The Mineralogy and Genesis of a Soil (Tilsit Silt Loam) of the Unglaciated Region of Indiana[1]

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The soils of Indiana have been formed from a variety of parent materials which include glacial tills, sedimentary rocks, and loess.

In a study of the influence of parent material on soil genesis in the unglaciated area, a Tilsit silt loam profile was sampled on a site underlain by the Borden group. This group consists primarily of sandstones and siltstones. The Tilsit silt loam is a (III) profile, has moderately slow surface drainage, is moderately well drained internally, and occurs on 2-4 percent slopes. The Tilsit belongs to the Zanesville catena and is characterized by the presence of a fragipan.

Methods and Procedures

The sand, silt, and clay fractions were separated by dispersion of the soil with sodium hexametaphosphate and the use of sedimentation and centrifugation procedures (6).

A method similar to that outlined by Krumbein and Pettijohn (4) and Milner (5) was used in the petrographic studies. The light and heavy minerals were separated by use of tetrabromoethane and centrifugation procedures. Clove oil was used as a mounting medium for the light minerals and Canada balsam for the heavy minerals. At least 300 grains were counted per slide in obtaining the individual mineral counts. Any mineral present in an amount less than 0.5 percent was reported as a trace.

Oriented clay specimens were prepared using the porous ceramic tile method suggested by Kinter and Diamond (3). X-ray diffraction patterns were made with a General Electric XRD-51 Diffractometer using copper $K\alpha$ radiation. The clay mineral composition of the coarse clay fractions was estimated by the method of Johns, Grim and Bradley (2) and is reported in parts per ten (Figure 1).

Results and Discussion

Vermiculite, montmorillonite, and illite are the dominant minerals in this soil (Figure 1). Heating tests indicated that chlorite was not present in significant amounts in any of the horizons.

Vermiculite is present in all horizons except the Y_4 and D_r. This observation and the fact that the montmorillonite content is never greater than 3 parts per ten would suggest that this soil has developed

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Figure 1

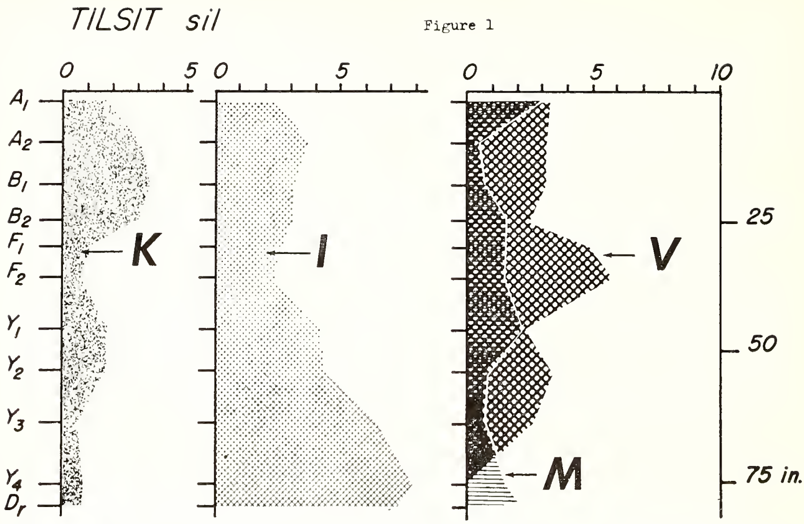

Figure 1. Clay mineral composition (parts per ten) of the coarse clay fraction of Tilsit silt loam. Legend: K = kaolinite; I = illite; V = vermiculite; M = montmorillonite.

under better drainage conditions than those on comparable slopes on Illinoian till.

The illite content of the lower part of the profile is very high, indicating that the Borden formation contains sediments high in illite content.

There are two zones with a rather high kaolinite content in the Tilsit soil. The first occurs between the A_2 and B_2 and the second between the Y_1 and Y_2.

Glass, Potter, and Siever (1) have reported that some of the Pennsylvanian shales are high in kaolinite. The direction of movement of the ice sheet in the Kansan and Illinoian glacial periods[1] suggests that Pennsylvanian sediments were incorporated into glacial tills of these periods in the west central part of Indiana. Further evidence for this is shown in Figure 2 which shows the diffractometer tracings of the clay fraction ($<2\mu$) of the various lithological units of the Cagle's Mill Reservoir section (7) (Table 2). Two units, no. 4 in the Illinoian, and no. 8 in the Kansan, show unusually large concentrations of kaolinite.

The petrographic data for the heavy and light mineral fractions are shown in Table 1. On the basis of the persistence or stability of minerals to weathering the following criteria for weathering and deposition were used: (1) an increase (positive slope) in the percent of

[1] Personal communication, Dr. William J. Wayne, Indiana Geological Survey, Bloomington, Indiana.

Figure 2. X-ray diffractometer tracings illustrating variations in clay-mineral suites of the Cagle's Mill Reservoir section.

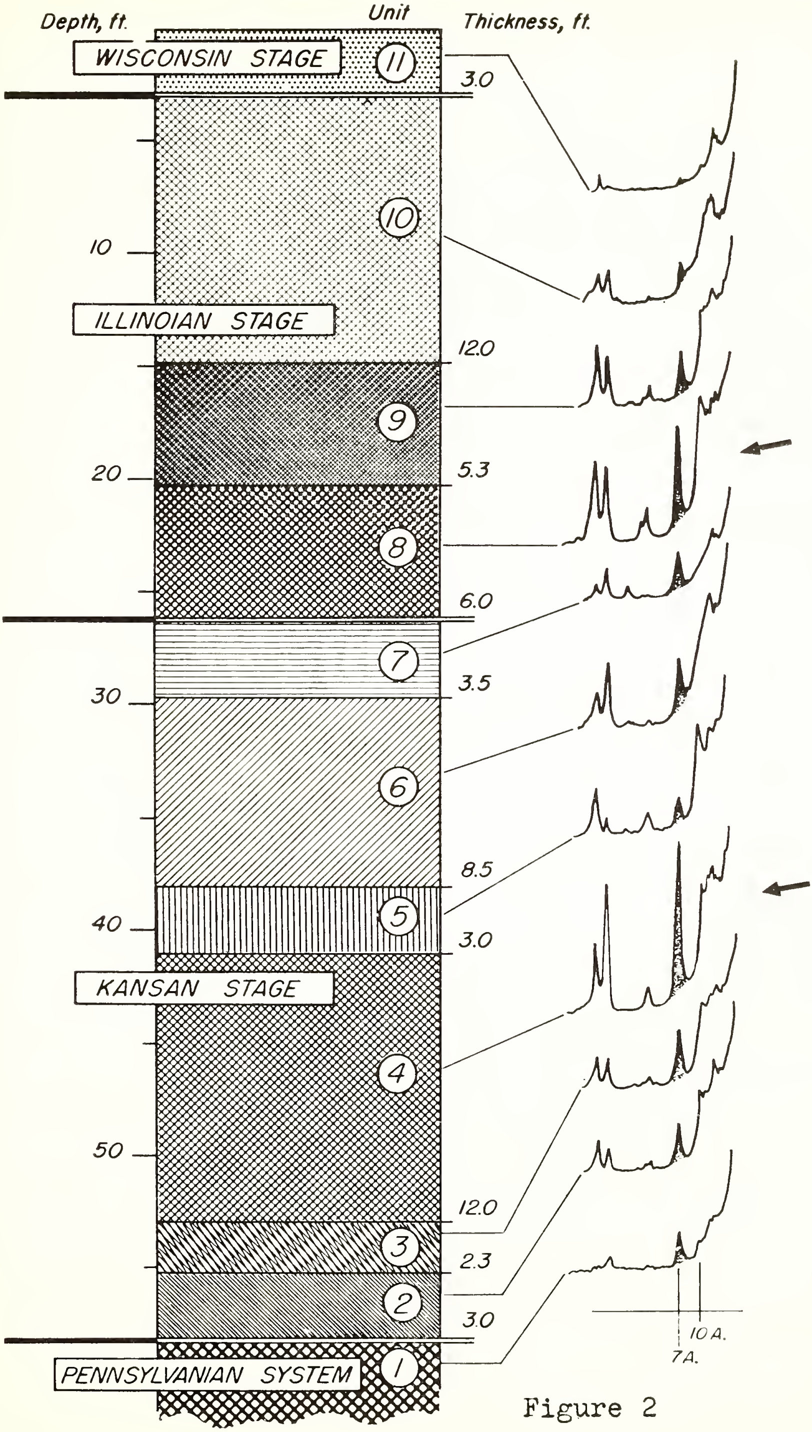
Depth, ft.
Unit
Thickness, ft.
WISCONSIN STAGE
11
3.0
10
10
ILLINOIAN STAGE
12.0
9
20
5.3
8
6.0
7
30
3.5
6
8.5
5
40
3.0
KANSAN STAGE
4
50
12.0
3
2.3
2
3.0
PENNSYLVANIAN SYSTEM
1
10 A.
7A.

Figure 2

TABLE 2

Description of Cagle's Mill Reservoir Section: SE¼ NE¼ Sec. 13, T12N, R5W, Putnam County, Ind. (Wayne, 1957)(7).

	Thickness, Feet
WISCONSIN STAGE	
11. Silt: yellowish-brown, clayey, not calcareous (probably wind-laid)	3.0
ILLINOIAN STAGE	
10. Till: brown, fractured, not calcareous, secondary limonite deposition along joints	12.0
9. Till: light-brown, calcareous, sandy, clayey	5.3
8. Till: dark-gray, calcareous, sandy, clayey, very pebbly	6.00
Total Illinoian	23.3
KANSAN STAGE	
7. Clay: brown to greenish-gray, not calcareous, silty to sandy	3.5
6. Till: brown, sandy and silty, not calcareous	8.5
5. Till: reddish-brown, calcareous, sandy and silty	3.0
4. Till: brownish-gray, calcareous, silty, sandy; oxidized extensively along joints; contains wood fragments in basal few feet	12.0
3. Clay, silty: brownish-gray, laminated, highly calcareous; contains scattered wood fragments throughout; lenticular, pinching out toward west in exposure	2.3
2. Silt: grayish-brown, mottled locally; calcareous and abundantly fossiliferous, becoming less so in lower 1.0 foot; wood, peat, and humus common at upper contact; lenticular, pinching out toward west in exposure (Cagle silt)	3.0
Total Kansas	32.3
Total Pleistocene	55.6
PENNSYLVANIAN SYSTEM (Mansfield formation)	
1. Sandstone, shale, and thin coal, overlain locally by as much as 12 feet of colluvial debris	Not measured

rutile and zircon in going from the D_r or C horizon toward the surface was assumed to indicate weathering; a decrease (negative slope) was taken to indicate deposition; (2) a decrease (negative slope) in the percent of tourmaline was assumed to indicate weathering while an increase (positive slope) represents deposition.

The data for rutile and zircon (Table 1) show two very prominent bulges in rutile and zircon content in the Tilsit at depths of 25 and 54 inches. These very pronounced rutile and zircon maxima are interpreted to indicate former weathering surfaces. The maxima for tour-

TABLE 1

Petrographic Analysis Data for the Light and Heavy Mineral Fractions (149 to 88μ) of the Tilsit Silt Loam

Horizon	Average Depth, Inches	Quartz, Percent	Degraded Mica, Percent	Potassium Feldspar, Percent	Plagioclase Feldspar, Percent	Chlorite, Percent	Muscovite, Percent
			LIGHT MINERALS				
A_1	2	28	69	1	2	..	..
A_2	10	39	55	1	trace	..	2
B_1	18	49	44	1	..	..	trace
B_2	25	53	46	..	..	..	..
F_1	30	49	51	trace	..	..	..
F_2	36	39	61	trace	..	..	..
Y_1	46	32	67	trace	..	..	..
Y_2	54	55	44	trace	..	..	..
Y_3	64	61	37	..	..	..	trace
Y_4	76	40	54	1	..	..	3
D_r	81+	54	37	..	..	..	8

Horizon	Average Depth, Inches	Magnetite, Percent	Epidote, Percent	Hornblende, Percent	Tourmaline, Percent	Zircon, Percent	Rutile, Percent	Pyroxenes, Percent	Others,[1] Percent
			HEAVY MINERALS						
A_1	2	46	19	18	trace	..	..	5	11
A_2	10	37	43	12	2	..	trace	2	4
B_1	18	42	37	9	3	1	1	1	6
B_2	25	50	36	2	1	5	3	1	2
F_1	30	51	45	1	trace	1	1	trace	2
F_2	36	57	29	4	6	trace	1	1	2
Y_1	46	66	19	2	5	2	..	3	3
Y_2	54	62	25	2	1	4	2	1	3
Y_3	64	73	9	5	2	1	..	1	9
Y_4	76	70	17	4	4	1	1	trace	3
D_r	81+	77	12	3	4	1	1	1	1

[1] Sphene, Muscovite, Chlorite, Garnet, Actinolite, Tremolite, Kyanite, Sodic-Amphiboles.

maline at 18 inches and 36 to 46 inches in this soil would denote deposition. The two maxima for tourmaline agree closely with the kaolinite maxima and when considered with the high kaolin content of certain lithological units of the Illinoian and Kansan tills would suggest that the Pennsylvanian materials incorporated into the tills could have been a possible source of the high-kaolin sediments for this soil.

Thus, clay mineral composition and petrographic data suggest that the genesis of the Tilsit soil has been influenced to a very significant degree by the deposition of loess on top of residuum from siltstone and sandstone.

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