SOILS OF THE HIGH TERRACE REMNANTS IN THE UPPER OHIO VALLEY

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INTRODUCTION

Soils on the high terrace remnants along the upper reaches of the Ohio River are similar to the dominant ones of the nearby uplands in some instances, but not in others. Major soils of the bordering uplands are members of the Gray-Brown Podsolic and associated groups (U. S. Dept. of Agriculture, 1938, pp. 1043–1044), which also include some of the soils on the high terraces. Certain soils on the terraces, however, have many characteristics of the Red-Yellow Podsolic group. Reasons for this are not readily apparent, though there seem to be several possible explanations. In an effort to gain further insight into their nature and origin, four profiles representative of major soils of the high terraces were examined carefully and described in detail. Two profiles were sampled by horizons for laboratory analysis. The lithology of the sediments in the terrace remnants was also studied to get some measure of its bearing on present soil character. These sediments, as they exist today, are in fact largely also soils and the nature of the highest level of glacial outwash is best described by description of its soil morphologies. Results of the study are reported in this paper.

DISTRIBUTION, TOPOGRAPHY, AND EXTENT OF THE TERRACES

Remnants of a high glacial outwash terrace, preserved mainly in former stream meanders, are scattered along the upper Ohio Valley (Leverett, 1902, pp. 84–94, 121–125, 1929, p. 229, 1934, pp. 101–102; Ireland, 1940, 1943; Hubbard, 1954). These lie mainly along the valley walls south of the glacial boundary (White, 1951), which is about 8 miles north of the study area.

These terrace remnants, lying at elevations of 960 to 1020 ft are the highest of four glacial outwash terrace levels along the Ohio River. Lower terraces occur at general elevations of 720, 760, and 850 ft. In the study area, the present channel of the Ohio River is at an elevation of approximately 650 ft. Uplands bordering the river valley consist of the knobs and ridges of the unglaciated but dissected Allegheny Plateau, largely between elevations of 1160 and 1260 ft. The general region is thus dominantly hilly.

The terrace remnants have been partly dissected but are gently sloping for the most part. The valley edges are marked by escarpments, though outcrops of bedrock form hills between a terrace remnant and the river channel in places.

The total area of the terrace remnants is not large, even though they are scattered along a considerable stretch of the river. Individual bodies are small, commonly ranging from one-half to a mile in width.

They are found at the Riverview Greenhouse, Chester (Leverett, 1934, pp. 101–102), the low level reservoir in East Liverpool (Leverett, 1902, p. 252), Spring Grove (fig. 1), Vulcan, Tomilson Run and Toronto (Leverett, 1902, p. 250), Globe Hill (Lessig, 1959a), south of New Cumberland (fig. 3) and between Salt Run and Rush Run (fig. 3).

SOIL PROFILE STUDY METHODS

Soil profiles were studied on two terrace remnants, one near East Liverpool and the other just west of Vulcan and Wellsville, Ohio (Hubbard, 1954, p. 368). The remnant near East Liverpool (fig. 1) will be called the Riverview Greenhouse Terrace in this paper, the name of a greenhouse on the terrace itself. The remnant west of Vulcan and Wellsville will be called the Vulcan Terrace. Specific locations of these profiles are given with the data on their morphology.

Profile descriptions follow the conventions and terminology outlined in the Soil Survey Manual (Soil Survey Staff, 1951), except as noted subsequently. Conventions for characterizing quantities of pebbles and the coats and stains of various kinds on ped faces are not provided in the Soil Survey Manual. Consequently, the quantities of pebbles are indicated as estimated percentages by volume and they were identified visually, by means of a hand lens, where such identification is noted. Coatings and stains on ped faces are described in terms of color according to Munsell notations, and in terms of estimated thickness and texture. Soil horizon colors are given for moist conditions and include Munsell notations. Determinations of pH, made colorimetrically in the field, are given in the profile descriptions but those reported in tables 1 and 2, together with data

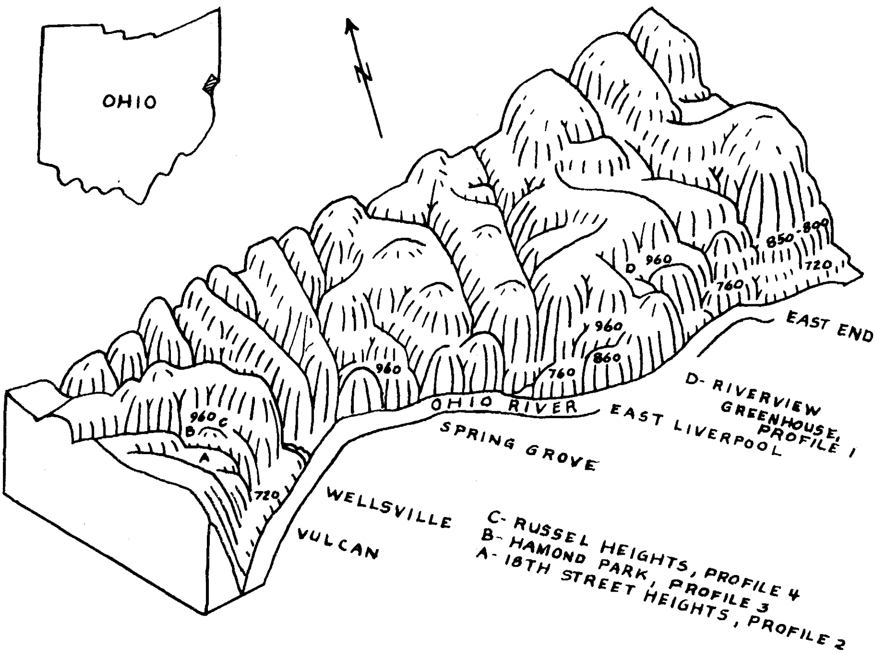

FIGURE 1. Block diagram of region around the Riverview Greenhouse and Vulcan Terraces.

on particle size distribution are laboratory determinations. Mechanical analyses were made in the laboratories of the Ohio Agricultural Experiment Station, according to the procedure described by Kilmer and Alexander (1949).

SOIL PROFILE ON THE RIVERVIEW GREENHOUSE TERRACE

This terrace remnant has a total area of about 300 acres and lies little more than one-half a mile north of the Ohio River near East Liverpool. The terrace forms parts of Secs. 12, 18 and 35 Liverpool Township, Columbiana County, Ohio (Wellsville, Ohio, W. Va-Pa. quadrangle map of the U. S. Geological Survey).

The profile was described and sampled at a point 900 ft southeast of the Riverview Greenhouse, which is at the corner of Anderson Boulevard and Thompson Park Road in East Liverpool. Approximately 1500 ft from the terrace escarpment, the site is in the north-central part of Sec. 18 and has a convex slope of 3 percent. Elevation is 1005 ft above sea level.

The glacial outwash in the terrace remnant ranges in thickness from 1 to 40 ft, with thick deposits occuring up to 1020 ft. In places near the valley wall, the outwash is covered by deeply weathered colluvium. Underlying bedrock has been observed at elevations of 960 ft or slightly less, though there are two hills of bedrock between the terrace remnant and the Ohio River.

Profile 1.—Description of well-drained profile from silty alluvium over glacial outwash. (Described and sampled by W. H. Hale and H. D. Lessig)

Depth and Horizon	*Profile Description*
0–2 in. A_1	Very dark grayish brown (10YR 3/2) silt loam; weak very fine crumb structure; friable; pebbles 3%; neutral (field limed); boundary abrupt smooth.
2–10 in. A_2	Dark brown (10YR 4/3) silt loam with few coarse faint very dark gray (10YR 3/1) stains; weak fine crumb structure; friable; rotted pebbles 3%; neutral; boundary abrupt smooth.
10–16 in. B_1	Dark brown (9YR 4/4) silt loam; moderate medium subangular blocky structure; dark grayish brown (10YR 4/2) 2 mm thick silty coats on ped faces; friable; rotted pebbles 1%; strongly acid; boundary clear smooth.
16–23 in. B_{21}	Dark brown (7.5YR 4/4) fine silt loam with common fine black Mn stains; moderate medium subangular blocky structure; very thin reddish brown (5YR 4/4) clay coats on ped faces; friable; rotted pebbles 3%; strongly acid; boundary clear smooth.
23–44 in. B_{22}	Strong brown (7.5YR 4/6) and yellowish red (5YR 4/5) sandy clay loam; strong medium angular blocky grading to strong coarse angular blocky structure; very thin reddish brown (5YR 4/4) and black Mn stained clay coats on ped faces; firm; rotted pebbles 10%; strongly acid; boundary gradual.
44–92 in. B_{23}	Yellowish red (5YR 4/6) gravelly sandy clay loam to sandy loam with common medium black Mn stains; moderate very coarse subangular blocky structure breaking to thick platy peds; 1 mm thick yellowish red (5YR 4/8) clay coats on horizontal ped faces, very thin strong brown (7.5YR 4/6) clay coats on vertical ped faces; firm; rotted pebbles 30%; strongly acid; boundary gradual.
92–108 in. B_3	Strong brown (7.5YR 4/6) gravelly loamy sand with many coarse faint dark yellowish brown (10YR 4/4) mottles; very weak coarse subangular blocky structure; black Mn stains on ped faces; firm in place, friable when disturbed; clay coated rotted pebbles 50%; strongly acid; boundary gradual.
108–120 in. C_{11}	Dark brown (10YR 4/3) gravelly loamy sand with many coarse black Mn stains; single grain structure; firm in place, very friable when disturbed; rotted pebbles 70% which crush in the fingers when rubbed; strongly acid; boundary gradual.
120–204 in. C_{12}	Dark reddish brown (5YR 4/4) gravelly sandy loam; single grain structure; very friable to non-coherent at 204-in. depth; pebbles 70% becoming harder at 204 in., pebble count of 950 pieces:—oxidized sandstone and siltstone which break in the fingers 69%, chert ghosts 6%, strongly altered quartzites 12%, ghosts of granite and other crystalline rocks 9%, concretions 4%; strongly acid. Note:—Gravel extends to 40-ft depth according to landowner and observation on nearby terrace escarpment, large crystalline cobbles are found in nearby excavations.

Major morphological features are: lack of well-defined fragipan, a well-drained profile, clay formed to 92 in. and clay coating on pebbles to 108 in., reddish hue

TABLE 1

Partical size distribution (in mm) (percent) of soil at Profile 1

Depth in inches	Horizon	Very coarse sand 2–1	Coarse sand 1–0.5	Medium sand 0.5–0.25	Fine sand 0.25–0.1	Very fine sand 0.1–0.05	Total sand	Silt 0.05–0.002	Clay <0.002	Fine clay <0.0002	pH
0–2	A_1	1.1	3.1	4.2	4.6	4.4	17.4	66.3	16.3	4.8	6.6
2–10	A_2	0.9	2.7	4.1	4.8	4.0	16.5	66.8	16.7	4.1	4.8
10–16	B_1	0.4	2.3	3.9	4.3	3.3	14.2	64.9	20.9	6.3	4.8
16–23	B_{21}	0.5	3.3	6.2	7.3	5.1	22.4	55.1	22.5	9.4	4.8
23–28	B_{22}	0.9	7.7	16.7	20.1	8.3	53.7	23.5	22.8	10.1	4.7
28–34	B_{22}	1.0	7.4	17.1	20.7	8.4	54.6	23.5	21.9	9.6	4.7
34–44	B_{22}	1.1	8.9	18.6	21.4	7.9	57.9	21.1	21.0	10.2	4.7
44–64	B_{23}	1.3	10.5	20.1	22.9	8.0	62.8	18.7	18.5	7.9	4.8
64–82	B_{23}	2.2	12.7	22.3	24.5	8.5	70.2	15.8	14.0	6.2	4.8
82–92	B_{23}	3.6	20.4	22.6	20.0	7.9	74.5	11.7	13.8	5.2	4.7
92–108	B_{31}	8.8	23.0	20.3	18.2	9.3	79.6	12.7	7.7	2.4	5.1
108–120	C_1	9.7	31.4	14.4	14.3	10.9	80.7	12.4	6.9	2.9	4.9
120–144	C_1	6.3	24.6	12.8	17.6	14.7	76.0	18.0	6.0	1.1	5.0
144–168	C_1	5.1	12.8	18.9	21.7	13.9	72.4	19.5	8.1	2.0	5.1
168–204	C_1	8.5	27.9	15.8	14.2	10.6	77.0	15.5	7.5	1.0	5.0

TABLE 2

Partical size distribution (in mm) (percent) of soil at Profile 3

Depth in inches	Horizon	Very coarse sand 2–1	Coarse sand 1–0.5	Medium sand 0.5–0.25	Fine sand 0.25–0.1	Very fine sand 0.1–0.05	Total sand	Silt 0.05–0.002	Clay <0.002	Fine clay <0.0002	pH
0–1	A_1	3.5	3.2	1.5	2.4	2.7	13.3	74.6	12.1	2.8	3.7
1–6	A_2	1.7	1.9	0.5	0.5	1.0	5.6	74.9	19.5	4.8	4.0
6–9	A_3	1.3	1.9	0.7	0.7	1.1	5.7	76.9	17.4	3.5	4.4
9–14	B_1	0.8	1.2	0.4	0.4	1.3	4.1	68.2	27.7	10.5	4.7
14–22	B_{21g}	0.5	1.0	0.5	0.8	1.8	4.6	54.1	41.3	24.2	4.7
22–32	B_{22}	1.5	1.9	1.0	1.6	3.1	9.1	59.3	31.6	10.5	4.8
32–42	B_{23}	2.2	3.3	1.6	2.4	3.9	13.4	55.0	31.6	9.7	5.1
42–48	B_{31}	0.7	1.1	0.7	1.1	2.4	6.0	64.4	29.6	8.4	5.5
48–55	B_{32}	0.7	1.3	0.8	1.2	1.8	5.8	50.1	44.1	14.0	6.0
55–60	B_{32}	1.5	2.3	1.7	2.4	2.6	10.5	45.2	44.3	14.9	5.8
60–80	B_{33}	0.5	1.6	1.0	1.4	1.6	6.1	43.7	50.2	16.9	6.5
80–110	B_{33}	0.1	0.1	0.2	0.3	0.2	0.9	44.0	55.1	12.3	7.0
110–135	C	0.1	0.1	0.5	1.1	0.6	2.4	37.0	60.6	15.3	7.4
135–153	$D_1(A_b)$	0.1	3.6	36.9	39.3	4.8	84.7	7.6	7.7	2.3	7.4
153–160	$D_2(B_{1b})$	0.1	3.0	17.5	33.2	14.0	67.8	17.4	14.8	6.3	7.4
160–190	$D_3(B_{2b})$	0.1	0.3	3.5	29.4	21.7	55.0	27.8	17.2	6.9	6.4
190–240	$D_4(C_b)$	0.1	0.2	5.7	45.1	20.1	71.2	17.1	11.7	4.6	6.3

with a strong chroma in the soil horizons between 23 to 92 in. These are properties of Red-Yellow Podsolic Soils (Simonson, 1950).

The upper part of the solum, with a slightly different morphology, is formed in silty material (table 1) which is common to these high terrace remnants on the Ohio side of the river. It contains a few cobbles and pebbles, does not extend as a silty mantle to nearby higher surfaces and contains about 4 percent of coarse and very coarse sand. It is interpreted by the author to be of alluvial origin rather than wind deposited. Its color and structure tend to grade to the color and structure of the underlying gravelly horizon. A soil developed in wind deposited material at Globe Hill on the West Virginia side (Lessig, 1959a) has only 0.7 percent of coarse and very coarse sand. However, without more conclusive evidence, contamination by loess cannot be precluded from the silty layer on the Riverview Greenhouse Terrace.

SOIL PROFILES ON THE VULCAN TERRACE

This terrace remnant occupies an area of about 450 acres a half mile northwest of the Ohio River near Vulcan and Wellsville, in parts of Secs. 10, 15 and 16, Yellow Creek Township. It is occupied by the suburbs of Russel Heights, 18th Street Heights and Hamond Park.

The bedrock surface beneath the Vulcan Terrace is irregular, ranging from 1010 to below 940 ft. The material covering the bedrock belongs to several geological events. Sandy and gravelly glacial outwash covers the bedrock at most places where it was observed, but in some positions near the valley wall the outwash is covered by 2 to 11 ft of lacustrine material. This is calcareous at a 9-ft depth (Profile 3). At the valley wall, the lacustrine material is underlain

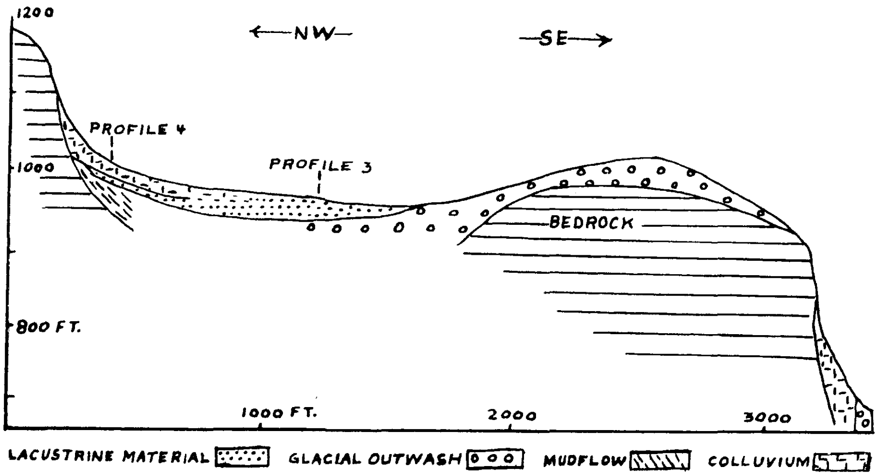

FIGURE 2. Section through Vulcan Terrace at Hamond Park.

by a thick mudflow from local higher rock layers and overlain by colluvium which is poorly sorted as though deposited in shallow water near a shore (Profile 4). Upslope the colluvium is much thicker and is not sorted.

The glacial outwash varies within short distances from silty and sandy alluvium, containing a few pebbles, to gravelly outwash. At 18th Street Heights large cobbles of crystalline rocks are frequent while only a few are found at Russel Heights. The soil developed in the gravelly outwash is similar to that at the Riverview Greenhouse and comments with regard to morphological data on the profile on the Riverview Greenhouse Terrace largely apply to the gravelly soils of the Vulcan Terrace.

The morphology of a soil developed from silty and sandy outwash at 18th Street Heights is described at a point 150 ft west of the terrace escarpment between two houses at the south end of West Street. It is on a three percent slope in the southwest corner of Sec. 10, Yellow Creek Township. Elevation is 980 ft above sea level.

Profile 2.—Description of a moderately well drained intergrading to a well-drained profile from silty glacial outwash over sandy glacial outwash. (Described and sampled by W. H. Hale and H. D. Lessig)

Depth and Horizon	*Profile Description*
0–1 in. A_1	Black (N 2/0) silt loam; moderate very fine crumb structure; friable; no pebbles in sample, large cobbles of sandstone and quartzite in area of sample pit; extremely acid; boundary abrupt wavy.
1–8 in. A_2	Very dark grayish brown (10YR 3/2) silt loam with coarse irregular zones of A_1 tonguing into A_2; moderate medium platy structure breaking into weak fine granular peds; friable; no pebbles; extremely acid; boundary abrupt smooth.
8–11 in. A_3	Dark brown (7.5YR 3/4) silt loam with dark gray (10YR 4/1) in vertical cracks, crushed color dark brown (10YR 4/3); moderate fine granular structure; friable; no pebbles; extremely acid; boundary abrupt smooth.
11–18 in. B_1	Dark brown (10YR 4/3) fine silt loam with dark brown (7.5YR 3/2) in vertical cracks; weak medium subangular blocky structure; friable; no pebbles; very strongly acid; boundary abrupt smooth.
18–24 in. B_{21}	Yellowish brown (10YR 5/4) silt loam; moderate medium subangular blocky structure; friable; strongly weathered pebbles 3%; strongly acid; boundary abrupt smooth.
24–29 in. B_{22}	Yellowish brown (10YR 5/4) coarse silty clay loam with common medium distinct strong brown (7.5YR 4/6) mottles; moderate medium subangular blocky structure; very thin brown (10YR 5/3) coats and coarse black Mn stains on ped faces; slightly firm; pebbles 5%; strongly acid; boundary abrupt smooth. Note: gravelly zone 10 ft horizontally away, imbedded in the silty alluvium, is mottled, has strong angular blocky structure, is extremely firm and contains 75% pebbles of local rocks and 25% of quartzite and chert, all strongly weathered.
29–39 in. B_{23m}	Brown (9YR 4/4) clay loam with common medium prominent yellowish red (4YR 4/6) mottles; fragipan breaking to strong medium angular blocky peds; 5 mm thick dark grayish brown (10YR 4/2) clay coats on vertical ped faces, thin yellowish brown (10YR 5/4) coats on horizontal ped faces; extremely firm; strongly weathered pebbles 5%, a few cobbles; strongly acid; boundary abrupt smooth.
39–48 in. B_{24m}	Strong brown (7.5YR 4/6) loam to sandy clay loam with few black Mn stains; fragipan with strong coarse angular blocky structure breaking to moderate very thick platy peds; 8 mm thick dark grayish brown (10YR 4/2) clay coats on vertical ped faces, very thin dark brown (7.5YR 4/4) clay coats on horizontal ped faces; very firm; a few cobbles; strongly acid; boundary clear smooth.
48–66 in. B_{31}	Strong brown (7.5YR 5/6) sandy loam; weak very coarse prismatic structure; very thin dark grayish brown (9YR 4/2) clay coats on prism faces; firm in place, friable when disturbed; pebbles 1%, a few cobbles; strongly acid; boundary gradual.
66–76 in. B_{32}	Yellowish brown (10YR 5/4) sandy loam with yellowish red (5YR 5/8) sandy horizontal zones; weak very coarse prismatic structure; very thin dark brown (7.5YR 3/4) clay coats on prism faces; firm in place, friable when disturbed; pebbles 10%; strongly acid; boundary gradual.
76–102 in. C_1	One inch thick layers of brown (10YR 5/3) silt and strong brown (7.5YR 4/6) sand with zones of fine black Mn stains; massive

breaking to platy fragments along bedding planes; friable; pebbles 5% occuring in thin layers of fine gravel; strongly acid; boundary gradual. Note: site 50 ft to the south is gravelly at this depth, alluvium is 20 ft thick.

The morphology of this soil differs from that described in Profile 1 in that it has a higher clay content throughout, a thinner zone of clay accumulation, more cobbles on the surface and throughout the profile, a finer textured parent material, a strong fragipan and a more yellowish hue. The profile is like that of the Gray-Brown Podsolic Soils of uplands of the region. However it was noted during field study that the color and structure vary in this profile whenever the lithology becomes more sandy and gravelly. It is also noted that the horizontal ped faces have more reddish coats than the vertical faces.

The silty material at 0 to 29 in. is like that material at 0 to 23 in. in Profile 1. Here on the Vulcan Terrace some of it is buried beneath the gravelly zone described under the B_{22} horizon, at 24 to 29 in., and large cobbles are found on it and in it.

Areas of imperfectly drained soil are also found on these terraces. Its morphology and origin was studied at Hamond Park (fig. 1). Here at Profile 3 the imperfectly drained soil is formed in lacustrine material which is underlain by a buried paleosol formed in sandy outwash.

The profile was sampled and described at a point 100 ft north of the road around Hamond Park, located in the SE¼ NE¼ Sec. 10, Yellow Creek Township. The site has a one percent even slope. It is at 960 ft above sea level.

Profile 3.—Description of imperfectly drained soil profile from lacustrine material over sandy outwash. (Described and sampled by W. H. Hale and H. D. Lessig)

Depth and Horizon	*Profile Description*
½–0 in. A_0	Black mull grading to mor, fibrous mat of roots, decomposition seems to be retarded; boundary abrupt smooth.
0–1 in. A_1	Black (N 2/0) coarse silt loam; weak very fine granular structure; friable; no pebbles; extremely acid; boundary abrupt wavy.
1–6 in. A_2	Brown (10YR 5/3) silt loam with few medium faint dark yellowish brown (10YR 4/4) mottles and gray (10YR 5/1) vertical stains, crushed color light brownish gray (10YR 6/2); weak fine granular structure; friable; no pebbles; very strongly acid; boundary abrupt wavy.
6–9 in. A_3	Grayish brown (10YR 5/2) silt loam with many medium distinct yellowish brown (10YR 5/6) mottles; weak medium granular to weak very fine subangular blocky structure; dark gray (10YR 4/1) stains on ped faces; friable; no pebbles; very strongly acid; boundary abrupt smooth.
9–14 in. B_1	Faintly mottled brown (10YR 5/3) and dark brown (7.5YR 4/4) silt loam; moderate medium subangular blocky structure; 2 mm thick brown (10YR 5/3) degraded clay coats on ped faces; friable; no pebbles; very strongly acid; boundary clear smooth.
14–22 in. B_{21g}	Strong brown (7.5YR 5/6) silty clay loam to silty clay with many medium prominent gray (10YR 5/1) and reddish brown (5YR 4/4) mottles; moderate coarse angular blocky structure breaking to strong fine angular blocky peds; 2 mm thick light brownish gray (10YR 6/2) silty clay coats on ped faces; less friable than B_1 but not firm; no pebbles; very strongly acid; boundary abrupt wavy.
22–32 in. B_{22m}	Strong brown (7.5YR 5/6) silty clay loam; weak fragipan with very weak coarse prismatic structure breaking to strong coarse angular

	blocky peds; 2 to 10 mm thick grayish brown (10YR 5/2) and gray (N 6/0) clay coats on ped faces and many black Mn stains on blocky peds; firm; small pebbles, concretions and channers 5%; material is laminated; very strongly acid; boundary gradual.
32–42 in. B_{23m}	Dark yellowish brown (10YR 4/4) fine silty clay loam with common medium faint grayish brown (2.5Y 5/2) mottles and coarse black Mn stains; weak fragipan with strong fine angular blocky structure; 2 mm thick grayish brown (2.5Y 5/2) clay coats on ped faces; firm; small pebbles and channers 5%; material is laminated with clay flows on laminae; strongly acid; boundary gradual.
42–48 in. B_{31m}	Dark yellowish brown (10YR 4/6) silty clay loam with common coarse distinct light brownish gray (2.5Y 6/2) mottles and black Mn stains; weak fragipan with weak coarse angular blocky structure; firm; no pebbles; material is laminated with light brownish gray (10YR 6/2) clay flows on laminae; strongly acid ranging to slightly acid in lower part; boundary gradual.
48–60 in. B_{32m}	Yellowish brown (10YR 5/6) silty clay loam with few black Mn stains; weak fragipan; 3 mm thick vertical gray (10YR 5/1) clay seams; firm; few pebbles; slightly acid; boundary and structure not determined, sampled with bucket auger.
60–110 in. B_{33}	Yellowish brown (10YR 5/7) silty clay with 10 to 20 mm thick zones of gray (N 7/0) clay increasing in number with depth; less firm than B_{32m}; no pebbles; well laminated; laminae 3 mm thick; neutral.
110–135 in. C	Yellowish brown (10YR 5/6) laminated silty clay with very dusky red (2.5YR 2/2) thin coatings on laminae; upper part has a few zones of gray as in B_{33}; no pebbles; calcareous, effervesces weakly; lower part of lacustrine material.
135–153 in. D_1 (A_b)	Yellowish brown (10YR 5/4) sand; neutral; boundary abrupt.
153–160 in. D_2 (B_{1b})	Strong brown (7.5YR 5/8) sandy loam; neutral; boundary gradual.
160–190 in. D_3 (B_{2b})	Yellowish brown (10YR 5/4) sandy loam with light brownish gray (10YR 6/2) mottles at 172 to 190 in.-depth; no pebbles; slightly acid.
190–240 in. D_4 (C_b)	Yellowish brown (10YR 5/4) loamy sand; slightly acid.

The morphology of this imperfectly drained soil is like that of other deeply weathered, imperfectly drained, Gray-Brown Podsolic soils, developed from water-laid material in the unglaciated part of Columbiana County. It has a distinct B horizon marked by clay accumulation, and the fragipan is weak. Fragipans in coarser textured, imperfectly drained soils are stronger.

The upper part of the solum at 0 to 42 in. is formed in an alluvial or lacustrine material which contains a few channers and small pebbles of local rocks at 22 to 42 in. The amount of channers increases in the upper part of this material as it extends toward the valley wall where it joins with the colluvium from upslope. The underlying part of the solum at 42 to 125 in. is formed in laminated lacustrine silty clay which apparently belongs to the same geological event because there is no paleosol between the upper and lower parts. The sandy material at 135 to 240 in. apparently belongs to a previous event as it has a palesool which was developed in its upper part and has a B horizon evident in both texture and color (table 2). The paleosol is more acid than the calcareous lacustrine mantle. Nearby this sandy material is not covered and here, a deeply weathered yellowish red soil is formed in it. The sandy material here, contains layers of gravelly glacial outwash and is like the material described on the Riverview Greenhouse

Terrace. The glacial outwash is underlain by 3 ft of an older very strongly acid lacustrine material not shown in figure 2. This material is being studied elsewhere and will be reported when study is completed.

About 800 ft northwest of Profile 3, at the foot of the valley wall (fig. 2, Profile 4), colluvium buries a lacustrine deposit two ft. thick which in turn lies over a mudflow.

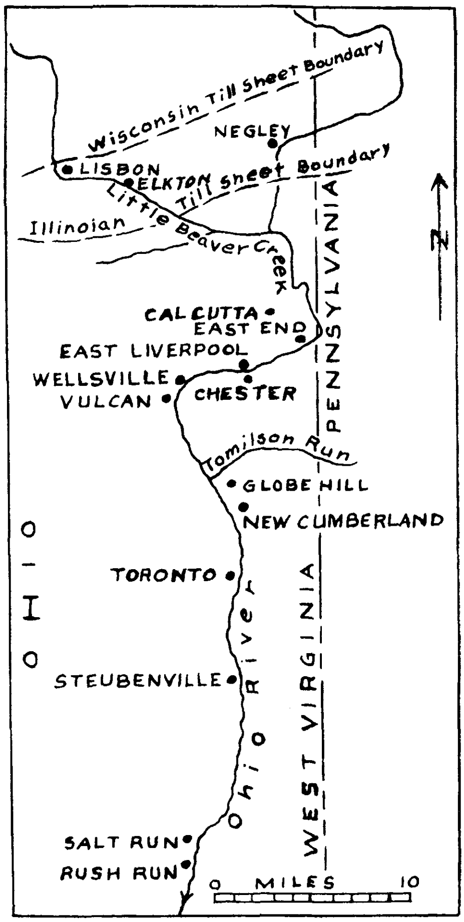

FIGURE 3. Map of Upper Ohio Valley.

The profile described here is located at the center of the NE¼ NW¼ Section 10, Yellow Creek Twp., along the west edge of Russel Heights in the foundation of the second house west of a small stream. The site is on a footslope of a steep valley wall, has a 12 percent slope and is at 970 ft elevation above sea level.

Profile 4.—Description of moderately well drained soil from colluvium over lacustrine silty clay over mudflow. (Described by W. H. Hale and H. D. Lessig)

Depth and Horizon	*Profile Description*
0–1 in. A_1	Very dark brown (10YR 2/2) silt loam; weak fine granular structure; channers 5%; very strongly acid; boundary abrupt smooth.
1–9 in.	Very dark grayish brown (10YR 3/2) silt loam; weak fine granular

A_2	structure; friable; channers 5%; very strongly acid; boundary abrupt smooth.
9–11 in. B_1	Yellowish brown (10YR 5/4) silt loam; moderate fine subangular blocky structure; friable to firm; channers 5% very strongly acid; boundary abrupt smooth.
11–16 in. B_{21}	Light olive brown (2.5Y 5/4) channery coarse silty clay loam; moderate fine subangular blocky structure; thin dark grayish brown (10 YR 4/2) clay coats on ped faces; friable to firm; channers and fine pebbles 25%; very strongly acid; boundary abrupt smooth.
16–23 in. B_{22}	Brown (10YR 5/3) channery coarse silty clay loam with many fine faint reddish brown (5YR 4/4) mottles; moderate fine subangular blocky structure; thin reddish brown (5YR 4/4) clay coats on ped faces; firm; channers and fine pebbles 20%; very strongly acid; boundary abrupt smooth.
23–34 in. B_{23gm}	Finely mottled strong brown (7.5YR 5/6) and gray (10YR 5/1) channery silty clay loam to silty clay; fragipan with strong medium angular blocky structure breaking to strong fine angular blocky peds; 1 mm thick gray (N 5/0) clay coats on ped faces; more firm than B_{22}; channers and fine pebbles 20%; strongly acid; boundary clear; horizon is lower part of water worked colluvium.
34–40 in. B_{24gm}	Dark brown (7.5YR 4/4) silty clay with many medium distinct gray (N 5/0) mottles; fragipan with strong coarse angular blocky structure breaking to strong fine angular blocky peds; 3 mm thick gray (N 5/0) clay coats on ped faces; firm to very firm; pebbles 5%; strongly acid; boundary clear; horizon is upper part of lacustrine material, is poorly sorted.
40–48 in. B_{25gm}	Medium distinctly mottled dark yellowish brown (10YR 4/4) and gray (10YR 5/1) silty clay; fragipan with strong coarse angular blocky structure breaking to strong fine angular blocky peds; 3 mm thick gray (N 5/0) coats on ped faces; firm; channers and fine pebbles 5%; strongly acid; boundary clear wavy.
48–62 in. B_{26g}	Dark brown (7.5YR 4/4) silty clay loam with many coarse distinct gray (10YR 5/1) mottles, and 9 in. thick vertical zones of total gley; weak very coarse prismatic structure breaking to moderate fine angular blocky peds; 2 mm thick gray (10YR 5/1) clay coats on ped faces; less firm than B_{25g}; no pebbles, well sorted; medium acid; boundary abrupt smooth; horizon is lower part of lacustrine material.
62–108 in. D	Large irregular masses of olive brown (2.5Y 4/4) silty clay loam and dark reddish gray (5YR 4/2) silty clay with 1 mm thick vertical seams of gray (N 5/0) clay; massive; flat siltstone channers of local rocks 20%; neutral; unsorted mudflow, reported by builder to be very thick beneath the excavation.

Major morphological features of this soil are a fragipan at 23 to 48 in., gleying at 23 to 62 in., and a strong textural and structural B horizon. Fragipans are unusual in silty clay horizons. This fragipan was so identified because the soil material was firm in a moist condition and brittle. The thickness of gleyed materials is great but not unusual for unglaciated soils in positions where internal seepage is received from upper slopes. The 9-in. thick, vertical gley horizon at 48 to 62 in. is unusual but such has been found by the author in deep horizons of highly weathered soils formed in thick alluvium. A deeply weathered soil is formed in the colluvium which is evidence that this material is not a recent or current deposit. This moderately well drained soil is like other Gray-Brown Podsolic soils. It differs from well-drained soils developed in colluvium, nearby, in that they lack B horizons, marked by clay accumulation.

The upper part of the solum at 0 to 23 in. is formed in colluvium which has been reworked a little by water and is apparently part of the same soil mantle described at Profile 3, 800 ft to the southeast, though nearer the shore of the body of water. The lower part of the solum at 34 to 62 in. is formed in lacustrine material which is like but not as well sorted as the laminated lacustrine silty clay of Profile 3, but also formed nearer the shore. The mudflow material at 62 to 108 in. apparently is formed from bedrock on the valley wall which includes neutral red clay shale. No evidence of buried paleosols was found at Profile 4. Apparently the mudflow, lacustrine and colluvial deposition occured as a contemporaneous sequence of events taking place long enough after the deposition of the glacial outwash that a paleosol was formed in the glacial outwash at Profile 3 before it was buried.

DISCUSSION

Soils of the high terrace remnants as found on the Riverview Greenhouse and Vulcan terraces have varied morphologies. The soil forming processes causing some soils in close proximity to each other to have morphological characteristics of the Red-Yellow Podsolic group and others to have characteristics of the Gray-Brown Podsolic group are not readily explainable. Red-Yellow Podsolic-like Profile 1 is well-drained while other less well-drained profiles are like local soils classed as Gray-Brown Podsolic soils. It appears that soil forming processes may vary according to soil internal drainage.

Another possibility is that Profiles 2, 3 and 4 have some properties of moderately well and imperfectly drained Red-Yellow Podsolic soils which the author has not recognized.

All four of these profiles have been subject to various climatic regimes which have occured since very early or early Pleistocene time. This is a much longer and more varied period of time than post-Wisconsin time. Some of these climatic regimes were such that Red-Yellow Podsolic soils were formed according to Peltier (1949, p. 47). Red-Yellow Podsolic-like soils are found on local early Pleistocene glacial outwash such as at the corner of Pennsylvania Ave. and Blakley St. in East Liverpool (Lessig, 1959b, p. 336). Another paleosol buried beneath fresh Illinoian till near Elkton, Ohio has latosolic properties (fig. 3) (Lessig, 1959c). This limited evidence indicates a warm humid climate during pre-Illinoian time.

However, the reddish (5YR) hue, with high chroma, found in well-drained soils formed from early and very early Pleistocene glacial outwash in Columbiana County is not found in equally old, well-drained soils on the same high terrace level in the tributary vallies which did not receive glacial outwash. These non-glacial soils have a more yellowish color, in the 10YR hue. It is possible that the more mixed lithology of the glacial outwash is responsible for the redder colors in the well-drained soils.

A well-drained soil formed in very early Pleistocene water-laid silty material near Calcutta (fig. 3) (Lessig, 1960) has a Gray-Brown Podsolic upper solum but below 42-in. depth there are iron-cemented-sand fragments and yellowish red soil material. I think that, here, a Gray-Brown Podsolic Soil is formed in a former Red-Yellow Podsolic Soil.

This sort of a soil forming process is reasonable under past and present climatic regimes. I am not prepared at present to form a suitable hypothesis for the differences of these various soils on the high terraces. It is hoped that further soil mineral and pedo-geological studies will lead to an elucidation of the Pleistocene history and the nature of the soils in the upper Ohio Valley.

The gravelly material of the Riverview Greenhouse Terrace is very deeply weathered, having structure to a 108-in. depth, firm consistence to 120 in., strong acidity to over 204 in., and the pebbles above the 204-in. depth, except those of quartzite, are rotted so that they crush in the fingers when rubbed. The pebbles in the silty and sandy material of the Vulcan Terrace are less weathered. A reason for this could be that the Vulcan site is only 150 ft from the terrace escarpment while the Riverview Greenhouse site is 500 ft from a dissecting ravine and is separated from the entrenched portion of the Ohio Valley by bedrock hills. Some of the upper soil material of the Vulcan site may have been removed by geological erosion because of its proximity to the terrace escarpment.

The pebbles of the Riverview Greenhouse and Vulcan terraces are weathered to a greater degree than those of the 850-ft terrace, remnants of which are found just north of the supermarket in East End, at the Corner of Pennsylvania Ave. and Blakley St. in East Liverpool (Lessig, 1959b) and at Globe Hill, W. Va. (Lessig, 1959a).

The glacial outwash of the Riverview Greenhouse and Vulcan terraces was deposited over preglacial stream levels which probably are a little lower than given by Leverett, and Stout, VerSteeg and Lamb (1943) because the rock floor of the Vulcan Terrace is below 960 ft at Profile 3. There is a lacustrine material beneath the glacial outwash at Hamond Park.

The very early and early Pleistocene sequence of events which deposited the varied soil materials on the Vulcan Terrace occured in two well separated stages because a paleosol was formed in the glacial outwash before it was buried by the lacustrine material at Profile 3. The arrangement of materials at Hammond Park and Russel Heights suggests the following sequence of events there: deposition of sandy and gravelly outwash over pre-glacial terrace levels; intrenchment of the outwash near the valley wall and soil formed in the outwash; mudflow from the valley wall deposited in part of the intrenchment; rise of water, burying the mudflow and part of the outwash with lacustrine material to 960 ft; deposition of colluvium along the valley wall and moving water conditions which reworked some of the colluvium which entered the body of water, depositing channers in the lacustrine material. All of these events must have preceeded the deposition of a less weathered glacial outwash at 830 ft at Globe Hill, 6 miles downstream.

At Globe Hill a gravelly glacial outwash was deposited over two stages of alluvial deposition over bedrock at 800-ft elevation. The events predating the 830-ft outwash at Globe Hill and postdating the 1020–960-ft outwash at Vulcan and the Riverview Greenhouse are not correlative. This suggests a long interglacial period and several geologic events between these two glaciations of the Allegheny Plateau.

Lower glacial outwash terrace levels at 760 and 720 ft near East Liverpool have less weathered soil materials and can be traced northward along Little Beaver Creek (fig. 3) to the Illinoian and Wisconsin till sheet boundaries. These terraces and their soils are under study and will be reported when their study is completed.

CONCLUSIONS

The well-drained soils, developed over gravelly glacial outwash, of the high terrace remnants at the Riverview Greenhouse and Vulcan have some properties of Red Yellow Podsolic soils while the soils with slower drainage are like the soils classed as Gray-Grown Podsolic soils which are normal to Columbiana County.

The glacial outwash of these terrace remnants belongs to the first glaciation of the Allegheny Plateau because it is the highest, most deeply weathered, in the upper Ohio Valley and is deposited over preglacial stream levels.

Lacustrine and colluvial deposits are also found on the high terrace remnants. They are attributed to other geological events. These preceded other geological events described at Globe Hill, West Virginia, in a preceding report. One layer of lacustrine material is older than the outwash of the first glaciation.

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