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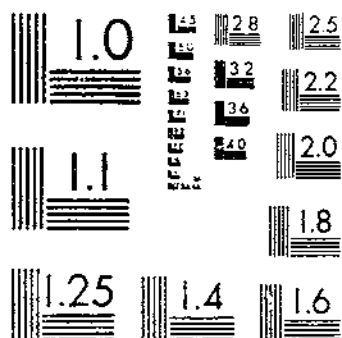
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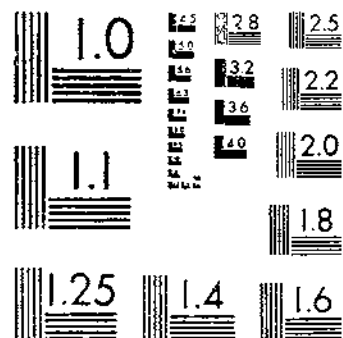
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UNITED STATES DEPARTMENT OF AGRICULTURE  
WASHINGTON, D. C.

# VARIATIONS OF THE COLLOIDAL MATERIAL EXTRACTED FROM THE SOILS OF THE MIAMI, CHESTER, AND CECIL SERIES

By R. S. HOLMES, Associate Chemist, and GLEN EDGINGTON, Assistant Chemist,  
Division of Soil Chemistry and Physics, Soil Investigations, Bureau of Chem-  
istry and Soils

## CONTENTS

	Page		Page
Introduction .....	1	Composition and properties of the colloidal material isolated from soils of three series—Continued.	
Methods .....	2	The mean variations .....	17
Description of samples .....	4	Differences in composition of colloids from soils of the dif- ferent series .....	19
The Miami soils .....	5	Summary .....	22
The Chester soils .....	7	Literature cited .....	22
The Cecil soils .....	8		
Composition and properties of the colloidal material isolated from soils of three series .....	10		
General relations between the profiles .....	15		

## INTRODUCTION

The work, the results of which are recorded, discussed, and interpreted in the following pages, was undertaken for the purpose of making a critical examination into the character of certain well-known American soils through an extensive study and comparison of the characteristics of their colloidal constituents. Soils belonging to three series were selected for the study, the Chester, Miami, and Cecil series, as defined and established by the work of the soil survey of the Bureau of Chemistry and Soils. According to the established definition of a soil series, all members in each series are alike in all characteristics except texture (coarseness or fineness of the soil particles) of the surface layer. Each member, or, as it is usually designated in the publications of the Bureau of Chemistry and Soils, each type, is characterized by a different surface texture. It is important to ascertain whether the colloid of a given soil series is similar in the various types of the series, and it is the purpose of this investigation to throw some light on these problems with respect to these three soil series. A sufficient number of widely separated profiles are included to represent fairly well the entire area of each soil series and to permit mathematical calculations of variability. Various horizons of the profile are investigated in order to determine the type of varia-

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tion peculiar to the series shown by the colloidal material through the soil profile. This investigation is supported by a recent bulletin by M. S. Anderson and Horace G. Byers (1),<sup>1</sup> which presents a similar study of the colloids of soil groups of widely different types.

Previous investigations (2, 18) have shown that the character of the colloidal material is fairly well correlated with the molecular ratios of silica to the sesquioxides of aluminum and iron, and that this ratio varies greatly for the colloids of different soils. In an investigation (10) on the variability of the colloidal material in a well-defined soil type, Leonardtown silt loam, the senior author found that colloidal material is fairly constant in composition and properties, not only in the A horizons but also in the B<sub>1</sub> and B<sub>2</sub> horizons. Ninety-five per cent of the inorganic material is composed of silica, alumina, ferric oxides, and their combined water. The silica-sesquioxide ratio is practically constant for all horizons. Of the four constituents the variation of the combined water is greatest, having a coefficient of variability of 6.

The same publication (10) also contained a review of publications by Hall and Russell (8), G. W. Robinson (14), Bradfield (4), and Robinson and Holmes (18), which reported composition of soil colloids. Recently, in 1929, R. E. Stephenson published a paper (19) on Colloidal Properties of Willamette Valley Soils, and in 1930, I. A. Denison of this bureau published an article (6) on the Chemical Composition of Colloidal Material Isolated from the Horizons of Various Soil Profiles. In no case, except that of the Leonardtown silt loam, is there found data sufficiently comprehensive to give the specific information sought.

## METHODS

The colloidal material was separated from the soil in much the same manner as described in a previous publication (10), except for preparation of the suspensions for the centrifuge. For this work a mechanical agitator was devised to do the work that had formerly been done by hand. This agitator (fig. 1) consists of the following parts: A container, *a*, of about 5 gallons capacity; a shaft, *b*, upon which are mounted five small screw propellers, *c*; and a scrubber, *d*, composed of brass rods and a wire cloth made to fit snugly the bottom of the container, *a*. The shaft is mounted within the container, *a*, with a rubber bearing, *e*, at the bottom, and a steel thrust ball-bearing, *f*, at the top. The shaft is revolved by an electric motor in the direction to give the propellers a lifting effect and at a velocity of from 1,800 revolutions a minute when empty to 900 when full.

The suspensions for the centrifuge are prepared with the agitator in the following manner: From 50 to 200 grams of soil, depending on the quantity of colloid present as estimated by the water-absorption method (15) is mixed with about 1 gallon of water and stirred, while enough ammonia water is added to make it slightly alkaline to phenol-phthalein. This mixture is poured into the agitator and stirred for 20 minutes. While the agitator is running the volume of water is gradually increased during the next 10 minutes to about full

<sup>1</sup> Italic numbers in parentheses refer to Literature Cited, p. 22.

capacity. At this time the motor is stopped, and after about 15 minutes the suspended material is drawn off. More water is added to the material left in the container of the agitator, and the operation is repeated. When the noncolloidal particles which settle out in the agitator become clean they are removed and discarded. The suspensions from the agitator are combined and passed through the

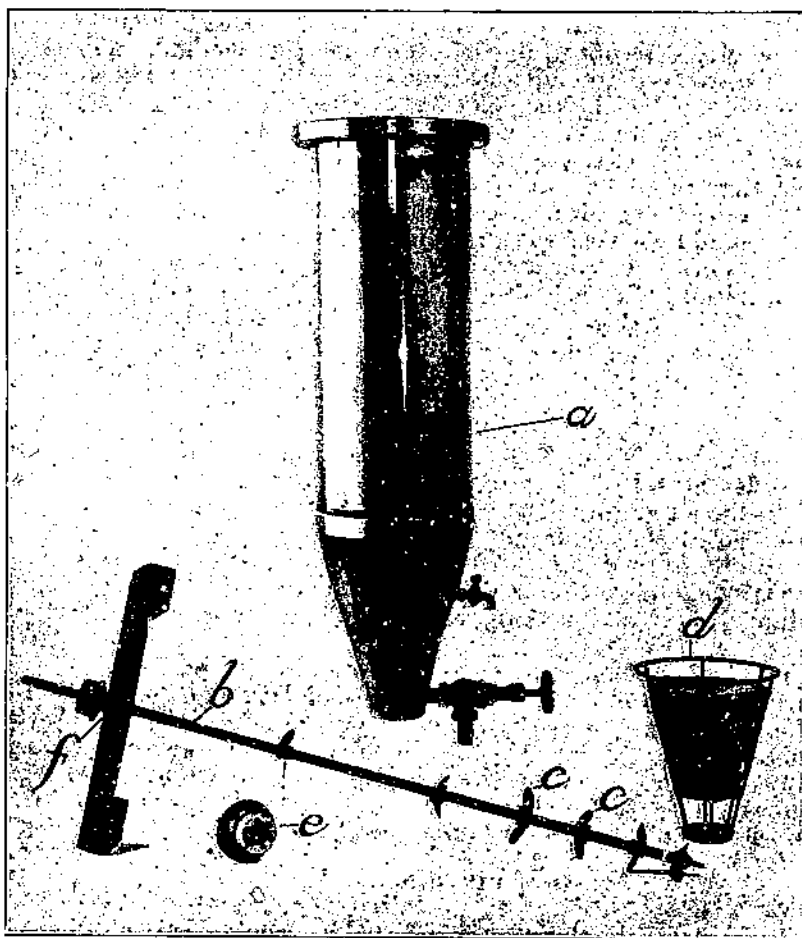


FIGURE 1.—Agitator for the purpose of separating colloidal material from the soil:  
*a*, Container; *b*, shaft; *c*, screw propeller; *d*, scrubber; *e*, rubber bearing; *f*, thrust ball bearing

supercentrifuge. The residue which collects in the centrifuge bowl is removed and returned to the agitator, and again suspended as before. The successive residues are returned until negligible quantities of colloid are obtained. This mechanical device enabled the authors to separate the colloidal material from two soil samples, of 200 grams each, per day. The material separated is considered a fair sample of the colloid of the soil, since in each case 75 per cent or more of the total colloid was separated.

The analysis of the colloidal material was made by the fusion method. It is commonly supposed that this material, since it is composed of very small particles, is soluble in acids. Experience has proved that this is not true, therefore the same procedure for analysis was followed as for a soil. The procedure for soil analysis is a modification of the method described by Hillebrand (9) for the analysis of silicate rock. The complete method for the analysis of soils is described in a bulletin by Robinson (17) of this bureau. Organic matter was determined by the dry-combustion method. The carbon dioxide evolved is multiplied by the factor 0.471. The combined water is taken to be the ignition loss less the organic matter. The figures given for the combined water are therefore subject to an error involved in the use of the Van Bemmelen factor. It is probable that this factor is rather constant for surface soils of the same series though it may vary considerably in different series as has been found by earlier work in this bureau (16).

Hydrogen-ion determinations of the whole soil were made electrometrically with a hydrogen electrode in a vessel of the bubbling type. These pH values should apply to the colloidal material since the colloid component is responsible for the reaction of the whole soil. The pH values of the extracted colloid were not measured as it was necessary to use ammonia in extracting this colloidal material.

Previous studies (2, 7, 15) have shown that in an atmosphere where the vapor pressure of water is high the quantities of water adsorbed by different soil colloids are comparatively constant, but vary greatly when the vapor pressure is low. Therefore the quantity of water adsorbed by the whole soils when kept over 3.3 per cent by weight of sulphuric acid was used in determining the colloidal content, and the quantity of water adsorbed by the colloids over 30 per cent of sulphuric acid was used in the study of the variations occurring in them.

The base-exchange capacity was estimated from the quantity of barium adsorbed from a neutral normal barium-chloride solution. The procedure followed was the same as that described in a previous publication (10), except for colloids containing calcium carbonate. These samples were treated with normal ammonium chloride to remove the adsorbed barium, instead of twentieth-normal hydrochloric acid which was used on all other samples.

#### DESCRIPTION OF SAMPLES

The soils of the three series selected are confined to, and have developed in, the eastern half of the United States under the influence of high rainfall and a temperature ranging from temperate to warm temperate. They have developed under a forest cover and are characterized by a podsollic profile.

The Chester and Miami soils are members of the gray-brown podsollic group as defined originally by Marbut (12, 13) under the name of brown forest soils, but to which at a later date the name as just given and now generally used in this country was applied by Baldwin (3). These soils are important agriculturally and are extensive in area as indicated by the following descriptions furnished by the soil survey division of this bureau. The entire area of each series is fairly well represented by the samples selected for this investigation.

As may be observed, each soil series is represented by nine or more profiles. All samples were selected by trained field men of the soil survey.<sup>2</sup> Particular care was exercised to ascertain that each sample had well-developed characteristics of its series. The samples of the soil collected were not composited; but each was taken from a single hole which represented an area of only a few square inches.

#### THE MIAMI SOILS

Miami silt loam is a member of a soil group which occurs in the Middle West, south of the true podsol soils, and is designated as a gray-brown podsollic soil. The samples reported in this investigation represent fairly well the entire area covered by Miami silt loam which is the most extensive and representative type of the Miami series. The Miami silt loam has a well-defined soil profile developed from medium to heavy textured glacial till under the influence of a deciduous forest and good but not excessive drainage. The following description indicates in some detail the field characteristics of Miami silt loam:

The surface leaf litter, consisting almost entirely of a loose accumulation of dried leaves, is only moderately abundant. The leaf mold, consisting of the somewhat packed and matted, disintegrated, and partly decomposed leaves and other plant remains, is thin; in most places it was observed to be from one-eighth to one-fourth inch thick. Beneath the organic-matter covering the mineral soil profile begins. In the Miami silt loam the texture profile is well developed and clearly defined. To a depth of some 12 inches, the soil is silt loam, from 12 to about 35 inches clay loam, and below that loam. These texture horizons may be taken as the primary horizons of the soil profile and designated A, B, and C. The A and B horizons together constitute the true soil, and the C horizon is the somewhat altered parent material, which ranges from medium to heavy textured glacial till.

Each primary horizon of the texture profile has characteristics which further subdivide it. The surface 2 inches of the mineral soil is very dark grayish brown in color, rich in organic matter, and when gently shaken out, falls into small soft roundish particles, from one-sixteenth to one-eighth inch in diameter, which cling to the plant roots. These particles are easily crushed when either moist or dry, and the whole mass is friable. There is a tendency to an irregular horizontal laminated or platy structure. Worm casts, wormholes, plant roots, and plant rootlets are very numerous. The dark color gradually fades with depth through the A horizon, the platy structure or breakage becomes more pronounced until the B horizon is approached, and the finer-grained structure is less pronounced. There is decreasing evidence of worm work and fewer plant roots and rootlets, but darker irregular channels occurring through the mass are probably filled-in wormholes.

With the change in texture from the A to the B horizon there is also a change in structure. The material of the B horizon breaks into irregular lumps ranging from one-fourth to 1 inch in diameter. These lumps are, in general, smaller at the top of the horizon, be-

<sup>2</sup> The Miami soil samples were collected by M. Baldwin, W. E. Thorp, and T. M. Bushnell. The Chester soil samples were collected by C. E. Marbut, S. G. Perkins, and W. E. Hearn. The Cecil soil samples were collected by W. E. Hearn and R. Wildermuth.



coming larger with depth. These small blocks, although fairly soft when moist and becoming a plastic mass with moderate pressure, are so hard when dry that they can not be crushed by ordinary direct pressure of thumb and finger. Within this layer (horizon B), the color of the soil material varies. The upper 4 or 5 inches are light brown or yellow brown on the faces of the structure blocks, with gray coatings in places. The interiors of the little blocks are more yellow, and a powdered mass of the material dries to light brownish yellow. There is a gradual transition to browner colors downward, at least to duller browns on the outside of the blocks, with more yellow in the interiors. A characteristic feature is a thin gell-like coating on the surface of the blocks, which is especially evident when they are moist. The lower 4 to 6 inches of the B horizon are marked by very dark-brown or black coatings on the structure blocks. Little pores and irregular tubes of about the diameter of a small needle are common features of the B horizon and are especially noticeable in the upper part. Plant roots and rootlets not only follow the breakage planes but penetrate the blocks. The root channels, especially of dead roots, are incased by darker-colored material.

The C horizon is calcareous glacial till of Late Wisconsin age. The upper 5 to 10 feet are light grayish yellow in color, firm and hard when dry but not extremely compact like some of the glacial drift farther east. The material tends, on exposure in banks, to develop irregular joint planes which separate the mass into angular blocks. Small stones and pebbles scattered through the mass consist of limestone, dolomite, shale, sandstone, granite, and other igneous and metamorphic rocks.

The Miami soils were developed under a normal rainfall of about 34 inches and under a mean annual temperature range for the area sampled of from 47° to 50.7° F.

A description of samples of Miami silt loam taken in various localities, arranged in order from north to south, is given in Table 1.

TABLE 1.—Description of Miami silt loam samples

Profile No.	Location of sample	Horizon	Depth	Colloid content		pH
				Inches	Per cent	
1	Eaton County, Mich., southeast corner of NW $\frac{1}{4}$ sec. 12, T. 4 N., R. 5 W.	A	6-10	9.6	4.00	
		B	18-30	25.2	5.40	
		C	34-40	5.2	7.80	
2	Washington County, Mich., 5 miles southeast of Ann Arbor.	A	0-8	11.9	5.85	
		B	8-30	35.8	6.30	
		C	54+	26.6	8.15	
3	Branch County, Mich., southeast $\frac{1}{4}$ sec. 19, T. 8 N., R. 5 W.	A	2-8	7.9	4.60	
		B	9-36	33.4	6.10	
		C	40-53	20.3	8.20	
4	Miami County, Ind., 3.5 miles northwest of Peru.	A	4-10	14.7	5.25	
		B	12-20	30.9	7.05	
5	Miami County, Ind., 2 miles south of Peru.	A	6-10	11.6	6.15	
		B	15-20	36.2	5.30	
		C	40-50	19.0	8.58	
6	Blackford County, Ind.	A	4-7	16.9	0.30	
		B	11-18	37.6	5.90	
		C	38-42	22.7	8.45	
7	Grant County, Ind., 2 miles east of Gas City.	A	3-0	10.1	0.70	
		B	10-26	33.6	4.80	
		C	32-42	19.5	8.30	
8	Hancock County, Ind., 4.5 miles south of Greenfield.	A	2-12	15.8	4.95	
		B	16-32	36.6	5.22	
		C	36+	14.1	8.58	
9	Rush County, Indiana.	A	5-14	13.9	5.53	
		B	14-18	18.1	4.98	
		C	00-04	12.1	8.67	

## THE CHESTER SOILS

The soils of the Chester series occupy an important area in the northern part of the piedmont plateau in Virginia, Maryland, Pennsylvania, and New Jersey. They have developed under a forest cover in which oak, chestnut, and hickory constitute the dominant trees. The parent material from which they have developed was accumulated in place by the residual decay of crystalline gneisses and schists some of which are granitic. As a whole, therefore, they contain a larger sand constituent than the Miami soils. The surface soils range from loams to sandy loams where the profile is normally developed, rather than silt loams, loams, and clay loams as in the Miami soils.

In virgin forests where most of the samples used were collected, the surface is covered by a layer of leaves and leaf mold, the latter being rather well decomposed but rarely having lost all trace of its origin. In extremely rare cases it is well granulated. The topmost 2 to 4 inches of mineral soil is dark colored, and in places where the texture is rather heavy it may be moderately well granulated, but, partly because of its dominant, rather coarse texture, it is not so well granulated as the corresponding layer in the Miami soils. This layer is usually described as the  $A_1$  horizon and is underlain by the  $A_2$  horizon consisting of yellow, reddish-yellow, or brownish-yellow material which is dominantly loam or sandy loam. The material in this horizon is, as a rule, less clearly laminated than the  $A_2$  horizon in the Miami soils and is practically structureless. These two subhorizons range from a total thickness of 5 to about 10 inches.

The B horizon consists of brown, strong yellowish-brown, or reddish-brown clay loam or clay. The transition from the A horizon to the B horizon is in most places gradual. The material of the B horizon breaks into moderately well-defined small angular particles ranging in size from a quarter of an inch or less to half an inch in diameter. This structure, or regular breakage, is best developed in the heavier members of the series, where it is as noticeable as in the B horizons of the Miami soils, but in the dominant members it is less perfect. The outsides of the particles are usually more deeply colored than the insides so that a broken fragment of the horizon, if the break has taken place along the outsides of the particles, is redder or more brown than the crushed material.

The top of the horizon is heaviest and best developed in all its characteristics, and there is a gradual merging with depth into the underlying parent material, or C horizon, consisting of loose material resulting from the disintegration and decomposition of the underlying crystalline rocks. This material is usually yellow to faint red and contains more or less partly decomposed and undecomposed minerals in which mica is often a noticeable constituent. In the A and B horizons mica may be present, more often in the latter, and quartz is usually present, but other identifiable minerals are not usually present.

The Chester soils were developed under a rainfall ranging from about 45 inches in northern New Jersey to about 50 inches in north-central North Carolina. The average annual temperature ranges between 47° and 53° F. in the northern end of the belt and between 57° and 63° in the southern end,

A description of samples of the Chester soils taken in various localities is given in Table 2.

TABLE 2.—Description of samples of the Chester soils

Profile No.	Location of sample	Horizon	Depth	Color	Colloid content	pH
					Per cent	
10	Warren County, N. J.	B	Inches 10-16	Yellow	22.3	6.30
11	do.	B	10-20	do.	25.0	7.50
12	Somerset County, N. J.	B	16+	do.	20.4	6.32
13	Chester County, Pa., 3 miles northeast of West Chester.	A	0-9	Brown	21.2	5.72
		B	9-28	Reddish brown	31.3	6.65
		C	40+	Yellowish brown	21.5	6.70
14	Lancaster County, Pa.	B	12-20	Grayish purple	27.6	4.75
15	do.	A	1-17	Brown	21.0	4.90
		A	1-8	do.	31.1	---
16	Cecil County, Md., 1 mile west of Blueball.	B	8-30	Grayish yellow	32.7	4.78
		C	12-60	Yellow	18.9	5.56
		C	44-60	Yellow brown	6.4	5.42
17	Cecil County, Md., one-fourth mile west of Colona.	A	0-9	Brown	14.2	6.50
		B	9-28	Yellow	21.6	5.14
		C	28-50	do.	11.8	6.05
		A	0-7	Grayish brown	15.0	5.45
18	Cecil County, Md., 1 mile west of Appleton.	B	7-32	Yellow	25.5	5.15
		C	44-60	Yellow brown	6.4	5.42
19	Cecil County, Md., 1 mile northwest of Rolandville.	A	0-10	Deep brown	18.6	5.62
		B	10-30	Brown	25.3	6.20
		A	1-9	Light brown	16.0	4.53
20	Harford County, Md.	B	9-28	Yellowish brown	26.0	4.80
		C	40-60	Yellow	7.0	4.35
		A	0-3	Brown	16.0	4.47
21	Montgomery County, Md., 3 miles northwest of Rockville.	B	8-34	Reddish brown	34.0	5.07
		C	54+	Red brown	17.0	4.90
22	Montgomery County, Md., one-fourth mile northwest of Glenmont.	A	0-3	Light brown	8.5	---
		B	8-32	do.	24.8	---
23	Arlington County, Va.	B	12-18	Light yellow	---	---
24	Fairfax County, Va.	A	0-7	Yellowish brown	14.3	---

## THE CECIL SOILS

The soils of the Cecil series occupy the southern part of the piedmont region of the eastern part of the United States, the belt crossing North Carolina, South Carolina, and Georgia, and ending in the eastern part of Alabama. These soils have developed from material accumulated in place by the residual decay of crystalline rocks, mainly schists and gneisses, some of which are granitic and practically all of which contain free quartz. The material is geologically identical with that from which the Chester soils have developed, and the Cecil soils also have developed under forest cover and in a region of high rainfall. The temperature under which development has taken place, however, is higher than for the Chester soils. The forest cover consists mainly of oak, together with chestnut and some pine.

The typical profile of the dominant fully developed member of the Cecil series, the sandy loam, consists of the following layers: A thin cover of leaf mold and loose leaves, of the same character as in the Chester soils but thinner. The leaf mold is underlain by a dark-colored sandy layer, ranging to about 4 inches in thickness and usually structureless. The organic matter is not well incorporated with the mineral constituents and disappears rather rapidly under cultivation. Beneath the dark-colored layer, designated as

in the Chester and Miami soils the A<sub>1</sub> horizon, lies a gray, pale-yellow, or reddish-yellow horizon, the color depending on the stage of podsol development, and this in turn depending, all other conditions being equal, on the texture of the material. If the material is rather sandy, development will be comparatively rapid, the horizon will soon become very sandy through eluviation and will become progressively light in color with the increasing sandiness. The dominant color, however, of this horizon, designated as A<sub>2</sub>, is pale yellow. The soil material is structureless, as a rule, but may show faint lamination.

The B horizon underlies the A<sub>2</sub> horizon, the transition being comparatively rapid, usually more so than in the Chester or Miami soils, and the difference in texture between the A and B horizons is greater than in the soils of either of the other two series. The color of the B horizon is strongly reddish yellow, yellowish red, or orange; the texture is clay loam or sandy clay; and the breakage into angular particles is more definite than in the B horizon of the Chester soils. The outsides of the structure particles are red, and the insides yellowish red. Small amounts of dark-colored organic matter in the form of insect casts and fillings of insect borings are present in the A<sub>2</sub> and B horizons, but they constitute a less important feature of the soil than in either the Miami or Chester soils. The best-developed and most characteristic part of the B horizon is the upper 6 to 12 inches. The soil material merges gradually with depth into the loose but still red disintegrated rock material designated as the C horizon. The thickness of the B horizon is about 3 feet, being greater than that of the corresponding horizons in the Miami and Chester soils.

The Cecil soils were developed under a rainfall of about 50 inches in the northern part of the belt in North Carolina and about 55 inches in the southern part, in Alabama. The average summer temperature of the northern part of the belt is a little less than 75° F., and that of the southern part of the belt in Georgia is about 80°. The average winter temperatures of the two parts of the belt are 40° and 50°, respectively.

The Cecil soils are podsollic, but because of their extensive eluviation, leaching of silica and bases, and their more intense red color they have been placed in the broad group of red soils by the field service of the Bureau of Chemistry and Soils.

Descriptions of several samples of Cecil soils are given in Table 3.

TABLE 3.—Description of samples of the Cecil soils

Profile No.	Location of sample	Horizon	Depth	Color	Colloid content	pH
			<i>Inches</i>		<i>Per cent</i>	
25	Goochland County, Va.....	A	0-8	Grayish yellow.....	9.6	4.58
		B	12-30	Red.....	25.2	4.55
		C	60+	Light red.....	5.2	4.45
26	Rockingham County, N. C.....	A	4-19	Grayish yellow.....	8.9	4.70
		B	16-38	Red.....	44.7	4.65
		C	70+	Yellowish red.....	20.7	4.42
27	Davie County, N. C.....	A	1-8	Grayish yellow.....	6.3	4.85
		B	20-60	Red.....	45.3	4.62
		C	50+	Yellowish red.....	27.3	5.58
28	Rutherford County, N. C., 6.2 miles west of Rutherfordton.	A	0-5	Reddish brown.....	20.1	4.80
		B	5-36	Deep red.....	51.5	5.15
		C	72-96	Brownish red.....	30.9	5.37
29	Rutherford County, N. C.....	B	6-40	Red.....	38.1	4.90
30	Clarke County, Ga., 1 mile north of Godfrey's store.	A	1-5	Reddish brown.....	11.2	5.70
		B	5-60	Deep red.....	54.0	5.30
		C	110-130	Yellowish red.....	29.7	4.50
31	De Kalb County, Ga.....	B	20-22	Red.....	49.3	5.15
32	Wilkes County, Ga.....	B	12-25	do.....	38.1	5.20
33	Wilkes County, Ga., 2.5 miles northeast of Washington.	A	0-9	Dark red.....	10.2	5.40
		B	9-36	Brownish red.....	31.0	.....
34	Oconee County, Ga.....	B	18-28	Red.....	47.5	4.83
35	Henry County, Ga.....	B	18-30	do.....	46.5	5.04
36	Fayette County, Ga.....	B	8-15	do.....	41.3	5.06
37	Butts County, Ga.....	B	19-20	Deep red.....	47.8	4.96
38	Meriwether County, Ga.....	D	15-25	Red.....	48.5	5.76
39	Troup County, Ga., 1 mile south of Lebanon.	A	2-6	Yellowish brown.....	4.3	5.10
		B	20-35	Deep red.....	43.3	4.85
		C	75-90	Purplish red.....	.....	4.48
40	Troup County, Ga., 6 miles east of Lagrange.	B	10-42	Deep red.....	38.9	4.64
		C	91-180	Yellowish red.....	.....	4.33
		A	0-7	Reddish brown.....	20.5	5.67
41	Chambers County, Ala., 6 miles west of Lanett.	B	8-24	Deep red.....	42.4	5.20
		C	25-59	Red.....	.....	4.85

## COMPOSITION AND PROPERTIES OF THE COLLOIDAL MATERIAL ISOLATED FROM SOILS OF THREE SERIES

The composition and properties of the Miami, Chester, and Cecil colloids are given in Tables 4, 5, and 6, respectively. In order to obtain more comparable data for the inorganic constituents, they are calculated on the inorganic basis, that is, weight of oven-dried material less organic matter. This mode of calculation eliminates the effect of the variable quantities of organic matter. The organic matter and properties are calculated on the colloids as a whole dried to constant weight at 100° C.

TABLE 4.—Composition and properties of colloidal materials isolated from Miami silt loam

Profile No.	Location of sample	Horizon	Depth	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	Combined H <sub>2</sub> O	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	MnO	Organic matter	Molecular ratio, SiO <sub>2</sub> / Al <sub>2</sub> O <sub>3</sub> +Fe <sub>2</sub> O <sub>3</sub>	Base exchange capacity per 100 grams	H <sub>2</sub> O vapor adsorbed per 100 grams
				Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
1	Eaton County, Mich.....	A B C	Inches	49.30	25.30	9.70	8.71	0.53	2.45	2.71	0.21	0.87	0.23	0.14	0.15	5.65	2.65	31.7	7.3
			6-10	48.00	24.21	11.16	7.96	.81	3.09	3.62	.25	.82	.17	.20	.10	1.69	2.59	37.5	9.4
			18-30	48.28	23.29	11.26	7.41	1.25	3.42	4.02	.34	.71	.20	.13	.12	1.46	2.68	42.6	10.0
2	Washtenaw County, Mich.....	A B C	0-8	50.84	25.45	9.23	6.44	.95	2.13	3.48	.35	.85	.28	.12	2.21	2.75	31.7	5.9	
			8-30	48.42	25.26	10.84	7.34	.93	2.76	4.58	.26	.80	.19	.23	.07	1.31	2.55	33.8	8.6
			54+	44.58	22.13	9.40	5.67	5.15	3.25	4.73	.53	.62	.12	.13	.07	1.10	2.69	23.7	6.3
3	Branch County, Mich.....	A B C	2-8	51.50	25.42	8.25	8.32	.20	2.17	2.74	.26	.92	.29	.21	.18	4.82	2.84	22.9	4.5
			9-36	47.50	24.48	10.85	7.01	.66	2.75	4.28	.10	.64	.15	.10	.07	1.37	2.48	33.7	8.1
			40-60	47.85	24.48	10.16	8.42	.92	2.21	2.61	.21	.64	.31	.14	.24	4.05	2.62	34.3	6.9
4	Miami County, Ind.....	A B C	4-10	48.97	24.70	11.78	7.07	.88	2.87	3.45	.18	.58	.20	.12	.14	1.72	2.52	42.5	9.5
			12-20	47.44	24.28	11.78	8.42	.92	2.21	2.61	.21	.64	.31	.14	.24	4.05	2.66	29.3	9.0
			6-10	49.87	24.25	9.97	8.39	.96	1.97	2.59	.13	.60	.38	.23	.24	5.77	2.75	31.3	6.6
5	Do.....	A B C	15-20	48.08	25.14	11.11	7.75	.88	2.48	2.86	.14	.51	.23	.10	.09	1.88	2.53	40.3	9.9
			40-50	44.91	23.15	10.24	7.44	3.73	3.11	4.20	.24	.48	.19	.14	.09	1.64	2.55	34.2	6.7
			4-7	50.81	25.70	8.33	6.49	.81	2.43	3.03	.25	.66	.19	.22	.10	6.50	2.78	36.8	8.1
6	Blackford County, Ind.....	A B C	11-18	47.05	25.64	11.13	7.72	.77	2.60	3.95	.15	.55	.12	.15	.12	1.77	2.48	39.1	6.6
			38-42	48.43	24.40	10.47	7.04	2.27	2.88	4.83	.20	.57	.17	.13	.08	1.12	2.64	32.8	6.5
			3-9	51.81	24.50	8.61	8.00	9.00	2.16	2.40	.20	.76	.30	.25	.13	5.70	2.92	32.9	5.6
7	Grant County, Ind.....	A B C	10-26	48.18	25.20	11.77	7.89	.54	2.54	3.27	.10	.69	.15	.11	.10	1.71	2.37	37.9	9.3
			32-42	40.56	23.25	10.57	6.34	1.46	2.98	4.76	.29	.67	.16	.19	.10	1.30	2.57	35.2	7.0
			2-12	47.47	27.58	9.89	9.23	.92	1.17	2.48	.34	.74	.40	.29	.28	6.47	2.39	36.5	7.1
8	Hancock County, Ind.....	A B C	16-32	47.53	25.15	12.45	8.44	.70	2.40	2.71	.07	.59	.22	.10	.14	1.96	2.43	40.5	9.5
			30+	37.13	24.25	11.45	7.23	1.50	3.09	4.28	.16	.60	.21	.12	.09	1.96	2.53	30.4	7.6
			5-14	47.48	25.25	10.09	9.98	.62	2.10	1.97	.16	.68	.20	.21	.20	8.03	2.50	41.1	6.9
9	Rush County, Ind.....	A B C	14-18	48.45	25.17	11.76	9.31	.47	2.09	2.06	.10	.67	.16	.28	.16	4.43	2.51	43.3	8.3
			60-64	42.38	21.75	9.64	5.93	8.00	3.40	4.20	.21	.56	.15	.12	.08	0.94	2.57	51.2	6.3
			Mean.....		49.78	25.34	9.36	8.22	.76	2.09	2.67	.23	.75	.29	.20	.20	5.95	2.60	32.7
Standard deviation	A B C	A B C		47.92	25.06	11.43	7.90	.74	2.62	3.42	.15	.65	.17	.15	.11	1.98	2.49	38.7	9.0
				46.26	23.34	10.37	6.73	3.14	3.16	4.47	.24	.61	.19	.13	.08	1.36	2.61	36.3	7.2
				1.52	.90	.73	1.04	.24	.35	.37	.07	.10	.07	.05	.04	1.09	.15	4.86	1.20
Coefficient of variability	A B C	A B C		1.37	.47	.51	.62	.15	.28	.74	.06	.10	.04	.06	.03	1.06	.06	3.20	.59
				1.08	.95	.67	.63	.23	.17	.30	.06	.07	.02	.03	.02	.31	.05	5.50	1.14
				3.1	3.5	7.8	12.6	31.5	16.7	13.8	30.4	13.3	24.1	25.0	20.0	18.3	5.5	14.8	18.5
		0.8	1.9	4.5	7.8	20.2	10.7	21.6	40.0	15.3	23.5	40.0	27.3	60.3	2.4	8.2	6.5		
		4.3	4.1	6.5	9.4	71.0	5.4	6.7	25.0	11.5	10.5	23.1	25.0	22.5	2.1	15.2	15.8		

TABLE 5.—Composition and properties of colloidal materials isolated from soils of the Chester series

Profile No.	Location of sample	Horizon	Depth	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	Combined H <sub>2</sub> O	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	MnO	Organic matter	Molecular ratio, SiO <sub>2</sub> / Al <sub>2</sub> O <sub>3</sub> +Fe <sub>2</sub> O <sub>3</sub>	Base exchange capacity per 100 grams	H <sub>2</sub> O vapor adsorbed per 100 grams
				Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Milliequivalents
10	Warren County, N. J.	B	10-16	40.00	32.76	11.83	12.87	0.55	0.86	0.65	0.08	0.55	0.10	0.08	0.04	1.07	1.68	15.3	6.7
11	do.	B	10-20	39.30	32.88	12.49	13.14	.49	.91	.40	.02	.54	.13	.14	.05	1.76	1.68	17.1	6.3
12	Somerset County, N. J.	B	16+	34.56	28.31	18.86	14.18	.65	1.23	.87	.05	1.06	.47	.18	.13	2.86	1.45	21.1	8.5
		A	0-9	33.07	29.35	16.08	12.98	.86	2.84	.94	.17	1.30	.46	.22	.58	11.71	1.44	29.9	6.8
13	Chester County, Pa.	B	9-23	33.19	27.69	20.05	11.06	.34	2.25	.95	.06	1.42	.45	.47	.26	4.22	1.38	18.4	6.5
		C	40+	35.46	27.51	10.24	12.34	.40	1.70	1.13	.07	.94	.49	.23	.17	3.49	1.51	18.2	6.7
14	Lancaster County, Pa.	B	12-20	30.11	29.54	16.15	12.10	.41	1.10	1.37	.06	.74	.18	.13	.14	1.62	1.66	18.8	7.2
15	do.	A	1-7	35.58	33.45	13.48	12.66	.35	.95	1.43	.21	.56	.37	.18	.35	6.30	1.43	18.5	6.4
		B	1-8	34.06	31.87	14.27	14.15	.09	2.43	.41	.01	.55	.89	.41	.35	10.50	1.41	27.7	6.4
16	Cecil County, Md.	A	8-30	40.40	28.70	15.35	11.35	.10	1.57	.88	.02	.51	.41	.09	.08	1.45	1.78	26.0	9.1
		B	42-60	38.45	35.14	8.27	15.48	.24	6.33	.38	.07	.23	1.27	.17	.09	3.90	1.61	18.7	5.7
		C	0-9	38.07	33.05	10.45	12.60	.71	1.66	1.35	.06	.67	.27	.27	.55	7.02	1.65	27.9	6.5
17	do.	A	9-23	38.76	32.28	12.73	12.26	.39	1.33	1.16	.15	.72	.15	.11	.09	1.80	1.62	18.2	8.0
		B	28-50	39.74	34.95	9.24	12.68	.21	8.6	.99	.02	.56	.14	.12	.17	1.97	1.64	14.1	7.1
		C	0-7	39.93	30.91	11.83	12.67	.56	1.51	1.08	.14	.69	.49	.37	.28	7.77	1.76	25.2	6.7
18	do.	A	7-32	42.56	28.10	13.85	10.61	.44	1.55	1.29	.12	.99	.20	.10	.10	1.80	1.98	25.7	9.2
		B	44-60	42.73	34.52	7.60	12.48	.36	6.4	.61	.08	.32	.28	.26	.20	2.90	1.84	15.0	6.1
		C	0-10	33.49	35.40	12.36	14.11	.53	1.38	.94	.02	.59	.37	.29	.27	6.15	1.31	22.5	6.3
19	do.	A	10-30	37.51	32.80	12.55	12.85	.35	1.21	.95	.02	.58	.38	.18	.09	1.32	1.55	19.9	7.8
		B	1-9	37.96	31.27	14.01	11.92	.52	1.28	1.06	.09	.52	.32	.37	.18	4.51	1.60	19.9	6.4
		C	9-23	39.28	30.38	15.12	11.50	.32	7.0	1.02	.06	.63	.27	.18	.09	2.03	1.66	18.1	7.5
20	Harford County, Md.	A	40-60	34.67	31.34	18.10	11.23	.31	8.5	.97	.18	.49	.81	.92	.13	6.53	1.37	12.0	5.0
		B	0-8	34.50	30.79	17.22	12.73	.36	1.17	.81	.05	.54	.49	.46	.38	7.52	1.40	22.7	7.3
		C	8-34	39.31	28.28	14.71	11.42	.45	1.38	.99	.05	.57	.22	.16	.15	2.24	1.77	26.9	10.5
21	Montgomery County, Md.	A	54+	37.30	30.56	16.56	10.88	.47	2.3	.98	.13	.58	.28	.40	.12	2.17	1.55	13.5	6.0
		B	0-8	40.62	31.23	11.74	12.25	.97	2.3	1.29	.33	.58	.20	.09	.08	4.11	1.77	29.0	7.2
22	do.	A	8-32	42.14	27.90	10.53	10.80	.65	1.28	1.85	.26	.81	.15	.05	.37	4.99	1.79	22.7	6.8
		B	12-18	38.19	30.17	16.30	10.07	.54	1.32	1.16	.18	.58	.20	.21	.05	4.16	1.59	20.6	8.8
23	Arlington County, Va.	A	0-7	36.85	29.50	16.86	12.59	.18	3.03	.90	.08	1.14	.31	.07	.23	5.54	1.54	20.7	6.5
24	Fairfax County, Va.	A	0-7	36.85	29.50	16.86	12.59	.18	3.03	.90	.08	1.14	.31	.07	.23	5.54	1.54	20.7	6.5
		B		36.47	31.68	13.83	12.86	.51	1.65	1.02	.12	.71	.42	.28	.33	7.11	1.53	24.4	6.6
		C		38.80	29.98	14.71	11.98	.44	1.28	1.04	.09	.75	.25	.17	.14	2.41	1.66	20.6	7.8
	Mean	A		38.06	32.33	13.16	12.51	.33	.93	.89	.09	.52	.54	.35	.15	3.49	1.59	15.3	6.1
		B		2.47	1.76	2.24	.68	.27	.83	.28	.03	.26	.18	.14	.15	2.30	.16	3.88	1.06
	Standard deviation	A		1.84	1.79	2.80	.96	.14	.37	.34	.07	.25	.12	.11	.10	1.20	.16	3.52	1.29
		B		2.69	2.78	4.88	1.47	.09	.36	.31	.05	.33	.39	.27	.04	1.52	.14	2.43	.67
		C		6.7	5.5	16.2	5.3	52.9	50.4	27.5	25.0	36.6	42.9	50.0	45.5	32.3	10.5	15.9	16.1
	Coefficient of variability	A		4.7	6.0	19.0	8.0	31.8	28.0	32.6	77.8	33.3	48.0	64.7	71.4	49.8	9.6	17.1	16.51
		B		7.1	8.6	37.1	11.8	27.3	38.7	34.8	55.5	44.2	72.2	77.1	26.7	43.6	8.8	15.8	11.1

TABLE 6.—Composition and properties of colloidal materials isolated from soils of the Cecil series

Profile No.	Location of sample	Horizon	Depth	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	Combined H <sub>2</sub> O	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	MnO	Organic matter	Molecular ratio, SiO <sub>2</sub> /Al <sub>2</sub> O <sub>3</sub> +Fe <sub>2</sub> O <sub>3</sub>	Base exchange capacity per 100 grams	H <sub>2</sub> O vapor adsorbed per 100 grams
				Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Milliequivalents
25	Goochland County, Va.	A	0-8	42.13	34.80	8.92	11.55	0.12	0.78	0.80	0.11	0.90	0.05	0.14	0.02	6.48	1.77	9.0	4.4
		B	12-30	38.10	35.73	11.46	12.80	.05	.52	.46	.06	1.06	.06	.06	.04	.57	1.50	8.3	6.0
		C	60-60+	38.01	33.85	13.50	12.40	.08	.56	.42	.05	1.38	.07	.10	.04	.57	1.51	7.6	5.7
26	Rockingham County, Va.	A	4-10	39.52	36.54	12.33	13.52	.20	.15	1.03	.02	.78	.14	.04	5.19	1.51	8.0	3.8	
		B	16-38	38.46	35.73	11.93	12.85	.15	.24	.64	.02	.88	.03	.03	.38	1.50	6.9	4.5	
		C	70-70+	37.39	34.81	13.27	12.97	.04	.21	.42	.05	.75	.12	.31	.09	1.12	1.46	5.8	4.3
27	Davie County, N. C.	A	1-8	42.38	34.57	8.77	12.13	.07	.42	.73	.02	.81	.31	.07	3.95	1.78	13.7	4.7	
		B	20-59	39.53	34.11	12.31	13.01	.31	.50	.36	.01	.79	.15	.02	.76	1.59	9.6	5.0	
		C	50-50+	39.08	33.91	13.11	12.35	.31	.51	1.00	.02	.72	.20	.05	1.50	1.55	10.5	4.9	
28	Rutherford County, N. C.	A	0-5	34.49	36.81	11.25	14.43	.22	.56	.35	.06	1.01	.26	.20	.09	4.26	1.33	9.4	3.6
		B	5-36	32.02	36.98	14.70	13.15	.25	.13	.18	.13	1.02	.12	.12	.06	1.11	1.18	5.6	3.3
		C	72-96	28.84	40.05	11.00	16.60	.23	.14	.18	.09	1.09	.79	.11	.14	.86	1.03	7.0	4.4
29	do.	B	6-40	33.46	36.91	14.97	12.50	.02	.23	.18	.08	.96	.02	.20	.04	1.35	1.22	4.9	4.1
		C	1-5	34.78	38.16	9.64	14.59	.21	.13	1.04	.02	1.10	.15	.23	4.82	1.33	10.7	4.7	
30	Clarke County, Ga.	A	5-60	33.26	35.24	11.82	14.71	.14	.54	.51	.03	.90	.10	.12	.10	.84	1.35	7.3	4.7
		B	110-130	34.02	34.71	15.32	13.51	.21	.51	.37	.05	1.10	.25	.13	.11	1.34	1.29	7.2	4.5
31	De Kalb County, Ga.	A	20-28	35.04	37.86	10.65	13.53	.25	.79	.30	.02	.73	.06	.18	.05	.68	1.33	8.2	5.3
		B	12-25	38.07	36.52	10.13	13.53	.23	.41	.22	.06	.45	.05	.12	.05	.88	1.52	7.5	3.6
32	Wilkes County, Ga.	A	0-9	34.73	36.89	11.27	14.75	.31	.23	.35	.01	.54	.11	.02	.14	1.44	1.20	12.5	3.8
		B	9-36	32.30	38.84	10.17	16.80	.35	.23	.30	.41	.01	.68	.05	.13	.02	.43	1.41	6.9
33	do.	A	9-36	36.14	36.96	10.34	14.31	.19	.67	.20	.02	.77	.11	.24	.03	.80	1.18	6.8	4.1
		B	18-30	32.68	40.25	10.80	14.70	.29	.30	.20	.12	.60	.08	.19	.05	.86	1.39	11.6	5.7
34	Oconee County, Ga.	A	18-28	36.14	36.96	10.34	14.31	.19	.67	.20	.02	.77	.11	.24	.03	.80	1.18	6.8	4.1
		B	18-30	32.68	40.25	10.80	14.70	.29	.30	.20	.12	.60	.08	.19	.05	.86	1.39	11.6	5.7
35	Henry County, Ga.	A	8-15	36.09	38.42	8.54	15.24	.19	.67	.20	.02	.77	.11	.24	.03	.80	1.18	6.8	4.1
		B	18-30	32.68	40.25	10.80	14.70	.29	.30	.20	.12	.60	.08	.19	.05	.86	1.39	11.6	5.7
36	Fayette County, Ga.	A	10-20	35.15	35.88	13.41	14.65	.06	.11	.52	.12	.91	.05	.08	.06	.64	1.34	8.0	3.7
		B	10-20	35.15	35.88	13.41	14.65	.06	.11	.52	.12	.91	.05	.08	.06	.64	1.34	8.0	3.7
37	Butts County, Ga.	A	8-15	36.09	38.42	8.54	15.24	.19	.67	.20	.02	.77	.11	.24	.03	.80	1.18	6.8	4.1
		B	18-30	32.68	40.25	10.80	14.70	.29	.30	.20	.12	.60	.08	.19	.05	.86	1.39	11.6	5.7
38	Meriwether County, Ga.	A	15-25	36.51	39.30	8.27	14.70	.12	.10	.39	.15	.57	.07	.07	.04	.83	1.39	9.1	4.6
		B	15-25	36.51	39.30	8.27	14.70	.12	.10	.39	.15	.57	.07	.07	.04	.83	1.39	9.1	4.6
39	Troup County, Ga.	A	2-6	36.77	37.54	8.76	14.56	.25	.36	1.00	.02	1.32	.22	.17	6.62	1.42	10.0	4.3	
		B	20-35	36.08	34.68	14.85	12.84	.02	.30	.45	.15	.56	.08	.08	.04	.77	1.39	6.6	3.1
		C	75-90	39.81	36.65	10.75	12.62	.07	.64	.64	.02	.60	.14	.03	1.36	1.55	5.7	3.4	
40	do.	A	10-42	37.70	33.43	14.04	12.82	.02	.65	.19	.13	.74	.02	.27	.06	2.61	1.51	6.7	3.6
		B	91-180	38.24	34.60	13.82	12.57	.20	.13	.53	.02	.95	.09	.05	1.30	1.49	6.6	4.0	
		C	0-7	35.18	35.80	12.84	13.24	.29	.45	.30	.05	1.00	.25	.10	1.17	7.35	14.0	3.8	
41	Chambers County, Ala.	A	8-24	34.25	34.47	15.20	13.84	.08	.18	.30	.07	1.15	.04	.39	.10	1.93	1.31	8.1	4.1
		C	25-59	36.09	34.12	14.85	12.57	.02	.07	.37	.17	.76	.04	.35	.20	1.91	1.40	10.3	4.5



TABLE 6.—Composition and properties of colloidal materials isolated from soils of the Cecil series—Continued

Profile No.	Location of sample	Horizon	Depth	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	Combined H <sub>2</sub> O	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	MnO	Organic matter	Molecular ratio, SiO <sub>2</sub> Al <sub>2</sub> O <sub>3</sub> +Fe <sub>2</sub> O <sub>3</sub>	Base exchange capacity per 100 grams	H <sub>2</sub> O vapor adsorbed per 100 grams
				Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
			Inches																
	Mean.....	A	-----	37.50	36.39	10.47	13.60	.21	.44	.71	.05	.94	.21	.13	.12	5.11	1.45	11.6	4.3
		B	-----	35.02	36.72	11.98	13.91	.16	.32	.35	.07	.78	.07	.15	.06	1.00	1.37	7.9	4.3
		C	-----	36.43	35.34	13.20	13.22	.14	.27	.49	.07	.92	.21	.17	.09	1.26	1.41	7.6	4.4
	Standard deviation.....	A	-----	3.08	1.17	1.54	1.14	.07	.18	.29	.03	.20	.08	.05	.07	1.56	.21	3.14	.51
		B	-----	2.31	1.89	2.03	1.13	.10	.21	.13	.05	.19	.04	.09	.03	.55	.12	1.89	.80
		C	-----	3.33	1.96	1.52	1.31	.09	.20	.23	.05	.24	.23	.10	.05	.39	.16	1.76	.60
	Coefficient of variability..	A	-----	8.2	3.23	14.7	8.4	33.3	40.9	40.8	60.0	21.3	38.1	38.5	58.3	30.5	14.5	27.1	11.8
		B	-----	6.5	5.14	16.9	8.2	62.5	65.6	37.1	71.4	24.3	57.1	60.0	50.0	55.0	8.76	23.9	18.6
		C	-----	9.1	5.56	11.5	9.9	64.3	74.1	46.7	71.4	26.1	109.5	58.8	55.5	30.9	11.3	23.1	13.6

## GENERAL RELATIONS BETWEEN THE PROFILES

The data presented in Tables 4, 5, and 6 show a marked constancy of the colloids derived from the various samples of each series, together with an equally marked divergence between the different series. This constancy is particularly evident with respect to the relative quantities of silica, alumina, iron oxide, and water. This feature of the data will be discussed in more detail later. It is desired here to emphasize the striking similarity of the profiles of each series. The variations in the character of the colloidal material which exist in respect to the three horizons of the profiles of a soil series are slight; nevertheless they are consistent.

Table 4 shows certain differences between the compositions of the Miami colloids within a profile. The data reported show that with but few exceptions there is a regular variation in the percentage of all the constituents. The monovalent and divalent bases except sodium, in which case the quantities are small and the analytical error comparatively large, all increase with depth whereas nearly all the other constituents decrease with depth. Denison (6) points out a similar variation in the base content of the colloids from other soil profiles derived from glacial material.

The work of McCool (11) with certain Michigan soil profiles shows in some cases significant differences in the character of the colloids from different horizons. The data of Anderson and Byers (1) show enormous differences between the different horizons of certain podsol soil profiles. The variations in the iron oxide in respect to the three horizons are very consistent for all profiles, indicating a translocation of this constituent from the A horizon to the B horizon. Base exchange and water adsorption capacities show the colloids of the B horizon to be more active than those of the A or C horizons. These variations, though slight in all constituents except the organic matter and calcium, are, however, consistent and more or less uniform in all profiles. The organic matter is unusually well confined to the A horizon in all profiles except No. 9. The content of sulphur, phosphorus, and manganese parallel fairly well the organic matter.

The data in Table 5 for the colloidal material of the Chester soil profiles show differences in some of the constituents in respect to the horizons. The percentages of silica, in contrast with the Miami profiles, are, with one exception, highest in the B horizon. There is some variation in the alumina, iron, and combined water in all profiles. These variations differ in magnitude and are, therefore, not consistent. However, they all follow the order indicated by the means of the horizons. The percentages of monovalent and divalent base constituents with few exceptions decrease with depth. The variations in the organic matter, sulphur, phosphorus, and manganese oxides are not so consistent in the Chester profiles as they are in the Miami though they occur in the same general order. Profiles 16 and 20 of the Chester series show an accumulation of organic matter, sulphur trioxide, and phosphorus pentoxide in the C horizon. The base exchange capacity indicates a more active colloid in the A horizons, and the water adsorbed indicates a slightly more active colloid material in the B horizons of most of the profiles of the Chester series.

Table 6 shows that the colloidal material of the Cecil soil profile is more constant with respect to all constituents, except organic matter and compounds directly associated with it, than other profiles. This is noted especially in the case of profiles 26, 27, 30, and 39. Denison (6) reports similar data for a Cecil profile from North Carolina. When the great depth of the C horizons of the Cecil profiles is considered the total quantity of these constituents so represented is very great.

As may be seen from Tables 1, 2, and 3 the hydrogen-ion concentration with only one exception is on the acid side in all horizons and shows little, if any, regular variation with depth except in the case of the C horizons of the Miami series in which the hydrogen-ion concentration is about that of calcium carbonate. The quantity of colloidal material is as a rule much greater in the B horizon than it is in the A or C horizons; this difference is much more pronounced in the Cecil series than it is in the Miami or Chester.

As may be seen from the foregoing discussion, the soil profiles of a given soil series are similar. The profiles of the three series here presented and those of the Leonardtown (10) are very dissimilar with respect to their chief constituents, but in certain features they resemble each other. In these soil series, with few exceptions, the quantity of organic matter, phosphorus, and sulphur is greatest in the A horizon. However, these constituents seem to accumulate slightly more in the C horizons than in the B horizons of the Chester and Cecil soil series, especially the Cecil. In general, the quantity of titanium oxide in the colloid of one soil series is about the same as it is in another. It varies within the profiles in no regular order except in the Miami series in which the quantities show a slight decrease with depth. However, the variations of certain constituents within a profile are very dissimilar in the different series. The silica increases with depth in most of the Chester profiles, whereas the reverse is true for the Miami and Cecil series. The active base constituents, calcium, magnesium, potassium, and sodium, vary in the Miami profiles in the reverse order to their variation in the profiles of the Chester and Cecil. The means for iron oxide, as given in Tables 4, 5, and 6, show this constituent to be higher in the lower horizons than in the surface soils in all three series, but the quantity of this constituent differs widely in the different series. An accumulation of iron oxide in the B horizon is indicated in the Miami and Chester series. The alumina, although varying in quantity within the series, does not show any distinct variation with depth. Such variations as are noted seem to follow no regular order.

Although the foregoing discussion, together with the tables, shows clearly the general similarity of the different profiles of a single series and a marked variation between the different series, the extent to which variation within a single horizon occurs is not clearly indicated. This is, perhaps, best revealed by calculation of the standard deviation and coefficient of variability.<sup>3</sup>

<sup>3</sup> In calculating these values the following formulas were used: Standard deviation,  $\sigma = \sqrt{\frac{\sum d^2}{N}}$ , and coefficient of variability,  $C = \frac{\sigma}{M} \times 100$ . D represents the deviation of each determination from the mean (M) of the whole number of determinations (N). A mathematical treatment of this topic by H. L. Rietz is to be found as an appendix in Principles of Breeding, by Davenport (5).

THE MEAN VARIATIONS

Since 90, 95, and 98 per cent of the Miami, Chester, and Cecil colloids, respectively, are composed of the four major constituents silica, alumina, iron oxide, and their combined water, the constancy of these constituents determines the constancy of the bulk of the colloidal material. In general, the coefficient of variability, that is, the percentage of the standard deviation, is much smaller for these major constituents than for those making up a minor part of the whole. These values are given in Tables 4, 5, and 6 for each soil series and are collected for direct comparison in Table 7. The coefficients of variability for the four major constituents of the Leonardtown, Miami, Chester, and Cecil series average 4, 5½, 11, and 9, respectively. The water of combination of the Miami colloids is the smallest of the four major constituents and varies most, though its coefficient of variability exceeds 10 in only one instance. In the colloids of the other two soil series the iron is the most variable of the major constituents, and is also the only constituent that has a variation greater than 10. The colloidal material of the Miami silt loam shows very much the same degree of constancy in respect to the four major constituents (silica, alumina, iron oxide, and combined water), and silica-sesquioxide ratio, base-exchange capacity, and water adsorbed, as does the colloidal material of the Leonardtown silt loam, whereas the colloidal material of the Chester and Cecil soil series shows a slightly less degree of constancy.

TABLE 7.—Coefficient of variabilities for chemical constituents and properties for the colloids of four soil series

Soil series	Horizon	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	H <sub>2</sub> O	CaO	MgO	K <sub>2</sub> O	N <sub>2</sub> O
Miami	A	3.1	3.5	7.8	12.6	31.5	16.7	13.8	30.4
	B	3.8	1.9	4.5	7.8	20.2	10.7	21.6	40.0
	C	4.3	4.1	6.5	9.4	71.0	5.4	6.7	25.0
Chester	A	6.7	5.5	16.2	5.3	52.9	50.4	27.5	25.0
	B	4.7	6.0	19.0	8.0	31.8	28.9	32.6	77.8
	C	7.1	8.6	37.1	11.8	27.3	38.7	34.8	55.5
Cecil	A	8.2	3.2	14.7	8.4	33.3	40.9	40.8	60.0
	B	6.5	5.1	16.0	8.2	62.5	65.6	37.1	71.4
	C	9.1	5.0	11.5	9.0	64.3	74.1	46.7	71.4
Leonardtown	A	3.1	3.7	5.7	5.7	30.8	12.6	4.2	37.1
	B	3.0	1.3	3.5	6.4	33.3	12.8	11.8	27.5

Soil series	Horizon	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	MnO	Organic matter	SiO <sub>2</sub> /R <sub>2</sub> O <sub>3</sub>	Base exchange	H <sub>2</sub> O adsorbed
Miami	A	13.3	24.1	25.0	20.0	18.3	5.5	14.8	18.5
	B	15.3	23.5	40.0	27.3	63.4	2.4	8.2	0.5
	C	11.5	10.5	23.1	25.0	22.5	2.1	15.2	15.8
Chester	A	36.6	42.9	50.0	45.5	32.3	16.9	15.9	16.1
	B	33.3	48.0	64.7	71.4	49.8	9.6	17.1	16.5
	C	44.2	72.2	77.1	26.7	43.6	8.8	15.8	11.1
Cecil	A	21.3	38.1	38.5	58.3	30.5	14.5	27.1	11.8
	B	21.3	57.1	60.0	50.0	55.5	8.7	23.0	18.6
	C	26.1	100.5	60.6	55.5	39.9	11.3	23.1	18.6
Leonardtown	A	10.0	46.9	48.0	33.3	32.5	5.0	13.0	3.8
	B	6.0	27.8	46.2	40.0	36.3	2.0	6.8	3.5

The coefficients of variability of the monovalent and divalent bases shown in Table 7 are much larger than the major constituents. That such should be the case is to be expected, as the fraction of the whole represented by these four constituents is small, and unavoidable analytical errors therefore largely affect the coefficient. It is also true that these materials are approaching the limit of complete extraction in the process of rock decomposition and will be subject to great variation due to differences in the accessibility of the material to soil-forming agencies. This variation is particularly marked in the Cecil series in which the sum of the averages of these four constituents is only about  $1\frac{1}{2}$  per cent of the total material of the A horizon and less than 1 per cent in the B and C horizons. However, this does not explain the wide variation of the calcium in the colloids isolated from the C horizon of the Miami series. The calcium oxide of the colloids in the C horizon averages 3.14 per cent and has a coefficient of variability of 71. This is to be expected, since the parent material is calcareous glacial till and the top of the C horizon is the transitional zone in respect to the calcium carbonate. Therefore, irregularities in the depth to which it was sampled would produce wide variation in the percentages of calcium. This is evidently true for the profiles reported in Table 4 as may be seen by comparing the high percentages of calcium oxide and the unusual depths of the C horizons of profiles 2 and 9 with the corresponding values in the other profiles.

The constituents of a soil colloid which vary about as much within a soil series as they do in different series are obviously of no value in distinguishing one soil series from another. This is somewhat the case with the organic matter, phosphorus, and sulphur in the series investigated, although in the Miami series the organic matter is unusually well confined to the A horizon in all profiles except No. 9. The titanium content of all the series shows a reasonably low coefficient of variability. Nevertheless, this constituent serves but little to differentiate one soil series from another since the quantities present differ very little in different soil series. It is to be emphasized that those constituents which vary widely between different series and are rather constant within a series, are most valuable for characterizing the colloidal material of a soil series. When the causes for the variations in the character of the colloidal material of a soil series, such as variations in temperature and rainfall over the area and the heterogeneity of its parent material, are considered, it might be said that the data herein presented show a remarkable constancy for this material in these rather extensive soil series.

Table 8 shows the relative quantities representing the mean values for chemical constituents and properties of colloids of four soil series.

TABLE 8.—Relative quantities representing the mean values for chemical constituents and properties of colloids of four soil series

[The largest value of each constituent is represented as 100 per cent]

Soil series	Horizon	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	H <sub>2</sub> O	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Miami	A	100.0	89.0	83.6	53.1	100	86	60	64
	B	96.2	68.2	77.7	56.8	97	84	77	43
	C	92.9	63.6	70.5	48.4	113	100	100	64
Chester	A	73.3	36.2	94.0	92.5	67	52	22	34
	B	77.9	81.7	100.0	86.1	58	46	23	38
	C	76.5	88.0	89.5	89.9	43	29	20	29
Cecil	A	75.3	93.1	71.2	97.8	28	14	16	14
	B	71.6	100.0	81.4	100.0	21	10	8	23
	C	73.2	96.3	89.7	95.0	18	0	0	20
Leonardtown	A	86.7	77.8	80.4	85.0	51	28	31	109
	B	80.6	75.3	92.5	83.8	39	27	28	94

Soil series	Horizon	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	SO <sub>3</sub>	MnO	Organic matter	SiO <sub>2</sub> R <sub>2</sub> O <sub>3</sub>	Base exchange	H <sub>2</sub> O ad-sorbed
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Miami	A	80	54	40	61	78	100	54	72
	B	69	31	30	33	26	93	100	100
	C	65	35	26	24	18	97	94	80
Chester	A	76	78	50	100	95	57	63	73
	B	80	46	34	42	31	62	53	67
	C	54	100	70	45	46	59	40	68
Cecil	A	100	39	26	36	67	54	30	48
	B	81	13	30	18	15	51	20	48
	C	98	39	34	27	16	52	20	61
Leonardtown	A	96	50	100	18	100	75	51	61
	B	82	33	52	12	37	75	61	78

\* This determination is not represented by 100 since the calcium determination in the C horizon is largely colloidal calcium carbonate and therefore not comparable to the other calcium determinations.

DIFFERENCES IN COMPOSITION OF COLLOIDS FROM SOILS OF THE DIFFERENT SERIES

The colloids of the different soil series examined are, in general, very different. Table 8 is designed to distinctly portray these differences. In this table all the individual constituents are calculated to a common basis. The highest value of each constituent is taken as 100, and that of the others, consequently, is expressed as a definite percentage of this maximum. The mean value of each constituent is thus compared with corresponding mean values in all the horizons of the four soil series.

The four major constituents form a very large part, from 90 to 98 per cent, of the total colloids. Consequently, the especially significant differences between the colloids should be revealed by variations of these factors. Examination of Table 8 shows that these major constituents vary widely in the different soil series.

In previous publications (2, 18) attention has been called to the silica-sesquioxide ratio as an index to the general characteristics of soils. If these series are arranged according to this ratio the order becomes Miami, Leonardtown, Chester, and Cecil in all horizons. This order is maintained for the four major constituents, if the reciprocal character of the relation is kept in mind, except for the interchange of position of the Cecil and Chester series in the A and B horizons with respect to the iron oxide and in the A horizon with respect to silica. The combined water varies inversely with the silica-sesquioxide ratio. This would seem to indicate that the quantity is dependent on the alumina and iron oxide present.

The silica-sesquioxide ratio is not followed so closely by the monovalent and divalent bases. Only in the case of potassium is the order what would be expected from the ratio, that is, decrease as the ratio decreases. In soils of the Leonardtown series the quantities of magnesium and calcium are lower than their silica-sesquioxide ratio would warrant, judging from the mean of that shown by the different series. The sodium content also is not in accord with the ratio, but not much stress can be placed on this fact because of the exceedingly small amount present in any case. The same parallel relationship with the silica-sesquioxide ratio is to be observed with the base-exchange capacity and water-vapor adsorption. These properties follow the order of calcium and magnesium, and compare most closely with the order of the calcium content. Although it is clear from the foregoing discussion that no one relation is adequate for differentiation of soil colloids, as represented by the four soil series considered, it is nevertheless true that, in general, the silica-sesquioxide ratio best serves this purpose. If it is used as an index of colloidal characteristics, then the Miami, Leonardtown, Chester, and Cecil soil series bear a numerical ratio to each other corresponding to 100:75:60:50, as expressed by the silica-sesquioxide ratio shown in Table 8. This relation as expressed by differences in base exchange capacity changes both the numerical differences and the order. The same statement holds for the calcium and magnesium oxides. The quantities of organic matter, phosphorus pentoxide, sulphur trioxide, and titanium oxide are so variable within each series that no general conclusions regarding the colloid characteristics are deducted from them.

The data presented for the four soil series considered show that although each has its own range of variation in colloid composition, the differences between series are sufficiently wide to sharply differentiate them. This result is to be expected when the soils are derived from different soil materials, developed under different climatic conditions, and differ in degree of maturity. The Miami series differs in these respects most widely from the other three, and its colloid composition is correspondingly different. On the contrary, the Chester, Leonardtown, and Cecil series are not so divergent in source and yet are sufficiently different, when studied under field conditions, to be differentiated one from the other. The character of their colloids likewise shows marked variation. This degree of variation is not to be expected between the colloids of all series, and it is, perhaps, obvious that gradations should occur between soil series with respect to the composition of their colloids even as there are soil areas difficult of satisfactory classification. This difficulty is illustrated in Table 9.

TABLE 9.—Average composition of colloids from various Chester soil profiles in comparison with the composition of the colloids of a soil profile varying from the Chester type

Value	Horizon	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	Combined H <sub>2</sub> O	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	SiO <sub>2</sub> / R <sub>2</sub> O <sub>3</sub>	Base exchange capacity per 100 grams	H <sub>2</sub> O vapor adsorbed per 100 grams
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent		Milliequivalents	Grams
11	A	36.47	31.68	13.33	12.86	0.51	1.65	1.02	0.12	1.53	24.4	6.6
	B	38.80	29.98	14.71	11.98	.41	1.25	1.04	.09	1.66	20.6	7.8
	C	38.06	32.33	13.16	12.51	.33	.93	.89	.00	1.59	15.3	6.1
21	A	30.41	30.45	17.40	11.62	.66	4.17	1.40	.10	1.24	29.0	8.6
	B	37.95	26.17	17.48	9.87	.30	3.21	1.88	.10	1.69	27.2	9.7
	C	42.78	29.63	10.53	10.62	.62	3.32	1.50	.58	2.03	29.2	7.7

<sup>1</sup> Average values for chemical character of Chester colloids from Table 5.

<sup>2</sup> Values for colloids of a Chester soil profile deviating from typical characteristics.

In Table 9 are given the inorganic composition, base-exchange capacity, and water-vapor adsorption, of the colloids derived from a profile of soil collected by S. O. Perkins of this bureau near Longwood, Pa. The area is typically Chester and the sample in question seemed normal in character except in the color of the A horizon. The soil material from which it is derived is also somewhat different from that of the ordinary Chester areas. For comparison, there is also given the corresponding average values for the Chester colloids given in Table 5. The B horizon is normal for the Chester profile, but peculiar differences occur in both the A and C horizons. The silica-sesquioxide ratio is lower in the A horizon and higher in the C horizon than in any other Chester sample examined. This would seem to indicate an abnormally highly weathered A horizon and an unusual lack of maturity in the C horizon. The rather high and uniform content of monovalent and divalent bases indicate uniformly a lack of maturity in all horizons. The water of combination, which should correspond to the silica-sesquioxide ratio, is much too low in the A horizon. Although it is true that the Chester colloids offer variations from the mean, no other single colloid examined shows such a wide range as this one. The sample most closely approaching the profile in question is profile No. 13 in Table 5, which is from the same county, and approximately 20 miles away.

A general conclusion which may be derived from the data presented in this study is that the colloids of a given soil series are remarkably constant in character and essentially different from those of even closely related series. It would be obviously of great advantage to soil science to so relate laboratory examination to the field characteristics of soils that the identification of a series by laboratory investigation would be possible. Such a relationship would aid in the differentiation of series and assist in the classification of indeterminate areas and in the identification of doubtful samples. Unfortunately the present data are not adequate for such purpose, yet hope of ultimate success is offered when similar data for other soil series shall have been accumulated.



## SUMMARY

An investigation is made of the extent to which the colloidal material is characteristic of the soil series.

Complete chemical analyses of the colloids isolated from a number of samples of profiles from each of the Miami, Chester, and Cecil soil series are presented, together with their base-exchange capacity and water-vapor adsorption.

A description is given of each soil profile, its location, hydrogen-ion concentration, and colloidal content.

The variations within the profile characteristic of the soil series are pointed out. The relative constancy in composition of the colloids of each series is calculated and discussed. A comparison is made between the colloids from the different soil series.

The character of the colloidal material from a soil profile not typical of its series is compared with the mean of that series.

The slight variations occurring within the profiles of each soil series are very similar; furthermore, the manner of variation within the profiles of one series differs from that of another.

The colloids of the various profiles of a soil series are remarkably similar in character and are essentially different from those of even closely related series.

## LITERATURE CITED

- (1) ANDERSON, M. S., and BYERS, H. G.  
1930. CHARACTER OF THE COLLOIDAL MATERIALS IN THE PROFILES OF CERTAIN MAJOR SOIL GROUPS. U. S. Dept. Agr. Tech. Bul. 228, p. 24.
- (2) ——— and MATTSO, S.  
1926. PROPERTIES OF THE COLLOIDAL SOIL MATERIAL. U. S. Dept. Agr. Bul. 1452, 47 p., illus.
- (3) BALDWIN, M.  
1928. THE GRAY-BROWN PODOSOIL SOILS OF THE EASTERN UNITED STATES. First Internat. Cong. Soil Sci. Proc. and Papers 4: 276-282.
- (4) BRADFELD, R.  
1925. THE CHEMICAL NATURE OF COLLOIDAL CLAY. Jour. Amer. Soc. Agron. 17: 253-270, illus.
- (5) DAVENPORT, E.  
1907. PRINCIPLES OF BREEDING . . . 727 p., illus., Boston, New York [etc.].
- (6) DENISON, I. A.  
1930. THE CHEMICAL COMPOSITION OF COLLOIDAL MATERIAL ISOLATED FROM THE HORIZONS OF VARIOUS SOIL PROFILES. Jour. Agr. Research 40: 469-483.
- (7) GILE, P. L., MIDDLETON, H. E., ROBINSON, W. O., FRY, W. H., and ANDERSON, M. S.  
1924. ESTIMATION OF COLLOIDAL MATERIAL IN SOILS BY ADSORPTION. U. S. Dept. Agr. Bul. 1193, 42 p.
- (8) HALL, A. D., and RUSSELL, E. J.  
1911. SOIL SURVEYS AND SOIL ANALYSES. Jour. Agr. Sci. 4: 182-223.
- (9) HILLEBRAND, W. F.  
1919. THE ANALYSIS OF SILICATE AND CARBONATE ROCKS. U. S. Geol. Survey Bul. 700, 285 p., illus.
- (10) HOLMES, R. S.  
1928. VARIATIONS OF THE COLLOIDAL MATERIAL IN TYPICAL AREAS OF THE LEONARDTOWN SILT LOAM. Jour. Agr. Research 36: 459-470.
- (11) McCool, M. M.  
1927. RESULTS OF SOME PHYSICAL AND CHEMICAL STUDIES ON SOIL COLLOIDS. Jour. Amer. Soc. Agron. 19: 289-297.

- (12) MARRUT, C. F.  
1921. THE CONTRIBUTION OF SOIL SURVEYS TO SOIL SCIENCE. Soc. Promotion Agri. Sci. Proc. Ann. Meeting 41: 116-142, illus.
- (13) ———  
1922. SOIL CLASSIFICATION. Amer. Assoc. Soil Survey Workers Bul. 3, p. 24-32. [Micrographed.]
- (14) ROBINSON, G. W.  
1917. STUDIES ON THE PALAEOZOIC SOILS OF NORTH WALES. Jour. Agr. Sci. [England] 8: 338-384, illus.
- (15) ROBINSON, W. O.  
1922. THE ABSORPTION OF WATER VAPOR BY SOIL COLLOIDS. Jour. Phys. Chem. 26: 647-653.
- (16) ———  
1927. THE DETERMINATION OF ORGANIC MATTER IN SOILS BY MEANS OF HYDROGEN PEROXIDE. Jour. Agr. Research 34: 339-356.
- (17) ———  
1930. METHOD AND PROCEDURE OF SOIL ANALYSIS USED IN THE DIVISION OF SOIL CHEMISTRY AND PHYSICS. U. S. Dept. Agr. Cir. 139, 20 p.
- (18) ——— and HOLMES, R. S.  
1924. THE CHEMICAL COMPOSITION OF SOIL COLLOIDS. U. S. Dept. Agr. Bul. 1811, 42 p.
- (19) STEPHENSON, R. E.  
1929. COLLOIDAL PROPERTIES OF WILLAMETTE VALLEY SOILS. Soil Sci. 28: 235-247.

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<i>Division of Soil Chemistry and         Physics</i> .....	H. G. BYERS, <i>Principal Chemist,         in Charge.</i>

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