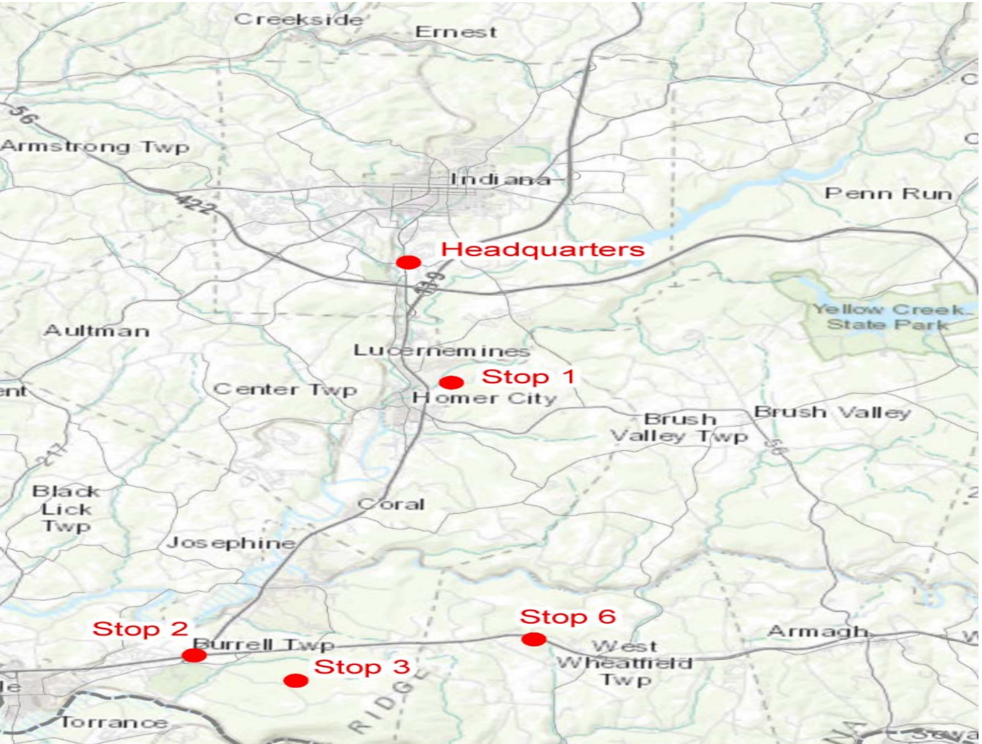
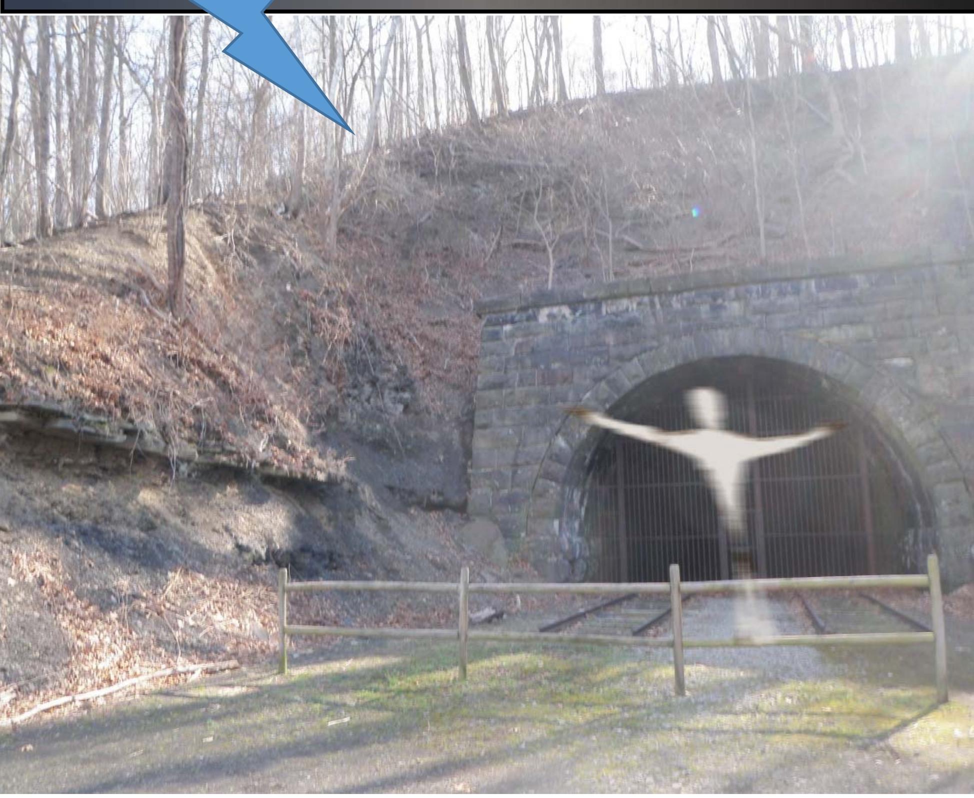


Energy & Environments: Geology in the "Nether World" of Indiana County, Pennyslvania



HOSTS:

PENNSYLVANIA GEOLOGIC SURVEY

UNIVERSITY OF PITTSBURGH AT JOHNSTOWN

GEOSCIENCE DEPARTMENT OF INDIANA UNIVERSITY OF PENNSYLVANIA

OCTOBER 6TH – 8TH 2016

81ST ANNUAL FIELD CONFERENCE OF PENNSYLVANIA GEOLOGISTS

SYSTEM	SERIES	GROUP OR FORMATION	FORMATION OR MEMBER	MAJOR BEDS
PENN.-PERMIAN	UPPER PENNSYLVANIAN/ LOWER PERMIAN	DUNKARD GROUP (PART)	GREENE FORMATION	
			WASHINGTON FORMATION	Upper Washington limestone Washington coal bed
			WAYNESBURG FORMATION	Waynesburg "A" coal bed Waynesburg coal bed
? PENNSYLVANIAN	UPPER	MONONGAHELA GROUP	UNIONTOWN FORMATION	Uniontown coal bed
			PITTSBURGH FORMATION	Sewickley coal bed Redstone coal bed Pittsburgh coal bed
		CONEMAUGH GROUP	CASSELMAN FORMATION	Morgantown sandstone Skelley marine zone
			GLENSHAW FORMATION	Ames marine zone (prominent) Pittsburgh red shale Noble marine zone (less prominent) Upper Bakerstown coal bed Carnahan Run marine zone (less prominent) Woods Run marine zone (prominent) Lower Bakerstown coal bed Nadine marine zone (less prominent) Pine Creek marine zone (prominent) Brush Creek marine zone (prominent) Brush Creek coal bed Mahoning sandstone (Big Dunkard*) Zone of brackish-water fossils Mahoning coal bed (F)
	MIDDLE	ALLEGHENY FORMATION		Upper (E) } Freeport coal beds Lower (D) } Upper Kittanning (C') coal bed Johnstown limestone Middle (C) } Kittanning coal beds Lower (B) } Vanport limestone Clarion (A') and Brookville (A) coal beds
	? LOWER	POTTSVILLE FORMATION		Homewood sandstone (First Salt sand*) Upper } Mercer coal beds Lower } Upper Connoquenessing sandstone (Second Salt sand*) Quakertown coal bed Lower Connoquenessing sandstone (Third Salt sand*) Sharon coal bed
MISSISSIPPIAN	UPPER	MAUCH CHUNK FORMATION		Mauch Chunk red beds
			LOYALHANNA MEMBER	Loyalhanna Limestone (Big lime*)
		POCONO FORMATION		Burgoon Sandstone Shenango sandstone

GUIDEBOOK FOR THE

81ST ANNUAL FIELD CONFERENCE OF PENNSYLVANIA GEOLOGISTS

OCTOBER 6 — 8, 2016

ENERGY AND ENVIRONMENTS:
GEOLOGY IN THE "NETHER WORLD" OF INDIANA COUNTY, PENNSYLVANIA

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The Pennsylvania Geologic Survey, The University of Pittsburgh at Johnstown, The Geoscience Department of Indiana University of Pennsylvania

Headquarters

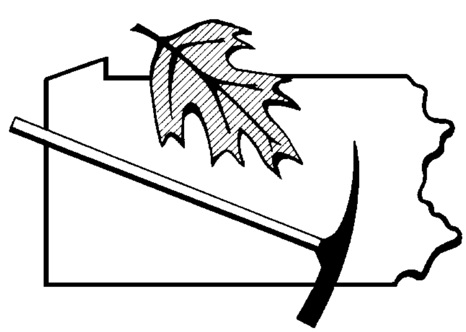
Park Inn by Radisson, 1395 Wayne Avenue, Indiana, PA 15701

Cartoons

John Harper

Cover

Railroad tunnel through Bow Ridge, near Conemaugh Dam



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ACKNOWLEDGMENTS

We extend special thanks to FCOPG officers, Katie Schmid, Kristen Hand, Stephen Shank and Connie Cross; trip organizers Joan Hawk and Bill Bragonier, stop leaders, guidebook contributors and volunteers,

and

- The bus company, Butler Motor Transit, Inc., for working with us to access even the least accessible outcrops
- The US government, for creating the interstate highway system that has given geologists the roadcuts to study these rocks, and flesh out the "Nether World" of Indiana County
- The traffic flagging service, Area Wide Protective, for keeping those roadcuts safe for geologists to examine

and

- Bill Bragonier, retired coal geologist, for his exhaustive work on the road log and his many fine articles discussing the relationship of the coal measures to the surrounding lithologies
- Dr. Frank Vento, Professor Emeritus, Department of Geology, Clarion University of Pennsylvania and President of Quaternary Geological and Environmental Consultants LLC, for speaking at our banquet
- John A. Harper, Pennsylvania Geologic Survey, retired, for continuing to provide "comic relief" on the blank pages of the roadlog and guidebook
- Thomas Whitfield, for his roadlog maps, and Michael Moore, for his cooperation
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and especially

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- **Mr. Scott Steele, for allowing us access to the quarry on his land**
- **Mr. Polka, for allowing us access to his land**
- **Allied Van Lines, for allowing us to park our buses on their property**
- **John & Kathy Starr, for property access**
- **Conemaugh Valley Conservancy, for property access**

STRATIGRAPHY

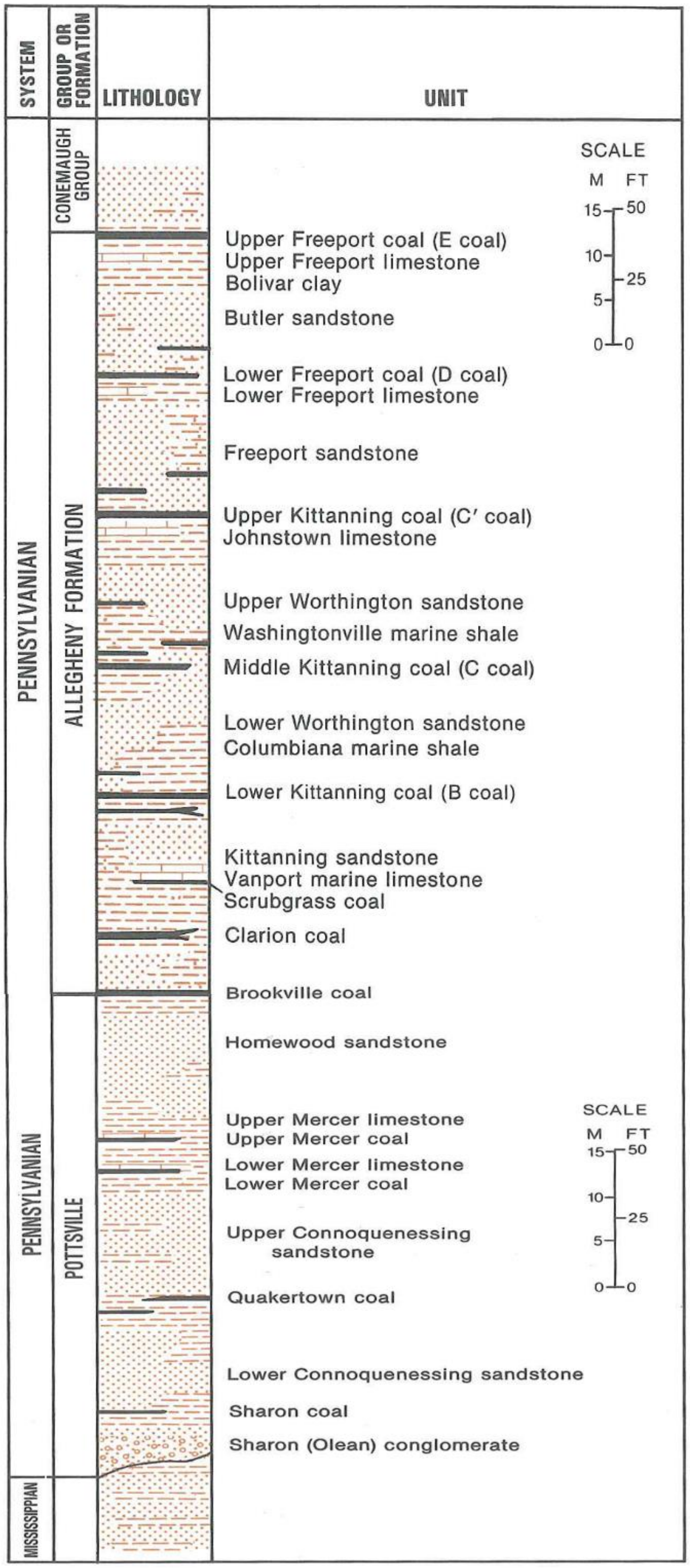
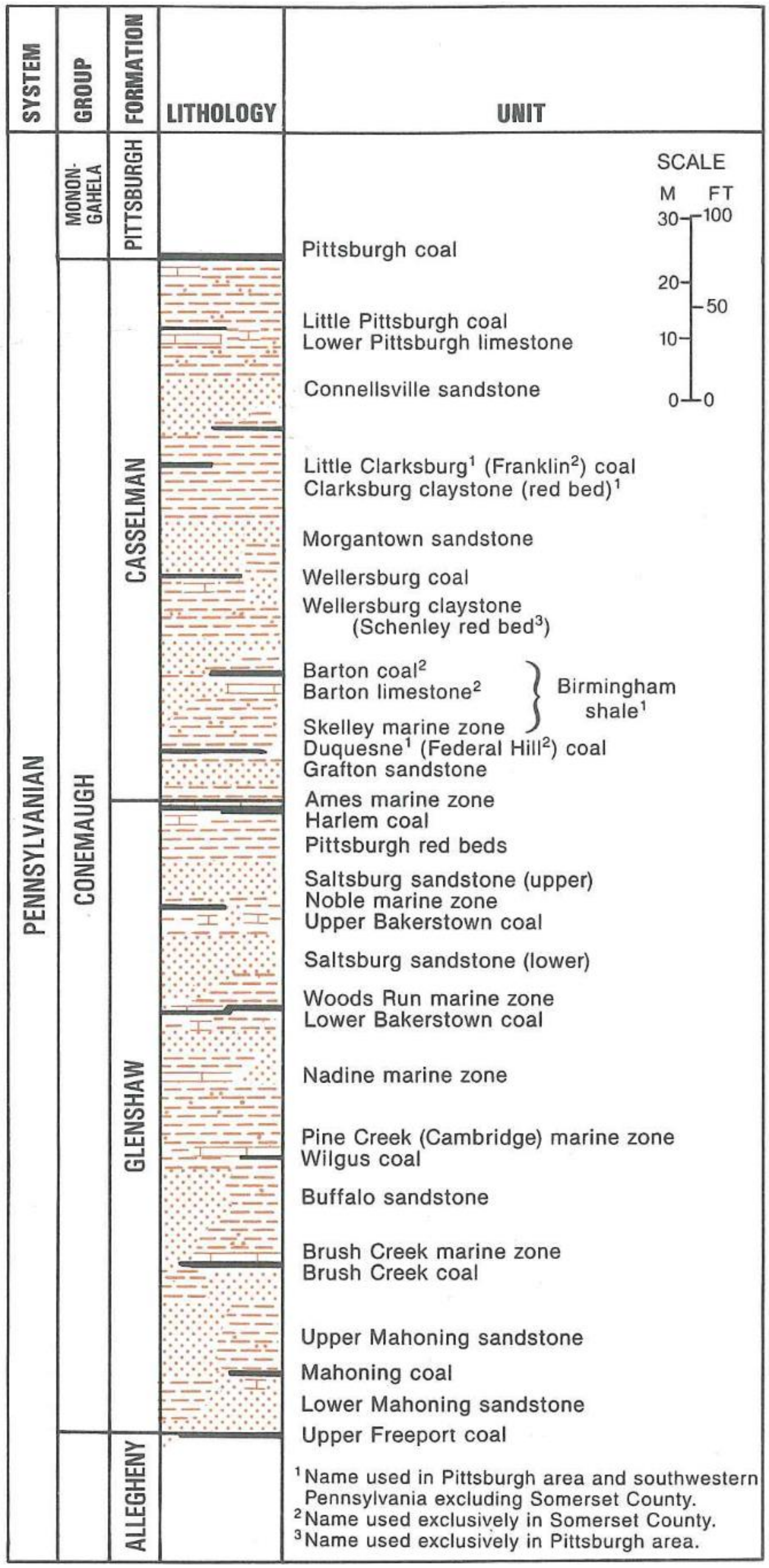


Figure 1. Generalized stratigraphic section of the Pottsville and Allegheny Formations of western Pennsylvania (modified from Edmunds, et al, 1999)

REFERENCE (*all figures in this section*):

Edmunds, W.E., Skema, V.W., and Flint, N.K., 1999, Pennsylvanian, chap. 10 *of* Schultz, C. H., ed., The Geology of Pennsylvania: Pennsylvania Geological Survey, 4th ser., p. 148-169.

Figure 2. Generalized stratigraphic section of the Conemaugh Group of western Pennsylvania (Edmunds, et al, 1999)



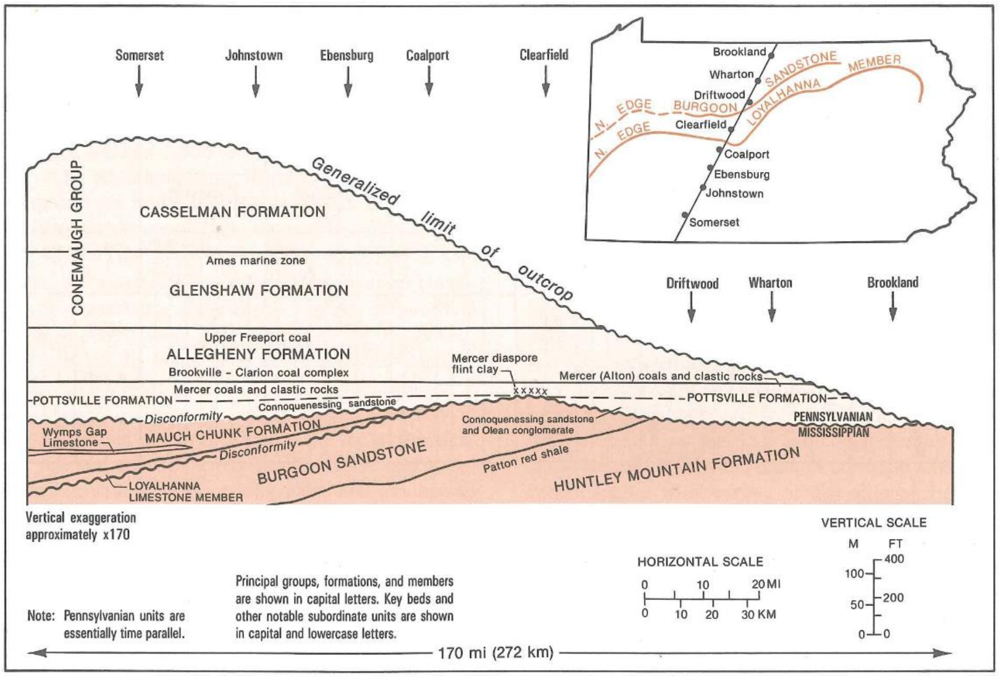


Figure 3. Generalized stratigraphic cross section of Pennsylvanian rocks from Somerset County to Potter County, through Indiana County at Johnstown. Note the darker shaded Mississippian section below and the nature of the Mississippian-Pennsylvanian unconformity. (Edmunds, et al, 1999)

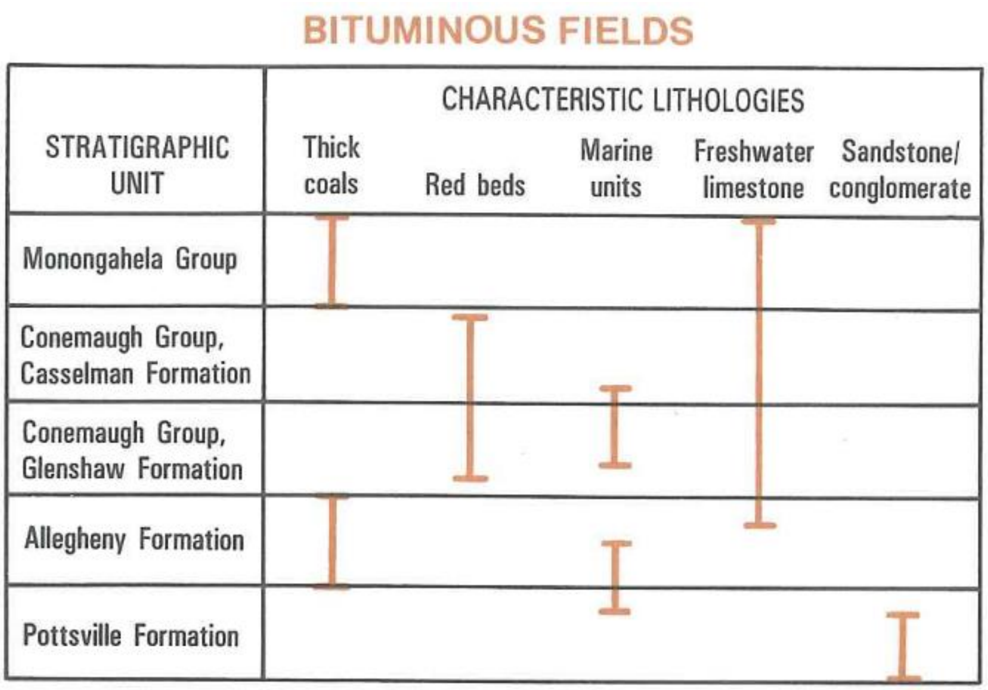
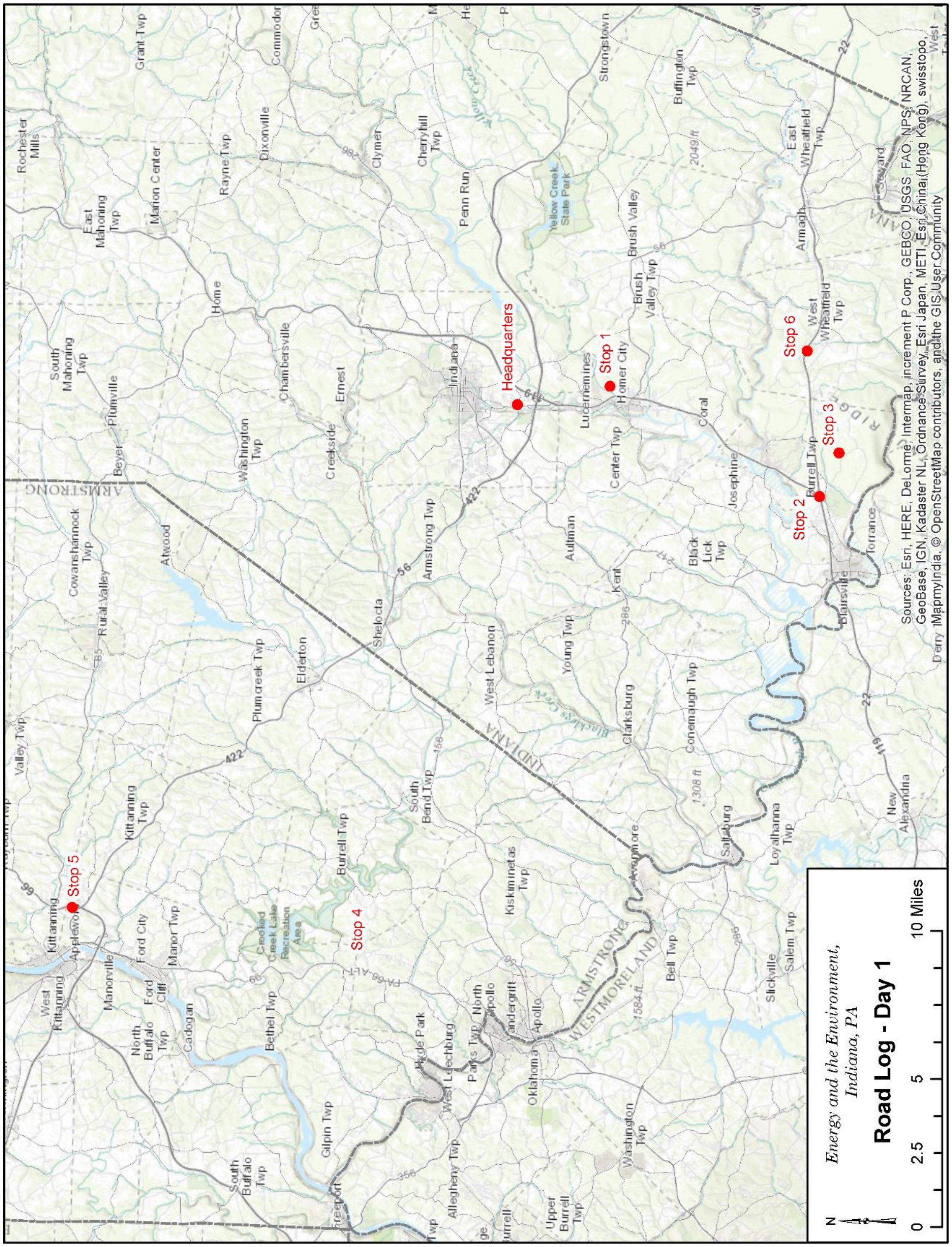


Figure 4. Stratigraphic distribution of definitive lithologic characteristics of the Pennsylvanian units in Pennsylvania. (Edmunds, et al, 1999)

ROADLOG – DAY 1



Segment	Cumulative	Day 1 Description
0	0	Park Inn - make left from back of parking lot onto Indian Springs Road
1.0	1.0	Turn right onto Rt 954 (S 6th street)
0.7	1.7	Cross over Two Lick Creek
0.6	2.3	Cross under US Rt 422
0.6	2.9	Intersection with Lucerne/Ferguson Roads go straight
0.6	3.5	Cross over Yellow Creek
1.0	4.5	Go Straight as you pass Snyder Road on the left
0.4	4.9	Turn right onto Tide Road
0.7	5.6	Keep left at the fork in the road (right side is called Tide Drive, stay on Tide Road)
0.7	6.3	Bony Pile becomes visible on the right side. The term Bony refers to the spoil or overburden removed during the coal mining process. It has a high ash content and is mostly comprised of shale.
0.4	6.7	Turn right to enter Lucerne Mines waste coal reclamation (owned by Northern Star)
		STOP 1 Lucerne Mines Bony Pile (40.54992, -79.14827)
	6.7	Exit Lucerne turn right back onto Tide Road
0.4	7.1	Pass under US Route 119/SR 56 - road name changes to Yellow Creek Street as you enter the town of Homer City
0.3	7.4	Turn left onto Greeley Street
0.2	7.6	Turn right onto Wiley Street
0.1	7.7	Turn left onto Ridge Avenue/ Main Street
0.2	7.9	Turn right onto south US Route 119/SR56
		Tidalites can be seen on left side in the roadside outcrop. These are stratigraphically near the Brush Creek Marine Zone.

Segment	Cumulative	Description
0.7	8.6	These are tidal bundles that are laterally accreted cyclic foreset beds separated by mud laminea generally indicative of an intertidal to subtidal depositional environment.
2.2	10.8	Village of Graceton, a coal company patch town. There is a Coal miners memorial for the Coral Mines and Coke Works (Mikesell Mine & Coke Works). In 1917 there were 202 bee hive coke ovens in operation.
0.1	10.9	Traffic light at power plant road, go straight
1.6	12.5	Cross over Blacklick Creek
0.7	13.2	Go Straight at the traffic light at Main Street in Blacklick
		Red and green beds of the Conemaugh Formation in roadcut on right
2.3	15.5	Pass under US Route 119/22
0.3	15.8	Turn left onto Pine Ridge Road
0.3	16.1	Turn left Old Farm Road
0.4	16.5	Turn left onto Route 22W
0.2	16.7	Take exit ramp to US Route 119
0.3	17.0	Pull off on exit ramp
		STOP 2 Route 119/ 22 Blairsville (40.4465, -79.21676)
0.0	17.0	Take left onto Route 119
0.2	17.2	Turn left on Pine Ridge Road - Tom's Run Golf Course on right
0.2	17.4	Veer right onto Strangford Road (Chestnut Ridge)
0.4	17.8	Turn left to continue on Chestnut Ridge Road
1.1	18.9	Take left to Pine Lodge
0.3	19.2	Bus parking at bottom of hill. Walk the rest of the way up to Pine Lodge

		**STOP 3 Lunch at Pine Lodge, Pine Ridge County Park (40.43732, -79.18863)**
	19.2	Drive back up the hill
0.3	**19.5**	Turn right onto Chestnut Ridge Road
1.0	**20.5**	Turn right onto Strangford Road (Chestnut Ridge Road)
0.5	**21.0**	Lift onto Pine Ridge Road
0.2	**21.2**	Turn right to on ramp to US 119 N
0.2	**21.4**	Go under Route 22
2.1	**23.5**	Go straight at traffic light at Main street in Black Lick
0.6	**24.1**	Slag piles visible on right side from coke ovens
1.0	**25.1**	Homer City Power Plant visible on the left
0.7	**25.8**	Intersection with Power Plant Road
0.6	**26.4**	Pass through the Village of Graceton
2.3	**28.7**	Go straight through the intersection with Route 56
0.6	**29.3**	Lucerne Coal Bony pile on the right
0.5	**29.8**	Stop light at past Lucerne Road
1.3	**31.1**	Stay straight on US 119/ SR 56 at Exit to Wayne Avenue
1.1	**32.2**	Take exit to Ebensburg/ Kittanning
0.4	**32.6**	Intersection with Route US 422 West
2.1	**34.7**	Pittsburgh redbeds of the upper Glenshaw Formation exposed on the left. The Skelley brackish zone is exposed behind the church above the road.
0.2	**34.9**	Pass under Route 286
2.0	**36.9**	Philadelphia Street Exit. Exposures of the Pine Creek marine zone in roadcut on right
0.5	**37.4**	Exposures of the Brush Creek Marine Zone of the lower Glenshaw Formationon the right.
3.8	**41.2**	Cross railroad tracks
0.4	**41.6**	Cross over Crooked Creek, enter village of Shelocta
0.6	**42.2**	Intersection with State Routes 156South/56 West on left

Segment	Cumulative	Description
0.5	**42.7**	Intersection with Wood Road on right. The visible roadcut on Wood Road is a fossil collecting locality on the Pine Creek marine zone and a stop on the 1989 Field Conference.
0.3	**43.0**	Former coal surface mine on right that is now reclaimed
0.3	**43.3**	Entering Armstrong County
0.7	**44.0**	Cross Plum Creek, Keystone Power Plant ash waste on left
1.1	**45.1**	Stop light at intersection with State Route 210, proceed straight on Route 422
0.5	**45.6**	Stop light at Saltworks Street, proceed straight on Route 422
1.9	**47.5**	Area of former Pipeline Explosion which created a huge fireball.
1.0	**48.5**	Outcrop of Mahoning channel sandstone on right
1.4	**49.9**	Village of Whitesburg
2.4	**52.3**	Blanket Hill Historical Site - Campsite for General John Armstrong's raid on the Indian village of Kittanning in 1756 during the French and Indian War
3.3	**55.6**	Rosebud Mining Billboard
1.3	**56.9**	Intersection with Scenic & Gladys Drives, Traffic Light
0.1	**57.0**	Follow sign for US Route 422 West to Kittanning/ Ford City (Middle Lane)
0.6	**57.6**	Merge onto Route 422 West/ PA 28
0.8	**58.4**	Pine Creek Marine Zone exposed on the left
1.0	**59.4**	Take Exit A PA Route 66 South towards Ford City
0.4	**59.8**	Cross Over Route US 422
0.9	**60.7**	Upper Freeport Limestone is recognizable as the resistant bed high in the road cut on the left
0.2	**60.9**	Traffic light at intersection with Fort Run Road and 5th Avenue

Segment	Cumulative	Description
0.2	**61.1**	Upper Freeport Limestone is exposed in road cut on the left
5.5	**66.6**	Left onto PA Alternate Route 66 (Dime Road)
2.0	**68.6**	Left onto Cochran's Mill Road
0.8	**69.4**	Enter Burrell Twp., Armstrong County, birthplace of Elizabeth Jane Cochran, late 19th century American journalist under the pen name of Nellie Bly, faked insanity to be committed to a woman's asylum. Her subsequent article "Ten Days in a Madhouse" prompted a grand jury investigation. She was also noted for her "around the world in 72 days" trip emulating Jules Verne's Phileas Fogg.
0.3	**69.7**	Right on Polka Hollow Road
0.6	**70.3**	Buses turn around then unload.
		Stop 4 Cochran's Mill Upper Freeport Section
0.6	**70.9**	Buses return to intersection of Polka Hollow Road and Cochrans Mill Road and park. Attendees walk to buses during and after Stop 4. After reload, resume road log by turning left onto Cochrans Mill road (PA Route 2028).
1.1	**72.0**	Right on PA Alt Route 66 (Dime Road)
2.0	**74.0**	Right on PA Route 66 North
5.5	**79.5**	Upper Freeport Limestone exposed in roadcut on the right
0.2	**79.7**	Intersection with Fort Run Road and 5th Avenue, Riverside Market on right
0.2	**79.9**	Upper Freeport Limestone is recognizable as the resistant bed high in the roadcut on the right
0.9	**80.8**	At end of bridge follow sign for Kittanning Business, proceed straight
0.4	**81.2**	Get in right lane, Follow sign for Kittanning Business East and To Routes 66 and 28

Segment	Cumulative	Description
0.4	**81.6**	Right onto PA Route 66 North and Route 28 - Indiana Road
0.4	**82.0**	Get into left lane
0.2	**82.2**	Veer left onto Millenium Road
0.5	**82.7**	Intersection with Dairy Way, proceed straight
0.6	**83.3**	Turn right onto PA Route 85 - Clearfield Pike
0.1	**83.4**	Turn Right onto PA Route 28 and 66 South
0.3	**83.7**	Exit right to East Business US Route Route 422 Indiana/ Kittanning
0.5	**84.2**	Park buses on exit ramp
		STOP 5 422/28 Pine Creek Marine Zone Exposure (40.808570, -79.489449)
0.1	**84.3**	Proceed on exit ramp to the intersection of Route 422, turn left onto Route 422 East
0.3	**84.6**	Intersection with Scenic & Gladys Drives, Traffic Light
7.0	**91.6**	Village of Whitesburg
1.4	**93.0**	Outcrop of Mahoning channel sandstone on left
1.3	**94.3**	View of Keystone Power Plant. On a clear day the Homer City and Conemaugh power plants may also be seen in the distance and form a straight line.
1.4	**95.7**	Enter village of Elderton
0.2	**95.9**	Stop light at Saltworks Street, proceed straight on Route 422
0.5	**96.4**	Stop light at intersectionwith State Route 210, proceed straight on Route 422
1.1	**97.5**	Cross Plum Creek
0.7	**98.2**	Indiana/Armstrong County line
1.1	**99.3**	Intersection with route 156 on right in village of Shelocta
0.6	**99.9**	Cross over Crooked Creek
0.4	**100.3**	Cross railroad tracks

Segment	Cumulative	Description
3.8	**104.1**	Stay in right lane. Follow signs for Route 422 East. Exposures of the Brush Creek marine zone on roadcut to left
0.5	**104.6**	Exposures of the Pine Creek marine zone in roadcut to left
2.0	**106.6**	Pass under Route 286
0.2	**106.8**	Pittsburgh redbeds of the upper Glenshaw Formation exposed on the left.
1.8	**108.6**	Take Exit A US Route 119 South to Blairsville
0.5	**109.1**	Stay in right lane - take Wayne Avenue Exit
0.2	**109.3**	Intersection with US Route 119 North
0.6	**109.9**	Stop light at Old 119, proceed straight
0.3	**110.2**	Turn right onto Indian Springs Road at stop light
0.1	**110.3**	**Turn left into Park Inn**

HARPER'S GEOLOGICAL DICTIONARY

AUTOCHTHONOUS - [Gr. Autos - self + chthon - earth, land] Your own personal piece of property, belonging only to you and no one else.

STOP 1: LUCERNE COAL REFUSE SITE

CAMBRIA RECLAMATION CORP

RECLAMATION VIA COAL REFUSE FIRED ELECTRIC GENERATION UNITS

TOUR – PRESENTED BY CAMBRIA COGENERATION

Stop Description **(40.54992, -79.14827)**

The Lucerne Coal Refuse Site is one aspect of Pennsylvania's Abandoned Coal Mine Legacy. Pennsylvania's Abandoned Mine Land (AML) problem has an estimated cost greater than $15 Billion to address. Funding to address the AML problem is primarily from Pennsylvania's annual allocation from the Federal AML Fund. It has been projected that Pennsylvania should receive over $1 Billion from this fund. However, those projections were based on a healthy coal industry where production was expanding, not to the contraction in the industry based on regulatory actions over the past 8 years that have impacted the electric generating industry and the coal industry.

The Lucerne Coal Refuse Pile resulted from the disposal of coal refuse from the Lucerne Mines that were developed in 1907, with the mines ceasing operations in 1929 (Lucerne Mine No.1), 1943 (Lucerne Mine No. 2) and 1967 (Lucerne Mine No. 3). Through the years (until 1948), the coal was delivered to the breaker where it was crushed and sized. At the breaker, men were employed to pick slate, rock, and sulfur from the conveyors for disposal. The operations slowly transitioned to mechanical separation with the construction and operation of the Lucerne Coal Cleaning Plant in 1948 (Mountjoy, accessed 8/02/2016)

The reject from the coal cleaning plant was delivered by conveyor to the Lucerne coal refuse site (Figure 1-1). The coal refuse disposal was placed on 125 acres of a 397 acre property of which 286 acres have been permitted. The 125 acre site is comprised of two specific areas of the property (Figure 1-2). Area 1 was primarily coarse coal refuse (the main site for mining operations) and Area 2 (sludge/coal slurry) as the coal cleaning process improved. There were over 8,700,000 tons of coal refuse placed on the site.

Figure 1-1. Library of Congress Photo showing boney pile (coal refuse) and Conveyor at Lucerne

The site has been permitted by Cambria Reclamation Corp. under Pennsylvania's delegated Coal Primacy Regulatory Program utilizing Subchapter F of Chapter 87 related to the re-mining areas with pre-existing pollutional discharges. A key aspect of the mine abatement plan was to use the coal refuse in a coal refuse fired electric generating unit utilizing Circulating Fluidized Bed technology (Figure 1-3) to combust the fuel. The emissions are controlled by injecting limestone into the boiler with the coal refuse to control SO_2 emissions, either combustion practices or Selective Non-Catalytic Reduction (SNCR) Technology to control NOx emissions, and baghouses to control particulate emissions. These units have been controlling these emissions from the start of operations as these technologies were installed when these units were built. (It should be noted that these units have been reducing SO_2 emissions between 90 and 95%; controlling NOx emissions; low emitters of mercury; and low emitters of filterable particulates). The coal ash produced by the combustion process is highly alkaline and meets requirements of Chapter 290 of the Pennsylvania' Department of Environmental Protection (PADEP).

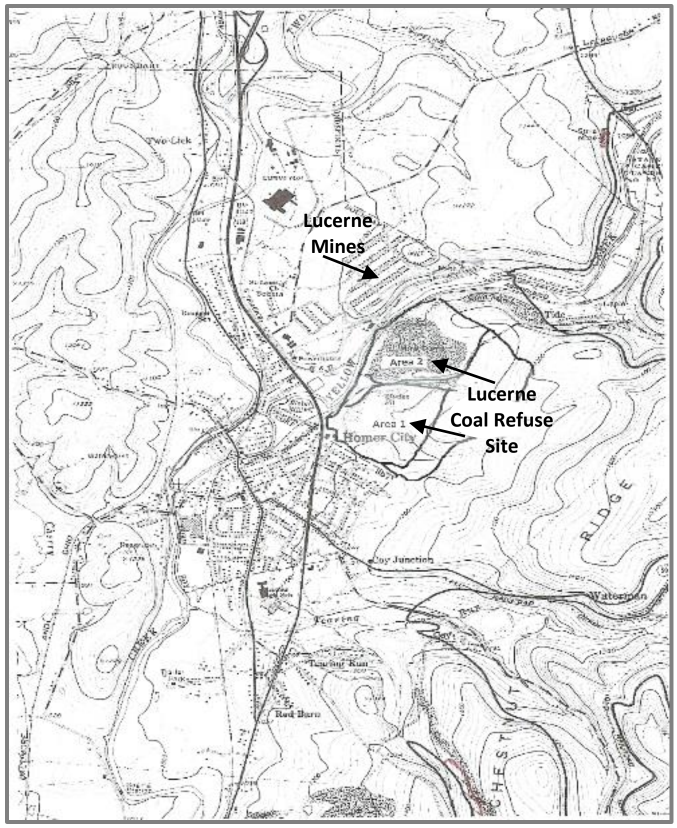


Figure 1-2. Location of Lucerne Coal Refuse Site (Area 1 & Area 2) and Lucerne mines, Indiana County

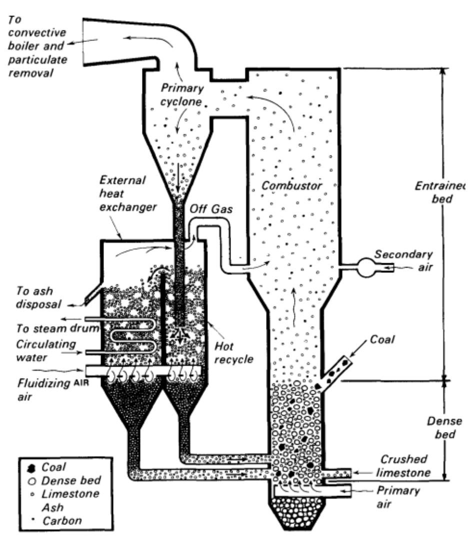


Figure 1-3. Generic Cross Section of a Circulating Fluidized Bed Combustor

The mining commenced in Area 1, in order to develop this portion of the site to accept ash when mining coal refuse in Area 2. As part of the development of this portion of the site, some of the slurry/silt was move and stockpiled on the coarse refuse site. This was needed in order to manage coal ash from the Cambria Cogeneration facility. This coal ash, approved for beneficial use in coal mine land reclamation, is being placed in that area. The active coal refuse mining activities are being conducted on the coarse refuse site (which has areas of silt/slurry). At this time, no ash is being placed in this area, as the site needs to be developed in a manner that maximizes the recovery of the coal refuse. In mining this area, the variability in fuel quality based in wide swings in Btu's and sulfur percentage, requires the development of "coal refuse 'highwalls'". The coal refuse is shipped to the plants on a daily basis by trucks loaded with coal refuse from the different highwalls that are mixed and blended at the plants to achieve a more uniform Btu and sulfur content. This allows for the mining of the coarse refuse to maximize recovery without it being limited by being ash bound; this insures that the acid producing material is burned and neutralized, so the site will not catch fire in the future and the water quality from the site will improve.

The site was un-reclaimed causing acid and iron discharges to an unnamed tributary of McGee Run and McGee Run as indicated by seeps and discharges from the areas where coal refuse was placed. There was silt laden runoff that was also discharging to the stream. In addition, there have been times when the pile was burning as evidenced by “red dog”. It is projected that upon completion, this should reduce the discharge load to the stream by 261,000 lbs. of acidity per year and 59,000 lbs. of iron per year.

When coal refuse burns in place, there are serious uncontrolled toxic emissions. The Pennsylvania Bureau of Abandoned Mine Reclamation indicates that there are 58 burning coal refuse piles. Based on the past, coal refuse sites have burned, some are burning now, and they will burn in the future.

Geologic and Groundwater Overview of the Lucerne Coal Refuse Site

This site is underlain by the Pennsylvanian Conemaugh and Allegheny Groups with the Glenshaw Formation at the surface (Williams and McElroy, 1997) (Figure 1-4).

The area has been extensively deep mined by Rochester and Pittsburgh Coal and Iron Company (R&P), both in the Upper Freeport and Lower Kittanning Coals (Bragonier and Glover, 1996). This mine complex is over 14,000 acres extending from the Lucerne area to the Ernest area. Structurally the site is located between the axis of the Latrobe Syncline, which is located approximately 1.4 miles northwest and the Chestnut Ridge Anticline, lying approximately 2.0 miles southeast of the coal refuse site (Bragonier and Glover, 1996).

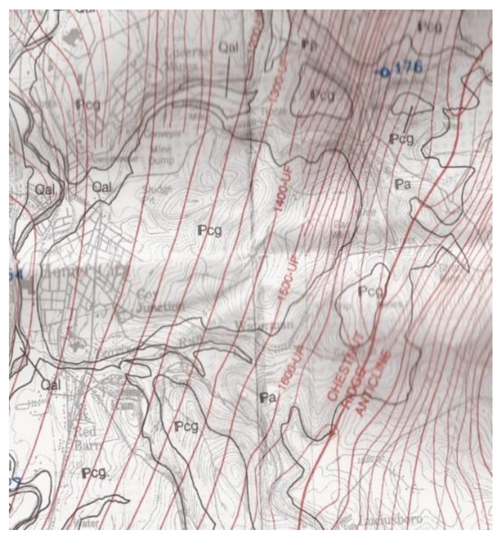


Figure 1-4. Geologic Map with Structural Contours (Williams and McElroy)

The coal refuse was placed on the sites with minimal considerations (not having legislation or regulation dealing with stability or environmental issues). In 1952, the Lucerne Mines constructed and operated a coal preparation and cleaning facility across the stream from the coal refuse site and sludge pit. Waste from the Lucerne Preparation Plant was transported to the coal refuse site, where it was dumped on the ground with minimal compaction. Later, sludge pits (coal slurry) were established to dispose of slurry from the preparation plant. Both the coal refuse site and the slurry sites were placed on the ground surface.

As seen from the geologic map in Figure 1-4, the valley adjacent to the coal refuse site contains Quaternary Age Alluvium (Qal) deposits (Williams and McElroy, 1997).

The groundwater system within the permit area consists of one or more perched water tables that feed McGee Run and its unnamed tributaries at the site. However, the extensive deep- mining of the Upper Freeport and the Lower Kittanning has had a major impact on ground and surface water in the area. The Upper Freeport Deep Mine has a major discharge adjacent to the permit area along Rte. 119.

Lucerne Today

Coal refuse from Lucerne is being sent to 3 Plants (Cambria Cogen, Colver and Seward). At this time and pending market conditions, the mining operations should continue for the next 3 to 5 years. Upon completion, additional coal ash will be placed to achieve the final contours, the site will have topsoil or best vegetative supporting material placed over the site and planted. Monitoring and final bond release will continue for a period of 10 years after the last load of ash is placed on the site.

The Dilemma

Coal Refuse Fired EGUs have proven that they are able to generate power, meet reasonable environmental regulations, and clean up the piles through the Coal Refuse to Energy Process (Figure 1-5). In the process, they have minimized or eliminated the mine drainage from these sites, eliminated the future potential of these sites to burn, and returned the land to a productive use with the vegetation becoming a carbon sink. Without these sites, there is no economical means to reclaim the sites to standards for regulated coal mining.

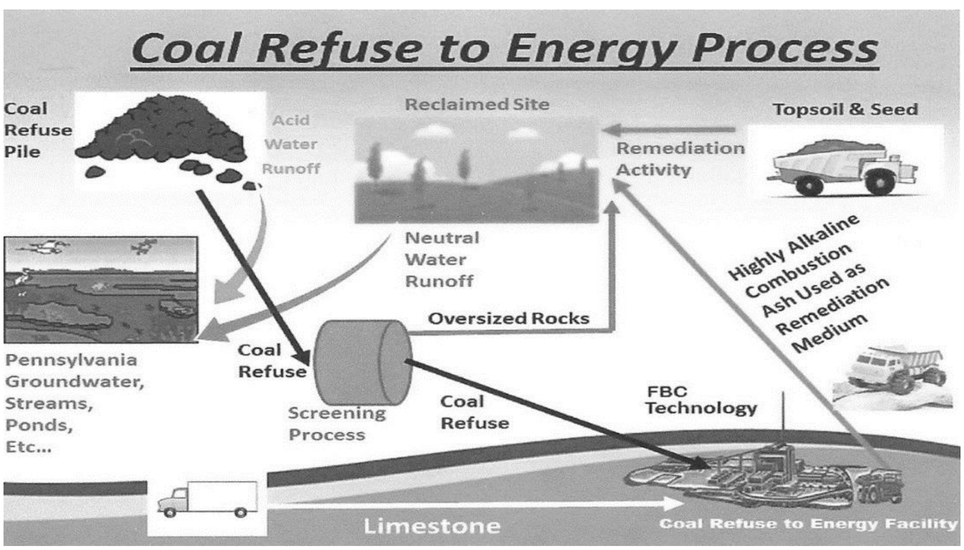


Figure 1-5. Coal Refuse to Energy – the Solution to Reclaiming Pennsylvania's Coal Refuse Sites

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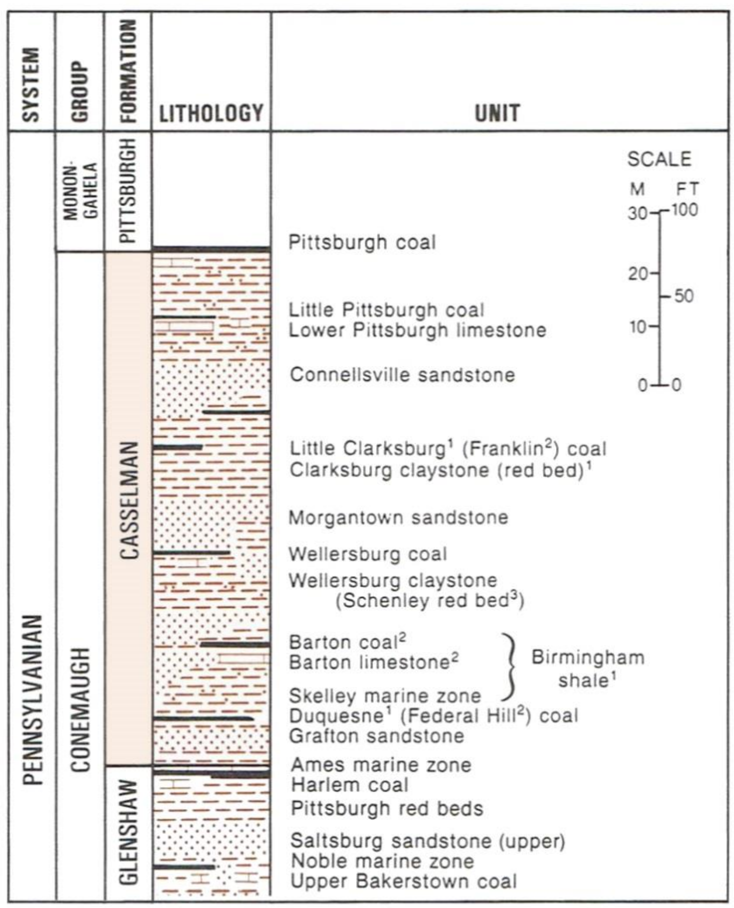
STOP 2: UPPER PENNSYLVANIAN CASSELMAN FORMATION

AT THE US-22/US-119 INTERCHANGE NEAR BLAIRSVILLE, PENNSYLVANIA

STOP LEADERS – CHRISTOPHER COUGHENOUR, UNIVERSITY OF PITTSBURGH-JOHNSTOWN
JOAN HAWK, CME MANAGEMENT LLC

Introduction **40°26’47” N, 79°13’06” W**

The highway interchange linking routes US-22 and US-119 two miles east of Blairsville, PA offers a series of extensive roadcuts that expose portions of the Casselman Formation. Two of these outcrops lie adjacent and nearly orthogonal to one another (separated by 110°) and offer a valuable perspective of the facies and architecture of the unit. These roadcuts cumulatively expose nearly 400 m of lateral section, with vertical exposures ranging from 2-6 m. The site is also of interest because the Casselman Formation (Figure 2-1) is one of the least-studied units in the Pennsylvanian System, owing to its general lack of economic and paleontological resources (Edmunds et al., 1999).



[1] Name used in Pittsburgh area and southwestern Pennsylvania excluding Somerset County.
[2] Name used exclusively in Somerset County.
[3] Name used exclusively in Pittsburgh area.

Figure 2-1. Generalized stratigraphic column of the Casselman Formation (modified from Edmunds et al., 1999).

Stratigraphic and Structural Setting

The site lies at the western edge of the northeast-trending Chestnut Ridge anticline within the Pittsburgh Low Plateau section of the Appalachian Plateau. Local dips are relatively steep for the plateau at 6.3° to the northwest (Bragonier and Glover, 1996). Previous mapping has placed the site within the Casselman Formation of the Conemaugh Group (Berg and Dodge, 1981). The Casselman is almost completely devoid of known marine deposits (save for the local Skelly marine zone) and exhibits few coals, unlike underlying units. For this reason, the Casselman Formation has been interpreted as representing alluvial and upper deltaic environments (Edmunds et al., 1979) and was a culmination of larger-scale regional regression that included the progradation of clastic wedges from highland source areas to the east (Greb et al., 2009). Questions remain, however, regarding the nature and evolution of the alluvial succession and paleoclimatic conditions during deposition of the Casselman in the Late Pennsylvanian (Virgilian).

A first step in this preliminary study was to try and ascertain the stratigraphic position (within the Casselman Fm) of the deposits exposed in the roadcut. Prior to the construction of the current interchange, Shaffner (1958) documented an occurrence of the Morgantown sandstone located just north of this outcrop along the original alignment of U.S. Route 119. The Ames limestone, marking the boundary between the Glenshaw and Casselman Formation, was also documented to occur 400 m from the site near the Chestnut Ridge Golf Club.

Three exploration drill holes from the archives of the Rochester & Pittsburgh Coal Company, IND-D-HELN-B0009, IND-D-HELN-B0011 and IND-D-HELN-B0012 show the total thickness of the Conemaugh to be approximately 222 meters (730 feet) with the Glenshaw approximately 375 thick and the overlying Casselman approximately 108 meters (355 feet) thick. These holes lie between approximately 1.5 kilometers (5,000 feet) and 3 kilometers (10,000 feet) from the outcrop. Two of the drill holes (B009 and B0011) were advanced through strata starting above the Pittsburgh Coal in the overlying Monongahela Group and extending through the Lower Kittanning Coal in the underlying Allegheny Group. The third drill hole, B0012, was advanced through strata starting at what is correlated to the Connellsville sandstone. These drill hole logs are included as Appendix A (digital version of the Guidebook). The Morgantown Sandstone occurs in the approximate middle of the Casselman Formation, lying approximately 40 meters (130 feet) above the Ames marine zone. These drill holes illustrate that its horizon is not always represented by sandstone. At some locations there is sandy shale bounded by redbeds; at another, shales and thin limestone. A thick sandstone, correlated to the Connellsville, encroaches on the Morgantown horizon where it is represented by shale and limestone.

Sedimentology of the Blairsville outcrop

Nearly all of the deposits exposed can be grouped into seven lithofacies (see Table 2-1). Lithofacies interpretations were made on the basis of grain size, sedimentary structures, lateral and vertical extent, and bounding surface geometry (Table 2-2). An example interpretation is given in Figure 2-2.

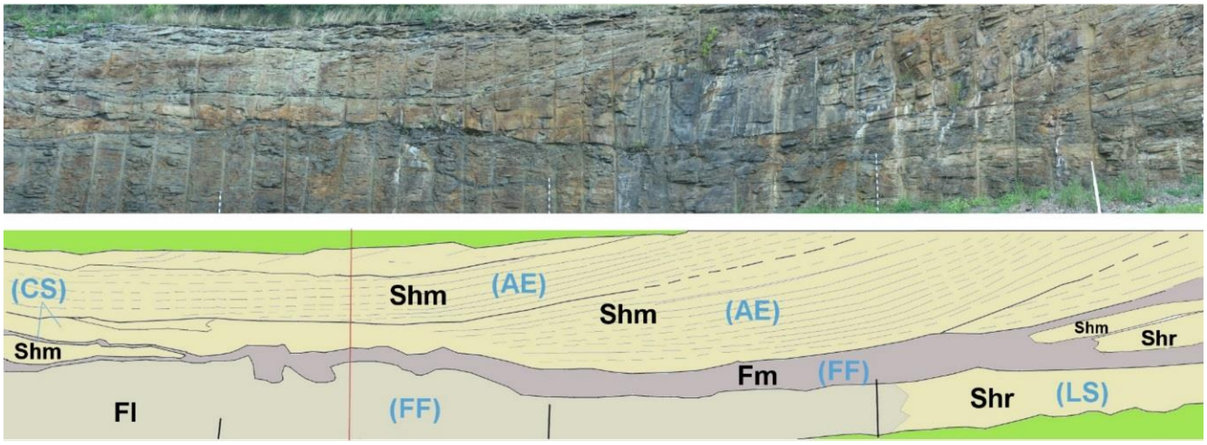


Figure 2-2. Example interpretation of deposits seen along a section of the south-facing (US-22 W exit ramp) outcrop. The staffs are 10 m apart. Lithofacies are denoted in black and architectural elements are in blue and parentheses (see Table 2-2 for element interpretations).

Table 2-1. Codes and descriptions for basic lithofacies observed in the study (modified from Miall, 1981)

Facies code	Lithofacies	Sedimentary structures
Fl	Silt (>50%), with some fine sand	Fine lamination (some heterolithic), small ripple cross lamination
Shr	Sand (>50%), fine to med with prominent silt	Horizontal lamination or ripple cross lamination
Fm	Mud	Massive, often with evidence of deformation
Shm	Sand (>80%), fine to coarse, with minor silt	Internal planar, horizontal lamination, sometimes with only thin, discontinuous silt (some appear internally massive on weathered surfaces)
Se	Sand, fine to coarse with intraclasts	Crude cross-bedding and/or massive appearance
St	Sand, fine to coarse	Solitary or grouped trough cross-beds
Sl	Sand, fine	Low angle (<10^{o}) internal cross-stratification

The facies observed at the site are dominated by sandstones, with siltstones composing most of the remaining size fraction. The sands are strongly quartzose, with some dark clasts, possibly tourmaline, present (Orsborn, 2015). Horizontal, planar internal stratification (often with minor ripple cross-lamination) is most common. This occurs in a gradation of grain sizes ranging from siltstones with thin sands (facies 'Fl') to sandstones with only thin, sometimes discontinuous silts (facies 'Shm'). Trough cross-bedded sands are frequent (facies 'St'). Facies Shm and St are often overprinted with apparent large-scale stratification. These decimeter-scale beds usually dip to the west and are interpreted broadly as accretionary elements comprising channel fills (Figure 2-2). Soft-sediment deformation can be observed in a number of the formerly horizontal, planar laminated siltstones and sandstones. Mud rip-up clasts are also present in several sandy deposits (facies 'Se') (Figure 2-3).

Another common facies is a deformed, fine-grained facies (Fm) commonly occurring below the channel sandstones. These may represent channel scour followed by slow sedimentation (initial abandonment). At one location, this facies completely fills a ribbon body, denoting an abandoned channel mud plug.

Figure 2-3. Mud rip-up clasts overlying a concave-up scour surface along US-119

Table 2-2. Summary of lithofacies interpretations and architectural elements observed in the study. Please refer to the guidebook for complete list of references.

Litho-facies	Interpretation	Architectural element(s)	Comments	Reference
Fl	Overbank (floodplain) primarily suspension	FF (floodplain fines element)	Often associated with Shr and laterally extensive/unbounded	See guidebook
Shr	Related to overbank traction transport and sheet flooding. Lower flow regime	LS (laminated sand sheet)	Second most common facies. Laterally extensive/unbounded geometry. Soft-sed deformation common	
Fm	Variously deformed/folded muds from floodplain shear and channel abandonment	FF (floodplain fines element) CH (channel element)	Most form thin (<1 m) irregular tabular bodies under channel sands. Prominent channel fill mud plug	
Shm	Channel belt deposition by accretion	AE (accretion element)	Most common facies on south-facing outcrop. Bounded by concave-up basal surfaces. Note: some Shm are levee deps., denoted as CS elements	
Se	Sediment dumping in channels. Scours due to avulsion (including crevasse channel cut)	CS (crevasse splay element) CH (channel element)	Intraclastic mud rip-ups and concave-up bases. Frequently exhibits steep margins that interfinger with Shr	
St	Within-channel migration of mesoforms (e.g. dunes)	AE (accretion element)	Generally observed on south-facing outcrop superposed with larger dipping surfaces. Strikes of set surfaces variable	
Sl	Overbank, related to shallow depth promoted upper flow regime and antidune migration	LS (laminated sand sheet)	Grades from Shr. Often overlies soft-sediment deformation	

Not listed in the tables are an isolated unit of coal (5 cm thick) and bioturbated claystone (at least 20 cm thick) along US-119. These units were just several meters apart and at nearly the lowest stratigraphic position of the site. This could record a different fluvial/hydrogeologic regime that favored longer retention of near-surface water and/or a shift in paleoclimate.

Fluvial style and the big picture

At the outcrop, it is evident that a large majority of deposits display evidence of bedload transport. The presence of long (10's of meters) sandy channel bodies and overbank/floodplain deposits that also contain relatively significant sand fractions suggest a sandy bedload system (Galloway and Hobday, 1996). Paleocurrent indicators observed, particularly the larger-scale accretion surfaces, were strongly unidirectional, implying possible low sinuosity. The lateral extent of the sand bodies suggests the system possessed a mobile channel belt (Gibling, 2006). An apparent lack of lateral accretion sets (epsilon cross-bedding), lack of divergent paleocurrent directions, and lack of oxbows/extensive "stable" floodplain suggest the system was not meandering. The Morgantown sandstone here broadly resembles a sandy, braided style (e.g. Wilson et al., 2014). More observations, including more extensive paleocurrent data, are needed to more definitively elucidate fluvial style in the Blairsville outcrop.

The sandy bedload architecture and aggrading nature of the system (evidenced by sand-body stacking and little evidence for terracing) preserved near Blairsville indicate at least strong, periodic fluxes of sediment during clastic wedge progradation. Whether this was a function of proximity to sediment sources, tectonic forcing, or dry climate (or some combination thereof) remains for further study. A recent study of (lower) Casselman deposits and paleoecology, prompted by the discovery of an amphibian (*Fedexia striegeli*, near Pittsburgh), reveals that this period of the Virgilian may have been fairly dry (Berman et al., 2010). Aside from the lack of bioturbation and pedogenic features, typical drylands indicators (e.g. desiccation cracks, gypsum pseudomorphs, or aeolian beds) were not present in the study area. Perhaps, further study of this unit and its correlatives in the region will reveal interesting evidence for basin-scale sedimentation dynamics and possible relations to tectonics, as well as regional paleoclimate.

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STOP 3: LUNCH

PINE LODGE, PINE RIDGE COUNTY PARK

(40.43732, -79.18863)

CORE – COLLIN LITTLEFIELD, SHIPPENSBURG UNIVERSITY

Figure 3-1. Example of core[1] from Indiana County in associated coal-bearing strata. The lunch stop will feature a Clearfield County core analyzed by students from Shippensburg University.

Core

The Core Library at the Pennsylvania Geologic Survey donated an un-locatable core to the Shippensburg University to be used in their Geography and Earth Sciences Department. This core provided a resource for practical knowledge in sedimentology, stratigraphy, and economic geology courses as well as prompted undergraduate research in sedimentology and stratigraphy this past spring semester. Through students' analysis of the core's stratigraphy and driller's logs, which was later uncovered, the core's origin was located outside of Brisbin in Clearfield County and provided an understanding of western Pennsylvania's coal fields.

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[1] PA DCNR Bureau of Topographic and Geologic Survey, Core Library, Ref. no 306Aa; IND 063-0083; boxes 76, 77 containing footages from 772-791.

NOTES

STOP #4: COCHRANS MILL ROAD UPPER FREEPORT

STOP LEADER – WILLIAM A. BRAGONIER, COAL GEOLOGIST, RETIRED

The Field Conference of Pennsylvania Geologists was given conditional site permission and any visitation to this site outside of this specific time and place under the supervision and liability coverage of the Field Conference is trespassing and strictly prohibited and will be prosecuted in accordance with all related Pennsylvania State Laws.

Stop Description

Exposures of the Upper Freeport coal on Cochrans Mill Road near the intersection with Polka Hollow Road and along an unnamed tributary in south-central Armstrong County, PA will be examined. Exposed are the lower 20 feet of the Uffington shale (overlying the Upper Freeport coal), the Upper Freeport coal and the underclay and Upper Freeport limestone beneath the coal (see Figure 4-1). This section may be examined by walking the streambed over a distance of approximately one half mile and is then repeated vertically in a roadcut on Cochrans Mill Road near its intersection with Polka Hollow road. Conferees are encouraged (but, of course, not required) to walk at least part of the streambed exposing the Upper Freeport coal.

Stratigraphy & Deposition

What makes this exposure appealing, if not compelling, is the nature of the Upper Freeport coal. Figure 4-2 illustrates the paleogeography of the Upper Freeport coal in central western Pennsylvania. Of particular interest is the northwest trending split seam area outlined in blue that traverses an area from northern Westmoreland County, through Indiana and Armstrong Counties and into eastern Butler County. The blue lines roughly define the 20% in-seam ash isopleth of the Upper Freeport coal. Within this area the coal obtains multiple "splits" or shale partings. In fact, some drill holes near the center of this area contain mostly shale with coal streaks and very little coal. This high ash zone is modified from Clark (1979).

It may be noted in Figure 4-2 that the location of the Cochrans Mill road exposure (Stop 4) is near the center of the Upper Freeport split zone, and this is reflected in measured section in Figure 4-1, derived from the exposures on Cochrans Mill Road. Here the Upper Freeport consists of alternating bands of coal and black shale. The black shale bands are of considerable interest in that they are composed almost entirely of fossilized tree trunks, which are quite visible in the streambed for approximately just under a half mile below the waterfall (although the exposures are somewhat intermittent downstream). Literally hundreds of tree trunks (Figure 4-3) have been preserved.

One of the most obvious features of the fossilized tree trunks is their lack of preferred orientation. Genetically, there are two taphonomic mechanisms that will produce this configuration. One is the autochthonous model of water stressed conditions. This is the "clastic swamp" of Gastaldo (1986, 1987) that may include a drowned swamp, sub-aerial exposure of a swamp or adverse changes in salinity and/or sediment influx, any of which would contribute to the long-term demise of a standing wetland forest. The other, the allochthonous model, assumes catastrophic deposition that essentially equates to a logjam.

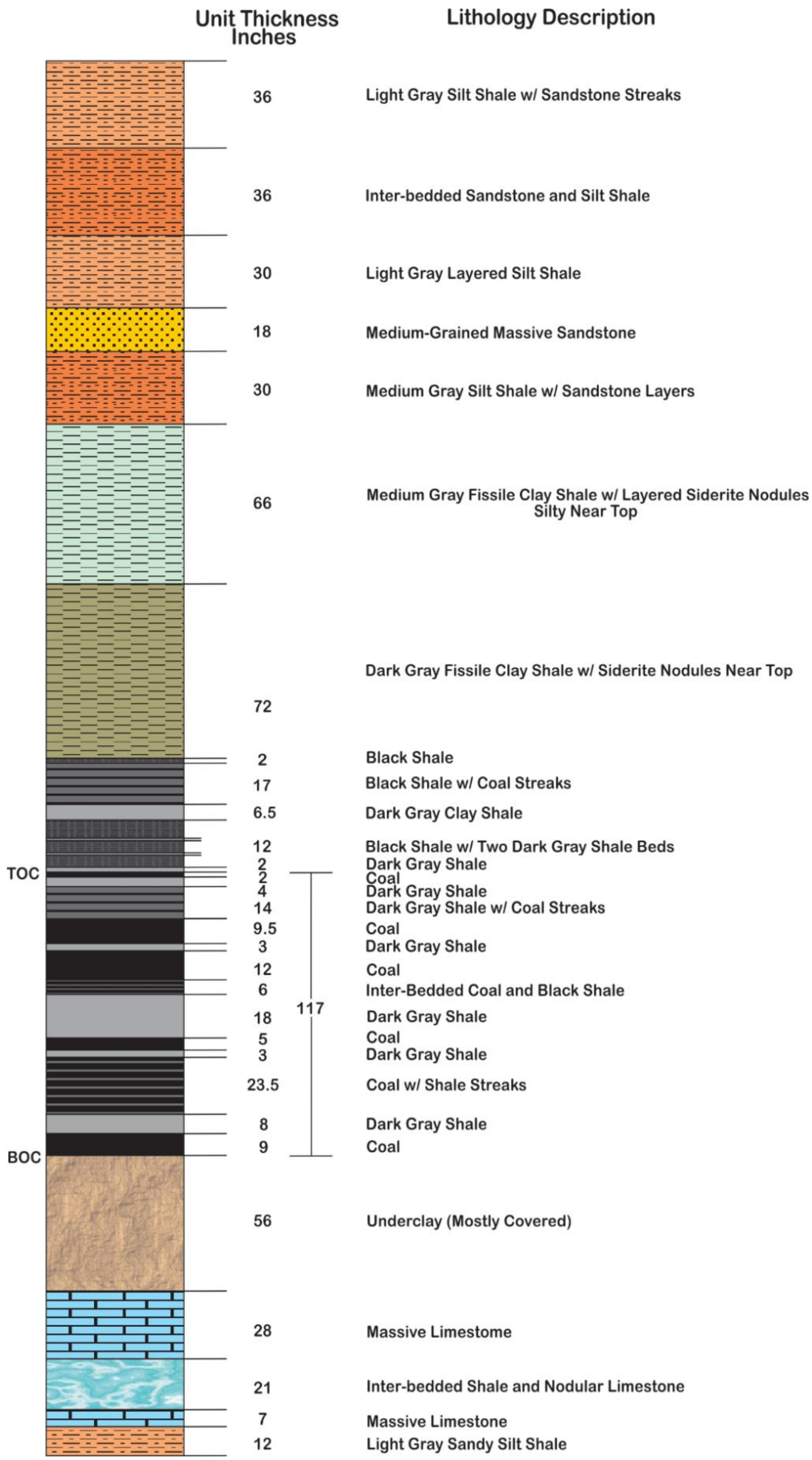

Figure 4-1. Stratigraphic Section of the Upper Freeport coal and surrounding rock units measured on Cochrans Mill Road.

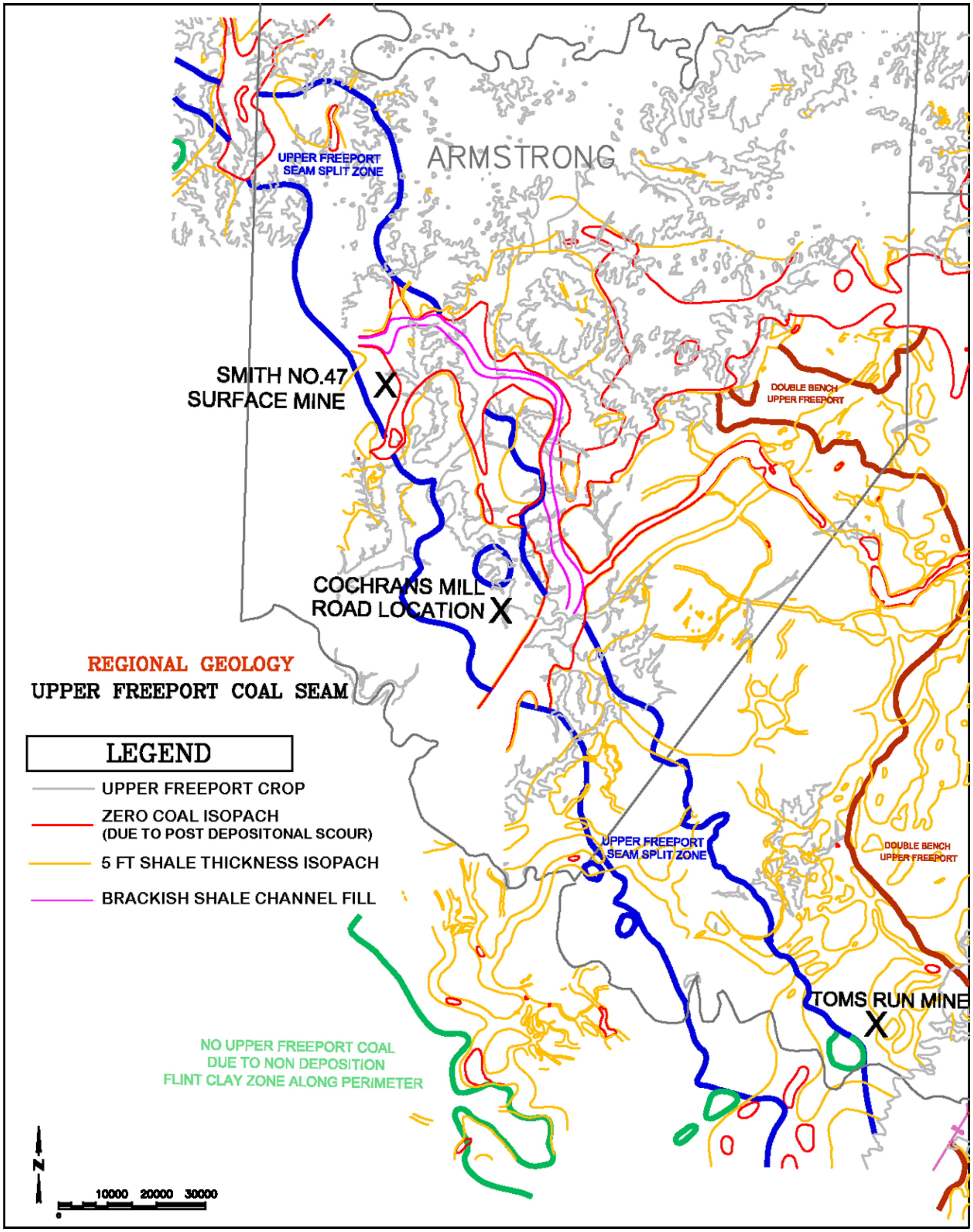

Figure 4-2. Map illustrating the paleogeography of the Upper Freeport seam split zone in a portion of central western Pennsylvania. The blue lines, which are modified from Clark (1979), roughly correspond to the 20% in-seam ash isopleth. Between the lines the Upper Freeport coal contains numerous shale partings. Also shown are the locations of the Toms Run Mine, the Cochrans Mill Road Upper Freeport exposure and the Smith No. 47 Surface Mine.

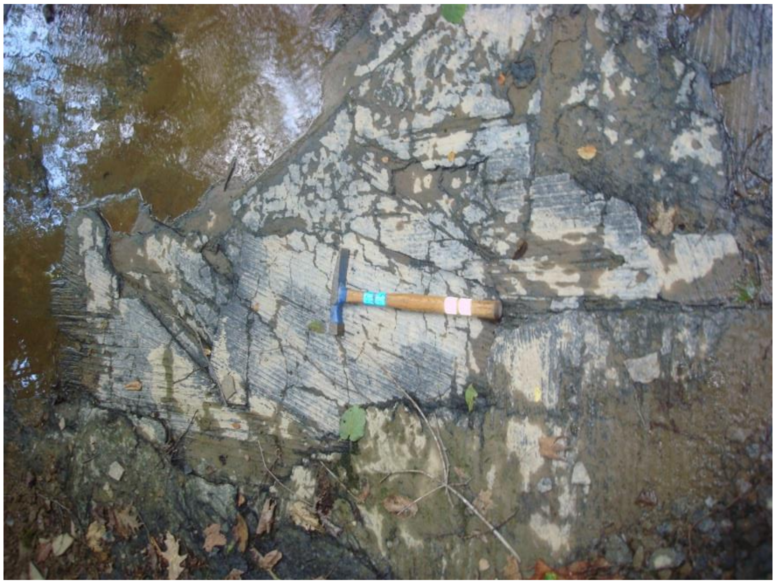

Figure 4-3. Fossilized tree impressions in the bed of an unnamed tributary to Crooked Creek in south central Armstrong County, PA

Discussion

The Stop 4 discussion will focus on which mechanism (autochthonous or allochthonous) appears more reasonable for the Cochrans Mill exposure based on regional observations related to the Upper Freeport split seam area shown in Figure 4-2. Note the location of the Toms Run Mine on Figure 4-2. Bragonier (2016) in the accompanying guidebook for the 2016 Field Conference of Pennsylvania Geologists develops an argument for a catastrophic single-event deposit overlying the Upper Freeport coal within a portion of the Toms Run Mine reserve area. This deposit is known as ***draw rock***, which is a mining term for rock in the immediate roof that falls during or shortly after mining. Overlying this single-event deposit (draw rock) are large numbers of fossilized logs and broken branches that appear very similar to those at Stop 4 (See Figure 4-4).

Figure 4-4. Fossilized tree impressions in the roof of Toms Run Mine northeast of Blairsville, PA in southeastern Indiana County, PA

A synopsis of the evidence for catastrophic deposition at the Toms Run Mine site is listed below and is subdivided into paleontological and sedimentological documentation. These will be discussed at Stop 4.

Paleontological evidence includes:

- Abundant remnants of branches and/or tree trunk material, the size of which is indicative of a higher energy flow regime. While most of this plant material has been deposited sub horizontally, a small percentage exists at high angles to bedding.
- The cross-sectional view of an entire compressed tree trunk partially filled with sediment deposited within the draw rock.
- The existence of large, randomly oriented tree trunks in the roof rock overlying the draw rock deposit interpreted as a floating log jam that constituted the final depositional facet of the catastrophic event.

Sedimentological evidence includes:

- The deposit is aerially restricted. There is a thickness variation from zero to ten feet and back to zero over a relatively short distance and the deposit exhibits a lineal geometry.
- A churned, chaotic texture of the draw rock highlighted by numerous small scale slickensides.
- Color banding largely restricted to the upper half of the deposit interpreted as a result of diffraction waves created by an initial catastrophic deluge.
- The existence of a large-scale current crescent (indicative of high-regime flow) in an outby section of the Toms Run Mine, the current direction of which matches the lineal geometry of the draw rock deposit.

Also note on Figure 4-2 the location of the Smith 47 surface mine, which is approximately 30 miles northwest of the Toms Run Mine. It may be seen that he upper Freeport coal is within the in-seam split zone shown in Figure 4-2. Overlying the Upper Freeport coal is approximately 1 foot of a soft clayey draw rock that appears very similar to the draw rock in the Toms Run Mine. The presence of draw rock in both mines prompted speculation that the single event deposit in Toms Run may be a more regional event somehow associated with the Upper Freeport split seam zone.

At the Cochrans Mill site, which is more centrally located within the Upper Freeport split seam zone, there are 47 inches of inter-bedded shale and coal that contain abundant fossilized trees and branches overlying the Upper Freeport split seam. There are numerous drill holes located within and adjacent to the Upper Freeport split zone and an attempt was made to develop an isopach map of the draw rock along the strike of the split zone. For various reasons (described in the 2016 Guidebook) the attempt was problematic. However, this attempt did yield several important generalizations including the following:

- There are numerous data points within the seam split zone that contain a lithology similar to draw rock overlying the split Upper Freeport seam.
- The thickness of the draw rock within the split zone increases toward the center.
- There is very little or no draw rock above the Upper Freeport coal adjacent to the split zone.
- The thickness of the draw rock decreases from southeast to northwest along the strike of the split zone.
- The width of the split zone thins substantially into Butler County (i.e. to the northwest).

The above observations suggest the Toms Run Mine draw rock has a more regional extent that is related to the northwest-striking seam split zone. However, based on the available data, which includes drill holes, deep mine observations and surface exposures, conclusions regarding depositional trends are difficult, if not contradictory.

Exposures at the Cochrans Mill area are conflicting. Here a substantial thickness of draw rock (47 inches) overlies the split coal seam and its similarity in appearance to the Toms Run Mine deposit would suggest that it was catastrophically deposited (compare Figure 4-3 to Figure 4-4). However, there is a problem. The partings within the split Upper Freeport seam are no different in appearance than the draw rock above the seam, yet they are intercalated with bands of apparently in-situ coal. The band thicknesses vary but generally increase toward the bottom of the seam. Within the split Upper Freeport seam, then, it may either be assumed there were multiple allochthonous events that interrupted a stable peat forming environment or a peat-forming swamp was intermittently subjected to water stressed conditions, resulting in multiple "clastic swamp" conditions. This amounts to a conundrum. While the latter option seems more reasonable, that is, there were not multiple catastrophic events, the similarity of the draw rock in the Toms Run Mine, the Cochrans Mill exposure and the Smith 47 surface mine cannot be summarily dismissed.

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STOP 5: PINE CREEK MARINE ZONE

US 422 BYPASS, KITTANNING

STOP LEADERS – JOHN A. HARPER, PENNSYLVANIA GEOLOGICAL SURVEY, RETIRED
BILL BRAGONIER, COAL GEOLOGIST, RETIRED

CAUTION

US ROUTE 422 IS A HEAVILY TRAVELED, HIGH-SPEED, DIVIDED HIGHWAY. STAY AS FAR OFF THE ROAD AND AS CLOSE TO THE ROADCUT AS YOU CAN!

Introduction **(40.808570, -79.489449)**

Stop 5 occurs on the onramp from PA 28/66 (from New Bethlehem) to US 422 East (Figure 5-1). The rocks exposed at Stop 5 are part of the Glenshaw Formation, the lower unit of the Late Pennsylvanian Conemaugh Group (Figure 5-2). In Pennsylvania, the Glenshaw contains four regionally extensive marine zones, including, from oldest to youngest, the Brush Creek, Pine Creek, Wood Run, and Ames. A fifth marine zone, called Nadine in Pennsylvania, is known from limited outcrops, despite being known as the eastern equivalent of the extensive Cambridge marine zone of eastern Ohio.

Figure 5-1. Location of Stop 5 at the US 422 bypass around Kittanning and other locations mentioned in the text

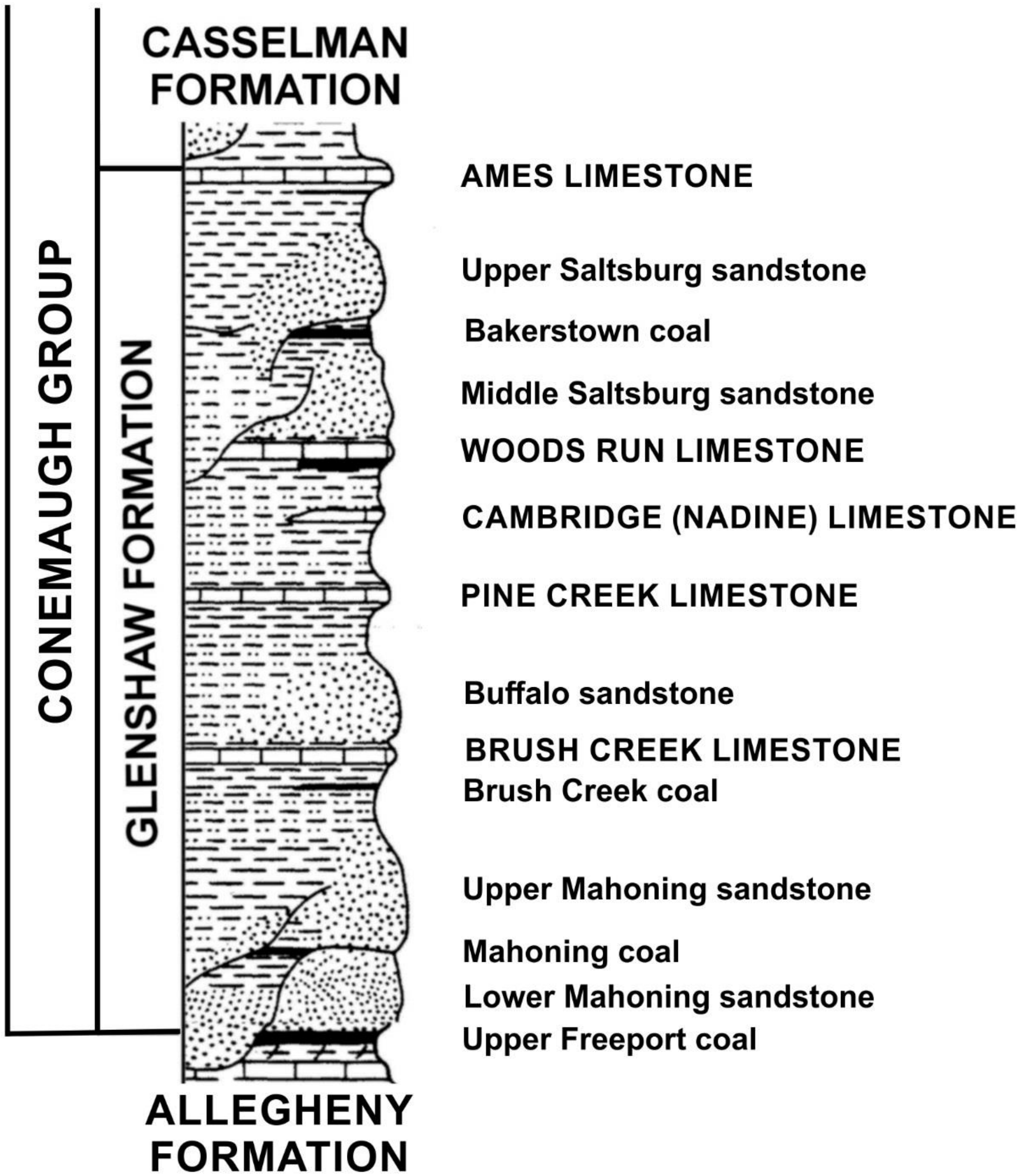

Figure 5-2. Generalized stratigraphic section of the Glenshaw Formation in western Pennsylvania. The marine intervals (in caps) are important marker horizons throughout the formation (modified from Harper and Laughrey, 1987).

The roadcut at Stop 5 exposes mostly Pine Creek and adjacent strata (Figure 5-3), although the Brush Creek limestone occurs near the base of the section along the bypass between the two onramps and the Woods Run marine zone occurs near the top of the outcrop above the Pine Creek. The Pine Creek is also exposed along the onramp from PA 28/66 to US 422 West, across the barrier from Stop 5, but the sharp curve prohibits its use as a field stop.

Figure 5-3. Photo of the Pine Creek limestone and associated rocks at Stop 5. The curvature is paleotopography rather than structure.

Pine Creek Marine Zone

White (1878) named the Pine Creek limestone for 2 ft (0.6 m) of "dove colored", fossiliferous limestone exposed in northern Allegheny County, PA. As a result of early miscorrelations (White, 1903; Stevenson, 1906), for years the Pine Creek was regarded as a synonym for the Cambridge Limestone. Because the name Cambridge had priority over the name Pine Creek, Pine Creek was dropped in Ohio and West Virginia, and even in some parts of Pennsylvania (e.g., Butts, 1906, who called the marine zone "Cambridge (Pine Creek)" here in the Kittanning area). We now know that the Pine Creek correlates to the Upper Brush Creek of Ohio and the Cambridge correlates to Pennsylvania's Nadine (Busch, 1984; Busch and Rollins, 1984) (Figure 5-2).

The Pine Creek limestone tends to be variable, ranging from gray and argillaceous to quite arenaceous. In its most form, the Pine Creek marine zone typically is a richly fossiliferous, shallow marine argillaceous limestone sandwiched between calcareous marine shales of various thickness. It is laterally extensive, being well known from western Pennsylvania, eastern Ohio, northern West Virginia, and western Maryland (Seaman, 1941; Busch, 1984). Because of its regional extent, lithology, and fossil fauna, it is an important marker bed for stratigraphic correlations within the Upper Pennsylvanian, for assessing regional sea level cycles (e.g. Busch & Rollins, 1984), and for use in correlating allocyclic (eustatic) events between the Appalachian Basin and Carboniferous basins in the mid-continent (e.g. Heckel et al., 1998; 2011).

Lithologically, the Pine Creek limestone typically occurs as a gray to greenish gray, argillaceous, sometimes arenaceous, fossiliferous limestone containing phosphate granules. The limestone often is sandwiched between dark gray to black, calcareous, clay shales containing marine fossils and siderite nodules. The fresh surface commonly is dark gray, whereas the weathered surface is a buff color (Figure 5-4). It is sometimes so arenaceous that the rock seems to be more sandstone than limestone (Richardson, 1932). We found the limestone at Stop 5 to be 12 in (30.5 cm) thick, although it appears to vary along the outcrop. Internal stratification of the limestone is very apparent. In most of the Glenshaw marine limestones, several layers can be discerned based on the presence of phosphatic nodules (lag deposits) and the presence of corals. At Stop 5, at least four separate layers can be distinguished within the Pine Creek limestone, separated on the basis of bedding, fissility, and frequency of fossils (Figure 5-4). The associated calcareous marine shales often include compact nodules and sand lenses as well as siderite nodules and fossils. In many places, the lower marine shale interval is thin or absent and the limestone lies directly on the Buffalo sandstone interval. At Stop 5, the Buffalo interval consists of about 25 ft (7.6 m) of predominantly gray, silty shale containing thin layers of siderite nodules. The limestone is underlain by 8 in (20.3 cm) of dark gray, homogeneous shale displaying a blocky fracture pattern and 22 in (55.9 cm) of light grayish green claystone. The claystone is an underclay, but all evidence of coal is missing at this locality. Shaak (1975) measured the Pine Creek interval in the hillside behind the Cadet Restaurant south-southeast of Stop 5 (Figure 5-1), where he documented a coal 22 ft (6.7 m) below the limestone, thereby showing one of the effects of paleotopography on the Pine Creek-Buffalo interval in the Kittanning area.

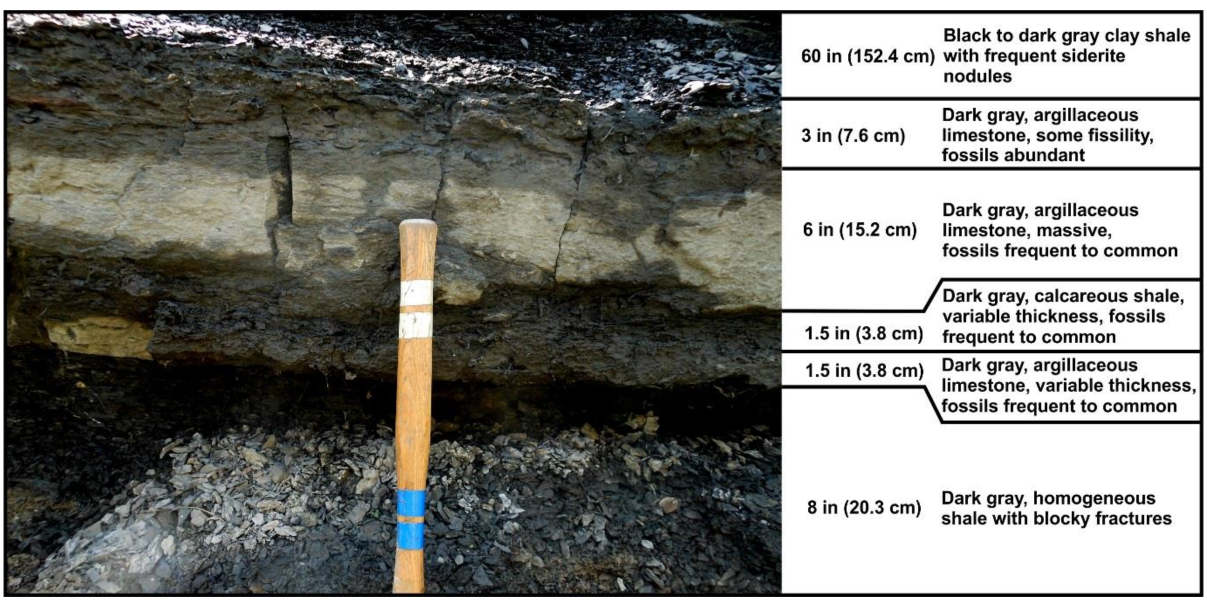

Figure 5-4. Details of the lithology of the Pine Creek marine zone at Stop 5.
Hammer handle for scale; distance between blue and white tape = 6 in (15.24 cm).

The Pine Creek marine zone typically is a prolific fossil producer, yielding numerous excellent specimens, although no one group is dominant (Seaman, 1941). Where it is fossiliferous, the limestone commonly contains horn corals, crinoid debris, a variety of brachiopods, some cephalopods, and other fossils that lived in an open marine environment. Although some of the mollusks, particularly the gastropods and bivalves, can be found in the limestone, they are far more commonly found in the shales because most were shallow water dwellers (upon walking up to the outcrop for the first time, we found two good specimens of the gastropod Shansiella just begging to be pulled out of the matrix). “Shark” teeth are not common, but they typically are found in the lower shales. Trace fossils also occur within the marine zone, including resting traces and assorted burrows. We found a nice example of what appears to be a cluster of Asterosoma burrows lying along the side of the road at Stop 5.

Other Marine Zones

The Brush Creek limestone is exposed at the lower (northern) end of Stop 5 (Figure 5-5A) and along the west side of PA Route 66 just above road level south of the exit ramp to US 422 Eastbound (see Figure 5-1) where it is almost entirely obscured by talus. Where exposed in the vicinity of Stop 5, the Brush Creek limestone contains a relatively sparse marine fauna, mostly fragmented corals, crinoids, and brachiopods. The corals typically are exposed in either transverse or longitudinal cross section, and so are unmistakable. Unlike most Brush Creek localities, the limestone is not sandwiched between dark-colored marine shales containing lots of fossils.

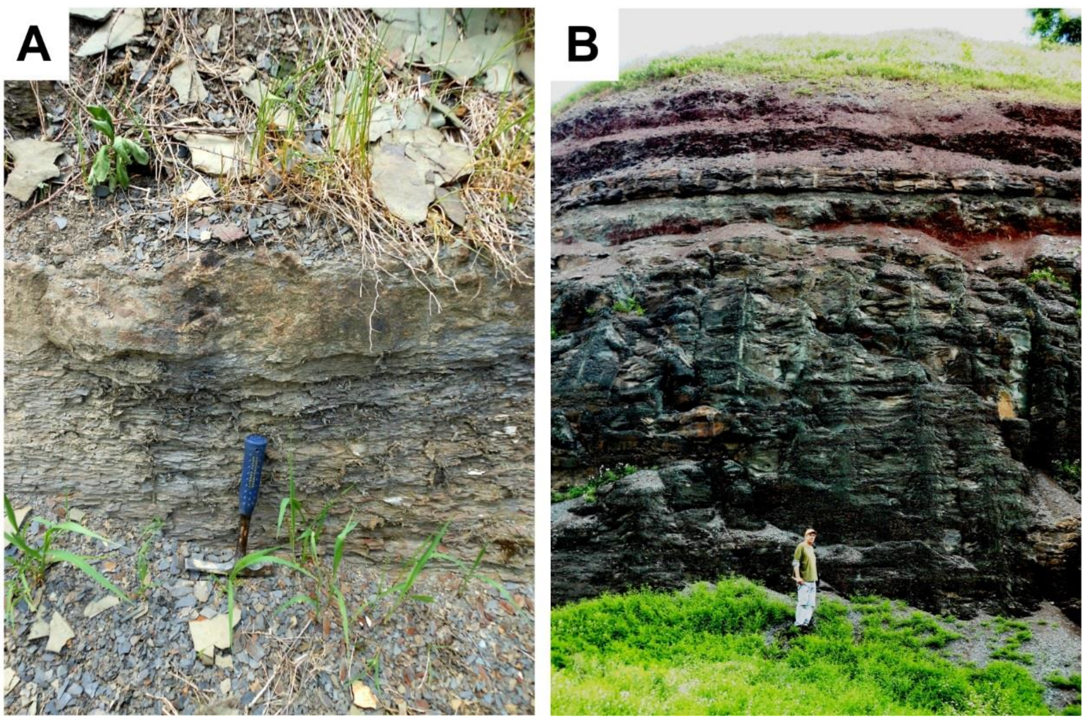

Figure 5-5. Other Glenshaw marine zones exposed at Stop 5. A – The Brush Creek limestone is exposed at the lower (northern) end of the onramp. Estwing rock hammer for scale. B – The Woods Run marine zone is exposed near the top of the roadcut, too high to get an accurate measurement. Notice the reddish or reddish-brown beds both above and below the limestone and its dark-colored marine shales. Geologist, 6 ft 2 in (1.9 m) tall, for scale.

The Woods Run marine zone, a fossiliferous marine limestone lying between the Pine Creek and Ames (Figure 5-2), is exposed near the top of the roadcut at Stop 5 (Figure 5-5B). The Woods Run commonly is overlain by dark gray shales with marine fossils. Burke (1958) named the Carnahan Run Shale for 5 ft (1.5 m) of dark gray, fossiliferous, marine shale separated from the Woods Run limestone by 21.5 ft (6.6 m) of reddish-brown shale carrying plant fragments. Wells (1983), however, determined that the Carnahan Run was merely a shale facies of the Woods Run. As you will see at Stop 5, the Woods Run marine zone is both underlain and overlain by reddish or reddish-brown beds (Figure 5-5B), probably the same beds Burke (1958) described as separating the Woods Run and Carnahan Run units.

On the Nature of Lower Conemaugh Unconformities

The on- and off-ramps to US 422 at Stop 5 provide an excellent three-dimensional exposure of the Pine Creek marine zone. One of the most significant features at this site is the undulating surface over which marine transgression strata were deposited. Immediately below the marine interval is a well-developed paleosol soil horizon that displays a high degree of lateral variability over a short distance. At the paleotopographic summit on the north end of the onramp, the clay is mottled red, green, and gray and contains abundant calcite nodules, mostly oriented parallel to the well-developed slickenlines within the clay. The red and green color disappears down the paleotopographic slope to the south, fading into light gray, but calcite nodules, still mostly aligned on slickensided surfaces, exist in the gray paleosol for some distance before disappearing downslope. In the lowest paleotopography visible at the site, the paleosol is a medium gray color and contains no visible calcite and minimal slickensides.

The mottled red and green and translocated calcite deposits are indicative of vertisols formed in dry-subhumid to semiarid climates (Cecil, 2003). Some degree of rainfall seasonality is required to form the slickensides. However the local paleotopography has obviously influenced paleosol development (i.e., a paleocatena). A ***paleocatena*** is a group of paleosols on the same buried land surface whose original soil properties differ owing to their different original landscape position and soil water regimes (Valentine and Dalrymple, 1975). The lateral changes in paleosol properties observable at this stop are best explained by lateral changes in soil moisture controlled by landscape position. Similarly, Fedorko (1998) equated lateral variations in Late Pennsylvanian organic and mineral paleosols over a 79-mi (127-km) long transect in northern West Virginia to a paleocatena. The underclay beneath the Pine Creek marine zone at Stop 5 fits the definition of a paleocatena on a micro scale, as well as the definition of a toposequence. A ***toposequence*** is a type of catena in which the differences among the soils result almost entirely from the influence of topography because the soils in the sequence all share the same parent material and have similar conditions regarding climate, vegetation, and time. The catena concept is similar to that of a toposequence, except that in a catena the member soils may or may not share a common parent material.

The maturity of soil development over an established paleotopographic surface prior to the Pine Creek transgression hints that Lower Conemaugh unconformities are temporally substantial. In eastern Ohio, where the Mahoning coal has been extensively mined, it is common to see the undulating surface of the Brush Creek marine zone in pre-law Mahoning surface mines. The typical interval between the Mahoning and Brush Creek horizons is approximately 50 to 60 ft (15 to 18 m). However, drilling by the East Fairfield Coal Company in eastern Carroll and northern Jefferson Counties, Ohio, demonstrates the extreme variability of this interval. Figure 5-6 shows this interval in four closely spaced drill holes from northern Jefferson County where it varies from 60 ft (18 m) to over 100 ft (30.5 m). A 100-ft (30.5-m) Brush Creek-to-Mahoning coal interval requires the deposition and subsequent erosion of at least 40 ft (12 m) of sediment. In addition, as illustrated, one of the eroded deposits was a red paleosol over 13 ft (4 m) in thickness and another was a thin marine/brackish transgressive unit known as the Rock Camp marine zone. Additionally, Tim Miller, geologist for the East Fairfield Coal Company (personal communication), has mapped the Brush Creek-to-Mahoning interval immediately to the west of the cross section in Figure 5-6 and found that the interval decreases to as little as 19 ft (5.8 m), revealing a local relief of over 80 ft (24 m) after compaction and lithification.

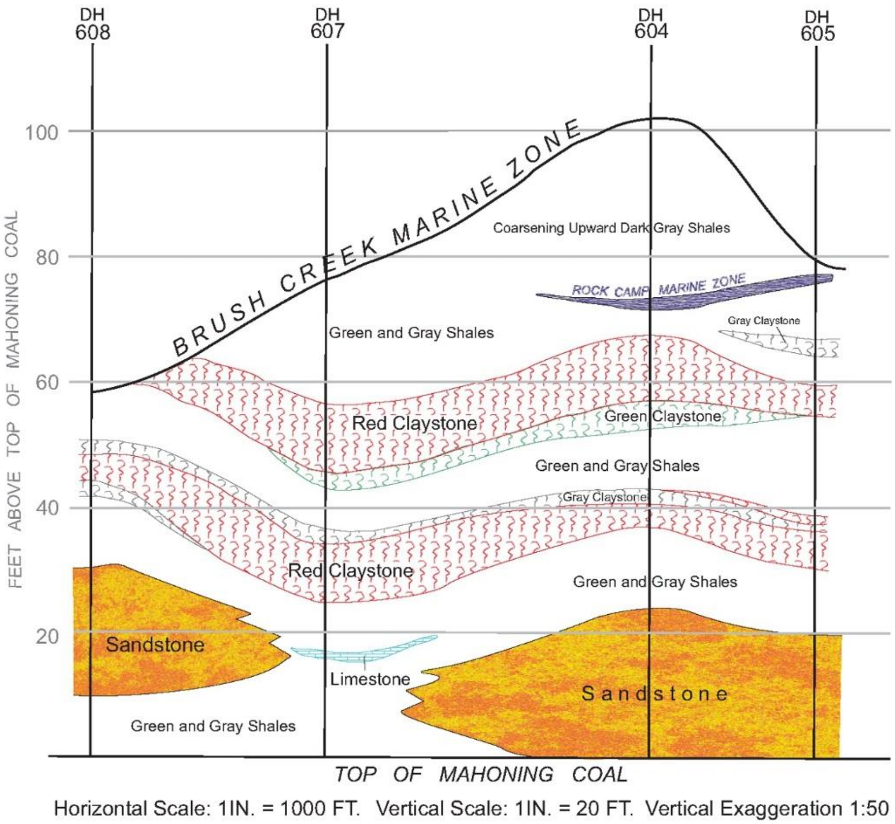

Figure 5-6. Cross-section defined by four diamond drill holes in Northern Jefferson County, Ohio, where the Brush Creek marine zone-to-Mahoning coal interval increases from a normal interval of 50 to 60 ft 15 to 18 m) (DH 608) to over 100 ft (30.5 m). The uncommonly high interval exposes stratigraphic units normally eclipsed, suggesting the unconformable surface immediately beneath the Brush Creek transgression has substantial temporal significance.

The point of this discussion is that at least the two lowermost Glenshaw marine zones have transgressed over very mature erosional surfaces. The amount of relief on the Brush Creek surface in Ohio indicates that a formidable amount of material, including a thick soil horizon, was deposited and eroded. It is suggested that the temporal interval involved was quite substantial. This insight is only possible due to the local “lifting off” of the Brush Creek marine zone, exposing rarely seen strata. What is not known, of course, is how much more strata were deposited and eroded for which there is no record.

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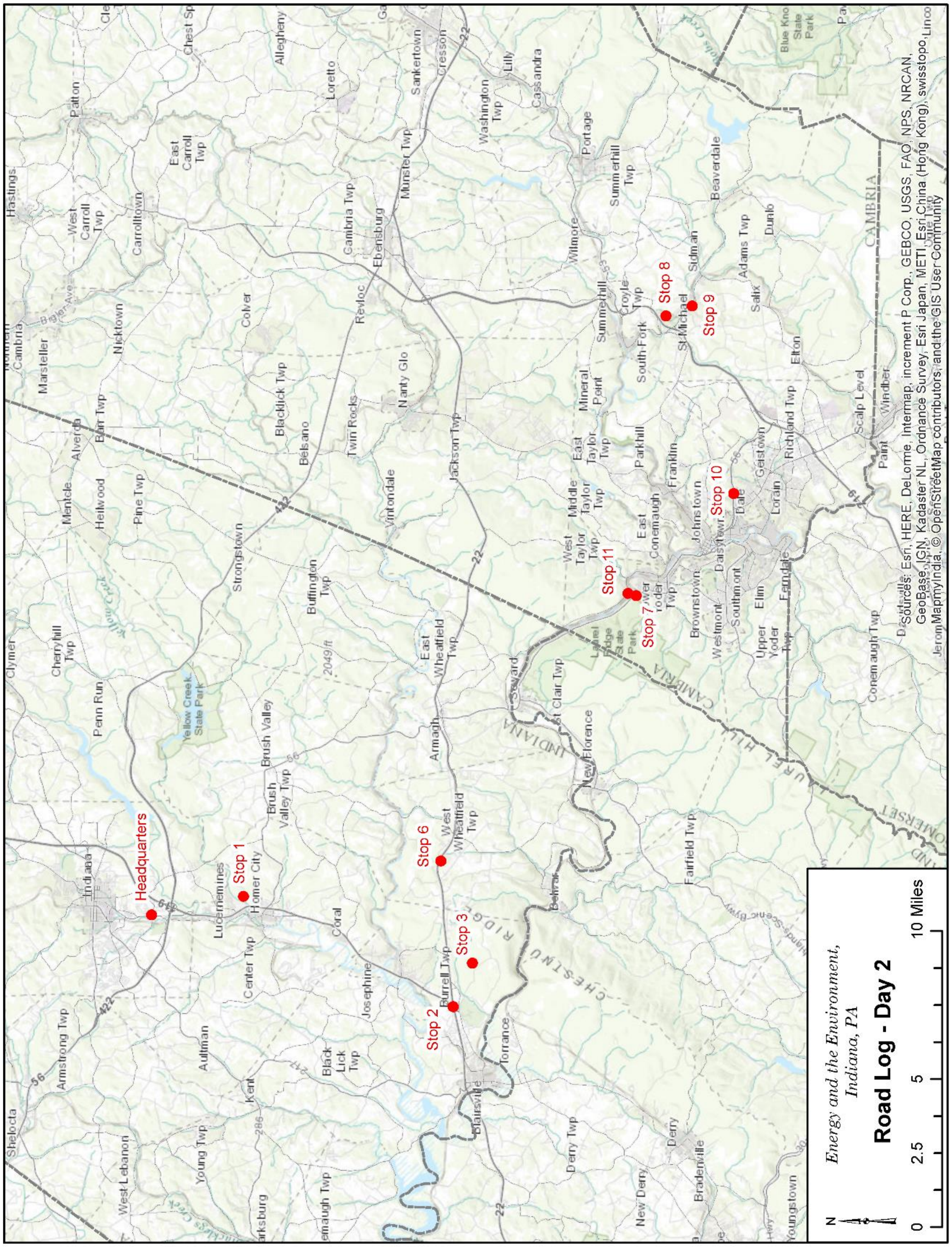
ROADLOG – DAY 2



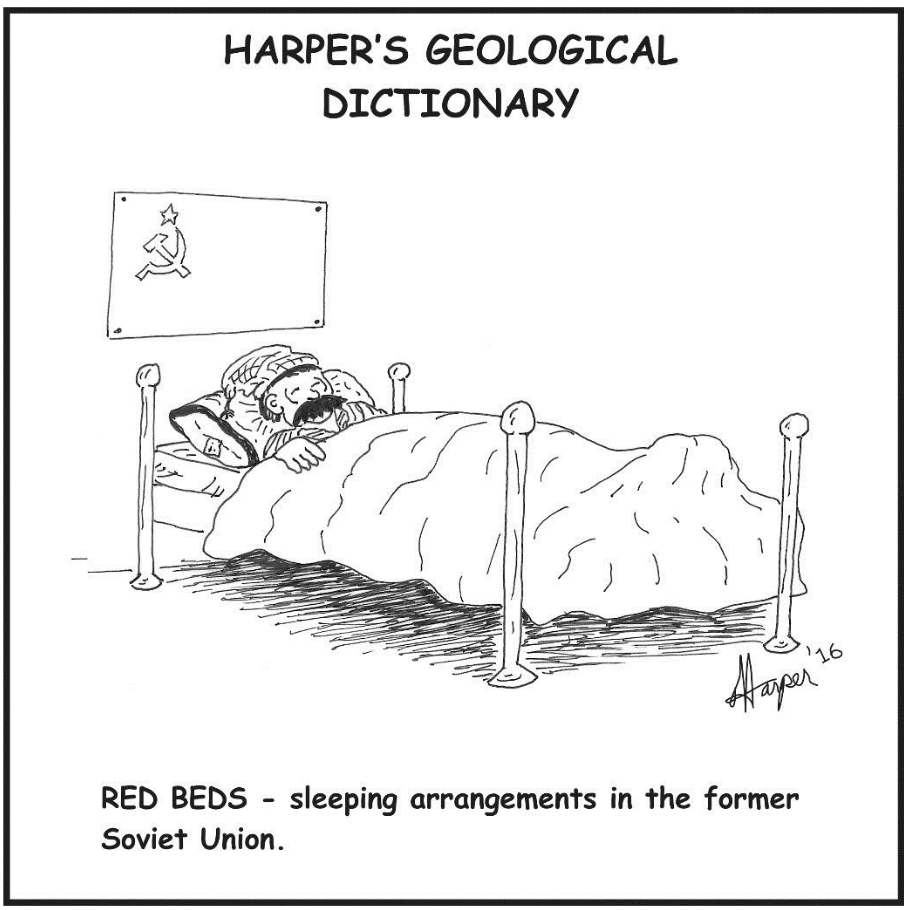
Segment	Cumulative	Day 2 Road Log Description
	0	Drive through to the back of the Park Inn Parking lot and turn right onto Indian Springs Road
0.1	0.1	At traffic light turn left onto Wayne Avenue
0.2	0.3	Traffic Light at intersection with Old US Route 119 go straight
1.3	1.6	merge with US Route 119
0.5	2.1	Cross Over Railroad
0.1	2.2	Cross over Two Lick Creek
0.7	3.0	Pass Lucerne Road
0.5	3.5	Pass Lucerne Bony Pile on left
0.5	4.0	Traffic light at intersection with PA Route 56 (Ridge Avenue)
1.6	5.6	Hoodlebug Trail on Right. The Hoodlebug was a trolley that ran between Indiana and Homer City on the Pennsylvania Railroad. The trail was originally part of the Catawba Path, a Native American trail that ran from the Carolinas to Upstate New York.
0.8	6.4	Coke Oven Lane - Bee Hive Coke Ovens preserved by Indiana Historical Society
0.6	7.0	Traffic Light at intersection with Powerplant Road / Luciusboro Road
0.5	8.5	Slag pile on left
0.1	8.6	Blacklick Creek
0.8	9.4	Traffic Light intersection with Main Street in Blacklick - look for the grayish looking redbeds of the Conemaugh in the southbound lane on the west side (right side).
1.6	11.0	Get in left lane
0.4	11.4	Take left to US Route 22 East to Ebensburg
0.3	11.7	Follow ramp signs to Ebensburg
0.4	12.1	Morgantown Sandstone of the Casselman Formation, Conemaugh Group - Pennsylvanian Age
1.5	13.6	View of Homer City Power Plant on Left
1.8	15.4	Summit of Chestnut Ridge
0.4	15.8	View of Conemaugh Power Plant to the right
0.7	16.5	Go past Clark Road: *Change to;* Go Past First Sign for Clark Rd
0.4	16.9	Turn Right onto Clark Rd.
0.1	17.0	Turn left and park in the grassy median

Segment	Cumulative	Stop 6 Upper Freeport Flint Clay (40.45363, -79.12365)
	17.0	Pull back onto access road
0.1	17.1	Reenter US Route 22 East
5.0	22.1	Take Brush Valley/ Armaugh exit to PA Route 56
0.2	22.3	Turn left towards Johnstown PA Route 56 East
0.1	22.4	Take note of Bull Dogs Hot Dogs with over 22 toppings for hotdogs and the location that has kept countless geologists fed over many, many years.
		Get stuck behind very slow coal trucks
2.3	24.7	Traffic light - Go straight past intersection with Charles Road/ Power Plant Road
0.1	24.8	Cross Over Conomaugh River *Should be;* Conemaugh River
0.5	25.3	Seward
0.1	25.4	Junction with PA Route 711 - stay on Route 56
0.9	26.3	Laurel Ridge State Park
0.6	26.9	Conemaugh River Gap
1.6	28.5	Westmoreland / Cambria County boundary - core of Laurel Hill anticline exposes Devonian Catskill Formation
2.0	30.5	Conemaugh Gap Scenic Overlook - marker states that the Conemaugh Gap is the deepest gap east of the Mississippi. Actually, it is not even the deepest in Pennsylvania. See Pennsylvania Geology Article "The Geologist Who went Into a Narrows But Came Out Through a Gorge" by Stuart Reese, vol. 38, no.2/3
0.7	31.2	Turn left Parking in empty lot
		Stop 7 Mississippian - Pennsylvanian Unconformity (40.35998, -78.95179)
	31.2	Exit parking area and turn left back onto PA Route 56
0.1	31.3	Entering Johnstown - PA Route 56 - Hawes Pike becomes Harold Avenue
0.1	31.4	Turn Right to follow PA Route 56 East - now Strayer Street - through Johnstown - follow road signs closely due to numerous turns and street name changes. Will stay on PA 56 East through Johnstown.
0.1	31.5	Turn left to stay on Route 56 - Strayer Street
0.2	31.7	Veer right to stay on Route 56 East - Strayer Street
0.1	31.8	Traffic light at Laurel Avenue intersection - go straight

Segment	Cumulative	Description
0.5	32.3	Traffic light - turn left onto Fairfield Avenue - to stay on Route 56 East
0.1	32.4	Route 56 East/ Fairfield veers to the left
0.4	32.8	Pass under railroad *Could say;* Railroad overpass instead, just a suggestion.
0.1	32.9	Turn right at traffic light at intersection with Broad Street. Stay on PA Route 56 East (PA Route 403 South)
0.9	33.8	PA Route 56 East/ 403 South curves to the right to merge with Roosevelt Boulevard.
0.3	34.1	Pass under railroad
0.2	34.3	Upper Kittanning Coal, Allegheny Formation, Pennsylvanian
0.1	34.4	Veer left and cross over Stoney Creek River
0.2	34.6	Inclined Plane on left. Stay straight on PA Route 56 South
0.2	34.8	Back across Stoney Creek River and then back across again - Route 56 now Johnstown Expressway
0.7	35.5	Lower Allegheny Coal exposure
1.5	37	Widman Street Exit
1.0	38.0	Middle Kittanning shale, Washingtonville Shale, Allegheny Formation, Pennsylvanian
1.4	39.4	Walters Avenue exit - more Allegheny Formation rocks
0.5	39.9	Get in left lane, take US Route 219 North to Ebensburg
5.5	45.4	Take exit for PA Route 869 East to St. Michael / Sidman.
0.2	45.6	Take right onto PA route 869 East (Locust Street) to St. Michael
0.3	45.9	St. Michael
1.1	47.0	Turn left on Lake Road (signs for Johnstown Flood National Museum). Cross Little Conemaugh River
0.3	47.3	Coal Miners Memorial Museum on left
0.9	48.2	Bus stop/ Pull off parking lot on right
		Stop 8 Johnstown Flood / South Fork Dam (40.34712, -78.77245)
	48.2	Load back on buses
0.4	48.6	Turn right on entrance road to Flood Museum, loop around parking lot
0.3	48.9	Turn left back onto Lake Road
0.4	49.3	Parking pull off, pick up spot
1.3	50.6	Turn right back onto PA Route 869 (Locust Street)
0.3	50.9	Turn right into Berwind Wayside Festival Park, Adams Township Volunteer Fire Company #2, St. Michael

Segment	Cumulative	**Stop 9 Lunch Berwind Park / St. Michael (40.3343, -78.76608)**
	50.9	Load back in buses
0.1	**51.0**	Turn right back onto PA Route 869 (Locust Street)
1.0	**52.0**	Get in left lane
0	**52.0**	Turn left onto US Route 219 South ramp
5.1	**57.1**	Take exit on right to PA Route 56 West - Johnstown Expressway
1.8	**58.9**	Middle Kittanning Coal, Allegheny Formation, Pennsylvanian
0.5	**59.4**	Washingtonville Shale, Allegheny Formation, Pennsylvanian
0.7	**60.1**	Take Widman Street exit on right
0.3	**60.4**	Bus parking on left just past Widman Street on on ramp
		Stop 10 Widman Street Exit Ramp (40.31293, -78.88572)
	60.4	load on buses and merge onto on ramp
0.1	**60.5**	Merge back onto PA Route 56 West (Johnstown Expressway)
1.5	**62.0**	Johnstown
0.5	**62.6**	Expressway ends. Follow signs for PA Route 56 West (Roosevelt Boulevard)
0.2	**62.8**	Pass the inclined plane
0.8	**63.6**	PA Route 56/ 403 veers left (now Broad Street)
0.7	**64.3**	Get in right lane
0.2	**64.5**	Continue straight on PA Route 403 North (Broad Street)
0.3	**64.8**	Turn right to stay on PA Route 403 North (Laurel Avenue). Cross over Conemaugh River
0.1	**64.9**	Turn left to follow PA Route 403 North (Cooper Avenue)
1.1	**66.0**	Veer left to follow PA Route 403 (Cramer Pike)
0.8	**66.8**	Buses pull off along road
		Stop 11 Loyalhanna Quarry (40.36607, -78.95234)
	66.8	load back on buses from quarry access road
2.2	**69.0**	Buses turn around
0.3	**69.3**	Indiana County
0.1	**69.4**	Murrysville Sandstone, Lower Mississippian gas producer
1.0	**70.4**	Crossbeds in the Loyalhanna Formation
0.4	**70.8**	Cramer
3.4	**74.2**	Take ramp on left to US Route 22 West

Segment	Cumulative	Description
1.0	75.2	Take exit ramp on right to PA route 56 Armaugh/ Brush Valley
0.3	75.5	Turn Right at end of ramp onto PA Route 56 West
6.2	81.7	Brush Valley - Brush Valley syncline mined for Lower Kittanning and Lower Freeport Coals
0.2	81.9	Intersection with PA Route 259
2.8	84.7	Turn Right onto PA Route 954 North to Indiana
0.8	85.5	Tide Road
1.5	87.0	Yellow Creek
1.1	88.1	Intersection with US Route 422
0.6	88.7	Two Lick Creek
0.8	89.5	Turn left on Indian Springs Road
0.8	90.3	**Turn right into Park Inn**



STOP 6: ROUTE 22 UPPER FREEPORT FLINT CLAY DEPOSIT

STOP LEADER – WILLIAM A BRAGONIER, COAL GEOLOGIST, RETIRED

Introduction **(40.45363, -79.12365)**

A roadcut on a turn-around ramp adjacent to US Route 22 near the Bolivar New Florence 7 ½ Minute quadrangle boundary (see coordinates) exposes brecciated flint clay deposits that exist at the horizon of the Upper Freeport coal seam. The flint clay is poorly exposed as a result the Pennsylvania Department of Transportation's efforts to cover the exposure, although numerous samples of the brecciated flint clay are available.

Coal seams within the Allegheny Group, and particularly the upper Allegheny coals, often end abruptly and are laterally equivalent to brecciated flint and semi-flint clays (Bragonier, 1989). Flint clays are a type of hard clay characterized by 1) a predominance of kaolinite, 2) a conchoidal fracture and 3) they are non-slaking (do not dissolute when immersed in water). Flint clays are part of a gradational continuum from plastic clays through semi flint and flint into the high alumina hard clays composed of aluminum hydroxide clay minerals including boehmite diaspore and gibbsite. The high-alumina clays are rare but flint, semi-flint and plastic clays are common in the coal measures of Pennsylvania. Table 6-1 describes the physical and mineralogical characteristics of the latter three clay types (Smyth, 1980).

The abrupt disappearance of upper Allegheny coal seams that are the apparent lateral equivalent of brecciated flint clay is a noteworthy observation in coal exploration drill holes. Figure 6-1 is a map showing the areal distribution of the Upper Freeport coal seam in central western Pennsylvania. The thick green line represents the coal/flint clay contact. In all observed instances, the flint clay is only present within approximately 2-3000 feet of the coal seam and thickens toward the coal seam. Typically, in drill holes within 1000 feet of an existing coal seam there is a 4:1 or 5:1 flint clay to coal ratio and the coal seam approximates the center of the flint clay section in drill holes aligned on a third datum.

Discussion

Bragonier (1989) summarized mechanisms for the genesis of flint clay deposits (reprinted in the 2016 Field Conference Guidebook) and concluded that flint clay deposits immediately adjacent to Allegheny and lower Conemaugh coal seams are a result of differential clay flocculation within lacustrine environments juxtaposed to coal swamps. The overall geometry exhibited in Figure 6-1 suggests a lacustrine environment surrounded by coal swamps. Due to the presence of limestone beneath the underclay of Upper Allegheny coal seams (and laterally correlative units) the chemistry of lake waters would likely be at least neutral if not alkaline. Near the peripheral margins of these lakes, however, organic acids introduced along the swamp margins would overwhelm the water chemistry. The effect of organic acids on the flocculation of clay particles is well documented. Hopkins (1898), Stout and others (1923), Hodson (1927), Schofield and Sampson (1954), Falla (1967), Keller (1968), Chukhrov (1970), Staub and Cohen (1978), and Keller (1981). Consequently, as peat accumulates, flocculated clay particles correspondingly amass along the lake margins and roughly approximate the thickness of the peat.

However, since the compaction ratio of peat is much greater than that of clay, the resultant flint clay to coal ratio seen in drill holes is on the order of 4:1 or 5:1 (Bragonier, 1989).

Table 6-1. Properties of the Flint Clay Facies (from Smyth, 1980)
Data compiled from Patterson and Hosterman (1960, p. F52-F58), Keller (1968, p. 113-115), Keller (1976, p. 262), Keller (1978a, p. 15, 19), Keller (1978b, p. 239, 241), and Keller (1982, p. 150-151).

CHARACTERISTICS	CLAY TYPE		
	FLINT	SEMI-FLINT	PLASTIC
FRACTURE	Conchoidal	Rough, irregular approaching conchoidal	Rough, irregular
HARDNESS	3	2-3	Softer than semi-flint
GENERAL CLAY MINERALOGY	85% kaolinite 15% illite+ mixed layer clays	60-85% kaolinite	60% kaolinite 40% illite+ mixed layer clays
NATURAL PLASTICITY	Almost no plasticity unless very finely ground with water	Little plasticity unless finely ground with water	Considerable plasticity when wet
SLAKING CHARACTERISTICS	Resistant to slaking	Intermediate between flint and plastic clays	Breaks down rapidly into small particles in water
SLICKENSIDES	Very few	Abundant Diversely oriented	Abundant Becoming sealed upon weathering and clay becomes homogeneous in appearance
S.E.M. CHARACTERISTICS	Kaolinite plates or flakes can be seen to be well-developed, interlocking, inter-grown, dense and randomly oriented	Shows some swirl pattern composed of overlapping curved kaolinite flakes. Flakes are less curved than in plastic clays	Shows platy, anhedral bent, and twisted flakes with a swirl pattern

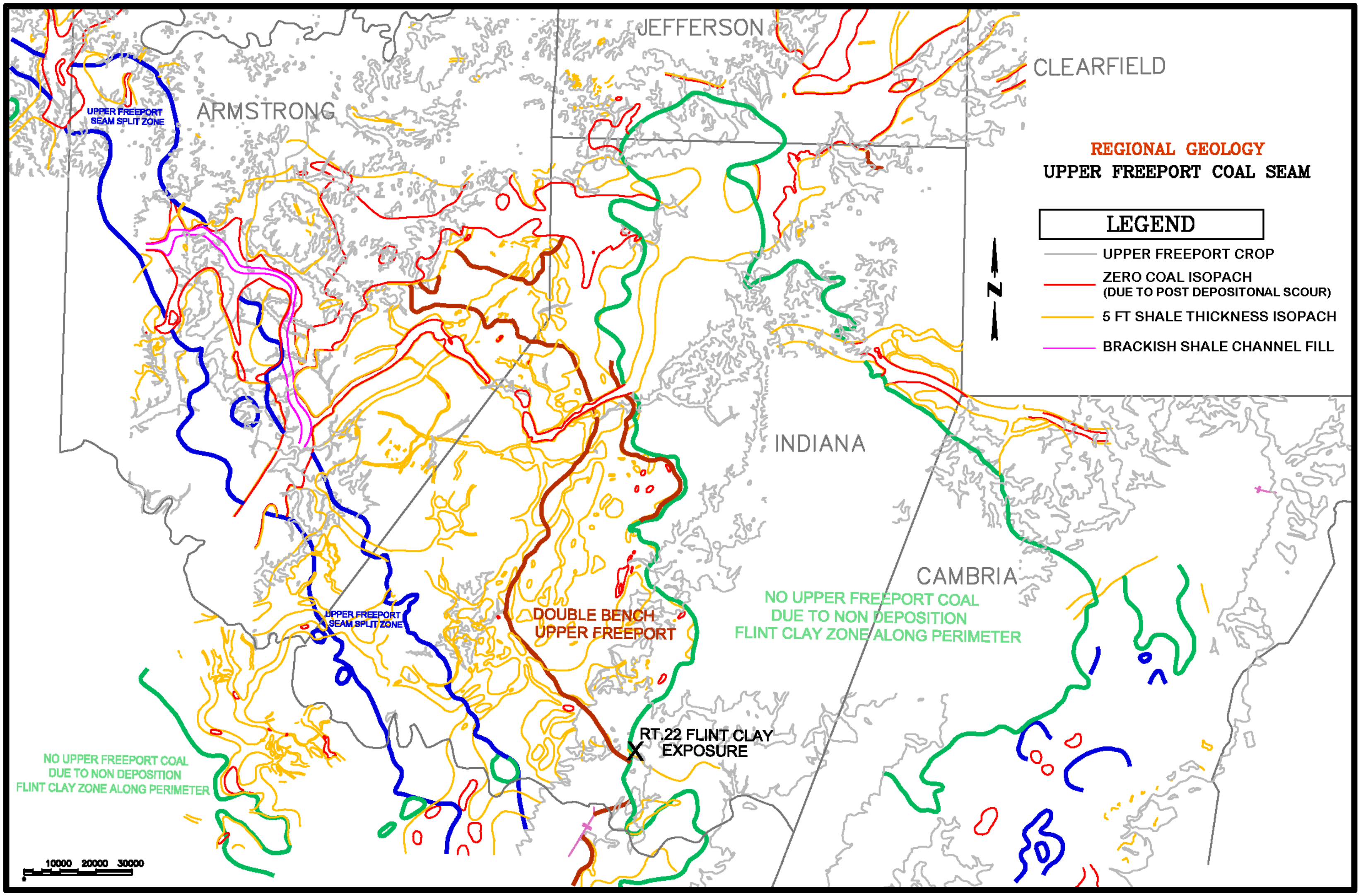


Figure 6-1. Regional geology of the Upper Freeport coal in central western Pennsylvania. Included on the map are lines showing the depositional limit of the coal with the flint clay zone along the perimeter, the in-seam split line, the zero isopach of the coal due to post depositional erosion by channel sandstone and the limit of the double bench coal. Also noted is the location of the Route 22 flint clay exposure.

The flocculation hypothesis is supported by the observation that many of the breccia fragments exhibit thin laminations. This is inconsistent with in-situ leaching on paleotopographic highs, the other primary origin of flint clays. Figure 6-2 is a sample taken from the road cut at STOP 6 that shows the characteristic brecciation observed in flint clays that are laterally equivalent to coal seams. Bragonier (1989) suggests this brecciation, which was formerly attributed to shrinkage and drying, is caused by loading of the flint clay prior to complete lithification. Conchoidal fracture is a result of isotropy, and a substance in a partially lithified gel-like state would exhibit the type of brecciation observed in flint clays with the accumulation of an overlying sediment load considering it would contain virtually no shear strength. In fact, the matrix material between brecciated flint clay fragments observed in drill holes and surface exposures is lithologically identical to the overlying sediment. It has simply been squeezed and slumped into the flint clay. It may also be demonstrated from surface exposures that sedimentary slumping occurred early after several feet of material had accumulated on top of the clay and that the flint clay was not sufficiently lithified at the time of slumping to incorporate underlying units in the slump.

Figure 6-2. Sample of brecciated flint clay from the roadcut at STOP 6. The length of the scale bar is three inches. Note that several of the individual fragments are thinly laminated indicating that they were deposited in a sub-aqueous environment of deposition.

Figures 6-3a and 6-3b are images taken in a surface mine on the Upper Freeport coal seam southeast of the town of Indiana, PA at 40° 34’ 22” N/ -79° 06’ 52” W. Figure 6-3a shows the Upper Freeport coal being mined on the western side of the pit. The coal is approximately 5 feet thick. Figure 6-3b shows an entire high wall composed of brecciated flint clay on the eastern end of the pit. The flint clay is also highly slumped as evidenced by the high angle fracture planes. Note that the thin Mahoning coal expands the length of both photos immediately above the slumped clay indicating that the slumping was pre-Mahoning deposition. The intense amount of slumping associated with the brecciated flint clay occurs as a result of the flint clay’s lack of shear strength. It is this slumping that prevents a field observation of the coal grading into the flint clay.

Figure 6-3a. Western side of Upper Freeport surface mine in central Indiana County, PA. The coal, which is approximately 5 feet in thickness, had not been removed at the time the image was taken. To reference to Figure 6-3b, note the angled fracture above the coal at the far right (eastern end) of the image. Also note the carbonaceous shale (dark band) at the Mahoning horizon in the high wall.

Figure 6-3b. Eastern side of Upper Freeport surface mine in central Indiana County, PA. The entire eastern high wall is composed of slumped flint clay (note the high-angle fracture planes). To reference to Figure 6-3a, note the western dipping fracture above the loader that is also visible in Figure 6-3b. Also note the carbonaceous shale (dark band) at the Mahoning horizon in the high wall. Its continuation over the underlying slumped interval indicates that the deformation is soft sediment and not structural.

The red color of the clay at the Route 22 exposure is poorly understood. Typically brecciated flint clays associated with coal seams are gray to greenish gray to green with minor amounts of red coloration, and this is characteristic of Upper Freeport flint clays as well. However, the Upper Freeport flint clays in southeastern Indiana and adjacent areas of Westmoreland County are predominately red. It is unclear whether this is due to localized post-depositional oxidation of the clay or if the clays were derived from a previously red source.

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STOP 7: PALEOSOL DEVELOPMENT ALONG THE MISSISSIPPIAN-PENNSYLVANIAN UNCONFORMITY

NEAR JOHNSTOWN, PENNSYLVANIA[1]

STOP LEADERS – MICHAEL C. RYGEL[2], SUNY POTSDAM
JACK D. BEUTHIN[3], WEATHERFORD LABORATORIES

Introduction **(40.35998, -78.95179)**

The Mississippian Pennsylvanian unconformity is a widespread stratigraphic surface formed in response to both a mid-Carboniferous eustatic event and the onset of tectonism. Although it is most easily recognized where pronounced erosional relief is developed in association with paleovalleys, well-developed paleosols formed in association with the unconformity surface have been documented at a few locations.

In this study, we examine the Mississippian Pennsylvanian boundary interval in a roadcut along PA Route 56 just to the north of the city of Johnstown. Specifically, we focus on an iron rich mudstone that is overlain by strata of the Pennsylvanian Pottsville Formation and underlain by a sandstone of the Mississippian Mauch Chunk Formation (Figure 7-1).

This mudstone exhibits many of the characteristics of a semi flint to plastic clay and is similar to units that were interpreted by Williams and others (1965) as residual clays formed on well drained interfluves of cyclothem bounding unconformities. We use a combination of geochemistry and micromorphology to show that the boundary mudstone and subjacent sandstone (herein termed the "Route 56 paleosol" represents a complex residual soil developed on an interfluve associated with the Mississippian Pennsylvanian unconformity.

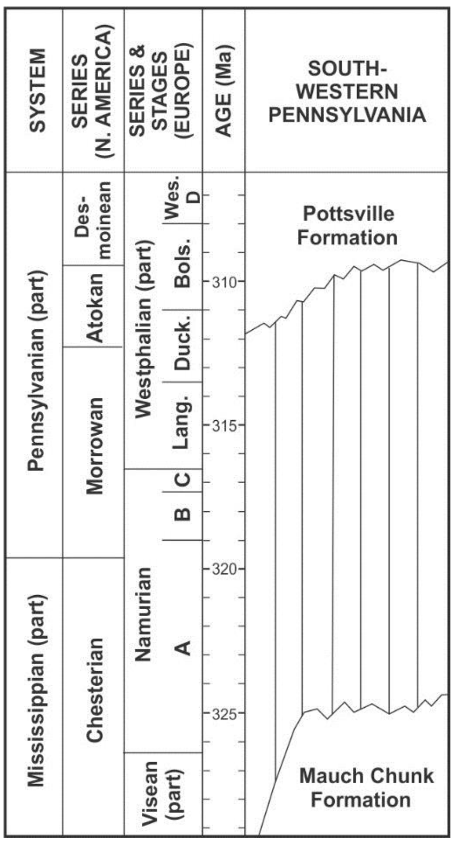

Figure 7-1. Upper Mississippian lower Pennsylvanian stratigraphy of southwestern Pennsylvania showing hiatus associated with the Mississippian Pennsylvanian unconformity. Chronostratigraphy after Edmunds (1993); numerical dates from Menning and others (2000). European stage names are abbreviated as follows: Langsettian (Lang.), Duckmantian (Duck.), Bolsovian (Bols.), and Westphalian D (West. D).

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[1] This contribution is largely derived from Rygel, M.C. and Beuthin, J.D., 2002, Paleopedology of a residual clay associated with the Mississippian-Pennsylvanian (mid-Carboniferous) unconformity, southwestern Pennsylvania; Southeastern Geology, v. 41, no. 3, p. 129-143.

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Description of the Route 56 Paleosol

Where measured, the paleosol consists of four horizon like units: two in the 1.5-m-thick boundary mudstone and two in the 5.5-m-thick subjacent sandstone (Figure 7-2). Laterally, the units vary in thickness and the boundary mudstone is locally truncated at the base of the Pottsville Formation.

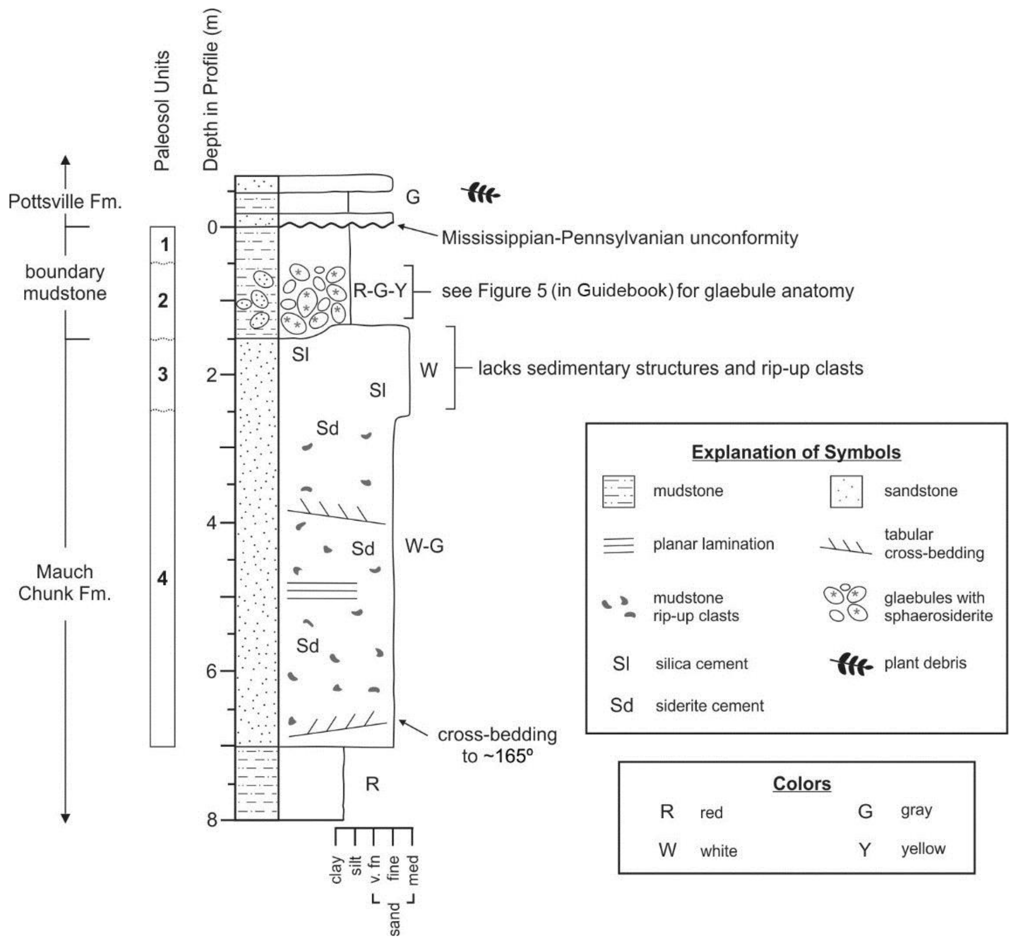

Figure 7-2. Sedimentological log of the Route 56 paleosol and associated strata.

Boundary Mudstone (Units 1 and 2)

Unit 1 is the uppermost part of the boundary mudstone; it is a 50-cm-thick, light olive gray silty mudstone with isolated lenses of muddy, very fine to fine grained sand. It is internally massive and has a slight vuggy texture with yellowish orange iron staining common around vug margins. Unit 2 is a 100 cm thick light gray to reddish yellow silty mudstone that contains numerous iron rich glaebules ranging from 5 to 26 cm in diameter. Glaebules have a tripartite concentric structure consisting of a sphaerosiderite rich core, iron depleted middle layer, and a ferruginous outer rind.

Clay fabric in Unit 1 and surrounding the glaebules in Unit 2 is mostly dull and weakly oriented with scattered patches of oriented, bright clay. Scattered framework grains of silt- to sand-sized quartz are present locally. Within the glaebules, the rinds are clayey and any fabric is obscured by amorphous iron. Scattered quartz grains in the rinds are fractured and corroded, with microveins of ferric material frequently lining the fractures. Clay within the core and middle layers of glaebules is generally well-oriented with patches of densely woven bright clay. Glaebule cores contain silt- to sand-sized grains of quartz, many of which are etched and embayed by siderite. Glaebule cores contain spherical aggregates or siderite with a radiating crystal habit. These sphaerosiderite rosettes range in diameter from 0.6 1.0 mm although they locally coalesce to form intergrown masses up to 1 cm in size. The radial form of many vugs indicates that they are molds of sphaerosiderite rosettes.

Bulk XRD analysis shows that clay content of the boundary mudstone ranges from 25.7 to 70.6%. Kaolinite and illite were the only detectable clays and the kaolinite:illite ratio ranged from 1.6 to 3.5. Quartz is the only other abundant silicate mineral and its abundance ranges from 24.2 to 57.3%. A glaebule core sample contained 15.0% siderite; no other carbonate phases were detected. XRD analysis failed to detect iron bearing minerals in the glaebule rinds, an anomaly that is consistent with the presence of amorphous iron in thin section. Silica, iron, and alumina are the primary constituents of the boundary mudstone. Silica is the most abundant, with values ranging from 41.95 to 88.84% by weight. Total iron ($FeO + Fe_2O_3$) reaches a maximum value of 33.8% in a glaebule rind from Unit 2. Ferric iron predominates in the rinds (99% of total iron) and ferrous iron is most abundant in the cores (88%). Alumina reaches a maximum value of 24.4% in Unit 1. Abundance of leachable bases ($MgO + CaO + Na_2O + K_2O$) ranges from 0.35 to 2.80% and the ratio of alumina to bases ($Al / MgO + CaO + Na_2O + K_2O$) can ranges between 13 and 23.

Subjacent Sandstone (Units 3 and 4)

Unit 3 is a 100-cm-thick, very light gray medium grained quartz sandstone with silica cement. It lacks primary sedimentary structures and labile clasts. It has a wavy and gradational contact with Unit 4. Unit 4 is a 450-cm-thick, light gray, fine-grained argillaceous sandstone with scattered euhedral siderite cement (not sphaerosiderite). It is cross-bedded, contains pebble sized rip up clasts of gray green mudstone, and has a sharp contact with underlying redbeds. Framework grains in Unit 3 are composed of fine to medium grained, subangular to subrounded monocrystalline (90%) quartz sand. Grain contacts in Unit 3 are commonly flat or concave convex and quartz overgrowths are common. Near the base of Unit 4, polycrystalline quartz grains and mudstone rip-up clasts become common.

Discussion

Evidence of Intense Pedogenesis

Numerous aspects of Units 1 and 2 indicate that boundary mudstone is a clayey residuum derived from deeply weathered parent materials. Abundant kaolinite and quartz suggests removal of unstable constituents by intense hydrolysis and leaching consistent with what would be expected in modern Oxisols or ferruginous soils. Intense weathering is also supported by the presence of runiquartz, a common feature of modern Oxisols. Clay fabrics within Unit 2 glaebules are likely relict features inherited from an earlier stage of pedogenesis. The oxidized rinds and reduced cores of these glaebules suggest a complex history of iron mobilization and redoximorphism. Although it is difficult to determine the nature of the parent material of the boundary mudstone, common coarse silt and sand suggest that at least some of the parent material was sandy.

Geochemical data also indicate that the boundary mudstone is a deeply weathered residual clay. Alumina/bases ratios of 13 to 23 indicate strong base depletion consistent with modern Oxisols. Even though iron is in both an oxidized and reduced state, total iron values of up to 33.78% compare well with that of some modern Oxisols. Like other paleosols associated with major geological unconformities, the Route 56 paleosol is enriched in resistant elements such as iron, aluminum, and silica. The subjacent sandstone exhibits varying degrees of pedogenic alteration. The presence of bedding and labile rip up clasts in the lower part of the sandstone (Unit 4) implies that it consists of relatively unaltered parent material. In contrast, the upper part of the sandstone (Unit 3) possesses several characteristics of a well leached, pedogenic ganister including quartz rich sand, silica cement, absence of sedimentary structures, and a downward transition into a compositionally less mature sandstone. The complexity documented within the Route 56 paleosol supports our interpretation of these rocks as a well-developed paleosol with a complex pedogenic history.

A Polygenetic History

The mineralogical and micromorphological disparities described above suggest a polygenetic origin involving contrasting soil forming regimes. For example, abundant kaolinite in the boundary mudstone indicates hydrolysis associated with a well-drained land surface but sphaerosiderite in the same part of the paleosol suggests gleying associated with a poorly drained environment. Altogether, the features of the paleosol are interpreted to record three phases of development as outlined below and in Figure 7-3.

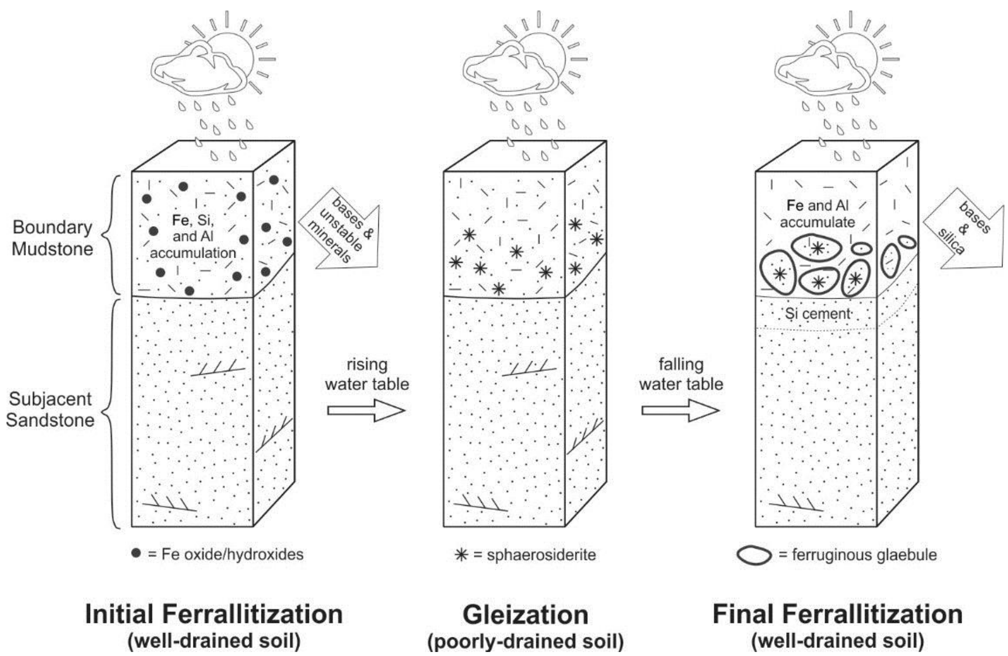

Figure 7-3. Three phase pedogenic model for the Route 56 paleosol illustrating development of ferruginous glaebules in the boundary mudstone.

Phase 1: During this phase, abundant rainfall and good drainage allowed for the leaching of bases and the destruction of unstable minerals by chemical weathering. This intense tropical weathering resulted in a residuum of kaolinite and quartz (preserved in glaebule cores) and the accumulation of iron oxides/hydroxides. During this initial phase, the Route 56 paleosol approached a state of development comparable to that of an Oxisol.

Phase 2: During this phase drainage conditions deteriorated as the water table rose. The iron oxides/hydroxides concentrated during Phase 1 were transformed into sphaerosiderite during gleying by alkaline, reducing water. These waters were probably meteoric rather than marine because the presence of sulfide in the system would have favored the formation of pyrite over sphaerosiderite.

Phase 3: During this final phase, the glaebules in Unit 2 were created by lowered or seasonally fluctuating water levels. Oxidation of sphaerosiderite created the iron-rich materials in the glaebule rinds. Much of this iron appears to be derived from the iron depleted, vuggy middle layer of the glaebules. The siderite rich cores of the glaebules represent pedorelicts of the gleization phase. Fractured runiquartz in glaebule rinds suggests intense physical and chemical destruction of quartz. This final phase of pedogenesis was followed by deposition of Pottsville sediments during onlap of the mid Carboniferous land surface.

Relationship to the Mississippian-Pennsylvanian Unconformity

The Route 56 paleosol is interpreted as an interfluve expression of the Mississippian Pennsylvanian unconformity. Unlike many floodplain paleosols, those developed on interfluves typically are polygenetic and have complex drainage histories related to changes in base level. Given the complexity seen within the Route 56 paleosol, it is difficult to unequivocally attribute polygenesis of the Route 56 paleosol to a single base level event. Although likely formed in association with the mid Carboniferous eustatic event that impacted much of the basin, the hiatus in the study area is large enough that the paleosol may also have been impacted by tectonic activity, climate change, and landscape evolution. Much like the Olive Hill clay of eastern Kentucky, the Route 56 paleosol probably records earliest Pennsylvanian weathering of exposed Mississippian strata in the aftermath of a "Mississippian-Pennsylvanian" event.

Conclusions

In many cases, identification of residual clays related to the Mississippian Pennsylvanian unconformity may requires more than just field observation. In this case, abundant siderite might lead one to infer that it was formed entirely in a poorly drained environment. However, micromorphological and geochemical analysis indicates a complex, polygenetic developed during the large time gap represented by the Mississippian-Pennsylvanian unconformity.

Despite its stratigraphic importance, the Mississippian-Pennsylvanian unconformity remains a cryptic feature at many localities in the Appalachian Basin (Brezinski, 1989; Edmunds, 1993). Given the insights from this study, it seems likely that the unconformity should be marked by more residual clays and mature paleosols on the northern and western flanks of the basin where prolonged exposure occurred. Continued analysis of paleosols associated with the Mississippian-Pennsylvanian boundary may yield better evidence for the unconformity and additional details of soil-forming processes related to unconformity development.

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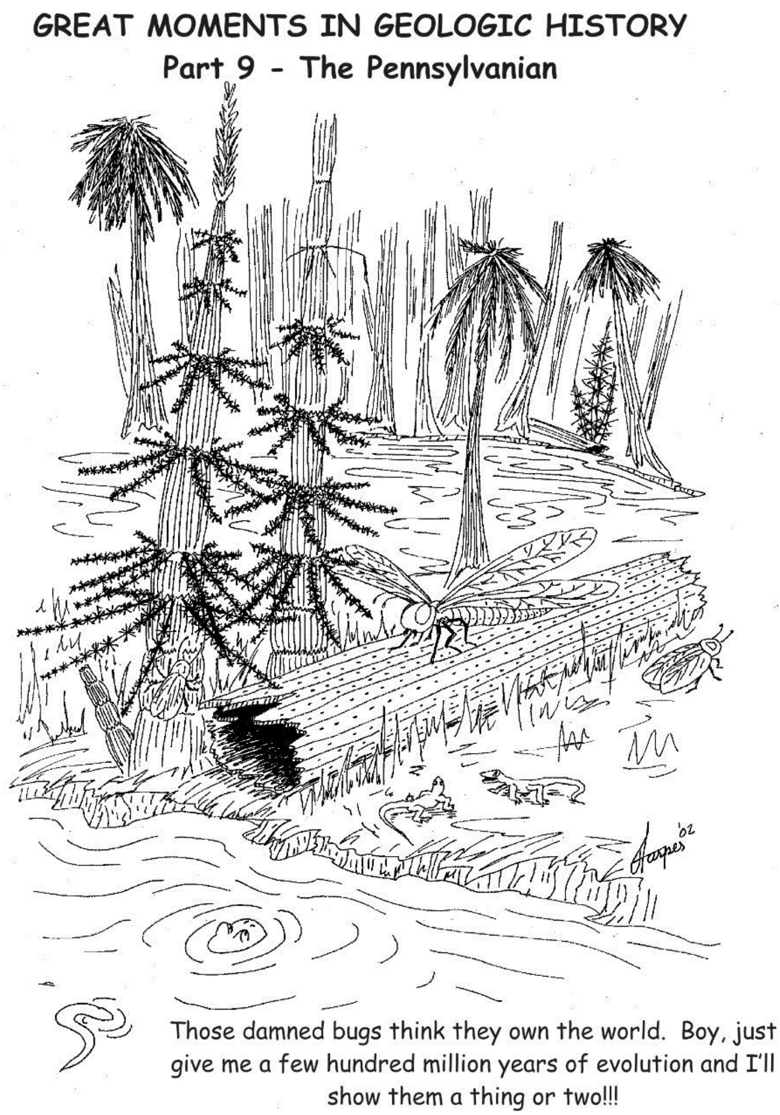

STOP 8: VISIT TO THE JOHNSTOWN FLOOD MEMORIAL

NEAR ST. MICHAEL, PA

STOP LEADERS – NEIL COLEMAN, UNIVERSITY OF PITTSBURGH-JOHNSTOWN
STEPHANIE WOJNO, NW MISSOURI STATE UNIVERSITY

NO ROCK SAMPLING
OR SURFACE DISTURBANCE IS PERMITTED AT THIS NATIONAL PARK SERVICE MEMORIAL

Historical Evidence – New Findings **(40.34712, -78.77245)**

The field conference previously visited the site of the South Fork dam in 1989, 100 years after the flood. We are returning to this site after 27 years because new research has been published regarding the hydraulics of the dam breach and the cause of the flood. Field work and hydraulic analyses by Coleman, Kaktins, and Wojno (2016), including LiDAR mapping of the lake basin, led them to challenge the findings of the American Society of Civil Engineers committee that investigated the disaster in 1889. That committee was chaired by the esteemed James B. Francis. Their 1891 report concluded that dam repair work by the South Fork Fishing and Hunting Club was not responsible for the dam breach. Coleman et al. dispute that finding and conclude that the confidence the Committee expressed that dam failure was inevitable was inconsistent with information available to the Committee.

Coleman et al. found that the changes made to the dam by the Club were indeed responsible for the disaster. Those changes included lowering the dam crest and failing to replace the five large discharge pipes beneath the dam. Lowering the crest greatly reduced the discharge capacity of the main spillway and eliminated the action of an emergency spillway on the western abutment. The emergency spillway was essential to protect the dam during major flood events. The original higher dam had twice the safe discharge capacity of the lower, reconstructed dam. Hydraulic analyses, evaluation of time of concentration, and 1889 observations of local streams show that the original dam would never have overtopped during the storm of May 30-31, 1889. The original dam was built using a "puddled clay" method on the upstream half of the embankment, which minimized water infiltration. The homogeneous-fill used by the Club to repair the dam would have led to deep infiltration and water saturation, causing the observed rapid liquefaction failure of the central embankment after the toe of the dam had been eroded by overtopping.

Readers are referred to the recent paper by Kaktins et al. (Pennsylvania History Journal, 2013) which provided new historical findings about the 1889 flood. The new paper by Coleman, Kaktins, and Wojno (2016) illustrates how it is possible to reevaluate a historic disaster using modern data and analyses and careful review of historical records. Their paper was published "open access" (Creative Commons CC BY-NC-ND license) in the Elsevier journal *Heliyon*, and therefore the full paper can be obtained without cost from the following website: http://www.heliyon.com/article/e00120?via=sd%3D&

Site Description

A walk around the loop trail from the parking lot that passes through the dam breach (Figure 8-1) follows a short presentation summarizing new research about the flood. There is a large berm of material on the west side of the foot path. This berm accumulated during the flood behind the western remnant of the dam. The easternmost foot path passes beside the stream and here you can see the dressed foundation stones that formed the base of the control tower, from which the original drainage pipes were opened or closed.

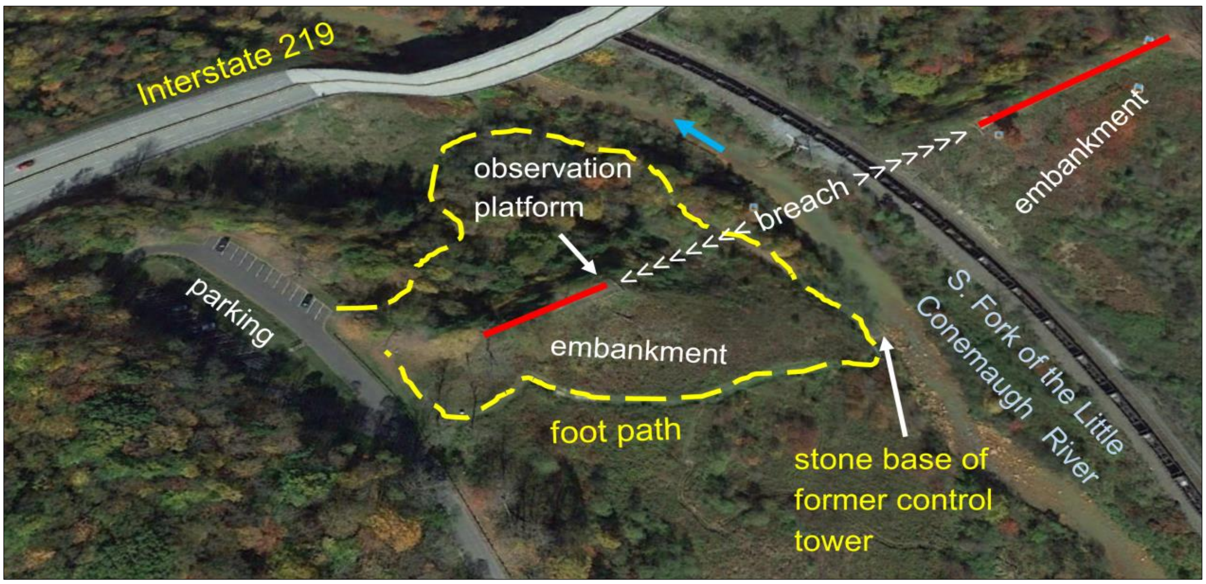

Figure 8-1. Parking lot at western abutment of former South Fork dam

The late Emeritus Professor Uldis Kaktins is standing on dressed stones that formed the base of the former control tower (Figure 8-2). These stones have survived many floods here on the South Fork of the Little Conemaugh River. The valves for 5 large discharge pipes were opened and closed from the former tower. The pipes themselves emptied into a stone culvert beneath the dam.

The original plans called for a stone tower, but to save costs the tower was made of wood. Note hemlock logs at lower right. The South Fork Fishing & Hunting Club acquired the property in 1880. As part of the Club's repair of the partial breach of July, 1862, hemlock logs were used to block the entrance to the remains of the stone culvert. The direction of stream flow is from right to left.

Figure 8-2. The late Emeritus Professor Uldis Kaktins stands at the base of the dam's former control tower

Proceed from the parking area at the eastern side of South Fork Dam along the footpath to see the bridge and main spillway (Figure 8-3). There is an observation platform at the western end of the dam crest that overlooks the dam breach. Note the twin railway line that passes along the stream through the breach.

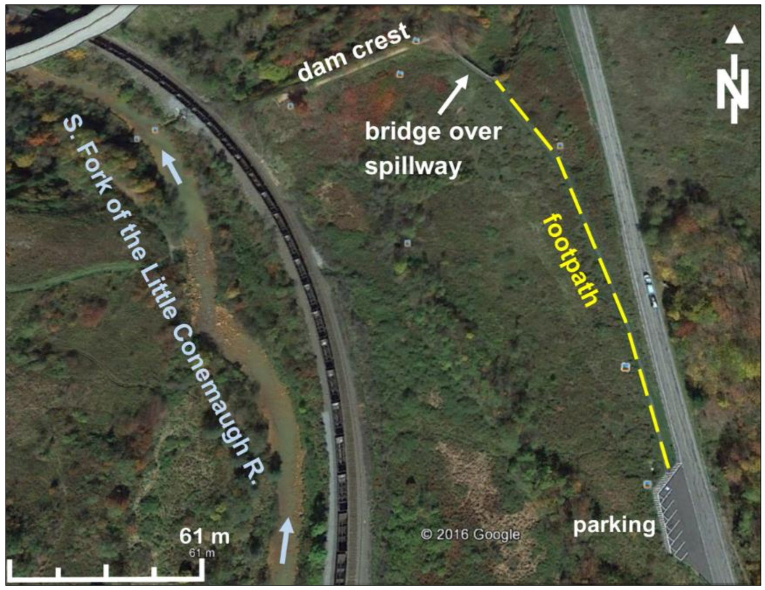

Figure 8-3. Parking lot at eastern side of South Fork Dam – visit to main spillway and eastern remnant of dam. Scale at left is 61 meters.

Figure 8-4 shows the view from the bridge over the former spillway, looking northward along the curving high wall that consists of sandstone beds of the Conemaugh Group.

A soil layer up to 0.5 m thick has accumulated on the spillway bare-rock surface since 1889, indicating a rate of accumulation of ~0.4 mm/yr. Some degradation of the high wall at right has occurred over time, but most of it is unchanged since the day of the dam breach. The NPS display board at lower left shows the picturesque waterfall that existed near the end of the former spillway.

Figure 8-4. View from the bridge over the former spillway. Note highwall to the right and display board photo of previous waterfall at lower left

The large riprap boulders seen in Figure 8-5 are from the original construction in the early 1850's. The riprap on this end of the dam were obtained from excavation of the main spillway. They are still in place, standing more than 0.6 m higher than the present crest, as a result of the embankment crest being lowered as much as 0.9 m by the SFFHC.

Figure 8-5. Large riprap boulders from the dam's original construction in the early 1850's. The white ruler at center of frame is 0.3 m long.

Saturday's lunch location (Stop 9) is Berwind Wayside Festival Park in nearby St. Michael, adjacent to the South Fork of the Little Conemaugh (Figure 8-6). In May of 1889, this location was at the bottom of Lake Conemaugh.

Figure 8-6. Formerly at the bottom of Lake Conemaugh, our Day 2 lunch location is now in the floodplain adjacent to the Little Conemaugh River. You can see the long, rectangular rooftops of the shelters in this Google satellite image.

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STOP 9: LUNCH

BERWIND WAYSIDE FESTIVAL PARK, ST. MICHAEL, PA

(40.3343, -78.76608)

Figure 9-1. Shelters at Berwind Wayside Festival Park.

NOTES

STOP 10: WIDMAN STREET ROAD CUT

JOHNSTOWN, PA

STOP LEADER – WILLIAM A BRAGONIER, COAL GEOLOGIST, RETIRED

Introduction **(40.31293, -78.88572)**

The accessible part of the road cut at the Widman Street exit of PA Route 56 (Figure 10-1) exposes a portion of the Allegheny Group from the upper split of the Middle Kittanning coal to the sandstone that overlies the Upper Kittanning coal. The higher cut immediately to the west of Widman Street the section is exposed to above the Upper Freeport coal. The lithologic sequence for the Widman Street road cut is shown in Figure 10-2. Diagrams of the entire Widman Street road cut based on photographs (plates 1, 2) follow, and are also detailed in the online appendix.

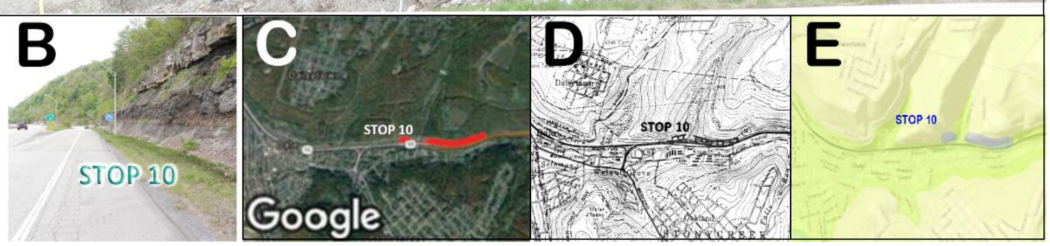

Figure 10-1. A) roadcut showing exposed portion of Allegheny Group. B) view along exit ramp C) satellite image, stop highlighted D) topographic map E) slopeshade (PAGEODE)

The Upper Kittanning coal has been extensively mined in the Johnstown area, including this location. Only remnant pillars represent the coal at this stop. In areas of the road cut where the coal has been mined, subsidence has been complete and the overlying sandstone rests directly upon the Upper Kittanning underclay. At several locations mine rails and mine posts may be seen protruding from between the sandstone and the underclay.

Discussion

The Johnstown limestone, which occurs directly beneath the Upper Kittanning underclay, traverses the entire length of the outcrop, but can best be observed immediately west of Widman Street. It is characterized by an irregular thickness and unusual knobby texture, both common

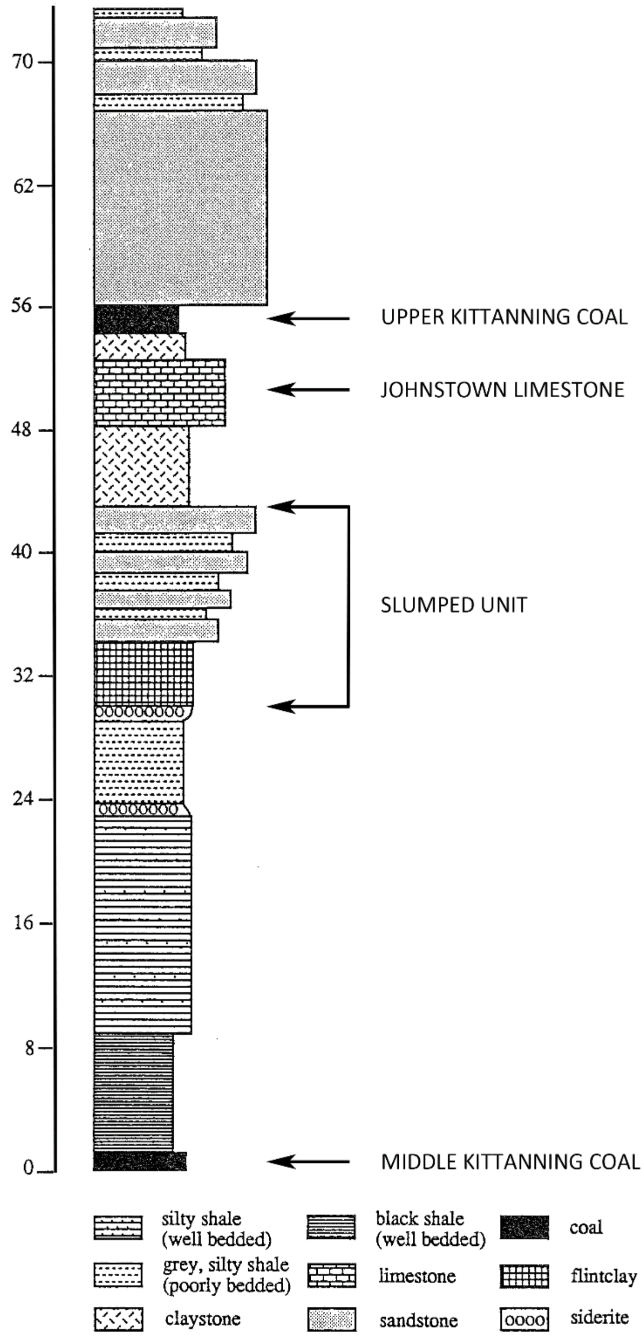

Figure 10-2. Measured stratigraphic section of the middle Allegheny Group exposed at the Widman St. exit of PA route 56 at Johnstown.

features of fresh water limestones. Suzanne Weedman, who co-led the Widman Street stop in 1989 postulated in her doctoral dissertation (Weedman, 1988, Weedman and Bragonier, 1989) that the knobby texture is due to expulsive dewatering of the underlying muds as they compacted. Close inspection of the base of fresh water limestones shows that the underlying clay is commonly carried up into the limestone. This indicated to Weedman that the early-cemented limestone fractured as it was compacted and allowed non-cemented muds to be extruded through the fractures. Pressure solution due to deep burial is thought to have enhanced these structures.

About 15 ft. (4.6 m) below the Johnstown limestone over most of the road cut is a flint clay (or perhaps more appropriately, a semi-flint clay) that is the basal unit of a coarsening upward sequence of sediments. The clay is characterized by a mottled orange-to-reddish iron-stained color. Below the flint clay is a sharp contact that can be traced through the entire length of the outcrop. The sharp contact is an exposure surface of short duration (i.e., a diastem) that displays faint characteristics of soil formation. The coarsening-upward sediments above the flint clay represent a small delta, or crevasse splay deposit that also exhibits lateral variation. The thickest and coarsest part of this interval occurs just east (uphill) of the eastern terminus of the Widman Street exit ramp. Here sandstone predominates but grades into finer-grained sediments in both directions as the sediment package correspondingly thins.

Lithologic units within the upward-coarsening sequence above the flint clay have been subjected to soft-sediment slumping throughout most of the exposure. This is evidenced by the existence of slump planes and extreme changes in the dip direction of these units. The flint clay is not highly brecciated but has been moved, as indicated by severe thickness changes, convoluted bedding and an intermixing of the overlying shale with the flint clay. The fracture of the clay is characteristically conchoidal, yet planar, also indicative of internal movement. *However, it is significant that the soft sediment slumping does* ***not*** *affect the unconformable surface immediately underlying the flint clay*. As noted, this sharp contact spans the length of the outcrop. This indicates that the flint clay was much less structurally cohesive than the underlying shale at the time of slumping. The clay, in fact, acted as a "shock absorber" for the underlying shales. Furthermore, the time of the slumping can be placed after the deposition of the slumped units but before the deposition of the Johnstown limestone, which is not slumped (i.e., shortly after the flint clay was loaded).

An argument for the lacustrine origin of the flint clay can be made at this stop. In the road cut to the immediate west of Widman Street, where the flint clay has been replaced by several inches of black carbonaceous shale with coal streaks, the distance from the base of the limestone to the black shale is only 7 to 8 ft. (2.1 – 2.4 m) as opposed to the 14 to 16 ft. (4.3 – 4.9 m) interval where the flint clay is present. Using the base of the Upper Kittanning limestone as a datum, this suggests that the flint clay formed in a paleotopographically low area relative to the coaly shale. The presence of organics surrounding a small lake may also explain why flint clay is present as opposed to very fine-grained shale, as the presence of organic acids has an influence on clay flocculation. (Falla, 1967).

Stratigraphic units below the flint clay are largely a series of coarsening-upward shales interpreted as a bay-fill sequence. Several specimens of the bivalve *Anthraconaia* have been collected from the shales immediately overlying the upper split of the Middle Kittanning coal. The presence of fresh water or brackish water fossils in these shales suggests that the depositional environment was lower delta plain. The environmental interpretation of the entire sequence is: peat swamp (M.K.) –> inter-distributary bay (coarsening-upward shales) –> lake (flint clay) –> crevasse splay (into the lake) –> carbonate lake (sediment starved) –> unconformity (U.K. underclay) –> peat swamp (U.K.) –> larger crevasse splay or channel. In other words, this area was a sediment starved costal swamp that received two periods of sediment influx, the second one being the larger.

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Plates

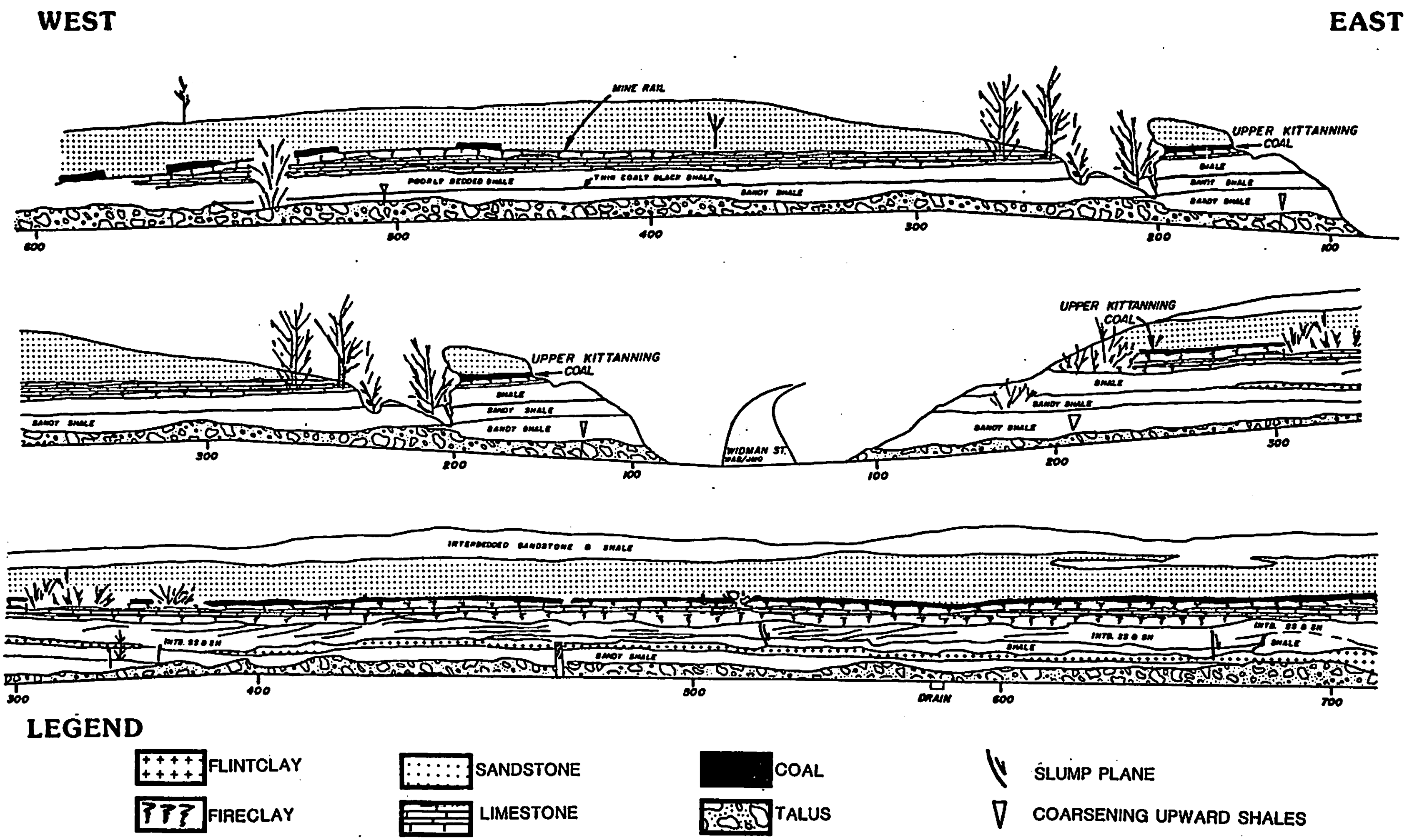


Plate 1. Diagram of the western portion of the roadcut at the Widman St. exit of PA Route 56. The diagram is constructed from photographs and is not to scale. Numbers indicate feet from the centerline of Widman St. along exit ramps to PA Route 56.

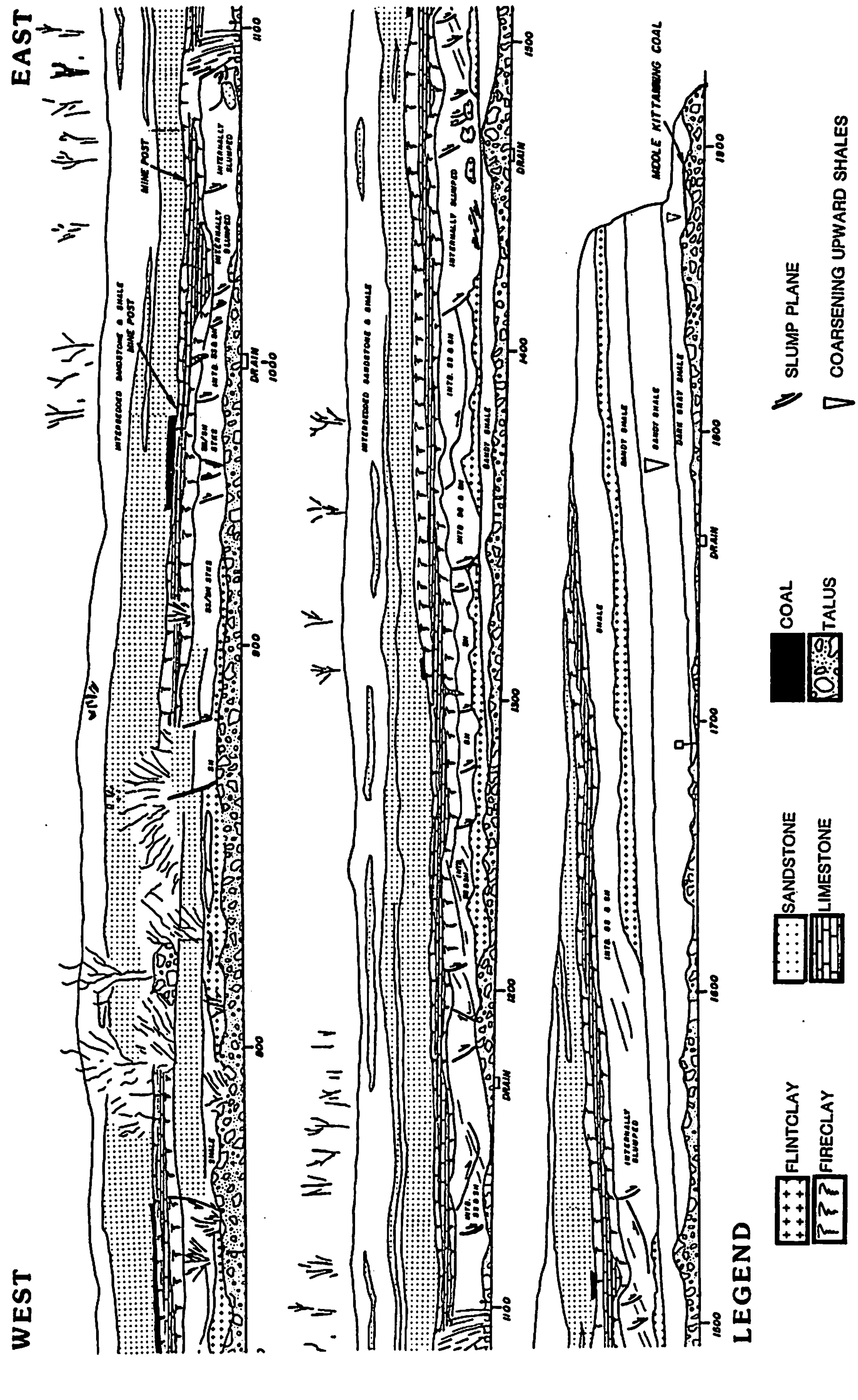
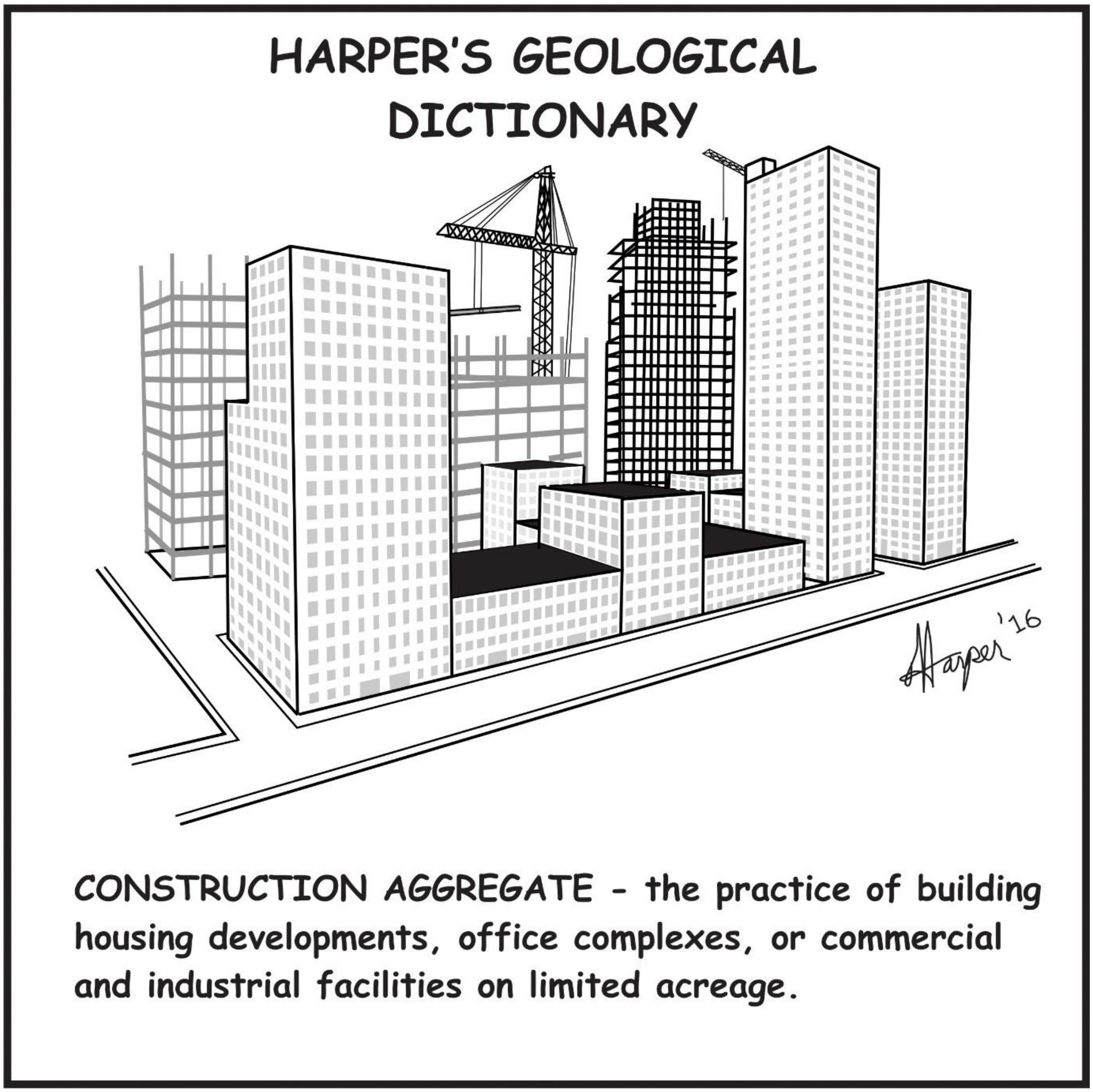


Plate 2. Diagram of the eastern portion of the roadcut at the Widman St. exit of PA Route 56. See Plate 1 for explanation.


HARPER'S GEOLOGICAL DICTIONARY
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CONSTRUCTION AGGREGATE - the practice of building housing developments, office complexes, or commercial and industrial facilities on limited acreage.

STOP 11: CONEMAUGH RIVER GORGE
DORNICK POINT LOYALHANNA LIMESTONE QUARRY

STOP LEADER – STEPHEN R. LINDBERG, UNIVERSITY OF PITTSBURGH-JOHNSTOWN

Site Description; Physiographic and Geologic Setting (40.36607, -78.95234)

The now abandoned "Dornick Point" Loyalhanna Limestone quarry is currently privately owned and access is restricted unless permission from the landowner is granted. The quarry was actively mined until the early 1970's for aggregate stone, specifically the Loyalhanna Limestone for use as a skid resistant crushed stone additive in the production of asphalt based roadway pavement. The quarry is located within Cambria County and is entirely within the Johnstown 7.5 minute quadrangle. The main quarry floor is located at 40.36°N - 78.94°W and roughly parallels the northeast side of Pennsylvania State Route 403 at an elevation of approximately 1,160 feet. Accessible by dirt road; the quarry extends for approximately 1,000 feet in a northwest-southeast direction.

Located within the Laurel Highlands of the Allegheny Mountain Section of the Appalachian Plateaus Province; the quarry (Figure 11-1) lies along the southeast limb of the Laurel Hill anticline. At this location the Conemaugh River is clearly visible as it cuts through the Laurel Hill anticline forming the Conemaugh Gorge. The Conemaugh Gorge trends approximately N30°W with an approximate relief of 1,500 feet. The quarry highwall provides an excellent exposure of the entire Loyalhanna Limestone; including the basal contact with the Burgoon Sandstone and lower part of the overlying Mauch Chunk formation. The Laurel Hill anticline is described as being an "open, slightly asymmetric fold with the dip on the southeastern limb ranging from 10° to 15° and from 8° to 10° on the northwestern limb" (Iranpanah and Wonsettler, 1989). Dips observed here in the quarry average 12° to the southeast.

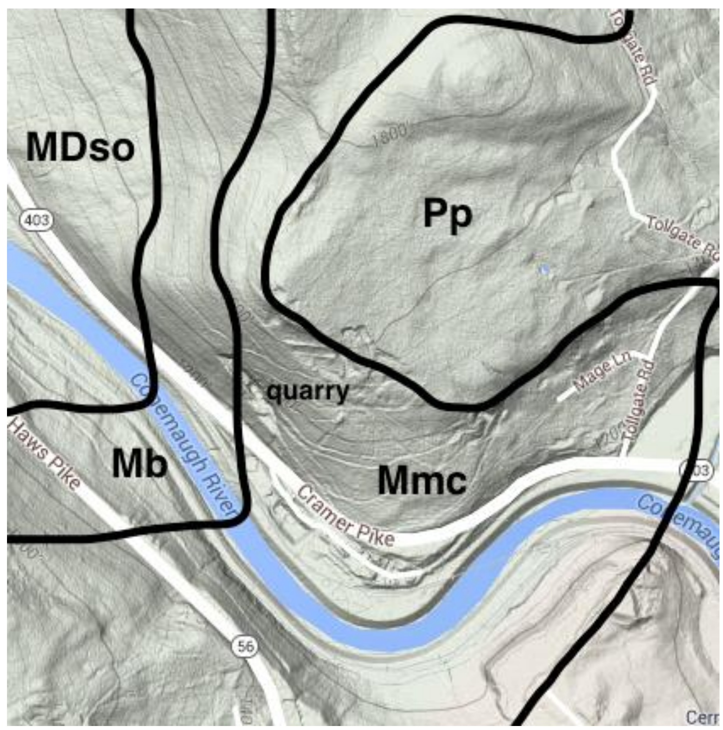

Figure 11-1. Shaded relief map of Conemaugh Gorge showing location of the Dornick Point Loyalhanna Limestone quarry. Geology based on the Johnstown Quadrangle, Atlas of the Preliminary Geologic Quadrangle Maps of Pennsylvania, 1981, PA Geological Survey. MDso, Shenango Fm. through Oswayo Fm., undivided. Mb, Burgoon Sandstone. Mmc, Mauch Chunk Fm. Pp, Pottsville Group.

The Loyalhanna Limestone

The Loyalhanna Limestone was named in 1904 by Charles Butts in which he describes it as:

> "Immediately overlying the Burgoon sandstone on the western side of the ravine at Allegrippus is a stratum of coarse calcareous sandstone. This stratum is marked by strong cross-bedding and a surface pitted by differential erosion, and these features give it a very distinctive appearance by which it is recognized at widely separated points in western Pennsylvania….This stratum is universally known in the region of its occurrence as the Siliceous limestone, though generally it is a rather calcareous sandstone. In deference to general usage it is here called a limestone, and the name Loyalhanna is proposed for it because it is well developed along the gorge in which that stream flows across Chestnut Ridge, in Westmoreland County, and because it is extensively on that stream in the quarries at Long Bridge, between Latrobe and Ligonier."
> (Butts, 1904)

A detailed description of the Loyalhanna Limestone is also included in W.C. Phalen's 1911 bulletin "Mineral Resources of Johnstown, Pennsylvania and Vicinity"

> "Another rock used in the manufacture of concrete is the Loyalhanna limestone member, which occurs at the top of the Pocono formation. It is about 45 feet thick in the Johnstown quadrangle. It is not a true limestone but rather a sandy limestone. It weathers in a peculiar and characteristic way…..This siliceous limestone is quarried and split into paving blocks which give satisfaction, and is crushed for use as ballast in railroad beds. For both uses it is well adapted, as its calcareous portion on solution and recrystallization tends to bind the fragments solidly together and yet leaves sufficient space between them to allow the free circulation of water. The siliceous limestone exposed near the viaduct between Mineral Point and South Fork has also been quarried for paving blocks."
> (Phalen, 1911)

Within Conemaugh Gorge exposures of the Loyalhanna average between 60-65 feet in thickness. In the Johnstown region the Loyalhanna varies in composition from an arenaceous calcarenite at the base to orthoquartzites at the top (Ahlbrandt, 1995). Age determination for the Loyalhanna Limestone has been based on correlation with the Greenbrier Series in West Virginia and Virginia and is considered by some (Ahlbrandt,1995) to be late Meramecium (Mississippian) in age. In Pennsylvania the Loyalhanna is assigned to the Chesterian (Ahlbrandt, 1995).

The depositional origin for the Loyalhanna Limestone, with its characteristic large-scale festoon cross bedding (Figures 11-2 and 11-3) has been the subject of debate for well over 100 years. Examination of individual foresets show they are composed of alternating layers of quartz and carbonate sand (Brezinski, 1989). The resulting differential weathering has produced the dramatic raised striped pattern observed on the Loyalhanna here in the quarry.

Ahlbrandt (1995) argues that the large scale crossbedding is evidence for an eolian depositional setting. Additional eolian depositional features such as sand flow toes, sand sheets and wind ripples provide further evidence to classify the Loyalhanna as an eolianite (Ahlbrandt, 1995). Brezinski (1984) argues that the Loyalhanna has a marine or shallow-marine environment and was deposited as an extensive submarine sand-complex with strong tidal currents similar to the modern day North Sea.

Adams (1970) proposes that the Loyalhanna was deposited on a high energy shallow marine shelf that received sediments from the Burgoon uplands. The interpretation of the depositional environment of the Loyalhanna Limestone continues to be controversial; close examination of depositional features provide evidence for either model.

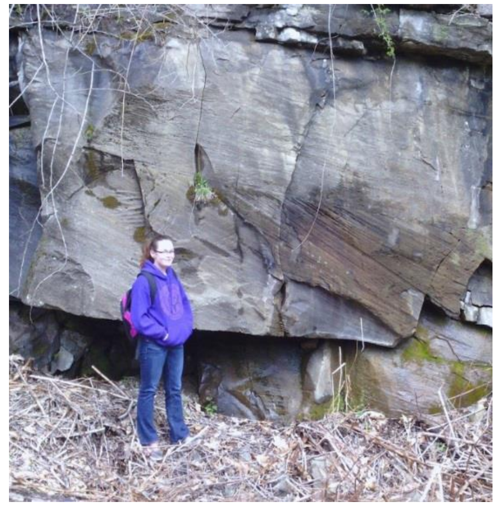

Figure 11-2. Large scale crossbedding visible in Loyalhanna Limestone at Dornick Point quarry, Conemaugh Gorge. Enthusiastic Pitt-Johnstown geology student for scale.

Figure 11-3. Example of the Loyalhanna's dramatic raised striped pattern observed in the quarry, produced by differential weathering. Brezinski (1989) attributed this differential weathering to individual foresets composed of alternating layers of quartz and carbonate sand.

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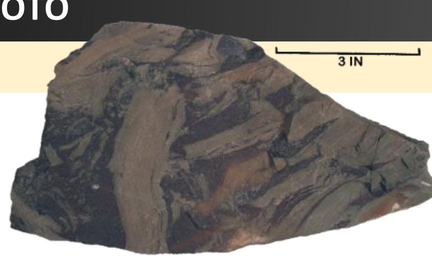

Brecciated Flint Clay from STOP 6