

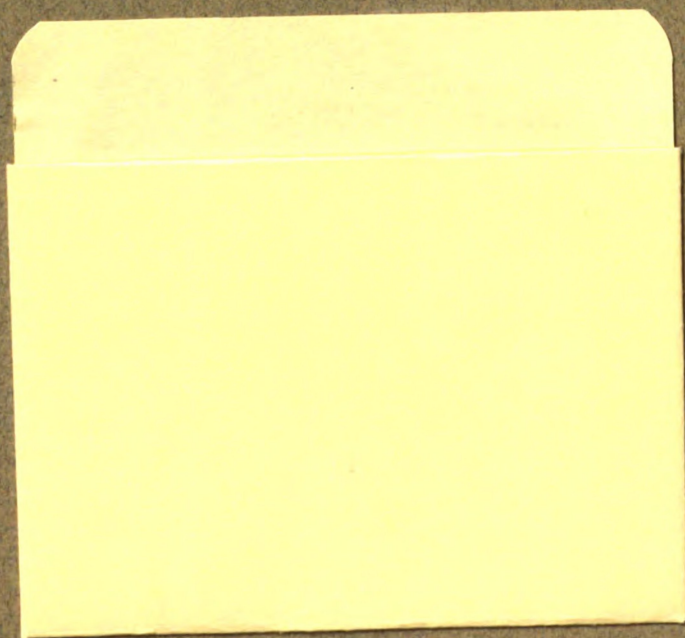


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A PROFILE STUDY OF FOUR EROSIVE
CLAYPAN SOILS OF THE
PIEDMONT PLATEAU REGION

Thesis for the Degree of M. S.
Howard T. Rogers
1936

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OF THE PEIDMONT PLATEAU REGION

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OF THE PIEDMONT PLATEAU REGION

By

Howard Topping Rogers

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A PROFILE STUDY OF FOUR EROSION CLAYPAN SOILS OF THE PIEDMONT PLATEAU REGION

INTRODUCTION

The Iredell, White Store, Helena, and Orange are four of the so-called "pipe-clay" soils of the Piedmont Plateau Region. These pipe-clay soils have heavy plastic clay zones in the B horizon. Soil surveyors have noted marked similarities in these soils from field observations. Some of the characteristics peculiar to this group are:

1. A highly impermeable plastic clay B horizon.
2. High erodibility for the slope position.
3. Fair to good surface drainage with markedly poor internal drainage.
4. Low crop-producing power.

The claypan nature of the B horizon of these four soils, linked with their apparent susceptibility to severe erosion, suggested a comparative study of their profiles. Quoting the Soil Conservation Service of the United States Department of Agriculture (32), "These soils are four of the most erodible soils in the Piedmont and at present we do not have sufficient data to enable us to make a statement as to the order of erodibility of these types. The field men place these soils in the order of White Store, Orange, Iredell, and Helena, with White Store the most erodible." As late as 1930, Middleton (16) wrote, "The literature reveals no laboratory studies which show any relation between erosivity and the physical and chemical characteristics of the soil types." A laboratory investigation of this nature would logically divide itself into two phases, a study of the physical and chemical properties of the soil in its entirety, and a study of the extracted colloids of the different horizons. The procedure would be to first determine the properties exhibited by the soils in common and then attempt to explain these characteristics by the nature of the colloidal fraction. This treatise will deal only with the properties of the soil profile.

DISTRIBUTION AND DESCRIPTION

The Iredell has been mapped in restricted areas over a wide range of the Piedmont Plateau Region. It has been estimated (19) that the Iredell comprises 2.36% of the Piedmont area of North Carolina, or about 473,152 acres; the White Store, 205,020 acres; Orange, 71,759 acres; and Helena, 20,800 acres. Their significant importance is due more to certain characteristics peculiar to the group, which are not readily explained by such influences as parent material, topographical location, and climatic conditions, than to the size of area occupied by the four soil series. The Iredell has been subjected to some investigations (23) (14) (27) because of the unusual properties of its profile. Marbut (15) pointed out that, in both regions of Red and Yellow and Gray-Brown Podzolic soils, dibasic igneous rocks have weathered to form extremely heavy plastic and tough clay materials. He reports that for these soils of the Iredell series no profile has yet developed, due partly to slightly imperfect drainage and imperfect oxidation, and notes the similar color of the surface soil and material beneath. Cobb (9) observed that the Iredell differs widely from typical soils of humid regions physically and chemically. He pointed out that it was called a young soil and that Marbut refers to it as an "AC soil", considering the clay horizon as weathered parent material and not a true B. Cobb disagreed with Marbut in these observations, as he concluded that the A horizon showed definite evidences of eluviation and podzolization, whereas the B horizon showed appreciable increases in alumina over the weathered rock beneath. He states that the Triassic sandstone and shale belt in North Carolina is cut by basic dikes which almost exclusively underlie Iredell soils. The slow development of the Iredell soils has been attributed to the deflocculated clay horizon which would serve to prevent the penetration of air and water. Davidson and Mecklenburg are soils which weathered from basic rocks in this area but show flocculation and oxidation of iron, with

the oxides moving down in the profile. Marbut (15) suggested that the Iredell A horizon developed by removal of finer particles which were not deposited in the B and C horizons.

*Table I. Chemical composition of four soil profiles -
Halifax County, Virginia.

Horizon	SiO ₂	R ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	MnO	P ₂ O ₅	K ₂ O	Na ₂ O	SO ₃	Al ₂ O ₃
Iredell loam												
A	55.45	25.89	11.24	.81	4.93	2.58	.35	.061	.254	.615	.268	13.43
B	44.93	40.39	14.91	.66	2.87	2.37	.06	.019	.182	.518	.105	24.75
C	47.49	30.37	12.12	.81	9.90	5.67	.21	.174	.568	.724	.099	17.00
White Store fine sandy loam												
A ₁	89.47	4.61	1.45	.11	.86	.32	.08	.06	.55	.10	.09	2.81
A ₂	91.13	4.91	1.50	.13	.81	.31	.06	.06	.54	.14	.12	3.16
A ₃	82.38	11.84	3.79	.27	.57	.41	.04	.15	.55	.11	.08	7.59
B ₁	60.70	29.09	7.21	.23	.35	.60	.04	.28	.43	.22	.08	21.33
B ₂	70.48	18.88	3.92	.20	.76	.61	.05	.21	.47	.27	.10	14.50
C ₁	68.73	25.13	4.81	.24	1.02	.70	.04	.27	.84	.59	.11	19.77
Helena fine sandy loam												
A ₁	91.52	4.08	.86	.18	.63	.35	.01	.181	.92	.22	.11	2.82
A ₂	93.57	4.11	.82	.22	.50	.36	.01	.066	.78	.16	.09	2.98
B ₁	81.63	13.36	2.51	.37	.41	.45	.006	.065	.66	.10	.08	10.40
B ₂	67.82	26.56	5.48	.32	.25	.93	Trace	.175	.46	.08	.98	20.58
C	60.33	35.99	5.28	.33	1.02	.88	.019	.060	1.82	.14	.10	30.29
Orange silt loam												
A ₁	85.97	7.71	2.86	.31	1.44	.31	.002	.38	.359	.153	.138	4.14
A ₂	88.31	8.81	3.36	.31	1.33	.30	.041	.37	.442	.135	.099	4.71
A ₃	81.54	12.84	4.39	.38	1.21	.47	.015	.07	.495	.096	.063	7.98
B	49.39	41.52	11.82	.39	.90	.85	.026	.06	.441	.108	.125	29.22
C	47.99	46.28	10.22	.36	2.71	1.57	.051	.07	.313	.475	.124	35.69

Analysis made on oven-dry samples; results given are average of duplicates.

*Recent unpublished data from The Virginia Agricultural Experiment Station, Blacksburg, Virginia.

The chemical analyses (Table I) show some important differences and points of similarity in the four soils. These points are best shown by the derived molecular values in Table II.

Table II. Relative molecular equivalents and ratios.

Horizon	*MOLECULAR EQUIVALENT COMPOSITION			MOLECULAR RATIOS		
	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	<u>Silica (sa)</u> Alumina	<u>Silica(sf)</u> Iron	<u>Bases (ba)</u> Alumina
Iredell loam						
A	.92	.070	.132	6.97	13.14	.48
B	.75	.093	.242	3.10	8.06	.17
C	.79	.076	.167	4.73	10.39	.72
White Store fine sandy loam						
A ₁	1.49	.009	.028	53.21	165.56	.71
A ₂	1.52	.009	.031	49.03	168.89	.65
A ₃	1.37	.024	.074	18.51	57.08	.24
B ₁	1.01	.045	.209	4.83	22.44	.08
B ₂	1.17	.025	.142	8.24	46.80	.15
C	1.14	.030	.194	5.88	38.00	.18
Helena fine sandy loam						
A ₁	1.52	.005	.028	54.29	304.00	.96
A ₂	1.56	.005	.029	53.79	312.00	.72
B ₁	1.40	.016	.102	13.73	87.50	.17
B ₂	1.13	.034	.202	5.59	33.24	.06
C	1.00	.033	.297	3.37	30.30	.15
Orange silt loam						
A ₁	1.43	.018	.041	34.88	79.44	.54
A ₂	1.47	.021	.046	31.96	70.00	.50
A ₃	1.36	.027	.078	17.44	50.37	.28
B	.82	.074	.287	2.86	11.08	.06
C	.80	.064	.350	2.29	12.50	.11

*These values were obtained by dividing the percentage of each mineral by its molecular weight. The molecular ratios were calculated from the molecular equivalents. The bases calculated in the base-alumina (ba) ratio included CaO, K₂O, and Na₂O₃.

Recognizing the danger of too much reliance on a total mineral analysis of soils, it seems that this method of expressing the composition data on an activity basis (molecules of the different minerals per unit weight of the soil) as suggested by Marbut (15), makes the picture less deceptive and more easily interpreted. The

molecular equivalents show evidences of translocation of iron and alumina compounds better than the percentage composition data.

A striking similarity of the four soils is the low base-alumina (ba) figure for the B horizon when compared with the parent material and the surface soil. Analytical data reported by Marbut (15) show the same characteristic for samples of Iredell from Iredell County, North Carolina. However, contrary to the data reported by Marbut (15), the data in Table II show a very definite accumulation of both iron and aluminum oxides in the B horizon of the Iredell. The same is true of the White Store and Orange profiles. In these soils, the molecules of these sesquioxides per unit weight of the soil are greater in number in the B than in the parent material or surface soil. The White Store, Orange, and Helena profiles show much greater losses of iron and alumina from the A horizon than the Iredell. This loss is not entirely accounted for in the concentration of these materials in the B horizon, and no doubt considerable quantities have been removed from the soil by leaching and erosion processes. The comparatively slow transition of iron and alumina in the Iredell profile may be due to the high percentage of bases present.

From the molecular relationships shown in Table II, it is very evident that the Iredell has undergone considerable weathering and transition of materials, but not to the same degree as the other soils in this group. There is considerable variation in the degree of profile development in the Iredell, as shown by samples from different locations and reports by different investigators.

Claypan Formation

It is doubtful if an entirely satisfactory explanation of the processes involved in claypan formation in humid regions has been offered. Smith (24) attempted to illustrate what may take place in the absence of a carbonate zone, such as is effective in the profile of the Chernozem claypan soils (8), by precipitating iron and clay sols on negatively-charged glass beads as a soil

skeleton. Smith pointed out that weathering processes in a humid region produce both negative silicate colloids and positive iron and alumina sols. Through illuviation processes, these positive colloids may build up on the negative sand particles as nuclei. In this manner, the "stone fruit-like" aggregate studied by Lutz (14) may be constructed by the alternate precipitation of negative and positive colloids. This is a less porous type of aggregate cemented with silica, the aggregates in turn being cemented together to form an impermeable soil layer.

The slope position of these soils is such as to give fair to good surface drainage (10). The Yadkin County, North Carolina, survey report (20) gives the topography of Iredell as level to gently or strongly rolling and its occurrence on interstream ridges and slopes. The samples taken for this study were found on the slopes and flat-top areas of the interstream ridges in the Virgilina District of Virginia. In each case, there was ample slope for good surface drainage.

Location and Profile Descriptions

Date Taken: December 28, 1934

Place: Halifax County, Virginia

Iredell sandy clay loam

Location: Four miles west of Halifax C.H. on Chatham road.

Cover: Mixed growth of blackjack, white, and red oak, and scrub pine.

A (0"-6") Dark gray-brown sandy clay loam, containing brown concretions or pebbles.

B (6"-18") Yellowish-brown heavy plastic clay which turns a rust-brown upon exposure to the atmosphere, and shrinks and cracks into large angular blocks.

C₁ (18"-22") Yellowish-brown and gray-speckled clay loam with evidence of decaying original rock.

C₂ (22"-26") Mingled dark green, brownish-yellow, and light gray soft decomposed rock.

Underlying rock - Basic rocks (diorite hornblende schist)

White Store sandy loam

Location: One and one-half miles southwest of Scottsburg towards Bannister River.

Cover: Mixed growth of blackjack and white oak, hickory, and scrub pine.

A₁ (0"-1") Gray fine sandy loam with small amounts of organic matter.

A₂ (1"-8") A light brownish-yellow fine sandy loam.

A₃ (8"-16") Brownish-yellow friable and crumbly fine sandy clay.

B₁ (16"-25") Brownish-yellow, with faint spots of dark red and yellow, stiff plastic clay.

B₂ (25"-35") A rust-brown or dull red heavy gritty clay.

C₁ (35"-42") A purplish or rust-brown friable clay loam, grading into the decomposed original sandstone.

C₂ (42"-50") Purple and rust-brown decomposed sandstone.

Underlying rock - Reddish-brown sandstone and shale.

Helena fine sandy loam

Location: Five miles southwest of Clover on Halifax C.H. Road.

Cover: Mixed growth of white oak, scrub and loblolly pine, and dogwood.

A (0"-6") A grayish-yellow fine sandy loam.

B (6"-35") A brownish-yellow and gray, with a few spots of red, heavy plastic clay which cracks into large angular blocks upon exposure.

C (35"-42") Rust-brown and gray soft decomposed rock.

Underlying rock - A mica and hornblende gneiss.

Orange silt loam

Location: Six miles southwest of Scottsburg on the Dryburg Road.

Cover: Red, blackjack, and white oak, hickory, and dogwood.

A₁ (0"-8") A grayish-yellow flour-like silt loam.

A₂ (8"-16") A yellow friable silty clay.

B (16"-27") Brown heavy plastic clay mottled with yellow and dark red colorations.

C (27"-38") Yellowish-brown clay loam with specks of white on yellowish-gray rotten rock.

Underlying rock - Virgilina greenstone.

Underlying Rocks

The underlying rock from which the parent material of each of these soils developed is quite different in character from that of the others (13). The points of sampling of White Store, Helena, and Orange were located on a geologic map of the Virgilina District (13).

The sandstone and shale which underlies the White Store is one of the disconnected areas of the Triassic (13) (22) found in the eastern portion of the Piedmont. The rock is deeply weathered with few natural exposures, which may contribute to the severe gullying characteristic of this type.

On the other hand, the Virgilina greenstone which underlies the Orange is not deeply weathered. Erosion has carried away the soil and parent material and allowed only a few feet of debris to develop over this slower weathering rock.

The mica and hornblende gneiss underlying the Helena is deeply weathered with the only outcrops along stream courses. This material is quite variable in character. The parent material of the Helena series, in general, developed from a mixture of acidic and basic rocks. The inconsistency of this material is reflected

in the soil which shows considerable variation in the degree of profile development and other characteristics.

EXPERIMENTAL

Physical Properties

The samples used in these studies were taken to the laboratory and screened through a 2 mm. sieve, air dried, and stored. Hygroscopic moisture determinations were made by drying a 2 gram sample at 110° C. for five hours. Maximum water-holding capacity was determined by the Hilgard cup method (11); moisture equivalent, by the method of Bouyoucos (4); and structural stability with 1N KCl solution, as outlined by Bouyoucos (3). The mechanical analysis was made by the Bouyoucos hydrometer method (5), and the aggregate analysis by a combination of the sieve method and the hydrometer method (6).

Table III. Moisture properties and relationships.

Soil	Horizon	Depth (in.)	Hygros. Moist.	Maximum Water Cap.	MOISTURE EQUIVALENT				SETTLING VOLUME				% Clay / .005 mm.
					Dist. Water	1N KCl	Change in M.E.	% Change Due to KCl	cc.Set. Vol-H ₂ O	cc.Set. Vol-KCl	cc.Change Due to KCl	% Change Due to KCl	
Iredell	A	0-6	1.59	49.89	23.05	31.55	+ 8.50	+36.9	12.35	13.25	+ .9	+ 7.28	23.9
	B	6-18	4.83	81.02	52.02	45.27	- 6.75	-13.0	19.4	19.0	- .4	- 2.06	62.6
	C ₁	18-22	3.04	66.85	34.74	26.82	- 7.92	-22.8	15.5	15.75	+ .25	+ 1.61	23.5
	C ₂	22-26	2.58	56.09	27.75	20.03	- 7.72	-27.8	13.5	13.75	+ .25	+ 1.85	19.9
White Store	A ₁	0-1	.49	40.98	18.85	13.03	- 5.82	-30.9	12.5	12.5	0.0	0.0	10.3
	A ₂	1-8	.30	30.25	11.11	10.16	- 0.95	- 8.6	11.0	10.45	- .55	- 5.0	12.0
	A ₃	8-16	.87	42.56	25.99	20.1	- 5.89	-22.7	13.25	13.25	0.0	0.0	30.7
	B ₁	16-25	2.85	77.77	43.78	44.33	+ 0.55	+ 1.3	18.7	19.7	+1.0	+ 5.46	58.7
	B ₂	25-35	1.76	64.79	33.91	32.48	- 1.43	- 4.2	17.4	17.6	+ .2	+ 1.15	42.6
	C ₁	35-42	1.47	55.01	31.01	30.35	- 0.66	- 2.1	15.3	16.35	+1.05	+ 6.89	22.3
	C ₂	42-50	1.23	49.61	21.18	17.82	- 3.36	-15.9	14.5	15.0	+ .5	+ 3.45	22.3
Helena	A	0-6	.17	32.29	12.96	11.97	- 0.99	- 7.7	9.85	10.3	+ .45	+ 4.56	13.6
	B	6-35	2.70	80.73	60.13	37.38	-22.81	-37.9	25.7	18.6	-7.1	-27.60	60.2
	C	35-42	2.43	64.38	40.54	25.91	-14.63	-36.1	16.25	15.5	- .75	- 4.62	25.7
Orange	A ₁	0-8	.24	42.64	29.68	25.74	- 3.94	-13.3	12.25	12.25	0.0	0.0	17.6
	A ₂	8-16	.41	45.72	28.77	23.47	- 5.30	-18.4	13.55	14.00	+ .45	+ 3.32	31.3
	B	16-27	2.10	91.80	46.52	49.23	+ 2.71	+ 5.8	20.4	22.00	+1.6	+ 7.88	74.4
	C	27-38	1.33	46.68	32.15	20.39	-11.76	-36.6	12.9	13.15	+ .25	+ 1.93	20.3

Effect of 1N KCl Solution on Structural Properties

Bouyoucos (3) suggested the effect of KCl on the water-holding power of a soil as a measure of the stability of its aggregates; likewise, its effect on the settled volume. Soils with unstable aggregates are reported to contract into smaller settling volume when saturated with KCl and to have lower moisture equivalent values.

This action of KCl might be due to the low hydration of the K-ion* which replaces H, Ca, Mg, and other ions on the soil colloids which possess more water-holding power. Jenny (12) concludes that clays with adsorbed divalent cations should contain more water than those saturated with monovalent ions. The exception to this is the monovalent H-ion, which has long been recognized for its peculiar behavior in ionic exchange. While it possesses little water of hydration during ionic exchange and is the smallest known ion, once adsorbed on the colloidal complex, it produces a highly hydrated system. Jenny (12) explains the hydrating properties of the different cations on a "space relationship" basis. In the case of H-ion systems, the additional water held is attributed to "chemical hydration". The position in the lyotropic series, as regards to degree of hydration, of the cations involved in base exchange with soil colloids has been established. This information with a knowledge of the cation constitution of the colloids in any given soil should provide a satisfactory explanation of such physical properties as swelling and water-holding capacity. Anderson (1) reports the order of the cation effects on heat of wetting and moisture adsorption to be $\text{Ca} \succ \text{Mg} \succ \text{H} \succ \text{K}$.

From the data in Table III, it is not possible to rank these soils as to the stability of their aggregates by the effect of KCl on settling volume and moisture equivalent. Some variations from the expected behavior are more significant. In fifteen out of the eighteen samples, KCl reduced the water-retaining capacity of the soil. However, significant increases were shown with Orange B

*Jenny, Hans - 1931. Behavior of Potassium and Sodium During the Process of Soil Formation. Mo. Res. Bul. 162.

and Iredell A. The effect of KCl in increasing the moisture equivalent value of the Orange B becomes more significant when a similar effect is noted on its settling volume. This electrolyte consistently increased the settled volume of this clay horizon in repeated trials, the average increase being 1.6 cc. or 7.9% of the settled volume in water. It is further noted that this horizon contains 74.4% clay ($\angle$.005 mm.) which is the highest clay content of any of the horizons of the four profiles. Approximately 90% of this zone is silt and clay. Just why this clay should swell and hold more water when saturated with KCl than when not treated with KCl must be attributed to some unusual qualities of its colloids. It would suggest that if the shrinking effect of KCl is due to the low hydration of the monovalent potassium ion, the Orange B colloids in their natural state must have adsorbed ions which possess lower hydration properties than potassium. Middleton, Slater, and Byers (18) pointed out that colloids of the lateritic type have small settling volumes and those with high silica-sesquioxide ratios much greater settling volumes. The cation exchange capacity of the colloids in Orange B is relatively low compared with that of the heavy clay zones of the other soils (Table VII). In fact, the cation exchange capacity of this clay with 76% colloids is about the same as that of the Iredell C₁ with less than 30% colloids. This points to the need for information on the quality and nature of the colloids and their adsorbed ions.

Aggregate and Dispersed Analyses

The degree of aggregation of the particles in a soil has a pronounced effect on soil structure and all of its related properties (2) (21) (27). Rhoades (21) defined the state of aggregation of a soil as its ability to break up into crumbs or granules. Tiulin suggested that only aggregates $\angle$.25 mm. in size are responsible for favorable soil structure, whereas Rhoades (21) proposed the point of intersection of the distribution curves, with and without dispersion. The latter

Table IV. Aggregate and dispersed analyses (% material).

Size of Particle (mm.)		Iredell sandy clay loam										Orange silt loam									
		A Horizon					B Horizon					C ₁ Horizon					C ₂ Horizon				
		Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.
Dispersed	Aggregate																				
1.0	7.84	4.93	21.6	1.03	16.6	.24	8.0	.48	12.0	1.63	3.0	1.42	2.8	.46	10.0	1.15	41.2				
1.0	.42-.84	8.65	16.6	1.67	19.6	.98	17.8	1.98	16.4	1.72	5.8	1.08	9.6	.41	17.4	1.64	14.6				
5-.5	.25-.42	8.57	8.0	2.32	10.2	5.31	13.0	9.76	18.0	1.95	3.0	1.35	4.8	.64	13.0	4.43	8.2				
5-.1	.177-.25	17.63	7.8	6.46	7.6	30.88	9.6	36.04	9.6	3.80	2.8	2.85	5.4	1.44	13.0	13.83	5.8				
5-.1	.149-.177	17.54	15.0	6.34	7.4	8.13	10.2	2.06	11.0	19.63	2.8	14.79	3.0	7.37	7.0	21.18	3.8				
.05	.05	42.68	22.5	82.18	26.0	54.46	30.5	49.68	25.0	71.27	62.6	78.51	60.0	89.68	39.4	57.77	24.4				
.03	.03	37.20	13.0	79.97	17.5	43.11	19.0	39.42	15.0	58.74	45.6	68.47	41.0	85.19	22.4	44.19	16.4				
.01	.01	23.05	7.0	68.52	10.0	29.29	2.0	26.07	7.0	30.67	17.6	42.37	12.0	76.0	5.4	27.37	5.9				
.005	.005	23.98	4.0	62.63	5.0	23.51	3.0	19.91	3.0	17.64	6.6	31.33	5.0	74.36	4.4	20.27	4.4				
.002	—	20.33	—	59.48	—	19.39	—	17.86	—	13.63	—	27.91	—	72.32	—	16.22	—				

Size of Particle (mm.)		White Store sandy loam										Helena sandy loam									
		A ₁ Horizon					A ₂ Horizon					A ₃ Horizon					B ₁ Horizon				
		Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.	Disp.	Agg.
Dispersed	Aggregate																				
1.0	7.84	1.13	5.4	1.76	4.0	1.97	5.4	.37	2.6	.53	5.6	1.99	8.0	1.26	5.6	.85	1.6	1.94	6.0		
1.0	.42-.84	3.99	14.2	3.63	7.2	2.99	10.4	1.34	8.8	1.08	6.4	8.62	22.4	7.15	13.8	1.61	2.8	5.34	17.2		
5-.5	.25-.42	9.25	9.0	8.99	11.0	8.77	11.0	4.55	9.0	2.56	7.0	21.99	5.8	13.10	13.0	3.41	4.4	13.10	18.6		
5-.1	.177-.25	30.97	10.2	30.40	9.0	22.25	10.0	21.26	11.4	19.78	8.0	19.74	11.6	28.78	12.4	9.02	5.2	24.81	8.4		
5-.1	.149-.177	22.30	10.0	22.12	9.0	17.21	7.0	7.54	8.6	21.24	9.6	9.59	5.6	19.56	9.0	13.06	4.2	9.6	9.6		
.05	.05	32.36	26.0	33.10	26.4	46.81	35.4	64.94	40.8	54.81	38.2	38.07	25.2	30.15	22.0	72.05	63.0	45.21	30.0		
.03	.03	23.92	14.0	23.07	15.4	39.75	24.4	58.43	31.3	40.80	27.2	34.02	19.2	26.64	14.0	69.99	54.5	39.06	23.5		
.01	.01	15.28	7.0	15.05	6.4	31.28	12.9	47.23	11.8	29.44	13.2	27.34	7.2	18.13	8.0	65.36	35.0	29.83	10.0		
.005	.005	10.25	4.0	12.04	4.9	30.67	4.4	42.55	6.8	22.33	6.2	22.28	5.2	13.63	6.5	60.23	24.5	25.73	5.0		
.002	—	8.24	—	10.03	—	26.63	—	39.09	—	20.30	—	21.26	—	11.63	—	59.20	—	22.14	—		

reported about the same results with hydrometer and elutriator methods for determining the per cent of structural elements. A comparative study of the Iredell and Davidson soils from North Carolina was made by Lutz (14). He found the Davidson granulated into large stable porous aggregates, whereas Iredell had a lower content of small compact aggregates.

The percentage of silt and clay which is aggregated into granules $\geq .05$ mm. in diameter was calculated from the aggregate and dispersed analyses data.

Table V. Degree of aggregation of the silt and clay.

Horizon $\rightarrow$	Iredell sandy clay loam				Orange silt loam			
	A	B	C ₁	C ₂	A ₁	A ₂	B	C
% of the silt and clay in aggregates $\geq .05$ mm.	47.3	63.4	43.9	49.7	12.2	23.6	56.1	57.8

Horizon $\rightarrow$	White Store sandy loam							Helena sandy loam		
	A ₁	A ₂	A ₃	B ₁	B ₂	C ₁	C ₂	A	B	C
% of the silt and clay in aggregates $\geq .05$ mm.	19.7	20.2	24.4	50.0	37.2	25.6	33.8	27.0	12.6	33.6

The per cent of silt and clay which was in aggregates $\geq .05$ mm. in the Helena B (the zone of minimum penetration) is only 12.6 as compared with 63.4 in the Iredell B. The White Store and Orange show slightly less aggregation of silt and clay than the Iredell. The degree of granulation in the heavy clay zone, the least permeable zone, determines the rate of percolation of water through the profile. Slater and Byers (25) pointed out the effect of the impervious zone on the percolation of water through the profile. This low aggregation of silt and clay may partly explain the fact that this soil settled out of suspension in distilled water very slowly, during the settling volume determinations. Colloidal

particles remained suspended in cylinders of distilled water for periods of two weeks in such quantities that accurate readings of the settled volume could not be obtained. This ease of dispersion of the colloidal fraction and the low per cent of silt and clay aggregated would lead to the conclusion that the Helena B is the most impervious of the four claypans studied. This conclusion is substantiated by the percolation ratio data in Table VII. Furthermore, this clay has the lowest colloid to moisture equivalent ratio of the four clay zones, as might be expected from its ease of dispersion, slight aggregation, and slow rate of settling. The only other soil in the four profiles which shows as little aggregation of silt and clay is the Orange A₁. This is readily explained by the large amount of silt in this zone. The per cent of the silt and clay which is in aggregates $\geq .05$ mm. in the Iredell B compares closely with the figures reported by Lutz (14). The soils with which he worked were prepared for the elutriator by screening through a 2 mm. sieve, as were the samples in this study.

Effect of Screening on Aggregates

Unquestionably, the treatment of samples previous to aggregate analysis determinations affects considerably the results obtained. Bouyoucos (6) used unscreened, air-dry lumps for the aggregate analysis with sieves and hydrometer. Baver (2) suggested "field moisture" and screened the soils through a 2 mm. screen for the elutriator. Yoder (31) suggested that screening destroys the larger aggregates and that "field moisture" introduces another variable. Rhoades (21) reported a high degree of aggregation with sieves when the soils have been air-dried and attributes this to the difficulty of rehydration after air-drying. It is doubtful if methods and procedure for structural analysis studies have been sufficiently perfected and standardized to make the data obtained more than indicative of general structural properties.

An unscreened sample of the Iredell B which had been air-dried was used to determine the effect of screening on the aggregates in a heavy clay.

Table VI. Effect of screening (2 mm.) on aggregates.

Size of Particle (mm.)	Iredell B		
	% Material		
	Screened	Unscreened	Dispersed (Screened)
7 2.0	—	6.0	—
.84-2.00	16.6	22.3	<u>mm.</u> (1.0-2.0) 1.03
.42-.84	19.6	30.1	(.5-1.0) 1.67
.25-.42	10.2	12.1	(.25-.5) 2.32
.177-.25	7.6	5.7	(.1-.25) 6.46
.143-.177	7.4	3.5	(.05-.1) 6.34
.05-.149	12.6	6.3	—
.03-.05	8.5	3.5	4.21
.01-.03	7.5	4.5	9.45
.005-.01	5.0	2.0	5.89
∠ .005	5.0	4.0	62.63

The data in Table VI show considerable distruction of the larger aggregates by screening through a 2 mm. screen. However, in evaluating the two methods the difficulty of representative sampling, when the samples are not mixed or screened, must be considered. Screening a heavy plastic clay of this type, which, when permitted to dry sufficiently to screen, becomes hard and brick-like, must alter the structure considerably.

Erosion Ratios and Related Properties

Middleton, Slater, and Byers (17) in their study of soils from the Erosion Experiment Stations have correlated certain physical properties of soils with their susceptibility to erosion. The most significant of these are the ratio of colloid to moisture equivalent, dispersion ratio, percolation ratio, and erosion ratio. The dispersion ratio was obtained by dividing the suspension percentage by the total per cent of silt and clay in a dispersed state, and multiplying the quotient by 100. The method for determining the suspension percentage of silt and clay used

by Middleton et al (17) approaches sufficiently the hydrometer aggregate analysis determination to use the latter figure. The percolation ratio was obtained by dividing the suspension percentage of silt and clay by the ratio of colloids to moisture equivalent. The relationship between the dispersion ratio and the colloid to moisture equivalent ratio was designated as the erosion ratio.

An examination of the derived data in Table VII points to some interesting variations in the expected behavior of the four profiles. It is assumed that the suspension percentage, dispersion ratio, percolation ratio, and erosion ratio vary directly as the erosivity of the soils and that the ratio of colloids to moisture equivalent decreases with erosivity. Within certain limits, then, the type of erosion and comparative degree of erosion may be predicted. As might be expected from the high silt content in the surface soil, Orange A₁ has the best combination of properties to induce severe sheet erosion. Excepting the surface one-inch organic matter layer of the White Store, the Orange A₁ has the highest erosion ratio of any of the surface horizons of the four soils. The Orange A₁ has a value of 85.3, whereas comparable horizons of White Store, Helena, and Iredell have erosion ratios of 59.1, 52.1, and 43.2, respectively. The supporting properties of erosion, dispersion ratio, percolation ratio, and colloid to moisture equivalent ratio rank these soils in the same order. The Orange A₁ (the most erosive soil) has a percolation ratio three times that of any of the other surface soils, with hardly significant differences in this property among the other soils. A low colloid to moisture equivalent value indicates that the colloid in question adsorbs water readily and holds it firmly. In this respect, the Orange surface soil is very efficient, which has been noted as characteristic of highly erosive soils. In contrast with the surface soil, Orange B was the least efficient of all the eighteen samples studied in its ability to take on water and hold it against gravitational

Table VII. Erosion ratios and related properties.

Horizon	(in.) Depth	% Colloid	Moist. Equiv.	Colloid M.E.* Ratio	% Sand & Silt (disp.)	% Clay (disp.)	Clay Ratio	Erosion Ratio	% Silt & Clay (disp.)	% Silt & Clay (aggreg.)	Disper- sion Ratio	Perco- lation Ratio
Iredell sandy clay loam												
A	0-6	28.05	23.05	1.22	74.70	23.98	3.12	43.2	42.68	22.5	52.72	18.4
B	6-18	68.52	52.02	1.32	36.39	62.63	.58	24.0	82.18	26.0	31.64	19.7
C ₁	18-22	29.29	34.74	.84	76.49	23.51	3.25	66.7	54.46	30.5	56.00	36.3
C ₂	22-26	26.07	27.75	.94	80.09	19.91	4.02	53.5	49.68	25.0	50.32	26.6
White Store sandy loam												
A ₁	0-1	15.28	18.85	.81	87.39	10.25	8.53	99.2	32.36	26.0	80.35	32.1
A ₂	1-8	15.05	11.11	1.35	87.37	12.04	7.26	59.1	33.10	26.4	79.76	19.6
A ₃	8-16	31.28	25.99	1.20	68.94	30.67	2.25	63.0	46.81	35.4	75.62	29.5
B	16-25	63.83	43.78	1.46	40.97	58.68	.70	34.0	70.00	34.8	49.71	23.8
B ₂	25-35	47.23	33.91	1.39	57.45	42.55	1.35	45.2	64.94	40.8	62.83	29.4
C ₁	35-42	29.44	31.01	.95	77.67	22.33	3.48	73.4	54.81	38.2	69.70	40.2
C ₂	42-50	27.34	21.18	1.29	77.72	22.28	3.49	51.3	38.07	25.2	66.19	19.5
Helena sandy loam												
A	0-6	18.13	12.96	1.40	85.62	13.63	6.29	52.1	30.15	22.0	72.96	15.7
B	6-35	65.36	60.19	1.09	39.43	60.23	.65	80.2	72.05	63.0	87.44	57.8
C	35-42	29.83	40.54	.74	74.27	25.73	2.89	89.7	45.21	30.0	66.36	40.5
Orange silt loam												
A ₁	0-8	30.67	29.68	1.03	81.12	17.64	4.60	85.3	71.27	62.6	87.83	60.8
A ₂	8-16	42.37	28.77	1.47	68.18	31.33	2.18	52.0	78.51	60.0	76.42	40.8
B	16-27	76.00	46.52	1.63	26.08	74.36	.35	27.0	89.68	39.4	43.93	24.2
C	27-38	27.37	32.15	.85	79.73	20.27	3.93	49.7	57.77	24.4	42.24	28.7

*Moisture Equivalent

pull, as was pointed out in the moisture relationships discussion. The high colloid to moisture equivalent value in Table VII bears this out. It was also concluded that Helena B is the most impervious to water penetration of any of the claypans. Its ease of dispersion, low degree of aggregation, and low percolation rate are reflected in the low colloid to moisture equivalent figure, high dispersion and percolation ratios, and high suspension percentage. The erosion ratio values increase with depth in the Helena profile. The result is that this soil would be expected to erode more rapidly, once the surface is removed by sheet erosion. The parent material of this Helena would be expected to move rapidly when gullying starts.

On the other hand, the parent material of the Orange, which has the most easily removed surface, has a low dispersion ratio and would be comparatively resistant to erosion. Moreover, it was previously pointed out that the underlying greenstone is a basic rock which is not as deeply weathered as some of the acidic rocks in this region. This combination of conditions would prevent the U-type gullying expected in the Helena and observed in some soils of the Piedmont.

The Iredell claypan has the lowest dispersion ratio of the four heavy clay zones, which may be associated with its comparatively high amount of silt and clay which is in aggregates γ .05 mm. in size. The result is a low percolation ratio and erosion value. It is the least erosive of the eighteen horizons of the four profiles.

Clay Ratio as a Criterion of Erosion

Bouyoucos (7) suggested the ratio of sand and silt to clay in a soil as a criterion of susceptibility of soils to erosion. He compared this textural relationship with the erosion ratio as reported by Middleton et al (17) and reports a fairly close agreement. The clay ratios of each of the eighteen samples were calculated and are shown in Table VII, alongside the erosion values. If the two

values are interchangeable, a reasonably high coefficient of correlation would be expected. The coefficient of correlation was determined and found to be $.262 \pm .2258$ (Table IX). This would indicate a very slight positive correlation between clay ratio and erosion ratio, which based on the standard error is wholly unreliable. For comparative purposes, the coefficient of correlation of the clay ratio data worked out by Bouyoucos (7) and the erosion ratio values reported by Middleton was calculated. A fair correlation ($.522 \pm .0902$) was found, but a coefficient of correlation of this magnitude suggests that erosional behavior can hardly be predicted from textural composition, if we assume the erosion ratio to be a reliable criterion of erosiveness.

Physico-Chemical Properties

Jenny (12) emphasized the effect of exchange adsorption on the physical, as well as chemical, properties of soils. Coagulation, dispersion, viscosity, hydration, and structure of clays are greatly affected by the nature and quantity of adsorbed ions. Differential leaching of bases is explained by the behavior of these cations during ionic exchange (30). The whole question of hydration of ions is introduced again when the exchange phenomena is considered.

As this study progressed, an increasing need for some information on the nature and properties of the colloidal fraction became evident. A number of observed structural properties should be better understood if such information were available at this point in the investigation. It was decided to determine the cation exchange capacity and total exchangeable hydrogen. From these data, total exchangeable bases and per cent base saturation were calculated. pH determinations with the quinhydrone electrode and organic matter determinations by the combustion train method were made in connection with the base exchange studies. The amount of exchangeable hydrogen and total exchange capacity were determined by the Parker barium acetate-ammonium chloride method (29). This method was modified by replacing the adsorbed ammonia with potassium by leaching the soil with 100 cc. of 4% KCl. After adding NaOH to the leachate, the ammonia was then distilled over into sulfuric acid and determined by titration with sodium hydroxide. Very good checks were secured, although extreme difficulty was experienced in leaching the heavy clay samples.

In the pH determination some difficulty was experienced in getting checks with the surface soil of Iredell. With different samples at different times a range of readings from pH 6.9 to 7.35 was secured, and considerable drift in potentiometer readings noted. The chemical analyses data in Table I show .35% MnO, which is a high concentration of this oxide. One p.p.m. of water-soluble manganese was found (26) in this soil. This high manganese content may account for the difficulty encountered with the quinhydrone method.

Table VIII. Base exchange properties, pH, and organic matter content.

Horizon	% Colloids	% Organic Matter	BASE EXCHANGE				pH
			Exchangeable Hydrogen *M.E.	Cation Exchange Capacity M.E.	Exchangeable Bases M. E.	Degree of Base Saturation (%)	
Iredell sandy clay loam							
A	28.05	1.32	2.69	8.03	5.34	66.5	7.3
B	68.52	.98	3.60	30.74	27.14	88.29	6.5
C ₁	29.29	—	1.78	21.21	19.43	91.61	7.2
C ₂	26.07	—	1.16	17.03	15.87	93.19	7.3
White Store sandy loam							
(0-1)							
A ₁	15.28	2.36	2.39	3.75	1.36	36.29	5.4
A ₂	15.05	.59	1.63	2.11	.48	22.75	5.0
A ₃	31.28	.39	5.30	6.73	1.43	21.25	4.6
B ₁	63.83	.35	17.1	25.60	8.5	33.2	4.7
B ₂	47.23	—	11.47	19.06	7.59	39.82	4.9
C ₁	29.44	—	7.75	15.77	8.02	50.92	5.1
C ₂	27.34	—	5.93	13.1	7.17	54.73	4.8
Helena sandy loam							
A	18.13	.65	.89	1.73	.84	48.55	5.5
B	65.36	.34	4.53	19.78	15.25	77.1	5.0
C	29.83	—	1.44	14.60	13.16	90.14	6.8
Orange silt loam							
A ₁	30.67	1.24	2.17	2.78	.61	21.94	4.9
A ₂	42.37	.49	2.86	5.00	2.14	42.8	4.8
B	76.00	.56	3.21	22.31	19.1	85.6	5.3
C	27.37	—	2.19	8.46	6.27	74.11	5.6

*Milligram Equivalents

The Iredell profile showed neutral to slightly alkaline reaction in the A and C horizons, whereas the B was slightly acid. Stevens and Cobb (27) (9) report that the clay horizon of the Iredell studied in North Carolina is always slightly alkaline. This neutral to alkaline profile distinguishes this soil from most soils of humid regions. The only horizon in the other profiles which approaches a neutral reaction is the parent material of the Helena. One clue to this high pH would be the high K_2O content of this material (Table I). This high K_2O content may be the result of weathering of the potash-alumino silicates, muscovite and biotite. A previous conclusion concerning the extreme impermeability of the Helena B is further substantiated by a minimum loss of exchangeable bases from the C horizon below, resulting in a high degree of saturation with basic elements. This is more evident when it is noted that the quantity of exchangeable bases held is comparable to that of the Iredell, which weathered from more basic rocks under similar climatic conditions. The high degree of base saturation in the Iredell B may partially account for the better aggregation of silt and clay in this zone (Table V).

The acid sandstone influence in the White Store profile is seen at a glance in both pH and cation exchange values. The White Store B_1 is only 33% saturated with bases, whereas the B of Iredell, Helena, and Orange are 88%, 77%, and 85% saturated, respectively. The high organic matter content of the White Store A_1 should be considered in connection with its high exchange capacity. Organic colloids have a much higher exchange capacity than mineral colloids.

The relative inactivity of the colloids in the Orange profile has been mentioned in discussing the unexpected behavior of Orange B in settling volume and moisture equivalent properties. While the parent materials of the four soils are uniform in colloidal content (27-30%), the cation exchange capacity of the Orange parent material is only about 50% of that of the other materials.

Table IX. Some relationships existing in the data on these four soils.

FACTORS CORRELATED	CORRELATION COEFFICIENT	NUMBER OF CASES
Clay ratio and erosion ratio	.262* ± .2258**	18
Hygroscopic water and maximum water-holding capacity	.806 ± .0848	18
Hygroscopic water and moisture equivalent	.749 ± .1065	18
Hygroscopic water and cation exchange capacity	.923 ± .0358	18
Per cent colloid and cation exchange capacity	.752 ± .1053	18
pH and per cent base saturation	.716 ± .1131	18
H-ion concentration and per cent base saturation	-.712 ± .1196	18

*Corrected for small number of cases by the formula $r^2 = 1 - (1-r^2) \frac{(N-1)}{N-2}$

**Standard error

Some of the relationships previously discussed are best shown by correlating certain factors. The coefficient of correlation (Table IX) for the clay ratio and erosion ratio data (Table VII) show that these two factors are only slightly related.

Relation of Hygroscopic Water to Maximum Water-Holding Capacity and to Moisture Equivalent

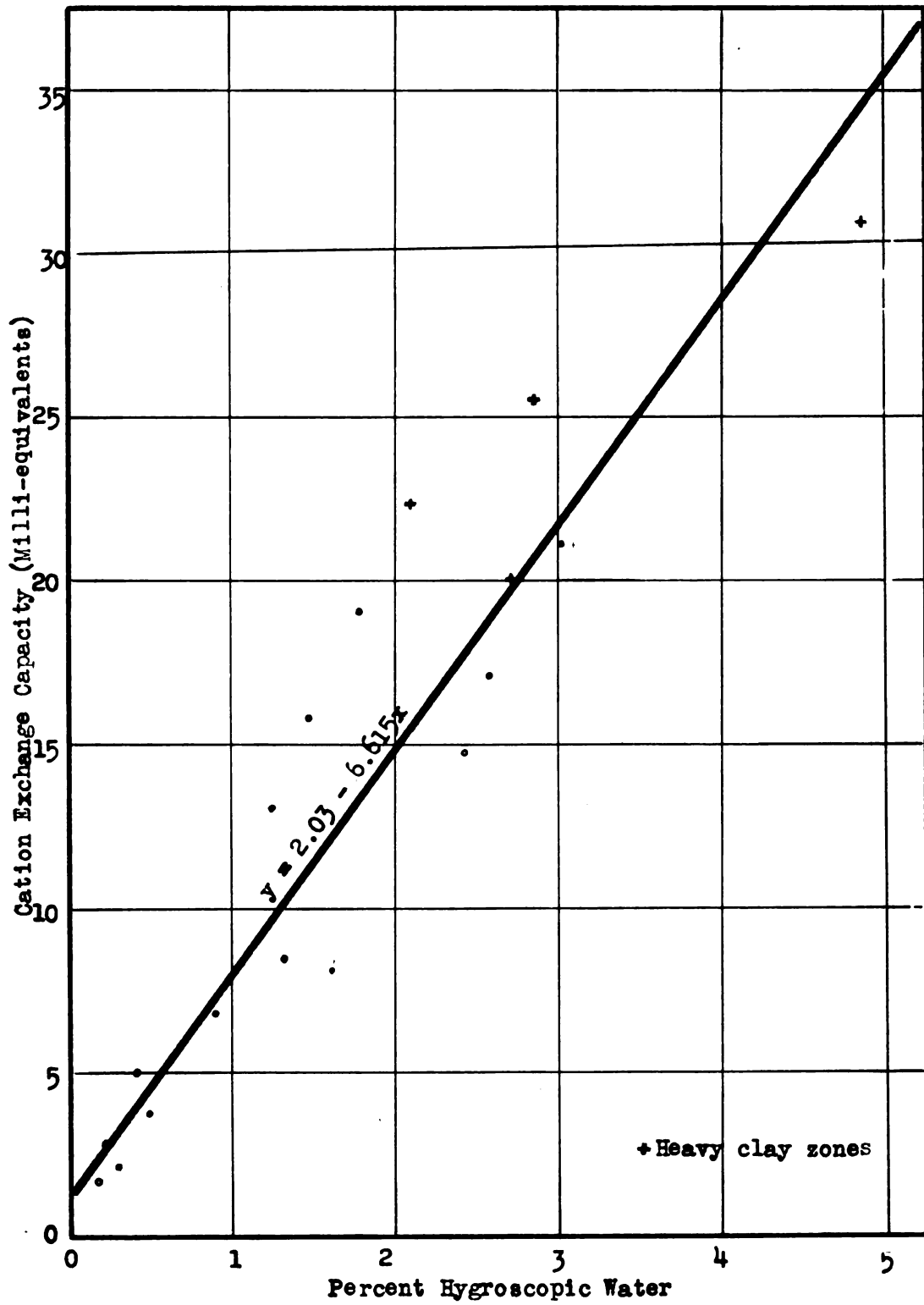
Turk and Millar (28) report a high correlation between hygroscopic water, maximum water-holding capacity, and moisture equivalent, in a Hillsdale sandy loam. They concluded that, since the methods used for these determinations are arbitrary and only relative at the best, the three determinations yield results of about equal value. The high correlation coefficients obtained when hygroscopic water and maximum water-holding capacity, and hygroscopic water and moisture equivalent were correlated point to the same conclusion. These correlations, showing the relationships existing between these properties in four complete profiles, emphasize the relationship between these water contents as well as those reported by Turk and Millar (28) which were obtained from one soil with different treatments.

Relation of H-ion Concentration to Per Cent Base Saturation

Identical correlation coefficients in opposite directions for pH and per cent base saturation, and H-ion concentration and per cent base saturation, as was obtained, would not be expected and is probably accidental with this set of data. A perfect linear correlation between pH values and H-ion concentration does not exist as the relationship is curvi-linear since the pH values are logarithmic. However, a reasonably high negative correlation coefficient would be expected when H-ion concentration is correlated with the per cent of base saturation. Similarly, a good positive correlation would be expected between H-ion concentration and per cent hydrogen saturation - but not with total exchangeable hydrogen. Walker, Firkins, and Brown (29) state, "It is reasonable to assume that the amount of replaceable hydrogen would have a direct relation to the hydrogen ion concentration of the soil". This relationship does not exist in a variety of soils with different exchange capacities. The H-ion concentration has no reference to the total amount of H-ions in the soil; but, as expressed by pH, is merely an expression of an equilibrium existing between H-ions and OH-ions. That this relationship does not exist between H-ion concentration and total exchangeable hydrogen is very evident from the data in Table VIII. White Store B₁ with a pH of 4.7 held 17.1 milligram equivalents of exchangeable hydrogen, whereas Orange A₂ with a pH value of 4.8 held only 2.86 milligram equivalents of exchangeable hydrogen. Moreover, Iredell A (pH 7.3) has 2.69 milligram equivalents of this cation, which is more than found in Orange A₁ with a pH 4.9.

On the other hand, a high negative correlation ($-.712 \pm .1196$) exists between H-ion concentration and per cent base saturation. White Store A₃ with the lowest pH (4.6) of the eighteen samples has the lowest per cent base saturation (21.25). Likewise, Iredell C₂ with the highest pH (7.3) has the highest per cent base saturation (93.19).

Figure I



RELATION OF HYGROSCOPIC MOISTURE TO CATION EXCHANGE CAPACITY

Relation of Hygroscopic Water to Cation Exchange Capacity

The correlation coefficient of most significance (Table IX) is that between hygroscopic water and cation exchange capacity. The correlation coefficient is $.923 \pm .0358$. Investigators have frequently noted the relationship between colloidal content of a soil and its ability to adsorb cations. To the writer's knowledge, no attempt has been made to correlate cation exchange capacity with another definite property of the colloidal fraction, such as its ability to hold hygroscopic water. Does the ability of a colloid to hold water against evaporation in air-dried conditions measure its ability or properties of ionic exchange? The correlation coefficient between these two properties is highly significant. The relationship is best shown in Figure I. The eighteen samples used in this study represent a wide range of textural properties, types of colloids, degree of base saturation, and other properties which might influence or reflect the factors of cation exchange capacity and content of hygroscopic water. If it is assumed that water adsorption and retention is a function of, and is proportional to, the surface exposed by soil colloids, we must conclude that base exchange is primarily a surface phenomenon from its close relationship to the moisture retention capacity of a soil.

SUMMARY

1. A study of the profiles of the Iredell, White Store, Helena, and Orange soils was made. These are four highly erosive claypan soils of the Piedmont Plateau Region of the Eastern United States.

2. The chemical composition, expressed as molecular equivalents, shows definite evidences of translocation of materials and profile development in all four soils. The Iredell shows the highest percentage of bases and least profile development.

3. The acid sandstone and shale of the White Store is deeply weathered, whereas the basic rocks underlying Iredell and Orange are less deeply weathered. The Helena developed from a mixture of acidic and basic rocks.

4. In structural stability tests, a 1N KCl solution reduced the water-retaining capacity of fifteen of the eighteen samples. The Orange B and Iredell A horizons showed significant increases in settling volumes and moisture equivalent values when saturated with KCl.

5. Only 12.6% of the silt and clay in the Helena claypan is in aggregates $\leq .05$ mm. as compared with 63.4% in the Iredell claypan. The colloids in the Helena B remained in suspension in distilled water for periods of two weeks or more. Such physical characteristics as a low colloid to moisture equivalent ratio, slight aggregation of silt and clay, ease of dispersion, slow rate of settling, and a high erosion ratio, indicate the Helena B to be the most impervious to water of the four claypans studied.

6. Aggregate analysis of screened and unscreened samples of Iredell B show considerable destruction of the larger aggregates by screening through 2 mm. sieves.

7. The erosion ratio and related properties indicate the Orange surface soil to be the most erosive of the four soils. In the Orange profile, erosivity decreases with depth. Severe sheet erosion rather than gullyng would be expected.

8. The erosion ratio values increase with depth in the Helena profile, which is indicative of rapid U-type gullyng, once the surface soil has been removed.

9. The Iredell B has the lowest dispersion ratio of the four claypans and a comparatively high amount of silt and clay in aggregates. With these characteristics and a low percolation ratio and erosion value, it should be the least erosive of the eighteen horizons.

10. Clay ratio as a criterion of erosion - a very slight positive correlation ($.262 \pm .2258$) was found between clay ratio and erosion ratio which due to the

magnitude of the standard error is unreliable.

11. The Iredell surface soil and parent material was neutral to slightly alkaline in reaction, whereas the B horizon was slightly acid.

12. The high degree of impermeability of the Helena B has apparently caused a minimum loss of bases from the parent material, as shown by a base saturation of 90.14% and pH of 6.8. This high pH was accompanied by a high K_2O content.

13. The acid sandstone influence in the White Store is reflected in pH and cation exchange values. White Store B_1 is only 33% saturated with bases, whereas the B horizons of Iredell, Helena, and Orange are 88%, 77%, and 85% saturated, respectively.

14. The colloids in the Orange profile are relatively inactive, as shown by a low ratio of cation exchange capacity to colloids.

15. High correlation coefficients obtained for both hygroscopic water and maximum water-holding capacity, and hygroscopic water and moisture equivalent show that any one of these values may be calculated from either of the others, by means of a constant, with a high degree of accuracy.

16. A high negative correlation ($-0.712 \pm .1196$) existed between H-ion concentration and per cent base saturation. The data obtained show that there is very little relationship between H-ion concentration and total exchangeable hydrogen in soils with different cation exchange capacities. White Store B_1 (pH 4.7) held 17.1 milligram equivalents of exchangeable hydrogen, whereas Orange A_2 (pH 4.8) held only 2.86. Iredell A (pH 7.3) held 2.69 milligram equivalents of this cation, which is more than that held by Orange A_1 (pH 4.9).

17. A correlation coefficient of $.923 \pm .0358$ was found when hygroscopic water content was correlated with cation exchange capacity. These two properties are more closely related than per cent colloid and cation exchange capacity (correlation coefficient $.752 \pm .1053$). This indicates that the ability of soil colloids to hold water against evaporation forces is an accurate measure of their ability to adsorb cations in ionic exchange.

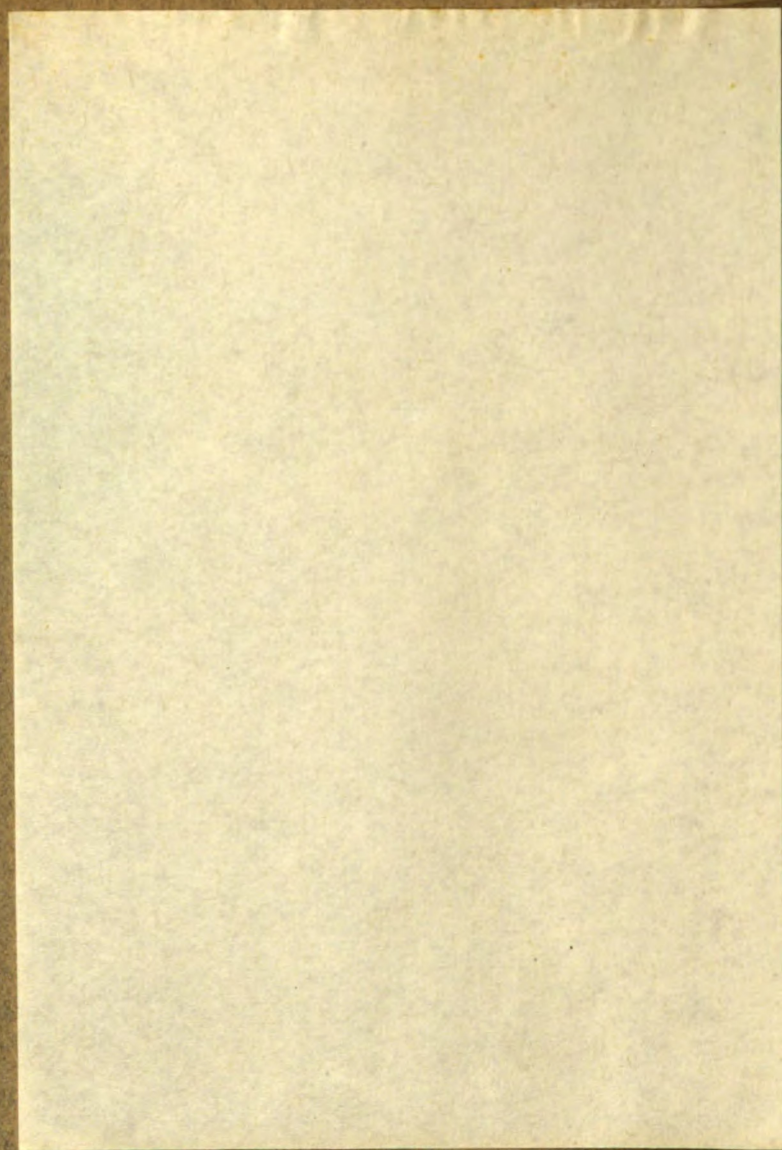
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