GENESIS OF SELECTED "RED" AND "BROWN" SOILS WITHIN THE REDDISH PRAIRIE ZONE

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CHAPTER I

INTRODUCTION

The Reddish Prairie soils of Vanoss and Teller comprise a significant area on river terraces and mantled areas of Southern Kansas, Central Oklahoma, and Central Texas. Since information regarding properties of Reddish Prairie soils is limited, two profiles with "brown" solums and two with "red" solums were investigated. Sampling was from high terraces of the Arkansas and Red Rivers.

Chemical and physical analyses along with detailed descriptions were made in order to provide quantitative data for an improved soil classification. These data will aid in determining the soil genesis and soil qualities in relation to agricultural and engineering uses.

It is hoped that the information collected will provide the soil surveyor who is differentiating soil series on the basis of "red" versus "brown" with enlightening information on some associated soil properties. Any information on why certain soils are "red" and other adjacent soils are "brown" would be a noteworthy contribution to soil science.

Other objectives are to add to the definition of Reddish Prairie soils as defined in the 1938 Yearbook of Agriculture (42*) and to classify the soils according to the 7th Approximation (35).

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*Numbers in parentheses refer to Literature Cited.

CHAPTER II

REVIEW OF LITERATURE

Geology

Major rivers provide the source of sediments for the parent material of Vanoss (brown) and Teller (red) soils. These river terrace parent materials are Pleistocence alluvium (7, 11, 13, 14, 36) which in some instances have been modified by wind (3). In Okfuskee County Teller is believed to be alluvium from "Red Beds" and Vanoss of older alluvium from "Red Beds" (4). Buckhannan (5) did some heavy mineral petrographic work on Vanoss from Cleveland County and found the source to be from the Rocky Mountain and High Plains Region. He stated that it was old alluvium of Pleistocene age. The Arkansas River (3) and Red River (40), along which Vanoss and Teller occur, drain areas of Tertiary mantled High Plains and Permian Red Beds.

The color studies on Permian were done mostly around the early 1900's. It was reported that the red color is due to ferric oxide and lowly hydrated iron oxides (1, 2, 28, 34, 38).

Iron to Red Color

Little information is available from research emphasizing the relationship between free iron and soil color, even though textbooks have long stated this relationship. Usually emphasis is placed on the removal of free iron in order to more accurately run other soil analyses such as particle size distribution and clay identification.

In color comparisons Khan (22) states that the red and brown soil color of terra rossa and allied soils may be due to redistribution of iron oxides over mineral particles, following reprecipitation from aqueous grass extracts. Norrish and Rogers (26) also studied residual soils and believe the redness depends on the percentage of free iron oxides in the clay which is governed by the amount of iron involved in the weathering of parent rock. In these residual soils there was a relationship between their color and their classification in the field.

McCaleb (24) found iron oxides distributed throughout the profile as very finely divided coatings on all particles, but more concentrated with the clay sized materials. Rich and Obenshain (29) found most of the free iron in the clay sized fraction.

In Virginia (29), a study was made on the distribution of iron in relation to soil drainage. The variation of free iron content is associated with soil factors which affect the reduction of iron, its mobility in solution and accumulation elsewhere by oxidation and precipitation. In general the horizon of clay illuviation also is the horizon of base and iron oxide concentration. Physical movement of solid phase iron oxide was evident in the well drained Matapeake soils. It was noted the free iron content of the clay fractions of different horizons was much more constant for this soil than the less well drained soils. This was interpreted as a greater physical movement of iron oxides in the well drained soil, concurrent with the eluviation of clay, and a greater movement of iron in solution (as ferrous iron) in the poorly drained soils.

There has been some research showing the direct effect of iron causing redness. During chemical investigations of some terra rossa and rendzina soils (25) from South Australia, it was found that if the soils of both groups were listed in order of increasing redness, there was a tendency for the free ferric oxide of the clay to increase. Samples of oxide streaks and pipestems were taken from Wisconsin loess for free iron determinations (8). A sample from dark gray (10YR 4/1) pipestems contained about 1.3 percent free iron, and one from yellowish red (5YR 4/8 to 7.5YR 5/6) pipestems, contained 9.1 percent free iron. Strong brown (7.5YR 5/6) streaks contained 3.2 percent free iron.

Climate

The present climate where most Teller and Vanoss are undergoing morphological development is one of a moist subhumid continental type (15). Locally where the samples were collected the average annual rainfall is 30.3 inches in Kay County and 39.0 inches in Bryan County (39). In Bryan County the evapotranspiration is about 37 inches or about 4 inches higher than Kay County (37). The average annual temperature for Kay County is 60.3° F. as compared to 63.8° F. for Bryan County. The January average temperature for Kay County is 36.6° F. and the July average is 83.2° F. For Bryan County the January average temperature is 43.3° F. and the July average is 83.4° F.

Vegetation

Few native trees occur in Kay County, except for narrow strips of timber along streams and in some places in the upland adjacent to the stream bottoms (23). Bryan County is mainly a prairie region with terraces supporting a growth of oak and hickory. Some savannah areas also occur (6).

CHAPTER III

MORPHOLOGY

The soils sampled as Teller-like and Vanoss-like are found on terraces along major streams in Southern Kansas, Central Oklahoma and Central Texas. Both soils are developed in Pleistocene alluvium sometimes modified by wind. Having undergone minimum morphological development, Teller and Vanoss may be classified as "Minimal" Reddish Prairies. The Teller soils are developed in reddish, fine sandy loams or silt loams. Vanoss, which has a browner subsoil and more silty textured horizons, is associated with the Teller soils in grassland areas within or adjoining the forested areas (15). Teller and Vanoss along with other associated soils are illustrated in Figure 1.

Descriptions of the Sampled Profiles

Teller-like fine sandy loam, (Red) Kay County

The site is a high terrace of the Arkansas River, elevation 1100 feet or approximately 100 feet above the river channel; present vegetation is native Big Bluestem (*Andropogon gerardi*)[1] and Little Bluestem (*Andropogon scoparius*) with a predominance of Little Bluestem; 3% convex slope; located 800 feet west and 168 feet south of northeast corner Sec. 28, T.27N., R.4E., Kay County, Oklahoma.

[1] Plant names follow those of Waterfall (1962).

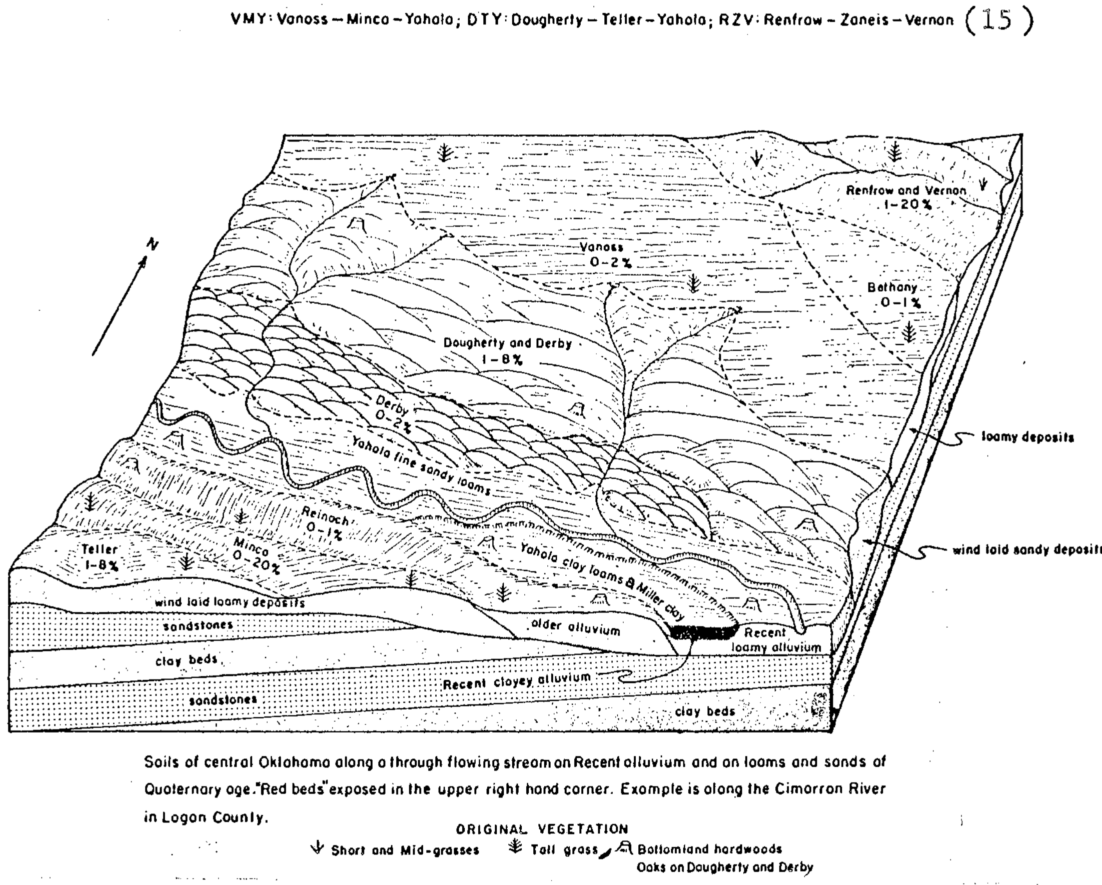

Figure 1. Block Diagram of Teller - Vanoss Soil Associations.

Figure 2. Soil Sample Site Locations.

Horizon	Depth Inches	Description
A11	0-10	Dark grayish brown (10YR 4/2, 2/2m) fine sandy loam; weak fine to medium granular; soft, very friable; pH 6.3; grades to layer below.
A12	10-14	Brown to dark brown (7.5YR 4/2, 3/2m) loamy fine sand; weak fine granular; soft, very friable; pH 6.0; grades to layer below.
B1	14-17	Brown to dark brown (7.5YR 4/4, 3/2m) fine sandy loam; weak fine granular; slightly hard, friable; pH 5.9; grades to layer below.
B2	17-28	Yellowish red (5YR 4/6, 4/6m) fine sandy loam, weak fine to medium granular, porous massive dry; hard, friable; greatest concentration of roots in this layer; few pinholes and worm casts; pH 5.2; grades to layer below.
B3	28-36	Yellowish red (5YR 5/6, 4/8m) fine sandy loam, dark reddish brown bands of sandy clay loam; weak fine granular to massive; slightly hard, loose; few roots but decrease gradually after this layer; pH 5.3; grades to layer below.
C11	36-46	Yellowish red (5YR 5/8, 4/8m) loamy fine sand, few dark reddish brown bands of silty clay loam; massive; slightly hard, loose; pH 5.3.
C12	46-60	Yellowish red (5YR 5/6, 4/8m) loamy fine sand; massive; slightly hard, loose; pH 5.7.
IIC	60-70	Yellowish red (5YR 5/6, 4/6m) stratified sandy loam that increases in clay with depth; massive; hard, friable; pH 5.8.

Note: In Kay County, as of January, 1964, this is an inclusion in the Shellabarger fine sandy loam mapping unit.

<u>Teller-like sandy loam, (Red) Bryan County</u>

The site is a high level terrace of the Red River with an elevation of 570 feet, approximately 70 feet above the river channel; cotton and peanuts are the main crops, native vegetation was grass with scattered oak; 0.2% slope; located 135 feet east and 1320 feet north of southwest corner Sec. 21, T.9S., R.9E., Bryan County, Oklahoma.

Horizon	Depth Inches	Description
Ap1	0-6	Brown (10YR 5/3, 3/4m) fine sandy loam; weak medium and fine granular; very friable; pH 6.8; plow boundary.
A1	6-9	Brown (10YR 5/3, 3/4m) fine sandy loam; moderate medium granular; worm casts running vertical; friable; pH 6.8; grades to horizon below.
A3	9-13	Brown (7.5YR 5/4, 4/4m) fine sandy loam; moderate medium granular; worm casts running vertical; friable; pH 6.7; grades to horizon below.
B21t	13-17	Yellowish red (5YR 5/6, 4/6m) fine sandy loam; weak coarse subangular blocky; worm casts become more numerous in the three horizons below; patchy clay films; friable; pH 6.4; grades to horizon below.
B22t	17-29	Yellowish red (5YR 5/6, 4/6m) fine sandy loam; weak coarse subangular blocky; firm; patchy clay films most pronounced in this horizon; pH 6.0; grades to horizon below.
B23t	29-39	Strong brown (7.5YR 5/6, 5YR 5/6m) fine sandy loam; weak coarse subangular blocky; friable; patchy clay films; some dark staining; clay balls from dime size to golf ball size; pH 6.0; grades to horizon below.
B3	39-50	Reddish yellow (7.5YR 6/6, 5/6m) fine sandy loam; structureless; very friable; some dark staining; clay balls; pH 5.9; grades to horizon below.
C	50-65	Yellowish brown (10YR 5/6, 7.5YR 5/6m) fine sandy loam; structureless; very friable; some dark staining; clay balls; pH 6.4.

Note: Extremely porous throughout profile. No evident roots below 20 inches. The lower horizons seem to be high in manganese or iron and contain occasional sandstone gravel.

Vanoss silt loam, (Brown) Kay County

The area is a high terrace of the Arkansas River with an elevation of 1050 feet or approximately 50 feet above the river channel; native vegetation was tall grass; present crop is wheat; 0-1% slope on almost flat topography with some slight undulations; located 1,300 feet east and 200 feet north of the south quartercorner Sec. 22, T.28N., R.3E., Kay County, Oklahoma.

The profile was desiccated below 8 inches at time of sampling.

Horizon	Depth Inches	Description
Ap1	0-9	Dark grayish-brown (10YR 4/2, 2/2m) silt loam; weak medium to fine granular; slightly hard, very friable to friable; pH 5.5; abrupt smooth boundary.
B11	9-13	Dark grayish-brown (10YR 4/2, 3/3m) silty clay loam which crushes to a more brownish color; weak medium subangular blocky; friable; pH 5.9; grades to layer below.
B12	13-17	Brown to dark brown (10YR 4/3, 3/4m); silty clay loam; moderate medium subangular blocky; numerous pinholes and worm casts; hard; pH 6.1; grades to layer below.
B21t	17-26	Brown (7.5YR 5/4, 4/4m) silty clay loam; strong medium subangular blocky; organic-clay coatings; hard; pH 6.3; below this layer roots decrease rapidly with depth; grades to layer below.
B22t	26-35	Brown to dark brown (7.5YR 4/4, 4/4m) silty clay loam; same as layer above except less clay skins and coatings; strong medium subangular blocky; hard; pH 6.3; grades to layer below.
B3	35-48	Brown (7.5YR 5/4, 4/4m) silty clay loam; strong medium subangular blocky; hard; pH 6.3; grades to horizon below.
C	48-60	Brown (7.5YR 5/4, 4/4m) silt loam; very weak subangular blocky to porous massive; friable; pH 6.3.

Note: Correlated as modal Vanoss in January, 1964, for a recent Kay County Soil Survey.

Vanoss-like loam, (Brown) Bryan County

The site is a high level terrace of the Red River with an elevation of 530 feet, approximately 30 feet above the river channel; native vegetation consisted of open areas of grass with scattered oak; present crops are cotton and peanuts; 0.1% slope, almost flat; located 75 feet east and 600 feet north of southwest corner of southeast quarter Sec. 34, T.9S., R.9E., Bryan County, Oklahoma.

Horizon	Depth Inches	Description
A_{p1}	0-6	Brown (10YR 5/3, 3/3m) loam; weak medium and fine granular; friable; pH 6.0; gradual smooth boundary.
A_{p2}	6-13	Brown (10YR 5/3, 3/3m) loam; weak medium and fine granular; friable; pH 6.2; gradual level boundary.
A1	13-19	Grayish brown (10YR 5/2, 3/3m) loam; moderate medium granular; worm casts and many coarse pores; sand and gravel pebbles; friable; pH 6.3; grades to horizon below.
B2	19-28	Brown (10YR 5/3, 7.5YR 4/4m) loam; mottling with few fine distinct yellowish-red to strong brown mottlings becoming fine distinct in following two horizons; moderate medium subangular blocky; firm; worm casts and many coarse pores; soft manganese and iron concretions; sand and gravel pebbles; patchy clay films; pH 6.4; grades to horizon below.
B3	28-42	Reddish yellow (7.5YR 6/6, 5/6m) loam; weak medium subangular blocky; many coarse pores; soft manganese and iron concretions; sand and gravel pebbles; friable; pH 6.4; grades to horizon below.
IIC	42-65	Light yellowish brown (10YR 6/4, 5/4m) loam; structureless; friable; soft manganese and iron concretions; pH 6.1.

Note: It appears at one time tillage has been at a greater depth than it is at present. The area has been under irrigation since 1955, with a minimum of two and a maximum of four irrigations per year.

CHAPTER IV

LABORATORY METHODS AND PROCEDURES

Physical Analysis

The samples were air dried in the laboratory and processed to pass a 2 mm. screen. Particle size distribution was then determined. Fifty gram samples were weighed and organic matter removed by using H_2O_2. The total sand was wet sieved and the amount of each sand fraction determined by weighing the sand left on the respective sieve. The remaining silt and clay was determined by a Bouyoucos hydrometer using the Day (9) procedure. The silt was separated from the clay in an International Centrifuge by using 100 ml. tubes and a centrifuge speed of 700 RPM. for 2 minutes and 54 seconds. The clay from only the major horizons was separated into two fractions, .002-.0002 mm. and $<$.0002 mm., by using a continuous flow refrigerated Servall Superspeed Centrifuge. The fine clay passed through the centrifuge at a rate of 100 ml./min. (15°C) at a speed of 14,000 RPM. The coarse fraction was redispersed and centrifuged 4 more times, making a total of 5 runs per clay sample.

Chemical Analysis

Soil organic matter was determined by the potassium dichromate wet oxidation method of Scholenberger (32). Total nitrogen was determined by the Kjeldahl method outlined by Harper (17). Total phosphorus determinations were made by perchloric acid digestion and development of the molybdate complex according to a procedure by Shelton and Harper (33). The soil pH was determined by using a Beckman pH meter on a 1:1 soil-water mixture. Soil cation exchange capacity was determined by saturation with ammonium acetate and then determining the amount of exchange ammonium by Kjeldahl distillation (19). The CEC-NH_4OAc leachate was saved to determine the extractable cations. The extractable sodium and potassium were determined on the flame photometer and calcium and magnesium by titration with Versenate (30). The clay cation exchange capacity was determined on both the fine and coarse fractions of the major horizons by saturation with sodium acetate (30) and then determining sodium on the flame photometer.

In free iron removal, to determine free iron, Jackson's (18) method of dithionite-sodium citrate with sodium bicarbonate buffer was used rather than Deb's (10) dithionite with water method. Deb's method, proposed by the 7th Approximation, causes an acid medium which tends to destroy some clay. The free iron was removed from .2 grams of both the fine and coarse clay fractions of the major horizons and then determined colorimetrically by Jackson's (20) Tiron method. The same clay samples were then placed in teflon beakers to which perchloric acid and hydrofluoric acid (20) were added to remove lattice iron. The amount of lattice iron was also determined by the Tiron method.

CHAPTER V

RESULTS AND DISCUSSION

Particle Size Distribution

Teller-like (Red) Soils

The particle size distribution for both Teller-like soils is presented in Table I. There is a similarity in the silt content of these soils in that it decreases with depth. Differences occur in the amount of silt and medium sand fractions. The silt content varies from 2 to 5 times higher in the Bryan County Teller-like than in the Kay County (Red) soil whereas the latter is 2 to 3 times higher in medium sand throughout the profile than the Bryan County Teller. An exception occurs in horizon IIC of the Kay County (Red) soil which appears to be a nonconforming layer in this soil profile.

The clay contents, both total and fine clay, were plotted with depth and are shown in Figures 3 and 4. The Teller-like soils show clay accumulations in the B horizons of both profiles which are indicative of argillic horizons. The curves for the Bryan County Teller-like are less abrupt and indicate a thicker argillic horizon than the Kay County Teller-like soil.

Vanoss-like (Brown) Soils

The particle size distribution for both Vanoss-like soils is presented in Table II. The Kay County Brown, which is modal for Vanoss, shows high silt and clay contents throughout the profile and small

TABLE I

PARTICLE SIZE DISTRIBUTION OF TELLER-LIKE SOILS

Horizon	Depth	Very Coarse Sand 2-1 mm.	Coarse Sand 1-.5 mm.	Medium Sand .5-.25 mm.	Fine Sand .25-.1 mm.	Very Fine Sand .1-.05 mm.	Silt .05-.002 mm.	Clay <.002 mm.
	inches	%	%	%	%	%	%	%
				Teller-like (Red) Kay County				
A11	0-10	0.3	5.6	25.9	33.5	10.1	14.8	9.8
A12	10-14	0.0	5.9	29.3	35.1	9.6	10.4	9.7
B1	14-17	0.0	5.8	26.5	35.9	9.4	9.4	12.9
B2	17-28	0.0	3.5	23.3	38.5	9.9	6.1	18.7
B3	28-36	0.0	2.7	24.9	42.4	10.7	5.5	13.7
C11	36-46	0.0	4.0	30.0	43.8	10.0	3.6	8.6
C12	46-60	0.0	5.9	29.9	39.1	11.9	4.8	8.4
IIC	60-70	0.0	5.1	19.5	26.9	11.8	21.2	15.5
				Teller-like (Red) Bryan County				
Ap1	0-6	0.0	1.2	10.9	31.0	15.3	35.6	6.0
A1	6-9	0.0	0.8	10.5	30.1	15.2	32.5	10.9
A3	9-13	0.0	0.9	10.1	28.2	13.4	32.1	15.3
B21t	13-17	0.0	0.9	10.1	28.7	14.1	29.1	17.1
B22t	17-29	0.0	0.9	10.5	30.8	13.8	26.1	17.9
B23t	29-39	0.0	0.8	11.7	35.4	14.2	20.3	17.6
B3	39-50	0.0	1.9	15.4	40.3	15.1	14.2	13.1
C	50-65	0.0	0.8	12.4	44.9	18.3	14.7	8.9

TABLE II

PARTICLE SIZE DISTRIBUTION OF VANOSS-LIKE SOILS

Horizon	Depth	Very Coarse Sand 2-1 mm.	Coarse Sand 1-.5 mm.	Medium Sand .5-.25 mm.	Fine Sand .25-.1 mm.	Very Fine Sand .1-.05 mm.	Silt .05 - .002 mm.	Clay <.002 mm.
	inches	%	%	%	%	%	%	%
				Vanoss (Brown) Kay County				
Ap1	0-9	0.0	0.3	0.5	1.5	9.8	65.6	22.2
B11	9-13	0.0	0.2	0.4	0.9	8.8	61.1	28.6
B12	13-17	0.0	0.2	0.3	0.7	7.0	58.1	33.7
B21t	17-26	0.0	0.2	0.2	0.5	5.6	59.1	34.4
B22t	26-35	0.0	0.1	0.2	0.4	7.3	61.7	30.3
B3	35-48	0.0	0.2	0.3	0.9	10.6	60.5	27.5
C	48-60	0.0	0.3	0.5	1.1	11.4	60.6	26.1
				Vanoss-like (Brown) Bryan County				
A_{p1}	0-6	0.0	0.7	4.1	9.1	29.5	45.5	11.1
A_{p2}	6-13	0.0	1.5	4.8	9.2	30.0	43.0	11.5
A1	13-19	0.0	1.1	3.9	8.0	26.6	45.8	14.6
B2	19-28	0.0	1.2	3.5	7.7	24.3	44.4	18.9
B3	28-42	0.0	1.4	4.5	9.6	19.5	45.9	19.1
IIC	42-65	0.0	2.7	7.8	16.0	17.9	35.8	19.8

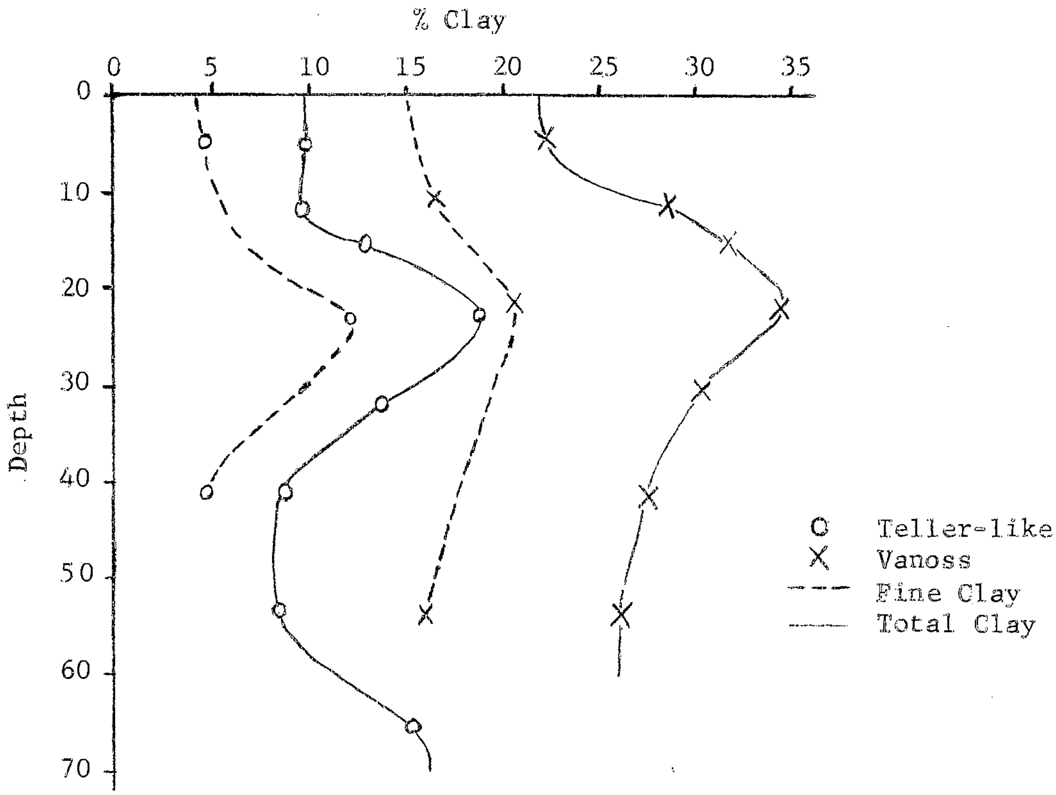

Figure 3. Fine and Total Clay Distribution with Depth in Kay County.

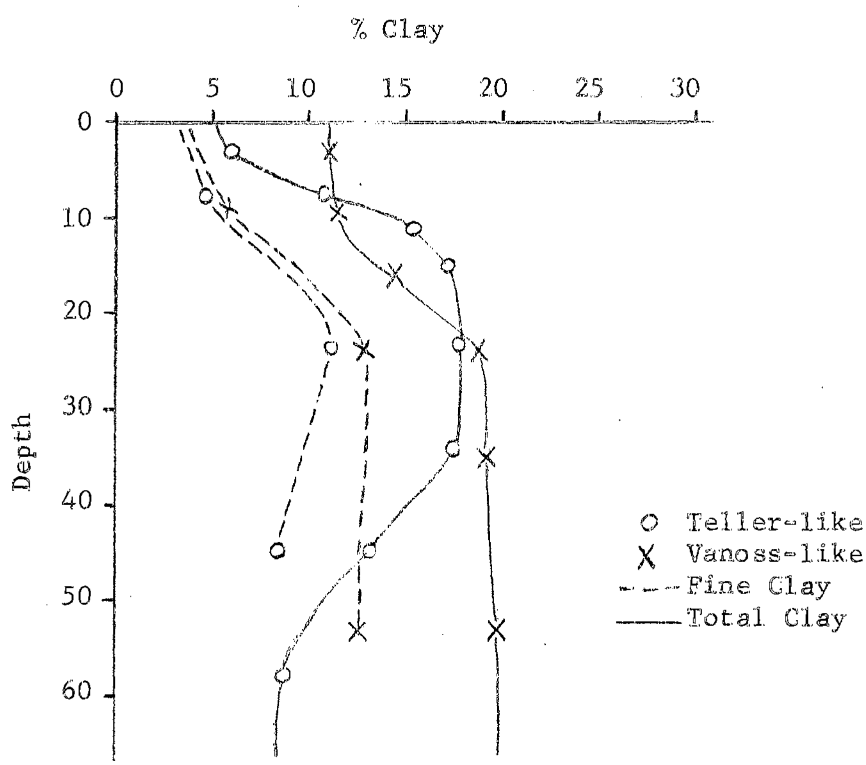

Figure 4. Fine and Total Clay Distribution with Depth in Bryan County.

amounts of sands. The Bryan County (Brown) soil is higher in sand and lower in both silt and clay than the Kay County (Brown). However, the very fine sand plus silt plus clay is 85 percent or higher in both Brown profiles.

The clay contents plotted in Figures 3 and 4 show that Vanoss (Fig. 3) has an argillic B whereas the Vanoss-like (Fig. 4) does not show a well defined argillic horizon above a C horizon. The poorly defined argillic horizon in the latter Brown may be due to the non-conforming IIC horizon. The IIC has a different proportion of sand fractions and less silt (Table II) and possibly originally contained more clay.

Red versus Brown

A comparison of the Red with the Brown soils as to particle size distribution shows the Red soils are more coarse textured with a greater sum of coarse plus medium plus fine sands over the finer Brown soils with a greater sum of very fine sand plus silt plus clay. The higher silt content of the Brown profiles remains constant with depth while it decreases with depth in the Red profiles.

Part of the data in Table V shows the percent fine and coarse clay in the total clay of the major horizons. Usually most of the clay is of the fine fraction except in the surface horizons. The greater percent of clay in the fine fraction agrees with the eleven profiles studied for clay minerals by Gray et al. (16).

Chemical Properties of Whole Soil

Data of chemical analyses of the whole soil are presented in Tables III and IV.

TABLE III

CHEMICAL PROPERTIES OF TELLER-LIKE SOILS

Horizon	Depth	1:1 pH	Base Saturation	Organic Matter	Total Nitrogen	Total Phosphorus	Extractable Cations Ca	Mg	K	Na	Cation Exchange Capacity
	inches		%	%	%	ppm	----me./100 g. of soil----------				
				Teller-like (Red) Kay County							
A11	0-10	6.3	105	3.4	.08	125	4.2	1.1	0.4	0.1	5.5
A12	10-14	6.0	110	2.7	.09	100	4.3	1.4	0.4	0.1	5.6
B1	14-17	5.9	97	3.0	.08	110	5.0	1.7	0.4	0.1	7.5
B2	17-28	5.2	83	2.1	.05	90	5.5	2.1	0.3	0.1	9.5
B3	28-36	5.3	97	1.0	.03	60	4.5	1.8	0.1	0.1	6.7
C11	36-46	5.3	100	0.5	.02	50	3.1	1.5	0.2	0.1	4.9
C12	46-60	5.7	120	0.3	.02	40	4.2	1.1	0.1	0.1	4.6
IIC	60-70	5.8	116	0.2	.02	40	6.9	1.6	0.3	0.1	7.7
				Teller-like (Red) Bryan County							
A_p1	0-6	6.8	155	1.7	.04	180	5.1	0.9	0.3	0.1	4.0
A1	6-9	6.8	131	1.2	.04	130	5.0	1.1	0.3	0.1	5.0
A3	9-13	6.7	119	0.9	.04	130	4.8	1.4	0.3	0.2	5.6
B21t	13-17	6.4	103	0.9	.04	120	5.2	1.4	0.3	0.1	6.8
B22t	17-29	6.0	101	0.8	.04	100	5.2	1.4	0.2	0.1	6.8
B23t	29-39	6.0	103	0.6	.03	90	4.9	2.0	0.3	0.2	7.3
B3	39-50	5.9	93	0.4	.02	85	3.9	1.4	0.3	0.1	6.2
C	50-65	6.4	108	0.3	.02	80	2.9	1.2	0.2	0.1	4.1

TABLE IV

CHEMICAL PROPERTIES OF VANOSS-LIKE SOILS

Horizon	Depth	1:1 pH	Base Saturation	Organic Matter	Total Nitrogen	Total Phosphorus	Extractable Cations Ca	Mg	K	Na	Cation Exchange Capacity
	inches		%	%	%	ppm	----me./100 g. of soil----------				
				Vanoss (Brown) Kay County							
A_p1	0-9	5.5	95	4.4	.12	270	6.5	2.3	0.7	0.1	11.2
B11	9-13	5.9	97	4.7	.12	320	10.0	3.2	0.7	0.1	14.5
B12	13-17	6.1	95	3.9	.11	285	10.2	4.4	0.6	0.2	16.2
B21t	17-26	6.3	102	3.0	.09	280	11.9	5.7	0.5	0.2	17.8
B22t	26-35	6.3	103	1.9	.07	230	10.5	6.2	0.3	0.2	16.7
B3	35-48	6.3	113	1.5	.05	230	10.5	5.4	0.4	0.2	14.5
C	48-60	6.3	112	1.1	.04	180	9.5	4.6	0.4	0.2	13.0
				Vanoss-like (Brown) Bryan County							
A_{p1}	0-6	6.0	117	2.4	.07	200	4.9	1.5	0.6	0.3	6.2
A_{p2}	6-13	6.2	120	2.4	.07	220	4.9	1.5	0.5	0.3	6.0
A1	13-19	6.3	127	2.8	.07	300	6.9	1.6	0.7	0.6	7.7
B2	19-28	6.4	123	1.5	.06	190	5.8	2.1	0.5	0.8	7.4
B3	28-42	6.4	128	0.9	.04	110	5.5	1.8	0.8	0.6	6.8
IIC	42-65	6.1	116	0.6	.02	110	5.0	2.9	0.6	0.4	7.7

Cation Exchange Capacity, Extractable Cations, pH and Base Saturation

Teller-like (Red) Soils

The cation exchange capacity (CEC) is low, less than 10 me. per 100 grams, in both Red soils. The CEC is closely related to the amount of clay for when the CEC increases in a profile the percent clay usually increases.

The extractable cations include both exchangeable and free cations (not attached to any exchange sites). Both soils are similar in the amount of each extractable cation. Calcium is the dominant cation followed by magnesium.

The pH of the Kay County Teller-like soil is lower ranging from 5.2 to 6.3 as compared to a 5.9 to 6.8 range in the Bryan County Teller-like.

The percent base saturation is around 100, always above 80 percent and usually above 100 percent.

Vanoss-like (Brown) Soils

The cation exchange capacity for Bryan County Vanoss-like soil is low, less than 10 me. per 100 grams, while the Vanoss in Kay County is about twice that of the Bryan County (Brown) soil.

The extractable cations are dominated by calcium followed by magnesium with again about twice as much calcium and magnesium occurring in the Kay County Vanoss. The higher amount of sodium in the Bryan County Vanoss-like soil could be due to sodium occurring in the irrigation water, this being the only sampling site under irrigation (note-under profile description, page 10).

Below the Ap horizons of both Brown soils the pH's are similar ranging from 5.9 to 6.3 in Kay County and from 6.1 to 6.4 in Bryan County. The pH of the Ap is 5.5 in Kay County and an average of 6.1 between the two Ap horizons in Bryan County.

The base saturation is usually above 100 percent for the Kay County Vanoss and always above 100 percent in the Bryan County Vanoss-like.

According to the soil pH, the percent base saturation would not be expected to be so high. The reason for this relationship in these soils is not known. The high base saturation is not caused by a high concentration of free salts (cations), because the me. of free salts in water extract was insignificant. Possibly it is partially due to low cation exchange capacity results of the soil. Frink (12) reports the NH_4 + CEC method may produce lower results due to solubilization of some ammoniated organic matter complex in lower alcohols. Or the low pH may be due to the presence of some form of exchangeable aluminum (21). One way to indicate the presence of exchange aluminum in soil is by a 1:1 KCl-soil mixture and determining the decrease in pH of this mixture. A few checks of this mixture on the soils lowered the soil-water pH about 1.0 unit. According to Jenny (21) this is a significant decrease.

Red versus Brown

Similarities seem to be more striking than differences in cation exchange capacity, extractable cations and base saturation. The exception is the Kay County (Brown) soil which is higher in exchange capacity and extractable cations, however these are closely related to the higher clay content. The pH's of the Red soils are less in the lower solum than in the Brown soils.

Organic Matter, Total Nitrogen and Total Phosphorus

Teller-like (Red) Soils

The curves in Figures 5 and 6 show the distribution of organic matter with depth. Organic matter generally decreases with depth. The Kay County (Red) soil, a virgin profile, has about twice as much organic matter and nitrogen as the Bryan County (Red) soil in the upper half of the profile. The total nitrogen (Table III) is the nitrogen in both the organic matter and mineral soil.

The amount of total phosphorus closely follows the pattern of the percent organic matter. It is generally assumed that 40 to 50 percent of the phosphorus occurs in the organic portion of soils (27). The Teller-like soil in Bryan County is about 40 ppm higher in each horizon than the Teller-like soil in Kay County.

Vanoss-like (Brown) Soils

In Kay County, the Vanoss also has about twice as much organic matter and nitrogen as the Bryan County Vanoss-like. The same is true for the Kay County (Red) soil which indicates more accumulation and less breakdown in northern Kay County than in the southern Bryan County soils. It was also observed, after drying the samples in the laboratory, that the northern soils were stronger in structure than the southern soils.

The Kay County Vanoss contains more total phosphorus, averaging about 70 ppm more per horizon, than the Bryan County Vanoss-like.

Red versus Brown

The Brown soils are consistently higher in organic matter and total nitrogen, averaging almost twice as much, and contain an average of over

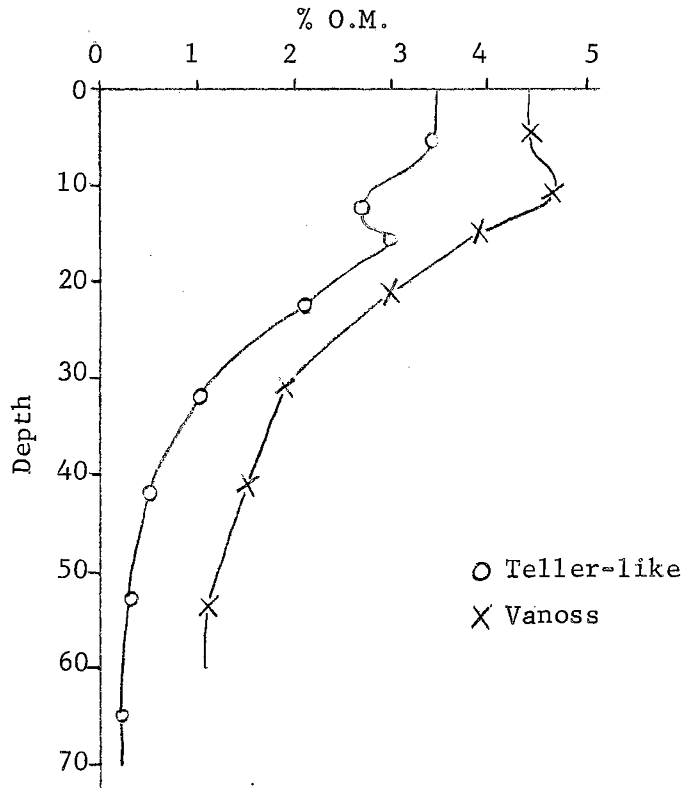

Figure 5. Distribution of Organic Matter with Depth in Kay County.

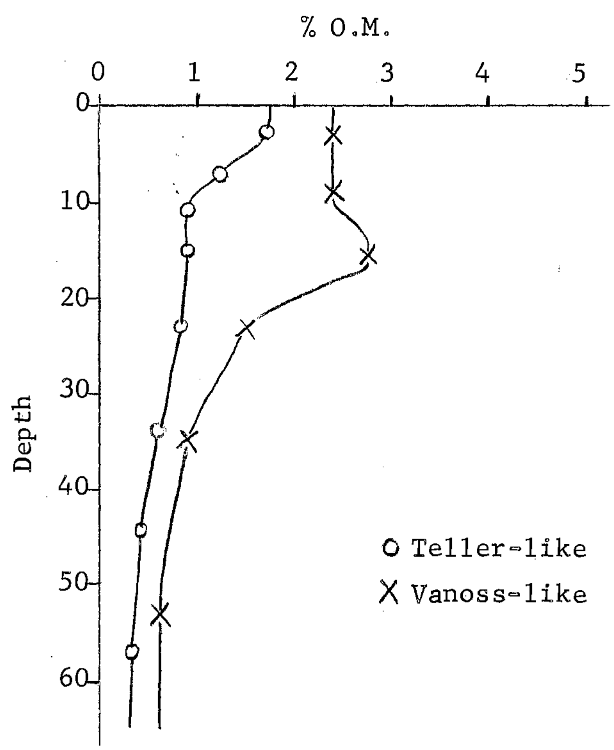

Figure 6. Distribution of Organic Matter with Depth in Bryan County.

twice as much total phosphorus, than do the Red soils.

Chemical Properties of the Clay

Cation Exchange Capacity

The higher cation exchange capacities of the fine clay, as shown in Table V, indicate more montmorillonitic type clays in the fine than in the coarse fraction. These qualitative data are substantiated by some unpublished work done in Reno County, Kansas (31), also along the Arkansas River, where the clay fraction of the Vanoss soil was shown by X-ray diffraction to be dominated by montmorillonite and illite.

Red versus Brown

The cation exchange capacity of the total clay is slightly higher in the Brown than in the Red soils. The greatest difference is between the fine and coarse fractions. The fine fraction in the Brown is usually higher in cation exchange capacity than the fine in the Red soils, whereas the reverse is the usual case with the coarse fraction.

Iron Determinations

Emphasis was placed on iron analysis because iron was thought to be a possible reason for the color difference between the chosen Red and Brown soils. In the particle size distribution, the color (red and brown) stayed mostly with the clay fraction. Thus, iron determinations were made on the clay fractions of the major horizons. After removing free iron the clay was either gray or bluish-gray in color. So determining lattice iron was not for color reasons but because it was easy to determine after removing free iron. Lattice iron is also a step in determining the mineralogy of the clay. Actually determining

TABLE V

FINE AND COARSE CLAY OF TOTAL CLAY AND ITS CATION EXCHANGE CAPACITY

Horizon	Depth	Coarse Clay .002 - .0002 mm.	Fine Clay <.0002 mm.	Cation Exchange Capacity: Coarse Clay .002 - .0002 mm.	Cation Exchange Capacity: Fine Clay <.0002 mm.	Cation Exchange Capacity: Total Clay <.002 mm.
	inches	---% of total clay--		----- me./100 g. of clay--------		
		Teller-like (Red) Kay County				
A11	0-10	54	46	44.9	61.3	52.5
B2	17-28	36	64	42.0	62.2	55.4
C11	36-46	47	53	51.6	69.8	61.2
		Teller-like (Red) Bryan County				
A1	6-9	56	44	28.3	77.5	50.0
B22t	17-29	38	62	28.1	59.0	47.3
B3	39-50	35	65	38.9	63.1	54.6
		Vanoss (Brown) Kay County				
B11	9-13	27	73	25.7	67.7	56.4
B21t	17-26	40	60	35.8	83.3	64.3
C	48-60	38	62	34.7	91.3	70.0
		Vanoss-like (Brown) Bryan County				
A_{p2}	6-13	51	49	26.0	85.3	55.1
B2	19-28	31	69	19.5	60.0	47.4
IIC	42-65	37	63	33.8	72.5	58.2

the mineralogy of these soils is outside the scope of this study.

The iron results in Table VI are presented as elemental iron (Fe) rather than iron oxide. Most of the free iron probably exists on the clays as iron oxide but some, no doubt, also exists as hydrated iron oxides and ferrous iron; thus due to the variation in the form free iron and lattice iron occurs, it is expressed in the elemental form. Rich (29) presents his results as percentage free iron (Fe).

Red versus Brown from Free Iron

The percent iron (total, of the clay) ranges from an average of 4.1 percent (average of 3 major horizons) in the Bryan County Teller-like to an average of 4.7 percent in also red Kay County Teller-like. There is usually a little more free iron in the Red soils than in the Brown soils. Averaging the free iron for all the Red soil major horizons and all the Brown soil major horizons showed 2.55 percent for Red and 2.30 percent for Brown soils. The best agreement between Munsell field colors (profile descriptions) with free iron redness is in the Bryan County (Red) profile. The B22t horizon is redder than the other two major horizons and also contains the most free iron oxide. Disagreement also exists, as shown within the Kay County (Red) profile where the C11 horizon is a slightly stronger red, 5YR 4/8m, as compared to the B2, 5YR 4/6m, but has 0.2 percent less free iron. The same relationship exists between the Brown Vanoss and the Kay County (Red) in the C horizon and C11 respectively with 0.2 percent more free iron in the C horizon of Brown Vanoss.

Since most of the iron affecting color occurs in the clay fraction a look at the amount of clay in each soil is necessary. With the

TABLE VI

IRON (Fe) ASSOCIATED WITH THE CLAY

		Coarse Clay			Fine Clay			Clay (Fine + Coarse)		
Horizon	Depth	Free	Lattice	Total	Free	Lattice	Total	Total Free	Total Lattice	Total Iron
	inches	%	%	%	%	%	%	%	%	%
				Teller-like (Red) Kay County						
A11	0-10	3.8	2.6	6.3	2.5	2.3	4.8	3.2	2.5	5.6
B2	17-28	3.8	2.2	6.0	1.6	1.8	3.3	2.4	1.9	4.3
C11	36-46	3.3	2.8	6.0	1.2	1.5	2.7	2.2	2.1	4.3
				Teller-like (Red) Bryan County						
A1	6-9	1.9	1.3	3.1	2.4	1.7	4.1	2.1	1.5	3.5
B22t	17-29	2.9	1.6	4.5	2.7	1.9	4.6	2.8	1.8	4.6
B3	39-50	2.8	1.5	4.2	2.5	1.9	4.4	2.6	1.8	4.3
				Vanoss (Brown) Kay County						
B11	9-13	2.5	2.2	4.7	1.8	2.3	4.0	2.0	2.3	4.2
B21t	17-26	2.4	2.2	4.6	2.0	2.7	4.7	2.2	2.5	4.7
C	48-60	2.6	2.1	4.7	2.2	2.8	4.9	2.4	2.5	4.8
				Vanoss-like (Brown) Bryan County						
A_{p2}	6-13	2.5	1.9	4.4	2.4	2.1	4.5	2.5	2.0	4.4
B2	19-28	2.0	1.6	3.6	2.5	2.6	5.1	2.3	2.3	4.6
IIC	42-65	2.5	1.7	4.2	2.4	2.3	4.7	2.4	2.1	4.5

exception of the Kay County Vanoss having more clay, the other profiles have essentially the same amount of clay, especially in the B horizons.

Other Iron Comparisons

More free iron would be expected in the fine clay fraction as was found by Rich (29). The Kay County soils (Teller-like Red and Vanoss Brown) have more free iron in the coarse clay than in the fine clay; while in the Bryan County soils the amount of free iron is very similar between clay fractions. Also, the Bryan County soils have more free iron than lattice iron whereas the Kay County soils are less different in the amount of free and lattice iron. This could support more weathering in the more southern county.

Other Possibilities as to Red versus Brown

Studying the iron data indicates how much iron exists, which fractions iron is associated with, and whether it is free or lattice, but not its oxidation state. Whether the free iron occurs in the ferric or ferrous form might show a significant difference. To pursue this study further Walker and Sherman (41) have a method to measure ferrous iron in soils. The method used in this study changed all the iron into the ferric state before it was measured colorimetrically. Daniels et al. (8) found very low ferrous iron content from brown to yellowish brown (10YR) Wisconsin loess. He also interpreted, from low amounts of ferrous iron and thin section observations, that the color of a grayish brown loess was a result of the color of the grayish silt grains.

Other possibilities might be the Brown soils are younger and have not oxidized as much as the older and more coarse textured Red soils. Also the Red soils, being more coarse, would naturally lend to better oxidizing and weathering conditions for both iron and organic matter.

Soil Classification by 7th Approximation

Teller-like (Red) Kay County

Order. . . . . Mollisol

Suborder. . . . . Udoll

Great Group. . . . . Argiudoll

Subgroup. . . . . . Typic Argiudoll

Family . . . . coarse loamy, mixed, thermic

7th Approximation name: coarse loamy, mixed, thermic, Typic Argiudoll.

Since the upper 20 inches of the argillic horizon averages 16.3 percent clay the family texture is coarse loamy rather than fine loamy. Presently there is not an established series within the coarse loamy family texture.

Teller-like (Red) Bryan County

Order. . . . . Mollisol

Suborder. . . . . Udoll

Great Group. . . . . Argiudoll

Subgroup. . . . . . Typic Argiudoll

Family . . . . coarse loamy, mixed, thermic

7th Approximation name: coarse loamy, mixed, thermic, Typic Argiudoll.

The mollic epipedon is thin (9 inches, according to horizon designations); but by averaging the top 10 inches, the epipedon qualifies as a mollic. This profile is not a good Typic Argiudoll; however within the present limits of the 7th Approximation, it fits best in this subgroup. If such a subgroup occurred this profile would more accurately be classed as a Humalfic Normudult.

Vanoss (Brown) Kay County

Order. . . . . Mollisol

Suborder. . . . . Udoll

Great Group. . . . . Argiudoll

Subgroup. . . . . . Typic Argiudoll

Family . . . . fine silty, mixed, thermic

7th Approximation name: fine silty, mixed, thermic, Typic Argiudoll.

Vanoss-like (Brown) Bryan County

Order. . . . . Mollisol

Suborder. . . . . Udoll

Great Group. . . . . Argiudoll

Subgroup. . . . . . Typic Argiudoll

Family . . . . fine silty, mixed, thermic

7th Approximation name: fine silty, mixed, thermic, Typic Argiudoll.

The family texture is bordering between fine silty and coarse silty when the argillic horizon starts at 13 inches, which is the first horizon of significant clay increase. However, considering the next two subsequent horizons this profile is placed into fine silty.

Red versus Brown

According to the 7th Approximation classification the only difference between the Red and Brown profiles is the family texture, coarse loamy for the Red and fine silty for the Brown. Both Red and Brown soils are mixed, thermic, Typic Argiudolls.

CHAPTER VI

SUMMARY AND CONCLUSIONS

From the particle size distribution it was found the Teller-like (Red) soils were more coarse textured than the Vanoss-like (Brown) soils. This is typically expected, but not always the case since overlapping of textures does occur in the field. There seems to be a need to run more mechanical analyses of these coarser Teller-like soils to determine whether a new series should be established in the coarse loamy family texture.

Below the surface horizons more clay was of the fine fraction than of the coarse fraction.

Chemically, the Kay County Vanoss (Brown), as compared to the other 3 profiles, had about twice the cation exchange capacity and extractable calcium and magnesium, which corresponds closely to the clay content which is also about double. Both Brown soils had about twice as much total phosphorus, organic matter and total nitrogen in comparison to the Red soils. The pH was slightly less in the lower solum of the Red soils than in the Brown.

As to the cause for the colors of red versus brown in the profiles studied, the answer is not strongly supported by the amount of free iron in the clay. An average of 2.55 percent free iron was found in the Red clays as compared to 2.30 percent in the Brown clays. A higher free iron content is often not indicated by redder Munsell colors; thus in some cases there is free iron to support color and in other cases there is disagreement. The amount of iron being essentially the same could be supported by other soil characteristics not being significantly different, such as pH, drainage and possibly parent material. Further research is needed to determine whether the color difference is due to ferrous-ferric differences, the influence of the silt color in the brown soils, a different time of parent material deposition, or some other reason.

There are slight indications of more weathering in the southern Bryan County profiles such as less organic matter, less lattice iron and weaker dry structure in comparison to the northern Kay County profiles.

From this study there does not seem to be enough measurable evidence to separate these soils on the basis of color in the field. However, from the difference in textures, coarse loamy as compared to fine silty, a separation is warranted.

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