GREATLY ALTERED DRIFT NEAR YOUNGSTOWN, OHIO[1]

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ABSTRACT

Greatly altered drift is exposed beneath early Wisconsinan (Altonian) Titusville Till in three separate but related buried valleys in two strip mines 6 miles apart near Youngstown, Ohio. The deeply weathered drift, with a maximum thickness of 33 feet, consists of three till units separated by sand, gravel, and silt. The silt contains organic matter beyond the limit of C^{14} dating.

The altered drift is greenish gray and non-calcareous. Pebbles in the drift are thoroughly rotted, easily crushed between the fingers, and commonly unidentifiable. A few crystalline pebbles are evidence for the glacial origin of the material. The lower units appear to be more intensely weathered than the upper ones, indicating that more than one period of weathering may be represented. These deeply weathered deposits are probably pre-Wisconsinan in age, but no specific age is assigned to them.

INTRODUCTION

During the summer of 1965, several exposures of considerably weathered drift were observed in the Allegheny Plateau of northeastern Ohio and northwestern

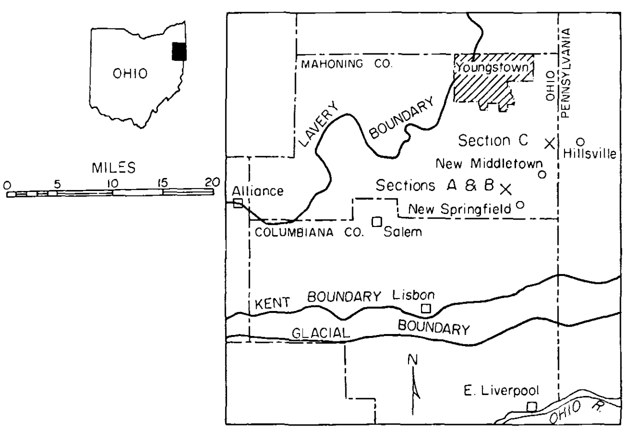

FIGURE 1. Index map showing location of sections described.

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Pennsylvania. This drift, which was exposed on fresh highwalls in strip mines, was in every instance overlain by younger unweathered drift. The weathered material occupied buried bedrock valleys, now filled by younger Wisconsinan drift and not visible on the modern land surface.

The purpose of this paper is to describe this greatly weathered buried drift and to attempt to determine its age and correlation. Any attempt to assign an age to this drift raises the fundamental question of dating glacial deposits on the basis

FIGURE 2. Photograph of Section A.

of degree of weathering. The factors influencing weathering rates are discussed below as they pertain to the interpretation of the stratigraphic sections described.

DESCRIPTIONS OF SECTIONS

Three excellent exposures southeast of Youngstown were studied (fig. 1). Two sections were measured in the East Fairfield Coal Company's New Middleton mine in the NW$\frac{1}{4}$ SE$\frac{1}{4}$ Sec. 18, T9N, R1W (Springfield Twp.), in southeastern Mahoning Co., Ohio. Section A was measured in a small filled valley, tributary to the larger filled valley in which Section B was measured. The larger buried valley is believed to have drained northwest into the valley presently occupied by Yellow Creek. Figures 2 and 3 show Section A at the time when the section was measured. Figure 4 is a schematic drawing of the fill of the small valley.

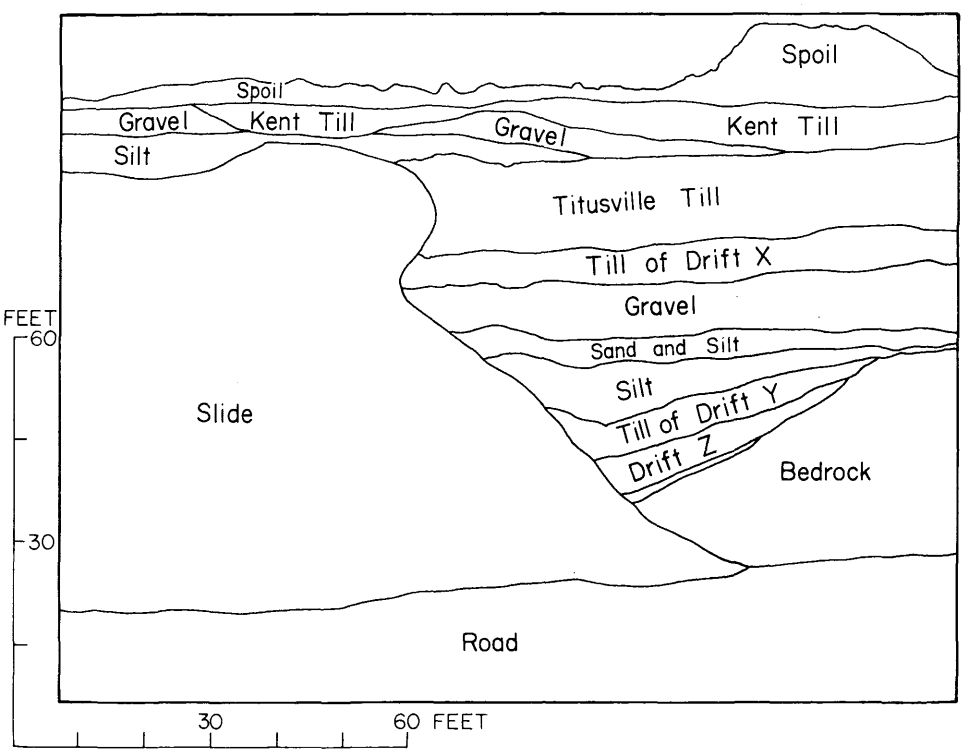

FIGURE 3. Tracing from photograph of Figure 2 to show units in Section A.

The third section, Section C, was measured on the highwall of the Carbon Limestone Company Quarry in the southeast corner of Poland Twp., Mahoning Co., approximately 500 feet north-northwest of the intersection of Miller and Kansas roads. This buried valley, which is about 6$\frac{1}{2}$ miles northeast of the other two buried valleys, trends approximately N 45° E and probably drained northeast into the present Mahoning River valley.

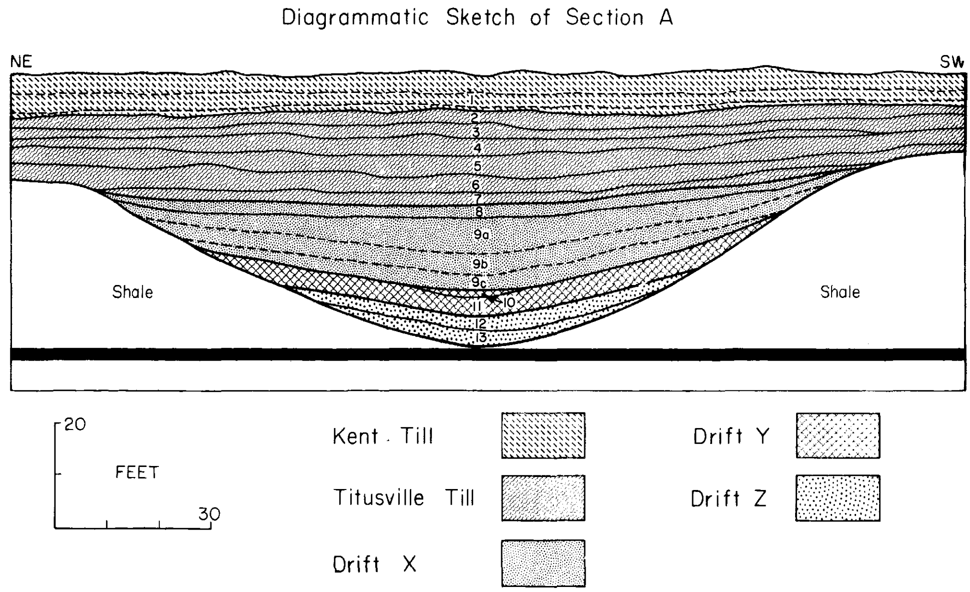

FIGURE 4. Diagrammatic sketch of Section A.

DESCRIPTION OF SECTION A

Unit No.	Description	Thickness Ft.	Thickness In.	Total Thickness Ft.	Total Thickness In.
Kent Till					
1	Silt loam, gray brown.	0	6	0	6
	Silt loam, yellow brown.	0	6	1	0
	Clay loam, mottled yellow brown and gray brown, clay flows well developed, breaks into small prisms.	1	4	2	4
	Till, noncalcareous, yellow brown to olive brown, silty, sandy, pebbly, clay flows well developed along peds, irregular horizontal partings.	2	6	4	10
	Till, calcareous, yellow brown 10YR 5/6 to light olive brown 2.5Y 5/6, silty, pebbly, mealy, few orange (7.5Y 5/8) spots, irregular horizontal partings. Sample 2817. Sa/Si/Cl; 33/46/21.	6	0	10	10
	Till, calcareous, dark olive gray 5Y 3/2–4/1, silty, pebbly, ½″–1″ horizontal partings, irregular prismatic fracture, thickness irregular. Sample 2816. Sa/Si/Cl; 41/32/27. Feldspar–23%.	3	0	13	10
Titusville Till					
2	Gravel, calcareous, grayish brown, mostly pebbles ½″–1″ with cobbles to 4″; loose, poorly sorted, basal contact irregular, thin silt at top.	4	0	17	10
3	Till, calcareous, olive gray 5Y 5/3, stony and pebbly, sandy, hackly fracture, hard and compact. Sample 2815. Sa/Si/Cl; 31/45/24. Feldspar–17%.	1	6	19	4
4	Silt, very calcareous, olive gray 5Y 4/2, massive, no bedding, hackly fracture, tough and compact; thin (4″) layer of gravel at base. Sample 2814.	4	10	24	2

SECTION A—*Continued*

Unit no.	Description	Thickness Ft.	Thickness In.	Total Thickness Ft.	Total Thickness In.
5	Till, calcareous, olive gray 5Y 5/2.5, silty, sandy, pebbly, fresh, large irregular blocky, compact, bright coatings on joints, thickness variable. Sample 2813. (*Titusville*) Sa/Si/Cl; 38/39/23. Feldspar-21%.	6	6	30	8
6	Sand and gravel, calcareous, gray, water-bearing.	2	0	32	8
7	Till, calcareous, dark olive gray 5Y 3/2, clayey, tough, plastic, breaks around pebbles, pebbles not weathered, contains inclusions of bedrock and soil, basal contact sharp. Sample 2812. Sa/Si/Cl; 16/35/49. Feldspar-29%.	4	4	37	0
Drift X					
8	Till, noncalcareous, dark gray 5Y 4/1, pH 7.2, upper 8″ darker gray brown and containing organic matter, intensely weathered; all pebbles are ghosts—very soft and easily crumbled; sandstones crumble; very hard when dry, moderately hard when wet, subangular pebbles; thin clayey silt at base. Sample 2811. Sa/Si/Cl; 31/45/24. Feldspar-14%.	3	10	40	10
9a	Gravel, olive brown to greenish gray 2.5Y 5/5, pick marks leave reddish orange streaks, compact but crumbles easily in the hand, tendency to cave where wet, composed of uniform pebbles ½″ and less, pebbles mostly sandstone and shale, easily crumbled, others rotted crystallines, sharp contacts above and below; 5″ gray sandy gravel at top. Sample 2810. pH 6.7.	5	8	46	6
9b	Sand, dark gray 5Y 4/1, fine, interbedded with silt and fine gravel, easily crumbles in hand, but hard to pick, pebbles soft and weathered. Sample 2809. pH 7.3.	3	6	50	0
9c	Silt, dark gray 5Y 4/1, soft and sticky, clayey below becoming sandy upward, laminated; contacts above and below are sharp. Sample 2808. pH 7.1.	3	2	53	2
10	Silt, dark gray brown, 5Y 3/2, peat-like in places, many small stems and rootlets, some colluvium mixed in, confined to valley bottom. Sample 2807. pH 6.4.	0	5	53	7
Drift Y					
11	Till, noncalcareous, dark olive gray, very pebbly, pebbles very rotted, more rotted than those below. pH 6.6.	1	4	54	11
	Till, noncalcareous, olive gray 5Y 5/2, same till as above but less weathered, soft crumbly pebbles of soft sandstone; massive, extremely hard to pick, till breaks across all pebbles; base marked by ½″ wavy streak of reddish brown sand, accompanied in places by sandstone channers. Sample 2806. Sa/Si/Cl; 30/40/30. Feldspar-7%. pH 6.9.	3	4	58	3

SECTION A—*Continued*

Unit No.	Description	Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
Drift Z					
12	Silt, noncalcareous; highly mottled olive gray 5Y 5/2, yellow 5Y 7/6, and strong brown 7.5YR 4/6; massive, devoid of bedding; traces of organic matter (stems) disseminated throughout unit; highly weathered; pebbles rare, all are very rotted; picks hard, but crumbly and can be crushed in the hand; basal contact irregular. Sample 2805. pH 7.0.	2	6	60	9
13	Till, noncalcareous, much weathered, strong brown 7.5YR 5/8 with some mottling of grays and yellows, pebbly, upper part colluviated with many irregular sandstone channers up to 8″ long, basal contact slightly irregular but sharp, some disseminated organic matter in upper part. Sample 2804. Sa/Si/Cl; 57/25/18. Feldspar-40%. pH 6.4.	0	10	61	7
	Bedrock, shale.				

Sa—sand (2mm–.0625mm)

Si—silt (.0625mm–.0039mm)

Cl—clay (<.0039mm)

Feldspar percentage is percent of feldspar in light minerals in 0.177–0.125mm size fraction.

DESCRIPTION OF SECTION B

Unit no.	Description	Thickness		Total Thickness	
		Ft.	In.	Ft.	In.
Kent Till					
1	Silt loam, gray brown.	0	6	0	6
	Silt loam, yellow brown.	0	6	1	0
	Clay loam, noncalcareous, yellow brown, pebbly, silty, mealy.	3	6	4	6
	Till, calcareous, yellow brown, sandy, moderately pebbly, mealy, good horizontal partings ½″ apart. Sample 2714. Sa/Si/Cl; 34/45/21.	3	0	7	6
	Till, calcareous, gray, otherwise as above. Sample 2713. Sa/Si/Cl; 32/47/21.	3	0	10	6
Titusville Till					
2	Sand, calcareous, brown, coarse, pebbly.	2	0	12	6
3	Till, calcareous, olive gray, silty, sandy, moderately pebbly, compact, massive. Sample 2712. Sa/Si/Cl; 33/45/22.	4	0	16	6
4	Sand and gravel, calcareous, gray, irregular scour surface on unit below.	9	0	25	6
5	Till, calcareous, olive gray, pebbly, compact, massive, occurs as lenses. Sample 2711. Sa/Si/Cl; 17/43/40.	1	0	26	6

SECTION B—*Continued*

Unit no.	Description	Thickness Ft.	Thickness In.	Total Thickness Ft.	Total Thickness In.
6	Sand, slowly calcareous, gray, variable, water-bearing, slumps badly.	10	0	36	6
7	Till, calcareous, olive gray, pebbly, occurs as discontinuous lenses.	1	0	37	6
Drift X					
8	Till, intensely weathered, greenish gray, all pebbles are rotted.	2	0	39	6
9a	Sand and gravel, severely weathered, greenish gray, crushed pebbles produce orange limonitic smears when struck by pick.	8	0	47	6

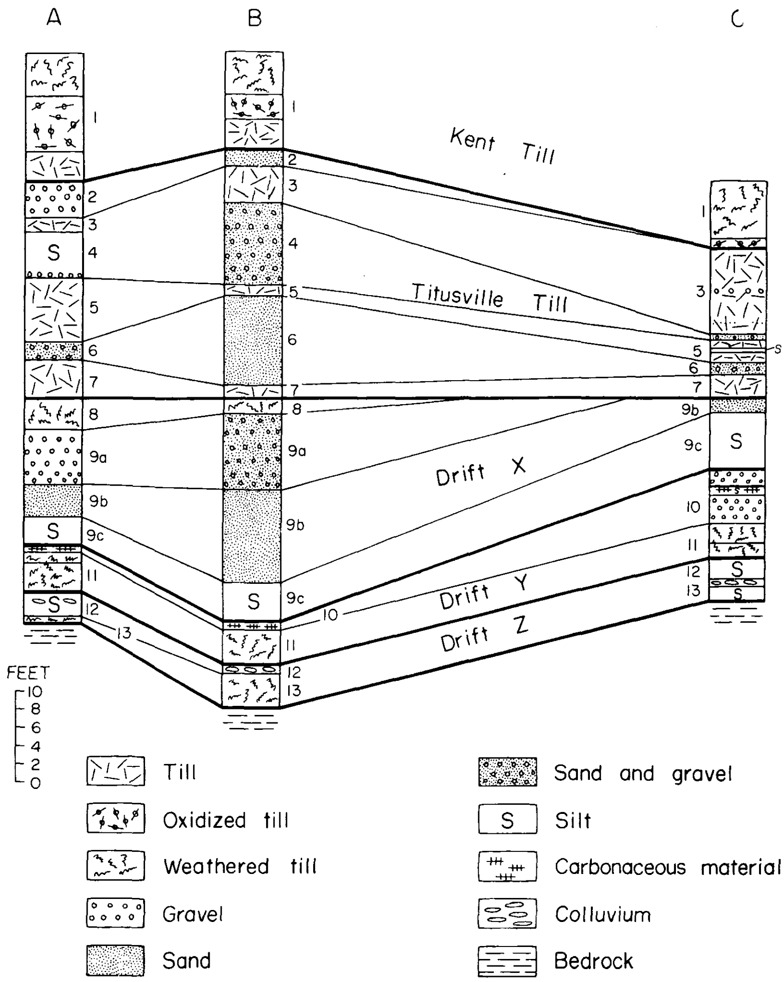

FIGURE 5. Correlation of sections.

SECTION B—(*Continued*)

Unit no.	Description	Thickness Ft.	Thickness In.	Total Thickness Ft.	Total Thickness In.
9b	Sand, silty, weathered, grayish brown.	10	0	57	6
9c	Silt, gray brown, laminated, contains sand lenses, more sandy upward.	4	0	61	6
10	Silt, noncalcareous, crumbly, few weathered pebbles, brown, carbonaceous, much disseminated organic matter, wood fragments collected at top. Sample 2803.	1	0	62	6
Drift Y					
11	Till, severely weathered, dull brown to tan, greenish gray at top, silty, pebbly, crumbly, pebbles very rotted.	4	0	66	6
Drift Z					
12	Colluvium, silty, tan and brown; large sandstone channers are firm but can be crumbled.	1	0	67	6
13	Till, noncalcareous, much weathered; mottled gray, tan, and brown, stronger brown at base and at top; pebbly, all pebbles rotted and indistinct; tends to be massive and structureless. Sample 2818.	3	6	71	0
	Bedrock, shale.				

DESCRIPTION OF SECTION C

Unit no.	Description	Thickness Ft.	Thickness In.	Total Thickness Ft.	Total Thickness In.
Kent Till					
1	Silt loam, gray brown.	0	10	0	10
	Silt loam, yellow brown, few pebbles.	1	10	2	8
	Till, noncalcareous, strong brown to yellow brown with darker mottling, pebbly, crumbly, zone of pedogenic clay accumulation, hard to pick, orange spots, clay flows.	3	6	6	2
	Till, calcareous, yellow brown, otherwise as above. Sample 2955. Sa/Si/Cl; 39/47/14. Feldspar-14%.	1	0	7	2
Titusville Till					
3	Till, calcareous, yellowish olive brown with occasional orange spots, pebbly, sandy, silty, crumbly, small prismatic structure, staining on stones, thin (3″) sand at base. Sample 2956. Sa/Si/Cl; 38/48/14. Feldspar-16%.	2	8	9	10
	Till, calcareous, olive brown, pebbly with more pebbles near base, stony, horizontal partings, rusty around pebbles, thin maroon streak at top. Sample 2957. Sa/Si/Cl; 34/46/20. Feldspar-17%.	2	3	12	1
	Till, calcareous, olive brown, more rusty than above, very stony, pebbly, large irregular blocky. Sample 2958. Sa/Si/Cl; 34/50/16. Feldspar-27%.	2	0	14	1

SECTION C—*Continued*

Unit no.	Description	Thickness Ft.	Thickness In.	Total Thickness Ft.	Total Thickness In.
	Till, calcareous, olive gray, rusty along joints, as above, thin (1″) sand at base. Sample 2959. Sa/Si/Cl; 32/50/18. Feldspar-28%.	1	0	15	1
	Till, very calcareous, olive gray with maroon cast, pebbly, sandy, quite hard. Sample 2960. Sa/Si/Cl; 33/49/18. Feldspar-28%.	1	6	16	7
4	Sand and gravel, gray, very wet.	0	6	17	1
5	Till, calcareous, drab olive, silty, clayey, many small pebbles, maroon bands throughout. Sample 2961. Sa/Si/Cl; 25/55/20. Feldspar-36%.	1	0	18	1
	Silt, calcareous, olive gray, bedded, smooth.	0	6	18	7
	Till, calcareous, drab olive gray, pebbly, stony, many bedrock fragments. Sample 2962. Sa/Si/Cl; 31/43/26. Feldspar-10%.	1	0	19	7
6	Sand and gravel, gray; contains maroon bands and beds of flow till; large stones at base.	1	6	21	1
7	Till, calcareous, olive gray, sandy, pebbly, stony, hard on outcrop but crumbly in hand, large blocky. Sample 2963. Sa/Si/Cl; 26/61/13. Feldspar-12%.	2	6	23	7
Drift X					
9b	Sand, noncalcareous, gray with brown gravelly streaks, greenish gray cast, fine grained.	1	4	24	11
9c	Silt, dark gray to dark olive, contains some sand in upper part, hard, massive, concoidal fracture. Sample 2964.	6	0	30	11
10	Gravel, greenish gray, pebbles rotten and crumbly, thickness variable. Sample 2965.	2	0	32	11
	Silt, gray, sandy, carbonaceous.	1	0	33	11
	Gravel, greenish gray, pebbles rotten and crumbly, thickens laterally. Sample 2966. Thin peat mat at top, peat at base. Sample 2970 from basal peat.	3	0	36	11
Drift Y					
11	Till, noncalcareous, olive drab, rusty, mottled, pebbly, silty, clayey, pebbles soft and weathered. Sample 2967. Sa/Si/Cl; 29/40/31. Feldspar-21%.	2	0	38	11
	Till, noncalcareous, yellow brown, pebbly, silty, moderately stony, less weathered equivalent of above, pebbles weathered and soft, breaks across pebbles. Sample 2968. Sa/Si/Cl; 28/38/34. Feldspar-13%.	1	8	40	7
Drift Z					
12	Silt, light gray, with strong brown mottling, browner below, grayer at base.	2	6	43	1
13	Colluvium, silty, strong brown, some gray mottling, many pebbles, all soft and rotten, compact, may be last remains of old till. Sample 2969. Sa/Si/Cl; 41/32/27. Feldspar-11%.	0	6	43	7
	Silt, mottled gray and brown, few pebbles, compact.	1	8	45	3
	Bedrock, shale.				

DISCUSSION OF STRATIGRAPHIC UNITS

The uppermost unit in all three sections is thin Kent Till (Unit 1) (White, 1960, p. A5–6). It is yellow-brown, loam to sandy loam till, moderately pebbly to pebbly, easy to break out when struck by a pick, and characterized by orange limonitic spots. The pebbles are mainly 0.5 to 2.0 cm in size. Dates of 24,600 ± 800 and 23,313 ± 391 radiocarbon years B. P. from wood in silt immediately underlying the Kent Till at Garfield Heights, Ohio (White, 1968, p. 749), indicate that the Kent Till is Woodfordian in age (Frye *et al.*, 1968, p. 16–18).

Underlying the Kent Till in all three sections is the Titusville Till (White and Totten, 1965, p. 234–235; White *et al.*, 1969), which is composed of three distinct beds of till (Units 3, 5, and 7) with some intercalated sand and gravel or silt (Units 2, 4, and 6). The Titusville Till is olive-gray, sandy, loam till, which is hard, compact, dense, commonly pebbly to cobbly, and breaks out with some difficulty when struck by a pick. Where oxidized, it is olive-brown. It contains much larger pebbles than the Kent Till and the matrix retains the imprint of the pebbles after they have been removed. It is particularly characterized by manganese staining on the pebbles, horizontal slabby partings, and rusty olive staining along joints and parting planes.

The Titusville Till has been traced into the Youngstown area from its type area near Titusville, Pennsylvania (White, G. W., personal communication). At Titusville, peat underlying the Titusville Till has been dated at 40,450 ± 870 radiocarbon years B. P. (White *et al.*, 1969), indicating that the till is Altonian (early Wisconsinan) in age (Frye *et al.*, 1968, p. E 14).

In Sections A and B, the Titusville Till rests directly on weathered till (Unit 8) (Figs. 2–5). In Section C, the Titusville Till rests on a sequence of weathered glaciofluvial sediments (Unit 9). The fabric of Unit 8, the upper of the buried weathered tills, with angular to subrounded pebbles supported in a loamy matrix, indicates that the sediment was originally till. The till is a dull greenish gray with completely rotted pebbles, whose original composition in most cases is unrecognizable. Many of the pebbles, which are very soft and crumble readily under slight pressure, contain muscovite, quartz, and clay, and appear to have been crystallines. Some pebbles of locally derived micaceous sandstone and siltstone were also recognized. Heavy limonite staining of the pebbles made identification of minerals in thin section impossible.

Unit 9 is a sequence of silts, sands, and gravels which becomes coarser upward. The gravel, Unit 9a, which is fine-grained, with pebbles less than one inch in diameter, has the same greenish gray color as the overlying till. The pebbles, which have soft and rotted interiors, are slightly case hardened at their surfaces. When struck by a pick, the crushed pebbles leave orange-to-brown streaks on the outcrop.

Underlying the gravel is dark grayish brown silty sand, Unit 9b, containing some pebbles. The upper contact of the sand is quite sharp.

Beneath the sand and gravel is gray-brown, soft, slightly sandy, thinly laminated silt, Unit 9c. This silt contains disseminated organic material and a few very small plant stems along bedding planes.

Unit 10 is a dark-gray-to-brown, fine organic silt, which locally becomes a silty peat. It is massive, crumbly, and contains a few soft weathered pebbles. The organic content increases upward, with considerable concentration of twigs and stems along the contact between Units 9 and 10, especially in depressions on the surface of Unit 10. Twigs from this silt in Section B were collected, but proved to be beyond the range of radiocarbon dating (I–1785). In Section C, Unit 12 includes fine-grained, weathered gravel containing twigs.

Unit 11 is a silty, sandy till, which is greenish gray to brown and tan in color and is very similar to Unit 8. The pebbles are rotten and limonite stained, just as in the weathered till of Unit 8.

Underlying Unit 11 is a thin silty colluvial zone containing flat sandstone channers, Unit 12. The silty matrix is mottled yellow, gray, and brown, and is quite tough when dry. The sandstone channers are oxidized, but do not appear greatly altered. Delicate stems, which appear to have been grass, are disseminated throughout the silt.

A mottled gray, yellow, and brown stony, sandy loam, Unit 13, is present at the base of all three sections. The pebbles are completely rotted and unrecognizable, as in the two tills above. The presence of two very much weathered crystalline pebbles in Section A supports the glacial origin of this sediment. In Section B, three and a half feet of pebbly till are present. In Section C, no crystalline pebbles were found in Unit 15, so this material may represent locally derived colluvium resting on weathered shale.

Two additional sections similar to those described above were observed in filled valleys exposed in strip mines in Center Twp., Columbiana Co.: one north of Lisbon, Ohio, in SE¼ NE¼ Sec. 1, T14N, R3W (Center Twp.); and the other in NE¼ NE¼ Sec. 19 west of Lisbon along U. S. 30 in T14N, R3W (Center Twp.). These exposures, however, are poor and little additional information was obtainable from them. The weathered material lies at the same stratigraphic interval as in the three sections above, is very similar in appearance and degree of weathering, and is believed to be correlative.

In northwestern Pennsylvania, a till with a well-developed paleosol developed on it, underlying the Titusville Till, has been traced over long distances. This lower till, which has been named the Mapledale Till (White *et al.*, 1969), locally overlies a second very much weathered till, the Slippery Rock Till (White, *et al.*, 1969). The relationship of these tills in Pennsylvania to the units reported here is not clear, partly because the materials described here are so badly weathered.

Age of Altered Drift

The age of these weathered materials is greater than the range of radiocarbon dating. Therefore any age assignment must be based on other evidence.

The depth and degree of weathering has long been used throughout North America as a means of time correlation in glacial sequences. Kay (1931) used depth of leaching and gumbotil thickness to characterize each of the interglacial stages in the Mississippi Valley. Leighton and Ray (1965) considered tills in northern Kentucky to be Kansan and Nebraskan in part on the basis of depth and degree of weathering. Lessig (1959, 1961) has recognized four distinctly different depths of weathering on the four major terrace levels in the upper Ohio Valley. He correlated the most deeply weathered profile with the Nebraskan and the three successively less severely weathered profiles with the Kansan, Illinoian, and Wisconsinan.

These authors, as well as others, have correlated glacial drift weathered under widely different climatic conditions on the basis of similar depths and degrees of weathering. Six groups of factors influence the rate and degree of weathering of earth material: (1) composition of original parent material, i.e., mineralogy, and texture and structure as they influence permeability; (2) climate, i.e., temperature and amount and distribution of precipitation; (3) topographic exposure of the material; (4) vegetation; (5) time; (6) the hydrologic environment within the soil or rock, i.e. the soil in relation to the flow system and the water chemistry. Depth and degree of weatherings can be validly used as a measure of time of weathering or age only when all the other five factors above are held constant or controlled.

As distance from the reference area increases, it becomes more and more difficult to assume that the effects of the soil-forming factors in the area under study have been identical to those in the type area. Textural and mineralogical differences among parent materials in the two areas can be extremely complex and are often unknown. Differences in texture and mineralogy result in different rates of water movement through the soil and different reaction rates within the soil. Minor climatic differences can produce changes in pedogenesis. The degree of climatic variation may increase with increasing distance from the reference area. The topographic position of the material while being weathered exercises a very strong influence on the depth to which the material is weathered. Geologists seldom are afforded the luxury of being able to select the location of exposures of weathering profiles for study. Changes in vegetation can profoundly affect the depth and degree of weathering. This is expecially significant in view of the location of Illinoian, Kansan, and Nebraskan type areas in regions of prairie vegetation, while the soils of most of the glaciated part of the eastern United States were developed under forest vegetation. Because the interaction of all the above factors acts to produce different soils in areas separate from one another, the degree of difference tending to increase with increasing distance of separation, it is difficult to justify the assumption that similar degrees of weathering in two widely separate localities are evidence of similar age.

Correlation on the basis of degree of weathering even within small local areas must be attempted with great care. Because Lessig worked exclusively with gravel terraces, situated in similar topographic positions on the sides of valleys, in an area small enough to assure climatic and vegetational homogeneity, his recognition of four different ages of terrace gravels on the basis of weathering is believed to be valid, whatever their time-stratigraphic correlation may be. Although the altered drift described in this paper is located in the same geographic area as the terraces studied by Lessig, comparisons of the degree of weathering to that described by Lessig are not valid because of differences in parent material, topographic position (especially angle of slope), and hydrologic environment.

The fact that the drift described in this paper was in a valley at the time it was being weathered favored a high water table. Abundant undecayed organic material in such an environment would produce reducing conditions. The greenish gray color of the drift and the preservation of unoxidized plant material indicate that the alteration of this material did in fact occur under reducing conditions and that presumably it has never been oxidized. Such conditions of weathering are common in undrained, boggy depressions on till plains or in poorly drained flats. In contrast, the weathering of the terrace gravels described by Lessig occurred under oxidizing conditions, probably above the water table. For this reason also, no attempt has been made to correlate these weathered materials with the terraces studied by Lessig.

At present the most valid method of correlating glacial sediments which are beyond the range of radiocarbon dating is by direct tracing of rock units or geosols (Morrison, 1968) from the type or reference area to the area under study. Because no such stratigraphic tracing between eastern Ohio and the type areas of pre-Wisconsinan drift in Illinois, Kansas, and Nebraska has yet been achieved, no age assignment can be made for the greatly weathered drift described above.

From stratigraphic evidence, it is clear that this weathered drift predates the Altonian (early Wisconsinan) Titusville Till. Although it could be very early Altonian, it is more likely to be pre-Altonian (pre-Wisconsinan), and may be Illinoian or even older. It is not all of the same age, but whether these buried and strongly weathered tills represent more than one glacial stage or only different substages of one stage is not known. It is to be hoped that, in the future, additional exposures and determination of subsurface geology by extensive drilling, as is now being done in Saskatchewan (Christiansen, 1968), will lead to firmer correlations with older drift of Pennsylvania, with older Ohio River valley terraces, and with older drift to the west.

Geologic History

The history of these deeply buried, greatly weathered tills and their associated deposits is complex, involving several ice advances. An initial ice advance over the eroded surface of Pennsylvanian rocks deposited Drift Z. It was followed by a period of colluviation and possibly of weathering of Units 12 and 13 (Drift Z).

A second ice advance deposited till of Drift Y (Unit 11). Following the retreat of this ice, there appears to have been a period of weathering. Alluvial or lacustrine silts, Unit 10, were deposited during this interval, perhaps near its end. In front of a third ice advance, proglacial silts, then sands, and finally gravel of Unit 9 were deposited. The till of Unit 8, Drift X, was deposited by this advance, after which, following the retreat of the ice, a long period of weathering ensued.

The advance of the Titusville glacier over the area approximately 40,000 radiocarbon years B. P. interrupted the weathering of the earlier drift. Following the retreat of the Titusville glacier, the final episode of glaciation in this area began with the advance of the ice which deposited the Kent Till approximately 23,250 radiocarbon years B. P.

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