FIELD TRIP HELD IN CONJUNCTION WITH THE NINTH NATIONAL CLAY CONFERENCE OCTOBER 5, 1960

by

W. N. MELHORN, JOE L. WHITE, H. P. ULRICH and E. J. YODER

Purdue University, Lafayette, Indiana

ROAD LOG: WEST LAFAYETTE TO HIGH BRIDGE AND RETURN

MILES

0.0 Load buses at west door of Purdue Memorial Center on University Mall. Turn left (west) onto Oval Drive and proceed to State St. Turn right (west) on State St., go one-halfblock, turn left (south) on South Memorial Drive and proceed south two blocks to Harrison Drive. Turn right (west) and go approximately one block west, stopping opposite Door 14 of the Service and Stores Building.

0.5 STOP 1. Gravel pit, Warsaw Silt Loam. (See profile description, laboratory and engineering data in Appendix A.) Proceed four blocks east on Harrison Drive to South Grant St., turn right (south) and go one block, then turn left (east) on Williams St. and go three blocks east.

1.2 Turn right (south) onto South River Rd.

6.6 This lower terrace of the Wabash Valley is the *Maumee* terrace. It is thought to mark the level of valley trenching by the Wabash River when it carried glacial meltwaters from early Glacial Lake Maumee in the Erie Basin through a breach in the Ft. Wayne moraine at Ft. Wayne, Indiana. An upper terrace level, the *Shelbyville*, is not well developed here but presumably marks the former level of valley filling by continental glaciers prior to trenching by the "Maumee torrent."

7.0 Small dunes on terrace to left of road. These dunes are present in the widest parts of the Wabash Valley only, and were formed by wind reworking of fine-grained materials of the Wabash valley train.

7.7 The road descends about 15 ft to the present flood plain. As can be seen in the next mile, the Maumee terrace is either absent or present only as a notching in the steep valley wall.

9.9 Miniature badlands developed on steep valley slopes where removal of vegetation has exposed till at the margins of the upland.

10.5 Upstream from this bridge across Indiana Creek, cross-bedded silts dip upstream in Indian Creek valley. This indicates that the Wabash valley train effectively dammed and ponded tributary streams at the point where the tributaries entered the major valley. Small bodies of standing water were left in the lower parts of the

https://doi.org/10.1346/CCMN.1960.0090102 Published online by Cambridge University Press

tributary valleys, in which the cross-bedded silts were deposited. Cnotinue west on gravel road, climbing hill to upland of Tazewell drift.

11.6 Ground moraine of Tazewell (Wisconsin) age. The drift cover on this upland, as determined from borings and seismic studies, is only 15–25 ft thick and lies on Mansfield (?) sandstone.

13.3 Warren–Tippecanoe county line.

14.2 Turn left (south) off black-top road just before reaching church building on outskirts of village of Green Hill. Proceed south on gravel road.

16.0 Turn right (west).

16.2 Turn left (south).

16.7 Turn right (west) and go approximately 0.7 mile to High Bridge.

17.5 STOP 2. High Bridge Section. Section is about 200 yd south of bridge and is reached by descending to the valley floor. (See Lithologic Description in Appendix B.) Little Pine Creek gorge has formed during reexcavation of a drift-filled valley of a major preglacial tributary to the Wabash River when the Wabash flowed in a Tertiary-age valley from 60 to 200 ft below the present valley floor. This old valley was graded to the ancestral Ohio and Mississippi Rivers which in turn were adjusted to a base level different from that of the present master streams. The lack of geomorphic adjustment of tributary streams, as evidenced by nickpoints seen in gullies at High Bridge, may represent an incomplete erosion cycle of late Tertiary or early Pleistocene age resulting from general crustal uplift of the region. Turn around and retrace route to Warren–Tippecanoe county line via Green Hill.

21.7 Warren–Tippecanoe county line. Turn left (north).

23.7 Junction State Highway 26. Turn right (east).

25.2 A few undrained natural depressions contain marshes or small lakes. These are the last vestiges of natural kettles on the Tazewell till plain, which otherwise has almost completely integrated surface drainage.

27.5 STOP 3. Goose Creek Clay Pit section. (See description and mineralogical data in Appendix C.) Section is on left side of road about 200 ft inside fence.

34.5 Arrive at Memorial Center, Purdue University Campus.

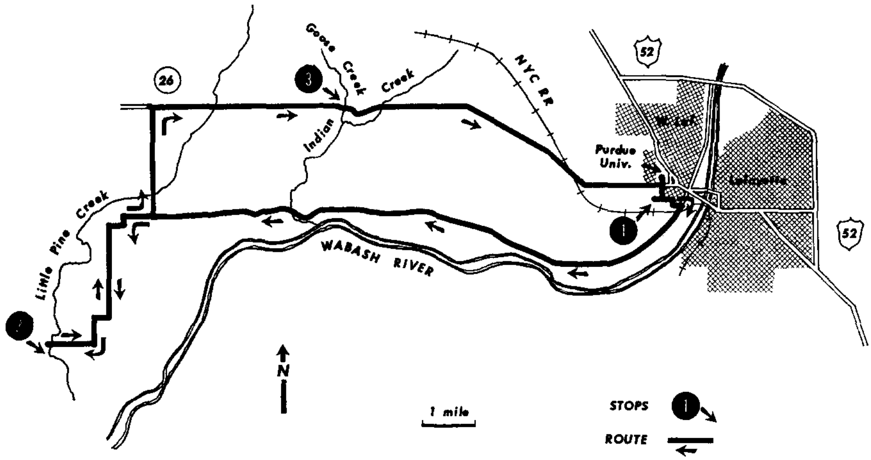

FIGURE 1.—Field trip route, West Lafayette to High Bridge and return.

https://doi.org/10.1346/CCMN.1960.0090102 Published online by Cambridge University Press

APPENDIX A

STOP 1: PROFILE OF A BRUNIZEM (WARSAW SERIES)

Purdue Campus

At this stop is a profile of Warsaw silt loam. The Warsaw soils are Brunizems that developed in loamy and silty material, 24–42 in. thick, that overlies stratified, calcareous gravel and sand. The Warsaw soils are Brunizem analogs of the Fox soils, which are in the Gray-Brown Podzolic great soil group. Warsaw soils are associated with the Westland and Abington soils of the Humic Gley great soil group.

The Warsaw soils developed under tall grasses. They are well drained to excessively drained, have little runoff, and have medium to rapid internal drainage.

The site sampled is nearly level (slopes of less than 1 percent) and is in bluegrass (*Poa* sp.). When sampled, the soil was dry down to the tongues of B_{23}, which were moist; the B_{22}, as described, is a darker brown than is typical for soils of the Warsaw series. Fibrous roots are concentrated in the A horizons, but a few larger roots extend down the tongues and through the solum to the loose gravel. The colors given are for moist soil.

Profile Description

A_{11} 0–2 in. 0–5 cm — Very dark grayish-brown (10 YR 3/2) silt loam; moderate, fine to very fine, granular structure; friable when moist; slightly acid; 1–3 in. thick; abrupt, smooth boundary. (Contains many roots, and a mat of very dark grayish-brown, fibrous roots and grass leaves, up to 2 in. thick, covers the mineral soil.)

A_{12} 2–13 in. 5–33 cm — Very dark brown (10 YR 2/2) silt loam high in clay; strong, fine to medium, granular structure; friable when moist, and hard when dry; slightly acid; 8–14 in. thick; clear, wavy boundary.

B_1 13–16 in. 33–40 cm — Dark-brown (7.5 YR 3/2 to 10 YR 3/3) silty clay loam; strong, fine to medium, subangular blocky structure; firm when moist, and very hard when dry; medium acid; 3–6 in. thick; clear, wavy boundary.

B_{21} 16–20 in. 40–50 cm — Dark-brown (7.5 YR 3/2 to 10 YR 3/3) slightly gravelly silty clay loam; moderate, medium, subangular and angular blocky structure; firm when moist, very hard when dry, and plastic and sticky when wet; medium acid; a few thin clay coatings on ped faces; 3–5 in. thick; clear, wavy boundary.

B_{22} 20–35 in. 50–86 cm — Dark-brown (7.5 YR 3/2) to dark reddish-brown (5 YR 3/2) gravelly clay; weak, coarse, subangular blocky structure; friable when moist; medium acid; medium, dark, organic-mineral coatings on pebbles and ped faces; 10–20 in. thick; clear, wavy boundary.

B_{23} 35–40 in. 86–100 cm — Dark reddish-brown (5 YR 3/2–2/2) gravelly sandy clay loam; weak, coarse, subangular blocky structure; friable when moist, and plastic and sticky when wet; slightly acid to neutral; black organic-mineral coatings on ped

		faces; 3–7 in. thick, but tongues extend 9–12 in. farther; abrupt, irregular boundary.
C	40 in. + 100 cm +	Brown (10 YR 3/3) fine gravel and sand with very thin coatings of silt; highly calcareous; rounded, dark- and light-colored igneous rock with many limestone pebbles and a few dark-brown shale fragments.

The B_{23} horizon is characteristic of this soil, but in places it is thin. Tongues of the B_{23} normally extend to depths of 1 or 2 ft, or more.

Warsaw silt loams appear to be thinly mantled with loess in some areas. The loams and sandy loams of the Warsaw series have clay loam B_1 horizons. The content of gravel in Warsaw soils is variable but commonly increases with depth. Where the solum developed over sand, there may be no gravel.

Warsaw soils are almost entirely cultivated; the crops are corn, wheat, soybeans, alfalfa, and grass–legume mixtures for hay or pasture. Sweet corn, tomatoes, and similar vegetable crops are grown on limited acreages near larger cities.

Laboratory data on the profile of Warsaw silt loam at Stop 1 are shown in Table 1. Investigation of clay mineralogy indicates much interstratified micaceous material that collapses to 10 Å on heating to 500 °C. Illite is poorly defined. Kaolinite is present in small but approximately equal amounts throughout the profile.

Engineering Data

The engineering data for the Warsaw soil are given in Tables 2 and 3.

Problems of grade and alignment.—Construction of major cuts and fills is not a problem, since the areas are nearly level. Most pavements for highways and airports are constructed at or near the original ground elevation on Warsaw soils. Some excavation is necessary if the highway climbs the face of a terrace, but this causes no special problems, for the roadbed is then on a nonplastic substratum.

Suitability for subgrades.—Warsaw soils have a substratum ideal for use in grades for highways and airports. The materials are granular and have a California bearing ratio mainly in excess of 80 percent. In fact, these materials have been used for base courses with much success. Similar gravels of the glacial terraces are the major source of aggregate in the vicinity of Lafayette.

The materials of the upper horizons, in contrast to those of the substratum, are plastic and normally contain some organic matter. They would provide a relatively resilient foundation, and pavement performance likely would be poor.

The actual suitability of Warsaw soils at Stop 1 depends on the position of the roadbed in relation to the layers of the soil profile, and on the relative thickness of the overburden above the substratum.

TABLE 1.—MECHANICAL AND CHEMICAL ANALYSES OF WARSAW SILT LOAM
(Analyses by Soil Survey Laboratories of the U.S. Soil Conservation Service)

Depth (in.)	Horizon	Particle Size Distribution (mm)										pH (1:1)	Organic Carbon (percent)
		Very Coarse Sand (2–1) (percent)	Coarse Sand (1–0.5) (percent)	Medium Sand (0.5–0.25) (percent)	Fine Sand (0.25–0.10) (percent)	Very Fine Sand (0.10–0.05) (percent)	Silt (0.05–0.002) (percent)	Clay (<0.002) (percent)	(0.2–0.02) (percent)	(0.02–0.002) (percent)	<2 (percent)		
0–2	A_{11}	1.8	3.8	2.0	2.0	3.3	61.7	25.4	25.7	40.3	3.1	6.7	4.04
2–13	A_{12}	1.2	3.5	1.8	1.3	2.4	62.7	27.1	25.1	40.6	Tr[1]	6.3	2.31
13–16	B_1	1.2	3.8	1.8	1.1	2.3	59.6	30.2	22.8	39.6	Tr[1]	5.5	1.61
16–20	B_{21}	2.1	4.4	2.0	1.5	2.4	53.5	34.1	20.7	35.8	Tr[1]	5.3	1.36
20–35	B_{22}	15.1	10.8	3.1	2.4	2.9	24.1	41.6	12.4	15.9	45.3	5.1	1.20
35–40	B_{23}	36.3[2]	9.5[2]	1.9[2]	1.9[2]	2.0[2]	11.8	36.6	6.6	8.1	58.1	6.9	0.93
40+	C	65.6[3]	12.0[3]	2.4[3]	2.3[3]	2.1[3]	12.0	3.6	8.4	6.8	73.3	8.3	0.06

Depth (in.)	Nitrogen (percent)	C/N	Free Fe_2O_3 (percent)	$CaCO_3$ Equivalent (percent)	Cation Exchange Capacity (NH_4OAc)	Extractable Cations (meq/100 g)					Base Saturation (NH_4OAc) (percent)	Base Saturation on Sum Cations (percent)	Sum of Extractable Bases	Sum of Extractable Cations	Ca/Mg
						Ca	Mg	H	Na	K					
0–2	0.332	12.2	1.7	<1	23.1	17.1	5.2	6.4	<0.1	0.1	101	78	23.3	29.7	3.3
2–13	0.199	11.6	1.7	—	18.4	12.4	4.1	7.9	<0.1	0.6	93	68	17.1	25.0	3.0
13–16	0.136	11.8	1.8	—	16.9	8.8	3.8	9.9	<0.1	0.2	76	56	12.8	22.7	2.3
16–20	0.118	11.5	2.1	—	17.9	9.8	3.7	11.5	<0.1	0.3	77	54	13.8	25.3	2.6
20–35	0.104	11.5	2.8	—	21.8	11.8	4.0	13.4	0.1	0.4	75	55	16.3	29.7	3.0
35–40	0.093	10.0	3.4	2	22.7	19.5	6.9	7.4	0.1	0.4	118	78	26.9	34.3	2.8
40+	0.006	10.0	1.2	34	2.0	10.9	0.8	<0.1	<0.1	<0.1	585	100	11.7	11.7	13.6

[1] Trace.
[2] Trace carbonates. Limestone fragments?
[3] Few carbonates. Limestone fragments?

TABLE 2.—SUMMARY OF ENGINEERING TEST RESULTS ON WARSAW SILT LOAM SOIL SAMPLES
(Surcharge weights of 20 pounds used during soaking and penetration tests)

Site, and Horizon Samples	Liquid Limit	Plasticity Index	Grain-size Analyses (percentage passing sieve)[1]				Maximum Dry Density (lb/ft³)	Compaction at Optimum Moisture Content (percent)	California Bearing Ratio	AASHO Classification[2]	Unified Classification[3]
			No. 4	No. 10	No. 100	No. 200					
Stop 1:											
(Warsaw silt loam):											
A	44.5	27.4	99.8	99.0	87.2	85.2	92.5	24.0	8	A-7-6(15)	CL
B_2	46.7	21.2	99.5	97.4	88.6	87.4	99.1	21.2	8	A-7-6(12)	CL
B_3	—	NP[5]	62.4	43.5	25.7	24.4	105.0	21.0	—	A-1-b(0)	SM
C[4]	—	NP[5]	73.3	30.9	4.5	3.8	123.0	—	—	A-1-a(0)	SW

[1] Mesh size as follows: No. 4 = 4.7 mm; No. 10 = 2.0 mm; No. 100 = 0.149 mm; No. 200 = 0.074 mm.
[2] Classification used by American Association of State Highway officials.
[3] Classification used by U.S. Army Corps of Engineers.
[4] If capital letter is not followed by an arabic numberal, composite samples were taken for the horizon.
[5] Nonplastic.

TABLE 3.—ENGINEERING DATA FOR WARSAW SILT LOAM SOIL

Horizon	Texture	Unified System	Suitability for Subgrade	Susceptibility to Frost	Highway Drainage	Highway Compaction	General Highway Design and Performance
A	Loam	CL	Fair: (CBR = 8)	Medium	General drainage excellent; major problem is overburden material which is slow to drain and causes ponding	Compaction not difficult; granular material best compacted with vibrator or smoothwheel compactor	Overall rating excellent; bituminous pavements can be relatively thin. Base course needed under rigid pavements if subgrade consists of overburden; use parent materials in pavements of Portland cement concrete or bituminous concrete
B_2	Loam	CL	Fair: (CBR = 8)	Medium			
B_3	Gravelly clay loam	SM	Good; noncompressible	Low			
C	Stratified gravel and sand outwash	SW	Excellent; noncompressible	Low			

https://doi.org/10.1346/CCMN.1960.0090102 Published online by Cambridge University Press

Compressibility of Warsaw soils depends on position in the soil profile. The granular materials in the substratum are not compressible; the overburden may be resilient, compressible, or both.

Frost action.—The material in the substratum is not susceptible to frost, but that in layers above the substratum is susceptible. Further, the substratum deposit is erratic and there are some "dirty" gravels in the substratum that are susceptible to frost. The danger of frost is minimized, however, by excellent drainage of the soil profile. As a general rule, frost problems are minor.

General performance of pavement.—Performance is excellent, primarily because internal drainage is excellent.

Drainage.—The profile of Warsaw soils is almost ideal in regard to drainage. The main problem is a perched water table, often encountered immediately after a rain. The perched water table can put some stress on pavements, but this can be minimized by providing adequate surface drains.

At the Purdue Airport, dry wells were used to permit surface water to move into the porous substratum. These dry wells are not satisfactory, as they are clogged or partially clogged with material from the surface.

Problems of construction.—There are few problems. Care must be taken to provide adequate surface drainage to safeguard against perched water tables. Compaction of the overburden can be done by sheepsfoot rollers or by rubber-tired equipment. Compaction of the substratum is best done by vibratory or smooth-wheeled rollers.

APPENDIX B

STOP 2: HIGH BRIDGE SECTION

NE 1/4 SW 1/4 Section 5, T. 22 N., R. 6 W.
Warren County

Unit	*Lithologic Description*	*Thickness, feet*
Pennsylvanian:		
12	Sandstone, iron-stained, soft, medium-grained; quartz grains rounded; locally grades into or is intermixed with breccia, like Units 8 and 10 ...	6.0
11	Sandstone, white, massive, medium-grained; quartz grains subangular, no staining	1.2

Unit	*Lithologic Description*	*Thickness, feet*
10	Breccia, angular to subangular fragments of siltstone imbedded in fine-grained, soft matrix of rose-colored sandstone	1.5
9	Sandstone, white, massive, medium-grained; quartz grains subrounded	1.1
8	Breccia, subrounded to angular fragments of greenish-gray siltstone in matrix of fine-grained, soft, dark rose-colored sandstone	2.7
7	Sandstone, light brown, massive, medium-grained, faintly crossbedded, locally heavily iron-stained	6.1
6	Breccia, subangular pebbles of greenish-gray siltstone in fine-grained, white or tan sandstone matrix; unit lenticular or of variable thickness; weathers to greenish clay	1.7
5	Sandstone, light brown, fine- to medium-grained; quartz grains rounded and clear; minor mica; less limonite staining than Unit 3	0.8
4	Breccia, angular to subrounded pebbles of greenish-gray siltstone in fine-grained, micaceous, light brown to white sandstone matrix (storm breccia?)	0.9
3	Sandstone, light brown, limonitic, medium- to fine-grained, micaceous; ironstone concretions and irregularly elongated nodules at base extend as roof pendants downward into siltstones of Unit 2; contact with Unit 2 irregular	0.8
	UNCONFORMITY	
Pennsylvanian (?) or Mississippian (?):		
2	Siltstone, dark gray, fine-grained, locally mixed with dark gray, calcareous shale. Unit more massive and lacks the conjugate fractures of Unit 1. Upper part of Unit 2 contains impressions of *Calamites*. Sheety structure present in lower part of unit	17.1
1	Siltstone, dark gray to black, fine-grained, micaceous; a few shaly partings. Lentils of brown, crinoidal (?) limestone as much as 9 in. thick present in lowest 4 ft of unit exposed. Thin partings and flakes of bituminous coal locally present 4–6 ft above base of section, organic matter abundant throughout. Siltstone is blocky and cut by two sets of recurrent fractures dipping 40° N. 25° W. and 60° S. 15–20° W.	18.0
	Total section	57.9

Units 3 through 7 form the compound waterfall near the head of the ravine.

In this area, Lower Pennsylvanian Mansfield sandstone commonly rests unconformably on units of the Lower Mississippian Borden Group of rocks (Osagian). At Attica, 6½ miles southwest of High Bridge, Mansfield sandstone lies unconformably on a Borden marine facies that contains abundant bryozoa, crinoids, brachiopods, and corals.

At High Bridge, however, typical Mississippian–Pennsylvanian areal relations are not present and only tentative age assignments have been given in the measured section. The limestone lenses and general physical characteristics of Unit 1 are suggestive of Borden units exposed elsewhere in the local area, but the minute partings of coal and the abundant plant material present from immediately above the limestones upward through the remainder of Units 1 and 2 are more characteristic of younger Mississippian or, more commonly, Pennsylvanian rocks in this region.

The recurrent breccia units above the unconformity are also of interest. The pebbles appear to be of nonlocal derivation, and physically they resemble lower Borden units that outcrop northwest of High Bridge in Benton County. Although the breccias may be a series of storm-breccia deposits, further study may suggest a different origin and cause of deposition. Bedrock units of Warren County have not received serious study for many years and the areal persistence of the breccias and related units therefore is unknown.

APPENDIX C

STOP 3: GOOSE CREEK CLAY PIT SECTION

SW 1/4 SE 1/4 Section 7, T. 23 N. R. 5 W
Tippecanoe County

Unit	*Description*	*Thickness, feet*
12	Soil zone; till, oxidized and leached, sandy, yellowish-brown	1.7
11	Gravel, medium; calcareous scattered large cobbles of quartzite, relict biotite gneiss; iron-stained nodular zone at base; oriented pebbles	1.6
10	Till, silty and clayey, very pebbly	3.7
9	Paleosol (?); clay-rich, sandy; local lenses of sand; cobble layer 0.3 ft from top; limonite nodules at base; noncalcareous	1.2
8	Sand, fine-grained, gray, calcareous (outwash?)	1.6
7	Till, silty and clayey, brownish-gray, calcareous; thin sandy partings; limonite zone near base	1.1
6	Till, dark blue-gray, clayey, calcareous, pebbly	1.7
5	Till, dark blue-gray, clayey, calcareous; alternating with fine-grained, faintly stratified sand (ablation till?)	2.8
4	Silt, very fine grained, oxidized, mottled, calcareous; grades upward into till; thickness locally as much as 1.1 ft	0.6
3	Till, pebbly, blue-gray, calcareous	1.9
2	Till, calcareous, light-brown; very thin clay-enriched and oxidized zone at top; interlayered with fine-grained, calcareous, brownish sand	2.9
1	Sand, brown, oxidized (below base of pit)	2.0+
	Total	22.8+

This pit is located in a stream-dissected portion of the Tazewell (Wisconsin) ground moraine of western Indiana. The interlayering of unsorted and sorted materials suggests stagnation and melting of the ice sheet by ablation rather than deposition during a series of local advances and retreats of Tazewell ice.

Clay Mineralogy

The X-ray diffractometer tracings for the $<2\ \mu$ fractions of most of the units of the Goose Creek Clay Pit Section are shown in Fig. 2. Illite is the dominant clay mineral in most of the sections, with 14 Å material second in

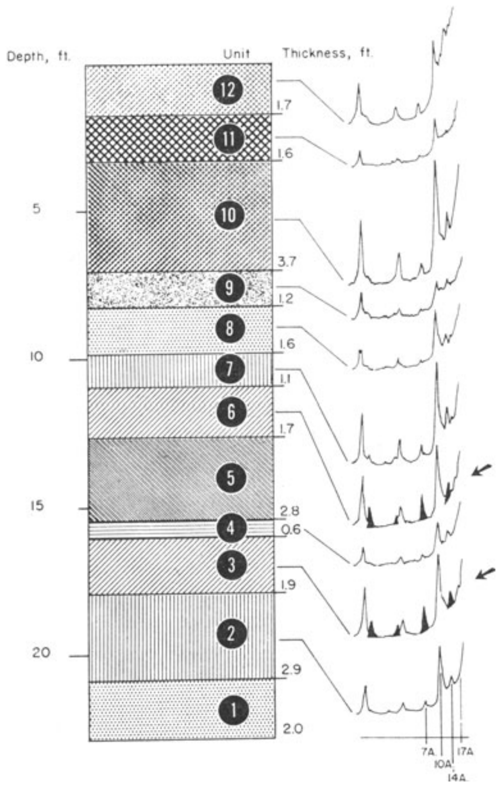

FIGURE 2.—X-ray diffractometer tracings illustrating variations in clay mineral suites of the Goose Creek Clay Pit section. Samples were treated with ethylene glycol. Chlorite lines are indicated in Units 3 and 6 by shading.

abundance. Kaolinite is present in small amounts. Heating tests indicate that the 14 Å material in Units 3 and 6 are predominantly chlorite; the other 14 Å materials are considered to be vermiculitic.

Chlorites normally are considered to be trioctahedral; attempts to establish the nature of the chlorite in this section by X-ray diffraction and infrared techniques thus far have failed to show evidence for trioctahedral composition.

https://doi.org/10.1346/CCMN.1960.0090102 Published online by Cambridge University Press