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Profile Properties of Some Loess-Derived Brunizem Soils of Southeastern Iowa[1]

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Brown (1936, p 18) summarized the information up to 1936 on the geography and classification of the prairie loess-derived soils of southeastern Iowa. The Tama and Grundy were the major series recognized. Field studies since 1942 indicated there was a need to revise the concept of these series. The present paper presents some data on selected profiles formerly classed with these series.

Profiles Studied

Six profiles were used in this study. Following the technique used by Hutton (1947) and Ulrich (1950) for southwestern Iowa, four profiles were collected on a loess-traverse beginning at about State Center and extending to southwest Henry County (Figure 4). An additional profile, Otley profile, P-18, was collected in northeast Lee County (See Figure 4).

Four of these profiles, P-261, P-262, P-263 and P-264 have been described in detail by Hunter (1950). The Tama profile collected in Marshall County has been reported on by Wilson, Riecken and Browning (1946). Brief descriptions of each of the profiles are given below, and a modal Otley, P-262, and the Grundy profile are described in somewhat more detail. The terminology used is essentially that given in the Soil Survey Manual (1951).

Profile P-262 (Otley* silt loam) was collected in a cultivated field on about a 4 percent slope near the SE NE Section 35, T. 77, R. 13 in Keokuk County. This profile is considered about modal for the Otley series. The A layer, extending to about 12 inches is a dark grayish brown (10YR3/2 moist) granular heavy silt loam; the 12-17 inch layer is transitional from the A to B horizon; the B layer extends from about 17 to 36 inches; the upper B is a dark yellowish brown (10YR4/4 moist) weak subangular blocky heavy silty clay loam, grading into a lower B horizon of slightly mottled yellowish brown (10YR5/4 moist) weakly developed, coarse blocky light silty clay loam; the C horizon from 36 to 48 inches is a slightly

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*Called Mahaska silt loam by Hunter (1950), but preferable name is Otley silt loam.

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mottled pale brown (10YR6/3 moist) to light gray brown (10YR 6/2 moist) light silty clay loam.

Profile P-261 (Otley* silt loam) was collected in a cultivated field, on about a 4 percent slope, near the NW½ SW of Section 29, T. 80, R. 15 in Poweshiek County. Profile P-261, grades towards the Tama silt loam; it has less clay in the B horizon than P-262, and is somewhat more "brownish" in color with fewer mottlings, indicating a somewhat better aerated (oxidized) profile than P-262.

Profile P-263 (Otley* silt loam) was collected in a cultivated field, on about a 4 percent slope, near the SW NW Section 34, T. 74 R. 11 in Keokuk County. This profile grades towards Profile P-264 (Grundy silt loam). Profile P-263 has slightly more clay and is more mottled in the B than is profile P-262, indicating it is somewhat more poorly aerated (oxidized).

Profile P-264 (Grundy silt loam was collected on about a 4 percent slope in a cultivated field near the SE SE NW Section 1, T. 70, R. 7 in Henry County. The A horizon, a very dark brown (10YR2/2 moist) friable silt loam, extends to about 14 inches; from 14 to about 18 inches a transitional A to B layer occurs; the B horizon extends from about 18 to 36 inches; the upper B is a dark gray (10YR4/1 moist) mottled, medium blocky silty clay, grading into a lower B of gray (10YR 5/1 moist), mottled, medium blocky heavy silty clay loam; the C horizon from 36 to 48 inches is a gray (10YR5/1 moist), mottled (with brownish yellow) silty clay loam.

The profile of Tama, P, collected about 2 miles north of Clemons in Marshall County, has been analyzed and reported on by Wilson, Riecken and Browning (1946). It is included in this study because it is considered to be essentially the starting point of the traverse towards southwestern Henry County.

An additional profile of Otley (P-18) included in this study was collected in an area of "local" loess in northeastern Lee County where a small area of the Mahaska-Taintor soil association has been shown by Simonson, Riecken and Smith (1952, p. 36) and indicated in Figure 4. Profile, P-18, was collected in a bluegrass roadside, on a 3 percent slope, near the southwest corner of the NW Section 21, T. 69, R. 5 in Lee County by W. D. Shrader and F. F. Riecken. It resembles profile P-262 in appearance.

Laboratory Studies

Mechanical analyses and porosity data were obtained on the

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Tama profile and have been reported on by Wilson, Riecken and Browning (1946). Similar data were obtained in this study on profiles P-261, P-262, P-263 and P-264. Mechanical analyses data were obtained on P-18.

Total nitrogen, pH and exchangeable cation were determined on two Otley profiles (P-262 and P-18) and the profile of Grundy (P-264). Such data on a Tama profile have been reported on by Smith, Allaway and Riecken (1950, p. 165).

Discussion

Physical Properties

The distribution of clay (less than 0.002 mm or 2 micron) with profile depth is given in figure 1 for some of the profiles. Data for the Tama profile, P- , previously reported by Wilson, Riecken and Browning (1946) are included for comparison. The Tama profile has about 33 percent clay at about 12 inches; the maximum clay content of the Tama soils usually occurs at 15 to 18 inches, but this particular Tama profile was collected in a cultivated field that had undergone moderate erosion. The Grundy profile (P-264) has about 45 percent clay at the 20-25 inch layer (B_2 horizon);

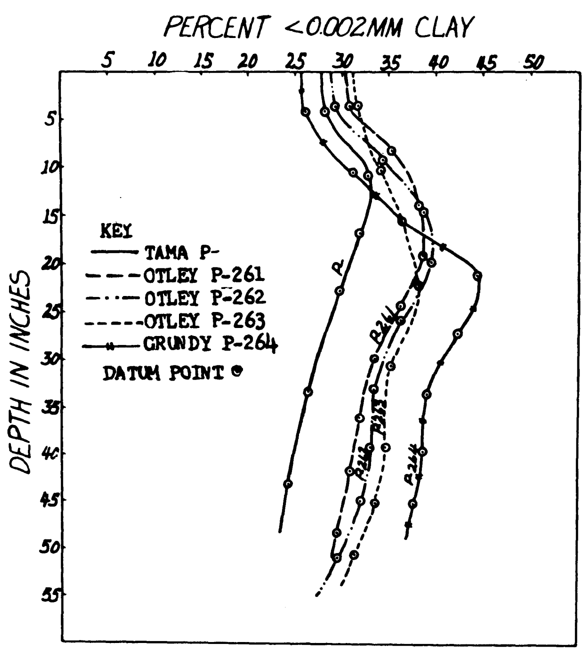

Figure 1. Distribution of clay (less than 0.002 mm or 2 micron) with depth in a Tama profile P- ; in three Otley profiles P-261, P-262 and P-263; and in a Grundy profile, P-264.

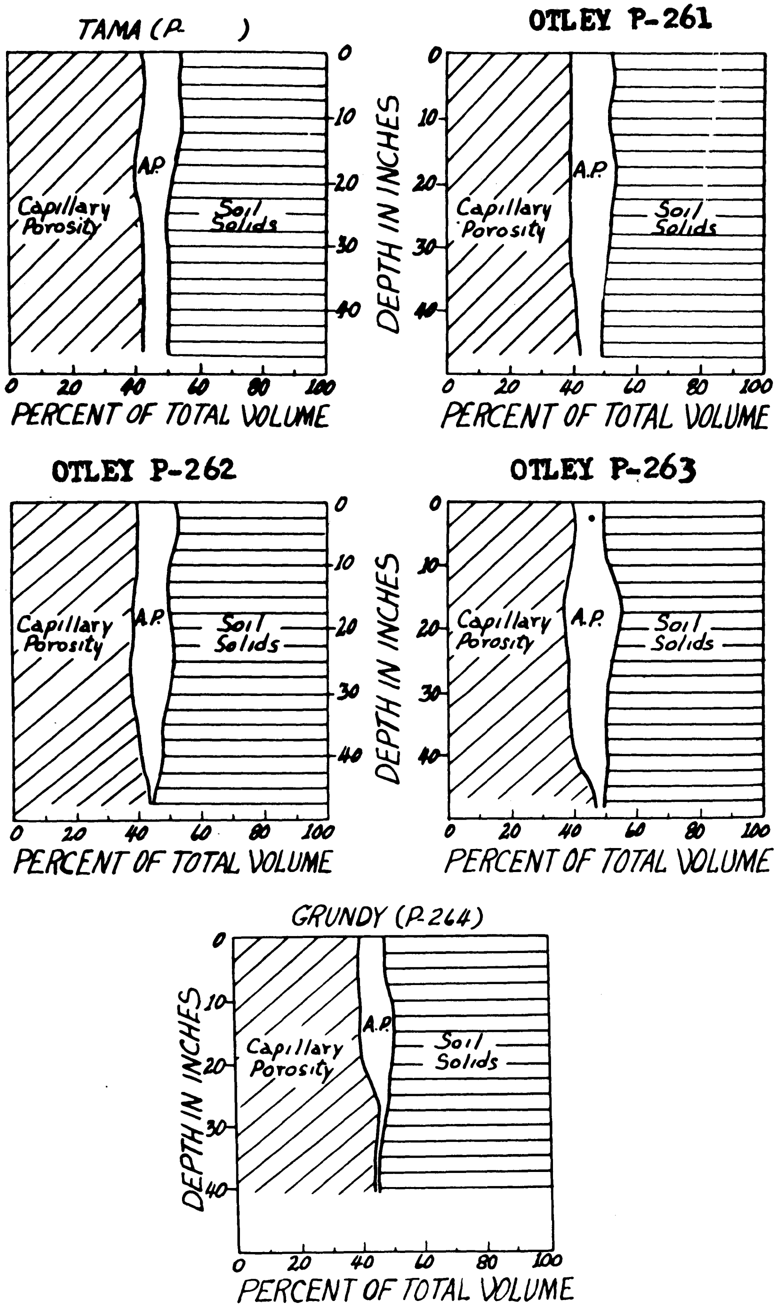

Figure 2. Capillary, aeration porosity (A.P.) and soil solids with profile depth of a Tama profile P- ; of three Otley profiles, P-261, P-262, P-263; and of a Grundy profile, P-264.

the Otley profiles (P-261, 262, 263) have about 38-40 percent clay in the 18 to 22 inch layer (B_2 horizon).

The Grundy profile (P-264) has the lowest clay content of any of the profiles in the surface (or A) horizon. Possibly some fine clay (less than .06 micron) has moved from the A to the upper B horizon as suggested by Ulrich (1950).

Porosity of the Profiles

Porosity data by the method described by Wilson, Riecken and Browning (1946) are shown graphically in figure 2. The aeration porosity (A. P. on figure 2) is highest in the Tama and Otley profiles, averaging about 8 to 12 percent. The Grundy profile (P-264) has a very low percent of aeration porosity below 25 or 30 inches. The aeration porosity data of the Otley profiles (P-261, P-262, P-263) are quite similar to the aeration porosity data of Sharpsburg soils reported by Wilson, Riecken and Browning (1946); the data on the Grundy profile (P-264) is quite similar to the aeration porosity data reported on a Grundy profile collected by the same workers in Clark County. Wilson, Riecken and Browning (1946) and Hunter (1950) have pointed out that for sloping soils with aeration porosity properties like Grundy soils, erosion control

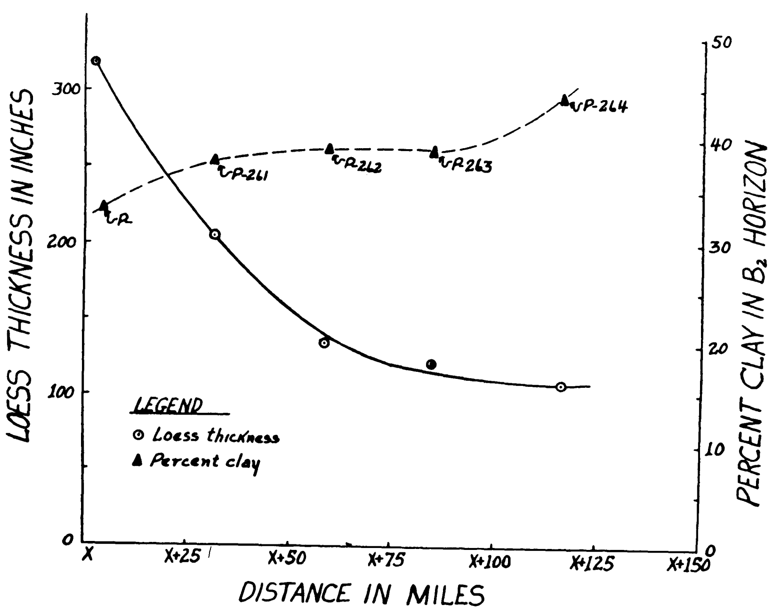

Figure 3. Relationship between loess thickness and maximum content of clay in the B_2 horizons of a Tama profile P,—3 Otley profiles (P-261, P-262 and P-263), and a Grundy profile, P-264. (As the definite source of the loess is not known the distance of the profile (Tama, P-) nearest the source is indicated by X).

is more complicated than on soils with aeration porosity properties like the Tama soils.

Loess Thickness and Profile Development

From figure 1, it is seen that the Tama profile has less clay in the B horizon than the B horizon of the Grundy profile; the B horizons of the Otley profiles have clay content intermediate between the Tama and Grundy profiles. To determine if the content of clay in the B horizon was associated with loess thickness, borings of the loess thickness were made on the closest flat to each of the profile sample sites. In figure 3, these loess thickness data and highest clay content of each of the B horizons are plotted. As the definite source of loess is not known, the Tama profile was indicated to lie "X" miles from the source. Distances of other profiles are measured from the site of the Tama profile. Figure 3 shows that the loess thins exponentially from about 320 inches (near State Center) to about 100 inches in southwest Henry County (near Salem).

From figure 3, it is also seen that there is a general inverse relationship between loess thickness and clay content of the B (B_2 or maximum clay content horizon) horizon. This relationship is not quite as regular as the relationship of loess thickness and B horizon development reported on by Hutton (1947) and Ulrich (1950) for certain loess-derived soils of southwestern Iowa.

Hunter (1950) has suggested that there might be more than one loess source for the Tama-Otley-Grundy soils of southeastern Iowa. While the major loess source of southwestern Iowa is undoubtedly the Missouri River bottomlands, it appears that the loess of southeastern Iowa has a more complicated and irregular source. Much of the loess of east-central Iowa originated from the Iowan drift plain (Kay and Graham (1943)) and can be called Iowan loess but the source of some of the loess of Jasper and other southeastern counties has been obliterated by the Cary and/or Mankato drifts. Radiocarbon dating (Libby 1952); Flint and Devey, (1951) P. 287) suggests that some of this loess may be as young as Tazewell in age. In addition, from limited observations it seems that the Skunk and Des Moines Rivers have been sources in places of small amounts of loess, possibly during each of the four Wisconsin substages.

Generally the three major prairie loess-derived soil associations of southeastern Iowa, namely the Tama-Muscatine, the Mahaska-Taintor and Grundy-Haig, occur in the major part as given by Simonson, Riecken and Smith (1952, p. 36) although small areas of Tama soils and Otley soils may occur where local loess occurs. Such an area has been shown by these workers in northeastern Lee

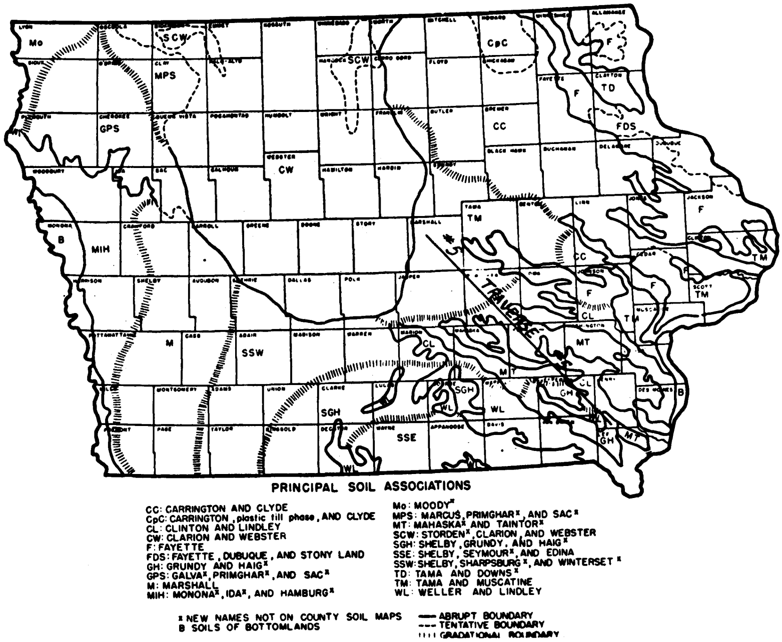

Figure 4. Location of travers (#5), along which the profiles were collected, and the location of the Mahaska-Taintor soil association in Lee County where the Otley profile, P-18, was collected.

County and indicated in Figure 4, where a small area of Mahaska-Taintor (and Otley) soil association occurs. Its occurrence in northeastern Lee County can only be explained on the basis of local loess; detailed loess thickness and profile development studies are needed in such local areas to aid in the clarification of the loess thickness-soil development relationship.

Chemical Characteristics

In Table 1 some chemical properties of 2 Otley profiles (P-262, P-18) and one Grundy profile (P-264) are given. The total nitrogen content is highest in the Otley profile (P-18) from Lee County. However, it was collected in a bluegrass roadside, whereas P-264 and P-262 were collected in cultivated fields; other studies have shown similar results (Ulrich (1950)) in comparing nitrogen content of near virgin soils as P-18 with cultivated soils as P-262 or P-264. The nitrogen content in all profiles reported in Table 1 are highest in the surface layer, then decrease, diffusion-like, with depth, as has been discussed for many Brunizem soils by Smith, Allaway and Riecken (1950). The nitrogen values for the Otley and Grundy profiles are quite similar.

The pH values for the Otley profile (P-262) and the Grundy profile (P-264) are essentially the same. The base saturation values are also very similar. Data for exchangeable Ca, Mg and K are also quite similar for these two profiles, except that there is a somewhat greater proportion of exchangeable Mg in the B horizon of the Grundy profile (P-264) than in the same horizon of the Otley profile (P-262). This relationship is in agreement with data reported by Catherwood and DeTurk (1928) for somewhat similar soils in Illinois. They considered that there was a lower ratio of exchangeable Ca to Mg in the soils with more B horizon development.

The exchangeable cation data and pH values for the Otley profile, P-18, are apparently not normal values; the exchangeable Ca values seem to high and exchangeable H values too low for the upper 15 to 20 inches; this profile was collected in a bluegrass roadside along a gravelled road and lime dust may have been responsible for causing these apparently abnormal values for exchangeable Ca and H. However, the data on clay in the profile show that the Otley profile, P-18, is quite similar to the other Otley profiles, with a clay content of about 38-39 percent in the B_2 horizons as compared to the value of about 44 percent for similar horizons in the Grundy profile.

Conclusions

The moderately sloping soils formed from loess under prairie vegetation show an inverse relationship between loess thickness and clay content in the B horizon. Three main series, namely Tama, Otley and Grundy, rather than two, are needed to show effectively these variations. The Otley soils have formerly been classified generally with the Grundy silt loam. The Otley series has properties intermediate between the Tama and Grundy, with most properties similar to the Tama.

Although there is a general relationship between loess thickness and profile properties, and though the general feature is that the Grundy series occurs farthest from the major source, it is apparent that local loess from the Skunk and Des Moines River causes deviations in this relationship. Properties of an Otley profile collected in northeast Lee County are similar to the other Otley profiles collected closer to the major source. The occurrence of the Otley profile (and related Mahaska and Taintor soils) in northeast Lee

Table 1

Clay content, exchangeable cations, pH and total nitrogen of selected layers of Grundy (P-264), and two Otley profiles, P-262 and P-18.

Horizon	Depth (inches)	pH[c]	<2 micron clay %	Total Nitrogen[b] %	Exchangeable cations m.e./100 gms soil[a] Ca	Mg	K	H	Base Saturation[d] %	Ratio Exchangeable Ca/Mg
				GRUNDY SILT LOAM (P-264)						
A_1	0-7	5.5	26.5	0.18	12.3	3.8	0.19	5.5	75	3.2
A_{11}	7-13	5.5	31.0	0.12	10.6	5.0	0.27	5.1	76	2.1
A_3-B_1	13-18	5.6	36.3	0.09	11.5	6.8	0.31	4.2	82	1.7
B_2	18-24	5.8	44.1	0.07	14.2	9.3	0.41	3.8	82	1.5
B_3-C_1	30-36	5.9	38.9		14.9	9.8	0.43	2.8	90	1.5
C_2	42-48	6.1	37.3		16.6	10.8	0.41	2.1	93	1.5
				OTLEY SILT LOAM (P-262)						
A_1	0-7	5.3	29.2	0.17	10.4	4.0	0.30	6.4	70	2.6
A_{11}	7-12	5.1	34.2	0.11	10.1	4.6	0.33	5.8	72	2.2
A_3B_1	12-17	5.0	38.1	0.09	12.1	7.2	0.35	4.9	80	1.7
B_2	17-23	5.3	39.3	0.06	13.8	8.2	0.38	4.3	84	1.7
B_3-C_1	30-36	5.9	33.5		13.9	8.1	0.36	3.9	85	1.7
C_2	42-48	6.1	32.0		14.1	8.4	0.34	2.7	89	1.7
				OTLEY SILT LOAM (P-18)						
A_{11}	0-4	7.6	29.7	0.29	28.7	2.8	1.23	0.2		
A_{12}	4-8	7.6	30.3	0.24	25.0	2.3	1.04	0.0		
A_{13}	8-12	7.5	31.8	0.19	22.4	2.8	0.83	0.8		
A_3B_1	12-16	7.1	34.3	0.15	18.4	3.4	0.86	1.5		
B_{21}	20-23	6.6	38.5	0.09	15.2	8.2	0.77	2.0		
B_{23}	26-28	6.4	38.4	0.07	14.8	9.8	0.65	1.7		
B_3C_1	32-36	6.2	36.4	......	14.3	9.5	0.58	2.0		
C_2	44-50	5.9	30.7	0.03	12.7	6.0	0.46	1.7		

[a]H+ determined by the Ba acetate method; Ca^+ Mg^{++} and K^+ by the NH4 acetate method, with K^+ by the flame photometer.
[b]Total nitrogen by Kjeldahl method by C. L. Coutas.
[c]pH by glass electrode.
[d]Base saturation is the ratio of Exch. Ca+Mg+K/Exch. Ca, Mg K+H times 100.

County can best be explained on the basis of local loess from the Skunk River.

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