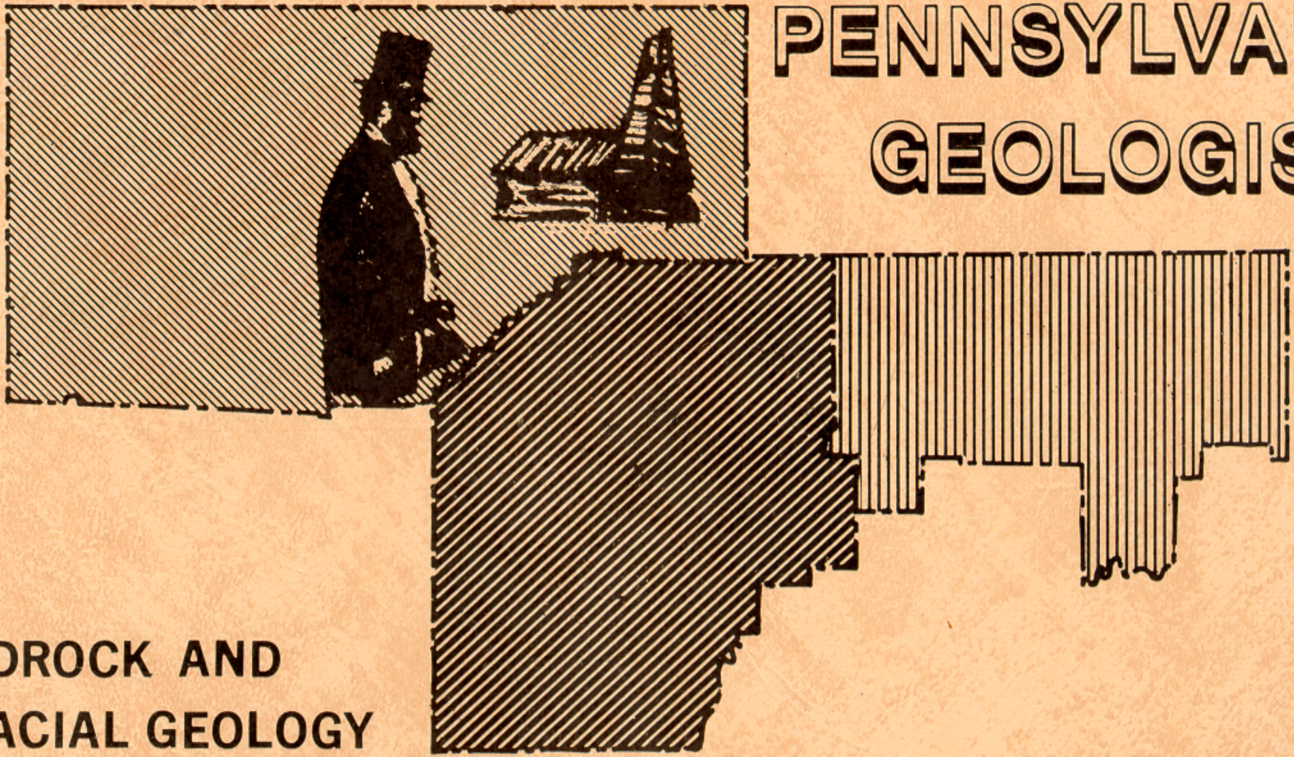
GUIDEBOOK

41st. ANNUAL FIELD CONFERENCE OF PENNSYLVANIA GEOLOGISTS



BEDROCK AND GLACIAL GEOLOGY OF NORTHWESTERN PENNSYLVANIA IN CRAWFORD, FOREST, AND VENANGO COUNTIES

TITUSVILLE, PA.

OCTOBER 1 & 2, 1976

Hosts: Slippery Rock State College,
Edinboro State College, and
Pa. Geological Survey

Guidebook for the

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BEDROCK AND GLACIAL GEOLOGY

OF

NORTHWESTERN PENNSYLVANIA

IN

CRAWFORD, FOREST AND VENANGO COUNTIES

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BY WILLIAM F. CHAPMAN AND JESSE L. CRAFT

INTRODUCTION

The area examined on this field trip is very near the boundary between the Glaciated and Unglaciated sections of the Allegheny Plateau Province. Both sections of the plateau are maturely dissected by streams with the amount of incision ranging from a few hundred feet to a few thousand feet. In the areas seen on this trip, the maximum relief is along the Allegheny River where it has cut its valley over 500 feet into the plateau surface which has an altitude here of slightly over 1,500 feet above sea level.

In the glaciated portion of the plateau, till and glaciofluvial deposits are found in varying degrees of continuity capping the dissected plateau surface and along the valley walls and bottoms. Deposits of at least one Illinoian (?) and several Wisconsinan glacial advances have been described in northwestern Pennsylvania. On this trip we will examine an Illinoian (?) till and middle Wisconsinan till with their respective glaciofluvial deposits. As we travel east to the Tionesta bedrock stop, we will leave the glaciated portion of the plateau. The boundary will not be easy to recognize however, due to the patchy distribution of the outermost Illinoian (?) deposits.

GLACIAL HISTORY

Most of the glacial studies in northwest Pennsylvania have been of a broad, regional nature and very few smaller scale (quadrangle size) investigations have been completed. Probably the best regional summaries to date are the map and accompanying text by Shepps and others, 1959; and a later stratigraphic study of northwestern Pennsylvania by White and others, 1969.

A. GLACIAL DEPOSITS

1. Distribution

Armed with this paucity of detailed data, we will discuss the Pleistocene deposits of this area. Figure 1 shows the commonly recognized tills in northwestern Pennsylvania.

Each of these tills was deposited by glaciers that overrode the Lake Erie basin and flowed up over the Allegheny Escarpment and onto the plateau. In general, the oldest glaciers advanced farthest and successively younger ice sheets partially covered these older deposits from the northwest (Figure 2).

Epoch	*Stage*	*Substage*	*Unit*	*Material*
PLEISTOCENE	Wisconsinan	Late (Woodfordian)	Ashtabula Till	Silty till, oxidizes dark brown
			Hiram Till	Clayey till, oxidizes chocolate brown
			Lavery Till	Silty till, oxidizes dark brown
			Kent Till	Sandy till, oxidizes yellow brown
		Farmdalian		Weathered till and basal paleosol
		Early (Altonian)	Titusville Till (several separate sheets)	Sandy, pebbly till, oxidizes olive brown; sand layers may separate till sheets
	Sangamonian (?)			Weathered till with silt loam paleosol
	Illinoian (?)		Mapledale Till (two sheets?)	Stony, sandstone-rich till, oxidizes yellow brown, very low in carbonate
	"Pre-Illinoian"		Slippery Rock Till	Deeply weathered till and paleosol with erratic pebbles

Figure 1. Glacial deposits in northwestern Pennsylvania (After White and others, 1969, p. 9)

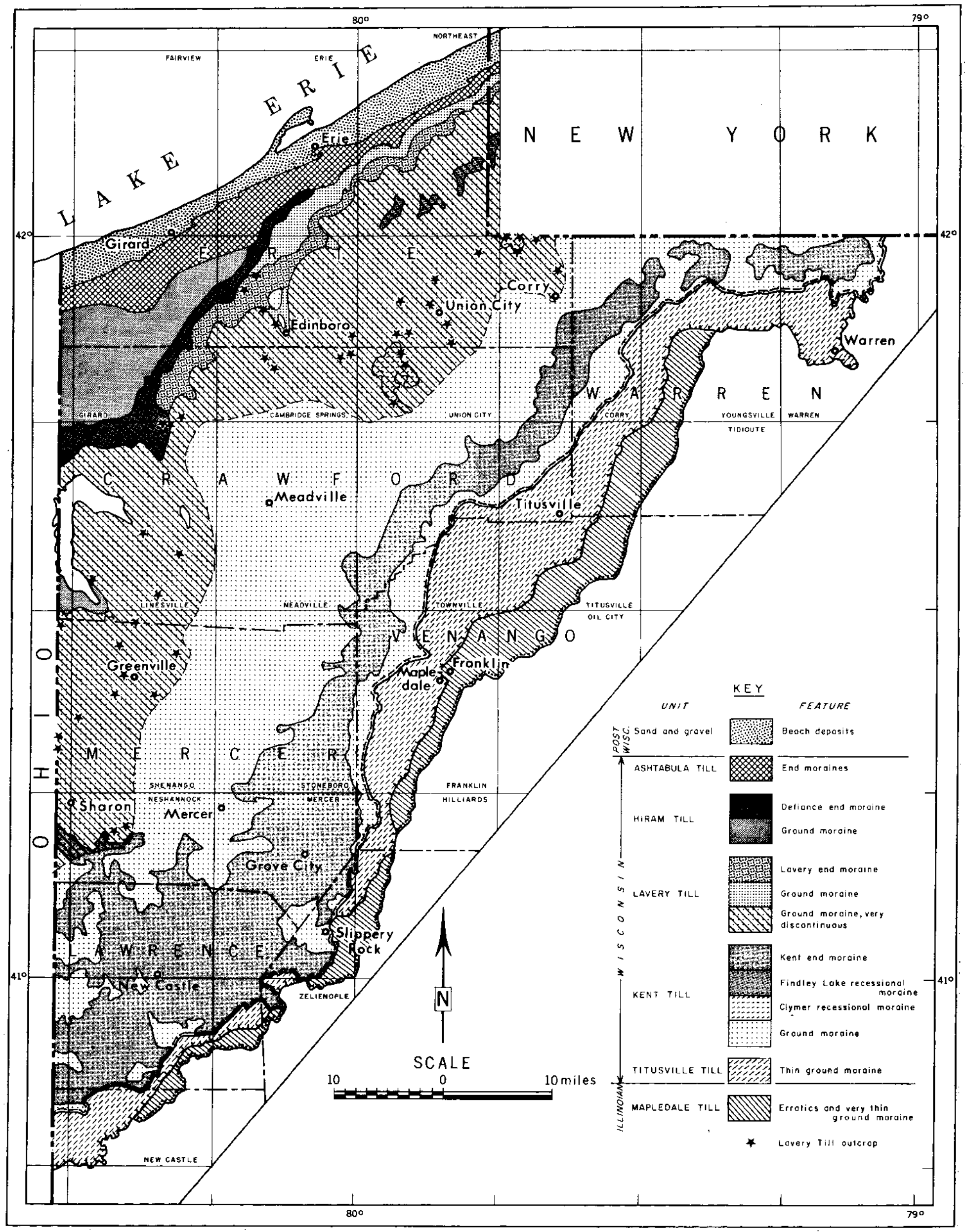


Figure 2. Distribution of glacial deposits in northwestern Pennsylvania (after White and others, 1969, p. 10).

2. Tills

On this trip two separate tills will be seen. The older of these is the Mapledale Till with its type section 1 mile southwest of Franklin, Pennsylvania; the other is the Titusville Till named for till south of Titusville, Pennsylvania. We will visit both of these type sections.

MAPLEDALE TILL

The unweathered Mapledale Till is dark gray to bright gray with Munsell soil color designations of 5Y 4/2 to 4/0. When found in the oxidized state (as we will see at Stop VII) it is dark yellow brown (10YR 4/4).

The Mapledale Till is quite variable in texture although it is usually sandy and pebbly with cobbles and surface boulders of sandstone. Grain size analysis of 24 samples by White and others, 1969, gave mean values of 44% sand, 36% silt and 20% clay.

Crystalline erratics are rare in the Mapledale Till and usually occur as pebble-size fragments. The typical lack of good, unequivocal erratics makes the positive identification of Mapledale Till difficult.

TITUSVILLE TILL

Overlying the Mapledale Till in places is the Titusville Till. The type section of this till is Stop V of the field trip. Fresh Titusville Till has a distinctive olive-gray color (5Y 4/2) but becomes more olive brown (2.5Y 4/4) when oxidized. Black manganese staining can be observed coating pebbles and along joints in the oxidized portion of the till. The overall mean texture of the Titusville Till is 45.4% sand, 36.9% silt and 17.7% clay; not dramatically different from the Mapledale Till texture. The color and manganese stains help to distinguish the two tills.

The Titusville Till varies in thickness from 0 to 110 feet with an average of about 20 feet (White, 1971). Where it is exposed, the till appears as a single sheet, although to the north and west as many as five separate Titusville Till sheets have been described (White and others, 1969). Where more than one Titusville Till is exposed in a cut, the adjacent tills are separated by a layer of sand and gravel which ranges in thickness from a few inches to 20 feet. The most continuous sand and gravel layer is found beneath the uppermost Titusville Till.

White and others, 1969, believe that these multiple till sheets separated by sand and gravel layers suggest that the Titusville ice underwent several minor readvances during its general retreat.

Carbon-14 dates obtained from peat deposits in gravel beneath the Titusville Till range from 35,000+1,835-2,385 years to 40,500 ±1,000 years (White and others, 1969). According to Dreimanis and Goldthwait, 1973, these dates would place the Titusville Till within middle Wisconsinan time (53,000 to 23,000 B.P.). Possible correlations of the Titusville Till with the Mogadore Till (Akron, Ohio) and with the Millbrook Till (northeast-central Ohio) have been suggested (White and others, 1969).

3. Glaciofluvial deposits

One of the glacial problems to be examined on this trip involves the nature, origin and age of the many glaciofluvial deposits in the area. Little recent work has been done with these sand and gravel deposits to determine their age and relationship to the former glaciers that occupied this area. There are at least two major groups of glaciofluvial deposits that can be seen. The first is the group of high terrace gravels, the tops of which lie 100 to over 200 feet above the floors of the present stream valleys. The second group is the relatively low floodplain gravels that are only 5 to 40 feet above the level of present streams.

ILLINOIAN GLACIOFLUVIAL DEPOSITS

Glaciofluvial deposits described as Mapledale outwash by White and others, 1969, will be seen at several stops on this trip. Most of these are above the present floodplains and extend to 100 feet or more above present streams. While some of the sand and gravel deposits we will see along Patchel Run appear to be deeply weathered, others of roughly the same topographic position are much "fresher" in appearance. Herein lies a problem to be investigated on the trip: which, if any, of these gravels are truly Illinoian in age?

WISCONSINAN GLACIOFLUVIAL DEPOSITS

Sand and gravel deposits of Wisconsinan age occur in two major settings. Some are seen in subsurface separating adjacent Titusville Till sheets. Others make up the relatively low terraces that rise 20 to 40 feet above French Creek and other local streams. It is also possible that some of the higher gravel terraces, such as at Reno, Pennsylvania, may also be of Wisconsinan age.

The various gravels to be seen on the trip clearly do <u>not</u> all show the same degree of weathering. If weathering can be considered to be a reliable indicator of age, then possibly some of the gravels previously referred to as Illinoian may be, in fact, early or middle Wisconsinan in age.

Carbon-14 dates from peat found in gravels east of Titusville, Pennsylvania, beneath Titusville Till suggest that some or all of these gravels may have been deposited during the latter part of the Port Talbot II Interstadial about 40,000 years ago. Pollen studies of these same peat deposits by A. A. Berti, 1975, revealed three pollen zones. "The pollen and macrofossils in the sediments indicate that spruce forests with openings were present on the adjoining uplands during deposition of the lower zone. By the time the upper zone was deposited, treeless areas had expanded." (Berti, 1975, p. 1683).

BEDROCK STRATIGRAPHY

BY ALBERT N. WARD, JR.

EXPOSED ROCKS

Introduction

We will have the opportunity to examine rocks representative of the Upper Devonian?, Mississippian, and Lower Pennsylvanian Systems. The stratigraphic terminology for the rocks seen on this trip follows that of Poth, 1963, for the Pennsylvanian units, and of Schiner and Kimmel, 1972, for Mississippian units (Figure 3).

Poor exposures and rock units with rapid lateral and vertical lithic changes characterize the rocks of western Pennsylvania. Accordingly, the exact relationships between some rock units in the Tionesta-Franklin region with those to the east and west have not been established.

PENNSYLVANIAN SYSTEM

Pottsville Group

Rocks belonging to the Sharon?, Connoquenessing, and Mercer Formations cap most of the hills between Tionesta and Franklin along the route of this field trip. The thickness of the Pottsville Group averages about 250 feet between Tionesta and Oil City. It appears to thicken in the Franklin area, where along the new Route 8 exposures the Connoquenessing-Sharon alone exceeds 205 feet.

Connoquenessing Formation

Above the Sharon? horizon is a sequence of sandstones and coal-bearing shales that constitute the Upper, Middle, and Lower Members of the Connoquenessing Formation. We will see these units at STOP VIII.

The Upper Member of the Connoquenessing is characterized by light-gray, medium-to coarse-grained sandstones that often grade laterally and upward into siltstones, silt-shale, and clay-shale of the Mercer Formation. The finer grained intervals exhibit small-scale trough cross-beds and ripple laminations. The coarser grained thick beds cut into underlying units and exhibit strong tabular and less frequently large-scale trough cross-beds. Ironstone nodules and clay chips are often found in the thicker beds. Numerous small bed forms, such as reactivation surfaces and foreset flow deformation, may be seen in these beds (Figures 4 and 5).

Harms and others, 1975, suggest that ripples occur only in grain sizes less than about 0.6 mm at low flow velocities. Tabular cross stratification and reactivation surfaces are associated with straight-crested features with well-defined avalanche faces called "sand waves". Sand waves form at moderate current velocities.

SYSTEM	GROUP	FORMATION	MEMBER
PENNSYLVANIAN	Pottsville	Mercer	
		Connoquenessing	Upper
			Middle
			Lower
		Sharon	
unconformity			
MISSISSIPPIAN		Shenango	Upper
			Lower
	Cuyahoga	Meadville Shale	
		Sharpsville Sandstone	
		Orangeville Shale	Bartholomew Siltstone
		Corry Sandstone	
DEVONIAN	Riceville		

Figure 3. Stratigraphic terminology for surficial rocks described in this guidebook (modified from Poth, 1963, and Schiner and Kimmel, 1972).

Figure 4. Reactivation surface suggestive of an interruption in the depositional process. The tabular cross-beds grade upward into ripple laminated silt-shale. These structures are most commonly found associated with sand waves. Upper Connoquenessing in the southbound lane, STOP VIII.

Figure 5. Foreset flow structures on a tabular cross-bedded unit. The unit is cut out by overlying trough cross-beds. Upper Connoquenessing in southbound lane, STOP VIII.

Trough cross-beds result from downflow migrating forms termed "dunes". The crests of such features are sinuous. Dunes form at high flow velocities. We will examine the relationships of these features as seen in the outcrops along the new Route 8 highway.

Spectacular lateral changes occur in the Pottsville units. Figures 6 and 7 illustrate such a change. The Upper Member of the Connoquenessing interfingers laterally (to the south) into Mercer shales. This occurs in the east wall of the northbound lane. If one stands on the center median at STOP VIII and looks at the west face of the southbound lane, only thick-bedded, dominantly north dipping, cross-bedded sandstone is evident. In the width of a modern superhighway, lateral facies changes result in thinning of the Upper Member of the Connoquenessing Formation by more than 30 feet! The Upper Member attains a minimum thickness of 90 feet at this site. This may well be an excellent example in the sedimentary record of a laterally migrating point bar and floodplain sequence.

The Middle Member of the Connoquenessing (Figure 8) consists of gray to dark-gray clay shales, mud shales, clay and one or more thin coal beds which are often correlated with the "Quakertown Coal". The upper contact of the member is usually sharp and erosional; the lower contact is gradational with the sandstone of the Lower Member of the Connoquenessing.

Field trip participants will see several small faults that cut the Middle Member but do not extend through the overlying Upper Member sandstones. Such faults probably are not tectonic in nature but rather are due to slump in muds and clays soon after deposition.

The Lower Member of the Connoquenessing has the same characteristics as the Upper Member. In many places this unit and the underlying "Sharon" interval cannot be separated. This occurs when both the Sharon and Lower Member of the Connoquenessing are sandstone.

Sharon? Formation

The interval between the Mississippian and the Lower Member of the Connoquenessing Formation is occupied by varicolored, thin-bedded, medium- to coarse-grained sandstone 35-70 feet thick. The thickly bedded units commonly grade upward into fine-grained thinly bedded sandstones, siltstones and shales. The finer grained sediments often contain carbonized plant fossils. Interbedded with the shaley layers are thin coal beds at some localities. Fine-grained sandstones and silt-shale are present at the Tionesta section (Figure 9) measured by Michael Lukert. They occur at an elevation of 1470 feet just above a covered interval.

South of Franklin in the new Route 8 cuts (STOP VIII) this interval is occupied by thick-bedded, light-gray to pink, coarse-grained, trough and tabular cross-bedded sandstone. The sandstone lies directly on Mississippian shale in the northbound lane. In the southbound lane, the sandstone is thinner bedded with the upper part covered. Coal chips occur in the float in the covered interval. They have not been seen in place. Rocks at these two locations occupy the stratigraphic position of the Sharon Formation.

Figure 6. Lateral gradation of Upper Connoquenessing into Mercer shales at STOP VIII.

Figure 7. The Upper Member of the Connoquenessing Formation at STOP VIII. Note the tabular cross-beds near the top. The unit is overlain by Mapledale Till. The observer faces the west wall of the southbound lane. See Figure 6 for a striking example of lateral facies change into Mercer shales along the east bank of the northbound lane.

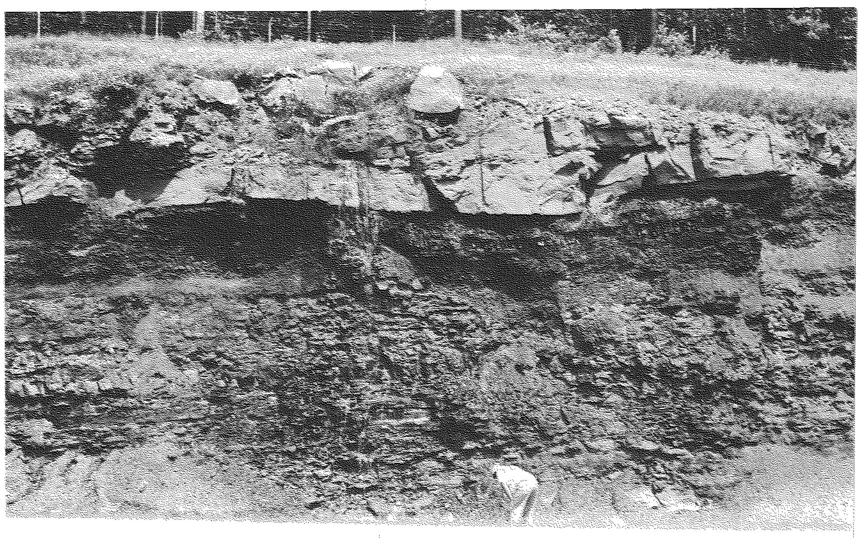


Figure 8. Contact of the Middle and Upper Member of the Connoquenessing. Coal below the sandstone is displaced by a small normal fault, STOP VIII.

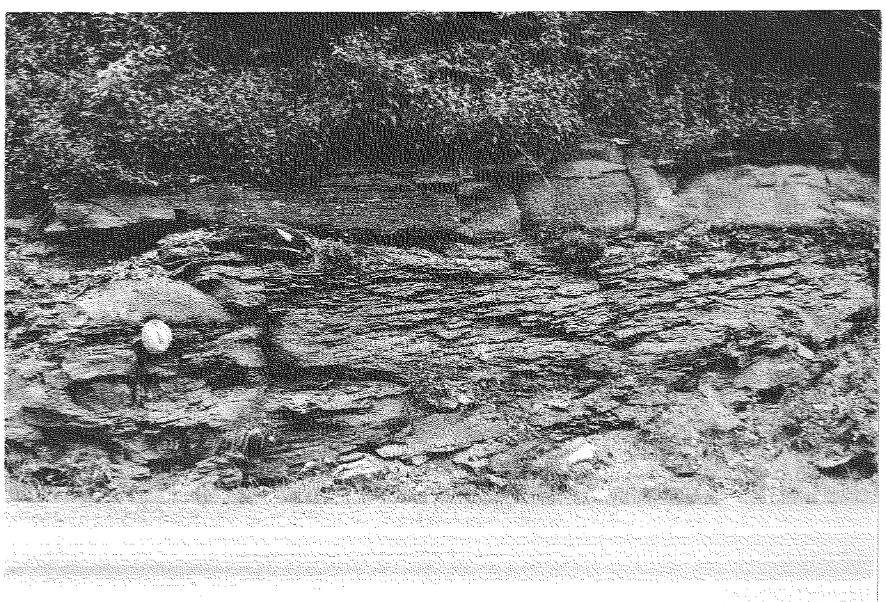


Figure 9. Silt shale and fine-grained sandstone of the Sharon? interval underlying Connoquenessing sandstones at Tionesta. Note the large ironstone concretion below and just left of the hat.

The interval is about 35 feet thick. Conglomeratic sandstone typical of the Sharon in its type locality has not been seen in the Titusville-Franklin area. It is not known if the Sharon of the type locality is laterally continuous with these beds.

MISSISSIPPIAN SYSTEM

Rocks assigned to the Mississippian System will be seen by field trip participants at several localities (STOPS I, II, IV, VI, VIII). The stratigraphic terminology used for these rocks has a complex history. Caster, 1934, Pepper and others, 1954, Sass, 1960, and Schiner and Kimmel, 1972, have dealt at length with the stratigraphic relations in western Pennsylvania. The most recent and detailed work in the area has resulted in extending eastward stratigraphic terms developed in eastern Ohio and the Sharon-Meadville area.

Accordingly, the Shenango Formation has been redefined to include all rocks between the Pottsville and the Cuyahoga Groups (Schiner and Kimmel, 1972). The Meadville Shale, Sharpsville Sandstone, and Orangeville Shale of the Cuyahoga Group appear to extend as far east as Tionesta. The Corry Sandstone separates the Cuyahoga Group from the Riceville shales.

Extension of terms eastward has resulted in modification of the traditional limits of the Riceville. Caster, 1934, Sherrill and Matteson, 1941, and Dickey and others, 1943, used the term "Cussewago Group" for the gray interbedded sandstones, siltstones, and shales that lie in the interval between the Corry and the ("red rock") purple shales of the Riceville Group. Work by Pepper and others, 1954, Sass, 1960, and Schiner and Kimmel, 1972, has shown that the Corry Sandstone lies above the shaley unit that separates the Corry from a sandstone horizon below. This lower sandstone is the Cussewago Sandstone. The intervening shale is the Bedford Shale. The term "Cussewago" has been restricted by these workers to the sandstone overlying the Riceville. They also restrict the Bedford Shale to the limits of the Cussewago Sandstone. The Cussewago Sandstone and hence the Bedford Shale do not extend into the Franklin-Tionesta region.

If one agrees with this interpretation, it follows that the Corry lies on Riceville wherever the Cussewago sandstone marker is absent (i.e., in the Tionesta-Titusville-Franklin area). Further, it has long been the practice to draw the boundary between the Mississippian and Devonian Systems at the "red rock" of the Riceville. If the rock directly underlying the Corry in the field trip area is termed "Riceville", it would appear that the systematic boundary lies within the Riceville.

Shenango Formation

On this trip, we will examine the Shenango Formation at STOP VIII along the new Pa. Route 8 south of Franklin. At this site the formation is 248 feet thick and nearly completely exposed. The Lower Member of the Shenango Formation is very well exposed at Tionesta along Pa. Route 36 above the entrance to the dam. At this location the Shenango is 165 feet thick.

The Shenango Formation has been divided into upper and lower members. The Upper Member (Figure 10) contains more mudstones and shales than the Lower Member. The Lower Member (Figure 11) contains from one to four thick cyclic sequences of sandstones and shales. However, as the field trip participants will see, the two units are gradational and not sharply separated. Indeed the cycles persist into the Upper Member. At STOP VIII and in the section measured by Michael Lukert at Tionesta, the cyclic nature of the Shenango Formation is well exhibited. Two measured sections of Mississippian exposures are provided elsewhere in this guidebook (STOPS I and VIII).

A typical cycle may begin with thin interbeds of mudstone, siltstone, and sandstone. The lower beds may contain abundant productid brachiopods, sometimes constituting a near coquina. Sandy layers grade upward into siltstones and mudstones, bearing current ripple and ripple drift laminations; finely comminuted carbonized plant fragments are common in the silty layers. These beds grade upward into highly burrowed mudstones that have a mottled appearance. Many beds contain ichnofossils, brush, bounce and prod marks and striations. In turn, these beds may be overlain by fine-grained sandstones that contain shale pebbles, ironstone nodules, bone chips, and brachiopod fragments in the basal beds. These sandstone units typically exhibit trough cross stratification. Units 32 through 35, and 36 through 39 in the Sandy Creek Section (measured by A. N. Ward, Jr.), STOP VIII, are typical cycles found in the Upper Member.

Cycles in the Lower Member are similar. Indeed the major difference between the members appears to be the scale of the sandstone units. A typical cycle of the Lower Member is illustrated by units 21 through 24 in the Sandy Creek Section.

Dickey and others, 1943, recognized three sandstone intervals constituting the lower Shenango. They referred to them as the "A", "B", and "C" (Carl) sandstones. Gamma ray logs, as well as measured sections, show the "B" interval to be at least two cycles of shale and sandstones. This is the situation at the Sandy Creek Section. At Tionesta the "A", "B", and "C" sandstones are well exposed along Pa. Route 36. The "B" sandstone (Figure 11) may attain thicknesses of over fifty feet. The "A" and "C" vary from about 20 feet to over 50 feet.

Pepper and others, 1954, and Schiner and Kimmel, 1972, have noted that the regional distribution of the Shenango, Corry and associated rock units is highly suggestive of deltaic sedimentation. The sandstone units appear to be portions of distributary channels, subaqueous levees and distributary mouth bars. The siltstones, shales and mudstones may represent interdistributary bay, marsh, and minor prodelta or shelf deposits. Coleman and others, 1964,

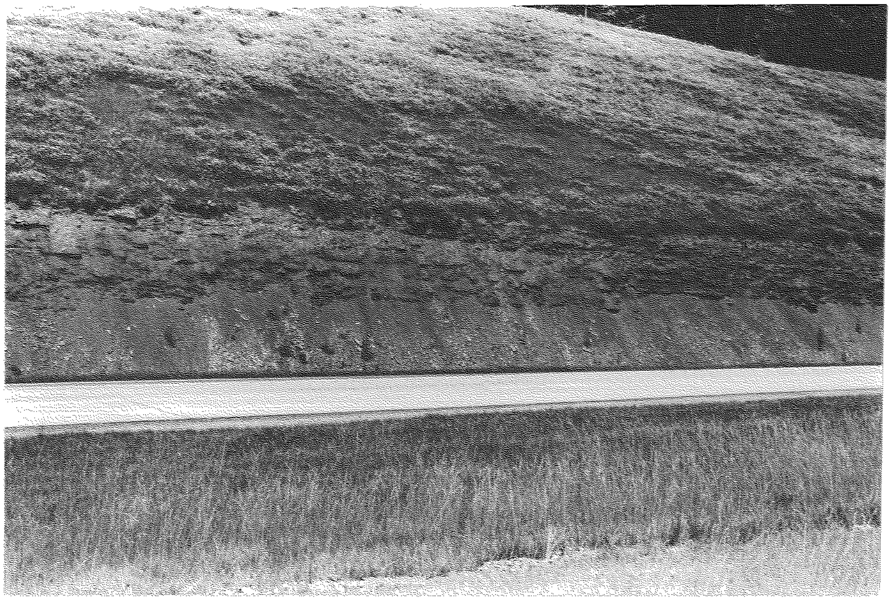


Figure 10. Upper Member of the Shenango Formation at STOP VIII.

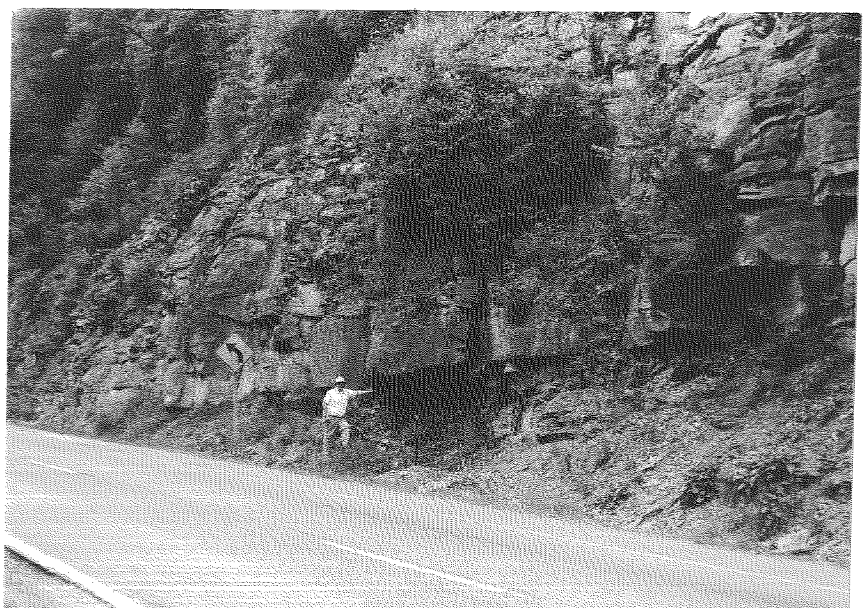


Figure 11. "B" sandstone of the Shenango Formation, along Pa. Route 36 at Tionesta.

indicate that ironstone nodules, plant fragments, and shell fragments occur together only in marsh environments associated with the Mississippi River delta distributary system.

Scour-and-fill structures with clay-chip inclusions are associated with distributary channel and subaqueous levee environments. This is much the same sequence as seen in outcrop at STOP VIII. At this site prograding distributary channel and subaqueous levee sands have built out over marsh and interdistributary bay deposits.

In the Upper Member of the Shenango, the cycles are thinner and tend to include thin beds of crinoidal sandstones near the top of the Mississippian. These sandstones may represent open-bay or shelf environments.

The crinoidal units are overlain by reddish shales and mudstones containing ironstone nodules and plant fragments. A few inches below the Pottsville a few siltstone beds contain well-preserved plant remains at Tionesta and along the new Route 8 exposures. They have tentatively been identified as Rhodea and Fryopsis at the Route 8 site.

Cuyahoga Group

The Cuyahoga Group includes about 150 feet of strata between the Corry Sandstone and the Shenango Formation. On this trip we will see the lower beds of the Cuyahoga Group at STOP I (Figure 16). These rocks have been divided into the Orangeville Shale at the base, the Sharpsville Sandstone in the middle, and the Meadville Shale at the top.

Meadville Shale

In the upper portion of the Cuyahoga Group are interbedded medium-gray and brown sandy shales. Platy sandstones with ripples, burrows, and orbiculoid brachiopods increase upward. This results in a gradational Shenango-Cuyahoga contact in many places. Some beds are conglomeratic. At Tionesta quartz pebbles have been concentrated along ripple crests in an 8-inch bed.

Sharpsville Sandstone

The Sharpsville interval contains thin greenish-gray platy sandstones often exhibiting low-angle trough cross-bedding. Ichnofossils, marine invertebrates and carbonized plant remains occur throughout the unit. Some beds are actually fossiliferous sandy argillaceous limestones. The limestones are light- to medium-dark-gray on a fresh surface, but weather to moderate yellowish brown. Unless broken, these calcareous rocks appear just like sandstone in the interval. They break with a characteristic conchoidal fracture.

Orangeville Shale

This formation grades into the overlying and underlying formations. It consists of thin platy beds of greenish-gray siltstone and sandstone, interbedded with gray shales. Sandstones and thin beds of conglomerates are concentrated near the base. Some of the lower sandstone layers are lithically like the Corry Sandstone.

In the Oil City region, Dickey and others, 1943, reported that a 1/2- to 1-foot-thick pebbly sandstone occurs about 22 feet above the base of the Orangeville. This unit thickens until at the Tionesta Dam spillway (STOP I) the marker is underlain by 15 feet of cross-bedded pebbly sandstone lying directly on the Corry.

Lying 1-3 feet above the Corry is a peculiar siltstone marker referred to as the Bartholomew Siltstone Member. The siltstone bears small burrows that give it a characteristic "graphic" appearance. Schiner and Kimmel, 1972, indicate that this unit can be traced from Meadville to Oil City.

Corry Sandstone

The Corry Sandstone is a very persistent unit found throughout the region between Tionesta and Franklin. We will see the Corry at STOPS I, II, and IV. It averages about 30 feet in thickness. It is characteristically a three-part yellowish-gray unit consisting of a lower and upper fine-grained cross-bedded sandstone separated by a thin siltstone-and shale-bearing unit. Only the lower beds are fossiliferous although ichnofossils are common throughout the formation. Caster, 1934, 1941, and Sass, 1960, have extensively studied the fauna found in the lower beds of this formation. They agree that it contains a Kinderhook marine assemblage in the lower sandstone.

Riceville Group

We will see only the upper beds of this group (STOPS II and IV) where it underlies the Corry Sandstone. At these locations interbedded sandstones, siltstones and shales grade downward into gray, red and brown shales. The reddish beds may represent the Devonian "Red Rock".

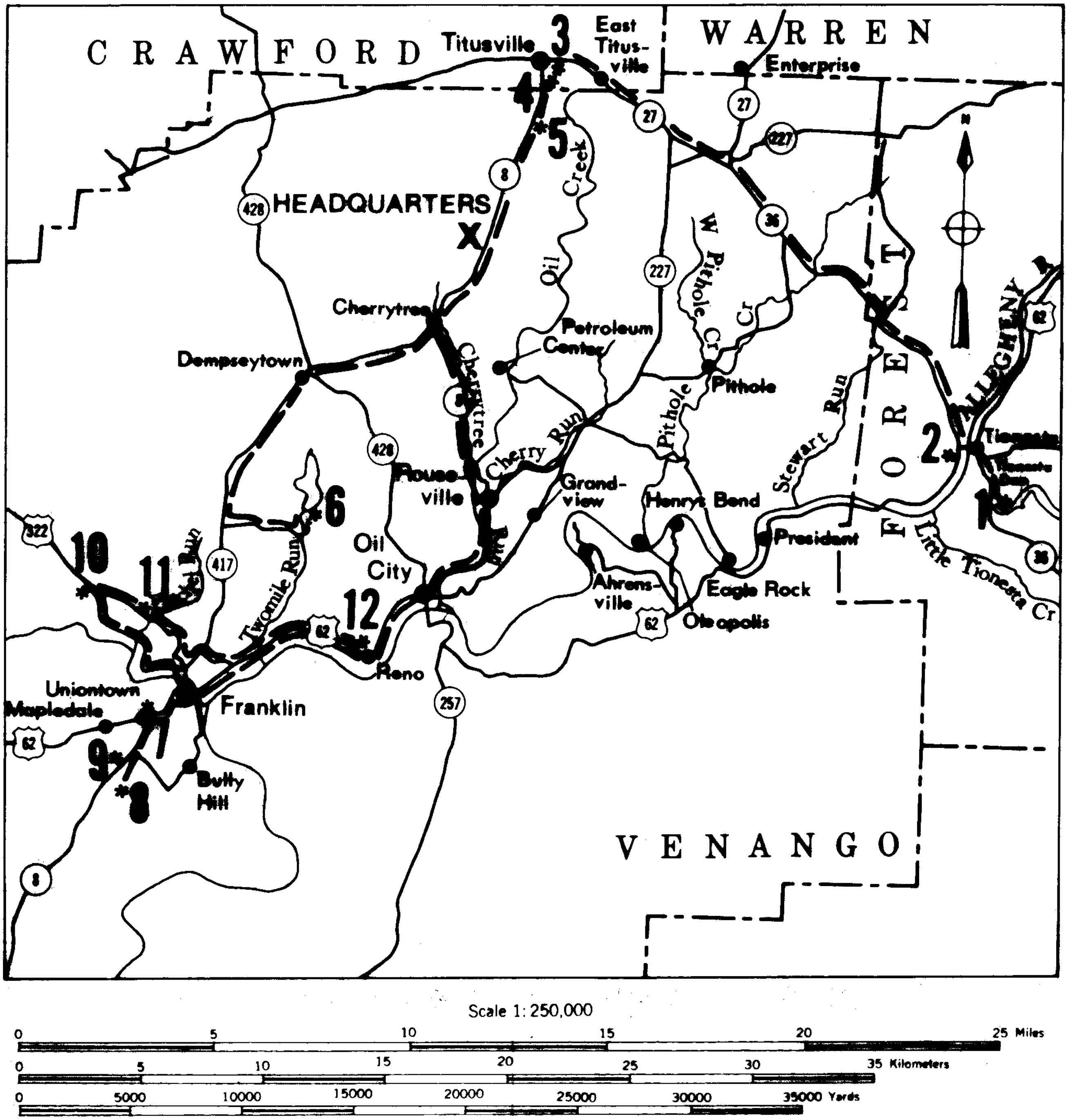


Figure 12. Map showing field trip route.

ROAD LOG

Friday, 1 October 1976

Departure from parking lot of the Cross Creek resort at 8:00 a.m.

Roadlog starts at intersection of Pa. Route 8 and entrance to Cross Creek. Figure 12 is a sketch map of the field trip route.

Cumulative Mileage	
0	Intersection of Pa. Route 8 and entrance to Cross Creek Resort. Turn left onto Route 8 north.
0.3	Titusville Till is exposed in road cut at the intersection of the road entering Route 8 on the north. The Cross Creek Resort is underlain by Titusville Till. Route 8 is approximately parallel to the eastern margin of the Titusville Till. The margin lies about one mile to the east of Route 8. The deep tributaries along the western part of the Oil Creek drainage basin may have been Wisconsinan drainage outlets.
0.8	Oil field on east side of road.
2.3	Crossroad left to Breedtown.
2.7	Type section of Titusville Till in road cut on east side. We will return to this site after lunch (STOP V).
3.1	Entrance to a gravel pit on the east side of the road. These gravels are overlain by till, lie on Mississippian rocks and are probably part of a kame terrace. Prominent gravel foreset beds cemented with calcite dip southward at this site. We will examine similar beds at the White City sand and gravel quarry (STOP III).
3.2	Shenango sandstones are exposed in the outcrop on the west side of the road. As we descend into the valley of Oil Creek we will pass through Shenango, Cuyahoga, Corry, and Riceville (Cussewago).
3.3	Cuyahoga siltstones, sandstones, and shales may be seen in the road cut on the west side of the highway.
3.5	Corry sandstone is exposed on the west side of the road.
4.0	Stoplight. Intersection of Route 8 with Bloss Street. Sign indicating Drake Well to the east. Continue straight ahead through Titusville.

The terminal moraine of the Wisconsinan ice sheet is present about two miles northwest of Titusville. Previous to the advance of the Wisconsinan ice sheet the drainage of this part of northwestern Pennsylvania was northwesterly towards what is now Lake Erie. Oil Creek flowed north instead of south as at present, and its headwaters probably were near Titusville. During the maximum advance of the ice sheet tongues of ice may have occupied the old preglacial valley of Oil Creek and Pine Creek as far south as Titusville. The ice deepened the valleys and probably also straightened and otherwise modified them.

While the ice sheet occupied the area to the north, it was impossible for the water to flow out in that direction. Furthermore, the melting of vast quantities of ice at the southern edge of the glacier provided abnormally large quantities of water to be disposed of. The upper valleys of the north-flowing streams were thus dammed up, and became short-lived lakes. The waters had to seek exit over the crests of the divides to the south. The large amounts of water quickly cut deep gorges. The valley of Oil Creek below Titusville is an excellent example of such a gorge. The old divide probably was near Boughton, and from there to Oil City the water followed and greatly deepened the channel of an old water course. The small side streams probably at first were unable to deepen their channels as fast as the main bed was deepened, and were left hanging, spilling their waters down over waterfalls. Since the retreat of the ice, most of them have cut back and smoothed out the waterfalls, but one stream on the west side of Oil Creek one mile above Miller Farm is still a hanging valley with waterfalls over hard sandstone ledges.

Evidence of the lake that occupied Oil Creek Valley can be seen in the terraced gravel banks on the hillsides south and east of East Titusville, and the large gravel banks on the main road one mile south of Titusville. The valleys of Oil Creek, north of Titusville, and Caldwell Creek were filled with debris, principally gravel, sand and clay. On Watson Flats, east of Titusville, the rock floor lies about 100 feet below the present valley surface, the original valley being filled to that height with soft clay and gravel.

4.3 Stoplight after railroad crossing - intersection of Route 8 and Route 27. <u>Turn right</u> (east) onto Pa. Route 27 east.

4.7 Stoplight. Intersection of Route 27 with S. Brown Street. S. Brown Street leads to Drake Well Park. Continue on Pa. 27 east.

5.0 Stoplight.

5.3 The first refinery in the Oil Creek region for crude petroleum was built nearby in 1860. The first run of oil was made in 1861. Oil was first refined in Pittsburgh by Samuel Kier about 1854.

5.7 Enter East Titusville.

6.6 Enter Venango County. The gravel pit across the valley to the south is owned by the White City Sand and Gravel Company. It consists of Titusville outwash gravels overlain by Titusville Till. We will return to examine this site (STOP III). As we go up the hill we will cross Cuyahoga sandstones and shales belonging to the Meadville, Sharpsville and Orangeville Formations.

7.4 Shenango sandstone in road cut to north.

9.3 Enter Borough of Pleasantville; intersection of Pa. Routes 27 and 227. Continue on Route 27 east.

10.0 Pleasantville. Intersection of Pa. Routes 27, 227, and 36. Continue straight on Route 36 south.

The Pleasantville or "Black Oil pool" was discovered on February 1, 1868 by the Harmonial well which is located in the borough about 1,000 feet southeast of this intersection. The well's best production was 125 barrels per day. Production was from the Third Stray sand. The sand is generally pebbly, especially at the top and bottom. It is remarkably uniform in thickness, ranging between 10 and 20 feet. The A.P.I. gravity of the oil ranges from 44° to 50°. The black-oil wells in this district produce no water with the oil. If water reaches the sand face from casing leaks the well is quickly and seriously damaged. The section of the pool within the town limits has been watered out. Pleasantville was an oil boom town. The large brick block buildings were built with oil money. The Eagle Hotel (torn down in 1957) was a large brick building with 50 rooms. John F. Carll, who was head of the oil and gas work for the Pa. Geological Survey from 1874 to 1888, had his office on the third floor of the large brick building directly across the street from the gasoline station. A number of buildings including the Chase House, a large hotel, were moved to Pleasantville from Pithole. The railroad grade from Pithole to Pleasantville was completed, a distance of six miles, but the rails were never laid. A fire on December 23, 1871, burned out most of the Pleasantville business section. The Chase House, a three-story frame building with a 150-foot front, was destroyed in the fire. The large red brick buildings replaced part of the burned out business section.

Harmonial Well, Pleasantville: One day, late in the fall of 1867, Abram James, an ardent spiritualist, was driving from Pithole to Titusville with three friends. A mile south of Pleasantville the "spirit guide" caused him to jump out of the conveyance and leap over the fence into a field on the William Porter farm. Hurrying to the north end of the field, James fell to the ground, marked the spot with his finger, thrust a penny into the dirt and fell back pale and rigid. Restored to consciousness, James told his friends of a revelation that streams of oil lay beneath the soil. He leased the property, borrowed money, raised a derrick over the spot where the penny lay, and commenced drilling amid the scoffs of unbelievers. When down 700 feet and past the third sand rock, he became the laughing stock of the region; but "Crazy James" kept on drilling. When he proceeded to build tanks to receive the expected oil, people laughed louder. Early in February, 1868, James struck oil and his well, called the Harmonial in honor of the spiritual philosophy, pumped 125 barrels a day. The usual hurly-burly followed. Operators at once rushed in to secure leases on adjoining farms, and the fact that experienced oil men were willing to pay $500 to $1250 an acre created confidence in the territory. New strikes increased the excitement.

11.9 Large blocks of Pottsville float may be seen on the adjoining hillsides. As we descend the hill we cross over the covered Pennsylvanian/Mississippian contact.

12.6 Oil field on both sides of road. Note some recent wells to the southwest.

13.2 Road to Pithole Museum on southwest.

14.9 Oil field.

15.0 Enter Forest County.

16.6 Pennsylvanian sandstone and shale at crest of hill.

17.2 Shenango sandstone outcrops on both sides of the road.

18.0 Cuyahoga shales and siltstones in road cut.

19.5 Riceville (Cussewago) sandstones, siltstones and shales on north side. Note that some shales have a very faint red or purplish tint.

19.6 Intersection of Pa. Routes 36 and 62. <u>Turn east (left)</u> on Route 36 south and cross the Allegheny River. Riceville (Cussewago) is exposed in the large road cut to south.

19.9 Stop sign at the intersection of Routes 36 and 62. Turn right on Route 36 south and proceed through Tionesta.

20.5 Cross Tionesta Creek. Note the gravel operations on the southwest.

20.8 Road cut on the southwest - Cuyahoga sands, shales, and siltstones are exposed.

21.2 Entrance to Tionesta Dam. Turn east (left) into entrance and cross the dam. At the end of the dam bear right (counter-clockwise) around traffic circle. Turn right at second road past Reservoir Maintenance and Information Center. Proceed past sign indicating spillway and continue into parking area at base of hill (STOP I).

21.8 Sandstone and conglomerate outcrop on left side of road lies on top of the Corry. Note how even bedded and massive the unit appears (Figure 13). This is very misleading for we shall see that in reality the beds exhibit strongly tabular to low-angle trough cross stratification (Figure 14). Dip is predominantly into the cliff face (towards the west) although some cross-beds dip in the opposite direction.

22.1 STOP I. SHENANGO FORMATION AND CUYAHOGA GROUP
Stop Leaders: M. Lukert and A. N. Ward, Jr.

Exposed here is the conglomerate marker (Figures 15 and 16) that is often found above the Corry. At this location the 16-foot interval between the Corry and the conglomerate is occupied by coarse-grained sandstone and conglomerate. The top of the Corry is exposed near road level just before we enter the parking lot. Overlying the conglomerate beds of the basal Orangeville Formation are the interbedded siltstones, shales, and fine-grained sandstones which are more typical of this unit.

Michael Lukert and students from Edinboro State College have measured and described the sequence beginning at the spillway and extending to the top of the hill (south along Route 36). This section at Tionesta and the exposures along the new Route 8 south of Franklin are the most complete in western Pennsylvania.

Elevation in Feet	Lithologic Description	Thickness in Feet
1500	Massive, cross-bedded sandstones interbedded with thin-bedded micaceous sandy siltstones.	
1480	Massive, orange-brown, medium-grained, cross-bedded quartz sandstone.	20

Figure 13. Conglomerate-bearing sandstone in the base of the Orangeville (STOP I). The Corry is exposed near road level at the far (north) end of the outcrop. Viewer is facing north.

Figure 14. Photograph taken at right angle to the upper sandstone ledge seen in Figure 13. Viewer is facing south and the large-scale tabular cross-bedding is dipping west.

Figure 15. Conglomerate marker in the basal Orangeville at STOP I. Note small-scale trough cross-beds grading into ripple laminations in sandstone layers covered by the hammer handle. The beds above the hammer possess tabular cross stratification.

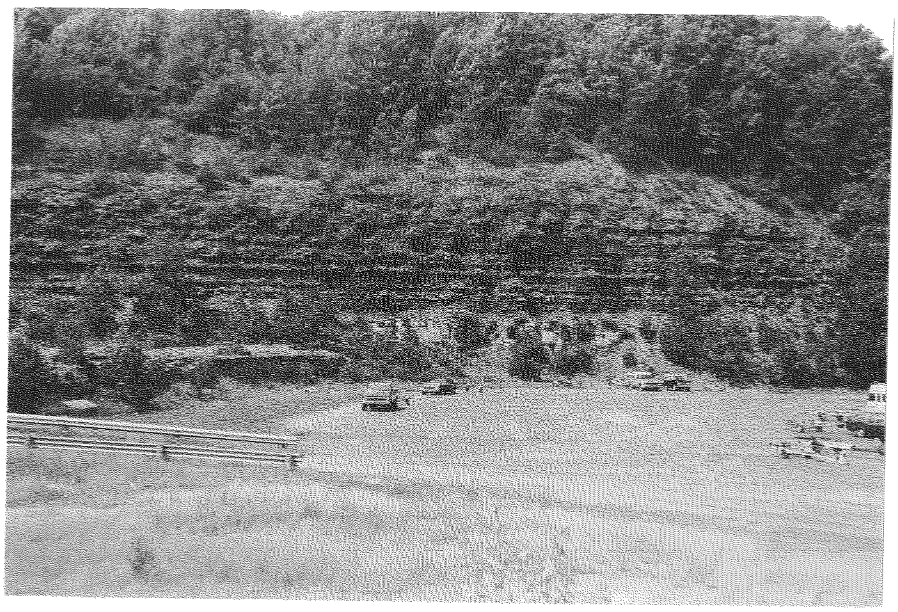


Figure 16. Orangeville sandstones, shales and siltstones overlying the conglomerate marker horizon at STOP I.

1470	Very thin bedded, gray to orange, fine-to medium-grained sandstone (Sharon Formation?). Base of Pottsville.	10
1428	Base of covered interval (Upper Member of the Shenango Formation).	42
1413	3'-3 1/2' layers of massive, olive-gray, fine-to medium-grained sandstone interbedded with shales and siltstones. Shenango C sandstone. (Top of Lower Member of the Shenango Formation.)	15
1373	Sandstone interbedded with light-olive-gray, purple, and light-brown, iron-stained shales, and scattered layers of fine sandstone and siltstone.	40
1355	Ironstone nodule layer overlain by massive, fine-to medium-grained, olive-gray, cross-bedded sandstone. Shenango B sandstone. Fragments of plant fossils in float.	18
1328	Massive sandstone grading to interbedded sandstone, siltstones and occasional shales; fragments of plant fossils in float.	27
1305	Base of massive, cross-bedded, olive-gray, fine-to medium-grained, micaceous sandstone. Ripple marks. Base Shenango A sand. BASE OF SHENANGO FORMATION.	23
1303	Shale interbedded with flaggy, olive-gray, fine-to medium-grained sandstone.	2
1281	Ledge of massive, olive-gray, fine-to medium-grained sandstone grading upward into interbedded fine sandstone, siltstone, and dark, purple shale.	22
1279	Massive, olive-gray, fine- to medium-grained sandstone as channel fill. Approximately 1 1/2 feet thick. Underlies 8" layer of puddingstone conglomerate.	1.5
1270	Interbedded siltstone, shale, and thin sandstones, pelecypods and fragments of plant fossils in float.	9
1260	Ledge of massive, olive-gray, fine-grained sandstone approximately 6' thick, containing ironstone nodules overlain by interbedded olive-gray shales and siltstones.	10
1257	Massive ledge of olive-gray fine-grained sandstone approximately 3' thick, containing brachiopod and pelecypod fossils; becomes more thinly bedded upward.	3

1253	Dark-gray, thin-bedded shale (in road cut).	4
1243	Dam entrance.	10
1225	Covered interval.	18
1222	Sandstone, thinly bedded.	3
1218	Massive, olive-gray, fine- to medium-grained sandstone, beds approximately 6" thick.	4
1170	Covered interval.	48
1155	Two prominent ledges of greenish-gray slabby cross-bedded sandstone. The upper 1 to 3 feet is conglomeratic. Base of the Cuyahoga Formation.	15
1152	Sandstone, fine-grained, yellowish-gray, trough cross-bedded (top of Corry).	3

Return to buses. Retrace route back through Tionesta, across the Allegheny River to the intersection of Routes 62 and 36 (approximately 2.9 miles).

Cumulative Mileage	
24.0	Intersection U.S. Route 62 and Pa. Route 36. Turn left (south) onto Route 62 and proceed approximately 0.2 mile. Park on wide berm in road.
24.2	STOP II. RICEVILLE STRATIGRAPHY Stop Leaders: M. Lukert and A. N. Ward, Jr. At this location reddish shales (Riceville) underlying the Corry and the Corry sandstones can be seen. The sandstone unit overlying the Corry at STOP I is not present here. Return to buses and proceed back along Route 36 north towards Titusville.
36.9	Turn left onto gravel road (0.1 mile south of Venango/Crawford County line). Entrance to White City Sand and Gravel Pit.
37.0	Cross small stream and bear right at sign indicating "White City Sand and Gravel".

37.05 STOP III. WHITE CITY SAND AND GRAVEL PIT, TITUSVILLE, PA.
Stop Leader: Jesse L. Craft

The glacial deposits you will be seeing on this field trip have been selected to demonstrate the primary field relationship between the different tills and associated gravels of the area. It is not our intent to show you the answers to problems, but to raise questions as to present interpretation of the glacial history of the region. Specifically, the questions relate to the existence of Illinoian Stage deposits and the age of the Mapledale and Titusville Tills.

The deposits of the White City Sand and Gravel Pit have been described by White and others (1969). A peat layer in the stream valley was uncovered by the owner of the pit, and C-14 dates from this pit established an age for the peat at approximately 40,000 years BP (White and others, 1969, and Berti, 1975).

The following stratigraphic section has been compiled from White and others (1969) and from Berti (1975) with the middle portion measured by Craft and Chapman for this field trip.

White and others (1969) and Berti (1975) described the peat deposit as being overlain by the Titusville Till and related gravels. However, as shown by the stratigraphic section, there exists approximately 75 feet of section that is covered. In their description, the gravel layers immediately overlying the peat deposit are yellow brown to orange in color and have been weathered extensively. However, the sands and gravels exposed in the gravel operation show little sign of extensive weathering. Limestone pebbles are common, along with calcareous siltstone. Crystalline rocks appear fresh.

One question that needs clarification is the correlation of the weathered gravel overlying the peat layers. Titusville gravels observed throughout the area rarely show weathering to the yellow-brown-orange coloration. Mapledale gravels, however, are intensively weathered as will be seen later in the field trip. The Mapledale deposits are commonly weathered to the yellow-brown-orange coloration.

An alternative speculation is shown on the left-hand column of the compiled stratigraphic section. This hypothetical time-stratigraphic framework suggested by Craft makes the Mapledale deposits Middle Wisconsinan in age instead of Illinoian and places the Titusville Till and its related deposits as earliest Late Wisconsinan in age. Figure 17 shows the suggested relationship among the various Wisconsinan deposits in this and surrounding areas according to Dreimanis and Karrow, 1972.

MEASURED SECTION - WHITE CITY SAND AND GRAVEL,
Titusville, Pa.

(Time stratigraphic nomenclature after Dreimanis & Karrow, 1972)

Suggested Interpretation of Time Relationships of Deposits, by Craft		Thickness	Description	Suggested Time Stratigraphy by White and others (1969)
			(Section from White and others, 1969)	PLUM POINT
EARLY NISSOURI STADIAL	Titusville Till		Elevation approximately 1300'	CHERRYTREE
			Surface disturbed.	
		1.4'	Soil zone.	
		2.6'	Till, thoroughly decomposed.	
		5'	Till, decomposed, manganese stained.	
		.9"	Silt.	
		1.0'	Till, oxidized, leached.	
		3.5'	Till, unaltered, grey.	
	Titusville Sand and Gravel		(Measured by Craft and Chapman, 1976)	
		? 6'	Gravel, horizontal bedding, coarse-grained, cemented with $CaCO_3$, topset beds of delta.	
		?20'	Gravel, coarse-grained, cemented with $CaCO_3$, beds dip 30^{o} E, **foreset beds of delta.**	
		15'	Sand and gravel, some cross-bedding but mostly beds are horizontal. Some fine sand and silt layers. Manganese oxide grain concentration in coarser layers, minor secondary cementation, may be bottomset beds of delta. Approximately 1255 feet ASL.	
		75'	Covered.	
Plum Pt.				
CHERRYTREE STADIAL	Mapledale Sand & Gravel		(From Berti, 1975, and White and others, 1969)	
			Covered 1180 feet ASL.	
		20'	Gravel, yellow-brown, coarse to medium.	
		3'	Gravel, yellow to orange-yellow.	
		.5"	Gravel, sandy-orange.	
			Unconformity with relief up to 5".	
PORT TALBOT INTERSTADIAL	Port Talbot II Interstadial	0-8 cm	Brown silty peat, with some sand.	PORT TALBOT
		8-29 cm	Dark brown moss peat. C-14 dates OWU-315: 35 000 +2835, -1835; and I-1845, 39 900 +4900, -2900. Hereafter referred to as the upper dated peat layer.	
		29-45 cm	Brown, silty peat, with some sand.	
		45-52 cm	Gray sand.	
		52-57 cm	Brown moss peat.	
		57-87 cm	Gray, gravelly sand, with a 1 cm peat layer (Pollen spectrum 13) at 80 cm.	
		87-107 cm	Brown to black, moss peat, gradually becoming silty at the base. C-14 dates: OWU-316, >37 500; and GrN-4996, 40 500 ±1000. Hereafter referred to as the lower dated peat layer.	
		107-142 cm	Gray sand with horizontal bedding and some thin silt beds containing plant detritus.	
		142-150 cm	Brown peat.	
		150-160 cm	Gray coarse sand.	
		at 160 cm	Groundwater table.	

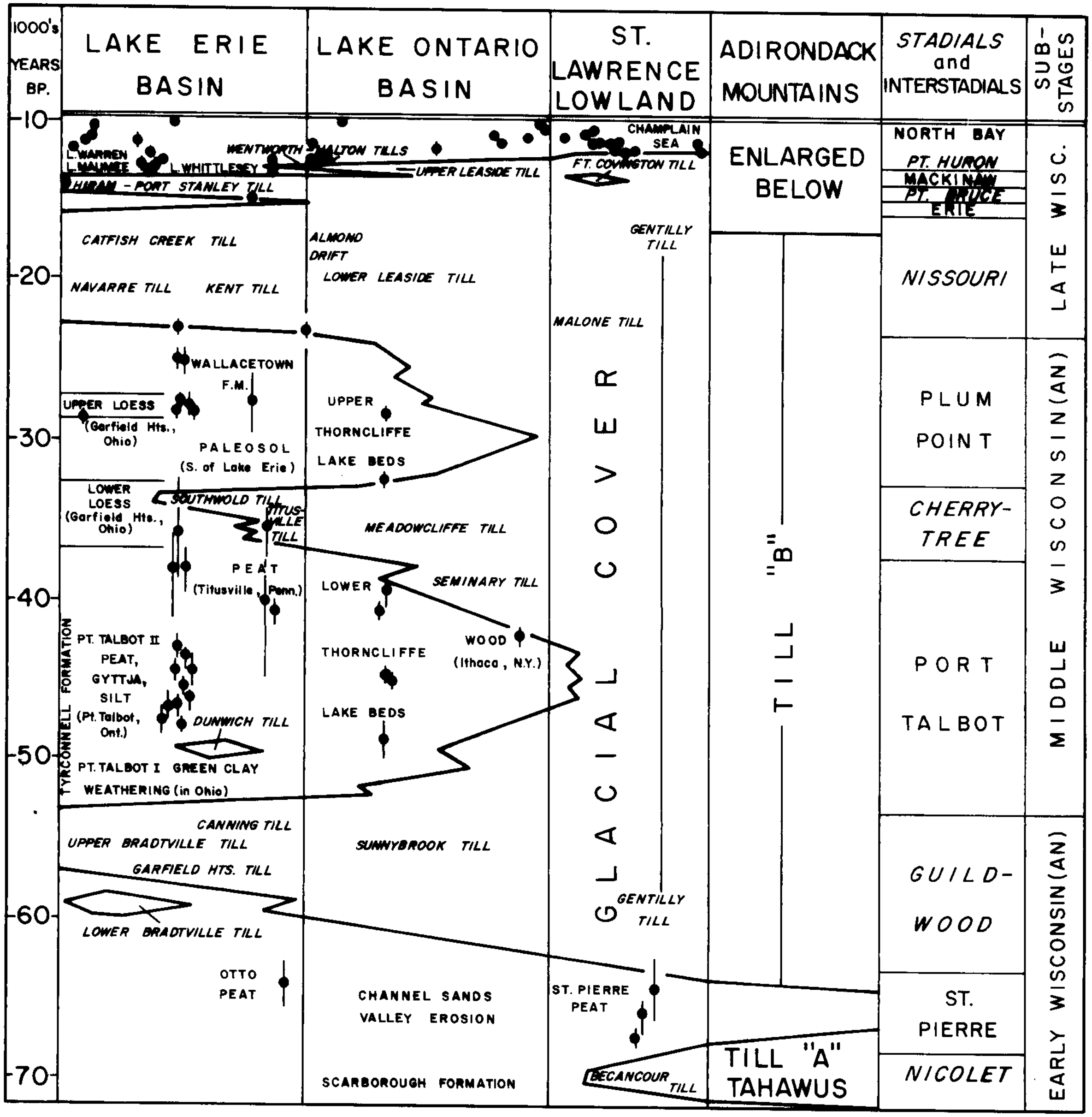


Figure 17. Time-space diagram showing glacial deposits (slant letters), nonglacial events, deposits and lake phases (vertical letters), the glacial margin as a heavy line, and radiocarbon dates (heavy dots with standard deviations as vertical lines). Time-stratigraphic divisions are listed in the two right-hand columns (from Dreimanis and Karrow, 1972).

Figure 18. Oblique aerial photograph of White City Sand and Gravel Pit.

A - Crusher and sorter.

B - Cemented cross-bedded gravel delta.

C - Area of dirty gravel with organic layer under "till-like" material.

D - Dirty gravel, present working face. Upper part possibly till.

E - Clean sand.

Figure 19. Delta topset and foreset bed, Area B of Figure 18.

A - Cemented deltaic gravels.

B - Titusville Till.

Figure 20. Area C of Figure 18.

A - Dirty gravel.

B - Organic zone contains branches and logs of wood.

C - Till-like material.

37.2 Return to Pa. Route 27 (stop sign). Turn left (west); proceed back through Titusville to the second stoplight.

37.3 East Titusville.

39.2 Second stoplight - turn left onto South Brown Street and follow signs to Drake Well Park (about 1.5 miles).

40.7 STOP IV. DRAKE WELL PARK AND MUSEUM. (Lunch stop)

Here we will have the opportunity to examine the exhibits in the museum and park, as well as examine a fossiliferous outcrop which is in the lower Corry or a sandstone of similar lithology just below the Corry. The sandstone beds just above track level (Figure 21) near the park entrance contain a diverse fauna. Porifera (*Titusvillia drakei*), articulate (*Rugoschonetes*, *Schumardella*, *Spirifer*) and inarticulate brachiopods (*Lingula*), bivalvia (*Parallelodon*, *Leiopteria*), nautiloid cephalopods, crinoid columnals, stelleroidea and gastropods (*Straparollus*), occur sparsely through the lower three or four feet of the Corry. Many of the beds contain ichnofossils as well as bounce, brush and prod markings, and striations.

THE STORY OF THE DRAKE WELL
by
William S. Lytle

Petroleum Beginnings

For over two centuries before Colonel Edwin L. Drake drilled his famous well, petroleum was known to exist in the United States. In the 17th century Franciscan and Jesuit missionaries are said to have alluded to oil in western New York, one describing a spring near present-day Cuba, New York, as containing a "thick and heavy water, which ignites like brandy and boils in bubbles of flame when fire is applied to it." In the 18th century there are reports of trade in oil brought to Niagara by the Seneca Indians; this probably gave rise to the early name for petroleum, "Seneca Oil." Lewis Evans' "Map of the Middle British Colonies in America," published in 1755, is the earliest known document to indicate the existence of petroleum in Pennsylvania.

Prior to 1845, the greatest source of petroleum in Pennsylvania, as well as in the United States, was along Oil Creek. As white settlers moved into this region and settled along this creek, they began to skim petroleum from little springs either in the bank or in the actual bed of the stream. Sometimes, this was done by floating a woolen or flannel cloth or a blanket on the water, wringing the cloth out when it was saturated with petroleum. They valued and used the oil exclusively as medicine.

Figure 21. Fossiliferous sandstone exhibiting trough to tabular cross-beds. These beds are either the lower Corry or are an interval of similar lithology just below the Corry (STOP IV).

According to one story the old pits which once dotted the land above and below the junction of Oil Creek and Pine Creek, a short distance south of Titusville, represent a very early - possibly a prehistoric - phase of this process for obtaining oil.

The First Petroleum Companies

In 1851 Dr. Francis Beattie Brewer, a graduate of Dartmouth College and a practicing physician, moved from Massachusetts to Titusville to join his father's lumber firm, Brewer, Watson and Company. Immediately he became interested in an old oil spring located near Upper Mill on the Hibbard farm, the company's property, about two miles below Titusville and within a few rods of Oil Creek. In the fall of 1853, he carried a small bottle of petroleum on a trip to Hanover, New Hampshire, to visit friends and relatives. While he was there, both Dr. Dixi Crosby, of the Dartmouth Medical School, and Professor O. P. Hubbard, of the Chemistry Department of Dartmouth College, examined the sample and pronounced it very valuable. A few weeks later George H. Bissell, Esq., another graduate of Dartmouth and a young lawyer in New York City, returned to his home in Hanover, saw the bottle of petroleum in Crosby's office, and wondered if petroleum could not be used as an illuminant. Aroused by the prospect, Bissell and his business partner, Jonathan G. Eveleth, decided, provided that a sufficient supply of petroleum could be found, to organize a company, buy the land, develop the oil spring, and market petroleum. After much negotiation and several trips to Titusville, Bissell and Eveleth purchased the Hibbard farm on November 10, 1854, for $5,000. Furthermore, on December 30, 1854, they organized the Pennsylvania Rock Oil Company of New York, the first petroleum company in the world.

Hard times, the dubious character of the venture, the ignorance of the value of petroleum, the lack of confidence in the promoters, and the fact that in the State of New York stockholders of joint stock companies were liable for all debts of the company, made it exceedingly difficult to sell stock. In April, 1855, Professor Benjamin Silliman, Jr., of Yale College, whom the promoters had employed to analyze the oil, made his report and pointed out its economic value. This proved to be a turning point in the establishment of the petroleum industry. A number of New Haven capitalists, headed by James M. Townsend, impressed by Silliman's report, agreed to buy stock, provided the company was reorganized under the liberal corporation laws of Connecticut. Under these circumstances, Eveleth and Bissell abandoned the original company and formed the Pennsylvania Rock Oil Company of Connecticut on September 18, 1855, with a capital stock of $300,000.

Owing to the lack of harmony which unexpectedly developed between the New Haven and New York stockholders, little progress was made. Consequently, Townsend and the other New Haven men decided to organize another company, lease the land, drill for oil, and monopolize the oil business. Thereupon, they organized the Seneca Oil Company on March 23, 1858, leased the Titusville property from the Pennsylvania Rock Oil Company of Connecticut, elected Edwin L. Drake as General Agent at an annual salary of $1,000, and sent him to Titusville in the spring of 1858 to drill for oil.

Edwin L. Drake

Drake had spent the first years of his life on farms in New York and Vermont. With a common school education, he left home at the age of nineteen for the West. At Buffalo he secured a job as a night clerk on a ship playing between that city and Detroit. During the next few years he was successively a hotel clerk in Michigan, a clerk in a dry goods store in New Haven and in New York City, and an express agent on the Boston and Albany Railroad. In 1849 he became a conductor on the New York and New Haven Railroad and moved to New Haven. During the summer of 1857 Drake fell ill and, although not prostrated, was compelled to relinquish his position with the railroad. While living at the Tontine Hotel in New Haven, he became acquainted with Townsend, talked with him about petroleum, and finally purchased $200 worth of stock in the Seneca Oil Company.

Without boasting about what he expected to do, Drake went quietly about his work in Titusville to dig a well at the site of the principal spring on the Hibbard farm. After several weeks of excavating, the workmen struck a vein of water that drove them out of the well; Drake abandoned the works and decided that it would be cheaper to drill. Without any previous experience in drilling, Drake went to Tarentum, Pennsylvania to observe the manner of drilling salt wells, to consult with salt-well owners, and to engage a driller. Upon his return home, he ordered a six-horse power steam engine and a "Long John" stationary, tubular boiler, to furnish power for drilling. He designed and built an enginehouse and a derrick, in which to swing the drilling tools. By August everything was in readiness for the driller but he failed to appear. Since Drake could not find another and the season was late, he installed his engine and boiler, then suspended operations for the winter.

In the spring of 1859 Drake secured the services of William A. Smith of Salina, who had worked on the salt wells at Tarentum. He agreed to do the drilling for $2.50 a day and "throw in" the services of his fifteen-year-old boy. Smith made the drilling tools - the kind that were commonly used in drilling a salt well - for Drake at Tarentum. They cost $76.50 and weighed between one and two hundred pounds. From Erie, Drake secured some cast-iron pipe in sections ten feet long. With a white oak battering ram, lifted by an old fashioned windlass, they drove the pipe thirty-two feet to bedrock and, about the middle of August, began to drill with steam power, averaging about three feet a day.

Striking Oil

On Saturday afternoon, August 27, as Smith and his sons were about to quit work, the drill dropped into a crevice at a depth of sixty-nine feet from the surface and slipped downward six inches. The men pulled out their tools and went home without any thought of having struck oil. Late Sunday afternoon "Uncle Billy," as Smith was known, visited the well, peered into the pipe, and saw a dark fluid floating on top of the water within a few feet of the derrick floor. Excited and overwhelmed, "Uncle Billy" sent his boy running to Upper Mill crying, "They've struck oil!" Quickly the news spread and the dwellers along the creek rushed into Titusville yelling to everyone as they met, "The Yankee has struck oil!" In the excitement no one thought of gauging the well but the best evidence indicates that it produced petroleum at the rate of about eight to ten barrels a day.

Drake seemed pleased to have successfully completed his well, but did not appear greatly excited or wildly enthusiastic. It is dubious whether he or others realized the significance of his achievement. In time the meaning of what he had done became clearer. Drake had demonstrated in a practical way how petroleum could be secured in greater abundance, and his well served as a textbook for future drillers; he had tapped the vast subterranean deposits of petroleum in the great basin of Oil Creek; and he had ushered in a new industry which provided the world with a cheap, safe, and efficient illuminant. Not only that, but on the eve of a mighty industrial expansion, Drake had opened up a source of unexcelled lubricating oil, an item of utmost importance to the Machine Age.

Upon the completion of his well, Drake ceased to be a factor in the development of the petroleum industry and others came in to take advantage of his achievement. After serving as a Justice of the Peace and buying oil for New York merchants, he left Titusville in 1863, soon lost everything he had saved by speculating in oil stocks, became the victim of a neuralgic affliction, and spent the rest of his life in an invalid chair. In 1873 the State Legislature of Pennsylvania provided him with an annual income of $1,500 until his death in 1880; the pension then went to his widow for her lifetime.

Memorials to Drake and his Well

The first movement to honor Drake and memorialize his famous well realized its goal on October 4, 1901, when a magnificent monument to the memory of Colonel Drake, the generous gift of Mr. Henry H. Rogers, was unveiled and dedicated in Woodlawn Cemetery, Titusville. Within a short time the body of Colonel Drake was exhumed at Bethlehem, Pennsylvania, and removed to Woodlawn Cemetery. The second movement, one for preserving and marking the site of the Drake Well, was inaugurated by the Canadohta Chapter, Daughters of the American Revolution, Titusville. About 1908 Mrs. David Emery donated to the Canadohta Chapter one acre of land upon which the Drake Well had been drilled. Upon this spot the women of this organization placed a native boulder, weighing about thirty tons, and on August 27, 1914, they placed on the stone a large bronze tablet with a replica in bas-relief of the Drake Well and an inscription dedicating the boulder.

Drake Well Memorial Park

Through the efforts of a group of public-spirited and historically minded citizens - John H. Scheide and James H. Caldwell of Titusville, S. Y. Ramage of Oil City, and A. R. Wheeler of Endeavor, and many others - the third movement was initiated to memorialize the birthplace of the petroleum industry by something more than an inanimate marker.

As a result of this movement the Board of Directors of the American Petroleum Institute voted in January, 1931, to raise $60,000 to construct a dike to keep the site of the Drake Well from being flooded, clear the ground, excavate and drain the area, construct and furnish a caretaker's house, and establish a museum and library, provided the Commonwealth would accept the property as a historical park and appropriate an annual sum for its proper maintenance and development. When all the improvements had been completed in the spring of 1934, the Commonwealth formally accepted the property on August 27, 1934, at the Diamond Jubilee celebration of the drilling of the Drake Well. At that time, the park included about twenty-four acres; since 1934 additional land has been donated and there are now about two hundred and twenty-nine acres.

In 1945 the D.A.R. monument was moved to the west side of the center oval and a replica of Drake's enginehouse and derrick was erected on the original site of the well. An old engine and steam boiler and other machinery typical of the early days was installed so that the well might be pumped in a simulated manner. As a part of a master plan to improve and enlarge the present park facilities, a new room was added to the west of the museum building in 1949. When the entire structure is completed, all of the exterior will be of Pennsylvania sandstone.

The Drake Museum

The Drake Museum is a treasure-house full of all sorts of historical materials and relics pertaining to the early history of the petroleum industry. Each year since 1934 the collection has been enlarged and enriched through the generosity of friends who have donated materials of all kinds. Today the Drake Museum is the largest single depository in the country for historical records and relics on the early history of the petroleum industry. Anyone who desires to donate historical materials or who knows of persons who might have such records and relics is requested to write to the Curator, Drake Well Memorial Park, Titusville, Pennsylvania.

The Drake Well Memorial Park is administered by the Pennsylvania Historical and Museum Commission. An Advisory Board of seven members, appointed by the American Petroleum Institute, makes recommendations to the Commission for the maintenance, improvement, and development of the institution. A Curator is in direct charge of the property.

40.7 Leave Park entrance and return to Route 8.

40.9 Bear left and cross Oil Creek.

41.1 Enter Crawford County.

41.2 Bear left at intersection (do not go under underpass)

41.5 Stoplight. Intersection of Route 8 (Smock Blvd.). Turn left (south) onto Route 8.

41.7 Corry outcrop along west bank of road (0.1 mile south of the Crawford - Venango County line).

42.6 STOP V. TITUSVILLE TILL TYPE SECTION
Stop Leader: William F. Chapman

The large borrow pit here is a fresh exposure of Titusville Till but is not the true type section. The Titusville Till type section is actually the grassy slope along Route 8 just uphill from this pit. Due to the present poor exposure of the type section we substitute this borrow pit.

The type section was first measured and described by Droste and Tharin (1958, p. 62) to examine the sequence of alteration of clay minerals in the till. The section was later republished (White and others, 1969, p. 23) giving the location as "a fresh cut in an excavation for relocation of Pennsylvania Highway 8, 1.6 miles south of the post office in Titusville and 1.2 miles southwest of the Drake Oil Well". In the Droste and Tharin 1958 paper, and later in Shepps and others, 1959, this till was referred to as "inner Illinoian". It was not until later carbon-14 dates from peat deposits associated with this till proved to be on the order of 35,000 to 40,000 B.P. that the Titusville Till was found to be of Wisconsinan age.

The type section is quoted as follows from White and others, 1969, p. 23.

	Unit Thickness		Aggregate Thickness	
	Ft.	In.	Ft.	In.
Wisconsinan (Altonian):				
Titusville Till:				
Zone I				
Loam, silty, gray brown; A-1 soil	0	9	0	9
Loam, silty, dark dusky yellow; A-2 soil	0	7	1	4
Loam, silty, clayey, moderate orange and gray mottling, small weathered siltstone and shale pebbles; upper B-1 soil	0	6	1	10
Loam, silty, clayey, pronounced orange and gray mottling, nusiform fracture, small weathered sandstone, siltstone, and shale fragments; middle B-1 soil	1	7	3	5
Loam, silty, clayey, pronounced orange and gray mottling, compact with some prismatic structure, well-weathered crystalline rocks, sandstone, siltstone, and shale fragments	1	0	4	5

	Unit Thickness		Aggregate Thickness	
Zone II	Ft.	In.	Ft.	In.
Till, silty, clayey, thoroughly weathered orange and gray stains in joints, manganese stain coating joint surfaces, weathered crystalline rocks, siltstone, and shales	1	11	6	4
Zone III				
Till, as below but not calcareous	2	3	8	7
Zone IV				
Till, silty, moderately pebbly, calcareous, moderate yellow brown to olive brown, rough horizontal fracture; till matrix is slightly calcareous, but many small carbonate pebbles react violently to acid. Coal fragments common in places	7	4	15	11
Zone V				
Till, as above but light olive gray; many joints are present, along which ground water has oxidized the gray till in zones varying in thickness from 1/16 inch to 1 1/2 inches	8	6	24	5
Sand and gravel, brown, calcareous, uneven contact with superjacent unit	7	6	31	11

At this stop and at the White City gravel pit (Stop III) we observe the Titusville Till(s) and some of its interesting aspects. The olive brown to olive-gray color of the Titusville Till makes it reasonably easy to distinguish from the more reddish brown, highly weathered Mapledale Till.

Other differences between the Titusville and Mapledale Tills include the texture and mineral composition summarized in Table 1.

Table 1. Mean texture and composition of Mapledale and Titusville Tills (modified after White and others, 1969, p. 44)

	Mapledale Till	Titusville Till
Sand (%)	44.0	45.4
Silt (%)	36.0	36.9
Clay (%)	20.0	17.7
Quartz (%)	94.6	87.9
Feldspar (%)	5.4	12.1
K-Feldspar (%)	53.1	52.9
Heavy Min. (%)	2.1	2.9
Calcite (%)	0.7	1.1
Dolomite (%)	0.6	1.3
Total Carbonate (%)	1.3	2.4

Both here and at the White City gravel pit the Titusville Till is underlain by gravel deposits, and the till itself is made up of several "till sheets" separated by layers of silt or sand and gravel. These intervening layers are typical of the Titusville Till. The interpretation made by White and others (1969) is that each silt, sand or gravel layer separates deposits from a different Titusville advance.

Also of interest is the black manganese staining commonly found in the till matrix and coating some pebbles in the Titusville Till. This phenomenon is not observed in Mapledale deposits.

45.2 Continue on Pa. Route 8 - entrance to Cross Creek Resort.

46.6 Pass road to left to Petroleum Center.

46.7 Large float blocks in field west of Route 8 are Pottsville sandstone, part of the Connoquenessing, which caps many of the ridges in this vicinity.

47.6 Village of Cherry Tree.

48.0 Intersection Pa. Route 8 and Route 417 south. Bear right on Route 417; proceed south toward Dempseytown.

48.6 Oakland Township line.

49.6 Outcrop of deeply weathered Connoquenessing sandstone may be seen on the left (south) side of Route 417. Sandstone is friable and is of the type commonly extracted as glass sand.

50.2 Fields strewn with Pottsville sandstone indicating the lithology of the underlying bedrock which is here obscured by a till blanket that covers most of the region.

51.6 Village of Dempseytown.

51.9 Cross intersection Pa. Route 417 and Route 428 north; continue on Route 417.

52.1 Intersection with Pa. Route 428 south. Continue straight on Route 417 south.

52.7 Large outcrop of Pottsville sandstone on the right (northwest side of Route 417).

55.7 Borough of Sugar Creek.

56.5 Intersection of Pa. Route 417 and Keely Road. Turn left (east) on dirt road.

57.1 Intersection of Keely Road and Cherrytree Road. Continue straight ahead (east) on Keely Road.

58.5 Keely Road dead ends (Stop). Turn left on Warren Road.

58.7 Outcrop to left is thin-bedded, flaggy siltstones of Mississippian age (probably Shenango). Titusville Till overlies bedrock. Titusville Till can be seen in the ditches from here to the next stop.

59.0 STOP VI. ENGINEERING AND ENVIRONMENTAL GEOLOGY OF THE JUSTUS DAM. Stop Leader: Jesse L. Craft

(Entrance to Two Mile Run County Park. Turn left (north) into entrance to Edith C. Justus Dam).

The Justus dam is an earth-filled structure lying on Mississippian rocks (Figures 22 and 23). The valley below the dam is cut into relatively impermeable shales and platy sandstones of the Meadville shale (Cuyahoga Group). At the contact of the Cuyahoga with the permeable sandstones of the overlying Shenango Formation numerous seeps and springs have developed. Water from the lake behind the dam is passing into the permeable Shenango sandstones and moving around the dam. These may be seen along the west valley wall at elevations of about 1185-1200 feet.

Leave Justus Dam - proceed back to the gravel road.

Figure 22. Justus Dam (STOP VI). Springs and seeps occur along the Cuyahoga - Shenango contact located in the valley wall just behind the trees at the position of AB.

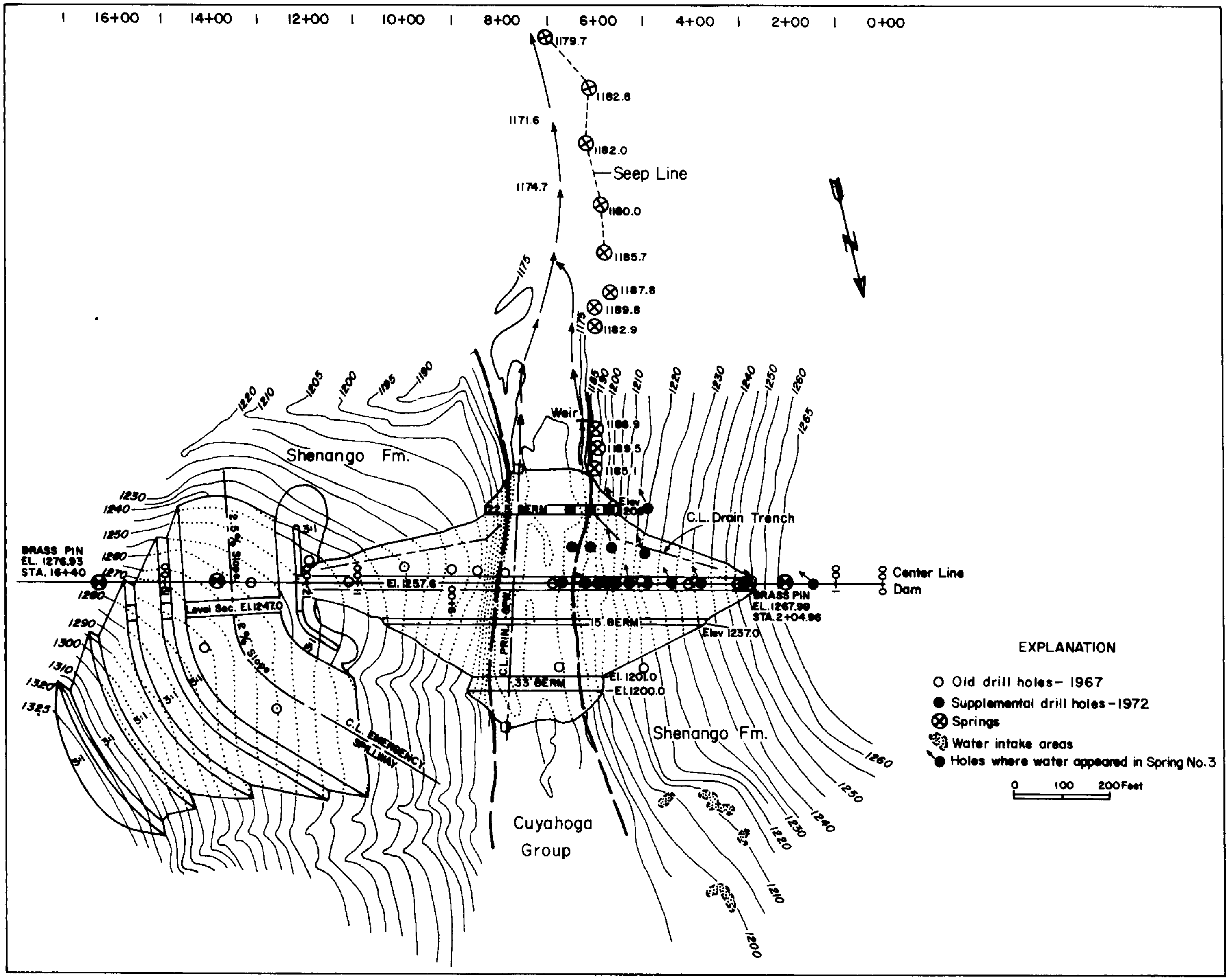


Figure 23. Topographic and geologic map, Justus Dam, Two Mile Run (after U. S. Department of Agriculture, Soil Conservation Service, supplemental geologic investigation map).

59.0 Turn right onto Foster Road at stop sign.

59.5 Turn right onto Keely Road (just before bridge and stop sign).

59.6 Titusville Till lying on Mississippian rocks is exposed in ditch to right.

61.0 Intersection - stop sign. Keely and Cherrytree Roads. Proceed straight ahead.

61.6 Stop sign, dirt road ends. Turn right (north) onto Route 417.

62.8 Bethel Church on right. Continue north on Route 417.

66.0 Village of Dempseytown; continue on Route 417.

68.6 Exposure near crest of hill is Connoquenessing sandstone. It is deeply weathered to an uncemented sand. This is the type of deposit often mined as glass sand in this region.

69.2 Cornfield to right. Rolling topography probably blanketed by Mapledale (?) Till which here lies on Mississippian bedrock.

69.7 Colluvium lying on Shenango rocks in road ditch to left.

70.1 Intersection of Routes 8 and 417. Turn left onto Route 8 north.

70.6 Till (Mapledale?) is exposed in the ditch to the right. It appears to be lying on bedrock. Possible glacial striae (bearing 0-10°) have been cut into the surface of a massive bed of Mississippian sandstone.

71.2 Drive-in theater. Exposure of Titusville ground moraine.

72.1 Oil field to right. Broad flat-topped ridges are underlain by Pottsville and are capped by Titusville Till.

73.0 Cross Creek Resort entrance.

ROAD LOG

Saturday, 2 October 1976

See Figure 12 for a sketch of the field trip route.

Cumulative Mileage	
0.0	Cross Creek entrance and Route 8. Turn right onto Pa. Route 8 south.
2.7	Intersection with Pa. Route 417. Turn left; stay on Route 8 south.
3.2	Entering Oakland Township.
3.8	Entering Cornplanter Township.
4.1	Road descends to floodplain of Cherrytree Run.
4.9	Cross Kane Run and continue through Kaneville on Route 8 south.
6.4	Cross Cherrytree Run. The Corry sandstone crosses Cherrytree Run about 0.3 mile north of this point.
6.6	Cross Oil Creek.
6.9	Rouseville Corporation boundary. The ridge to the east is underlain by a small anticline. The valleys of Cherrytree Run and Oil Creek join along the axis of a syncline. Both of these structures trend NE-SW. The ridges are capped by Upper Connoquenessing sandstone.
7.6	Cross Cherry Run. The Corry sandstone outcrops at or just above highway level from here through Oil City. It is a major marker horizon in this area. It dips about 25 feet per mile to the SW in this area.
8.0	Rouseville Corporation boundary.
8.2	Cross Oil Creek. Note sign on right (west) "McClintock No. 1".

McClintock No. 1: Oldest producing oil well in the United States. This well has produced continuously from the Second and Third sands since August 1861. It was drilled only two years after the Drake Well.

Characteristically the Third sand is pebbly, and pebbles are more abundant in the upper part of the sand body. The permeability is extremely variable, ranging from several thousand millidarcies in the pebble beds of the thick parts of sand in the northern part of the pool to less than one millidarcy average in the finer and poorer parts of the sand. The permeability, porosity, and oil content, as a rule, decrease as the thickness decreases.

The Third sand of the Rouseville-Oil City Pool is characterized by multiple bars or "streaks", as it is in the Titusville area. Belts ranging from 500 feet to 2,000 feet in width, trending north or northeast, are separated by relatively poor and barren belts of approximately the same width. The oil is dark green, with an A.P.I. gravity of 42 degrees to 47 degrees. Since 1930 parts of the pool have been repressured with air.

The Second Venango sand is also productive in this Rouseville-Oil City Pool. It covers a larger area than the Third sand. Most drilling before 1880 was in the hope of finding large Third sand wells, and the Second sand was not generally developed until the late 1880's. This sand is 20 to 35 feet thick. The sand is generally medium to coarse grained with a conglomeratic bed either at the top of the sand body or in the middle. The porosity is between 15 and 20 percent, the oil saturations 15 to 30 percent, and the permeability ranges up to 600 millidarcies. Initial productions ranged between 5 and 50 barrels per day. Some of the early wells had a much higher initial production. At present much of the pool is operating under air drives.

9.4 Oil City Corporation limit.

10.6 Corry outcrop extends about 5-6 feet above road level. Cuyahoga shales and sandstones form the beds in the upper part of the exposure.

10.9 Intersection with U.S. Route 62 south; <u>continue</u> on Route 8 south.

11.7 Cross Charley Run and enter Sugar Creek Township. The highway is running along the top of the Corry. The Corry outcrop crosses the Allegheny River about 0.8 mile west of Reno. The interbedded shales, siltstones and sandstones of the Cuyahoga Group can be seen along the steep banks beside the highway. They are subject to slumps and slides during wet seasons.

14.5 Entrance to Reno Gravel Pit on the right (this will be STOP XII later today).

16.4 Cross Two Mile Run. If the leakage at Justus Dam eventually causes failure of the dam, the floodwaters will enter the Allegheny River at this point.

18.2 Cross French Creek

Entering Franklin: As we cross the bridge over French Creek we see exposed on the high cliff to our right almost the entire section of the Cuyahoga Group. This group lies between the Shenango Formation and the older Corry sandstone. The top of the Corry here is about at river level. The Cuyahoga Group is approximately 150 feet thick and consists of alternating beds of shale, sandstone, and sandy limestone. It becomes increasingly sandy upward and grades into the Shenango above.

The upper half of the Cuyahoga Group of this area is the approximate stratigraphic equivalent of the lower Meadville and Sharpsville Formations of Crawford County. Very fine grained, yellowish- to reddish-brown sandstones predominate in this upper part of the group. Interbedded with these sandstones are gray to brown sandy shales. Although locally continuous and sharply defined, the individual members can be identified in isolated outcrops only by intervals to other horizons. Both lateral and vertical gradations occur between the sandy shales and argillaceous sandstones. Local lenses of sandy limestone occur at several horizons, especially in the northwestern part of the quadrangle. These limestones are sparingly fossiliferous. Upon weathering they leave a compact brown sand mass that is not readily distinguished from a noncalcareous sandstone.

The lower half of the Cuyahoga Group is the approximate stratigraphic equivalent of the Orangeville Shale of Crawford County. In this area gray to brown shale predominates in the lower part of the group. These shales range from argillaceous to arenaceous. Fine-grained, yellowish- to greenish-gray, flaggy sandstones and siltstones up to five feet thick occur at several horizons through this part of the section. Locally these sandstones, and less frequently the shales, are highly calcareous and grade laterally into layers of siliceous or argillaceous limestone. Here four of these highly calcareous siltstones, or silty limestones, ranging up to two feet thick, are developed in the interval extending from 45 to 60 feet above the Corry sandstone. This is the general horizon of the Meadville Lower limestone of Crawford County. Thin layers and concretionary masses of siderite are well developed in the darker shales of the lower part of the Cuyahoga Group.

Just 300 yards above the bridge and opposite the Evans well, a well was drilled on the high cliff. As the bit was penetrating the formations at creek level the bit swung free. The tools were hauled out and the bailer run. When the bailer was dumped the fluid had an odd smell. The driller tasted it and discovered it was beer. Just then an excited man came running up the hillside and told them they had drilled into a cave where he kept his beer in large barrels and their bit had penetrated one of these barrels. The barrel was moved aside and the well was continued to the oil sand and became a productive well, of oil that is.

Franklin: The Franklin Heavy Oil field is an extensive area characterized by the type of oil produced from it. This field is not a continuous producing area, but all First Sand oil within its limits is several degrees lower in gravity than the oils of the other Venango Sand fields. This "heavy oil" is about 31 degrees A.P.I. and bright green. It is especially valuable because of the large percentage of high-grade lubricating oil that it contains. It is lower in the percentage of gasoline than the other Venango Sand Crudes. It is distinguished also by having a paraffinic base and napthenic light fractions. It is classed as an intermediate base oil by the U.S. Bureau of Mines.

The discovery well of this field was drilled late in 1859. Oil seeps in the bed and along the banks of French Creek at Franklin had been known and utilized long before the drilling of the Drake well at Titusville in 1859. Immediately following the successful completion of the Drake well, Mr. E. Evans, encouraged by an oil seep on his Franklin property, deepened his water well. Oil was struck in a crevice at 72 feet and, when tubed, his well produced, by hand pumping, 10 to 15 barrels of oil daily. This well, which was located on the west bank of French Creek opposite The Point, about 200 yards to the right of the bridge, was the first productive well in this area and the third in the Venango district.

The Evans well made Franklin one of the early scenes of intensive development. In 1861, before the area was thoroughly tested, development here was stopped abruptly by the drilling of flowing wells along Oil Creek. A second period of development starting about 1869 reached its peak before 1875. Drilling, which occurred periodically throughout this period, was particularly active from 1878 to 1880 and from 1890 to 1910.

The First sand, the producing horizon of this field, is predominantly coarse-grained sandstone and conglomerate. It ranges up to 85 feet thick. Although commercially productive in less than half the surface area of the field, the First sand here is rarely totally devoid of oil. Drilling has proved that no large pools occur within the non-productive portions of the field. In these non-productive areas the sand is generally thin, tightly cemented, and contains water.

Except for a gentle south-plunging anticline between Wyattville and Oak Forest School and a gentle syncline east of this school, the structure of the sand has a fairly uniform south regional dip. In this field, as in most of the Venango district, the localization of oil accumulation has been influenced much more by the sand conditions than by the structure.

This field is located north of Franklin. The entire production is now owned by the Wolf's Head Oil Refining Co., Inc. Formerly producers were paid an additional 75 cents a barrel for this oil due to the large percentage of lubricating oil that it contains.

Franklin Forts: Four tenths of a mile south of Route 8 along the Allegheny River is the site of Fort Venango. It was built in 1760 by the British to assert control of the area. Indians attacked and destroyed it in 1763 during Pontiac's uprising.

Near this site is the site of Fort Machault, a French fort, built in 1754-55 to guard the route to the Ohio. In 1759 French forces massed here to retake Fort Duquesne. On news of the fall of Fort Niagara they burned Fort Machault and fled.

18.4 Turn right on Pa. Route 8 and U.S. Route 62 south.

19.1 Turn left on Pa. Route 8 and U.S. Route 62 south.

19.3 Turn right on road immediately after Plummer Road. Road is hidden just over the crest of a hill. Poorly exposed outcrops range from Cuyahoga to Pottsville (at top of ridge).

20.1 STOP VII. MAPLEDALE TILL TYPE SECTION
Stop Leader: W. F. Chapman

Here we will examine the type section of the Mapledale Till as described by White and others, 1969, p. 15. They describe this type section as having been "measured on the north wall of an excavation for a shopping center [military building] lying between a street that was formerly the old U. S. Route 62 and the present Route 62, 1 mile southwest of the City Hall in Franklin and 1/4 mile northeast of the road junction of U. S. Route 62 and State Route 8".

The most detailed, published type section of the Mapledale Till (White and others, 1969, p. 15) is quoted as follows:

Illinoian?:	Unit Thickness Ft.	In.	Aggregate Thickness Ft.	In.
Mapledale Till:				
Soil and disturbed material	3	0	3	0
Silty clay loam, mottled	1	0	4	0
Loam, very sandy and deeply weathered till, mottled	1	0	5	0
Till, severely weathered, mottled	1	0	6	0
Till, sandy, yellow-brown, weathered	1	0	7	0
Till, sandy, dark yellow-brown to brown	3	0	10	0
Till, sandy, dark-yellow brown, very stony, not much weathered, noncalcareous	3	0	13	0
Till, sandy, stony, gray-brown, noncalcareous	1	0	14	0
Till, mixed gray and brown, noncalcareous	2	0	16	0
Till, sandy, stony, gray, noncalcareous	2	0	18	0

There are several problems to be considered at this stop:

1. Is this material really till? Although the exposure is not nearly as fresh now as when described, erratic pebbles are very difficult to find in the "outcrop" and the material does not everywhere resemble till.

2. What is the relationship between the material in the type section (below road level) and the colluvium (?) in the borrow pit (at and above road level)?

3. If the material in the type section is till, is it Illinoian, and how does it correlate with the till exposed in the new Route 8 road cut (Stop VII)?

4. What is the source of the sewage effluent that is seeping out of the bank in this Mapledale Till?

20.5 Junction Pa. Route 8 south. Turn right (south).

21.1 Entrance to Chess Lamberton Airport on right. The ridge is capped by Mapledale Till which overlies Upper Connoquenessing sandstone and Mercer shales.

23.4 STOP VIII. THE SANDY CREEK SECTION
Stop Leaders: A. N. Ward, Jr., W. F. Chapman, J. L. Craft

At this locale we shall examine an almost unbroken sequence of strata extending from the transitional contact of the Upper Member of the Connoquenessing Formation with the Mercer shales at the top of the hill through the Mississippian-Pennsylvanian boundary into the Lower Member of the Shenango Formation. Figure 24 is an oblique air photo showing the exposures along the new Pa. Route 8 south of Franklin. Figure 25 shows the upper beds of the Shenango Formation, the lower beds of the Pottsville, and the position of the Mississippian-Pennsylvanian boundary.

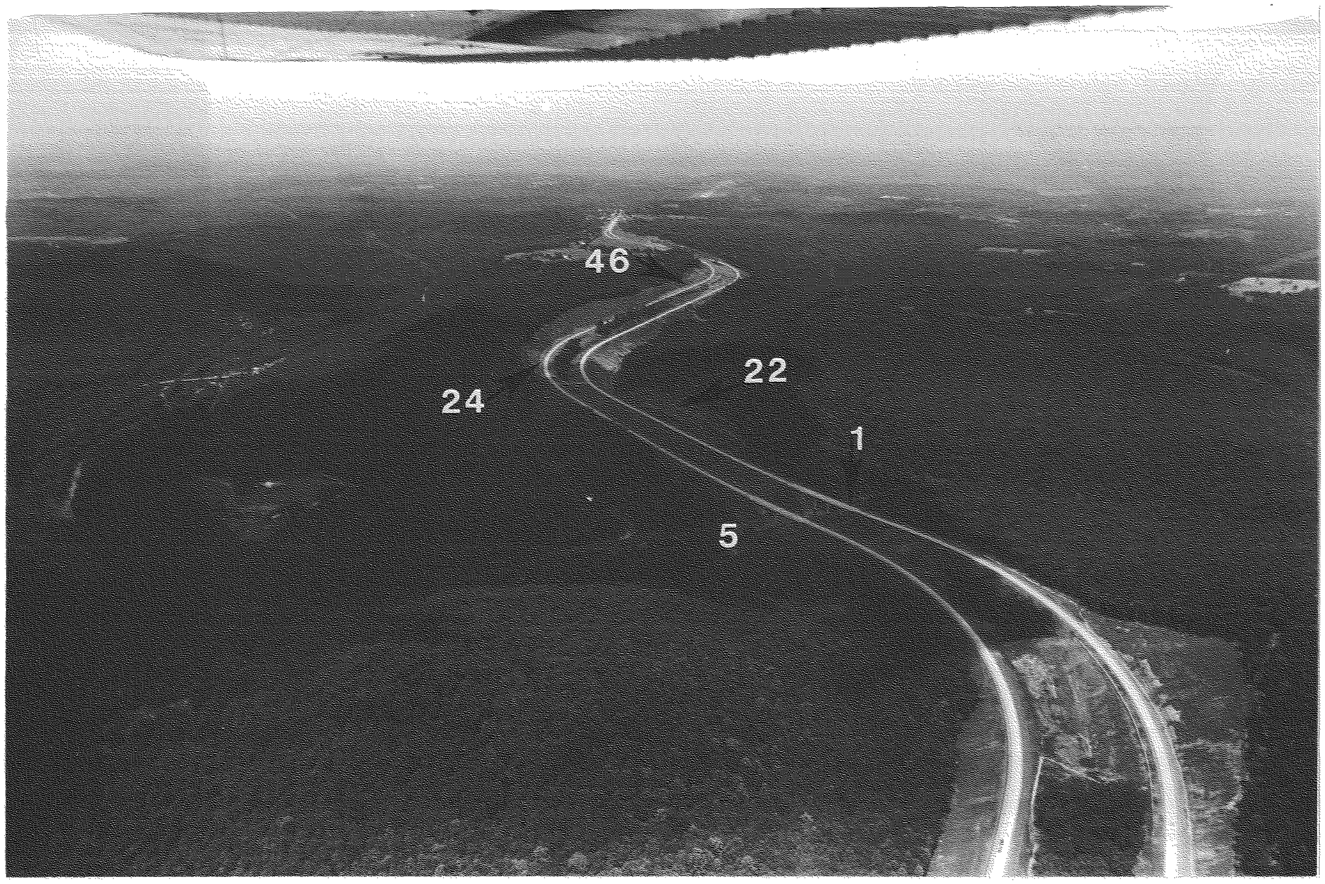


Figure 24. Oblique air photo of the new Route 8 road cuts south of Franklin (Stop VIII). Sandy Creek section, units 1, 22, 24 (top of the lower Shenango), and 46 (approximate top of the upper Shenango) are indicated.

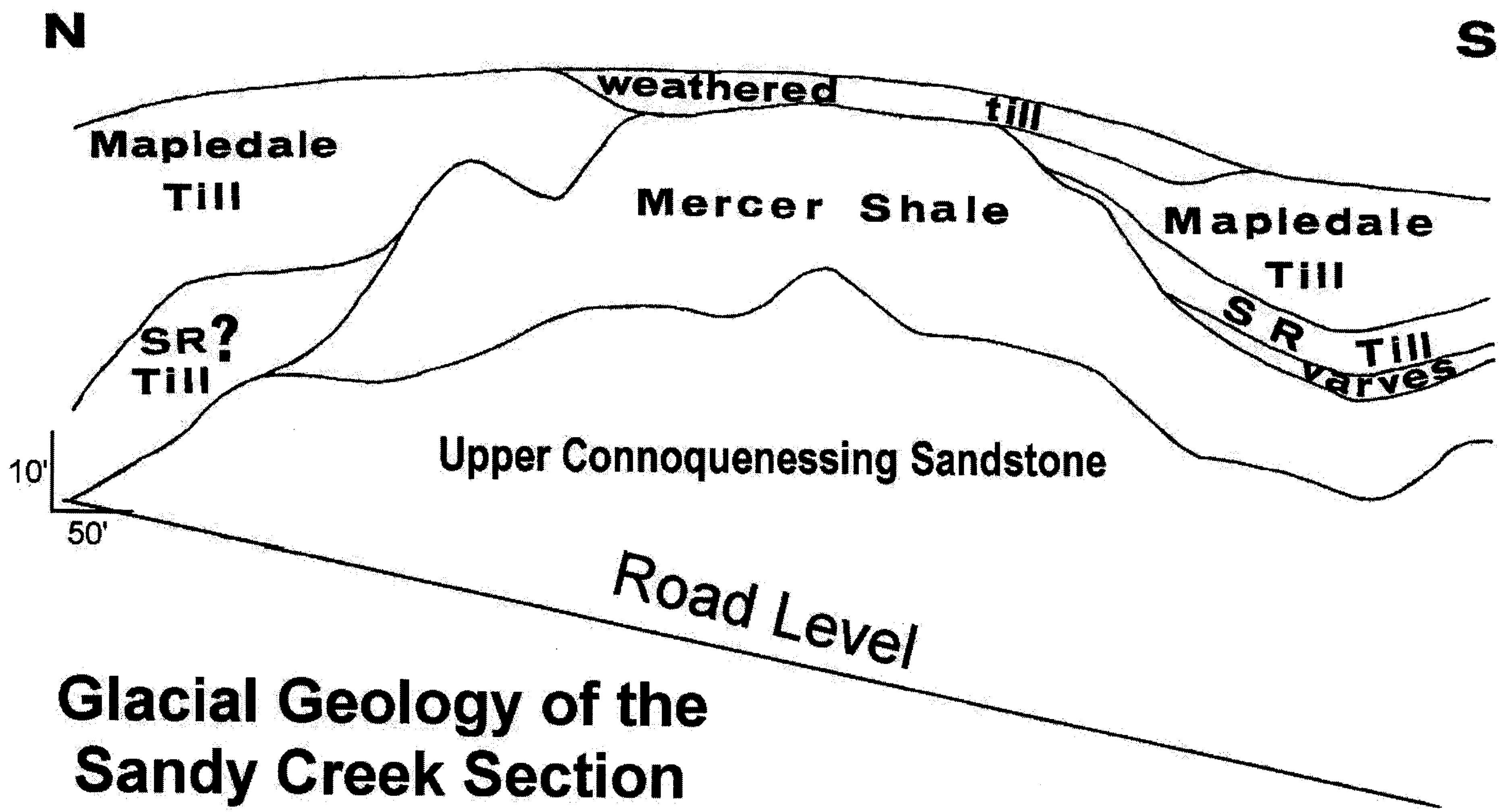
Figure 25. Sandy Creek section along southbound lane of new Route 8 south of Franklin. Crinoidal sandstone (unit 44), and the approximate boundary between the Mississippian (M) and the Pennsylvanian (P).

On the slopes overlying the upper Connoquenessing in the northbound lane is a particularly fine exposure of Mapledale Till.

The Mississippian interval was measured and described by A. N. Ward, Jr. and students from Slippery Rock State College.

The Sandy Creek section begins at creek level just east of the northbound land bridge spanning Sandy Creek, and continues northward through unit 22 onto the east side of the northbound lane of the new Route 8. Beginning with unit 24 the section continues northward on the west side of the southbound lane.

Unit	Lithologic Description	Thickness Feet
	PENNSYLVANIAN SYSTEM Pottsville Group	
	Connoquenessing and Sharon	
47	Sandstone, medium- to coarse-grained, light-gray and grayish-orange, thick trough to tabular cross-bedding, basal contact sharp (in northbound lane). Underlying shale beds exhibit some folding which results in angular discordance with the overlying Pottsville. The lower Connoquenessing is 90 feet thick at this site.	
	MISSISSIPPIAN SYSTEM Shenango Formation	
	Upper Member	
46	Covered in southbound lane; however in the north lane this zone contains an ironstone-bearing brown shale with several thin beds of medium-grained sandstone near the top. The sandstones contain abundant large carbonized plant remains tentatively identified as _Rhodea_, and _Fryopsis_. This unit is overlain unconformably by Pottsville sandstones.	5
45	Clay shale and sandstone, dark-green and light-olive-brown, ripple lamination, abundant carbonized plant fragments, ironstone nodules, some of which contain a few marine invertebrate fossils.	5
44	Sandstone, as in unit 42.	2
43	Clay shale, olive-gray to light-olive-gray, contains sparsely fossiliferous clay ironstone nodules.	2



Glacial Geology of the Sandy Creek Section

Gary M Fleeger, 1976

Unit	Description	Thickness Feet
42	Sandstone, light-gray, weathers grayish olive, fine-grained, micaceous, forms a very prominent marker, parts into 1/2-inch ripple-laminated beds, crinoid debris as molds occur on the surface and base of the unit, brush and prod marks are common, surface covered by limonitic and hematitic encrustations, unit interfingers with shale below.	2
41	Clay shale and mud shale, moderate-olive-brown, dark-gray, light-olive-gray, micaceous, contains several one-inch bands of clay ironstone nodules which contain numerous brachiopod and bone fragments, a few scattered burrowed and ripple-laminated one-inch sandstone beds.	30
40	Clay shale, mudstone, and mud shale, moderate-olive-brown, ripple laminations, 1-2 inch beds of shale and mudstones interfinger laterally, some very tiny carbonaceous fragments.	6
39	Sandstone, dusky-yellow, thickly bedded, trough cross-beds, base fills erosion channels in underlying shale, shale chips and fossils as in unit 35.	4
38	Clay shale, medium-gray, top eroded.	1
37	Sandstone, as unit 35, persistent bed 1-2 feet thick.	2
36	Mudstone and mud shale, pale-olive and medium-gray.	1
35	Sandstone, dusky-yellow, fine-grained, argillaceous, medium-bedded, shale-chip pebbles occur in base of beds with bone fragments, possible brachiopod molds.	1
34	Mudstone, mottled pale-olive, grayish-yellow-green, and medium-gray, sandy, micaceous, bioturbated.	3
33	Sandstone, olive-gray, fine-grained, argillaceous, thick ripple laminations, parts into very thin beds, carbonized plant remains.	3
32	Mudstone, siltstone, and sandstone, medium-gray, trough ripple lamination, some ripple drift laminae, bioturbated, productid and phosphatic brachiopods. One thin bed one foot from base of unit is nearly a shell bed of productid casts and molds, carbonized plant fragments in silty layers.	5
31	Shale and mud shale, dark-gray, overlain by ledge of burrowed and rippled mudstone.	11

Unit	Description	Thickness Feet
30	Clay shale and mud shale, medium-dark-gray, ripple laminations, carbonized plant fragments, one very thinly bedded siltstone layer at top of unit with rippled surface, Bifungites, and carbonized plant remains.	1
29	Mudstone, mud shale, medium-dark-gray, sandy, in four very thin beds, burrow- and ripple-laminated.	3
28	Siltstone, dark-gray, argillaceous, micaceous, tubular burrows, carbonized plant fragments.	3
27	Sandstone, as below.	1
26	Sandstone, light-olive-gray, medium-grained, argillaceous, micaceous, thin to thick ripple laminations, separated from overlying unit by thin 1/2-foot silt shale.	3
25	Mud shale, medium-gray, very thinly laminated, carbonized plant fragments.	2
	Lower Member	
24	Siltstone, silt shale, and fine-grained sandstone, light-olive-gray, thinly bedded, with trough ripple cross-laminae, crests trend 140°, 190°, a few sandstone stringers occur between silt beds, carbonaceous wood fragments are abundant.	6
23	Covered interval - section is continued at first road cut in the southbound lane.	18
22	Sandstone, pale-olive, fine- to medium-grained, very thin to thin beds bearing ripple trough cross-bedding, ripple crests bear N.70°E., base and top covered with till and platy sandstone float but unit appears to become thicker bedded upward.	6
21	Clay shale and mud shale, medium-dark-gray, weathers to yellowish gray, a few scattered one-half-inch beds of fine-grained micaceous sandstone, clay ironstone nodules occur throughout the unit, carbonaceous plant fragments, some sandstone stringers contain burrows that open upward into monticules that appear as round concentric rings on surface, marine fossils, unit is poorly exposed.	39
20	Sandstone, bluish-gray to light-olive-gray, fine- to medium-grained, micaceous, thin one-half-inch beds.	1
19	Claystone, grayish-olive.	1

Unit	Description	Thickness Feet
18	Clay shale and interbedded mud shale, medium-gray, mostly covered but appears to interbed with the underlying unit.	11
17	Sandstone, very light gray to greenish-gray, beds grade upward into more even 1-2 foot beds.	8
16	Sandstone, olive-green, medium- to coarse-grained, in massive overlapping lenses consisting of trough cross-beds 2-4 feet thick, lenses become finer grained upward, bases of lenses contain shale chips and clay ironstone nodules.	8
15	Sandstone, olive-gray, fine- to medium-grained, micaceous, argillaceous, iron-stained, 1/2-1 inch low-angle wedge cross-beds (az. 045-075), carbonized plant fragments, basal contact sharp, top contact irregular due to erosion, float block from this interval contains brachiopods.	2
14	Silt shale and clay shale, dark-gray, carbonized plant fragments in silty layers.	20
13	Mud shale grades upward into clay shale, dark-gray, weathers olive green, some 1- to 2-inch beds of sandstone in the upper 2 feet of the unit, iron-stained.	5
12	Mud shale, light-greenish-gray, bioturbated.	5
11	Sandstone, olive-green, medium-grained, micaceous, low-angle trough cross-beds 1/2 to 1 foot thick - only top of the unit is exposed.	2
10	Covered interval - massive blocks of sandstone in float.	10
9	Sandstone, same as below, fine-grained, trough cross-beds in sets 1 to 2 feet thick.	15
8	Sandstone, light-gray and light-greenish-gray, fine-grained, trough cross-beds and ripples, beds about one foot thick, some mudstone interbeds. "A" sand.	5
	Cuyahoga Group	
	Meadville Shale	
7	Sandstone, light-olive-gray and greenish-gray, fine-grained, trough cross-beds in 2- to 6-inch beds, bioturbated, interbedded with about 25% gray shale.	5
6	As in unit 5, but section contains more thin beds of sandstone.	20

Unit	Description	Thickness Feet
5	Mud shale, medium-gray, with local 1/2- to 1-inch sandstone.	10
4	Sandstone, mottled medium- and greenish-gray, fine-grained, micaceous, rippled thin beds 1 to 3 inches thick interbedded with mud shale, bioturbated, about 90% sandstone, orbiculoid brachiopods in float.	5
3	Covered interval.	12.5
	Sharpsville Sandstone	
2	Limestone, medium-dark-gray, weathers moderate yellowish brown, argillaceous, platy low-angle trough cross-beds 1 to 4 inches thick, breaks with a conchoidal fracture, contains alate spirifers, phosphatic brachiopod fragments, gastropods, borings.	0.5
1	Sandstone, greenish-gray, fine-grained, argillaceous, micaceous, low-angle trough cross-beds 1 to 2 inches thick dip to south, bed markings common (groove casts trend N.7°E., N.11°E.; interference ripples trend N.34°W., N.60°E., N.1°W., N.15°W., striae N.4°W.).	2

Cumulative Mileage

23.4 Leave Pa. Route 8 cut and return to Chess Lamberton Airport for lunch.

25.7 STOP IX. CHESS LAMBERTON AIRPORT. Lunch Stop.

Leave Chess Lamberton Airport, and <u>turn left</u> onto Route 8 south.

26.7 Behind armory on left (west) is the Mapledale type section (STOP VII).

27.8 <u>Turn right</u> on U. S. Route 62 and Pa. Route 8 at flashing stoplight. Proceed through Franklin; cross railroad tracks.

28.1 Stoplight, <u>turn left</u> on U. S. Route 322 west. Follow Route 322 west toward STOP X.

28.4 Cross French Creek.

28.6 Intersection of Pa. Route 417 and U. S. Route 322. Turn left; continue on Route 322 west.

29.9 Borough of Sugar Creek. Outcrop to right is Orangeville shale.

30.1 Ruins of old Wolfs Head refinery. As we proceed up French Creek valley at river level to left (south) float blocks of Corry sandstone can be seen. The valley walls are cut into rocks of the Cuyahoga Group.

30.8 Entrance to STOP XI to right (Bear's Dairy Shoppe on left). Continue straight.

31.4 Village of Sugar Creek.

31.9 River terrace on left (west).

33.1 Terrace to left (west).

33.6 STOP X. BERKHARDT FARM GRAVEL PIT.
Stop Leader: Jesse L. Craft

This is one of the low-level outwash gravel terraces of the Oil City-Franklin area. Pit is excavated in gravel from a higher level terrace than at 33.1. The gravel from this pit is being hauled to the treatment plant in Franklin where it is crushed and washed to produce Class "A" aggregate for use by PennDOT.

Buses turn around and return to mileage point 30.8 on U.S. Route 322.

36.2 Turn left just beyond Bear's Dairy Shoppe.

36.9 Stop sign. Cross unnamed highway and proceed straight ahead.

Figure 26. Oblique aerial photo of working face in outwash terrace, Berkhardt Farm gravel pit (Stop X). Terrace elevation 1093 feet ASL.

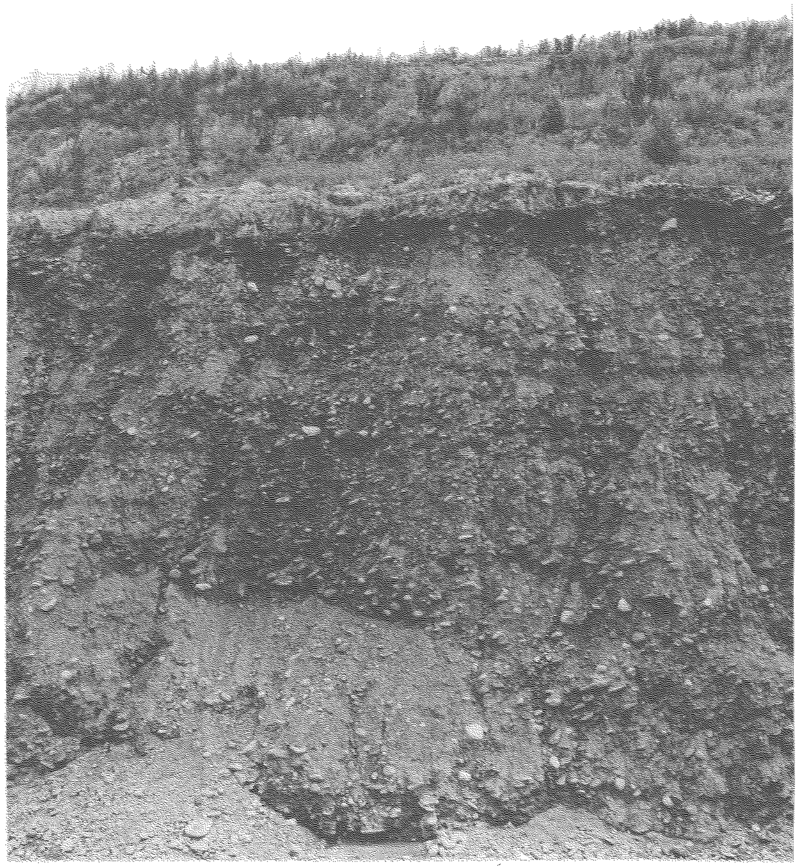


Figure 27. Five to 15 feet, fine sand, silt, some clay and organic material.

35+ feet, dirty coarse gravel, horizontal bedding throughout. Individual gravel layers have well-developed shingle structures indicating water flow from northwest to southeast.

Close-up of "A" on preceding page.

36.95 STOP XI. FOUR CORNERS GRAVEL PIT.
Stop Leaders: W. F. Chapman and J. L. Craft

This deposit has been described by White and others (1969) as a Mapledale gravel kame. They describe 55 feet of gravel in this deposit. The deposit, as presently exposed, is composed predominantly of horizontally stratified coarse gravel, the south end changing abruptly to irregular-bedded layers of gravel, sand and some silt dipping at steep angles with numerous small faults towards the north. Typical collapse structures found associated with ice-contact kame deposits are present at this site. Note the weathered character of the sand and gravel layers, especially at the south end of the deposit.

Leave STOP XI. Return to intersection with U.S. Route 322 - turn left (east) and proceed to STOP XII.

37.3 Gravel pit on right. If one looks closely at the pit, an oil well casing may be seen rising from the floor of the pit. The operators have very carefully excavated around the old well in order to avoid touching it and thus becoming legally responsible for plugging the well.

As you pass over the hill a few blocks of Pottsville may be seen near the ridge top.

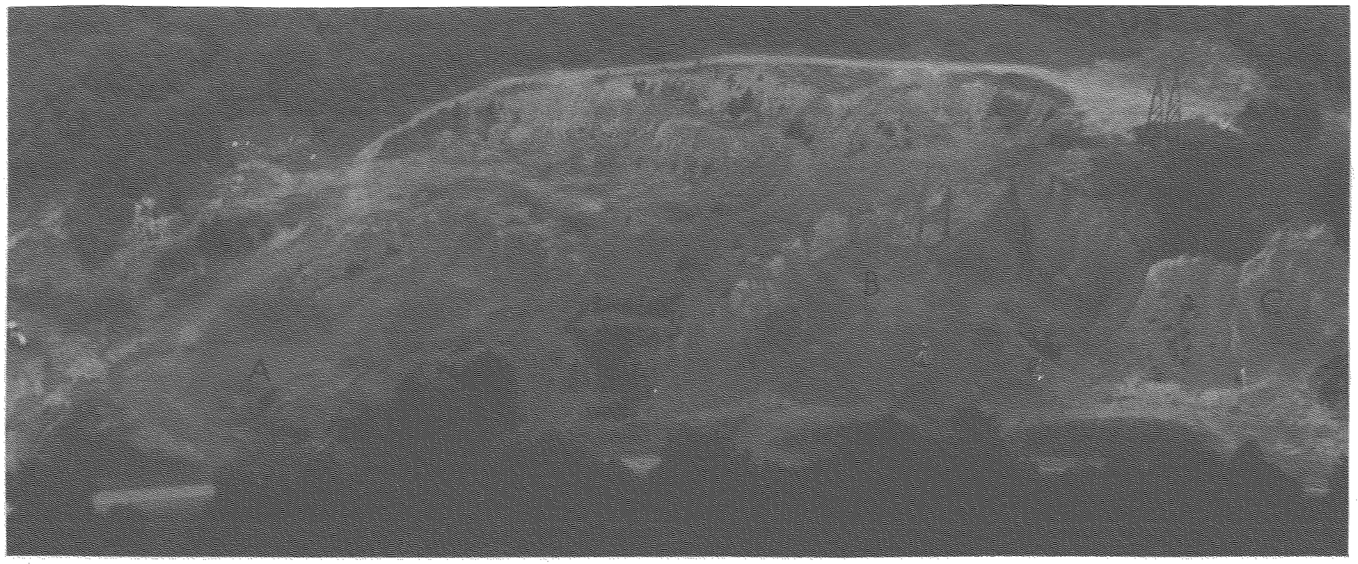


Figure 28. Aerial oblique photo of Mapledale gravel deposit at the crossroads 0.6 mile north of Foster Corner on the west side of Patchel Run (Stop XI). A, area of intensively weathered sand and gravel. B, poorly sorted horizontal-bedded coarse gravel. C, ice-contact collapse structures.

38.9 Follow Route 8 north back to the entrance of Reno Gravel pit (mileage point 14.5).

43.3 Turn left to Reno Gravel pit.

43.5 STOP XII. RENO GRAVEL PIT
Stop Leaders: J. L. Craft and W. F. Chapman

This gravel pit (Figure 29) lies at an altitude of approximately 1,100 feet (120 feet above the Allegheny River). The gravel here is part of a much larger deposit which extends west for 4,000 feet and east for about 5,500 feet. Unlike the gravels at the White City pit (Stop III) and those under the Titusville Till (Stop V), these Reno gravels have nearly parallel bedding (Figure 30). The cross-bedding typical of the other pits is lacking here.

The weathering of particles and matrix in this pit does not seem to be as severe as in the gravel at Stop XI. Pockets of gravel in this pit are cemented strongly with calcium carbonate. The cementing makes these portions difficult to utilize, although the gravel in the cemented zones is of better quality than unconsolidated portions of the same gravel layers.

Figure 31 is a plot of the particle size analysis of gravels collected from one of the carbonate-cemented knobs and a sample

Figure 29. Aerial oblique photo of Reno Sand and Gravel pit. Terrace elevation is 1,100 feet ASL.

Figure 30. Close-up of working face at "A" on photo above. Note horizontal bedding.

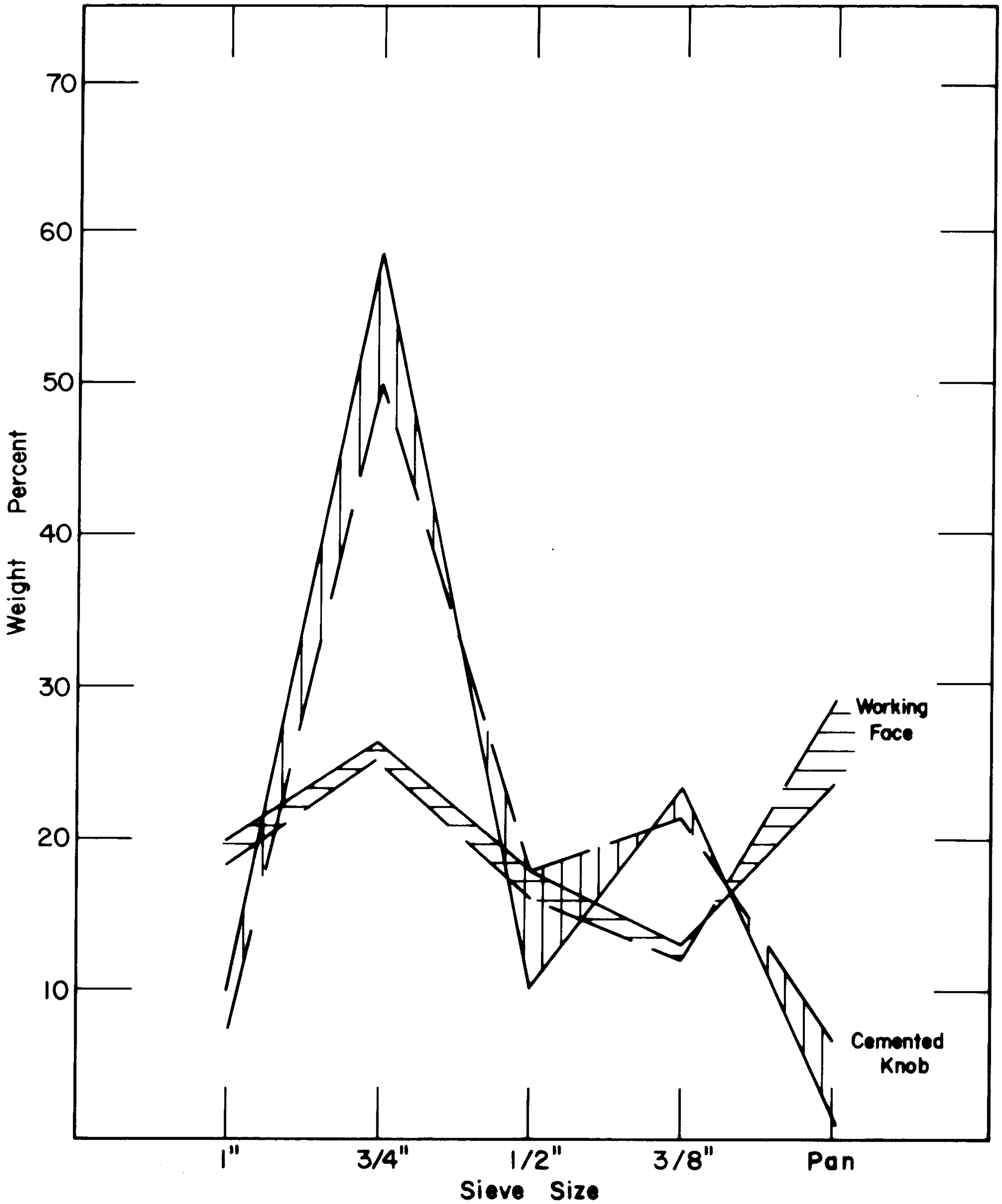


Figure 31. Freeze-thaw testing of gravel from the working face of the Reno gravel pit and from a carbonated cement knob in the pit. Solid line represents particle size distribution before immersion in sodium sulfate; dashed line represents particle size distribution after immersion in sodium sulfate.

collected from the uncemented working face. These two samples were collected from the same stratigraphic layer. Note the shift in particle size from the coarser fraction to the pan. This gravel is rated by PennDOT as a Class "C" gravel.

57.5 Return to Cross Creek (14.5 miles).

End of 1976 Field Conference of Pennsylvania Geologists.

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