March 7, 1960

To the Graduate Council:

I am submitting herewith a thesis written by Kusuma Shankar entitled "Formation and Morphology of Crossville Loam." 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:

Laurence N Skold

Robert S. Dotson

Accepted for the Council:

Dale Wantling
Dean of the Graduate School

FORMATION AND MORPHOLOGY OF CROSSVILLE LOAM

2 R
33

A Thesis

Presented to

The Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Kusuma Shankar

March 1960

ACKNOWLEDGMENTS

I am greatly indebted to Dr. M. E. Springer, Associate Professor in Agronomy, University of Tennessee, and my major professor for initiating me into this study, for guiding me during the entire course of this investigation and helping prepare this thesis. It is my esteemed duty to thank him for providing me with so many opportunities to acquire knowledge.

I wish to place on record my deep sense of gratitude to Professor L. N. Skold, Head of the Department of Agronomy, University of Tennessee, for his keen interest and invaluable guidance in the preparation of this thesis. I am grateful to Dr. R. S. Dotson, Assistant Methods Specialist, University of Tennessee, for general help and encouragement. I am deeply indebted to Dr. L. F. Seatz, Professor of Agronomy, University of Tennessee, for suggesting suitable laboratory procedures and for his valuable criticisms and encouragement. To Mr. R. R. Dickson, State Climatologist, U. S. Weather Bureau, I am grateful for providing me with data on actual and potential evapotranspiration at Crossville.

My thanks are due to Mr. J. A. Elder, Mr. J. H. Winsor and Mr. D. K. Springer, of the Soil Conservation Service, for their cooperation and for observing the sites at which the samples were collected.

I wish to express my sincere appreciation to Mr. K. B. Sanders for giving me all the help in laboratory determinations, and to Mr. T. J. Longwell for all his help in my field studies.

Appreciation and gratitude is also expressed to Mrs. H. L. Smith for her patient, quick and neat typing of the final copies of this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Pedology, the study of soil as a natural body, is relatively a young science. In recent years recognition of the soil as a basis of national wealth has given it and the science of Pedology a high degree of importance. The background of observations upon which the generalizations of this young science rests is as yet comparatively limited, and a final universal statement of many basic and fundamental principles has not been agreed upon by scientists. Therefore, each addition to the existing body of knowledge or a restatement of observations from a different point of view is considered to be of some value at this particular time in the development of the science. Again, in this era of fast growing human population and industrial expansion, the science of Pedology must yield information of agricultural and economic value.

This purpose particularly appears to be true in case of the Cumberland Plateau, where soils differ widely both in their physical suitability for use and in their management requirements. Such differences are caused by a number of characteristics, which ultimately affect the productivity of the soil and thereby its use and management.

These statements of prevailing conditions explain the need for the type of study presented here. The purpose of this study on the formation and morphology of Crossville loam then, was to gain more information on such a soil.

The Crossville soils are on the uplands and usually are in association with Hartsells series. This association is principally on the broader less-dissected divides. Both series have in places been classified under the Red-Yellow Podzolic great soil group. However, in spite of the fact that many gradational characters are apparent in this great soil group, Crossville loam does not seem to fit into the general descriptions. An attempt was made in the investigation as presented in this paper to reevaluate the characteristics of Crossville loam and to place it under a suitable great soil group. This soil, Crossville loam, differs from the Hartsells in being browner throughout the profile and, in places, in being shallower to bedrock. In addition to classifying the soil, attempts were made in this paper to find the reasons for the characteristics it has attained.

CHAPTER II

REVIEW OF LITERATURE

Cumberland Plateau

Location and extent of area

The Cumberland Plateau is located in the western part of the southern Appalachian Highlands, an area extending from northern Virginia and eastern Kentucky southwest through eastern Tennessee into Alabama and Georgia. The width of the Plateau is 71 miles at the Kentucky-Tennessee line and about 50 miles along the southern boundary of Tennessee. The elevation ranges from 1000 to 3000 feet above sea level with an average of 1800 feet--Leburn[1]. Referring to the Plateau, Newcome and Smith (1958) said:

> It lies within the eastern half of Tennessee, is bounded on the west by the Highland Rim Plateau and on the east by the Valley and Ridge province. Within the Plateau lies the Sequatchie Valley, a deep, narrow valley formed by the erosion of rocks previously folded and faulted.
>
> The Cumberland Plateau, including the Sequatchie Valley, comprises an area of 5100 square miles in Tennessee and contains all or part of Pickett, Fentress, Scott, Campbell, Claiborne, Overton, Morgan, Anderson, Putnam, Cumberland, Roane, White, Van Buren, Bledsoe, Rhea, Grundy, Sequatchie, Hamilton, Franklin and Marion counties.

Climate

According to Newcome and Smith (1958), the climate of the Plateau is temperate. It is cooler than that of the adjacent lowlands and this,

---

1/Leburn, E. J. The Cumberland Plateau, its agricultural situation and possibilities. Unpub. M.S. Thesis. University of Tennessee, Knoxville, Tenn. 1942.

along with the large wooded areas, is responsible for the many resorts, summer homes, assembly grounds for church organizations, and private schools in the province.

Hubbard et al. (1950) reported moderate winters with short cold periods, and mild summers with cool pleasant evenings in the area. Summer temperatures higher than 90° F. are rare, and the difference between the mean summer and winter temperatures is about 33°. The mean seasonal temperatures on the Plateau in winter are 38.7° F.; in spring 54.7°; in summer 72.1°; in fall 57.0°; and the mean annual temperature is 55.6° F. An average frost-free period of 179 days extends from April 18 to October 14.

They explained that the annual precipitation of 54.2 inches is well-distributed. About 83% of the rain is equally distributed in winter, spring and summer seasons. The lightest rainfall in the fall coincides with the ripening and harvesting of many agricultural crops.

The average monthly and annual precipitation at Crossville, over a 27-year period prior to 1940 is shown in table 1 and the monthly and annual precipitation for each year since 1940 is shown in table 2.

Dickson[2] estimated the mean degree days, below 65° F., for the Plateau Experiment Station. Dickson (1959) also pointed out that potential evapotranspiration estimated by the Thornthwaite method is a function of temperature, latitude and time of year. During computations of actual evapotranspiration, he assumed that evapotranspiration is

---

2/Dickson, R. R. Mean degree days. Tennessee weather bureau: L.S. 5801. 1958.

Table 1.--Average precipitation in inches, Crossville, Tenn.[a]

Length of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
27 years	5.36	4.32	5.75	4.64	4.10	4.44	5.39	5.17	3.01	3.48	3.43	5.03	54.17

a/From 'Climate and Man', USDA year book 1941.

Table 2.--Monthly and annual precipitation at Plateau Experiment Station, Grossville, Tenn. 1941-59[a]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	2.42	0.62	3.61	6.08	0.91	3.45	6.97	5.03	1.48	3.28	3.97	4.01	41.83
1942	3.65	4.87	6.39	0.88	2.60	6.67	9.70	10.33	2.29	2.41	3.51	13.05	66.35
1943	2.50	4.17	5.53	6.48	3.28	2.45	2.39	2.50	5.31	2.28	1.57	2.04	40.50
1944	2.30	10.51	7.93	5.82	6.09	1.78	3.00	4.89	13.44	0.60	3.86	5.59	65.81
1945	3.56	7.58	4.17	6.35	7.84	3.84	7.23	3.85	2.76	4.07	7.40	5.49	64.14
1946	6.67	6.14	3.88	4.51	5.03	5.14	2.96	5.21	4.91	2.95	4.52	3.48	55.40
1947	10.91	1.54	4.40	2.47	3.33	3.75	5.60	3.56	1.29	0.90	4.04	3.38	45.17
1948	4.02	10.59	7.51	2.33	3.05	4.59	3.45	2.20	2.64	2.42	10.44	6.14	59.38
1949	12.28	3.90	5.48	4.71	2.37	6.82	5.84	8.16	1.12	4.77	1.66	5.94	63.06
1950	14.79	6.78	6.32	1.96	7.04	4.90	5.22	7.74	3.40	0.93	5.31	3.29	67.68

Table 2.--continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1951	8.13	8.03	8.22	5.23	3.00	4.19	2.77	1.31	4.88	2.06	7.28	11.58	66.68
1952	7.44	2.88	7.37	2.35	3.21	2.80	1.58	1.80	2.20	0.76	3.33	4.25	39.97
1953	6.37	6.08	4.77	5.98	4.54	4.08	6.29	1.82	2.14	0.76	1.71	5.87	50.43
1954	11.95	3.76	5.12	5.04	4.65	3.04	1.78	1.70	3.42	4.44	3.89	9.52	58.30
1955	2.40	7.18	9.90	4.51	4.69	5.63	4.40	1.72	2.88	3.04	3.89	3.86	54.10
1956	4.99	10.93	4.42	7.30	3.16	2.32	9.31	1.16	1.81	4.27	2.21	8.29	60.17
1957	9.40	6.91	3.11	6.01	3.63	7.86	2.81	2.90	8.86	3.59	9.78	6.73	70.59
1958	3.01	2.47	4.36	6.48	3.53	2.91	6.06	2.27	3.57	0.79	4.58	1.79	41.82
1959	4.32	4.41	5.93	4.30	4.26	3.71	3.81	5.83	2.23	5.29	4.90	7.00	55.98

a/Climatological data -Tennessee. Weather Bureau. U.S.D. Com. vols. 46-64. 1941-59.

limited by soil water content and that available water at field capacity equals 4 inches. His data for mean degree days (below 65° F) together with average daily and monthly evapotranspiration, for the period 1931 to 1955 are given in table 3. On the data furnished by Dickson, R. R., the soil moisture status of soils is calculated and presented in figure 1.

Geology

Luther (1959) reported that the Plateau is underlaid by a coal-bearing formation making it a part of the greatest coal-bearing formation in the United States. It is made up of rocks of the Carboniferous age which are divided into three series, namely, the Mississippian, Pennsylvanian, and Permian. The rocks of the area are principally of the Pennsylvanian series with those of the Valley in the Mississippian series. Those of the Mississippian series are comprised mainly of limestone and underlie the Pennsylvanian series in thick beds. The upper strata of the region being of the Pennsylvanian series are formed of sandstone, shale, and conglomerates.

Crossville Loam

Hubbard et al. (1950) described Crossville loam in Cumberland county. They reported that this soil has been formed from weathered material of a rock formation consisting of sandstone and some shale. External drainage ranges from very slow to medium, and internal drainage is medium. Although the soil is well-drained, here and there are some small, seepy places. The relief is level to undulating, the gradient being not more than 5%. They said:

Table 3.--Mean degree days below 65° F., and average daily and monthly potential evapotranspiration at the Plateau Experiment Station, Crossville, Tenn.[a]

No.	Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	Mean degree days below 65° F.	840	740	600	300	110	20	0	0	70	260	590	840	4370
2	Average daily potential evapotranspiration (inches)	0.01	0.01	0.03	0.06	0.11	0.16	0.18	0.16	0.12	0.06	0.02	0.01	--
3	Average monthly potential evapotranspiration (inches)	0.3	0.4	0.9	1.9	3.4	4.7	5.5	4.8	3.5	2.0	0.7	0.4	--

a/Dickson, R. R. Mean degree days. Tennessee weather bureau: L.S. 5801. 1958.

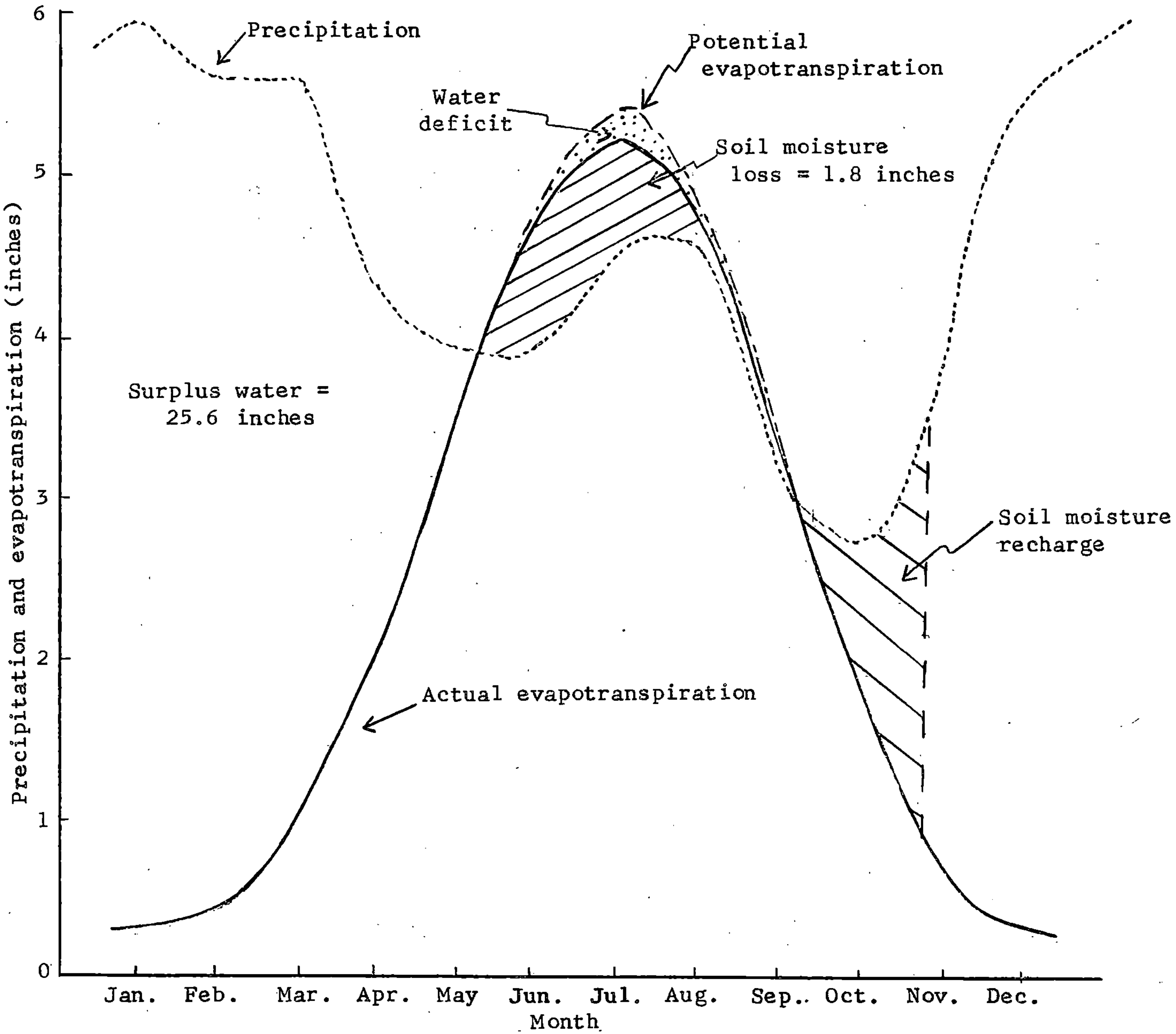

Figure 1--Average potential evapotranspiration and precipitation through the year at Crossville for the period 1931-1955 (Data furnished by Dickson, R. R., Tennessee State Climatologist, U. S. Weather Bureau).

The soil occurs in nearly all parts of the county in relatively small to medium sized areas. The total of 5856 acres occupies positions on smoother parts of interstream divides in association with the Hartsells series.

Under virgin conditions a profile of this type has the following characteristics:

0 to 2 inches, dark grayish-brown or dark-brown friable loam. A fairly large quantity of organic matter is mixed with the mineral material of this layer.

2 to 7 inches, grayish-brown or brown, mellow loam.

7 to 22 inches, yellowish-brown, friable, fine sandy clay.

22 to 30 inches, grayish-brown or brownish-gray, friable, fine sandy loam mixed with many angular sandstone fragments up to 6 inches in diameter.

30 inches +, sandstone bedrock in horizontal strata; in places some shale is interstratified with the sandstone.

Throughout the extent of this soil the layers of the profile vary considerably in thickness. In cultivated fields the color of the plowed layer is generally lighter than that of the surface soil in forested areas.

This soil has excellent workability, good conservability, and fair productivity. It is strongly acid and has a low content of mineral plant nutrients and a fair to low supply of organic matter. The soil is easily pervious to moisture, air, and roots, and its water-holding capacity is moderate. Moisture conditions are favorable for plant growth, and the control of erosion presents little or no problem. This soil is fair to good crop-land and good pasture land.

In the soil survey of Marion County, Tennessee, Series 1950, No. 2 (1958), the rolling phase of Crossville loam (5-12% slopes) was described as a well-drained, friable soil that developed from the residuum of nearly level-bedded acid sandstones. The soil is normally on rather long and mild east-facing slopes in association with the Hartsells, Linker and Muskingum soils. It differs from the Hartsells in being much browner in the upper 14 inches and generally somewhat shallower over sandstone bedrock.

It has developed under a predominantly deciduous forest. The profile description is as follows:

0 to 1 inch, very dark-gray friable loam; high in organic matter; soft, fine crumb structure.

1 to 6 inches, dark-brown, very friable loam to silt loam; weak medium crumb structure; gradual transition to layer below.

6 to 13 inches, dark-brown, very friable clay loam to silty clay loam; weakly-developed fine blocky structure.

13 to 20 inches, yellowish-brown friable silty clay loam to clay loam; weakly-developed fine blocky structure.

20 to 26 inches, yellowish-brown friable clay loam to silty clay loam, faintly splotched or mottled with strong brown; weakly developed fine blocky structure; contains many small pebbles weathered from fine-grained conglomerate; layer rests upon sandstone bedrock.

The soil is strongly acid and apparently low in natural fertility. It allows easy penetration of roots. It is easy to work and moderately easy to conserve. Water is readily absorbed and fairly-well retained. The water-supplying capacity is about medium. The soil is practically free of stones.

Actually, this soil is well-suited to all crops and pasture plants commonly grown. Its shallowness to bedrock restricts the feeding zone for the deep-rooted crops, but generally it is deep enough for successful growth.

Hartsells Fine Sandy Loam

Hubbard et al. (1950) classified this series under the great soil group of Red-Yellow Podzolics, and associated with Crossville and Muskingum series. The relief is level to gently undulating; external drainage is very slow to medium and internal drainage medium. According to them, the profile characteristics under virgin conditions are as follows:

0 to 2 inches, gray mellow fine sandy loam mixed with a small

quantity of decayed vegetable matter.

2 to 9 inches, grayish yellow or yellowish-gray friable fine sandy loam.

9 to 30 inches, yellow or brownish-yellow friable fine sandy clay containing a few red and brown mottles, apparently caused by decomposed fragments of sandstone rather than by imperfect drainage.

30 to 34 inches, yellowish-gray fine sand mixed with many small partly weathered sandstone fragments.

34 inches +, sandstone bedrock containing thin layers of shale in places; the strata of the bedrock are horizontal.

The vegetation under virgin conditions consist of post, southern red, scarlet and blackjack oaks, hickory and pine.

The soil survey (1958) for the Marion County, Tennessee, described Hartsells fine sandy loam, undulating phase, as a very strongly acid soil of the uplands, on level-bedded acid sandstone under a predominantly deciduous forest. According to this report a typical profile shows its characteristic features as follows:

0 to 9 inches, yellowish-brown to light yellowish-brown very friable fine sandy loam to loam, weak medium crumb structure; upper 1 to 2 inches stained dark with organic matter.

9 to 15 inches, yellowish-brown, very friable light clay loam to sandy clay loam; weakly developed coarse crumb to very fine blocky structure.

15 to 32 inches, yellowish-brown to brownish-yellow, very friable light clay loam or fine sandy clay; weak fine to medium blocky structure.

32 inches +, strong brown to reddish-yellow friable sandy clay or sandy clay loam; weak medium blocky structure; sandstone bedrock is generally at depths of 3 to 5 feet.

This soil is low in organic matter, plant nutrients and natural fertility. However, it is very permeable to air, roots and water. Its water-supplying capacity is medium, surface run-off is slow, and internal drainage is medium. The soil varies mainly in depth to bedrock, the normal range being 2 to 7 feet.

According to the soil survey (1958), Franklin County, Tennessee, Hartsells fine sandy loam rolling phase soils are strongly acid, low in organic matter and plant nutrients. Run-off is medium and internal drainage is medium. These soils are permeable to air, moisture and plant roots. The moisture supplying capacity is fair.

Sol Brun Acide

Tavernier and Smith (1957) reported that the name "Sol Brun Acide" is now used in Belgium, France and possibly other European countries for a class of soils at the great soil group level. Baur and Lyford (1957) found similar soils developed under forest vegetation in the northeastern United States. These authors further stated, that in the past these soils have been included with Brown Podzolic, weak Podzol, weak Gray-Brown Podzolic or Red-Yellow Podzolic soil groups.

Recognition of Sol Brun Acide as a distinct great soil group has been recent, in the United States. Cline (1955) found many soil types, in New York, as belonging to this great soil group. He named these soils as "Acid Brown Earth". Baur and Lyford (1957) preferred to use the European name "Sol Brun Acide". Krebs and Tedrow (1957) used the term "Acid Brown Forest Soil".

Tavernier and Smith (1957) reported that an acid kind of profile represents the original "Braunerde" of Ramann, and that they were common in southern New England, New York, the Appalachian Plateau extending south to the highlands of Tennessee and west to include some of the soils from the acid drifts of Ohio and Minnesota; and on the west coast in Washington and Oregon.

Thorp and Smith (1949) proposed a definition of Red-Yellow Podzolic as:

"a group of well developed, well drained acid soils having thin organic (Ao) and organic mineral (A_1) horizons over a light-colored bleached (A_2) horizon, over a red, yellowish-red, or yellow and more clayey (B) horizon. Parent materials are all more or less siliceous. Coarse reticulate streams or mottles of red, yellow, brown, and light gray are characteristic of deep horizons or Red-Yellow Podzolic soils where parent materials are thick."

Robinson (1949) reported some differences between Brown Forest Soils (Sols Brun Acide) and the Gray-Brown Podzolic soils, chiefly in terms of base status and in their structure.

According to Kay (1937)[3] the essential difference between a Brown Earth and a podzolized soil would appear to be the composition of the clay fraction. This is usually constant throughout the Brown Earth profile, whereas in a podzolized soil a relatively siliceous A horizon overlies a B horizon enriched in sesquioxides from above.

Baur and Lyford (1957) pointed out three major differences between Podzols and Sols Brun Acide. According to them, Sols Brun Acide morphologically exhibit (a) uniform colors in the B horizon rather than a more intense color in the upper part of the B horizon such as characterizes Podzols and Brown Podzolic soils; (b) weak subangular blocky structure throughout the B horizon rather than granular structure like that characteristic of the upper B horizon of most Podzols and Brown Podzolic soils; and (c) uniform texture throughout the solum contrasting in this respect with Gray-Brown Podzolic and Red-Yellow Podzolic soils which have silicate clay accumulation in the B horizon.

3/Quoted from Tavernier and Smith (1957).

In an attempt to distinguish Acid Brown Earths from the Gray-Brown Podzolics, Cline (1955) reported the former as more strongly leached, generally more acid, and lacking the distinct clay accumulation in the B horizon. Baur and Lyford (1957) reported a leached horizon (A_2) in Sol Brun Acide soils. However, Ulrich et al. (1959) reported no leached horizon in the Sols Brun Acide of California. It therefore appears that a gradational character of the horizons is required.

In this connection, it is interesting to note that Simonson (1949) remarked, in his paper on the genesis and classification of Red-Yellow Podzolic soils, that eluviation and illuviation in their geneses are not adequate as explanations for horizon differentiation in the profiles; the dominant processes are the formation of silicate clay minerals in the deeper horizons and the destruction of those minerals in the upper horizons.

According to Simonson (1949) Red-Yellow Podzolic soils have been developed from all sorts of materials ranging from granites, gneisses, schists, sandstones, shales, limestones, and various unconsolidated sediments. In contrast to this Sols Brun Acide have been developed from sandstones or parent materials rich in quartz--Soil survey, Marion county (1958); Hubbard et al. (1950); and Ulrich et al. (1959).

Morphologically Red-Yellow Podzolics are characterized by a clear zone of eluviation, A_2, and a zone of illuviation, B; the color of the textural B horizon is generally darker at the upper portion of the horizon (Cline, 1955). According to Tavernier and Smith (1957), Sols Brun Acide do not have a zone of illuviation and are characterized by a (B) horizon, B in parentheses, usually referred to as a color B horizon. In most cases there is no zone of eluviation (destruction or removal of silicate minerals in the A horizon is not evident).

CHAPTER III

METHODS AND PROCEDURES

Field Methods

The soils sampled for analyses were located at five sites and represented profiles of the Crossville series of the Cumberland Plateau. Site 1 is cultivated and the rest are virgin. The first three sites are located in Cumberland County, and the fourth and fifth sites in the Bledsoe State Forest, Bledsoe County. All the sites were seen and sites 1, 2, and 3 were carefully observed by soil scientists of the Soil Conservation Service. All the sites were on gentle slopes. They were widely spaced and were located well inside forest areas, with the exception of site 1 which was in a cultivated area, to avoid contamination and human interference. They were apparently free of erosion, and with the possible exception of site 1 had no accumulation of eroded materials from other areas. The soil profiles were described *in situ* from the faces of excavations according to the procedure outlined by the Soil Survey Staff (1951). Bulk samples of each horizon were collected in clean cloth bags, after descriptions of the profiles had been made. All Munsell color notations were taken on moist soil. Extreme care was exercised while taking bulk samples from each horizon to avoid contamination from other horizons.

Laboratory Procedures

The soil samples were dried in an air oven at 65° C., crushed to pass through a 2 mm. sieve, and stored in 1-quart cartons in the laboratory.

All determinations, unless otherwise stated, were made in duplicate.

Mechanical analyses were made by the pipette method as described by Kilmer and Alexander (1949) and Kilmer and Mullins (1954). Soil pH was determined on pastes with the Beckman pH meter. Organic matter content was determined by the chromate oxidation method (wet combustion) as described by Walkley and Black (1934) with modifications by Peech et al. (1947). Cation exchange capacity was determined by distillation of adsorbed ammonia after extraction with sodium chloride, as described by Peech et al. (1947). Exchangeable bases were estimated in 0.2 N ammonium chloride solution with a Beckman DU flame spectrophotometer, with No. 9200 flame attachment and No. 4300 photomultiplier assembly, as outlined by Shaw and Veal (1956). Exchangeable aluminum was estimated in standard potassium chloride leachates of soils after treatment with excess potassium flouride to form a neutral hexaflouride complex, as described by Coleman et al. (1959). Free iron oxide was extracted from soil with sodium hydrosulfite and determined with standard potassium permanganate as outlined by Deb (1950). Available phosphorus was determined according to the method of Bray and Kurtz (1945).

CHAPTER IV

RESULTS

Detailed profile descriptions were made in the field. The object was to get a clear understanding of the morphology of soils in the Crossville Series. Descriptions of the soil profiles follow.

Soil Profile Descriptions

SITE-1

Soil profile: Crossville loam--cultivated

Ap 0-9 inches, Dark brown (10YR3/3 to 10YR4/3) loam; moderate fine granular structure; friable; medium to slightly acid; clear and wavy boundary; 7 to 10 inches thick.

$(B)_{21}$ 9-15 inches, Dark yellowish brown (10YR4/4) loam; moderate medium and fine subangular blocky structure; friable; strongly acid; gradual wavy boundary; both medium and fine roots common; 5 to 7 inches thick.

$(B)_{22}$ 15-22 inches, Dark yellowish brown (10YR4/4) or yellowish brown (10YR5/4) loam; moderate medium and fine subangular blocky structure; friable; strongly acid; clear and wavy boundary; with a few fragments of sandstone; old medium roots commonly distributed with few new fine roots sometimes entering the same channels of decomposed old roots. 6 to 9 inches thick.

$(B)_3$ 22-24 inches, Yellowish brown (10YR5/4) loam, moderate medium subangular blocky structure; friable; strongly acid; gradual and wavy boundary; a few sandstone fragments; a few fine roots distributed mostly at the upper region; 4 to 6 inches thick.

C 27-36 inches, Yellowish brown (10YR5/4) loam with a few distinct brown (7.5YR5/4) mottles; weak medium subangular blocky structure; very friable; strongly acid; gradual and wavy boundary; with common sandstone fragments 6-11 inches thick.

D_r 36 inches +, Slightly weathered brown to dark brown level bedded sandstone.

<u>Topography:</u> Gently sloping at the edge of a bench; gradient ranges from 2 to 5%.

<u>Drainage and permeability:</u>

Well drained. Surface runoff is medium and internal drainage is medium to rapid.

<u>Vegetation:</u> Cultivated; alfalfa. Roots numerous to 15 inches below the surface.

<u>Location:</u> About 280 yards south and slightly west of the point at which the railroad leaves the north edge of the Plateau Experiment Station.

SITE-2

<u>Soil profile:</u> <u>Crossville sandy loam--forested.</u>

A_{00}, A_0	1-0 inches	Thin layer of loose and partly decomposed leaves and twigs, typically from deciduous trees; common fungal molds; extremely acid.
A_1	0-3 inches	Dark brown (10YR3/3) to Dark yellowish brown (10YR4/4) sandy loam; weak medium granular structure; very friable; very strongly acid; clear and smooth boundary; numerous roots well distributed.
A_3	3-7 inches	Dark yellowish brown (10YR4/4) or yellowish brown (10YR5/4) sandy clay loam; weak coarse granular structure; friable; very strongly acid; gradual and wavy boundary; numerous roots well distributed.
$(B)_{21}$	7-12 inches	Dark brown (7.5YR4/4) loam; weak medium subangular blocky structure; very friable; very strongly acid; gradual and wavy boundary; numerous roots.
$(B)_{22}$	12-17 inches	Dark brown (7.5YR4/4) or Dark yellowish brown (10YR4/4) loam; weak medium subangular blocky structure; friable; very strongly acid; gradual and wavy boundary; common fine roots.
$(B)_3$	17-21 inches	Dark yellowish brown (10YR4/4) sandy loam; single-grained and medium subangular blocky structure; very friable; very strongly acid; gradual and wavy boundary; common sandstone fragments and a few stones; a few fine roots mainly at the top of the horizon.

C	21-36 inches	Yellowish brown (10YR5/4) loamy sand with common sandstone stones and fragments; single-grained and structureless; friable; very strongly acid; gradual and wavy boundary.
D_r	36 inches+	Partially decomposed level-bedded sandstone.

Topography: Sloping, gradient 5 to 7% near the lower end of the slope.

Drainage and permeability:

Surface runoff slow to medium and internal drainage is medium to rapid.

Vegetation: Chiefly deciduous with oaks dominating, planted white pines of 12 to 15 years growth ranging from 13 to 15 feet in height and 2 to 4 inches in girth. Sparse grass undergrowth.

Location: About 100 feet west of the east arm of the lake near the picnic ground on the Plateau Experiment Station.

SITE-3

Soil profile: Crossville loam--forested.

A_{00},A_0	1-0 inches	Thin layer of loose and partly decomposed leaves and twigs, mostly from the oak trees; few fungal molds; extremely acid.
A_1	0-4 inches	Dark brown (10YR3/3) loam; moderate medium granular structure; very friable; very strongly acid; clear and smooth boundary; numerous medium and fine roots well distributed.
A_3	4-8 inches	Dark brown (7.5YR4/3) loam; weak coarse granular and weak fine subangular blocky structure; very friable; very strongly acid; clear and smooth boundary; numerous medium and fine roots.
$(B)_{21}$	8-13 inches	Dark brown (7.5YR4/4) loam; weak medium and fine subangular blocky structure; very friable; very strongly acid; diffuse and wavy boundary; common medium and numerous fine roots.
$(B)_{22}$	13-18 inches	Dark brown (7.5YR4/4) sandy clay loam; weak medium subangular blocky structure; very friable; very strongly acid; clear and wavy boundary; sandstone rock appears at 15 inches depth. Common fine roots.
$(B)_3$	18-24 inches	Dark yellowish brown (10YR4/4) to yellowish brown (10YR5/4) sandy clay loam; weak medium and fine subangular blocky structure; very friable; very

		strongly acid; gradual and wavy boundary; a few fine roots.
C	24-36 inches	Yellowish brown (10YR5/4) sandy clay loam; loose and weak medium subangular blocky structure; very friable; very strongly acid; abrupt and smooth boundary; horizon free of rock fragments but a few quartzite pebbles present, no roots.
D_r	36 inches +	Partially weathered sandstone rock.

<u>Topography:</u> Sloping with slope ranging from 7 to 9%; convex position on the center of the slope.

<u>Drainage and permeability:</u>

Surface runoff is medium to rapid, internal drainage is medium to rapid and the soil is below field capacity during most of the year.

<u>Vegetation:</u> Dominantly oak forest constituted of white oaks, post oak and black oak; hickory common, and a few sour wood, huckleberries and blackgums.

<u>Location:</u> About 0.8 mile north of Campbell junction on a dead-end road which turns off to the left at a small church.

SITE-4

Soil profile: Crossville loam, fine-textured subsoil variant--forested.

A_{00}, A_0	1-0 inches	A thin film of A_{00} overlying 1/2 inch thick layer of mull type of humus; extremely acid.
A_1	0-3 inches	Dark brown (7.5YR3/2 to 10YR3/3) loam, weak to moderate medium granular structure; friable; very strongly acid; clear and irregular boundary; numerous roots.
A_3	3-8 inches	Dark brown (7.5YR3/2) clay, weak subangular blocky structure breaking into medium granular structure; firm, sticky when wet; very strongly acid; gradual smooth boundary; numerous coarse roots.
B_2	8-14 inches	Dark brown (10YR4/3) clay; moderate medium subangular blocky structure; very firm; very strongly acid; gradual and wavy boundary; common medium roots; few sandstone fragments.
B_3	14-20 inches	Dark brown (7.5YR4/4 to 10YR4/3) clay; moderate medium subangular block structure; firm to very firm; very strongly acid; diffuse boundary; common sandstone fragments; medium and fine roots common and on top of the parent rock.
D_r	20 inches +	Ferruginous quartz sandstone, partially decomposed with iron oxides as binding agent.

Topography: Gently sloping with 4 to 5% slope gradient, sloping from northeast to southwest and situated on a slightly convex position about 75 yards away from a small stream.

Drainage and permeability: Surface runoff is slow and internal drainage very slow; lateral movement of water on top of the sandstone parent rock.

Vegetation: Forest dominated by postoaks and white oaks, some pines and dogwood and occasionally hickory. Poor stunted growth of the open grove; average measurements of postoaks being 25 to 30 feet in height and 2 to 6 inches in girth. Fairly abundant undergrowth of grasses, chiefly *Danthonia spicata*.

Location: One mile south of the junction of highways 4253 and 101, in the Bledsoe state forest, about 50 yards on the west (right) side of road.

SITE-5

Soil profile: Grossville loam--forested.

A_{00}, A_0	1-0 inches	Matted layer of partly decomposed leaves and twigs; very strongly acid.
A_1	0-2 inches	Dark grayish brown (10YR4/2) loam; moderate coarse granular structure; very friable; very strongly acid; clear and smooth boundary; numerous roots; a few earthworms evident.
A_3	2-5 inches	Dark brown (10YR4/3) loam; moderate coarse granular structure; very friable; very strongly acid; clear and smooth boundary; numerous medium and fine roots.
$(B)_{21}$	5-13 inches	Dark brown (7.5YR4/4) loam; moderate fine subangular blocky and coarse granular structure; friable; very strongly acid; gradual and smooth boundary; roots common.
$(B)_{22}$	13-22 inches	Dark brown (10YR4/3) loam; moderate medium and fine subangular blocky structure; friable; very strongly acid; clear and smooth boundary.
C	22-30 inches	Yellowish brown (10YR5/4) loam; weak subangular blocky structure grading to massiveness at bottom; very friable; very strongly acid; clear and smooth boundary.
D_r	30 inches +	Partially decomposed level-bedded sandstone rock.

<u>Topography:</u> Gently sloping; gradient 4 to 5% situated about 100 yards upslope from site 4 on the southwestern slope, on a slightly convex surface.

<u>Drainage and permeability:</u>

Surface runoff is slow to medium and internal drainage slow to medium. Water movement more lateral than downward.

<u>Vegetation:</u> Common black oaks followed by post oaks, hickory and blackjack oaks. The grove is richer in growth than that on site 4. The undergrowth contains less grass and more shrubs.

<u>Location:</u> About 100 yards away and on the northeastern side of site 4, on the other side (east) of the road.

The soils are formed from rocks of the Pennsylvanian series and overlie such resistant rocks as the Crossville sandstone and Rockcastle conglomerate. The parent material is formed either in situ from these rocks or is a colluvium of weathered rocks rich in quartz.

The different horizons in each of the soil profiles were free of clay-coatings or clay-films over soil particles. The Sola in all the profiles exhibited similar colors in each of the horizons.

Laboratory Determinations

Particle size distribution of the different horizons of all the five soil profiles is presented in table 4. There was a small amount of very coarse sand in each horizon in these soils. The coarse sand content ranged from 0.1% in A_3, and (B) horizons of site 5 to 7.2% in the C horizon of site 2. Very coarse sand and coarse sand together constituted a small portion of the sand content in all soils. Medium sand and fine sand contents made up most of the sand fraction in the first three sites, while fine sand and very fine sand formed a major part of the sand fraction in sites 4 and 5.

The silt content decreased slightly from the A horizon downward in sites 3 and 4. In sites 1 and 2 the amount of silt tended to be greater in the (B) horizons than in the A and C horizons. There was more silt in all the horizons of site 5 than in the other soils.

The clay content progressively decreased with depth, with the single exception of site 4 which was characterized by a textural B horizon. The clay content of A_p and $(B)_{21}$ horizons in site 1 and the A_1 horizon in site 4 was slightly more than 26%. These horizons were identified in the textural class of loam but were close to the border separating loam and clay loam.

The soil reaction, organic matter content, cation exchange capacity, amounts of exchangeable calcium, magnesium, potassium and aluminum, readily soluble iron oxides, and available phosphorus are presented in table 5. pH values were determined on fresh soil samples as well as on air-dry samples. Since there was practically no difference

Table 4.--Percentage particle size distribution in the different horizons of 5 Crossville soils

Site no.	Name of soil	Horizon	Depth (inches)	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
1	Crossville loam (cultivated)	Ap	0-9	0.1	1.9	14.1	16.9	4.0	34.6	26.7
		$(B)_{21}$	9-15	0.1	1.7	10.6	8.8	2.0	48.7	26.2
		$(B)_{22}$	15-22	0.1	1.8	10.5	10.7	2.6	49.9	22.2
		$(B)_3$	22-27	0.2	2.2	13.0	15.2	3.5	46.5	17.7
		C	27-36	0.2	2.1	16.1	21.2	4.9	35.7	18.8
2	Crossville sandy loam	A_1	0-3	0.4	4.5	30.8	20.3	2.9	21.6	17.4
		A_3	3-7	0.2	3.3	26.3	18.4	2.8	25.1	21.5
		$(B)_{21}$	7-12	0.2	3.6	25.4	17.1	2.3	29.2	20.6
		$(B)_{22}$	12-17	0.2	3.4	26.4	16.5	2.1	29.1	20.0
		$(B)_3$	17-21	0.3	3.7	28.7	18.6	2.5	25.3	19.1
		C	21-36	0.6	7.2	42.4	27.4	4.3	7.6	8.5

Table 4.--continued

Site no.	Name of soil	Horizon	Depth (inches)	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
3	Crossville loam	A_1	0-4	0.9	3.9	13.9	19.6	2.8	34.8	23.1
		A_3	4-8	0.4	3.6	13.6	19.7	2.4	32.8	24.7
		$(B)_{21}$	8-13	0.4	3.9	15.3	20.9	2.7	30.7	23.5
		$(B)_{22}$	13-18	0.3	3.8	15.1	22.2	2.8	28.4	24.5
		$(B)_3$	18-24	0.4	4.6	17.3	25.4	3.3	25.9	21.8
		C	24-36	0.7	5.1	19.9	29.5	3.7	17.7	22.7
4	Crossville loam fine-textured subsoil variant	A_1	0-3	0.6	0.6	4.1	11.3	8.0	49.6	26.3
		A_3	3-8	0.3	0.5	2.1	8.4	5.3	35.3	46.9
		B_2	8-14	1.8	1.5	3.0	9.2	4.6	28.6	50.2
		B_3	14-20	3.1	2.0	3.6	13.5	6.0	22.3	47.8
5	Crossville loam	A_1	0-2	0.2	0.2	0.9	18.6	14.8	40.7	23.5
		A_3	2-5	0.2	0.1	1.1	18.3	14.0	44.8	20.8
		$(B)_{21}$	5-13	0.1	0.1	1.0	16.9	13.4	42.8	25.0
		$(B)_{22}$	13-22	0.1	0.1	1.1	17.5	13.1	48.8	18.3
		C	22-30	0.3	0.3	1.5	25.6	19.6	36.0	16.7

Table 5.--Chemical properties of the different horizons of 5 Crossville soils.

Site no.	Name of soil	Horizon	pH	Organic matter %	C.E.C. me./100g.	Exchangeable Cations me./100g. Ca	Mg	K	% Base saturation	Exchangeable Al me./100g.	Free Fe_2O_3 (%)	P ppm.
1	Crossville loam (cultivated)	Ap	5.8	3.0	11.9	4.97	0.86	0.25	51.1	0.6	1.6	57
		$(B)_{21}$	4.6	0.7	13.1	0.81	0.45	0.25	11.5	2.7	1.1	2
		$(B)_{22}$	4.7	0.5	9.2	0.41	0.29	0.20	9.8	2.3	0.9	2
		$(B)_3$	4.6	0.3	7.1	0.28	0.25	0.14	9.4	2.5	0.8	2
		C	4.6	0.2	6.3	0.23	0.22	0.14	9.3	2.1	0.7	3
2	Crossville sandy loam	A_{00}, A_0	4.2	-	-	-	-	-	-	-	-	-
		A_1	4.5	3.7	10.1	0.22	0.11	0.17	5.0	1.8	2.1	12
		A_3	4.7	1.5	8.8	0.16	0.08	0.15	4.5	1.7	1.6	6
		$(B)_{21}$	4.7	0.9	8.7	0.30	0.31	0.16	8.8	2.7	0.6	5
		$(B)_{22}$	4.7	0.6	8.0	0.34	0.35	0.14	10.4	2.8	0.7	5
		$(B)_3$	4.6	0.6	7.5	0.40	0.31	0.13	11.1	2.6	0.7	6
		C	4.6	0.3	3.6	0.10	0.14	0.10	9.5	1.3	0.5	3

Table 5.—continued

Site no.	Name of soil	Horizon	pH	Organic matter %	C.E.C. me./100g.	Exchangeable Cations me./100g. Ca	Mg	K	% Base saturation	Exchangeable Al me./100g.	Free Fe_2O_3 (%)	P ppm.
3	Crossville loam	A_{00},A_0	4.2	-	-	-	-	-	-	-	-	-
		A_1	4.5	7.5	17.8	0.20	0.13	0.22	3.1	2.5	2.7	11
		A_3	4.8	1.7	10.5	0.12	0.07	0.14	3.1	2.3	1.7	5
		$(B)_{21}$	4.8	1.1	9.9	0.16	0.09	0.15	4.0	2.4	1.2	5
		$(B)_{22}$	4.8	0.8	9.8	0.10	0.12	0.14	3.7	3.2	1.1	5
		$(B)_3$	4.8	0.4	8.5	0.12	0.18	0.12	5.0	3.3	0.8	5
		C	4.6	0.4	7.2	0.12	0.20	0.11	6.0	3.2	0.6	5
4	Crossville loam, fine-textured subsoil variant	A_{00},A_0	4.3	-	-	-	-	-	-	-	-	-
		A_1	4.6	5.9	18.9	0.40	0.07	0.22	3.7	2.8	3.2	1
		A_3	4.7	1.8	16.6	0.25	0.07	0.21	3.2	5.2	1.1	trace
		B_2	4.7	0.7	19.8	0.25	0.27	0.26	3.9	6.3	1.6	trace
		B_3	4.7	0.6	18.4	0.19	0.27	0.21	3.6	3.3	1.0	trace

Table 5.--continued

Site no.	Name of soil	Horizon	pH	Organic matter %	C.E.C. me./100g.	Exchangeable Cations me./100g. Ca	Mg	K	% Base saturation	Exchangeable Al me./100g.	Free Fe_2O_3 (%)	P ppm.
5	Crossville loam	A_{00},A_0	4.7	-	-	-	-	-	-	-	-	-
		A_1	4.7	2.6	10.3	0.39	0.10	0.17	6.4	2.1	1.8	2
		A_3	4.8	1.7	7.2	0.16	0.05	0.14	4.9	2.2	1.3	trace
		$(B)_{21}$	4.9	1.1	7.6	0.15	0.05	0.13	4.3	3.0	0.8	trace
		$(B)_{22}$	4.9	0.6	6.8	0.10	0.12	0.11	4.9	3.4	1.1	trace
		C	4.9	0.3	4.4	0.05	0.19	0.08	7.3	2.3	1.1	trace

between the two determinations only the data on the air-dry samples are presented in table 5.

There was little change in pH values in the mineral soil horizons with depth. They were very strongly acid in reaction. The organic layers were extremely acid in reaction, with the single exception of that in site 5 which was very strongly acid. The A_p horizon of the cultivated soil, which had been limed, was only slightly acid.

The organic matter content in each of the soils decreased rapidly with depth. Organic matter in the A_1 horizons ranged from 2.6% at site 5 to 7.5% at site 3. The organic matter in the B horizons of all the soils was considerably lower than that in the A horizons. The C horizons were characterized by even smaller amounts of organic matter at all the five sites.

There was a decrease in the cation exchange capacity with depth in four sites. Site 4 was an exception because cation exchange capacity changed little with increasing depth. The exchange capacity was highest in the A_1 horizon and lowest in the C horizon in these soils.

Exchangeable basic cations were consistently low, and content of each basic cation was less than one milliequivalent per 100g. of air-dry soil. The only exception to this was calcium in the A_p horizon of site 1, which had been limed. There was a general decrease in the exchangeable calcium content with depth, with the exception of site 2 in which the (B) horizon had more exchangeable calcium than the A and C horizons. The exchangeable magnesium content tended to increase with depth. The amount of exchangeable potassium was lower than that of exchangeable calcium, and decreased with depth in all the soil profiles.

The amount of exchangeable aluminum was higher in the (B) horizon than in A or C. Within the A horizon of sites 2, 3 and 5 there was more exchangeable aluminum in the A_1 horizon than A_3 while in site 4 the reverse was found.

The A horizon in each profile contained the maximum amount of free iron oxides, and the content decreased with depth. The range in the free iron oxide content varied from 3.2% in the A_1 horizon of site 4 to 0.5% in the C horizon of site 2.

Each horizon of each site showed an acute deficiency of readily available phosphorus. However, the A_p horizon of the cultivated soil contained 57 ppm as a result of fertilization.

CHAPTER V

DISCUSSION

Profile descriptions in Chapter IV explain the soil characteristics in detail. The soils are fairly shallow to bedrock and are about 30 to 36 inches in depth. The A horizons of the profiles have granular structures and the B horizons exhibit subangular blocky structures. All the soils are well drained and are permeable to air, water and plant roots. They have moderate to high available moisture storage capacity and their physical properties are quite suitable for crop production. However, the soil in site 4 is shallow to bedrock and thus lower in available moisture storage capacity.

The study of particle size distribution indicated no apparent migration of silicate clay minerals into lower horizons. It was therefore concluded that a migration of mineral soil particles into lower horizons was not necessary in the formation of the Crossville series. This finding is in agreement with those of some European workers reviewed by Tavernier and Smith (1957), for Sols Brun Acide. In addition, the lack of clay coatings on soil particles in the lower horizons indicated the absence of the process of illuviation of mineral particles in these profiles.

Since sandstone is low in clay and rich in quartz the amount of silt and sand together formed a major portion of the soil particles. Such a texture favorably influences aeration, permeability and available water holding capacity. The horizons in site 4 had much more clay than could be expected of a stratum such as sandstone. The variation in the subsoil of site 4 may possibly be due to the influence of shale.

It is now seen that the proportions of silt to clay, and the clay contents in each horizon are more or less the same throughout the depth in all the soils. The slight textural deviations between horizons may, therefore, be considered due to the differences in weathering and other factors of clay synthesis and not to the processes of eluviation and illuviation of mineral soil particles.

The Hartsells series which is in association with the Crossville series is characterized by a textural B horizon and results of the processes of eluviation and illuviation are evident. There is more clay in the A horizons of soils of the Crossville series than in soils of the Hartsells series.

The soil color varied but little with depth throughout all the profiles. The colors of A_1 horizons in all the profiles were more or less similar, being dark brown in the first four sites and dark grayish-brown in site 5. The color of the B horizons was also dark brown, but the chroma in the (B) horizon in the cultivated soil was one unit more than others. There is a characteristic appearance to Crossville soil that helps to distinguish these soils from Hartsells which are characterized by light colors in the lower horizons. Again the color within the (B) horizon was the same both in the upper and lower regions of the horizon. On this ground, any possibility of classifying Crossville soils under the great soil group of Red-Yellow Podzolics is ruled out, as the color within the B horizon of the latter as reported by Simonson (1949) varies with depth, being darker in the upper region and lighter in the lower region of the horizon. The uniformity of soil color in all the horizons of Crossville soils is similar to that of Sols Brun Acide, according to observations made by Robinson (1949), who added that the free iron oxides present give a brownish or reddish brown color which may be masked by humus.

The organic layers lying over the mineral soils are more acid than the mineral soil horizons. Because of liming, the cultivated A_p horizon was only slightly acid. The acidity in the virgin soils may be explained as due to a very low base saturation of the clay fractions in addition to organic matter in the A_1 horizons. Since the humus is of mild type and there is lack of intimate mixing of humus with mineral soil particles in the A_1 horizons no breakdown of silicate clay complex was noticed.

The organic matter content of soils decreased invariably with depth. The partly decomposed leaves and twigs overlying the profile, in virgin soils, were loose and moist. There was no tendency towards the development of a raw humus layer. In the predominantly oak forest, under which the Crossville soils are found, the leaf-fall covering the soils decays rapidly and produce a mild humus. Similar conditions were noticed by De Sigmond (1938) and Robinson (1949) for the formation of Sols Brun Acide. The organic cover on site 5 was a little matted, but this condition is not of much significance in the formation of humus. The lighter color of the A horizon in this site was correlated with the nature of its organic layer.

Since both the organic matter content and free iron oxides decrease with depth it is not clear how these soils are able to maintain a uniform color throughout the profiles. However, it may be considered that there is sufficient organic matter to mask the color due to iron oxides, and that additional amounts of both organic matter and free iron oxides do not make the soils appear darker. It is true that the value increases by one or two units from the A horizon down to C horizon, but this increase in value is too insufficient to be dependent upon the considerable decrease in the amounts of organic matter and free iron oxides.

In contrast to soils of the Crossville series, those of Hartsells have increasing amounts of free iron oxides with depth. Since the organic matter content decreases with depth, it is suggested that the amount of organic matter is not sufficient to darken the color due to iron oxides. Iron oxides, therefore, are chiefly responsible for brighter colors in the lower horizons in the Hartsells series.

The data obtained on cation exchange capacity are interesting in that there exists a correlation between the clay content and the exchange capacity. However, the exchange capacity of A_1 horizons was found to be more than that of other horizons. This was due to the contribution of colloidal organic matter. All the soils were low in bases. The percent base saturation, with the exception of site 2, was nearly constant in each profile though there was a tendency for lower values with depth. In site 2 there was a little increase in base saturation in the lower horizons. The exchangeable calcium was higher in the upper horizons and decreased with depth, whereas exchangeable magnesium increased with depth resulting in lower calcium to magnesium ratios with depth.

The exchangeable aluminum content was greatest in the B horizons, indicating the buffering capacity of the clay minerals against breakdown due to excess of hydrogen ions. The increasing amounts of exchangeable aluminum in the B horizons may be explained as due to the organic matter contributing a major portion to the exchange capacity in the A horizons, whereas the mineral colloidal clay complex was the only source of exchange reaction in the lower horizons. Hence, more aluminum was given out by the clay particles to counter the effects of hydrogen ions on the clay surface. The amount of exchangeable aluminum in the C horizon was proportional to its clay content.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Field study of Crossville loams was followed by the selection of 5 sites, 4 in virgin forest and the other in a cultivated field. Profiles were described and samples taken at each site. Certain laboratory determinations were made on these samples.

The Crossville soil is usually formed on gently sloping to sloping topography, where the open grove is dominated by oaks. The thin organic cover is generally loose and gives rise to a mild type of humus. A parent material low in bases and rich in quartz appears to be a prerequisite for the formation of this soil. A temperate climate with an abundant and well distributed rainfall is ideal for the formation of Crossville loam. These factors of soil formation are very similar to those for the formation of other Sols Brun Acide.

The distinction between horizons is not clear or distinct and the soils are characterized by uniformity in color throughout the profile. They are medium textured soils with neither a zone of eluviation nor a zone of illuviation. They are very strongly acid in reaction, and free iron oxides contribute to the dark brown color of the soils. These soils are very low in bases and available phosphorus, the latter possibly limiting the growth of vegetation. The soils are permeable to air, water and roots and have a moderate to high available water holding capacity. Since the soils are shallow to bedrock and are on gently sloping gradients all water received in excess of their moisture holding capacity is drained away rapidly.

There is apparently no migration of finer soil particles into the lower horizons. The soils lack leached A_2 horizons and textural B horizons. The single exception is site 4 which has a textural B horizon. The color is uniform in all the horizons possibly due to distributions of free iron oxides and organic matter. Sites 2 and 3 are considered to have profiles typical in characteristics for Crossville loams. Site 4 is considered to be Crossville loam fine-textured subsoil variant. Sites 1 and 5 are lighter in color than the others. Crossville loam is classified under the great soil group of Sol Brun Acide. Taking into consideration the profiles at sites 2 and 3 a general description of the Crossville loam is suggested as follows:

A_{00}, A_0	1-0 inches	Thin layer of loose and partly decomposed leaves and twigs, typically from deciduous trees; few to common fungal molds; extremely acid, 1/2 to 1 inch thick.
A_1	0-3 inches	Dark brown (10YR3/3) loam; moderate to weak medium granular structure; very friable; very strongly acid; clear and smooth boundary. 3 to 4 inches thick.
A_3	3-7 inches	Dark brown (10YR3/3) to dark yellowish brown (10YR4/4) loam to sandy clay loam; weak coarse granular structure; very friable; very strongly acid; clear to gradual wavy boundary; 3 to 4 inches thick.

$(B)_{21}$	7-12 inches	Dark brown (7.5YR5/4 to 7.5YR4/3) loam; moderate fine subangular blocky to weak medium subangular blocky structure; friable; very strongly acid; gradual and smooth boundary to diffuse and wavy boundary; 5 to 8 inches thick.
$(B)_{22}$	12-17 inches	Dark brown (7.5YR4/4 to 7.5YR4/3) loam; weak to moderate medium subangular blocky structure; friable; very strongly acid; clear and smooth boundary; 5 to 9 inches thick.
$(B)_3$	17-21 inches	Dark yellowish brown (10YR4/4) to yellowish brown (10YR5/4) sandy loam to sandy clay loam; weak medium and fine subangular blocky structure; very friable; very strongly acid; gradual and wavy boundary; 4 to 6 inches thick.
C	21-36 inches	Yellowish brown (10YR5/4) loamy sand to sandy clay loam; weak medium subangular blocky structure to single grained structure; very friable; very strongly acid; abrupt smooth boundary to clear and smooth boundary; 8 to 15 inches thick.

<u>Topography</u>

Gently sloping to sloping; 4 to 9%, and slopes slightly convex in shape.

<u>Drainage</u>

Surface runoff slow to medium and internal drainage medium to rapid.

Vegetation

Chiefly deciduous with oaks dominating, such as post oaks (Quercus stellata), white oaks (Quercus alba), blackjack oaks (Quercus marilandica) and black oaks (Quercus velutina); a few hickory (Carya spp), huckleberry (vaccinium sp), sour wood (Oxydendrum arboreum) and Smilax sp; and a few grasses like Danthonia spicata.

Use

Still largely in forest. Cleared areas are used for cultivation and pasture. Common crops include corn, small grains and potatoes.

Range in characteristics

Depth to bedrock ranges from about 20 to 36 inches; thickness of solum from about 14 to 24 inches. Texture of the A horizon ranges from loam to sandy loam, that of (B) from loam to sandy clay loam, and C may be loamy sand to sandy clay loam.

Great soil group

Sol Brun Acide

LITERATURE CITED

LITERATURE CITED

1. Baur, A. J. and Lyford, W. H. Sols Bruns Acides of the northeastern United States. Soil Sci. Soc. Am. Proc. 21:533-536. 1957.

2. Bray, R. H. and Kurtz, L. T. Determination of total, organic, and available forms of phosphorus in soils. Soil. Sci. 59:39-45. 1945.

3. Cline, M. G. Soils and soil associations. Cornell Agr. Ext. Ser. Bul. 930. 1955.

4. Coleman, N. T., Weed, S. B., and McCracken, R. J. Cation exchange capacity and exchangeable cations in Piedmont soils of North Carolina. Soil Sci. Soc. Am. Proc. 23:146-149. 1959.

5. Deb, B. C. The estimation of free iron oxides in soils and clays and their removal. Soil. Sci. 1:212-220. 1950.

6. DeSigmond, A. A. J. The Principles of Soil Science. Murby. London. p 53. 1938.

7. Dickson, R. R. Some climate-altitude relationships in southern Appalachian Mountain region. Bul. Am. Meteor. Soc. 40:352-359. 1959.

8. Hubbard, E. M., Matzek, B. L., Austin, M. E., Bacon, S. R. and Goodman, K. V. Soil survey - Cumberland County, Tenn. Series 1938. No. 25:35-36. 1950.

9. Kilmer, V. J., and Alexander, L. T. Methods of making analyses of soils. Soil Sci. 68:15-24. 1949.

10. Kilmer, V. J., and Mullins, J. F. Improved stirring and pipetting apparatus for mechanical analysis of soils. Soil Sci. 77:437-441. 1954.

11. Krebs, R. D., and Tedrow, J. C. F. Genesis of three soils derived from Wisconsin till in New Jersey. Soil Sci. 83:207-218. 1957.

12. Luther, E. T. The coal reserves of Tennessee. Tenn. Dept. Cons. and Com. Div. of Geology. Bul. 63. 1959.

13. Newcome, R., Jr., and Smith, O., Jr. Ground-water resources of the Cumberland Plateau in Tennessee. Division of Water Resources. Dept. of Conservation, Tennessee: 1-6. 1958.

14. Peech, M., Alexander, L. T., Dean, L. A., and Reed, J. F. Methods of soil analysis for soil-fertility investigations. USDA Circ.

757. 1947.

15. Robinson, G. W. Soils, their Origin, Constitution and Classification. 3rd. ed. Wiley. New York. 1949.

16. Shaw, W. M., and Veal, M. C. Flame photometric determination of exchangeable calcium and magnesium in soils. Soil. Sci. Soc. Am. Proc. 20:328-333. 1956.

17. Simonson, R. W. Genesis and classification of Red-Yellow Podzolic soils. Soil Sci. Soc. Am. Proc. 14:316-319. 1949.

18. Soil Survey - Franklin County, Tennessee. Series 1949, No. 8:34-35. 1958.

19. Soil Survey - Marion County, Tennessee. Series 1950, No. 2:26-27. 1958.

20. Soil Survey Staff. Soil Survey Manual. Agricultural Handbook 18. USDA. 1951.

21. Tavernier, R., and Smith, G. D. The concept of Braunerde (Brown forest soil) in Europe and the United States. Adv. Agron. 9:217-289. 1957.

22. Thorp, J., and Smith, G. D. Higher categories of soil classification: order, sub-order and great soil group. Soil Sci. 67:117-126. 1949.

23. Ulrich, R., Arkley, R. J., Nelson, R. E. and Wagner, R. J. Characteristics and genesis of some soils of San Mateo County, California. Soil. Sci. 88:218-227. 1959.

24. Walkley, A., and Black, I. A. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci. 37:29-38. 1934.