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Properties of Two Profiles of the Hayden Series[1]

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The soils formed under forest vegetation from Late Wisconsin glacial till in Northcentral Iowa were classified, according to the summary by Brown (1936), chiefly with the Conover series. In the soil survey of Story County, similar soils were classified with the Ames and Lindley series according to Meldrum, Perfect, and Mogen (1941). The Ames series is a Planosol formed under forest vegetation and occurs on nearly level to slightly level areas. As the Lindley soils occur principally in the Kansan till area, they include soils with ferretto-like profiles. Thus, it seemed desirable to introduce a new series for most of those soils classified as Lindley in the Story County soil survey and for the sloping soils mainly classified as Conover in Boone County. Therefore, the Hayden series, originally established in Minnesota as the Gray Brown Podzolic correlative of the Clarion series, a Brunizem, has been introduced into Iowa as has been discussed by Simonson, Riecken, and Smith (1952).

This paper is a report of a study of two Hayden profiles, with a discussion of its relationship to the Clarion series and also to some other Gray Brown Padzolic series.

Description of Profiles

One Hayden profile was collected in the Cary till area. It was collected on an 8 percent slope in an area of white oak and bluegrass near the NE corner of Section 29, T. 82, R. 26 in Boone County. This profile, P-396, has a thin (0-3″) very dark gray (10YR 3/1 moist) loam A_1 horizon; from 3 to 9 inches, there is a dark grayish brown (10YR4/2 moist) sandy loam A_2 horizon; a transition A_3-B layer occurs from 9-13 inches; the B horizon extends from 13 to about 36 inches, the upper part of which is a medium blocky, dark brown (10YR4/3 moist) slightly plastic loam; the C horizon from about 36 to 50 inches is a light yellowish brown (10YR 6/4) friable calcareous loam.

The other Hayden profile, P-401, was collected in the Mankato till area. It was collected in a mixed tree-grass area on a 10 percent slope near the SE corner of Section 34, T. 87, R. 27 in Webster

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County. The description, essentially according to terminology of the Soil Survey Manual (1951), is given below:

A_1	0-3″	(1)	Very dark gray (10YR3/1 moist) friable granular loam.
A_2	3-7″	(2)	Dark grayish brown (10YR4/2 moist) friable loam, with weak platy to fine blocky structure.
A_3	7-11″	(3)	Dark brown (10YR4/3 moist) friable loam with weakly developed fine blocky structure.
B_{21}	11-16″	(4)	Dark brown (10YR4/3 moist) slightly plastic light clay loam; with medium blocky to sub-angular blocky structure.
B_{22}	16-21″	(5)	Dark grayish brown (10YR4/2 moist) slightly to medium
	21-26″	(6)	plastic light clay loam, with medium blocky to sub-angular blocky structure.
B_3	26-31″	(7)	Yellowish brown (10YR5/4 moist) with some dark grayish
	31-36″	(8)	brown slightly to medium plastic heavy loam to light clay loam.
C_1	36-42″	(9)	Yellowish brown (10YR6/4 moist) with some dark grayish brown, friable loam, calcareous.

The Hayden series developed under forest vegetation is classified as a Gray Brown Podzolic soil (Simonson, Riecken, and Smith, 1952). They classified the Clarion soils, formed from similar calcareous friable Late Wisconsin (Cary and Mankato) till under prairie on moderate slopes as a Brunizem. The Clarion soils have a thicker (10-12″), darker (10YR3/1) surface layer (A_1), and a B horizon without the distinctive blocky structure of the Hayden series.

Laboratory Studies

Mechanical analysis, exchangeable cations (Ca, Mg, K, H), pH, and total carbon and nitrogen were determined on the two Hayden profiles. The methods used are described by Green (1952). In addition, "free iron oxides" by the method of Swenson (1951) was determined on the whole soil. The data are presented in Table I.

In addition, some data from several other profiles are included for comparison. These data are included in Figures 1, 2, and 3. Data for the Clarion loam profile P-49 and P-97 have been presented by Riecken, Allaway, and Smith (1947); the free iron oxide data have been discussed by Green (1952).

Discussion

Clay Distribution

The data on distribution of clay (less than 2 micron) as is illustrated in Figure 1, show a greater content of clay in the B horizon at depths of about 15 to 30 inches for the Hayden profiles, P-396 and P-401. Data on two Clarion profiles, P-49 and P-97, by Riecken, Allaway, and Smith (1947) show that in the Clarion profiles the clay content of the B horizon is less than the clay content of the B horizon of the two Hayden profiles. These data for the P-97 profile are also shown in Figure 1. Shrader (1950) has suggested that for soils developed from similar parent materials of the same geological age, those developed under forest will have lower clay content in the A horizon than those developed under prairie. This conclusion would seem to apply to the difference in the texture profile of the Hayden and Clarion profiles. However, one might be somewhat more certain of this interpretation if the parent materials of the Hayden profiles, P-396 and P-401, were more uniform, as for instance if the parent material was loess.

In Figure 1, the clay distribution with depth of a Weller profile,

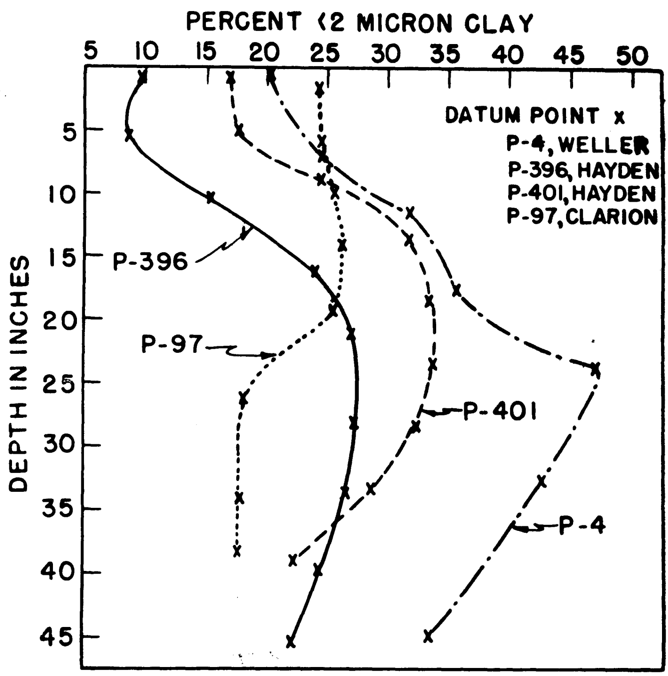

FIGURE 1. DISTRIBUTION O <2 MICRON CLAY WITH DEPTH OF TWO HAYDEN PROFILES AND A WELLER PROFILE, AND A CLARION (P-97) PROFILE.

P-4, is included. The Weller profile is formed from loess under forest. It occurs typically on slopes of 3 to 4 percent gradient in southeastern Iowa. The Weller profile is considered to have a rather well-developed B horizon. As it has developed from pre-Cary-Mankato loess, it is an older soil and represents a more ad-

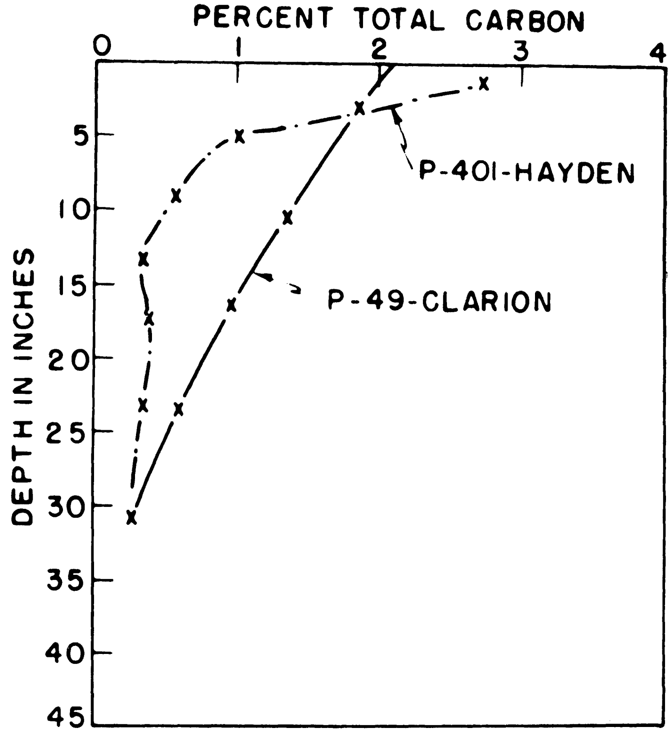

FIGURE 2 DISTRIBUTION OF TOTAL CARBON WITH DEPTH OF A HAYDEN (P-401) AND A CLARION (P-49) PROFILE.

vanced stage of weathering than do the Hayden profiles. One might hypothesize, as Smith, Allaway, and Riecken (1950) have done for Brunizem soils, that with time, and no change in other factors of soil formation, the Hayden profiles will develop increased amounts of clay in the B horizon, much as now occurs in the Weller profile. If the Weller profile is approaching the "maximal" stage of weathering, then the Hayden profiles are possibly in the "minimal to medial" stage of weathering (Smith, Allaway, and Riecken, 1950).

Organic Carbon and Exchangeable Cations

In the Hayden profiles, the organic carbon content is highest in the immediate surface (0-3″) layer, and decreases rapidly in the next layer (A_2); it remains almost constant at lower depths. In Figure 2, the distribution of organic carbon is shown with depth for the Hayden profile, P-401. Also in Figure 2, the distribution of organic carbon with depth for a Clarion profile, P-49, is shown (data from Riecken, Allaway, and Smith, 1947). The organic carbon content of the Clarion profile, a Brunizem, decreases gradually, diffusion-like, with depth. This is a feature of most Brunizem profiles as has been pointed out by Smith, Allaway, and Riecken (1950). As these writers point out, however, the organic carbon of Gray Brown Podzolic soils decreases abruptly from the thin immediate surface layer.

From Table 1, the pH values for the Hayden profiles are highest at the immediate surface (A_1), then reach a minimum in the lower A (A_2) to upper B (B_2) horizon. This is also a characteristic of most Gray Brown Podzolic soils; this is in contrast to most Brunizems which have the lowest pH values at the surface, with a gradual, diffusion-like, increase in pH values with depth (Smith, Allaway, and Riecken, 1950).

Free Iron Oxides (Calculated as Fe)

Free iron oxides of the Hayden profiles by the method of Swenson (1951) are given in Table 1. The highest free iron oxide values occur in the B_2 horizon, also the horizon of highest clay content. In general the content of free iron oxides is closely associated with the clay content, which relationship is also brought out by comparing distribution with depth of the free iron oxide and clay in the Hayden profile, P-401, in Figure 3 and 1, respectively. The highest content of free iron oxides is about 1.32% for the Hayden profile P-401. From Figure 3, it is seen that the free iron oxide content of the Hayden profile, P-401, has a different distribution with depth than does the Clarion profile, P.49.

Conclusions

The Hayden profiles, P-396 and P-401, have properties like those described for other Gray Brown Podzolic soils. There is no indication that the profile P-396, collected in the Cary till in Boone County is weathered more than the profile (P-401) collected in the Mankato till area in Webster County. The Hayden profiles are much less weathered than the Weller profile, based on the content of clay in the B horizon.

In contrast to the diffusion-like distribution with depth of organic carbon and pH of the Clarion profiles, the Hayden profiles have an abrupt decrease of organic carbon from the surface and minimum pH values in the lower A and upper B horizons.

Table 1

Mechanical analyses, pH, total carbon and nitrogen, and exchangeable cations for Hayden profiles, P-396 and P-401.

Horizon	Depth inches	pH	Total C %	Total N %	Exchangeable cations m.e./100 gms.				Base Saturation %	Free Iron Oxides %	Mechanical analysis	
					Ca	Mg	K	H			Sand %	<2 micron clay %
					Hayden loam, P-396							
A_1	0-3	6.0	2.43	0.23	8.0	1.4	0.25	3.1	76	0.46	52.3	9.1
A_2	3-9	5.7	0.50	0.07	2.8	0.6	0.16	1.7	68	0.44	54.2	7.4
A_3	9-13	5.2	0.36	0.06	5.1	1.4	0.19	2.3	75	0.68	50.2	15.2
B_1	13-19	5.3	0.41	0.07	8.8	2.6	0.20	2.1	85	0.91	44.8	24.2
B_{21}	19-25	5.1	0.33	0.06	10.4	3.3	0.22	2.7	84	1.04	42.2	27.1
B_{22}-	25-31	5.2	0.29	0.06	10.5	3.7	0.24	2.4	86	1.27	44.7	27.0
B_3	31-37	5.4	0.23	0.06	11.6	3.8	0.24	2.2	88	1.28	41.3	27.1
B_3C_1	37-42	7.2	0.36	0.06	11.8	3.6	0.22	....		1.25	41.3	24.4
C_1	42-50	8.0	2.63	0.05	......	....	......	....		0.71	36.7	14.4
					Hayden loam, P-401							
A_1	0-3	6.1	2.71	0.25	12.0	3.3	0.33	3.8	81	0.54	30.8	17.0
A_2	3-7	6.0	1.00	0.18	8.4	2.1	0.14	2.2	83	0.58	30.6	17.8
A_3	7-11	5.7	0.59	0.10	10.1	3.6	0.42	2.7	84	0.73	27.6	24.2
B_1	11-16	5.0	0.34	0.09	12.3	5.3	0.31	3.8	83	1.15	30.7	31.7
B_{21}	16-21	4.9	0.40	0.09	13.4	6.1	0.28	3.8	83	1.30	32.3	33.6
B_{22}	21-26	4.8	0.39	0.08	13.7	6.6	0.30	3.4	86	1.29	35.4	33.8
B_{31}	26-31	5.2	0.39	0.08	15.0	6.9	0.31	2.6	90	1.32	37.0	32.3
B_{32}	31-36	6.6	0.36	0.06	15.7	6.9	0.26	1.0	96	1.18	36.4	28.2
C	36-42	7.8	1.42	0.06	......	....	0.21	....		0.90	34.0	22.3

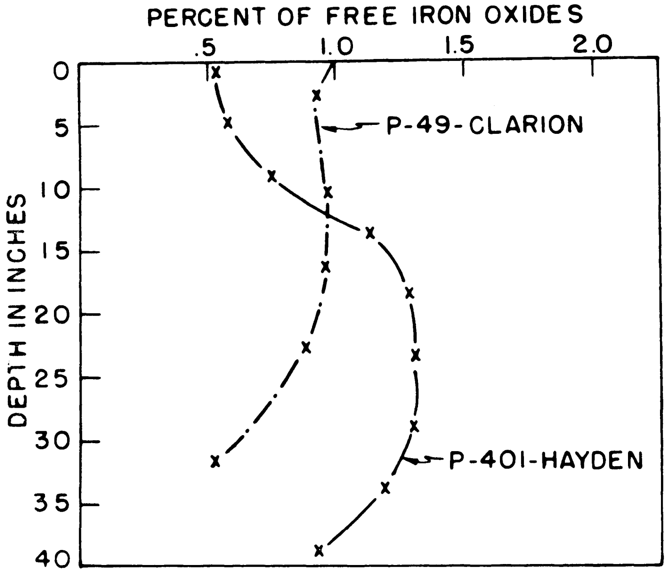

FIGURE 3 DISTRIBUTION OF FREE IRON OXIDES WITH DEPTH OF A HAYDEN (P-401) AND A CLARION PROFILE (P-49).

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