Day Three
Sunday, May 21, 1995

BEDROCK GEOLOGY AND URBAN GEOLOGIC PROBLEMS OF NORTHERN ALLEGHENY COUNTY, PENNSYLVANIA

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Introduction

Welcome to the third day of the Pittsburgh Geological Society's 50th Anniversary Field Trip. This day has been designated the "Fossils and Stratigraphy" day, but in reality you will be seeing a lot more than just fossils and strata. There's a little bit for everyone, from geologic structure to soft-sediment deformation, from landslides long past to landslides active now, from ancient stream channels to even more ancient animals.

On this trip we will be visiting five sites in the northern half of Allegheny County. The first site is a roadcut along I-279 near the Camp Home Road interchange that exposes one of western Pennsylvania's more important, more interesting, and **most destructive** portions of the local stratigraphic section. The second site, Fall Run Park in Shaler Township, is a beautifully preserved (mostly) little segment of western Pennsylvania as it might have looked 200 years ago. But look closely – thanks to the environmental problems inherent in developing Pittsburgh's suburbs, it might not be around much longer. The third site is the famous Bakerstown Station railroad cut which exposes some of the most complex geologic structure in southwestern Pennsylvania. Stop 4 is the Witco Corporation plant near Bakerstown Station where movement in the unstable claystones of the Pittsburgh red beds is having a destructive impact on a parking lot and to one of the company's buildings. The fifth site, on I-79 at the Wexford exit, is a view of an ancient meandering stream in cross section showing both lateral and vertical aggradation.

Meeting Point: Carmody's Tavern and Banquet Hall
Meeting Time: 8:00 AM to 8:30 AM. **DISEMBARK AT 8:30 AM PROMPTLY.**

Mileage Interval	Mileage Cumulative	Field Trip Itinerary
0.00	0.00	Parking lot of Carmody's tavern and banquet hall on Route 910 just west of the Wexford exit of I-79 (Figure 3-1). Turn left onto Nicholson Road.

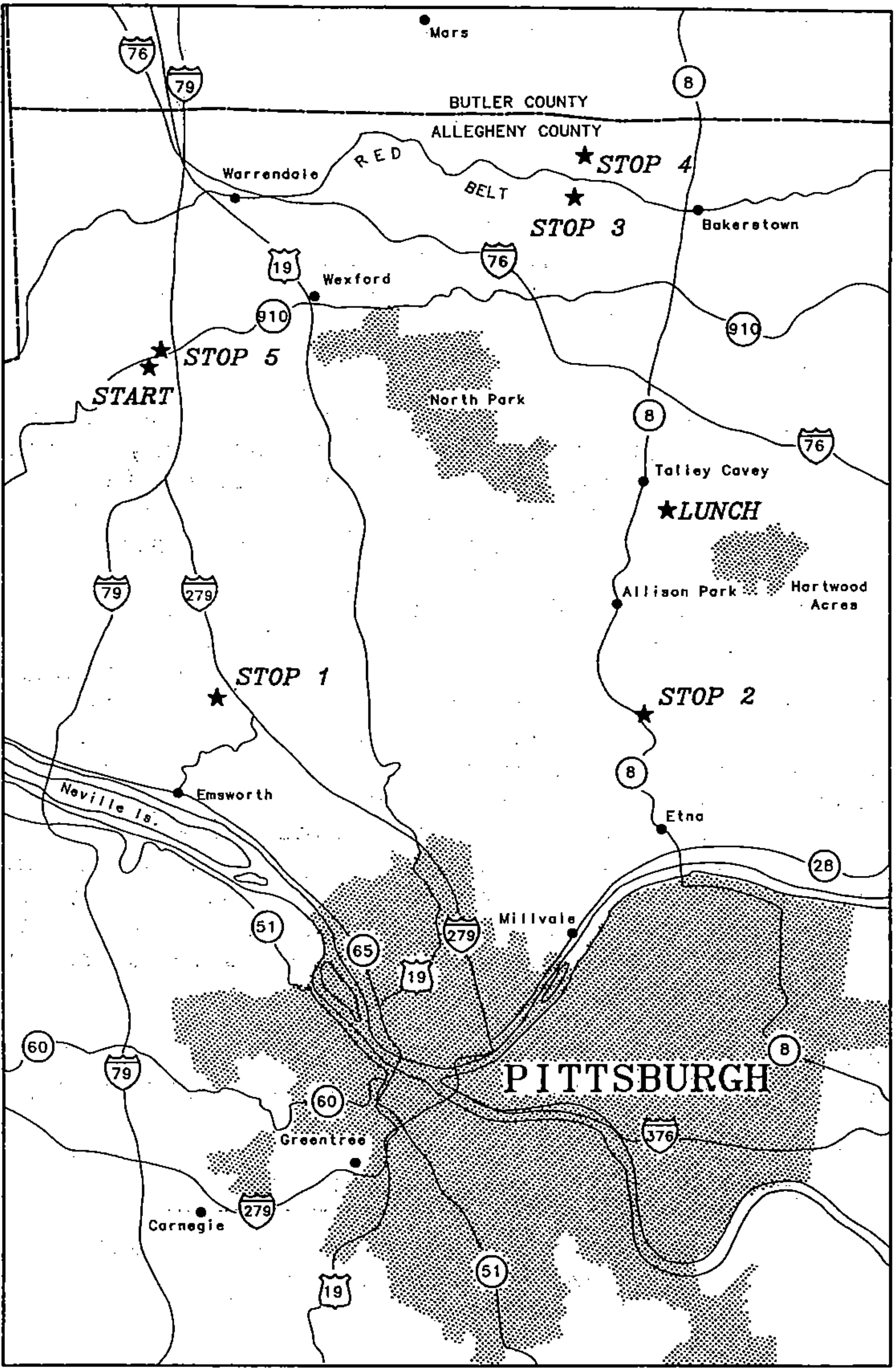


Figure 3-1. Map showing the locations of field stops for Day Three.

0.10	0.10	Turn right onto Route 910 (the Orange Belt) and head east toward Wexford.
0.20	0.30	Turn right onto the entrance ramp to I-79 southbound.
0.40	0.70	Merge left into traffic on I-79.
1.00	1.70	Connellsville sandstone (upper Casselman Formation) outcrop on right.
0.85	2.55	Roadcut on right side of highway exposes a small, gentle anticline and syncline in the Clarksburg limestone and overlying Connellsville sandstone. The Clarksburg limestone here contains numerous nonmarine fossils, mostly ostracodes and worm tubes (*Spirorbis*). The folds seen here are not tectonic in origin. They represent draping caused by differential compaction of mudrocks and sandstone.
0.15	2.70	Bear left onto southbound entrance to I-279.
1.00	3.70	Roadcuts on the left over the next 0.45 mi. expose thick sequences of lower and middle Casselman Formation sandstones that probably consist of Combined Morgantown and Birmingham units.
0.70	4.40	Roadcut on the left extends approximately 0.3 mi. to the south, exposing a thick sequence of sandstone. A cursory look at this outcrop as you drive by appears to reveal a single sandstone unit. However, there are some distinct differences within the sandstone. The lower portion of the outcrop consists of thick-bedded, massive, gray sandstone, highly fractured in a nearly circular pattern, with mineralization stains along the fractures. The upper part of the outcrop consists of massive yellowish sandstone, very different from the lower part. Around the bend from where the outcrop begins, a thin coal seam with underlying dark-colored shale splits the seemingly single sandstone unit into two discrete units. In stratigraphic terms, what you see is the Wellersburg coal and shale interval separating the underlying Birmingham sandstone from the overlying Morgantown sandstone. The coal and shale disappear abruptly to the north beneath a Morgantown stream channel that has scoured into the top of the Birmingham.

0.75	5.15	Roadcut on the left is a good illustration of the state highway department's approach to reducing erosion of roadcuts by cutting numerous small terraces into sloping surfaces. We will see more of this technique at Stop 1.
0.75	5.90	Small landslides (earth-flow lobes) in the unstable mudrocks of the upper Glenshaw Formation (Pittsburgh red beds) occur on the right. These rocks are very unstable and have caused numerous problems for homeowners and highway engineers for as long as people have lived in southwestern Pennsylvania.
0.65	6.55	Turn right onto dirt access road leading to large roadcut on the right and park on the flat area below the terraces.

STOP 1
LARGE ROAD CUT ON I-279 NEAR CAMP HORNE ROAD

Passengers will disembark from the bus and gather around for a brief lecture before climbing the slope. As you ascend the cut, try to take some time looking at the various lithologies at each terrace or bench. You might be surprised at what you find.

Stratigraphy

This large roadcut exposes the strata of the middle Conemaugh Group, from the Upper Saltsburg sandstone at the base to the Morgantown sandstone at the top. From the base of the cut upwards, you will encounter the following section (Figure 3-2): 1) gray sandstone at the level of the parking area; 2) seven terraces of red and gray claystones (red beds) containing caliche nodules; 3) five terraces of red and gray claystones, very weathered, with some spheroidal weathering, greenish reduction zones, root casts, manganese dendrites, and questionably, some trace fossils; 4) the Ames Limestone Member; 5) two terraces of red and gray claystones; 6) the top terrace, containing a small lens of gray sandstone and a barrier of large sandstone blocks used to prevent rockfalls from reaching the highway; and 7) the steep flat face of sandstone at the top which contains a basal layer of mud chips and slabs that exhibit soft-sediment deformation, indicating an origin in stream-bank failure. The sandstone originated as a channel deposit, but the exact nomenclature is in question. As with the roadcuts to the north, this might be a combination of Birmingham and Morgantown sandstones, or it might represent only one of them. Notice the irregular base of this rock unit, typical of stream channels that cut into the surrounding strata and then fill the gaps with sand.

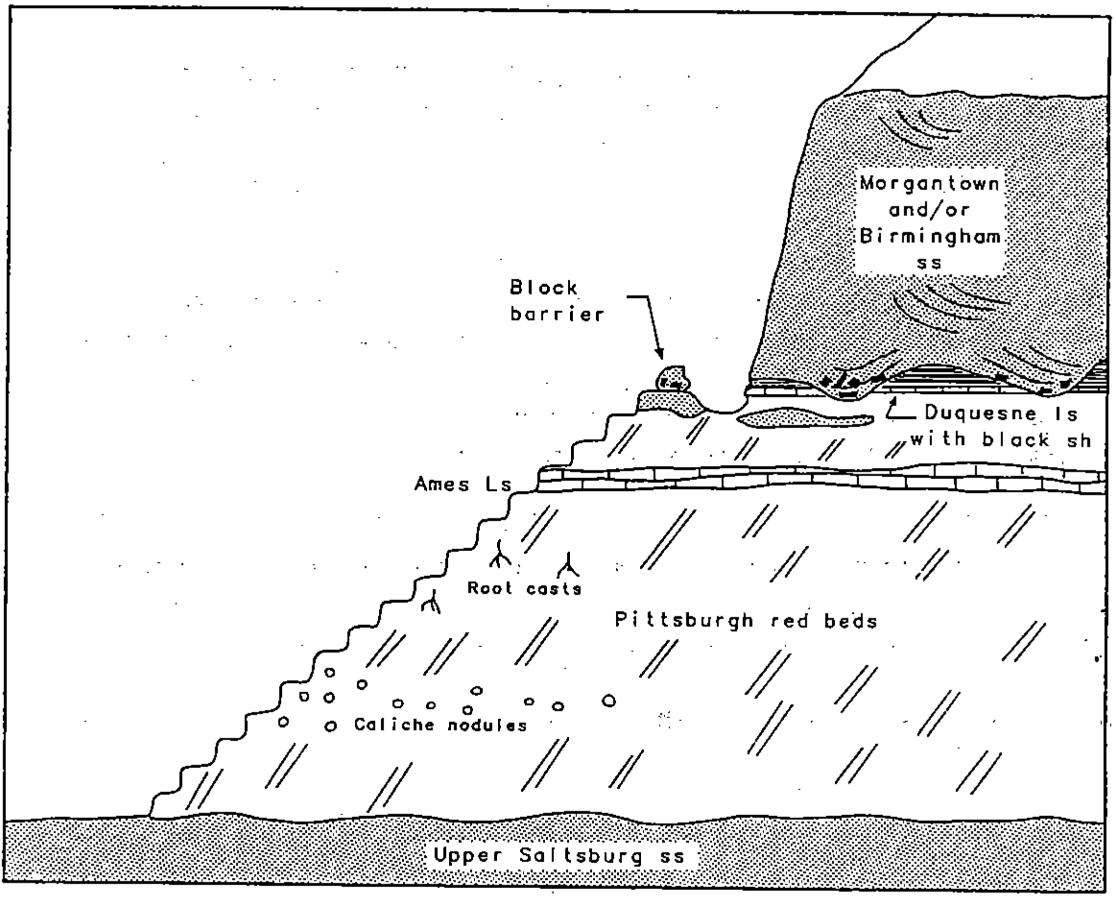


Figure 3-2 Generalized cross section of the roadcut on I-279 just north of the Camp Horne Road exit (Stop 1).

Geotechnical Aspects

The cyclic nature of the rocks of western Pennsylvania creates a plethora of construction problems because of their diverse and heterogeneous nature. Although thick, massive sandstones such as that at the top of this roadcut might be relatively stable, the associated rocks typically consist of thin coals and limestones and thick sequences of mudrocks that have a tendency to fail under the seemingly minor stress situations, like gravity. Each of these rock types possess different physical properties that, in conjunction with climate, slope, and other factors, affect their stability. For example, the Pittsburgh red beds, which are notorious as the cause of most landslides in the Pittsburgh area, slake rapidly in water. Kapur (1960) found that these typically red claystones tend to lose strength with each seasonal cycle (freeze-thaw, wetting-drying). Porosity is relatively high, up to 40% according to Pomeroy (1980), but permeability is very low; therefore, the water that collects in the rock has little chance of draining and ends up helping to destablize the claystone from the inside out. In comparison with an "average" Conemaugh sandstone, the Pittsburgh red beds have little strength (Table 1). Since the red beds constitute only one of numerous unstable rock units, most of the local geologic section has caused headaches among western Pennsylvania's engineering firms.

Table 1. Rock test data for the Pittsburgh red beds and Saltsburg sandstone (McGlade et al., 1972).

CHARACTERISTIC	PITTSBURGH RED BEDS	SALTSBURG SANDSTONE
Shear normal to bedding	320 psi	974 psi
Shear cross-angle to bedding	466 psi	1,255 psi
Unconfined compressive strength	1,661 psi	9,991 psi
Tensile strength	576 psi	4,330 psi
Bearing capacity	4-8 tons/ft^2	25 tons/ft^2

The terracing of roadcuts, called serrated slopes, can be seen along I-279 between this locality and East Ohio Street on the North Side. The original intent of this type of terracing was in helping to develop a soil profile and vegetation growth, and therefore to prevent erosion, on slopes underlain by medium hard rock. However, the project engineer decided to use it everywhere except on the sandstone cliffs, regardless of rock strength (W. Adams, personal communication, 1995). There are two main reasons this technique does not work very well on these slopes: 1) the red beds tend to collect water and saturate the slope, rather than sheeting off as originally intended; and 2) seeding, which was supposed to begin within days of completion of the terraces, never occurred. No seeds - no plants - no erosion control.

Fossils

A large variety of fossils can be found in several strata at this locality (Figure 3-3). The claystones within the interval of the Pittsburgh red beds contain vertical stains that probably represent casts of land plants growing in a paleosoil. It also might be possible to find a few trace fossils of "worms" that crawled over stream bottoms in the thin sandstones in this interval.

The Ames Limestone is, arguably, the most fossiliferous stratum in western Pennsylvania. It contains a wholly marine fauna dominated by brachiopods and horn corals, but also has a rich molluscan assemblage of snails, clams, and cephalopods. Less obvious elements include "algae," foraminiferans, bryozoans, chiton plates, trilobites, crinoids (both intact and disaggregated), isolated starfish plates, and shark teeth. It also contains a wealth of trace fossils.

The Duquesne interval, which occurs just below the nearly vertical sandstone cliff at the top of the cut, is well known for its nonmarine fish fossils. Outcrops of the Duquesne limestone around the Pittsburgh area are particularly fossiliferous, containing large quantities of the worm tube *Spirorbis*, ostracodes, and conchostracans, in addition to the remains of bony fish and lungfish. The jet black shale lying above the Duquesne limestone also contains the remains of many fish. By carefully splitting the shale a collector may find hundreds of small, rhomboidal scales of the bony fish *Elonichthys*, as well as the spines and bones of this and other fish. It is possible at times to find patches of scales, indicating that the remainder of the fish may be present within the rock (Figure 3-3). Finally, the sandstone at the top of the cut contains a basal lag deposit of logs and other plant debris in association with abundant mud chips and slabs. These can be seen in many of the blocks laid out at the top of the terraced portion of the cut.

Fossils of the Ames Limestone

The Ames Limestone typically occurs in several easily identifiable layers, including a 0.5-3 in (1.25-7.5 cm) basal layer of hard calcareous shale, 18-36 in (45-90 cm) of very hard, very fossiliferous, argillaceous limestone, an upper layer about 10 in (25 cm) thick of brittle calcareous shale and all of these layers contain fossils (Figure 3-3).

The basal layer, which Brezinski (1983) called the calcareous shale lithofacies and Saltsman (1986) referred to as *Neochonetes*-mollusc shale lithofacies, commonly contains a hash of phosphatized shell debris and organic-matter stains. This is the molluscan layer of the Ames representing the initial transgressive phase of the Ames seaway into Pennsylvania. It is dominated by snails and clams, with some nautiloids (probably floated in after death), brachiopods, particularly *Neochonetes granulifer*, and other faunal elements. Most molluscs have shell structures of aragonite, the metastable form of calcium carbonate; after death and burial the aragonite tends to dissolve or recrystallize

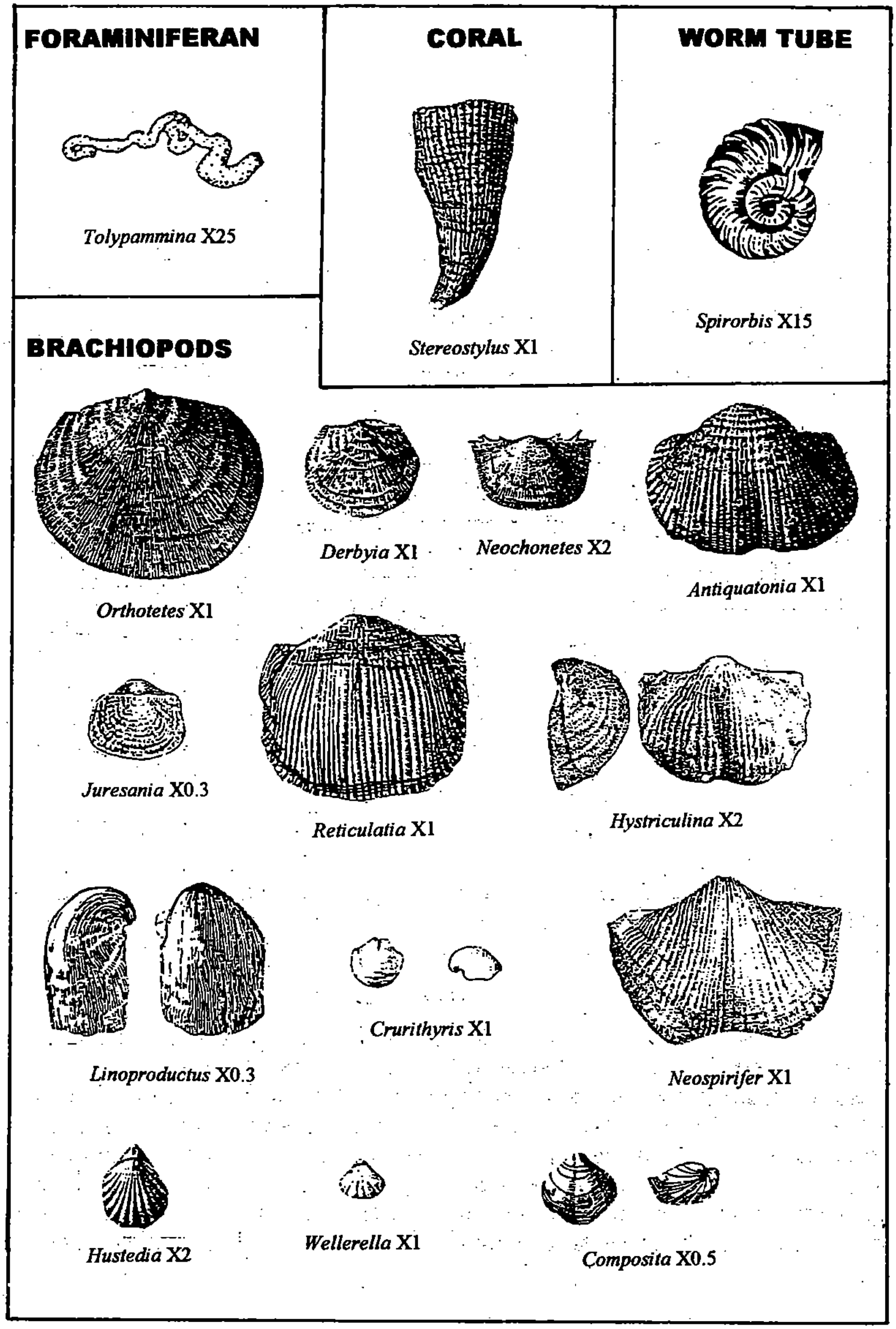


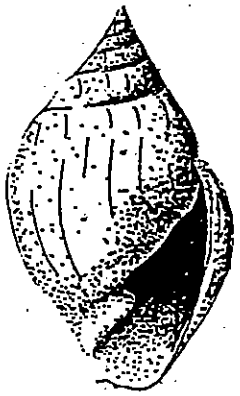
Figure 3-3 Common fossils that can be found in the Ames Limestone and Duquesne shale.

GASTROPODS


Retispira X1.5


Pharkidonotus X1


Raphistomella (*Ananias*) X3


Strobeus X2

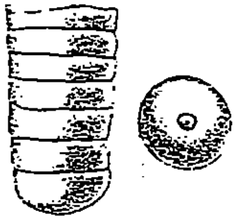
BIVALVES


Nuculopsis X2

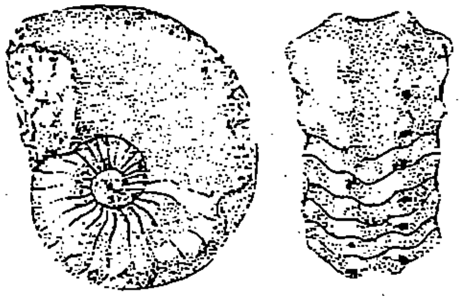

Astartella X1


Septimyalina X0.5

CEPHALOPODS

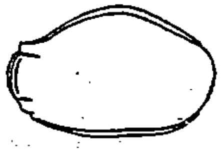

Mooreoceras X2


Pseudorthoceras X1

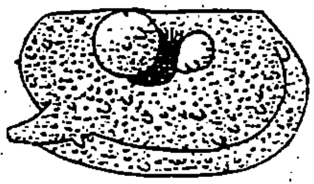

Tainoceras X0.5

OSTRACODES


Amphissites X35


Bairdia X27

Polytilites X60



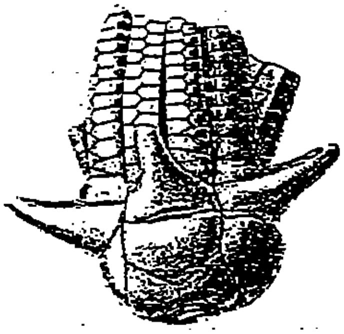
CONCHOSTRACANS


Palaeolimnadopsis X1.5

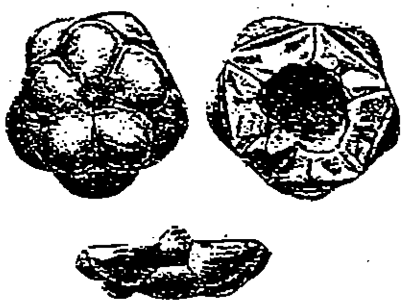

Euestheria X5

CRINOIDS

Crinoid columnals

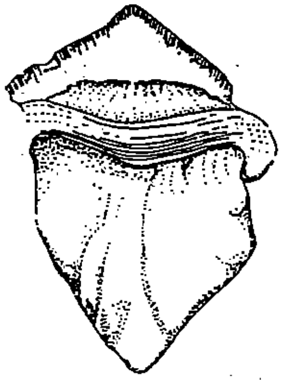


Delocrinus X1



Endelocrinus X2

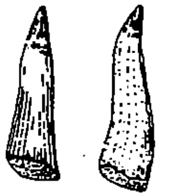
FISH



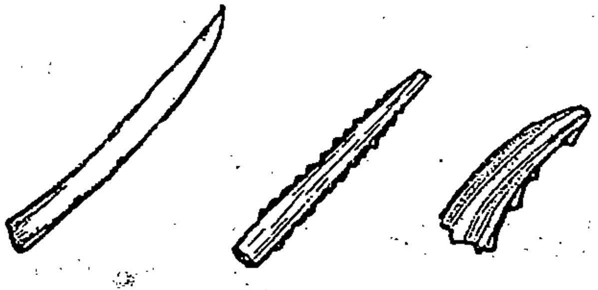
Petalodus X2

Cladodus X1.3

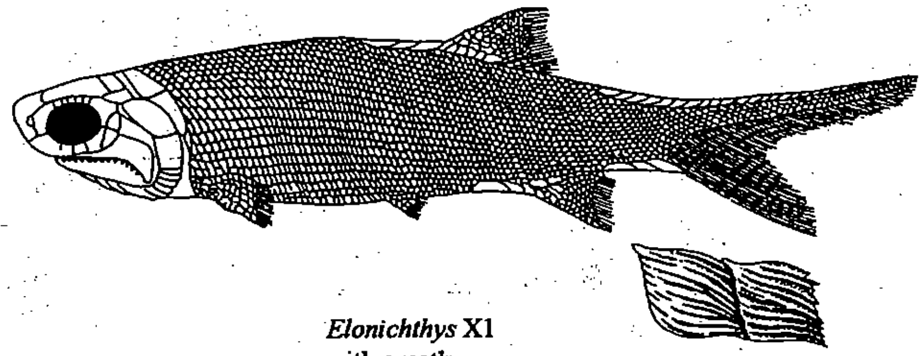
Diplodus X14



Paleoniscus X7

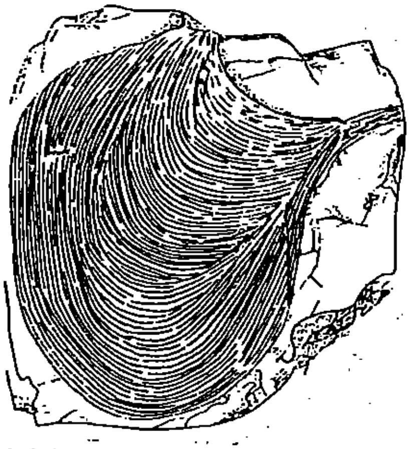


Miscellaneous fish spines X5



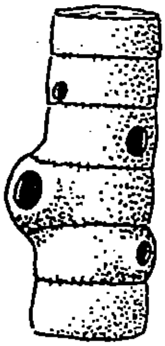
Elonichthys X1
with greatly
enlarged scales

TRACE FOSSILS



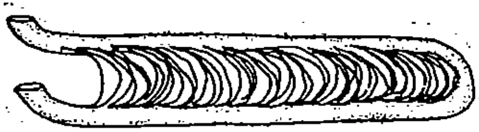
Zoophycos X0.5

Conostichus X0.3

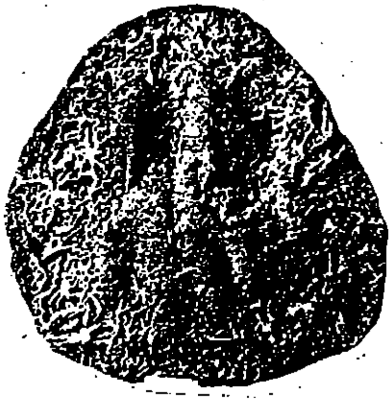


Tremichnus X1

Clionolithes X6



Rhizocorallium X0.6



Clionolithes X0.5

Zapfella X1

Zapfella X4.5

Conchotrema X2

into calcite. In this lower molluscan layer, however, many of the molluscan shells have been either preserved as aragonitic shells (probably due to the organic matter in the sediment) or replaced by phosphatic minerals that preserve them in exquisite detail. The enterprising collector might even be able to spot a fossil or two with preserved color banding highlighting the shells. Look for pieces of limestone that appear to be coated with tar or asphalt. The whitish blotches in this dark tar-like organic material are fragments of shell material.

The middle layer of limestone, seemingly representing a single depositional event, constitutes the Ames Limestone proper or what is regarded as the typical Ames. This "single" open-marine depositional event actually represents a sequence of deposits that have more or less coalesced. Layer boundaries are extremely difficult to detect, but can be seen in terms of accumulations of black phosphate pebbles and the horn coral *Stereostylus*. Saltsman (1986) recognized a variety of lithofacies in this layer, representing separate depositional environments.

The upper shale section of the Ames, which is highly weathered and not well exposed at this locality, typically contains abundant brachiopods (especially *Crurithyris* and *Composita*). *Crurithyris* commonly occurs in such abundance that it makes the rock look like a conglomerate. For this reason Saltsman (1986) called it the *Crurithyris* shale lithofacies. The rock itself consists of easily broken, buff-colored, slightly calcareous shales and other mudrocks, often containing a profusion of calcareous nodules, that represent the regressive phase of the Ames incursion. Fossil content decreases upward rapidly within this layer.

In most places where the Ames crops out, the collecting is almost unparalleled in western Pennsylvania. The easiest collecting occurs in the calcareous shales above and below the main limestone bed. These shales generally weather readily and the calcite shells, which are more resistant than the clay-rich matrix, readily erode out of the outcrop. In the limestone the rock and shells are equally resistant; therefore, the shells commonly break during attempts to remove them. Invertebrate shell fragments are commonly easy to find. More diligent searching is required to locate whole or almost complete specimens.

The most abundant marine invertebrate fossils in the limestones are species of the horn coral, *Stereostylus*, numerous kinds of brachiopods (especially *Crurithyris*), and the plates and columnals of crinoids. Many fossil forms, particularly molluscs, are more common, and easier to collect, in the lower unit. The Ames Limestone also contains many ichnofossils (trace fossils). *Conostichus*, interpreted as the resting trace of a jellyfish or sea anemone, occurs all through the Ames and can be collected near the upper surface. *Tremichnus* fossils, swollen pits in the surface of crinoid stems and plates, can be found almost anywhere crinoid debris is common. *Clionolithes*, *Conchotrema*, and *Zapfella* are tiny borings made by sponges, worms, or barnacles in fossil sea shells.

Road Log continues from stop 1

0.15	6.70	Exit STOP 1. Return to I-279 and turn right onto southbound lane.
0.75	7.45	Bear right onto exit ramp at Exit 21 to Camp Horne Road.
0.40	7.85	Turn right onto Camp Horne Road.
0.30	8.15	Buffalo sandstone exposed in roadcut on right and in numerous roadcuts from here down to the intersection with Route 65 in Emsworth.
0.60	8.75	Turn left into Avonworth Community Park.
0.10	8.85	Park in lot and disembark.
0.10	8.95	Return to Camp Horne Road and turn right.
0.60	9.55	Turn right onto entrance ramp to I-279.
0.60	10.15	Merge with traffic on I-279.
1.60	11.75	Exit 20 to Bellevue. Stay on I-279. From this point south to Pittsburgh most of the highway roadcuts exhibit the terraced aspect seen at Stop 1. The bedrock ranges from lower Casselman Formation to upper Glenshaw Formation (i.e., Birmingham shales and siltstones at the Bellevue exit down to the Upper Saltsburg sandstone at Suffolk Street across the highway from St. Boniface Church) and the entire section is prone to instability.
5.40	17.15	Bear right on exit ramp at Exit 15 to Route 28.
0.50	17.65	Turn left onto East Ohio Street.
0.35	18.00	Merge with traffic on northbound lanes of Route 28 at the H. J. Heinz plant.

0.40	18.40	Troy Hill, on the left, is flat-topped and lower in elevation than the surrounding hills. Troy Hill represents a remnant of the preglacial Allegheny River valley. During the Pleistocene, the Allegheny, Ohio, Monongahela, and Youghiogheny rivers cut down through the surrounding bedrock, forming the present landscape of Pittsburgh, and leaving the older valley floors high and dry. Similar features, called the Parker Strath (strath is an old Scottish word meaning a wide, flat valley), can be seen at Natrona Heights, the University of Pittsburgh Applied Research Center in Harmarville, the main campus of the Community College of Allegheny County on the North Side, in Bellevue, McKeesport, Homestead, Oakland, and many other places.
1.25	19.65	This stretch of Route 28 has had numerous problems over the decades with landsliding. Notice the number of houseless foundations on the left side of the road.
0.35	20.00	Exit 3 to Millvale. Continue north on Route 28.
0.20	20.20	Pittsburgh and Schenley red beds and intervening strata, including the Ames Limestone, are exposed in the hillside on the left side of the highway for 0.8 mi. Colluvial soils, derived from the red claystones, have a long history of earthflow-type landsliding in southwestern Pennsylvania, causing a great deal of damage and expense annually. This exposure seemed to be more trouble than usual over the years, and in the late 1980s and early 1990s the highway department had to remove a sizable amount of soil and deeply weathered bedrock while attempting to widen the highway.
0.90	21.10	Shaler Waterworks on the left supplies ground water to the North Hills areas from alluvial sand and gravel of the present Allegheny River valley.
0.90	22.00	Bear left onto the exit ramp at Exit 5 and merge with traffic on Route 8. The cliffs on the right expose rocks of the upper Glenshaw Formation to upper Casselman Formation, from the Upper Saltsburg sandstone near

		road level to the Connellsville sandstone at the top. Can you tell where the Ames Limestone is in this section?
0.50	22.50	The roadcut on the right exposes a beautiful little cut-and-fill channel sandstone in the Lower Saltsburg sandstone (middle Glenshaw Formation).
0.40	22.90	Exposure of the Pine Creek limestone on the right, adjacent to the intersection of Route 8 and Catherine Street in Etna. The Pine Creek lies at an elevation of 760 feet above sea level here but rises in elevation as you travel north toward the axis of the Kellersburg anticline at Allison Park. The underlying shales and siltstones grade northward into sandstone (Buffalo) along the length of this outcrop. One historical note: I. C. White, who did the original field work and mapping of this portion of Allegheny County during the Second Geological Survey of Pennsylvania (White, 1878), called the limestone bed at this spot the Brush Creek. What is especially fascinating about this is that White was the author who first described and named the Pine Creek limestone.
0.50	23.40	Flood control project in Pine Creek on the left opposite the intersection of Route 8 and Saxonburg Boulevard. The state Bureau of Flood Protection removed a thick spur of Buffalo sandstone that was responsible for a large meander loop in Pine Creek (it crosses beneath Route 8 near the Burger King restaurant, curls around Shaler Plaza and crosses beneath Route 8 about 100 yards south of the intersection). The spur and loop blocked water flow during times of high runoff, creating floods in this part Shaler Township. The sides of the flood control channel south of the excavation are lined with grouted rip-rap for erosion control.
1.60	25.00	Turn right onto Fall Run Road at the traffic light and cross the bridge over Pine Creek.
0.05	25.05	Turn left into Fall Run Park and drive past the houses on the left into the park.

0.20	25.25	Drive to the end of the access road to the circle and disembark from the bus, Stop 2.

STOP 2
FALL RUN PARK, SHALER TOWNSHIP

As you get off the bus, observe the sylvan beauty of the park. It is rare that land speculators and politicians would save something as wonderful as this from overdevelopment. The park has not been spared completely, unfortunately, as the township saw fit to run a sewer line down the middle of the valley and to let developers build on the hilltops above the park. However, much remains of the natural beauty, including the waterfalls that give the main stream, and thus the park, its name. And as you walk through the park, keep a lookout for rock outcrops, alluvial deposits, rock falls, fossils, and environmental problems. There are a variety of interesting things, geologically speaking, to see.

Geomorphology

Fall Run Park is situated on 92 acres of rugged land in Shaler Township just north of Wittmer (Figure 3-4). It is a long, narrow park that preserves the natural beauty of western Pennsylvania in one of the more rapidly growing suburban areas of Pittsburgh. The park occupies a relatively steep-sided gorge with relief in excess of 200 ft (61 m) at the southern end; the average relief is approximately 130 ft (40 m). In places the slopes exceed 50 percent.

The valley of Fall Run is approximately 1 mi (1.6 km) long and 1,200-1,500 ft (366-457 m) wide. It contains four perennial tributaries of Fall Run, as well as several intermittent ones. The hallmark of this wonderful valley, a waterfall on Fall Run that exceeds 20 ft (6 m) in height (site E on Figure 3-4), occurs just north of the midpoint of the park and separates it into two distinct parts. The upper valley (above the falls) is broad and U-shaped with a grass-carpeted valley floor averaging 150 ft (46 m) wide, and forested valley walls sloping at approximately 20°. The lower valley, in contrast, is canyon-like with a narrow valley floor, about 25 ft (7.6 m) wide, and steeply sloping, rugged, often barren walls. The stream gradient is 182 ft/mi (34.5 m/km)

Stratigraphy

The bedrock underlying Fall Run Park ranges through most of the Glenshaw Formation of the Conemaugh Group, from the shales and fissile siltstones in the middle to upper Mahoning unit near the confluence with Pine Creek to the Pittsburgh red beds near the higher elevations. The Ames Limestone occurs near the hilltops above the park boundaries. As you walk through the park, spend some time examining the relatively

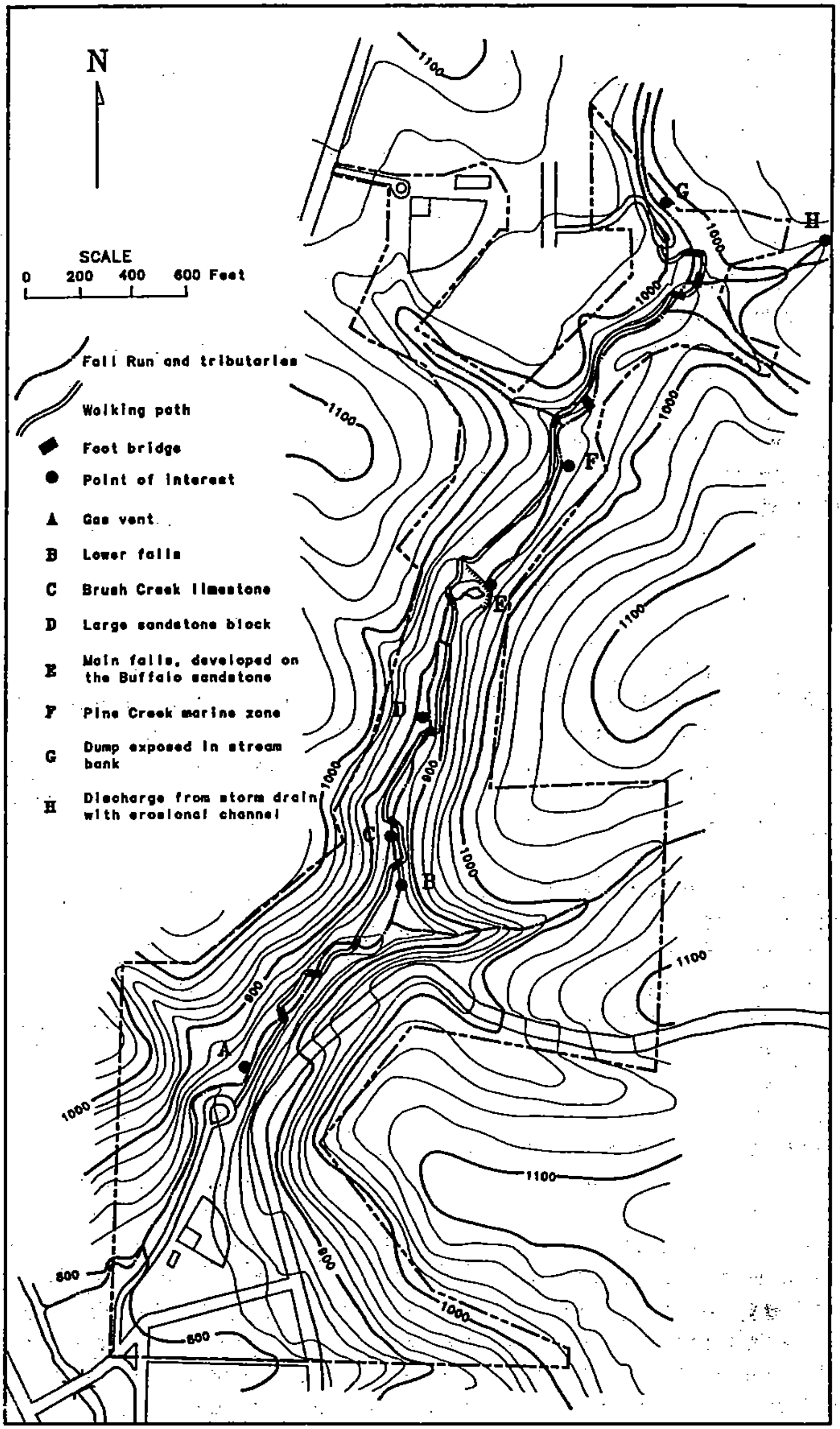


Figure 3-4 Topographic map of Fall Run Park (mod. from R. Mueller Assoc., 1969).

rare outcrops. The creek bed itself provides many of the better exposures. The stream flows over alternating stretches of alluvium and smooth sections of bedrock, typically either shale or limestone. The bedrock slopes gently to the east-northeast. As such, many of the individual beds form questa-like obstructions in the stream, creating many cataracts.

The main waterfall (site E on Figure 3-4), as well as others seen high on the canyon walls within the tributary channels, developed on the Buffalo sandstone. The Buffalo forms a resistant layer in many places in Allegheny County, notably along Route 65 between Emsworth and Glenfield, and at Underhill where Saxonburg Boulevard intersects Route 8.

A small waterfall, more accurately described as a cataract (site B), is situated farther downstream from the main falls. The waterfall has a drop of about 5 ft (1.5 m). It occurs stratigraphically below the Brush Creek limestone (site C) and is developed on what is probably a fissile siltstone of the Mahoning unit.

Gas Vent

Near the lower end of the park, a natural gas seep in the bed of Fall Run bubbles away (site A). We have no conclusive idea as to the origin of the gas, but there are several possibilities: 1) the gas could be leaking from a nearby pipeline; 2) it could be "swamp gas" leaking from the sewer system that runs through the park; 3) it is leaking from abandoned coal mines that used to dot the area (apparently farm banks in the Upper Freeport or Mahoning coal); 4) it is leaking from what used to be Peoples Natural Gas' Mt. Royal gas storage field. Peoples operated the storage field between 1949 and 1980, storing gas in the Thirty Foot sand (Upper Devonian, Venango Group) about 1,650 ft (503 m) below ground level; or 5) it is leaking from one or more abandoned wells. Maps of the area on file at the Pennsylvania Geological Survey show a small collection of historical oil wells just east of Fall Run. No wells are shown in the specific area of the gas bubbles, but that might be simply a lack of good historical information.

Fossils

Two fossiliferous units crop out in Fall Run Park, the Brush Creek limestone and the Pine Creek marine zone. The Brush Creek is a dark-colored argillaceous limestone less than one foot thick that forms the bed of Fall Run at site C. The Pine Creek marine zone occurs above the main waterfall at site F. Like the Ames Limestone at the I-279 locality, the Pine Creek here consists of three layers, a lower fossiliferous, black, calcareous shale, the brown to tan-colored limestone, which is not greatly fossiliferous, and a layer of black shale above that contains ironstone concretions. Shell material, mostly crinoidal hash and brachiopods, is common in some of the float material, but it is difficult to tell which unit created the most debris. The trace fossil *Zoophycos,* the feeding trace of a worm which swept the sea floor in a semicircular pattern, can be seen on the underside of float blocks within the stream channel south of the outcrop. The dark-colored feeding-trace pattern is easily distinguished against the buff-colored weathering of the rock. Other trace fossils noted were *Conostichus,* the anemone resting trace found in the Ames Limestone at Stop 1, and *Rhizocorallium,* a burrow made by some kind of worm that created a U-shaped tube in the mud.

Environmental Aspects

One of the more noticeable aspects of Fall Run Park is the impact of urbanization on the valley itself. The valley wall is ringed with houses from several stages of development, beginning in 1968 before stormwater management was required. This consequently has promoted accelerated headward and lateral erosion of some of the tributaries by funneling stormwater runoff from these developed areas into drainpipes that empty into Fall Run at the tops of the tributaries. Some stormwater also went to the sewer running through the park, causing occasional overflows. Perhaps the worst problem occurred when stormwater runoff was allowed to erode two new "tributaries" to Fall Run at the northern end of the park (site H in Figure 3-4).

Headward erosion represents the grand opus of overdevelopment around Fall Run Park. The two new tributaries at site H occur as a result of letting stormwater drain directly into unprotected colluvium, rather than into existing tributary channels. Runoff has carved V-shaped gullies that measure 8 ft (2.4 m) wide, 5-9 ft (1.5-2.7 m) deep, and 50-200 ft (15-60 m) long. The walls of these gullies are steep and devoid of vegetation, making them ugly scars rather than a picturesque stream valleys. Originally, both drains emptied into concrete enclosures supported by concrete slabs. Because of headward erosion, however, the enclosure around the easternmost drain has since been undermined and fallen into the eroded channel. The second, more northern tributary exposes bedrock at its upper end, creating a sloped waterfall on the valley floor that drops approximately 5 ft (1.5 m). The drain at the head of this gully also is being undermined. Sometimes the discharge has been so powerful that it directly erodes the gully wall 6 ft (1.8 m) beyond the opening of the drainpipe.

Developers building in the area after 1974 have been required by law to install sedimentation ponds. These are designed to protect streams by: 1) trapping sediment behind a dam, rather than letting it be washed away; and 2) collecting excess runoff and allowing it to drain out of the pond to an established tributary at a rate less than or equal to the natural discharge rate for the area. The contrast between the older "piped" tributaries and the more recent "ponded" ones is remarkable. "Unponded" tributaries typically exhibit rough, craggy gullies where the bedrock is exposed, vegetation is sparse, and trees on the slopes above the gullies have been undermined. Unaffected tributaries generally look more natural, with vegetation and forest litter covering the ground. It is unfortunate that the erosion and sedimentation laws aren't retroactive –

Fall Run Park could use some relief from an abundance of precipitation on too much concrete and asphalt.

Road Log Continues from Stop 2

0.20	25.45	Return to Route 8 and turn right.
0.30	25.75	Roadcuts expose the Mahoning sandstone (lower Glenshaw Formation) on both sides of Route 8.
0.40	26.15	Upper Freeport sandstone and shale (upper Allegheny Group) are exposed in the roadcut on the right. The Upper Freeport coal, which is about halfway up the hillside, is only a few inches thick here. The sandstones and shales represent stream channel and floodplain deposits.
0.25	26.40	The hillside on the north side of the warehouse on the left contains a small exposure of the Upper Freeport coal and adjacent shale. The Upper Freeport is 3 ft (0.9 m) thick here, and the rocks represented by the Upper Freeport sandstone and shale at the last outcrop have been replaced by limestones and shales representative of a lake environment.
1.30	27.70	Dirt access road to the left leads to the Allison Park railroad station. The railroad cut here also exposes the Upper Freeport coal and adjacent rock, and the coal has returned to its thickness of only a few inches. The coal is just above road level because the axis of the Kellersburg anticline passes close to Allison Park. The type locality of the Pine Creek limestone is on the hillside up the Pine Creek valley to the left beyond Allison Park.
0.40	28.10	The Upper Freeport sandstone is exposed in the roadcut on the right. Over the next mile, the road rises through the upper Allegheny and lower Conemaugh groups. Route 8 in northern Allegheny County is so heavily developed that few exposures exist north of Talley Cavey.

0.45	28.55	Upper Freeport limestone is exposed in the excavation and roadcut on the left at the junction with Harts Run Road.
2.00	30.55	Turn right onto Wildwood Road.
0.10	30.65	Turn right onto School Road.
0.20	30.85	Turn left onto Topnick Drive.
0.60	31.45	Turn left into Hampton Township Community Park and park on the gravel on the right side of the road and disembark.

LUNCH STOP

0.90	32.35	Return to Route 8 and turn right.
5.65	38.00	Turn right onto the exit ramp to Bakerstown.
0.30	38.30	Turn left onto Bakerstown Road (the Red Belt).
2.05	40.35	Turn left onto Station Hill Road.
0.30	40.65	The bus will pull over to the right and let passengers disembark, Stop 3.

STOP 3
RAILROAD CUT AT BAKERSTOWN STATION

We will get off the bus on the west (railroad tracks) side of the road. Walk down the abandoned loading ramp to the railroad tracks and proceed north along the tracks to the railroad cut below Bakerstown Road.

Around 1915 (Ross, 1933), the Baltimore and Ohio Railroad excavated a deep cut through the drainage divide that separates runoff to the south, through the Pine Creek drainage system, from runoff to the north, through the Connoquennessing Creek drainage system. This cut, just north of Bakerstown Station, replaced a tunnel whose collapsed opening still can be seen adjacent to (directly west of) the cut. The cut exposes what appears to be the most structurally complex area in the exposed surface rocks of the Pittsburgh Low Plateau section of the Appalachian Plateau province. Here we will observe numerous examples of listric-normal faults, tilted blocks, an angular unconformity, and a text-book example of a conjugate joint (fault) set.

Stratigraphy and Paleoenvironmental Interpretation

Ross (1933) examined the Bakerstown Station cut while it was still fairly fresh and was able to establish the stratigraphy before much of the cut was covered by colluvium. He noted that the strata exposed included the middle of the Conemaugh Group, basically from the Pittsburgh red beds at the bottom to the Morgantown sandstone at the top. The red beds and the Ames Limestone have not been exposed for many years at this locality – Wagner et al., (1970, p. 64; Figure 3-5) made no mention of either of these lithologies in their discussion and diagram of the cut.

Currently exposed strata include small portions of the claystones above the Ames (typically called Schenley when they are red colored) (#3 in Figure 3-5); the Duquesne coal, which is about one ft (0.3 m) thick here (#4); several distinct subunits of the Birmingham shale (#5-#8); and the Morgantown sandstone (#9). The basal part of the Morgantown has numerous, relatively thick lenses of coal that could represent the remnants of the Wellersburg or some very thick floating plant mats. The Morgantown, which commonly is a very resistant sandstone, caps the hill. It might be entirely responsible for the existence of the drainage divide mentioned above, but without further study (and a lot of core drilling) we might never be certain.

Structure

The most prominent structural features at this locality are the tilted blocks offset by normal faults seen on both sides of the cut. Other features that we will examine are joints and faults and their relationship to soft sediment deformation within the lower Morgantown sandstone.

Tilt Blocks and Normal Faults

Figure 3-5 is a redrawing of the spectacular west wall of the railroad cut made by Wagner et al., (1970), based in part on Ross' (1933) unpublished MS thesis. The cut runs north-south and is separated into a southern and northern section on the west side by a 200-ft (61-m) long retaining wall, which is conveniently abbreviated in the diagram. The east side of the cut is more completely exposed because retaining structures are of more modest scope. Trying to match faults from east to west across the tracks should provide lots of fun.

The rock sequence is interrupted by a series of listric-normal faults, most of which apparently dip to the north (to the right in Figure 3-5). The two on the south (or left) dip

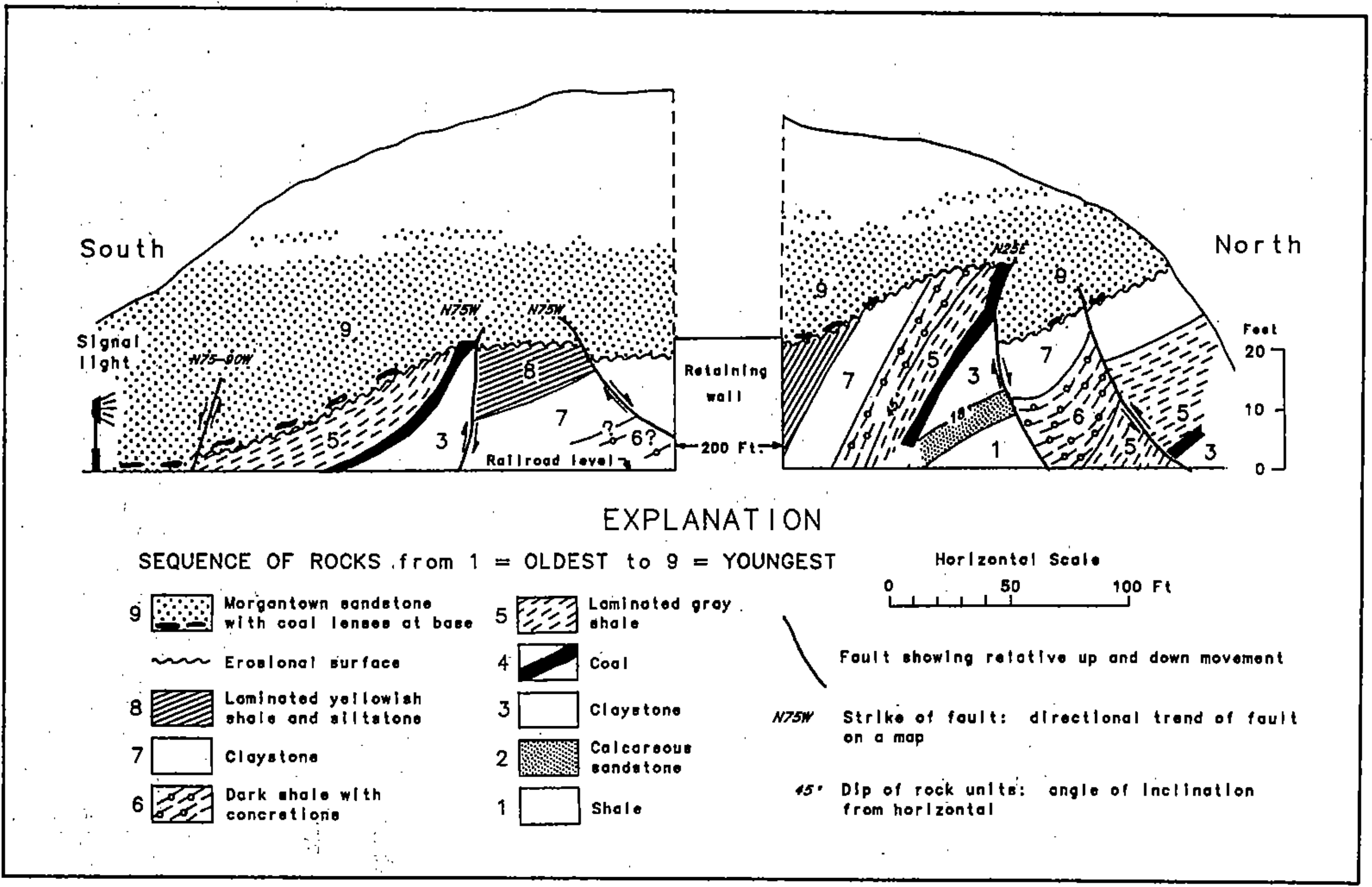


Figure 3-5 Illustration of the west wall of the railroad cut at Bakerstown Station (modified from Wagner et al., 1970, p. 65, fig. 38). Note the vertical exaggeration (2.6X) distorts the dip of strata and faults.

to the south. Between the faults the rock units are tilted so that the beds dip up to 45° S. By matching faults on opposite sides of the tracks Wagner et al., (1970) indicated that the northern faults strike approximately N25E whereas the southern ones have strikes ranging from N75W to N90W.

An angular unconformity at the base of the Morgantown sandstone can be recognized in the field by the occurrence of coal lenses just above the contact and by the truncation of different rock units below the erosional surface. Most of the faults enter and then disappear within the lower few feet of the Morgantown. The main (or first) faulting event took place before Morgantown deposition. Birmingham strata were offset approximately 30 ft (9 m) along the larger of the two northern faults shown in Figure 3-5). After faulting, the rotational blocks were partly eroded and then buried by sandy sediments of the Morgantown River system, forming an angular unconformity. Early in Morgantown time, the faults were reactivated, resulting in a few feet of displacement of the unconformity and lower Morgantown sand. Subsequently, the entire fault complex was buried by the main mass of Morgantown sand.

Richardson (1932) was the first to mention the tilting and faulting at Bakerstown Station, but he offered no explanation of its cause. Ross (1933) speculated that these occurred as a result of ancient landslides, possibly caused by stream erosion. Wagner et al., (1970) proposed an ancient stream lying to the north of the exposure, although the different strikes of the faults suggest a meandering channel lying to the north of the cut. The stream scoured out a channel with steep and unstable banks. Large blocks broke loose from the banks and slid into the channel. Figure 3-6 is a cartoon illustrating a possible sequence of events for the Bakerstown Station railroad cut. Features such as this are not seen very often, according to Laury (1971). Surprisingly, although the geologic record of large-scale stream-bank failures is meager, the Pennsylvanian section in the Appalachian Plateau appears to be relatively well represented.

During late "Birmingham" time, a large stream (the Birmingham River) to the north or northwest had carved a deep channel through the Ames Limestone (Figure 3-6A). The cut bank to the south removed the buttress supporting the sequence of semi-consolidated strata. A series of Toreva (slump) blocks developed suddenly along listric-normal faults (Figure 3-6B), perhaps in response to seismic activity resulting from the Alleghenian orogeny, which was already underway 250 to 300 mi (400 to 500 km) to the east (present cardinal direction). In this sense, it might resemble the Turnagain slide in Anchorage, Alaska that was triggered by the Good Friday earthquake in 1964 (Grantz et al., 1964: Figure 17). Failure might have begun as a block glide above a decollement within the unstable claystones of the Pittsburgh red beds (which even today are responsible for most of the landslide damage in western Pennsylvania), producing a breakaway scarp to the south. This was followed immediately by the development of an antithetic normal fault, dropping a wedge-shaped fault block forming a graben. Erosion of the high ridges on each slump block occurred during latest

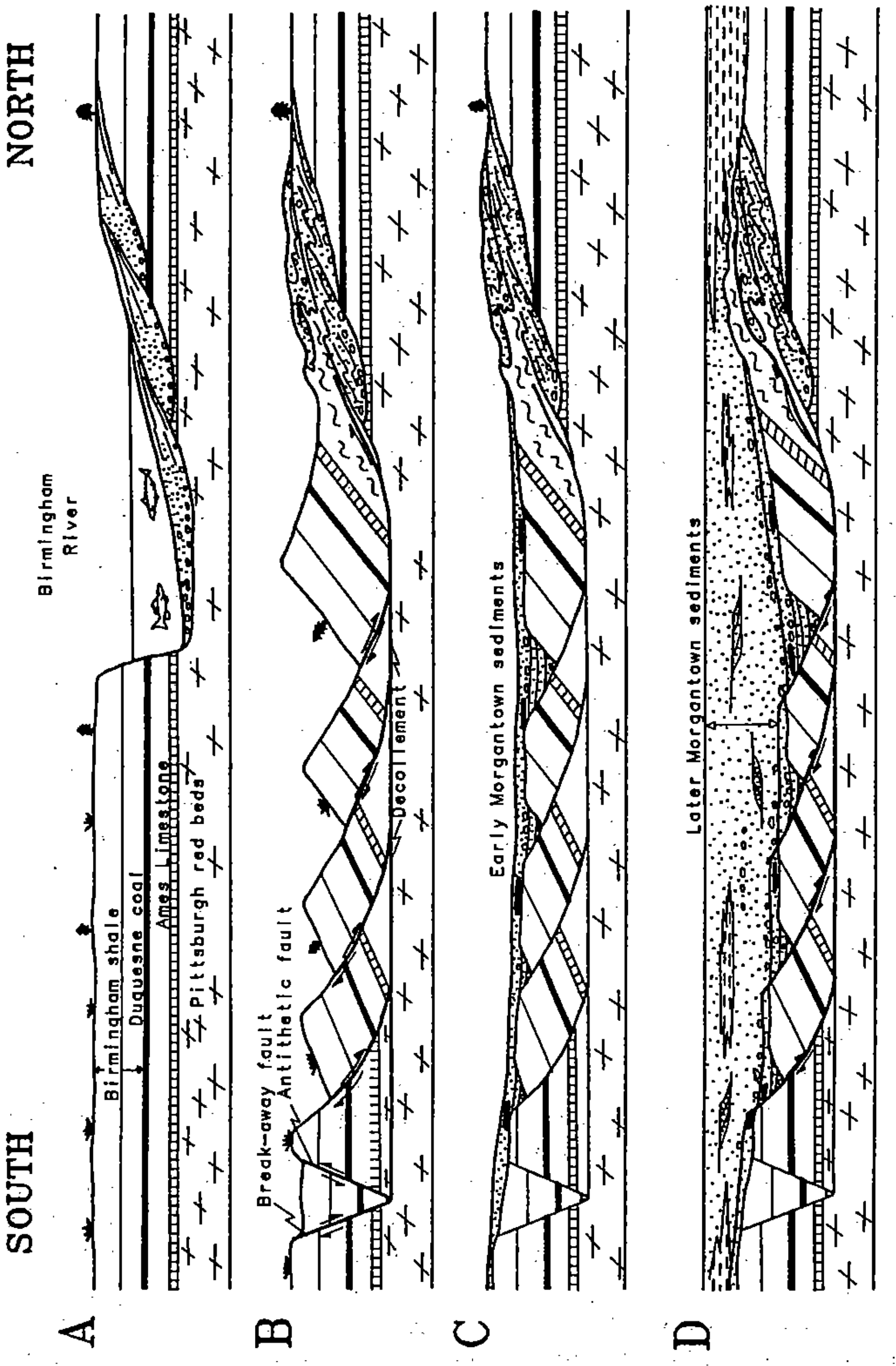


Figure 3-6 Diagrammatic sections of a hypothetical sequence of events in the development of tilted blocks at Bakerstown Station. A) The Birmingham River meandering north of the locality carves a cut-bank into semi-consolidated sediments. B) A disaster, possibly an earthquake, triggers a massive landslide as blocks of the semi-consolidated land surface slide on a decollement in the unstable clays at the base of the section. C) Later, as the Morgantown River system begins crossing the area, the blocks are eroded and filled with sand, logs, rip-up material, and plant mats or segments of semi-lithified peat (possibly Duquesne or Wellersburg). D) Continued loading causes slippage, this time involving the semi-consolidated sandstones.

"Birmingham" time and/or "Wellersburg" time (Figure 3-6C). The dearth of any evidence for the typical dark-colored Wellersburg lithologies could be due to a complete lack of deposition. However, if the coal lenses within the basal Morgantown are the remains of the Wellersburg seam, the erosion must have occurred just prior to initial deposition of sand and silt in early "Morgantown" time. Alternatively, the sandstone with basal coal lenses referred to here as Morgantown might actually be a Wellersburg sandstone. At some time during this sequence of events, the local area underwent a raising of base level, due either to sea level rise or regional subsidence. Whatever the cause, the formerly elevated land surface began to be covered by streams, eroding the slump blocks and leading to deposition of coarse sediment in early "Morgantown" ("Wellersburg"?) time. Differential loading of the slump blocks in the depressions between the original land surface and slip planes (slump scarps) destabilized the Toreva blocks. The inherited instability of the slump material as a foundation for the Morgantown sand deposition led to reactivation of block movement along the faults. Slip planes propagated upward through the early "Morgantown" sediments (Figure 3-6D). The entire complex was subsequently buried by channel deposits later in "Morgantown" time.

Joints and Soft-Sediment Deformation

At the south end of the railroad cut, on the east wall where the excavation is about 25 ft (7.5 m) deep, the Morgantown sandstone exhibits numerous examples of soft-sediment deformation, typically within the basal coal lenses, related to faulting caused by sediment loading. At the time of deformation, the Morgantown was probably semi-consolidated sediment showing a variety of mechanical properties. Figure 3-7 illustrates one portion of the rock in this area, showing the complexities of the local structure on a finer scale.

The Morgantown sandstone exhibits a textbook-quality conjugate-joint set intersecting at about 60°, which produces rhomboid joint blocks. The 60° angle is bisected by the maximum principal stress, the force of gravity, called σ_1 (Figure 3-7A). The joints are parallel to the circular sections of a triaxial stress ellipsoid. At the time the original deformation took place, it is likely that σ_1 was the result of sediment loading within the Morgantown River channel. The individual strata involved are described in Table 2. The coal was probably a peat or very low-rank coal at the time of deformation whereas the other units were all semi-consolidated sand deposits. Under compressive stress near the intersection of what is now the conjugate joint set, unit 3 was mobilized and forced downward, injecting into unit 2. This allowed a block of unit 4 sand to move downward along conjugate normal faults, creating a small graben. Notice that no faulting occurred along the plane of these fractures in the unit 1 sand below the coal. Soft-sediment deformation occurred because of extension in the direction of σ_3 (the least principal stress). Figure 3-7B illustrates that similar structural relationships occur in a 6-8 in (15-20 cm) cross-bedded sandstone about 20 ft (6 m) to the right (south).

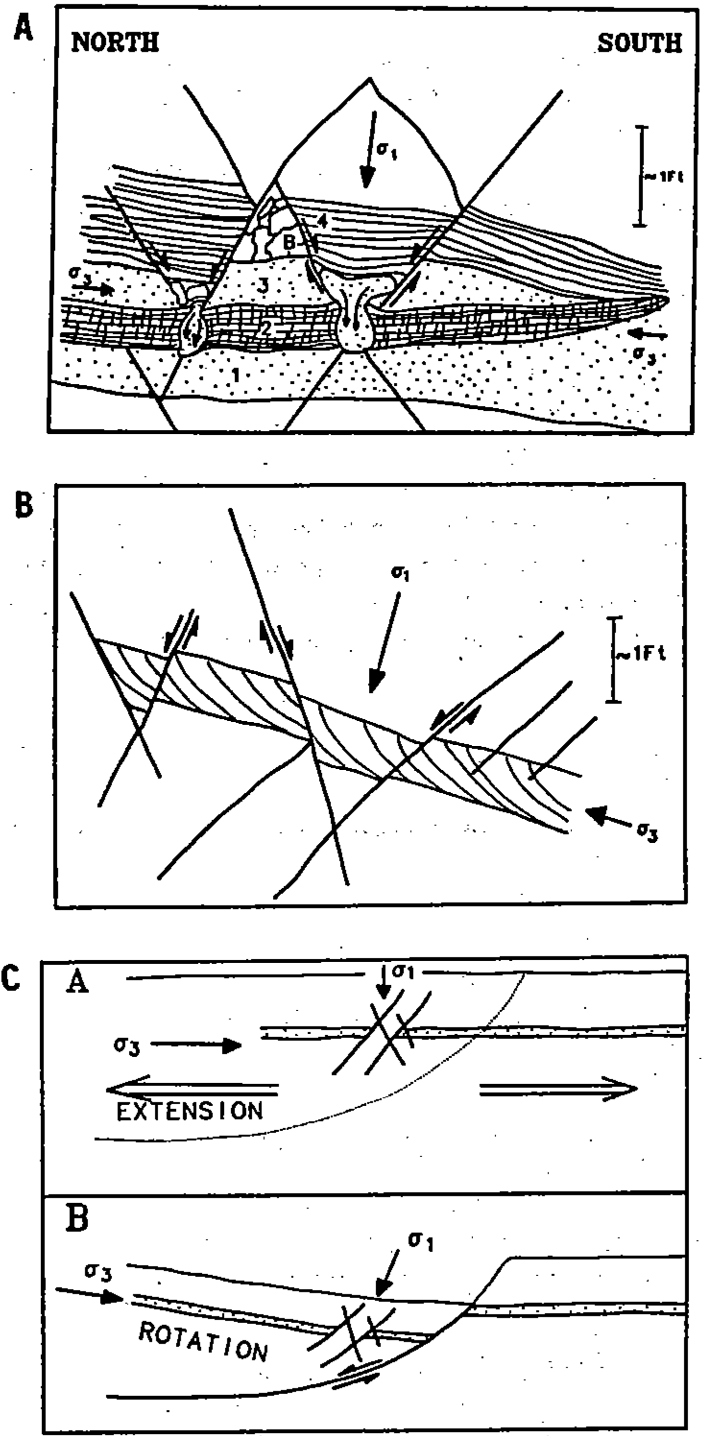


Figure 3-7 Sketches of portions of the southeast wall of the Bakerstown Station railroad cut showing a) joints/faults and related soft-sediment deformation that developed in the basal Morgantown sandstone prior to reactivation of slide failure (D in Figure 3-6) and b) the relationship of faults to a 6-8 in (15-20 cm) thick cross-bedded sandstone layer in the Morgantown sandstone and c) section of a portion of the Bakerstown Station paleo-landslide illustrating the change in orientation of the maximum principal stress (σ_1). Before sliding, σ_1 is oriented vertically (gravity and overburden pressure) and after sliding, rotation of the Toreva block on the listric-normal fault has reoriented σ_1 a few degrees clockwise from vertical. The dashed line represents the future slip surface.

Table 3-2. Description of lithologic units shown in Figure 3-7A and the approximate mechanical characteristics at the time of deformation.

UNIT	LITHOLOGY	MECHANICAL CHARACTER
4	Thin-bedded, rust-colored sandstone	Brittle
3	Massive sandstone, poorly consolidated	Fluid
2	Highly cleated coal	Ductile
1	Massive sandstone, fairly well consolidated	Brittle

You will notice that in Figures 3-7A and B that σ_1 is not vertical. Figure 3-7C (a and b) illustrates the possible sequence of events that would result in the current orientation of fractures and stresses. During early "Morgantown" time, after the lower sandstone and peat/coal had been deposited, the section underwent soft-sediment deformation as described above. Figure 3-7C(a) shows a future slip surface. Later, sediment loading destabilized the semi-consolidated strata, resulting in the formation of a Toreva block (Figure 3-7C(b)). Rotation along the listric-normal fault reoriented all fracture planes and stress directions a few degrees in a clockwise sense.

Road Log Continues from Stop 3

0.30	40.95	Return to Bakerstown Road and turn right toward Bakerstown.
0.10	41.05	Turn left onto State Road.
0.55	41.60	Turn left onto Middlesex Street.
0.10	41.80	Turn left into Witco Corporation's shipping and receiving driveway. Proceed to gate and into parking lot, Stop 4.

STOP 4
WITCO CORPORATION

This will be a relatively short stop on our itinerary. We will get off the bus in the large paved area close to the loading dock. Mr. Daniel J. Green, the Plant Manager, has kindly given us special permission to enter company property. At the request of the Witco Corporation, the taking of photographs is prohibited. ***Please leave your cameras on the bus!***

Geotechnical Aspects

Present here is a classic example of an earth flow caused by failure of the Pittsburgh red beds. The irony is that this stratigraphic unit set the stage for the catastrophic landslide failure we just observed in the railroad cut 1/4 mi (400 m) away, and here, 300 ma later, it is still causing trouble!

The warehouse was constructed in 1980 on a swampy area that was filled. The hillslope was excavated to provide a sufficiently large site and the design called for a single bench; the exposed hillslope was planted in crown vetch to retard erosion. Movement started one or two years after the completion of construction, and now, almost 15 years later, the slope continues to move, albeit at a very slow but inexorable pace.

The most obvious feature, a lobate mass about 200 ft (61 m) long and 3-4 ft (0.9-1.2 m) high, has moved 25-30 ft (8-9 m) out into and under the paved area. A glide plane probably exists at depth, but at present it is occluded ("blind thrust"). The toe is very wet and "juicy." Domes several feet high formed of bituminous concrete pavement appear at the toe. This shows that the movement originates below grade, i.e. this is not a surficial slide or flow. You can observe fine examples of hummocky topography coated with crown vetch behind the toe. With a modest amount of digging beneath the vegetation, you should be able to discover the soft red clay of the moving mass. A crown scarp is present at the head of the flow, giving it a slump-like character.

We invite you to examine the asphalt paving behind the building -- it looks like waves on water. The asphalt is beginning to creep up over the concrete foundation. This area once was wide enough to drive a vehicle through. Thus, while the hillslope behind the building is not involved in the earth-flow lobe, it is indeed gradually moving north toward the building. Red clay is readily obvious at the slope-pavement interface.

Look at the corner of the building at the loading dock. The massive pillar supporting a steel beam seems unaffected, but the horizontal reinforced concrete slab has failed brittley and is being raised. The asphalt pavement, on the other hand, is flowing and behaving in a ductile fashion. Nappe-like folds are evolving in the pavement.

Witco Corporation is very concerned about potential damage to their structure and are looking into remedial activity to prevent further movement. Any suggestions?

Road Log Continues from Stop 4

0.20	42.00	Return to Middlesex Street and turn right on State Road.

0.55	42.55	Turn right onto Bakerstown Road and follow the Red Belt to I-79.
1.30	43.85	The road follows the crest of topography that forms a local drainage divide in this area.
1.50	43.35	Pine-Richland High School on left.
1.60	44.95	Active oil field equipment consisting of a pumper and a stock tank can be seen in the yard on the left. We are crossing the northern terminus of the Keown oil field which produces from the Upper Devonian Venango Group.
3.25	48.20	Junction with US-19. Continue straight on the Red Belt.
0.80	49.00	Turn left onto the entrance ramp to I-79.
0.50	49.50	Merge with traffic on I-79. We will cross the axis of the Brush Creek anticline near the merging lanes. Upper Casselman Formation rocks, particularly the Connellsville sandstone, are exposed in numerous roadcuts between here and the Wexford Exit.
1.40	50.90	Bear right onto the exit ramp at Exit 22 (Wexford Exit).
0.20	51.10	Pull over to the right side of the road. Passengers will disembark here and climb to the top of the hill overlooking I-79, Stop 5.

STOP 5
ROADCUT ON I-79 AT INTERSECTION WITH ROUTE 910

We will spend some time looking at the outcrop across I-79. Those who want to have a look at the outcrop on this side of the highway can walk down the ramp, but must be careful of relatively high-speed traffic on the ramp. A small (approximately 6 ft tall) structure about 200 yd (183 m) north along the ramp can be seen in the outcrop on this side. Can you determine what it is?

Stratigraphy

The rock exposed in this roadcut is the Connellsville sandstone, the youngest recognized sandstone unit in the Conemaugh Group. The top of the Connellsville lies from 60 to 100 ft (18 to 30 m) below the base of the Pittsburgh coal and about 200 ft (approximately 60 m) above the top of the Ames Limestone. The rock typically consists of relatively thin lenses of fine- to medium-grained "dirty" sandstone (arkosic litharenite) interbedded with dark-colored shales. In the Pittsburgh area, the sandstone gets to be about 50 ft (15 m) thick as a unit. Up until the middle part of this century, the Connellsville sandstone was an important source of construction aggregate and flagstone, and in cases where the bedding thickens dramatically, dimension stone (Johnson, 1928). At this locality the sandstone is about 45 ft (14 m) thick.

Paleoenvironmental Interpretation

The roadcut on the east side of I-79 shows the progression of a meandering stream through time in profile. If we could get right up on the rock face to have a look at lithologies and sedimentary structures, we might observe a host of features related to channel deposition and lithification.

The outcrop appears to represent several stages of meandering in a medium-sized river (termed here the Connellsville River) that was shifting position on the floodplain from north to south (left to right as you view it). Meandering river systems have been studied extensively in the modern fluvial environment, in outcrops such as this, and in the subsurface via geophysical logs, cores, and drill cuttings. Excellent reviews of the exhaustive work on meandering streams can be found in LeBlanc (1972) and Walker and Cant (1984), and we urge all interested readers to check out these papers. For this guidebook, we present only the briefest of summaries that you can use to attempt to decipher the I-79 roadcut.

Meandering is a natural tendency of all aggrading streams due to a fundamental instability of flow in the channel (Figure 3-8). Once meandering begins, it is maintained by erosion of the outer bank with concomitant deposition on the inside of the meander loop, at the point bar. Over time, as the meander loop grows "tighter," the point bar accretes in the direction of erosion on the outer bank (Figure 3-8). Point-bar deposits typically consist of fining-upward sequences of terriginous clastic sediment, but the actual grain size of these sediments depends on the current velocity, which keeps sediment grains suspended in the water column. High energy streams can carry boulders – and when enough energy has been lost, even the finest material will settle out. The total thickness of the point-bar deposit depends on channel depth.

Eventually, all aggrading meandering streams change channels in one of two ways, by cutoff of a loop during normal stream development or by abandoning an entire channel segment due to a major diversion somewhere along the length of the stream. In either case, when a meander is abandoned it gradually fills with finer sediment during times of floods (clay plug). Two primary types of sand deposits occur as a result of meandering streams, the point-bar deposits and the abandoned channel deposits.

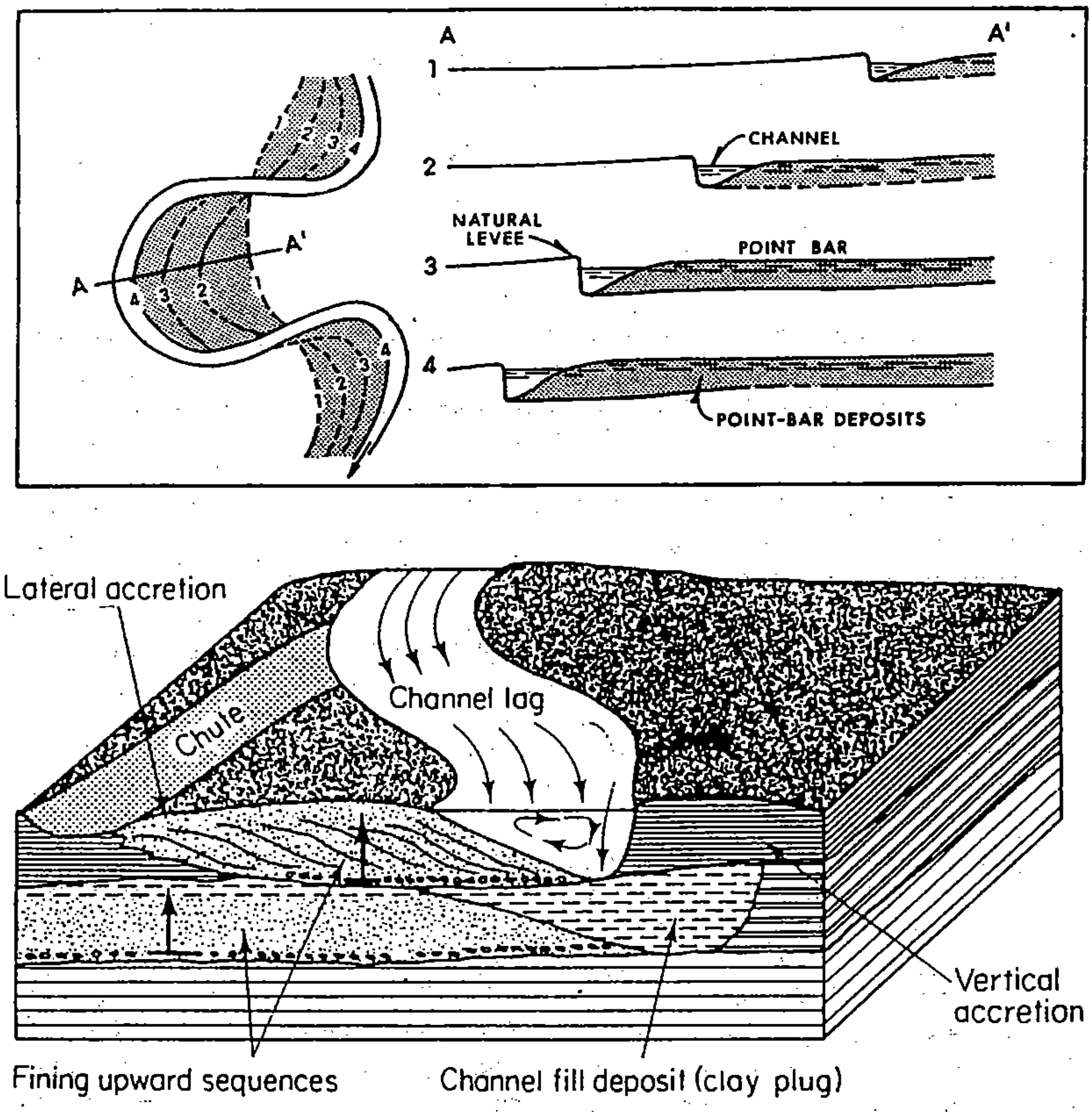


Figure 3-8 Aggradation of a point bar complex in a typical meandering stream. Top, lateral accretion of a point bar as the stream meander loop begins to tighten (from LeBlanc, 1972, p. 149, fig. 11). Bottom, block diagram of a meandering channel and its floodplain showing vertical accretion of fluvial deposits (from Blatt and others, 1980, p. 634, fig. 19-4).

Point bar sands generally occur in the lower portion of the bar and may constitute 75% or more of the sand deposited by a meandering stream (LeBlanc, 1972). Abandoned channels might have some sand, but the majority of the fill material probably consists of clay and silt. Outside of the stream channel, deposition occurs on the floodplain during floods. Unlike the stream itself, which builds through lateral accretion, the floodplain builds through vertical accretion.

Using this information see if you can see the various components of the meandering Connellsville River in the I-79 roadcut. Based on some preliminary work done by N. K. Flint and J. D. Stoner in 1983, the predominant lithology is gray to greenish-gray, fine- to medium-grained sandstone that is interbedded with argillaceous sandstones and silty to sandy shales. Individual sandstone bodies range from a several centimeters to a few meters thick. As the Connellsville River shifted, it cut deeply into established channel and overbank deposits, creating discordant contacts dipping at various angles to the normally flat-lying sediments. Various meanders appear in separate places and various stratigraphic levels in the outcrop, indicating the migration of the meander loops laterally and vertically with time. Figures 3-9 and 3-10 show a diagrammatic representation of the I-79 outcrop and a paleogeographic interpretation, respectively.

Road Log Continues from Stop 5.

0.40	51.50	Drive to the end of the exit ramp and turn right onto Route 910 (the Orange Belt).
0.20	51.70	Turn left onto Nicholson Road.
0.05	51.75	Turn right into Carmody's parking lot and disembark.

End of Road Log for Day Three

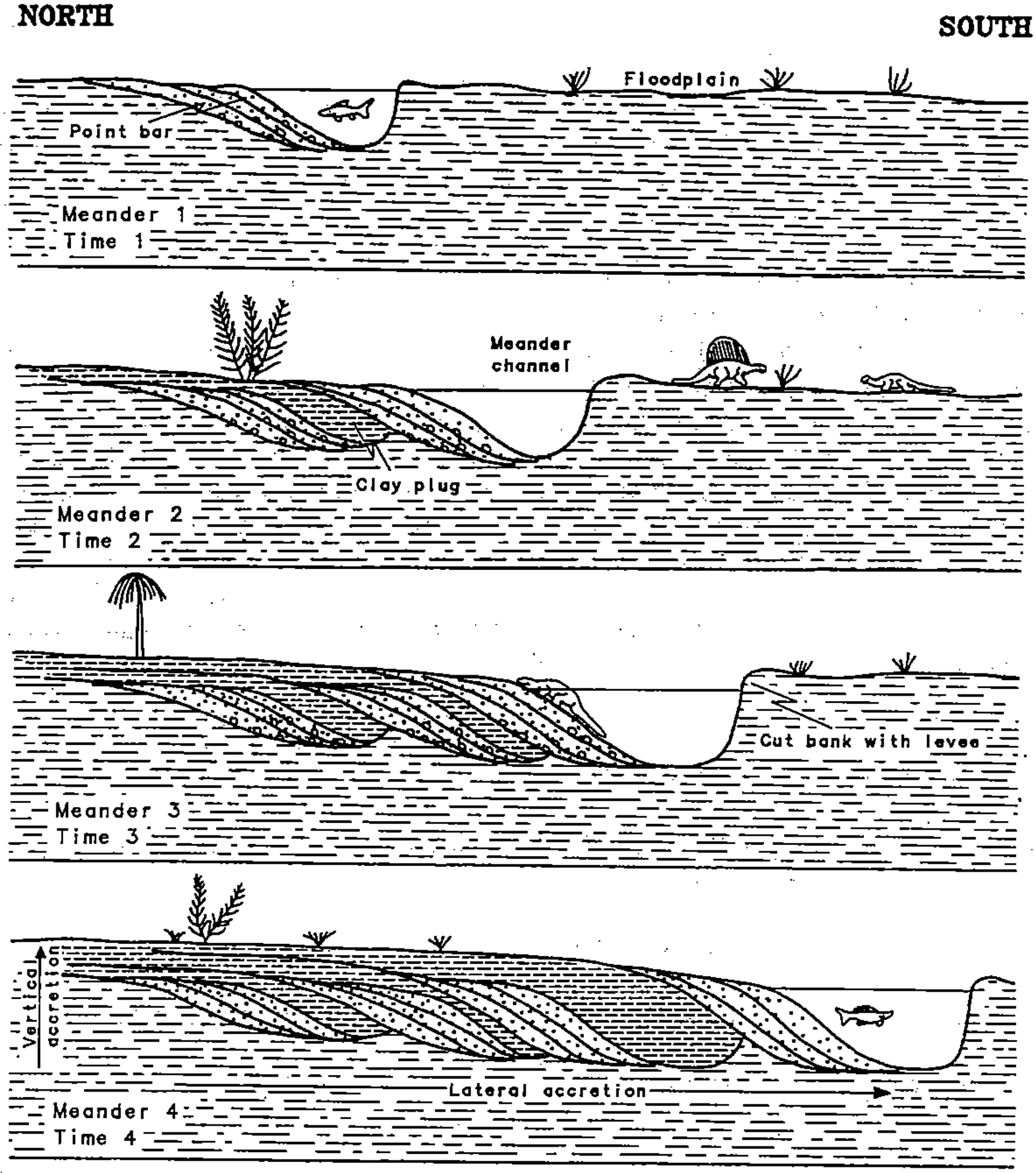


Figure 3-9 Diagrammatic sketch of the roadcut on I-79 just north of the Wexford exit, showing the sequence of vertical and lateral accretion of channel deposits in the Late Pennsylvanian-age Connellsville River system.

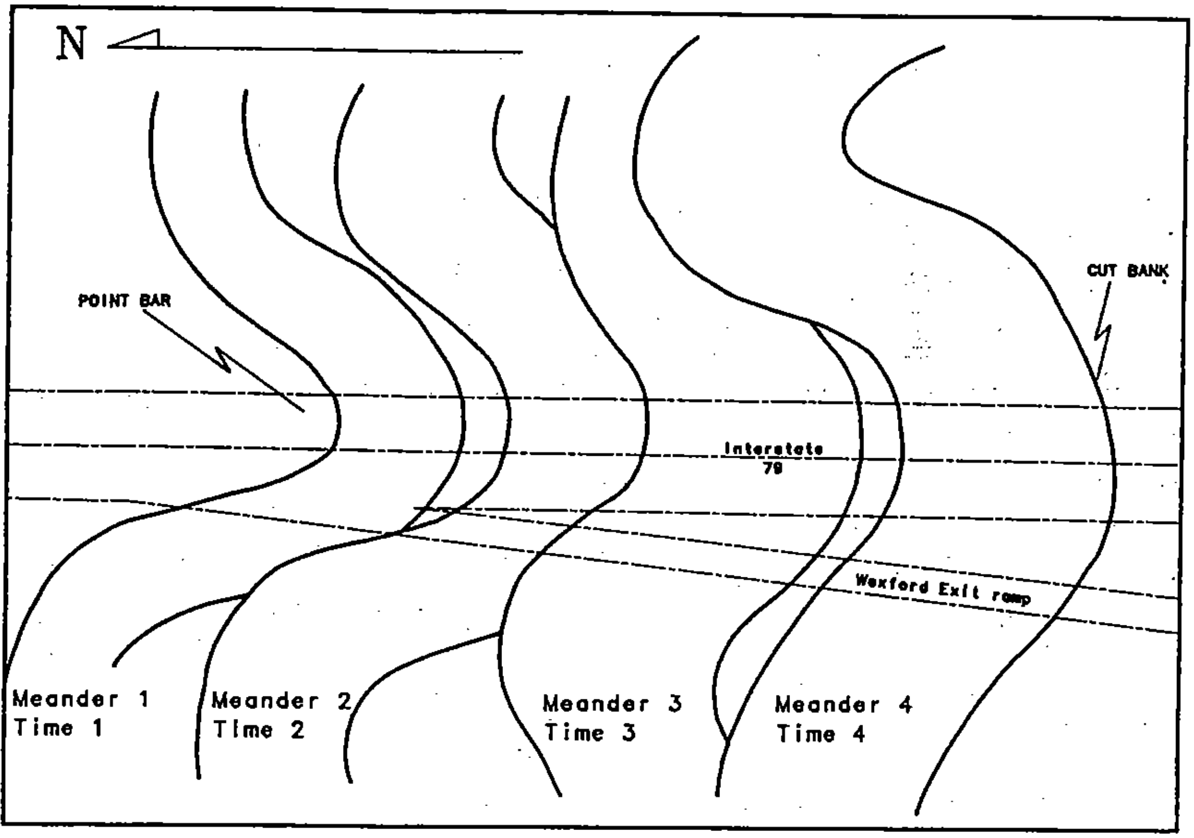


Figure 3-10 Paleogeographic interpretation of meander belt accretion in the Connellsville River system shown in Figure 3-9.