-33	5.0	3.7	12.1	8.0	0.8	1.8	0.3	0.1	4.5	24	27	-
R	33+	-	-	-	-	-	-	-	-	-	-	-	-

*Chemical analysis by Oklahoma Agricultural Experiment Station - Project H-1383

TABLE III--Continued

Horizon	Depth (In.)	pH 1:1 H_2O	pH 1:1 KCl	CEC meq/100g	Extractable Cations meq/100g H	Ca	Mg	K	Na	Al	Base Saturation NH_4OAc %	Sum of cation - %	Organic Matter %
					Stephenville No. 2 - Coal County								
A1	0-4	5.6	4.6	8.5	4.2	2.9	0.8	0.3	0.2	0.6	48	49	2.5
A2	4-9	5.4	4.1	3.2	0.5	1.0	0.3	0.3	0.1	0.7	52	77	0.7
B1	9-14	5.4	4.1	3.5	1.5	0.8	1.1	0.5	0.1	0.6	70	62	-
B2t	14-20	5.0	3.7	13.0	9.5	1.1	3.8	0.2	0.1	3.2	40	35	-
B3	20-25	5.2	3.8	11.3	11.1	1.3	3.8	0.1	0.1	3.9	52	32	-
R	25+	-	-	-	-	-	-	-	-	-	-	-	-
					Hartsells No. 1 - Pittsburg County								
A1	0-4	6.3	-	8.3	3.1	6.2	0.9	0.3	Tr	0.0	89	70	2.3
A2	4-16	5.3	-	2.6	1.7	0.9	0.3	0.1	Tr	0.1	50	43	0.3
B21t	16-21	4.9	-	10.2	10.9	0.9	2.4	0.2	0.1	2.0	35	25	0.3
B22t	21-26	5.0	-	11.1	11.2	1.0	2.5	0.2	0.3	4.4	36	26	0.3
B23t	26-32	5.0	-	15.5	12.7	2.2	4.2	0.3	0.7	5.2	48	37	0.3
B3	32-50	5.1	-	15.9	9.8	3.4	5.3	0.3	1.1	3.1	64	51	0.2
R	50-58+	-	-	-	-	-	-	-	-	-	-	-	-
					Hartsells No. 2 - Pittsburg County								
A1	0-3	6.0	-	6.5	3.5	4.3	0.7	0.2	Tr	0.0	80	60	2.3
A2	3-17	5.0	-	2.8	2.6	0.6	0.3	Tr	Tr	0.3	32	26	0.6
B21t	17-27	5.5	-	7.2	3.3	3.3	2.0	0.2	Tr	0.3	76	62	0.2
B22t	27-36	4.8	-	7.9	6.2	1.4	1.9	0.2	Tr	2.2	44	36	0.2
B3	36-48	4.7	-	8.0	7.1	0.9	1.9	0.2	Tr	3.2	38	30	0.2
R	48-66+	4.7	-	9.0	8.6	1.0	1.9	0.2	0.1	4.1	36	27	0.2

TABLE III--Continued

Horizon	Depth (In.)	pH 1:1 H_2O	pH 1:1 KCl	CEC meq/100g	Extractable Cations meq/100g H	Ca	Mg	K	Na	Al	Base Saturation NH_4OAc %	Base Saturation Sum of cation - %	Organic Matter %
					Hartsells No. 1 - McCurtain County								
A1	0-6	5.1	3.7	10.9	11.1	1.6	0.9	0.3	Tr	1.9	26	20	2.7
A2	6-16	5.2	3.9	4.7	2.6	0.6	1.0	0.1	Tr	1.8	36	39	0.7
B2t	16-26	5.1	3.6	14.6	12.0	0.7	1.6	0.3	Tr	5.7	18	18	-
B3	26-34	5.4	3.6	14.7	13.1	0.9	0.5	0.2	0.1	6.1	11	11	-
R	34+	5.2	3.7	12.1	12.1	0.7	1.0	0.1	0.1	6.3	15	13	-
					Hartsells No. 2 - McCurtain County								
A1	0-4	4.6	3.7	-	-	-	-	-	-	-	-	-	-
A2	4-14	4.9	3.9	3.5	3.7	1.8	0.7	0.1	0.1	0.6	76	42	0.6
B2t	14-28	4.9	3.5	13.9	10.2	1.6	1.8	0.2	0.1	2.7	26	29	-
B3	28-37	4.6	3.4	-	-	-	-	-	-	-	-	-	-
R	37-45+	4.5	3.4	6.8	7.4	0.9	0.7	0.1	0.1	4.1	26	19	-
					Hartsells No. 1 - Coal County								
A1	0-8	6.1	5.2	4.3	2.8	2.4	0.6	0.4	0.1	0.5	81	56	1.1
A2	8-15	6.3	5.1	3.6	1.9	2.1	0.6	0.6	0.1	0.1	94	64	0.4
B21t	15-22	5.6	4.4	14.3	4.1	3.4	2.5	0.3	0.2	0.4	44	61	0.4
B22t	22-28	5.1	3.9	13.1	6.4	1.8	1.5	0.3	0.1	2.1	29	37	-
B3	28-32	4.9	3.7	14.1	8.0	1.6	0.8	0.4	0.2	3.8	22	28	-
R	32+	-	-	-	-	-	-	-	-	-	-	-	-

TABLE III--Continued

Horizon	Depth (In.)	pH 1:1 H_2O	pH 1:1 KCl	CEC meq/100g	Extractable Cations meq/100g H	Ca	Mg	K	Na	Al	Base Saturation NH_4OAc %	Base Saturation Sum of cation - %	Organic Matter %
					Hartsells No. 2 - Coal County								
Ap	0-9	5.7	4.7	5.7	2.9	2.8	0.8	0.4	0.2	0.0	72	59	0.9
B21t	9-21	5.4	4.1	11.8	4.7	2.4	1.9	0.4	0.1	1.1	41	50	0.7
B22t	21-29	5.3	4.1	10.1	6.0	1.9	2.2	0.4	0.5	0.6	50	46	0.5
B3	29-35	5.0	4.2	11.4	4.3	2.1	3.0	0.4	0.1	0.7	49	57	-
R	35+	-	-	-	-	-	-	-	-	-	-	-	-
					Hartsells No. 1 - Atoka County								
A1	0-5	5.5	3.8	4.8	7.0	0.8	1.0	0.3	0.1	1.0	44	24	3.0
A2	5-14	5.2	3.9	2.4	1.8	1.5	1.0	0.1	Tr	0.4	110	59	0.6
B2t	14-26	4.7	3.6	18.2	12.8	3.0	3.3	0.4	0.1	2.1	38	35	0.8
B3	26-38	4.8	3.6	15.1	11.3	2.3	3.5	0.1	0.2	2.4	40	35	-
R	38+	-	-	-	-	-	-	-	-	-	-	-	-
					Hartsells No. 2 - Atoka County								
A1	0-4	5.6	4.9	7.3	1.6	3.0	1.0	0.1	Tr	0.0	57	72	1.1
A2	4-10	4.9	3.8	3.6	2.4	2.5	0.8	0.1	Tr	0.4	93	58	0.5
B2t	10-24	4.9	3.5	8.9	8.2	1.3	1.8	0.4	0.1	2.9	40	30	0.3
B3	24-32	4.8	3.5	13.6	10.5	1.6	2.8	0.5	0.1	4.2	37	32	-
R	32+	4.9	3.2	-	-	-	-	-	-	-	-	-	-

TABLE III--Continued

Horizon	Depth (In.)	pH 1:1 H_2O	pH 1:1 KCl	CEC meq/100g	Extractable Cations meq/100g H	Ca	Mg	K	Na	Al	Base Saturation NH_4OAc %	Sum of cation - %	Organic Matter %
					Linker No. 1 - McCurtain County								
A1	0-5	5.6	4.2	13.1	5.3	3.2	5.0	0.3	Tr	0.6	65	62	3.8
A2	5-12	5.4	3.9	4.4	2.9	1.0	0.7	0.1	0.1	0.7	41	38	0.5
B2t	12-30	5.5	3.5	17.2	7.7	1.4	3.9	0.3	0.1	12.3	21	32	-
B3	30-38	5.4	3.3	20.0	12.6	1.2	2.1	0.3	Tr	8.2	18	22	-
R	38+	4.9	3.2	13.9	10.2	0.7	1.4	0.3	0.1	8.1	25	20	-
					Linker No. 2 - McCurtain County								
A1	0-4	5.1	3.9	9.6	10.9	1.4	1.2	0.3	Tr	1.8	36	21	3.4
A2	4-12	5.6	4.1	2.6	1.3	0.6	0.8	0.2	0.1	0.5	64	56	0.4
B21t	12-18	4.9	3.5	11.3	4.8	1.6	1.1	0.5	0.2	1.8	31	42	-
B22t	18-28	4.9	3.5	22.7	14.3	1.1	2.7	0.4	0.1	7.5	19	23	-
B3	28-38	4.9	3.4	22.3	14.2	0.6	2.1	0.2	0.1	8.9	13	17	-
R	38-46+	4.8	3.4	10.9	10.8	0.6	1.2	0.2	0.1	7.0	19	16	-

plants and to the insolubility of Ca-humates upon drying. Mg-humates do not become insoluble upon drying and are, therefore, removed by leaching from the surface with an accumulation in the B horizons. Extractable K is relatively consistent for all pedons with 0.1 to 0.6 meq/100g in all horizons. Na content is neglible in all pedons. All the pedons, except Stephenville Nos. 1 and 2 - Lincoln County, and Hartsells No. 2 - Coal County, contain an appreciable amount of extractable Al. These three pedons have less than 1.3 meq/100g in all horizons. In contrast all other pedons have 2.4 to 12.3 meq/100g maximum accumulation in the lower horizons. The A horizons of all pedons have typically been leached of most of the Al with accumulation in the lower horizons. Again, this agrees with McCaleb (12) findings. These amounts of Al are significant and contribute highly to the acidic cations contained in the lower horizons of these pedons.

The relation of CEC to percent clay in Figures 15, 16, 17, and 18 of four representative pedons shows a fairly good correlation. The A horizons have the lowest value with highest values in the B horizons. The variation in the A horizons is apparently due to the influence of organic matter of the A1 horizon and to the influence of eluviation of the A2 horizon. The estimate of the CEC of the clay from the relationship of CEC to percent clay as suggested by Kellogg (11) is 35 meq/100g for Stephenville No. 1 - Lincoln County, and 15 to 20 meq/100g for the other three pedons. This would suggest the dominant clay minerals of the Stephenville pedon are illite and kaolinite with minor amounts of montmorillonite and/or vermiculite. The CEC of the other three pedons suggests the clay minerals to be dominantly kaolinite and illite.

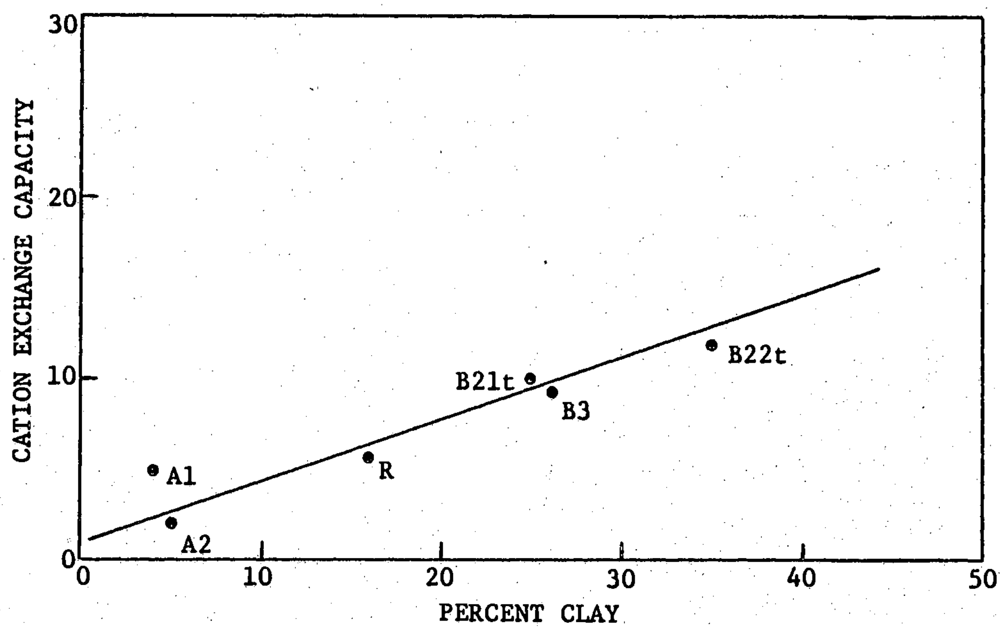

FIG. 15 - CATION EXCHANGE CAPACITY IN RELATION TO PERCENT CLAY FOR STEPHENVILLE NO. 1 - LINCOLN COUNTY

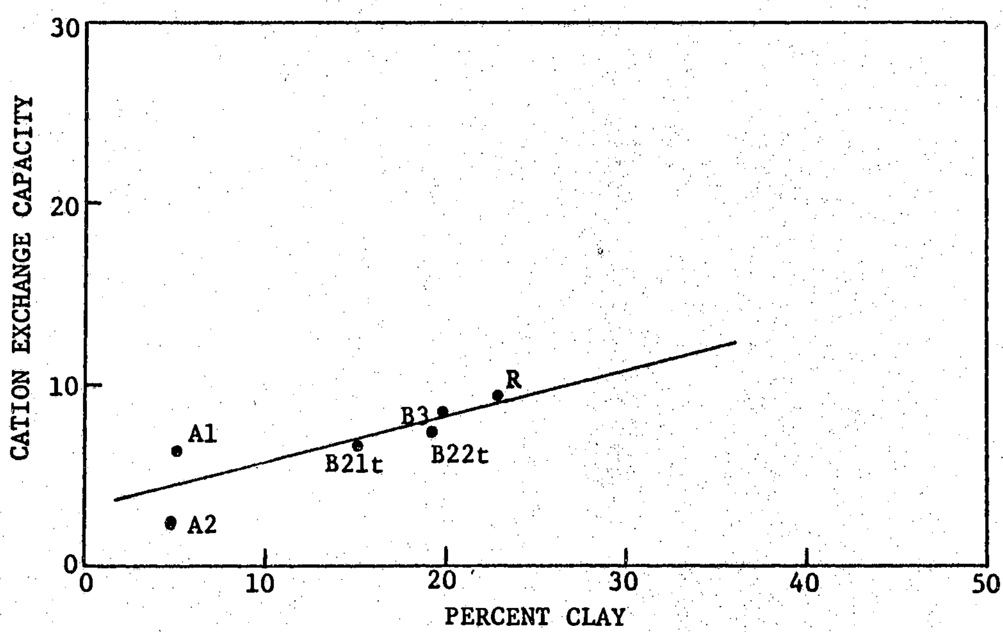

FIG. 16 - CATION EXCHANGE CAPACITY IN RELATION TO PERCENT CLAY FOR HARTSELLS NO. 2 - PITTSBURG COUNTY

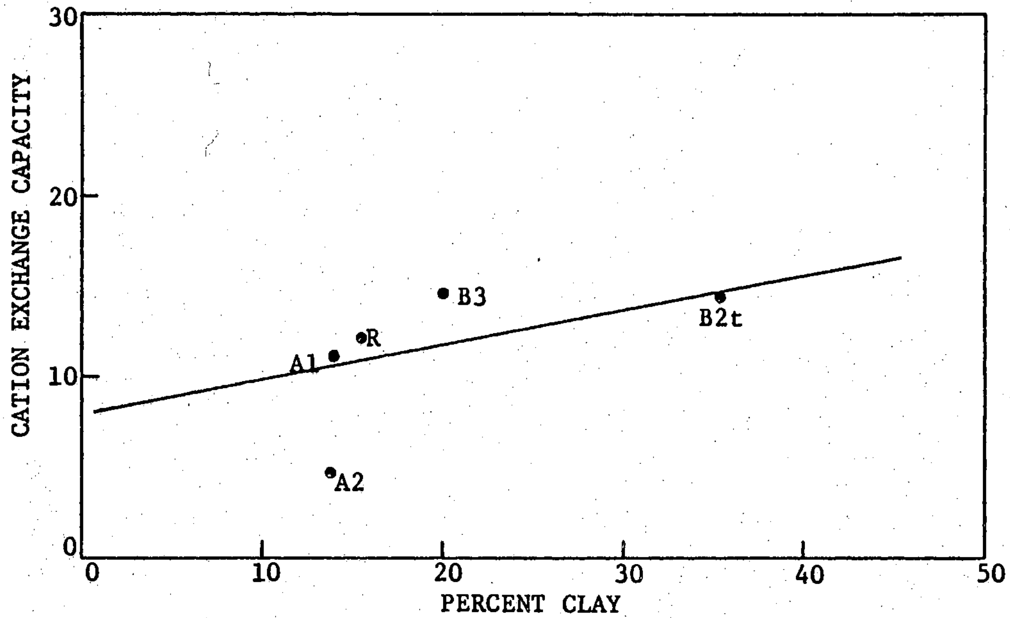

FIG. 17 - CATION EXCHANGE CAPACITY IN RELATION TO PERCENT CLAY FOR HARTSELLS NO. 1 - McCURTAIN COUNTY

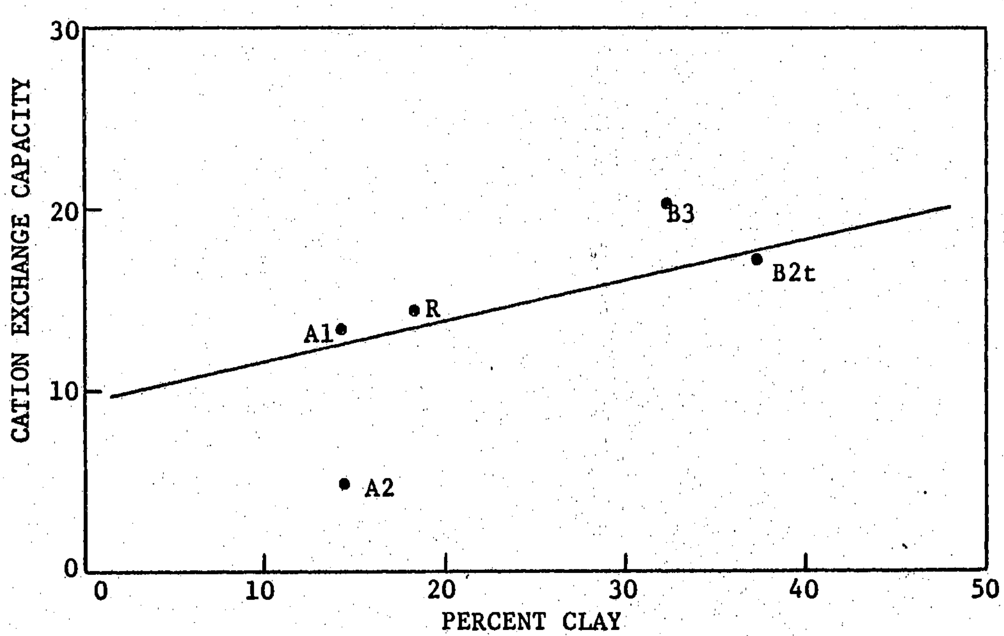

FIG. 18 - CATION EXCHANGE CAPACITY IN RELATION TO PERCENT CLAY FOR LINKER NO. 1 - McCURTAIN COUNTY

The percentage base saturation (sum of cations) as stated previously is essential in classification of these soils into Orders, the highest category. The base saturation varies considerably between pedons, however, within pedons there is some consistency. The surface horizons generally have the highest values with a regular decrease with depth. The lowest values occur immediately above the lithic contact in most pedons. The pedons have base saturations that range from 20 to 83 percent in the A1 horizon, 26 to 77 percent in the A2 horizon, 18 to 70 percent in the B2t horizon, and 11 to 56 percent in the B3 horizon. Only five pedons have base saturations of 35 percent or more in the B3 horizon (immediately above the lithic contact). These are Stephenville Nos. 1 and 2 - Lincoln County, Hartsells No. 1 - Pittsburg County, Hartsells No. 2 - Coal County, and Hartsells No. 1 - Atoka County.

The relationship of CEC, extractable cations, extractable acidity, and base saturation of these pedons exemplifies the intense weathering regime these soils have undergone.

Soil pH

The soil pH values in Table III indicate maximum values in the A1 horizons with a slight decrease with depth. The values for the A1 horizon range from 5.1 to 6.6, except for Hartsells No. 2 - Pittsburg County, which has a value of 4.6. Variations occur between pedons but no correlation is noted between pH and intensity of weathering. Also, no correlation is observable between pH and extractable Al. However, the 1:1 KCl values range from 0.7 to 2.1 lower than the 1:1 H_2O values which reiterates the high content of extractable Al (9).

Organic Matter

With the exception of the surface horizons, all pedons are extremely low in organic matter (Table III). The surface horizons have from 1.0 to 3.8 percent organic matter, while all other horizons have 0.1 to 0.7 percent. Organic matter distribution with depth for four pedons - Stephenville Nos. 1 and 2 - Lincoln County, and Hartsells Nos. 1 and 2 - Pittsburg County, is shown in Figures 19 and 20. Two distinct types of curves are evident. The Stephenville pedons exhibit a primary accumulation of organic matter in the surface horizons and a secondary accumulation in the B2t horizons. The Hartsells pedons exhibit a maximum accumulation in the surface horizons with a sharp decline to the underlying horizons that continually decrease with depth. It appears that removal of organic matter is proceeding at the same rate or faster than addition and transfer in the Hartsells pedons and that removal is somewhat slower than addition and transfer in the Stephenville pedons.

Alfisols - Ultisols Demarcation

Base Saturation Versus Precipitation

Precipitation appears to be one of the most valid variables considered in determining a demarcation between the Orders - Alfisols and Ultisols. The regression of precipitation on base saturation is shown in Figure 21. The correlation coefficient (r) is -.84 which denotes good relation between these two variables. The demarcation between Alfisols and Ultisols occurs at 42 inches.

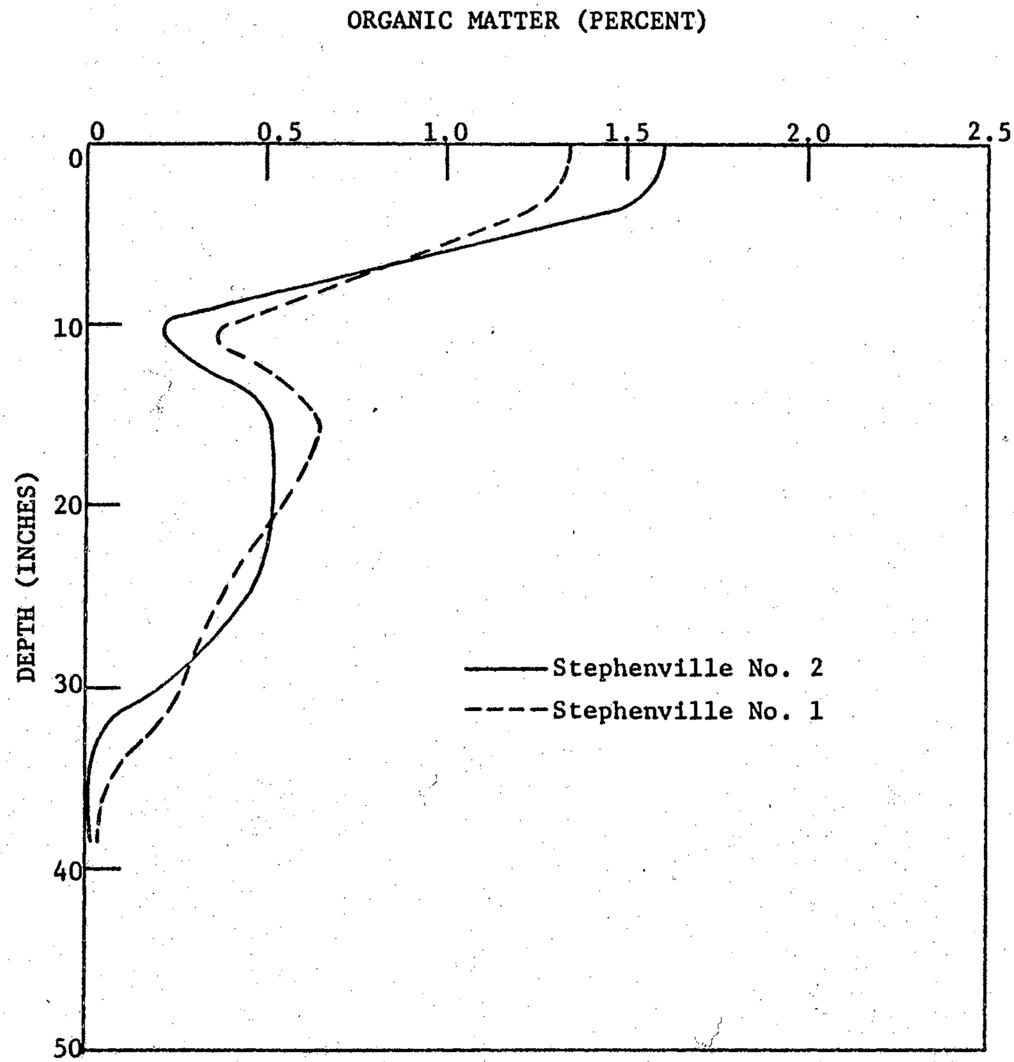

FIG. 19 - DISTRIBUTION OF ORGANIC MATTER WITH DEPTH IN STEPHENVILLE SOILS - LINCOLN COUNTY

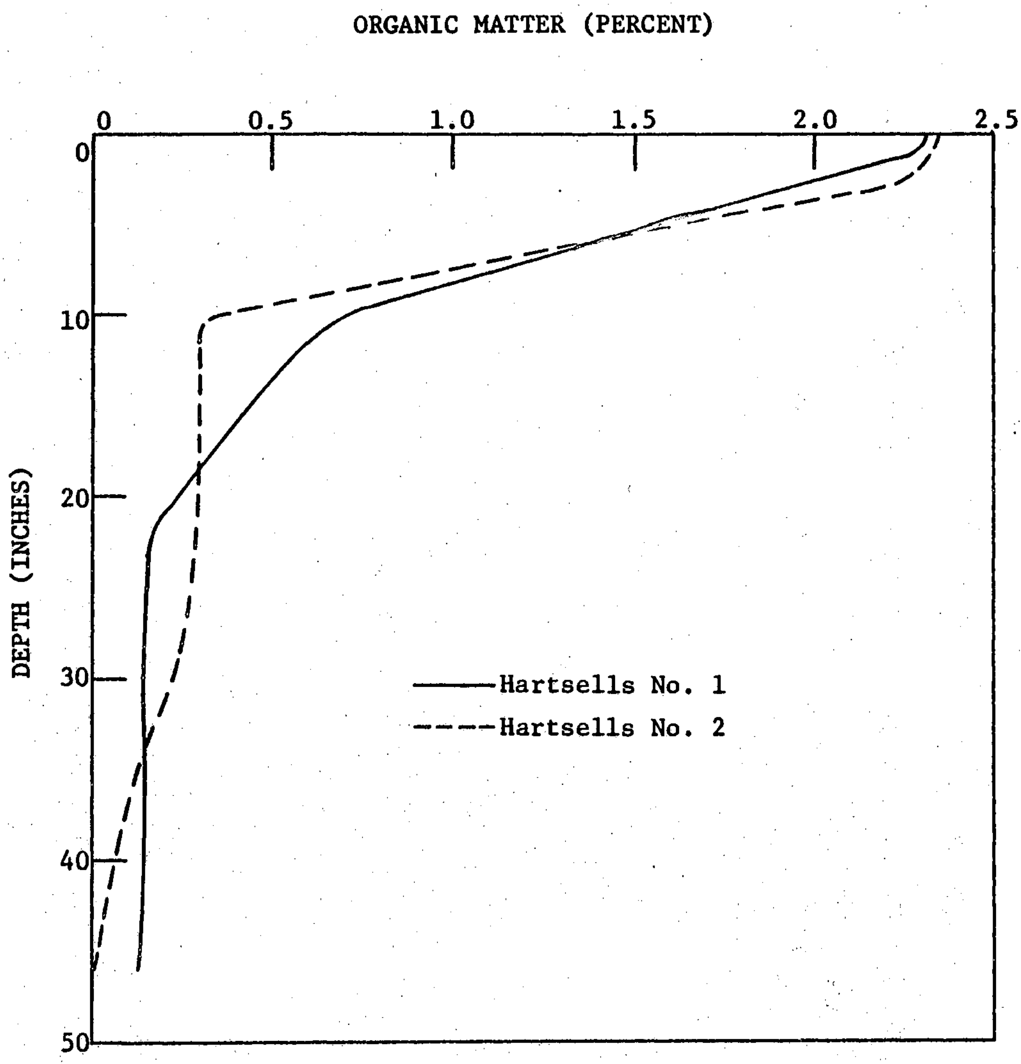

FIG. 20 - DISTRIBUTION OF ORGANIC MATTER WITH DEPTH IN HARTSELLS SOILS - PITTSBURG COUNTY

Base Saturation Versus P-E Index

The regression of P-E index on base saturation is shown in Figure 22. The correlation coefficient is -.84 which is the same as for precipitation and denotes equality in importance of this variable. The separation of Alfisols and Ultisols occurs at P-E index 68. This approaches the high limit of P-E 64±6 which is presently being used (2).

Base Saturation Versus Temperature

The regression of mean annual temperature on base saturation shows fairly good correlation with a correlation coefficient of -.75 (Figure 23). The correlation is not as significant as precipitation or P-E index, however, it does denote fairly good relation between the two variables and does warrant consideration in separation of the Alfisols and Ultisols. The demarcation occurs at 62.7^{o} F.

Base Saturation Versus Clay Content, Evapotranspiration and pH

The regression of clay content and pH (1:1 Soil - H_2O) of the horizon immediately above the lithic contact, and evapotranspiration on base saturation were plotted separately. The correlation coefficients were: r = .13; r = - .007 and r = - .10, respectively. These correlations are approaching zero and denote very little relation between the variables. The relation between the variables is so minute they should not be considered as criteria for separation of these Alfisols and Ultisols. The regression of pH on base saturation is shown in Figure 24. The relation of these two variables is least significant of all tested. This is contrary to past belief that acidity increased from the northwestern to the southeastern part of the study area.

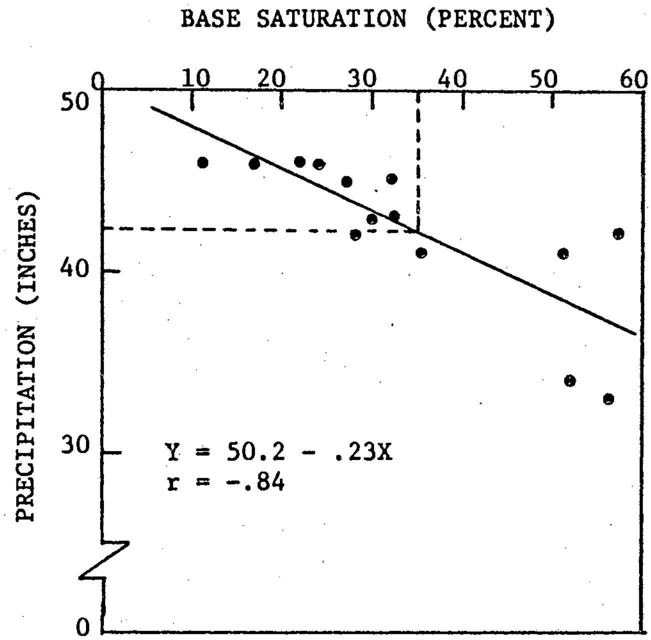

FIG. 21 - BASE SATURATION IN RELATION TO PRECIPITATION

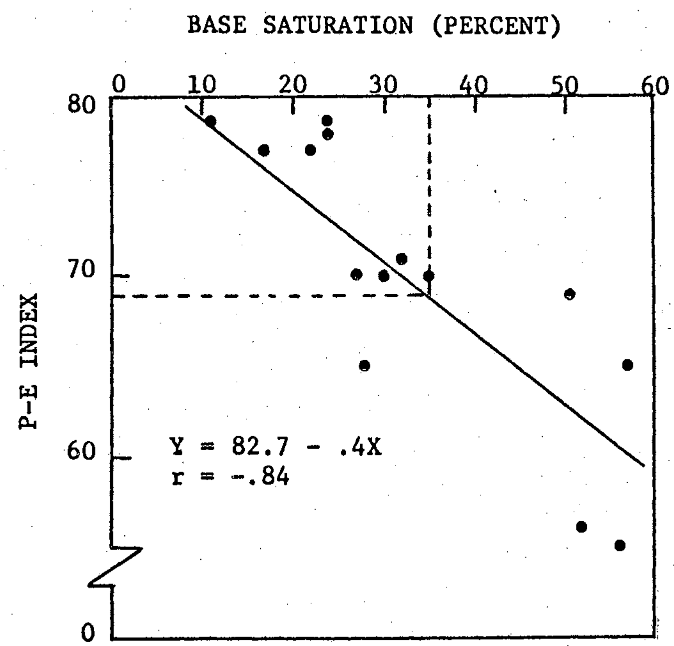

FIG. 22 - BASE SATURATION IN RELATION TO P-E INDEX

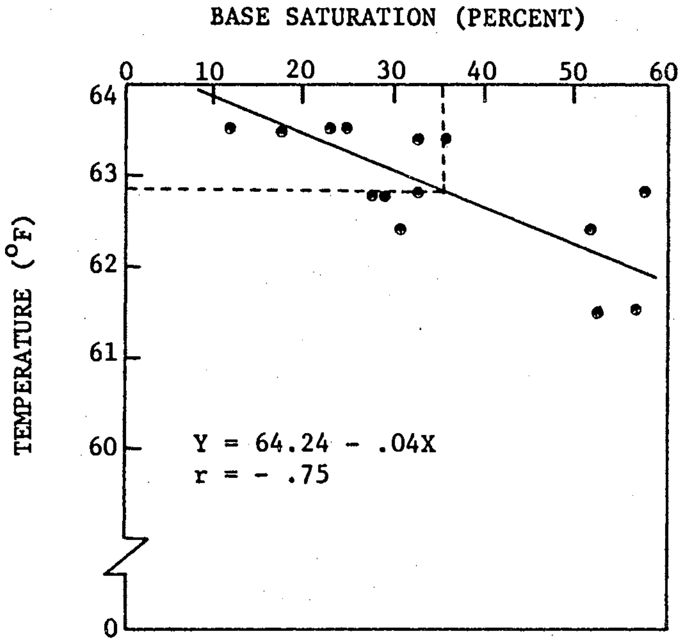

FIG. 23 - BASE SATURATION IN RELATION TO TEMPERATURE

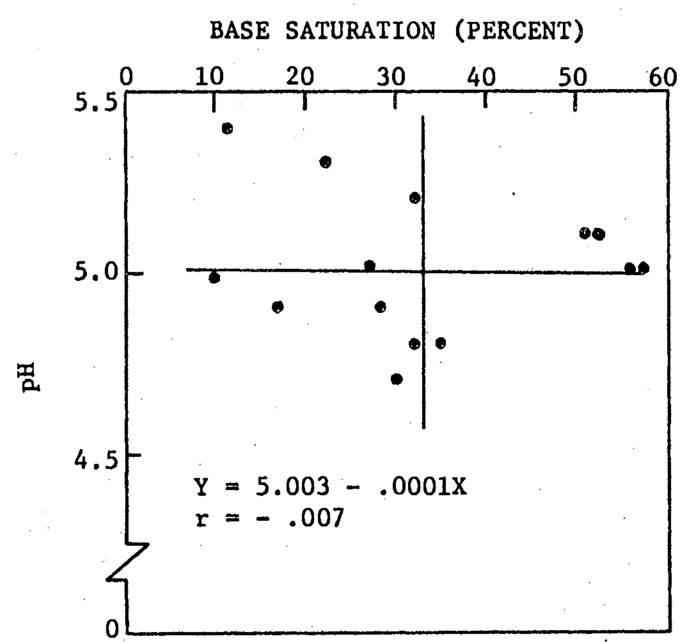

FIG. 24 - BASE SATURATION IN RELATION TO pH

Soil Classification

Mineralogical data of Stephenville Nos. 1 and 2 - Lincoln County, and Hartsells Nos. 1 and 2 - Pittsburg County, indicate 90 to 95 percent quartz content which classifies these pedons as siliceous (14). It is, therefore, assumed that the other pedons have siliceous mineralogy. The mean annual air temperature for the study area is 61 to 64^{o} F. and soil temperature is about 2^{o} F. higher (16) which classifies the soil temperature as thermic. The clay content of the argillic horizon of all pedons ranges from 18.2 to 37.6 percent, and all pedons have more than 15 percent materials coarser than very fine sand which classifies the textural family as fine loamy, or fine, depending on clay content.

The classification of the fourteen pedons according to the March 1967 supplement of the 7th Approximation is as follows:

Ultic Hapludalfs -- fine loamy, siliceous, thermic

Stephenville No. 1 - Lincoln County
Stephenville No. 2 - Lincoln County
Hartsells No. 1 - Pittsburg County
Hartsells No. 2 - Coal County

Ultic Hapludalfs -- fine, siliceous, thermic

Hartsells No. 1 - Atoka County

Typic Hapludults -- fine loamy, siliceous, thermic

Stephenville No. 1 - Coal County
Stephenville No. 2 - Coal County
Hartsells No. 2 - Pittsburg County
Hartsells No. 1 - McCurtain County
Hartsells No. 2 - McCurtain County
Hartsells No. 1 - Coal County
Hartsells No. 2 - Atoka County

Typic Hapludults -- fine, siliceous, thermic

Linker No. 1 - McCurtain County
Linker No. 2 - McCurtain County

Soil Genesis

The processes of addition, removal, transfer, and transformation within the Hartsells, Linker and Stephenville soils are very similar, therefore, a single hypothesis will suffice to define their origin. The soil genesis can be defined by a working hypothesis expressed in the form of a model as suggested by Arnold (1). This model is built on research concerning these soils and the theories they relate.

It is assumed in the model (Fig. 25) that development is proceeding on a geomorphically stable upland area with no addition or deletion of parent material. The parent material consists primarily of acid sandstone thinly interbedded with claybeds, shales or siltstone. In some areas the parent materials have been tilted and development is hastened, however, the same processes apply but at a different rate. The first stage of development begins with incipient weathering of the parent material. When weathering has occurred to produce sufficient soil to support a sparse savannah vegetation, the addition of organic matter commences. Very little development occurs during the first stage with only a thin A1 horizon over a R horizon. This stage of development is indicative of Entisols.

Continuation of development hastens after the first stage. The low carbonate content of the parent material does not inhibit the leaching of bases and the weathering of silicate clay minerals. The acid environment as well as the climatic conditions are conducive to intensive weathering and maximum soil development.

As the soil leaves the first stage and approaches the second stage of development, albic and cambic horizons have formed. These soils now have assumed the properties of Inceptisols. The vegetation

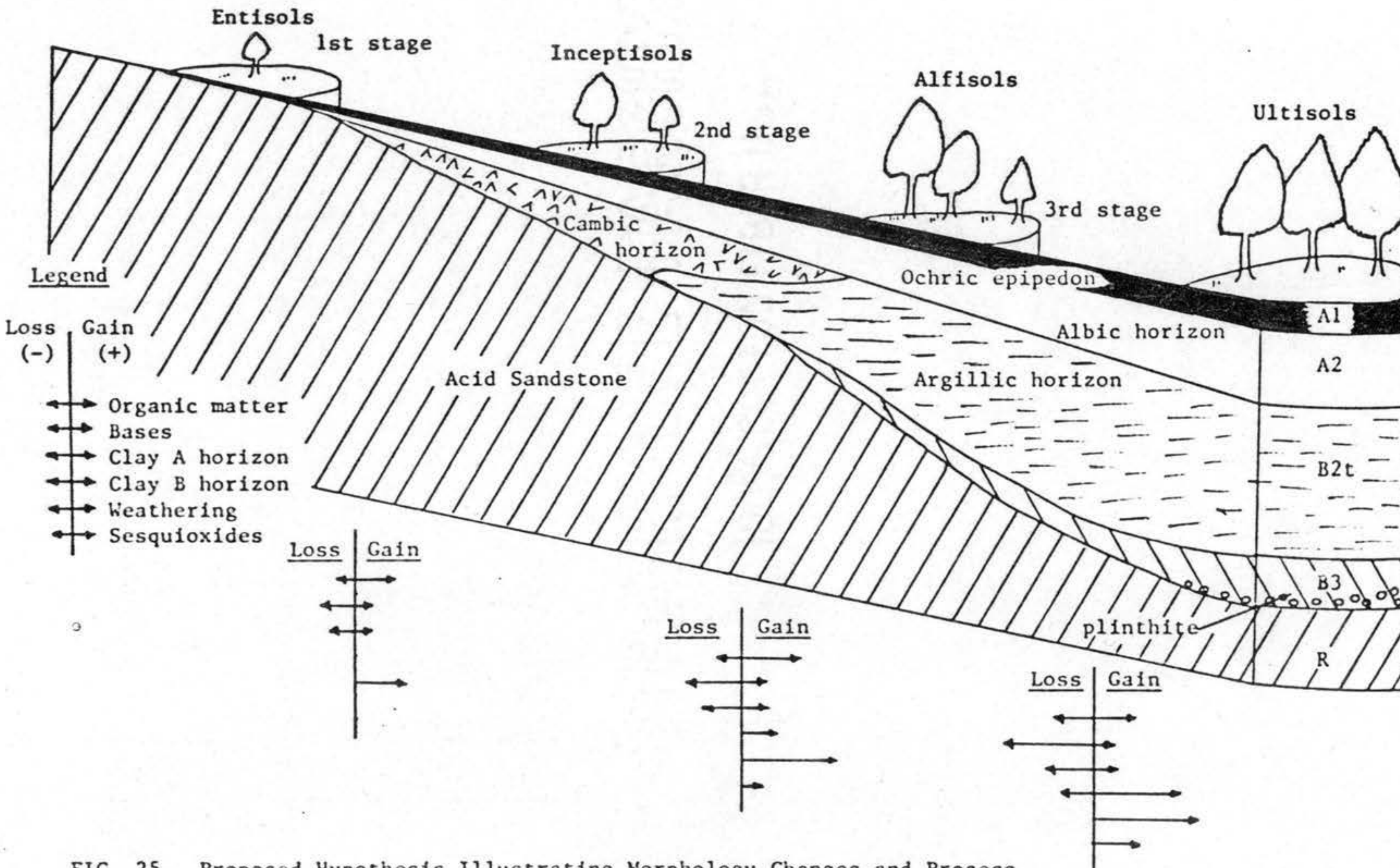

FIG. 25. Proposed Hypothesis Illustrating Morphology Changes and Process Rates for Hartsells, Linker and Stephenville Soils.

of forest and grasses have become more dense and organic matter addition exceeds losses and the A1 horizon is slightly thickened. The ochric epipedon thickens and becomes drastically leached of bases and assumes a bleached appearance except for the thin upper layer which has been enriched with organic matter. Continued weathering of parent material, leaching of bases, translocation of clays from the A horizon and formation of silicate clays in situ have resulted in the formation of a cambic horizon which in a short time will begin to take on the appearance of an argillic horizon.

Upon inception of the argillic horizon, the third stage of development has begun. The A1 horizon is maintained, the albic horizon is thickened due to continued leaching and translocation of clays to the argillic horizon and the argillic horizon has become strongly developed. Bases are continually leached during this stage and hydrogen is the dominant cation. The soils have now assumed the properties of Alfisols. The bulk of the clay minerals and oxides of the argillic horizon are formed in situ (12). Fluctuating moisture contents seem to be responsible for orientation of clays and clay film formation. Development continues within the argillic horizon as the pores and root channels of the lower portion are sealed with materials from the above horizons. Rearrangement occurs between grains and in small pores, resulting in a more strongly developed horizon. Also, this limits the upward boundary of the argillic horizon to the potential source of weatherable materials in the A horizon. The intensity of weathering is causing degradation of silicate clay minerals and the formation of sesquioxides.

With time and increased leaching the bases are almost completely removed and the colloids become H- and Al-saturated. The degradation of the clay mineral has increased and the accumulation of sesquioxides is beginning to form soft plinthite in the lower B horizon. At this stage of development the soils have assumed the characteristics of Ultisols.

From the proposed hypothesis, the morphological changes and process rates of soil development can be determined for each pedon studied by relating it to the classification of the pedon.

CHAPTER V

SUMMARY AND CONCLUSIONS

Forested soils of similar morphology occur extensively throughout central and eastern Oklahoma. These soils have developed from acid sandstone and have previously been classified as Red-Yellow Podzolic soils. Four pedons of the Stephenville series, eight pedons of the Hartsells series and two pedons of the Linker series were studied to obtain morphological, chemical and physical properties. Also, a study was undertaken to determine a demarcation between Orders - Alfisols and Ultisols - of this area.

These highly weathered soils all have an ochric epipedon, an albic horizon, an argillic horizon and a lithic contact within 20 to 50 inches. They have a thin A1 horizon, low in clay and high in organic matter, an A2 horizon low in both clay and organic matter that rests abruptly on a B2t horizon. Clay content of this horizon ranges from 18.2 to 37.6 percent clay. The soils developed from Permian sandstone contain more sand and less silt than those developed from the Pennsylvanian sandstone. The pedons sampled in McCurtain County are higher in silt content than the other pedons sampled. No discontinuity or stratification was noted in any pedon.

The CEC of these soils is relatively low with highest values in the B2t horizon that range from 8 to 23 meq/100g with most value about 13 meq/100g. The effect of organic matter on CEC can readily be seen in these pedons. The A1 horizons have values of 1 to 9 meq/100g higher than the A2 horizons with minimal differences in clay content. H is the dominant cation of all pedons. Mg is the dominant basic cation in all pedons except Stephenville Nos. 1 and 2 - Lincoln County. All the pedons except Stephenville Nos. 1 and 2 - Lincoln County, and Hartsells No. 2 - Coal County, contain an appreciable amount of extractable Al. These three pedons have less than 1.3 meq/100g accumulation in the B horizons while all other pedons have 2.4 to 12.3 meq/100g. The A horizons have typically been leached of most the the Al.

An estimate of the CEC of the clay of four pedons was 35 meq/100g for Stephenville No. 1 - Lincoln County, and 15 to 20 meq/100g for other pedons from Pittsburg and McCurtain Counties. This indicates the dominant clay minerals of the Stephenville pedon are illite and kaolinite with lesser amounts of montmorillonite and/or vermiculite. The CEC of the other three pedons is indicative of kaolinite and illite. The base saturation (sum of cations) of the lower B horizons, which is the criteria for separation of the Alfisols and Ultisols, ranges from 11 to 56 percent with only five pedons exhibiting values of 35 percent or more.

The pH of all horizons ranges from 4.6 to 6.6 and values generally decrease with depth. No correlation was noted between pH and intensity of weathering. The 1:1 KCl values are lower than the 1:1 H_2O values which is indicative of the high Al content. The organic matter is highest in the Al horizons with 1.0 to 3.8 percent and a sharp decline to the underlying horizons. The organic matter of all other horizons is very low with values that range from 0.1 to 0.7 percent. Some pedons exhibit a secondary accumulation in the B2t horizon.

Precipitation and/or P-E index appears to be the best criteria for soil scientists to use in the field in making Alfisols - Ultisols demarcation. The demarcation occurs at about 42 inches precipitation and at about P-E index 68. Temperature showed fairly good correlation but not as good as precipitation or P-E index. With temperature, the demarcation occurs at 62.7° F. The correlation of pH, clay content and evapotranspiration on base saturation denotes very little relation. It is so minute these variables should not be considered criteria for separation of these Alfisols and Ultisols in the field.

From the data presented it is concluded that intensity of weathering increases from the northwestern part of the area to the southeastern part. This is indicated by the higher base saturation, lower extractable Al content and higher CEC of the clays of the pedons in the northwestern part. Also, all three series - Hartsells, Linker and Stephenville - should be recognized in this area. The Stephenville soils occur west of the 42 inch precipitation line or P-E index 68 and are classified as Alfisols. The Hartsells and Linker soils occur east of this line and are classified as Ultisols. It should be remembered, however, that in some areas these soils will be intermixed and only laboratory data will reveal the classification.

LITERATURE CITED

1. Arnold, R. W. Multiple Working Hypothesis in Soil Genesis. Soil Sci. Soc. Amer. Proc. 29: 717-724. 1965.

2. Bartelli, L. J. Oklahoma Soil Survey Workshop Unpublished Notes, Principal Soil Correlator, S.C.S., U.S.D.A., Ft. Worth, Texas. 1967.

3. Bennema, J. The Red and Yellow Soils of the Tropical and Subtropical Uplands. Soil Sci. 95: 250-257. 1963.

4. Cline, M. G. Basic Principles of Soil Classification. Soil Sci. 67: 81-91. 1949.

5. Day, P. R. Report of the Committee on Physical Analyses. Soil Sci. Soc. Amer. Proc. 20: 167-169. 1956.

6. Gray, F., and H. M. Galloway. Soils of Oklahoma. Dept. of Agronomy. Oklahoma State University. 1959.

7. Harlan, Jack R. Grasslands of Oklahoma. Dept. of Agronomy. Oklahoma State University.

8. Jenny, Hans. Factors of Soil Formation. McGraw-Hill Book Company. New York and London. 1941.

9. Jenny, Hans. Reflections on the Soil Acidity Merry-go-Round. Soil Sci. Soc. Amer. Proc. 25: 428-432. 1961.

10. Joffe, J. Pedology. Pedology Publications, New Brunswick, New Jersey. 1949.

11. Kellogg, C. E. The Place of the Laboratory in Soil Classification and Interpretation. S.C.S., U.S.D.A. 1962.

12. McCaleb, S. B. The Genesis of the Red-Yellow Podzolic Soils. Soil Sci. Soc. Amer. Proc. 23: 164-168. 1959.

13. Simonson, Roy. What Soils Are. Yearbook of Agriculture. U.S.D.A. 1957.

14. Soil Conservation Service, U.S.D.A. Soil Survey Laboratory Data and Description for Some Soils of Oklahoma. Soil Survey Investigation Report No. 11. 1967.

15. Soil Conservation Service, U.S.D.A. Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples. Soil Survey Investigation Report No. 1. 1967.

16. Soil Conservation Service, U.S.D.A. Soil - Temperature Regimes - Their Characteristics and Predictability. 1964.

17. Soil Survey Staff, S.C.S., U.S.D.A., 1960, Soil Classification, A Comprehensive System, 7th Approximation as amended March, 1967.

18. Soil Survey Staff, Soil Survey Manual. U.S.D.A. Handbook No. 18. 1951.

19. Thornthwaite, C. W. An Approach Toward a Rational Classification of Climate. Geogr. Rev. 38. 1948.

20. Thorp, J. and G. D. Smith. Higher Categories of Soil Classification: Order, Suborder, and Great Soil Group. Soil Sci. 67: 117-126. 1949.

21. U. S. Department of Commerce. Weather Bureau - Climate of the States - Oklahoma. January, 1960.

22. Yearbook of Agriculture. Soil and Men. U.S.D.A. 1938.

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