A PRELIMINARY STUDY OF SOME CHEMICAL, PHYSICAL AND MINERALOGICAL PROPERTIES OF SOME DEEP SURFACE SOILS OF EASTERN OKLAHOMA

By

KENNETH G. BRENGLE

Bachelor of Science

Oklahoma Agricultural and Mechanical College

Stillwater, Oklahoma

1953

Submitted to the Faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE
July 1954

Thesis Approved:

Fenton Gray
Thesis Adviser

Lester W. Reed

Robert MacVicar
Dean of the Graduate School

ACKNOWLEDGMENTS

The writer wishes to express his thanks to Dr. J. Q. Lynd and Dr. L. W. Reed for their aid and suggestions; to Dr. H. V. Eck for the use of his laboratory and equipment; and to H. M. Galloway for his assistance in collecting samples and field descriptions. The writer is especially indebted to Dr. Fenton Gray for his helpful suggestions, criticisms and inspiration.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF ILLUSTRATIONS

INTRODUCTION

Unusually thick, silty surface soils occupy rather extensive areas in eastern Oklahoma. In Tulsa County (11) a deep surface phase of Parsons was mapped in association with Parsons silt loam and other Prairie soils. In Wagoner County, soils having thick surface soils and a prominent A_2 horizon resting on a compact clay layer have been mapped and correlated as the Taloka series.*

Thick surface soils and especially thick A_2 horizons are uncommon and unnatural. These thick, silty textured soils seem to indicate a loess mantle. This mantle may be due to some entirely different climatic regime than the B and C horizons.

Additional physical, chemical and mineralogical data are needed to supplement the morphology to aid in determining the genetic relationships of the very prominent horizons. This additional information would also aid in better and more reliable soil management recommendations for these soils. These soils appear to be better soils for crop production than present crops indicate. They are extremely erosive, impermeable and of rather low organic matter

---

*Unpublished Soil Survey report of Wagoner County, Oklahoma.

content and have poor aggregation as compared to other Prairie soils.

The primary objective of this study is to better characterize these deep surfaced soils by some additional physical, chemical and mineralogical determinations and by correctly interpreting this information try to explain the origin and genesis of the Taloka soils.

REVIEW OF LITERATURE

The Taloka soil series was established in Okfuskee County, Oklahoma, in 1940. In this county this series is composed of silt loams and very fine sandy loams that were developed on high alluvial terraces of the North Canadian and Deep Fork Rivers. The native vegetation was mixed forest and grass. The parent materials of these soils were described as old alluvium transported from the western plains and the Reddish Prairies. The Taloka soils (3) were classified as clay pan soils transitional to the Prairie and Red-Yellow Podzolic soils.

The soils mapped as Parsons silt loam, deep phase in Tulsa County have morphological characteristics similar to the Taloka soils of Okfuskee and Wagoner Counties.

Bray (1) investigating the processes by which differentiation of textural horizons take place in soils of level areas of the Prairie region of Illinois found the process to be essentially the formation of a 2:1 lattice type clay in both the A and B horizons with translocation of part of the clay formed in the surface soil to the B horizon. The translocation is by percolating waters which have a reduced velocity in the B horizon resulting in deposition.

Smith (22) in laboratory studies of clay pan formation found evidence that clay minerals may be deposited in the B horizon by flocculation by electrolytes in the ground water. He also believes that iron oxides carrying a charge opposite that of clay particles may tend to flocculate the clays in the B horizon. This latter effect may tend to stabilize colloids in the upper horizons causing a slower clay pan formation on well drained soils.

Haseman and Marshall (6) reported on the development of the Grundy silt loam of Missouri. This clay pan soil was developed from loess which was uniform to a depth of 69 inches. Using zircon as an inert and immobile reference point they were able to calculate the changes of other constituents. The clay content of the whole profile had increased with definite evidence of the movement of colloids within the profile. x The A horizon had lost a large amount of the clay it originally contained while certain layers of the B horizon nearly doubled their original clay content. There was a net increase in the volume of the whole profile, however the A horizon had decreased in volume.

These same investigators, working with the Tilsit silt loam in Missouri, found depositional differences reflected by the total heavy minerals, the distribution of zircon among the various fractions and the mechanical analysis. The mechanical analysis showed significant differences in particle size distribution between almost all horizons of the profile particularly in the coarser fractions. The differences in the distribution of the total heavy minerals of the various fractions were significant, especially between the deeper horizons of the profile.

Marshall (13) recognizes that although a mechanical analysis of the soils may give an indication of depositional differences its value is limited due to the chemical weathering taking place, the depletion by leaching in certain horizons and the accumulation in other horizons. These factors tend to obscure the true relationships between the different horizons.

According to Jeffries and Jackson (9) mineralogical studies of the soil can be considered from two general viewpoints: (1) "Determination of the principal constituent minerals, their nature and characteristics"; (2) "Determination and study of the accessory minerals and their relationship."

The first viewpoint is probably best suited to study some aspects of fertility and to study the basic chemical and physical properties of the soil, while the second viewpoint is applicable to studies of the formation of the soil and has been used largely to distinguish between loessial deposits and the underlying material.

According to Johannsen (10), Scheibler, in 1861 using sodium metatungstate, was the first person to use a heavy solution to determine the density of minerals. Marignac in 1862 used a solution of sodium silico-tungstate and Schaffgotch in the same year used an aqueous solution of acid mercuric nitrate.

Pearson and Truog (19) conclude that the specific gravity method of determining the mineralogical content of a mixture has an advantage over the x-ray since the x-ray requires a certain mineral to be present in rather large quantities in order for a diffraction pattern to be recorded.

Many liquids have been used for specific gravity separation of minerals, however bromoform (s.g. 2.87) and s-tetrabromethane most nearly fit the desirable characteristics as listed by Krumbein and Pettijohn (12) for such solutions.

Bromoform was first used by van der Kolk and is probably the most commonly used heavy liquid. It is miscible in all proportions with carbon tetrachloride, benzene, ethyl alcohol and acetone. This solution is liable to excessive convection currents, rapid evaporation, decomposition by strong light and deterioration by heat.

Acetylene tetrabromide (tetrabromethane) is becoming more widely used as a heavy liquid for mineral separations. It is a colorless liquid miscible in all proportions with carbon tetrachloride, benzene and nitrobenzene giving a range of specific gravities from that of the tetrabromethane (2.95) to 1.6 or 0.9 depending on which diluent is used. According to Pearson and Truog (19) tetrabromethane and nitrobenzene mixtures have the added advantage of having a low vapor pressure.

The heavy minerals comprise about 83% of the known minerals as listed by Milner (17). This group is often referred to as the accessory group because its relative abundance is small although there is a great variety of minerals in it. Most soil genesis studies are concerned with the minerals in this group that are resistant to weathering.

According to Haseman and Marshall (6) minerals vary in their resistance to weathering depending on their hardness, cleavage, coefficient of expansion, solubility under a given environment and the original cracks present in the crystal. Pettijohn (20) states that whether a mineral survives intrastratal solution depends on the nature of the mineral, the pH of the intrastratal solution, the permeability of the bed and the velocity of flow of the ground water, the temperature and the geologic age of the deposits. The heavy mineral suite becomes more complex with a decrease in geologic age of the sediments. The disappearance by solution of the least stable minerals from the older deposits is the apparent answer for this change.

Goldrich (4) studied the degree of weathering of granite gneiss and proposed the stability series for the accessory group in order of declining resistance to weathering as zircon, ilnenite and magnetite, hornblend and epidote, titanite and apatite.

Zircon and tourmaline, since they are not noticeably attacked by any acids or bases, are considered stable under weathering conditions and considered satisfactory as indices in soil formation studies. However, Goldrich (4) found that zircon was sometimes chemically attacked and in such cases it displays a dusky, granular appearance. Haseman and Marshall (6) report Druif's work on tropical soils of Sumatra in which he concludes that all minerals, including zircon, dissolve under the chemical conditions which prevail in the soils of the tropics.

Heavy mineral procedures and the equipment necessary for the separation and identification of the minerals are discussed fully by Jeffries and Jackson (9), Volk (27) and others and the method of separation used in this study will be discussed elsewhere, however, some phases and difficulties should be discussed here. Haseman and Marshall (6) found separation difficult with particles less than 0.02 mm and usually two centrifugings were necessary to separate all minerals of the accessory group. They proposed four possible explanations: (1) Too small a difference between the density of some of the minerals and the liquid; (2) Entrapment of particles by air bubbles; (3) Entrapment by lighter particles; (4) Electrical attraction between particles resulting in the coagulation of the lighter and heavier minerals. Since the densities of the minerals differed from the density of the liquid by 0.1 units, which they considered great enough, and increasing the speed and time of centrifuging and evacuation of the samples to remove the air showed no appreciable increase in minerals recovered, they concluded that electrical attraction must be responsible for the small recovery. This was supported by the observation that in all cases where poor recovery of heavy minerals occurred, coagulation of the particles in the heavy liquid took place a few seconds after shaking.

Krumbein and Pettijohn (12) refer to the extreme fineness of particle size which causes the material to "ball-up", however they offer no explanation for the condition. Other reasons for poor separations are convection currents in the separating liquid, inclusion within the mineral grain and alteration products which cause the density to differ from the theoretical value. Most of these difficulties can be overcome by the use of controlled temperature and repeated separations.

Matelski (16) describes a method by which he froze bromoform after centrifugation and removed the different mineral groups. This procedure had the advantage of using only the inexpensive, regular type centrifuge tubes.

The removal of free iron oxides prior to petrographic analysis is necessary to prevent the alteration of the specific gravity of coated mineral grains and to prevent obscuring the optical properties during identification.

The separation of the different groups is usually made at a specific gravity of 2.95 for the accessory group and at 2.70 for the muscovite group with the quartz and feldspar groups being in the fraction below 2.70. Marshall and Jeffries (14) found that one separation at either of these densities with attention to the heavy minerals is sufficient for the solution of parent material problems. With one separation you must concentrate on the relative quantity of the most resistant heavy minerals and secondly accumulate information on the losses by weathering of other minerals.

Marshall (13) outlines three steps that he considers necessary in order to trace depositional differences in the original parent material. These steps are the expression of the separate fraction employed as a percentage of the whole soil, the percentage of the total heavy minerals in the separate fraction and the percentage of the most resistant minerals in the heavy mineral suite. To apply these steps, heavy mineral studies should be made on a number of size fractions and at least two and preferably three or more mineral species should be identified.

Petrographic studies of soils in central Oklahoma by Buckhannan and Ham (2) show definite heavy mineral suites for the soils formed on the materials of the Permian age and those developed from old and recent alluvium. Epidote was present in the alluvium of the Tertiary age in rather large quantities and was not found in the older Permian materials. This striking difference of heavy mineral suites was a good basis for the determination of the parent materials studied.

Working with brown podsolic soils Matelski and Turk (15) found that the total amount of heavy minerals was greatest in the C horizon and the B horizon, in most cases, had the lowest amount.

MATERIALS AND METHODS

The shaded areas on the map (Fig. 1) indicate the location of the Taloka soils in a recent survey of Wagoner County, Oklahoma. These soils occupy flat to gently undulating landscapes with slopes of .5 to 3%. Some occupy flats apparently developed on old alluvium and others are on upland flats in areas of residual parent materials. In these Taloka areas about 80% of the soils are of the Taloka series, the rest being soils such as Dennis, Choteau and others which occupy the steeper portions along the natural drains and terrace edges. These Taloka areas are adjoining other areas containing Taloka, Teller, Choteau, Dennis and Riverton in intimate mixtures, primarily along terrace edges. In all areas of Taloka soils occur small areas of Parsons silt loam which generally occupy the flattest portions of the region where the surface is slightly concave. The native vegetation of the Taloka soils as indicated by surface color was tall grasses.

The samples from the profile of the Taloka No. 1 were taken from an upland area that is gently undulating with a slope of about 1%. The area is 1/2 mile west of Tullahasse, Oklahoma, in the SW 1/2 NW 1/4, S30, T16N, R17E.

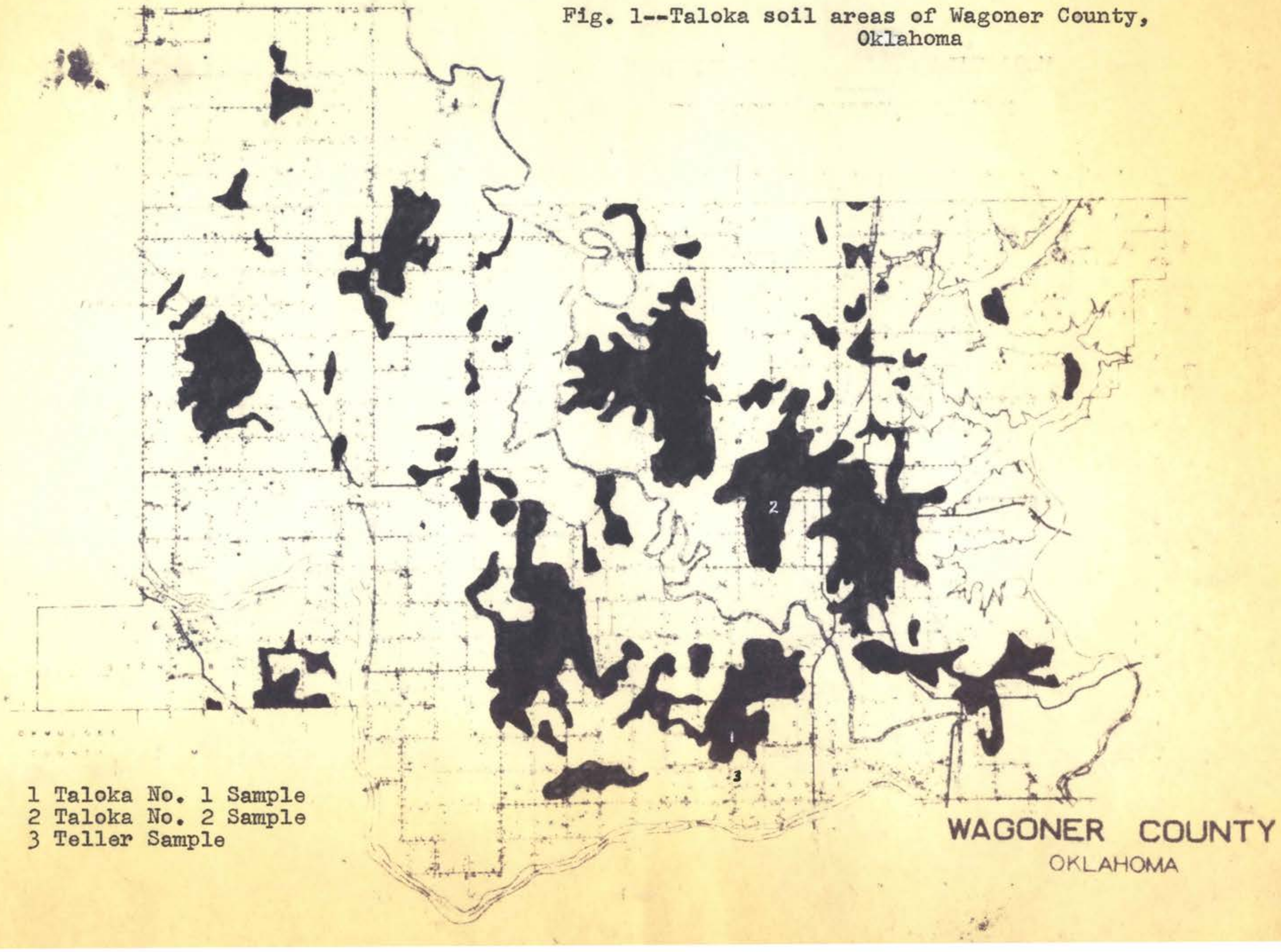

Fig. 1--Taloka soil areas of Wagoner County, Oklahoma

Profile description of Taloka silt loam-1

A_1 0-20 inches. Very dark grayish brown (10Yr 3/2) moist; silt loam; faintly specked with brown and strong brown; fragmental breakage which breaks further to weak medium granules; pH 5.7.

A_{21} 20-26 inches. Brown (10Yr 4/2) moist; silt loam; splotched with dark brown; weak medium granular; friable; contains few small incipient iron concretions; pH 5.6.

A_{22} 26-32 inches. Light brownish gray (10Yr 5/3) moist; silt loam; contains many soft brown iron concretions from 1/8 inch to 3/8 inch in diameter; soft and floury; weak granular to massive; pH 5.8.

B_{21} 32-42 inches. Grayish brown (10Yr 5/2) moist; silty clay loam; mottled with 20-40% yellowish brown; reddish brown and red and specked with black iron concretions 1/16 to 1/8 inch in diameter; weak medium blocky; very firm; very slowly permeable; root penetrations through cracks are very fine; pH 5.9.

B_{22} 42-54 inches. Grayish brown clay mottled with yellowish brown and strong brown; very slowly permeable; pH 6.6; this layer is less reddish and more grayish than the above layer; it contains a few fine concretions of iron and a few rounded, apparently water worn silt stone fragments.

C 54-60+ inches. Mottled grayish brown; yellowish brown and strong brown clay; containing about 5% of medium iron concretions and chips of silt stone; very firm and very slowly permeable; pH 6.9; this layer is similar to the horizon above but it is lighter colored and more mottled.

The area from which the samples of the Taloka silt loam No. 2 were taken occupies a broad bench position which runs toward Wagoner on the east and the Verdigris River on the west and south. The samples were taken from an undisturbed fence row which appeared to have a normal thickness of A_1 horizon. These soils can be found 2 miles southwest of Wagoner, Oklahoma, in the NW 1/4, NW 1/4, S20, T17N, R18E.

Profile description of Taloka silt loam-2

A_1 0-11 inches. Dark grayish brown (10YR 4/2; 3/5/2) moist; silt loam; weak medium granular; friable; pH 5.7.

A_{21} 11-16 inches. Dark grayish brown (10YR 5/2; 4/2) moist; silt loam splotched with brown; fragmental breakage; weak medium granular; friable; pH 5.7; specked with brown and strong brown; contains a number of fine insect holes and root channels; strong penetration of bluestem roots.

A_{22} 16-24 inches. Light browish gray (10YR 5/3) moist, silt loam; splotched with dark brown and strong brown; very weak granular to massive; pH 5.9; soft and floury; contains a number of small to medium black pellets and many stains from these pellets. Rest abruptly on:

B_{21} 24-36 inches. Very dark grayish brown (10YR 3/2) moist; clay; strongly mottled with red; medium blocky; very slowly permeable; fine roots penetrate along aggregates; pH 5.7.

B_{22} 36-60 inches. Strongly mottled light gray (10YR 7/2) moist; grayish brown (10YR 4/2) moist yellowish brown (10YR 5/7); clay; weak medium blocky; firm to very firm; slowly permeable specked with red and very dark brown; the latter around the incipient iron concretions; pH 6.6.

C 60-100 inches. Same as above layer but somewhat more gray and less brown; this material contains a few iron concretions and a few fine grass roots penetrate between the aggregates; no silt stone or sandstone fragments but material is very uniform textured; pH 6.6.

The Teller sandy clay loam that was used for comparison in this study came from a high (terrace) one mile north of the Arkansas River, in SW 1/2, NW 1/4, S31, T16N, R17E.

Profile description of Teller sandy loam

A_1 0-11 inches. Dark-brown (7.5YR 3/2) moist; sandy loam; weak medium granular; friable; porous and permeable; pH 5.4; grades to horizon below.

B_1 11-18 inches. Brown (7.5YR 5/3; 4/3) moist; heavy sandy loam; weak medium granular; friable; porous and permeable; pH 5.3; contains slightly more clay and less very fine sand than A_1 layer finely specked with dark brown around fine root holes; grades to horizon below.

B_{21} 18-28 inches. Brown (7.5YR 5/4; 4/3, moist) sandy clay loam; moderate medium granular; slightly firm; porous and permeable; pH 4.9; stained with strong-brown (7.5YR 5/6) around the fine root holes; grades through a 2 inch transition to horizon below.

B_{22} 28-36 inches. Yellowish-red (5YR 5/6; 4/6) moist; sandy clay loam; moderate medium granular; firm; hard when dry; porous and permeable; pH 4.9; specked and streaked with brown and pink; grades through 4 inch transition to horizon below.

C 36-70+ inches. Red (2/5YR 4/6; 3/6M) Heavy clay loam; moderate medium granular; friable; porous and permeable, pH 5.1; streaked with 10-15% pink (7.5YR 7/4); fine roots well distributed in this layer; material changes little to greatest depth sampled; contains occasional irregular bands of pink material about 1/4 inch thick in the lower part.

Materials and Methods Employed in Study

The pH of the soil from each horizon was determined by the use of the Beckman pH meter from a 1:1 soil water mixture.

The organic matter was determined by the wet conbustion method of Harper (5). Total nitrogen was determined by the Kjeldahl method.

The soil samples were treated for the removal of free iron oxides and organic matter prior to mechanical analysis and the specific gravity separations, using the method of Jeffries (8). A 2 gram sample of soil was placed in a 100 milliliter pyrex centrifuge tube and 10 milliliters of .1 normal HCl was added and allowed to stand for one hour. The acid was decanted off and the sample was washed three times with 5% NaCl. Five milliliters of ten per cent hydrogen peroxide was added to the soil and thoroughly stirred and allowed to stand for two hours at room temperature then evaporated on the steamplate. This was repeated for two treatments.

Forty milliliters of solution containing 4.15 grams of potassium oxalate was added and stirred until all of the organic matter free soil was loose from the bottom of the tube. The tube was placed in a hot water bath and heated to 80° C.; 10 milliliters of solution containing 0.95 grams of oxalic acid was added and the heat was raised to 90° C. A strip of magnesium ribbon about eight inches long was placed in the hot suspension. The suspension was stirred with the temperature maintained at 90 to 95° C. After three to five minutes the ribbon was removed and 5 milliliters of solution containing 0.48 grams of oxalic acid was added and the heating maintained until the clays and sands were gray. The suspensions were centrifuged at once and washed free of iron with 50 milliliter portions of 5% NaCl with four washings. After the soil was free of iron it was washed twice with 20 milliliter portions of 95% alcohol followed by two washings with 20 milliliters of acetone. The soil was then dried and weighed for the mechanical analysis. The soil treated by this method prior to the separation of silt and clay was treated in larger samples using a proportionate amount of the solutions. These samples were filtered through 50 cm, No. 541 filter paper and washed immediately with 5% NaCl solution, alcohol and acetone as described above.

The mechanical analysis was run by the pipette method of Olmstead, Alexander, and Middleton (18). Ten grams of the soil that was treated for the removal of organic matter and free iron oxides was placed in a 16 ounce prescription bottle. One hundred and fifty milliliters of distilled water and 10 milliliters of dispersing agent were added to the bottle and the sample was shaken over night with a wrist action shaker. Sodium hexametaphosphate was used as the dispersing agent. The samples were washed through a 270 mesh sieve to remove the sand which was oven dried and weighed. The coarse, medium, fine and very fine fractions of the sand were separated, dried and weighed. The silt and clay were dispersed for five minutes with a mechanical mixer, the suspension was then transferred to a 1000 milliliter graduated cylinder and shaken by inverting the cylinder several times. The suspension was then allowed to stand until it was time to take a 25 milliliter aliquot for a 0.02 mm particle determination. The suspension was allowed to stand undisturbed until time for a 0.002 mm determination. The aliquots were oven dried and weighed. The time for drawing the aliquots was determined by the particle settling time chart of Tanner and Jackson (25).

Calculation of separate percentages

$$\% \text{ sand} = \frac{\text{Weight of sand}}{\text{Weight of sample}} \times 100$$

$$\% \text{ of fine silt and clay} = \frac{\text{Weight 0.02 aliquot}}{\text{Weight of sample}} \times \text{factor} \times 100$$

$$\% \text{ of clay} = \frac{\text{Weight of 0.002 aliquot x factor}}{\text{Weight of sample}} \times 100$$

% of fine silt = % fine silt and clay - % clay

% of coarse silt = 100 - % sand - % fine silt - % clay

$$\% \text{ of each sand fraction} = \frac{\text{Weight of fraction}}{\text{Weight of total sand}} \times \% \text{ total sand}$$

$$\text{Factor} = \frac{V}{v}$$

V = Volume of water in cylinder (1000 ml.)

v = Volume of pipette (calibrated by weighing amount of water delivered.)

The coarse silt and the very fine sand were used for the specific gravity separation of heavy minerals. Approximately 25 grams of the previously treated soil was sieved to remove the sand, with the very fine sand being saved for the heavy mineral determination. The silt and clay were placed in 1000 milliliter beakers graduated in centimeters. Ten milliliters of sodium hexametaphosphate were added and the volume brought to the 10 centimeter mark with distilled water. The suspension was then mixed on a mechanical mixer for 10 minutes and allowed to stand until only the particles less than 2 microns were still in suspension. The supernatant liquid was drawn off, evaporated and the clay saved. This procedure was repeated until the liquid was clear at the end of the settling time. The fine silt was removed by the same method. The coarse silt and very fine sand were then washed with acetone, dried and five grams weighed out for the specific gravity separation of heavy minerals.

The heavy mineral separation was made at specific gravity of 2.90 using a mixture of s-tetrabromethane (sp. gr. 2.98) and nitrobenezene (sp. gr. 1.20). The heavy solution was standardized by weighing 100 ml. of each liquid to be used. The specific gravity was determined by dividing the weight in grams by the volume in milliliters using the average of three weighings. After the two liquids were mixed in the right proportions the weight was again checked. This method was found to be accurate to the third decimal place. The desired mixture was obtained by the use of the formulas:

$V_1 = n_2 - n$

$V_2 = n - n_1$

V_1 = volume of liquid of lighter specific gravity

V_2 = volume of liquid of heavier specific gravity

n = desired specific gravity

n_1 = light specific gravity

n_2 = heavy specific gravity

The centrifuge tubes used in this separation were designed to trap the heavy minerals so they could be easily removed. The tubes were made by grinding a hole in the bottom of a 15 milliliter taper bottom centrifuge tube and attaching a short vial to the bottom of the tube with a piece of rubber tubing. A piece of large rubber tubing was placed around the upper part of each tube to keep it from hitting the brass pocket of the centrifuge.

The vial was filled with the heavy liquid (s.g. 2.90) and the end of the tube was inserted carefully to avoid trapping any air in the vial. The tube was then filled to the desired depth with the solution and 5 grams of the oven dried separate were placed in the solution. The tube was shaken to disperse the soil and then centrifuged at 1200 rpm for five minutes. A rubber stopper was placed in the tube to prevent the solution from draining out and the vial was emptied into a filter. Gently pressing the stopper forced out any heavy minerals left in the bottom of the tube. The vial was washed several times with acetone to remove the heavy mineral particles. The heavy minerals were washed with acetone and oven dried. The sample was transferred to a tared watch glass, weighed and the percentage calculated.

$$\% \text{ of heavy minerals} = \frac{\text{Weight of heavy minerals}}{\text{Weight of separate used}} \times 100$$

The medium mineral group (s.g. 2.70-2.90) was determined in the same manner and the light mineral group (<2.70) was determined by difference.

The base exchange capacity of the 2 micron clay was determined from a 5 gram sample (21). The sample was washed with 150 milliliters of 40% ethyl alcohol then leached with 200 milliliters of neutral normal ammonium acetate. The sample was washed again with alcohol to remove the excess ammonium acetate. The separate was transferred to a distilling flask, 150 milliliters, of distilled water and a teaspoon of magnesium oxide were added. Approximately 125 milliliters were distilled into a 500 milliliter receiving flask containing 25 milliliters of 0.15 N H_2SO_4. The excess acid was titrated with 0.074 N NaOH using a mixture of methyl-red and methylene blue as the indicator.

$$\text{Milliequivalents per 100 grams} = \frac{\text{m.e. acid} - \text{m.e. base}}{\text{weight of sample}} \times 100$$

Milliequivalents of acid = ml. acid x normality of acid

Milliequivalents of base = ml. base x normality of base

The bulk density was run by the method described by Westin (28). Natural clods from each horizon sampled were oven dried, weighed and saturated in hot paraffin. The waxed clods were then weighed in air and in water. The waxed clods were weighed in water by the use of a small wire basket hung from the same balance used to weigh the clods in air.

$$\text{Bulk density} = \frac{\text{wt. of oven dried clod}}{\text{wt. of waxed clod in air} - \text{wt. waxed clod in water}}$$

RESULTS AND DISCUSSION

The results of the chemical and physical determinations of the Taloka silt loam ~~No. 1~~ are shown in Tables 1 and 2.

The organic matter content of the horizons of this soil shows a decrease to a depth of 32 inches, in the 32-42 inch horizon there is an increase. This increase in the organic matter is verified by the total nitrogen determination. Organic matter accumulations at this depth are uncommon in soils of this area and indicates that either the process of podsolization has been active in this soil or that the silty upper horizons are mantle material deposited on the underlying clay material after some soil development had occurred. Due to the impermeable nature of the horizon where the accumulation has occurred it is probable that some podsolization has taken place, however, it does not seem likely that in this area podsolization would be active to the degree indicated by the organic matter accumulation.

The pH of this soil increases with depth which is common in soils of this area with impermeable subsoils.

The base exchange capacity of the clay (<.002mm) fraction indicates a mixture of clay minerals, probably of illitic and montmorillonitic types. The distribution of the clay minerals of the different horizons indicates that there has been very little downward movement of finer fractions

TABLE 1

CHEMICAL PROPERTIES OF THE TALOKA SILT LOAM NO. 1

Sample Layer Depth in inches	% OM	% total Nitrogen	pH	B.E.C. <.002 Fraction m.e./100 gm
0 to 20	1.59	.064	5.7	44.2
20 to 26	.90	.039	5.6	36.0
26 to 32	.26	.045	5.8	40.4
32 to 42	.95	.077	5.9	38.4
42 to 54	.71	.038	6.6	44.0
54 to 60	.31	.017	6.9	43.4

TABLE 2

PHYSICAL PROPERTIES OF THE TALOKA SILT LOAM NO. 1*

Bulk	Particle Size Distribution in Percent						
Density	1-2mm	1-.25	.25-.1mm	.1-.05	.05-.02	.02-.002	<.002
1.10	1.15	4.20	7.28	18.36	40.58	12.00	16.43
1.28	2.54	3.76	6.29	13.75	42.22	13.79	17.56
1.38	1.77	3.21	6.51	13.97	38.99	13.57	21.96
1.50	0.82	2.50	6.46	11.22	34.47	12.82	31.71
1.48	1.07	2.66	5.49	10.77	23.95	12.89	43.17
1.47	0.33	3.29	5.69	8.52	25.79	11.77	44.71

* Sample layer depth same as in Table 1.

within the profile. The 32-42 inch layer is lower in base exchange capacity than the 0-20 inch layer or the 26-32 inch layer.

The higher bulk density in the lower three horizons of this soil shows the increased compact condition of the soil.

The particle size distribution shows a general decrease in the particles larger than .002 mm and an increase in clay content of the horizons with depth. There is some variation in the coarser fractions and the clay content of the 26-32 and the 32-42 inch layers. The .05-.02 fraction has more variation between the 32-42 inch layer and the 42-54 inch layer.

The chemical and physical determinations of the Taloka silt loam No. 2 are shown in Tables 3 and 4.

The organic matter distribution in this soil is quite similar to that of the Taloka No. 1. There is an increase in the 24-36 inch layer which corresponds to the 32-42 inch layer of the first Taloka. The total nitrogen again verifies this accumulation.

The base exchange capacities of the <.002 mm fraction indicate the same types of clay minerals found in the Taloka No. 1 are present in this soil, however the distribution is quite different. The clays of the lower three horizons have the higher exchange capacities indicating a higher percentage of montmorillonite type of clay minerals.

TABLE 3

CHEMICAL PROPERTIES OF THE TALOKA SILT LOAM NO. 2

Sample Layer Depth in inches	% OM	% total Nitrogen	pH	B.E.C. <.002 Fraction m.e./100 gm
0 to 11	1.48	.066	5.7	36.2
11 to 16	.93	.043	5.7	36.2
16 to 24	.65	.037	5.9	38.6
24 to 36	1.36	.080	5.7	41.0
36 to 60	.70	.041	6.6	44.2
60 to 100	.32	.011	6.6	41.0

TABLE 4

PHYSICAL PROPERTIES OF THE TALOKA SILT LOAM NO. 2*

Bulk	Particle Size Distribution in Percent						
Density	1-2mm	1-.25	.25-.1mm	.1-.05	.05-.02	.02-.002	<002
1.28	0.49	1.42	3.85	10.59	46.68	21.33	15.64
1.15	0.66	1.27	3.60	9.54	49.51	19.18	16.33
1.54	0.79	1.73	3.28	10.75	39.98	22.77	21.85
1.65	0.14	0.66	2.08	5.33	23.33	24.53	44.72
1.64	0.12	0.73	2.48	7.18	25.61	21.07	42.60
1.64	0.25	0.73	2.05	6.86	22.95	20.85	46.34

---

* Sample layer depth same as in Table 3.

The bulk density also increases with depth in this profile but it is considerably more in the lower four horizons of this soil than in the corresponding horizons of the Taloka No. 1.

The particle size distribution of the Taloka No. 2 has noticeable variation between the upper three horizons and the lower three. Below 24 inches there is considerably less in the coarser fractions of the horizons and more clay. The .02-.002 fraction is about constant throughout the profile.

The Teller sandy loam which is considered to be developed from mantle material was used in this study as a comparison to find any possible relationships between it and the Taloka profiles.

The chemical and physical determinations of the Teller profile are shown in Tables 5 and 6.

The organic matter content of the horizons decreases with depth which is common for Prairie soils.

The pH also decreases with depth in the profile. This is common in this area in soils with permeable subsoils.

The base exchange capacity of the clay fraction of the various horizons of this soil indicate a lower percentage of montmorillonite type of clays than was found in the Taloka soils.

There was less variation in the particle size distribution throughout the profile of the Teller than there was in the soils previously discussed. The increase in clay in the

TABLE 5

CHEMICAL PROPERTIES OF THE TELLER SANDY LOAM

Sample Layer Depth in inches	% OM	% total Nitrogen	pH	B.E.C. <.002 Fraction m.e./100 gm
0 to 11	1.45	.061	5.4	38.2
20 to 28	.64	.039	4.9	36.6
50 to 70	.60	.022	5.1	27.7

TABLE 6

PHYSICAL PROPERTIES OF THE TELLER SANDY LOAM*

Bulk	Particle Size Distribution in Percent						
Density	1-2mm	1-.25	.25-.1mm	.1-.05	.05-.02	.02-.002	<.002
1.65	0.41	8.55	35.72	13.35	14.38	6.70	20.80
1.71	0.00	9.56	31.38	12.68	14.68	2.02	28.70
1.74	0.00	8.43	37.94	8.91	7.60	4.12	33.85

---

* Sample layer depth same as in Table 5.

C horizon is not common for the Teller series. The 1-.25 and .25-.1 mm fractions of this soil are considerably higher in percent than the same fractions of the Taloka soils.

The heavy mineral distribution in the Taloka No. 1 (Table 7) shows a variation at the 32 inch depth which is large enough to indicate variation in the parent materials. The percentage of heavy minerals in the 32-42 inch layer is higher than the percentage in the underlying layers.

The variation in the distribution of the heavy minerals of the Taloka No. 2 (Table 8) is not so obvious as that in the Taloka No. 1. However the same trend is apparent with the higher percent of heavy minerals being in the upper three horizons.

In the Teller profile there is a noticeable difference in the heavy mineral distribution between the 20-28 inch layer and the 50-70 inch layer. (Table 9)

The medium mineral group of the .1-.05 mm fraction (Figures 2 and 3) of the two Taloka profiles shows similar trends. Both show a large increase with depth. The similarity in the .05-.02 fractions between this group is not so apparent. The Teller profile seems to have the same general trend in the A and B horizons although the fewer horizons sampled in this soil make a comparison rather difficult.

Figures 4 and 5 show the comparison of the light minerals in both fractions of the three soils sampled. The .1-.05 fraction of the two Taloka soils shows a general decrease

TABLE 7

HEAVY MINERAL (s.g. 2.90) DISTRIBUTION IN FRACTIONS OF THE TALOKA NO. 1 PROFILE

Horizon depth in inches	Fraction .1-.05 % HM in Fraction	Soil	Fraction .05-.02 % HM in Fraction	Soil	Total % heavies in layer from .1-.05 and .05-.02 Fractions
0-20	0.525	.0965	0.603	.245	.3415
20-26	0.353	.0485	1.165	.492	.5405
26-32	0.398	.0556	1.163	.453	.5086
32-42	0.499	.0560	0.989	.341	.3970
42-54	0.427	.0460	1.054	.252	.2980
54-60	0.383	.0326	0.965	.249	.2816

TABLE 8

HEAVY MINERAL (s.g. 2.90) DISTRIBUTION IN FRACTIONS OF THE TALOKA NO. 2 PROFILE

Horizon depth in inches	Fraction .1-.05 % HM in Fraction	Soil	Fraction .05-.02 % HM in Fraction	Soil	Total % heavies in layer from .1-.05 and .05-.02 Fractions
0-11	.369	.0391	.860	.401	.4401
11-16	.336	.0321	.673	.333	.3651
16-24	.394	.0423	.851	.340	.3823
24-36	.336	.0179	1.153	.269	.2769
36-60	.446	.0320	1.062	.272	.3040
60-100	.370	.0254	1.204	.276	.3014

TABLE 9

HEAVY MINERAL (s.g. 2.90) DISTRIBUTION IN FRACTIONS OF THE TELLER PROFILE

Horizon depth in inches	Fraction .1-.05 % HM in Fraction	Fraction .1-.05 % HM in Soil	Fraction .05-.02 % HM in Fraction	Fraction .05-.02 % HM in Soil	Total % heavies in layer from .1-.05 and .05-.02 Fractions
0-11	1.729	.231	2.149	.309	.540
20-28	1.870	.237	1.621	.238	.475
50-70	1.779	.158	1.823	.139	.297

with depth. In the .05-.02 fraction there is considerable variation in percent of light minerals in comparable horizons of the two Taloka profiles, but Taloka No. 1 shows a slight decrease with depth and Taloka No. 2 shows a greater decrease. The A and B horizons of the Teller show a trend similar to the Taloka profiles in the .1-.05mm fraction but no such relationship exists in the .05-.02mm fraction. The percentage of light minerals is considerably less in both fractions of the Teller soil.

The chemical, physical and mineralogical properties of the two Taloka soils studied are quite similar. An organic matter accumulation in the B_{21} horizon was not reported in the Taloka soils of Okfuskee County or the deep phase Parsons of Tulsa County.

These characteristics indicate a lack of genetic relationship between the two different textured materials of the

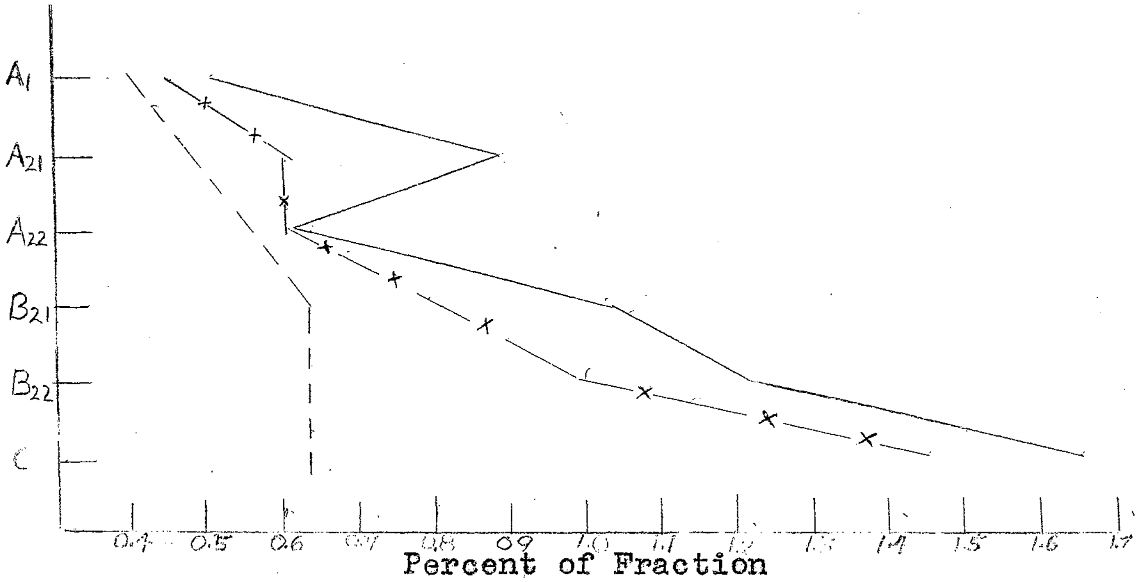

Fig.2--Distribution of the medium mineral groups (2.70-2.90) of the .1-.05 mm fraction of the two Taloka profiles and the Teller profile

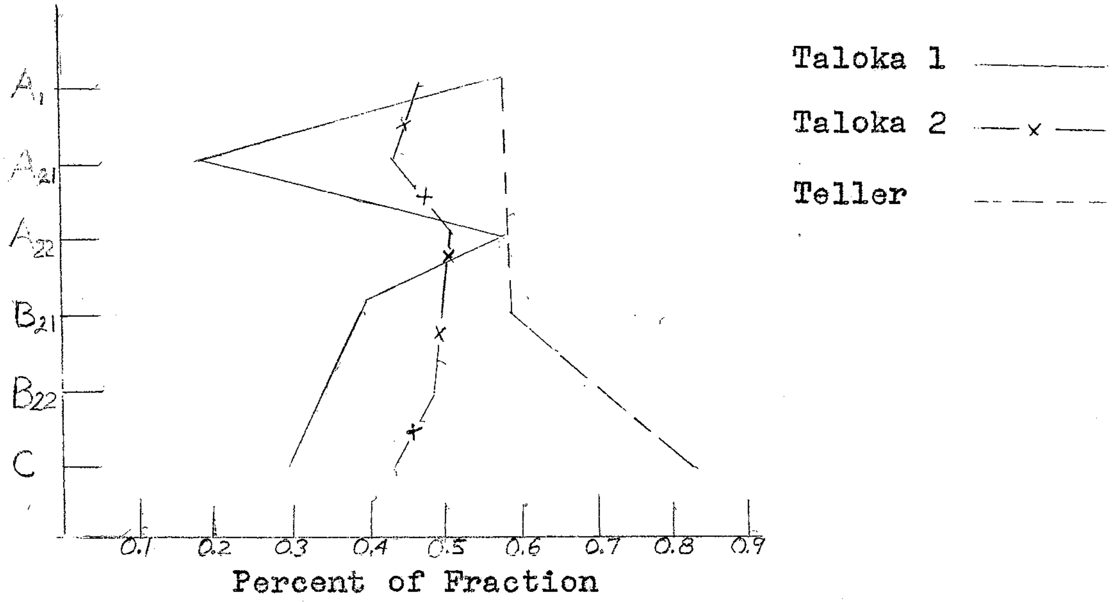

Fig.3--Distribution of the medium mineral groups (2.70-2.90) of the .05-.02 mm fraction of the two Taloka profiles and the Teller profile

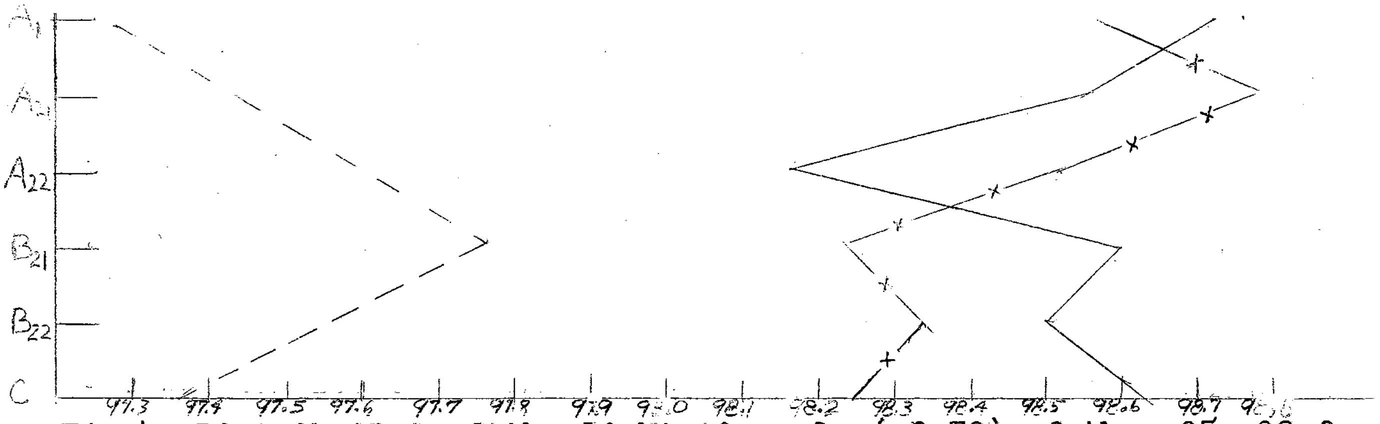

Fig.4--Distribution of the light minerals (<2.70) of the .05-.02 fraction of the two Taloka profiles and the Teller profile

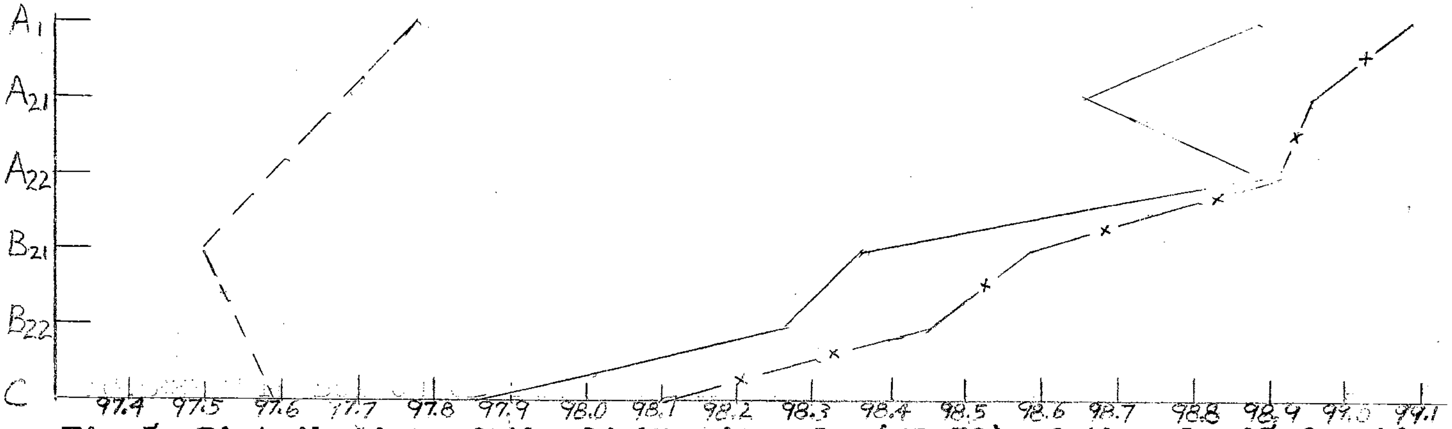

Fig.5--Distribution of the light minerals (<2.70) of the .1-.05 fraction of the two Taloka profiles and the Teller profile

Taloka profiles studied. This lack of any relationship is probably due to the silty material being a loess mantle deposited on the underlying clay.

Ulrich (26) working in Iowa found that the depth of loess decreased with distance from the point of initial deposition, with this decrease in depth of the deposit there was an increase in the clay content of the horizon of maximum accumulation, with movement and accumulation of the finer clay. There was also an increase in the bulk density of the horizon of accumulation as the mantle depth decreased. Smith (23) in Illinois and Hutton (7) in Iowa found similar relationships in loessial soils.

Assuming the silty upper horizons of the Taloka soils in Wagoner County to be aeolian deposits from the Arkansas River the same relationships would exist. The Taloka silt loam No. 2 is approximately seven miles farther from the river than the Taloka No. 1 and the depth of the silty material is eight inches less. Although the clay content of the upper three horizons of both soils is about the same it is plausible that the higher clay content of the B_{21} horizon of the second Taloka is due to that horizon becoming the layer of maximum accumulation in the present profile. The base exchange capacity of the clay fraction of the two soils indicates that the montmorillonite type of clay minerals have been transported from the surface horizons of the Taloka No. 2 and accumulated in what is now considered the

B_{21} horizon to a greater extent than in the other Taloka profile. According to Wilkinson (29) montmorillonite had the highest base exchange capacity and was usually found in the fraction less than 0.1 micron in diameter. The bulk density of this horizon in the Taloka No. 2 is also greater than the corresponding horizon of the other Taloka soil.

The lower content of total sand and the higher percentage of total silt in the upper horizons of the Taloka No. 2 is further evidence of an aeolian deposit from the Arkansas River since one would expect the finer particles to be deposited further from the source.

The variations in the particle size distribution of the Taloka soils indicate that the silty material was deposited after the underlying clay. This is more apparent in the Taloka No. 2 at a depth of 24 inches than it is in the Taloka No. 1 at a depth of 32 inches, however, since there is a large difference in coarse silt at the 42 inch depth it appears that mixing of the different materials in the 32-42 inch layer of this profile has destroyed the effect of depositional differences to some extent.

The variation in the distribution of the heavy minerals in the different horizons of these soils shows a depositional difference between the two different textured materials. Each profile has a higher percentage of total heavy minerals in the upper three horizons. The total heavy minerals of the 32-42 inch layer of the Taloka No. 1 strengthens the supposition that mixing of the two different materials took place in this layer.

The relationship between the percentage of total heavy minerals and the different horizons found in Brown Podsolic soils by Matelski and Turk (15) is not present in these soils.

The total heavy minerals in the A and B horizons of the Teller soil appear to be quite similar to those found in the upper three horizons of the Taloka soils. It is apparent from the total heavy minerals in the 50-70 inch layer of the Teller that this is a non-conforming layer underlying the true parent material.

The underlying clay horizons of the two Taloka soils are quite similar in the characteristics studied. This is apparent in the total heavy minerals, the particle size distribution and chemical results of the comparable horizons of the two profiles. The total heavy minerals of the C horizon of the Teller sandy loam are quite similar to those of the clay horizon of the Taloka soils.

Identification of several species of the heavy mineral fraction would be necessary to ascertain the relationship of the various horizons of the Taloka soils examined. According to Marshall (13) if there is no depositional variation the relative proportion of the highly resistant minerals should be the same for any size fraction throughout the profile and the particle size distribution of a given resistant mineral should be the same. The identification of these resistant minerals is also necessary to determine the origin of the materials present in the profiles and to calculate the losses and gains in the profiles.

SUMMARY AND CONCLUSIONS

The chemical, physical and mineralogical characteristics of the two Taloka profiles are very similar. The chemical and physical characteristics of the Taloka No. 1 as compared to the same properties of the Taloka No. 2 show the relationships that would be expected in a loessial deposit.

The particle size distribution and the distribution of the total heavy minerals of these soils indicate depositional differences between the silty upper horizons and the underlying clayey material. These differences are probably due to the upper three horizons of the Taloka soils ~~examined~~ being loess deposits from the Arkansas River. The particle size distribution of the Taloka [illegible] ~~No. 1~~ shows evidence of mixing of the loess deposit and the underlying material in the 32-42 inch layer.

The percentage of total heavy minerals in the A and B horizons of the Teller profile are quite similar to those found in the upper three horizons of the two Taloka soils. The heavy minerals of the layer designated as the C horizon of the Teller soil in this study shows that it is evidently a non-conforming layer which is unrelated to the A and B horizons, however it appears to be related to the clay layers of the Taloka soils.

Identification of some species of the accessory groups of ~~these~~ Taloka soils would help to ascertain the apparent depositional variations. This further study would enable the determination of the parent materials and the calculation of the losses and gains within the profiles.

It is apparent from this study that the horizons are not genetically related throughout the profiles of the Taloka soils. The following horizon designations are proposed for these soils:

A_1	Darker colored surface mineral horizon
A_{21}	Lighter colored horizon transitional to one below
A_{22cn}	Light colored horizon containing considerable iron concretions
A_{1b}	Former surface horizon of the buried profile
B_{2b}	Horizon of accumulation of the buried profile
C_b	Parent material of buried profile

These subscripts (24) more clearly show the relationships within the profiles. Apparently soil development has not occurred to a great enough extent in the upper three horizons to clearly indicate the proper designations for these horizons, however, the data indicate that they are of similar origin.

BIBLIOGRAPHY

1. Bray, R. H., 1935. The origin of horizons in clay-pan soils. Amer. Soil Sur. Assoc. Bull 16: 70-75.

2. Buckhannan, W. H. and Ham, W. E., 1942. Preliminary investigations of heavy mineral criteria as an aid in the identification of certain soils in Oklahoma. Soil Sci. Soc. Amer. Proc. 6:63.

3. Buckhannan, W. H. et. al., 1952. Soil survey Okfuskee County, Oklahoma. series 1940.

4. Goldrich, S. S., 1938. A study of rock weathering. Jour. of Geol. 46: 17-58.

5. Harper, H. J., 1948. Tentative methods for the analysis of soil and plant material, Soils Laboratory, Oklahoma A. and M. College.

6. Haseman, J. F. and Marshall, C. E., 1945. The use of heavy minerals in studies of the origin and development of soils. Missouri Agri. Exp. Sta. Res. Bull 387.

7. Hutton, C. E., 1950. Studies of the chemical and physical characteristics of a chrono-litho sequence of loess-derived prairie soils of southwestern Iowa. Soil Sci. Soc. Amer. Proc. 15: 318-328.

8. Jeffries, C. D., 1947. A rapid method for the removal of free iron oxides in soils prior to petrographic analysis. Soil Sci. Soc. Amer. Proc. 11: 211-212.

9. Jeffries, C. D. and Jackson, M. L., 1949. Mineralogical analysis of soil. Soil Sci. 68: 57-73.

10. Johannsen, A., 1918. A manual of petrographic methods. Ed. 2, McGraw-Hill, New York.

11. Knobel, E. W. and Brensing, O. H., 1942. Soil survey, Tulsa County, Oklahoma. series 1935.

12. Krumbein, W. C. and Pettijohn, F. J., 1938. Manual of sedimentary petrography. Appleton-Century-Crofts, Inc., New York.

13. Marshall, C. E., 1941. A petrographic method for the study of soil forming processes. Soil Sci. Soc. Amer. Proc. 5: 100-103.

14. Marshall, C. E. and Jeffries, C. D., 1946. Mineralogical methods in soil research: Part I The Correlation of soil types and parent material with supplementary information on weathering processes. Soil Sci. Soc. Amer. Proc. 10: 397-405.

15. Matelski, R. P. and Turk, L. M., 1947. Heavy minerals in some Podsol soil profiles in Michigan. Soil Sci. 64: 469-487.

16. Matelski, R. P., 1951. Separation of minerals by subdividing solidified bromoform after centrifugation. Soil Sci. 71: 269-272.

17. Milner, H. B., 1929. Sedimentary Petrography. 3rd Ed. Thomas Musby Co., London.

18. Olmsted, L. B., Alexander, L. T. and Middleton, H. B., 1930. A pipette method of mechanical analysis of soil on an improved dispersion procedure. U.S.D.A. Tech. Bull. 170.

19. Pearson, R. W. and Truog, E., 1938. Procedure for the mineralogical subdivision of soil separates by means of heavy liquids specific gravity separation. Soil Sci. Soc. Amer. Proc. 2: 109-114.

20. Pettijohn, F. J., 1941. Persistency of heavy minerals and geologic age. Jour. Geol. 49: 610-625.

21. Russel, D. A., 1950. A laboratory manual for soil fertility students. William C. Brown, Co., Dubuque, Iowa.

22. Smith, G. D., 1934. Experimental studies on the development of heavy clay-pans in soils. Missouri Agri. Expt. Sta. Res. Bull. 210.

23. Smith, G. D., 1942. Illinois loess: variations in its properties and distribution. Illinois Agri. Expt. Sta. Bull. 490.

24. Staff, Soil Survey, 1951. Soil Survey Manual, U.S.D.A. Handbook No. 18, Government Printing Office, Washington, D.C.

25. Tanner, C. B. and Jackson, M. L., 1947. Nomographs of sedimentation times for soil particles under gravity or centrifugal acceleration. Soil Sci. Soc. Amer. Proc. 12: 60-65.

26. Ulrich, R., 1949. Some physical changes accompanying Prairie, Wiesenboden and Planosol soil development from Peorian loess in southwestern Iowa. Soil Sci. Soc. Amer. Proc. 14: 287-295.

27. Volk, N. J., 1933. Formation of Muscovite in soils and refinements in specific gravity separation. Amer. Jour. Sci. 26: 114-129.

28. Westin, F. C., 1953. Solonetz soils of eastern South Dakota: Their properties and genesis. Soil Sci. Soc. Amer. Proc. 17: 287-293.

29. Wilkinson, G. E., 1952. A clay mineralogical study of certain Reddish Prairie soils of Oklahoma with an estimation of the montmorillonite and illite content. M. S. Thesis. Oklahoma A. and M. College.

VITA

Kenneth G. Brengle
candidate for the degree of
Master of Science

Thesis: A PRELIMINARY STUDY OF SOME CHEMICAL, PHYSICAL AND MINERALOGICAL PROPERTIES OF SOME DEEP SURFACE SOILS OF EASTERN OKLAHOMA

Major: Soils

Biographical and Other Items:

Born: May 18, 1926, at Perry, Oklahoma.

Undergraduate Study: Northern Oklahoma Junior College, Tonkawa, Oklahoma, 1946-1948; Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma, 1949-1950, 1952-1953.

Graduate Study: Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma, 1953-1954.

Experiences: Urban reared; U. S. Army Air Force, 1944-1946; Conservation and Soil Conservation Service, 1949; U. S. Army, 1950-1952; Teaching Assistantship, Oklahoma Agricultural and Mechanical College, 1953-1954.

Member of Phi Sigma Society, Agronomy Club, and the American Legion.

Date of Final Examination: June, 1950.

THESIS TITLE: A PRELIMINARY STUDY OF SOME CHEMICAL, PHYSICAL AND MINERALOGICAL PROPERTIES OF SOME DEEP SURFACE SOILS OF EASTERN OKLAHOMA

AUTHOR: KENNETH G. BRENGLE

THESIS ADVISER: DR. FENTON GRAY

TYPIST: Elizabeth J. Kerby
KERBY TYPING SERVICE