80th Annual Field Conference of Pennsylvania Geologists

October 8th-10th, 2015

Hosts

Pennsylvania Geological Survey

Pennsylvania Department of Environmental Protection

Bloomsburg University

Kutztown University

Penn State University

Susquehanna University

St. Clair Community & Historical Society

Schuylkill County Historical Society

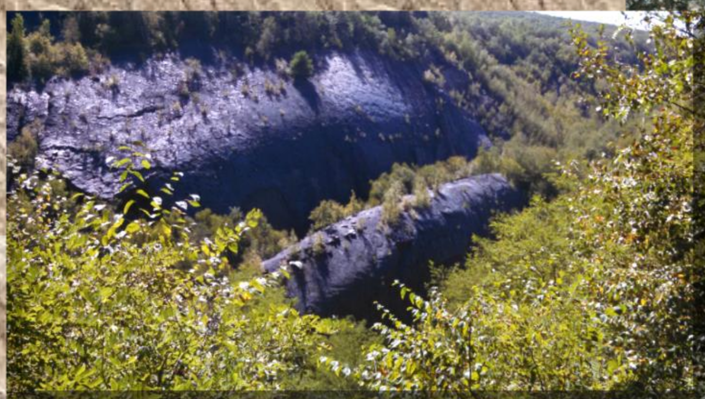
Blaschak Coal Corp

Reading Anthracite Company

Pottsville Materials (H&K Group)

Corson Quarries, Inc.

Conglomerate



Coal

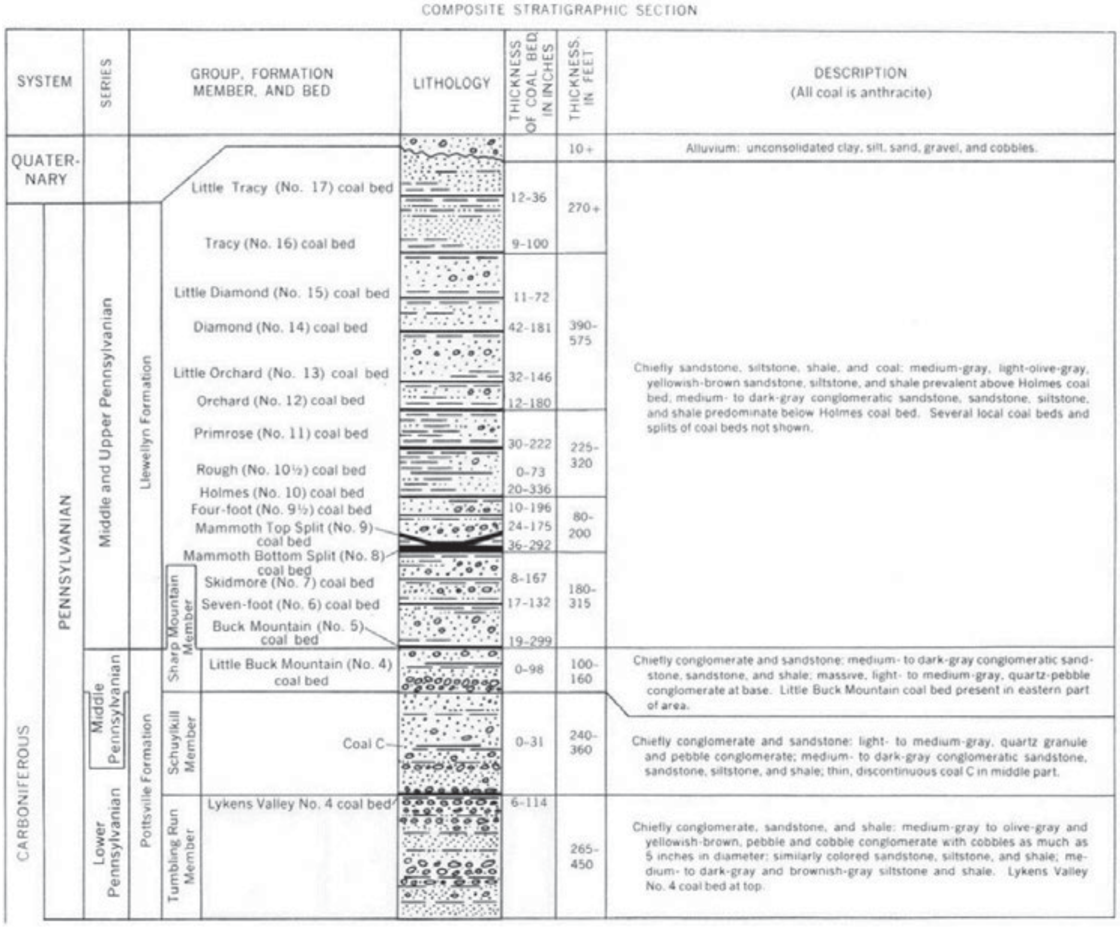
and

Calamites

Coal lay in ledges under the ground since the Flood, until a laborer with pick and windlass brings it to the surface. We may well call it black diamonds. Every basket is power and civilization. For coal is a portable climate. It carries the heat of the tropics to Labrador and the polar circle: and it is the means of transporting itself whithersoever it is wanted. Watt and Stephenson whispered in the ear of mankind their secret, that a *half-ounce of coal will draw two tons a mile*, and coal carries coal, by rail and by boat, to make Canada as warm as Calcutta, and with its comfort brings its industrial power.

Ralph Waldo Emerson, The Conduct of Life—"Wealth" 1860

COMPOSITE STRATIGRAPHIC SECTION



ROADLOG FOR THE

80TH ANNUAL FIELD CONFERENCE OF PENNSYLVANIA GEOLOGISTS

OCTOBER 8 — 10, 2015

CONGLOMERATE, COAL, AND CALAMITES

GEOLOGY, MINING HISTORY, AND PALEONTOLOGY OF "THE REGION"

SCHUYLKILL, NORTHUMBERLAND, AND COLUMBIA COUNTIES, PENNSYLVANIA

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Hosts

Pennsylvania Geological Survey, Pennsylvania Department of Environmental Protection, Bloomsburg University, Kutztown University, Penn State University, Susquehanna University, St. Clair Community and Historical Society, Schuylkill County Historical Society, Blaschak Coal Corporation, Reading Anthracite Company, Pottsville Materials-H&K Group, Corson Quarries, Inc.

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Group Conferee photo of the 2014 Field Conference of Pennsylvania Geologists
at Carlisle .... back cover

ACKNOWLEDGMENTS

The Field Conference officers, organizers, and editors would like to take this opportunity to acknowledge all the hard work and effort that has gone into making this 80th Anniversary of the Field Conference of Pennsylvania Geologist come to fruition. We would like to start by thanking all the contributors and stop leaders that, in some cases, have been dreaming about this conference for years. Their drive and dedication toward the sharing of both the geological and historical significance of this region is commendable and inspiring.

Thank you:

* David DeKok, Banquet Speaker, "Centralia: How a Mine Fire Destroyed a Pennsylvania Town and Became a Worldwide Phenomenon"

  A big "Thank You" goes to David DeKok, our banquet speaker, for taking the time out of his busy schedule to provide a more personal understanding of the Centralia story.

  A special thanks goes out to Robin Anthony, our Road Log and Guidebook editor, for her endless patience and amazing execution of this monumental task; to Gary M. Fleeger for his thoughtful memorial of Richard P. Nickelsen, to John Harper, for continuing to provide "comic relief" on the blank back pages of the Roadlog & Guidebook, and to Thomas Whitfield for his cheerful assistance with the location maps for Day 1 and Day 2, no matter how many times we asked for changes.

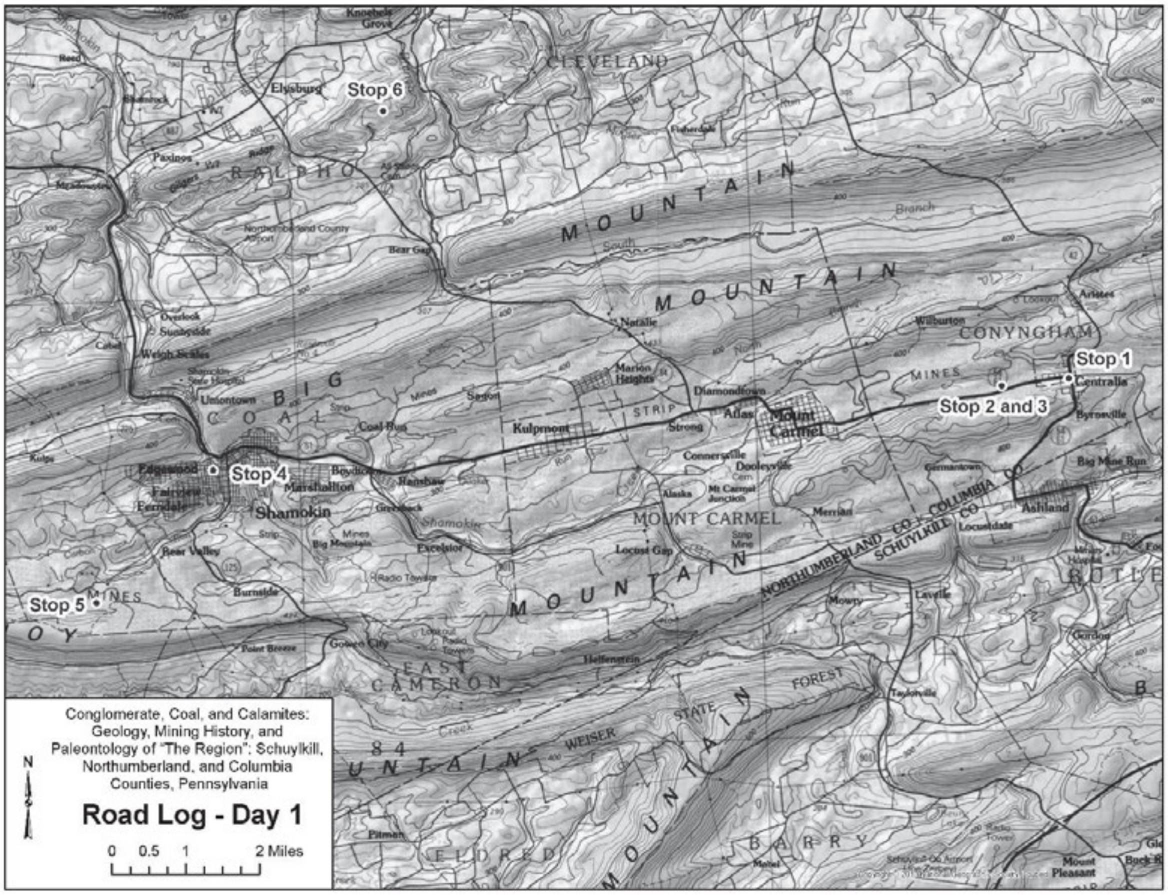
  Last but not least we would like to acknowledge all of the businesses listed below that make this event happen by graciously allowing us to disrupt their operations and traipse all over their property:

Thank you:

* **Blaschak Coal for access to their mines for Stop 2 and 3**
* **Corson Quarries for access to their quarry for Stop 6**
* **Anthracite Outdoor Adventure Area for their work with the Whaleback**
* **Pottsville Materials for access to Stop 8 and 9**
* **Reading Anthracite for access to their lands for Stop 8, 9, and 12**

*** and finally, thanks to historic Yuengling Brewery, of Pottsville, for providing scale to field photos of conglomerate, coal & calamites.

DAY 1 ROADLOG



Day 1 Road Log route map with STOP locations

MILES

Int.	Cum.	Description
0.0	0.0	Leave parking lot of MainStay Suites. Just to north of entrance to Inn is a prominent, north-dipping ledge of massive Pottsville (Sharp Mountain) conglomerate.
0.1	0.1	Stop sign. Turn right on SR 1009.
0.2	0.3	Stop sign. Turn left on PA 54 West.
0.4	0.7	Cut in north-dipping Llewellyn Formation to left.
0.7	1.4	Enter Mahanoy City. Founded in 1859 and incorporated as a borough in 1863, Mahanoy City was "home" to numerous anthracite collieries for more than 100 years, beginning in the mid-19th century. Among them were the North Mahanoy, Hill's, Vulcan, Buck Mountain, New Boston, Tunnel Ridge, and St. Nicholas collieries.

0.8 2.2 4th traffic light on Centre Street at intersection with Main Street. To right is the old, soon to be demolished (or already taken down) Kaier Brewery Building. Charles D. Kaier opened the brewery in 1880, with the present building being erected three years later. By 1912, the brewery was producing 100,000 barrels of beer per year. It reputedly operated illegally all through Prohibition, pumping off beer through a pipe to a nearby barn. The Kaier Brewery closed in 1968.

Farther back along this road to the northeast is the old Springdale Shaft in Bowman's Patch, where one of the last wheeled-headframes in the Anthracite region is still standing. Opened by the Lentz Lilly Corp. on land leased from the Delano Land Co. in about 1867, the mine was abandoned in 1897 and began to fill with water. To protect adjacent mines, the Philadelphia and Reading Coal and Iron Co. began pumping operations, keeping the mine intermittently active into the 1940's. The machinery in the adjacent Engine House is beautifully intact.

Headframe of the Springdale Shaft at Bowman's Patch

0.2 2.4 Traffic light at Catawissa Street. To left is the Molly Maguire Historical Park, completed in 2010 and featuring a statue by sculptor Zenos Frudakis of a hooded man bound hand and foot with ropes and standing on a gallows (but sans rope around his neck). The park also contains a plaque listing the names of all those who died violently during the Molly Maguire era—the 20 "Mollies" who where hung (some rightly, some wrongly), their victims (mostly coal company personnel), and those killed in retaliation by vigilantes and coal-company operatives.

PHMC Historical Marker to the right reads:

> *VICTOR SCHERTZINGER (1888-1941)*
> *Violin prodigy who performed with John Philip Sousa and later became a film director and composer. He pioneered the use of original music for films, and his film "One Night of Love" won best musical score and sound recording Oscars in 1934. He composed the pop standard "Tangerine." Among many films he directed were two of the Hope and Crosby "Road movies. He was awarded a star on the Hollywood Walk of Fame. His childhood home was here.*

0.5 2.9 Leave Mahanoy City.

0.2 3.1 On top of Broad Mountain off in the distance to the left is the John B. Rich Memorial Power Station (COGEN). Starting-up commercially in mid-1988, the plant has a net-power output of about 80 megawatts (MW) using processed culm that has a heat value of 7762 BTU /lb. As of 1996, the Rich COGEN plant was consuming about 425,000 tons of culm per year. Processed steam from the plant is being used by the Mahanoy State Correctional Institution (SCI) on Morea Road just to the east of the plant.

0.9 4.0 Blaschak's St. Nicholas Breaker to right. Constructed in 1955 to process anthracite from a deep mine that the Blaschak Coal Corp. acquired at St. Nicholas, just down the road, in 1945, the breaker has been upgraded in 1967 and 2002 to handle coal mined at numerous strip mines. In 2010 Blaschak acquired mining rights to the Lattimer Basin north of Hazleton. Company coal sales reached a peak in 2014, topping out at 374,000 tons.

Blaschak's St. Nicholas Breaker on PA 54 (mile 4.0)

0.2 4.2 Old St. Nicholas Breaker of Reading Anthracite Co. (if still standing) to right. The breaker was constructed in 1930 and began operating in 1932, being acclaimed as the largest and most productive anthracite breaker in the world.

It closed down in 1963, standing idle for many years as a monument to the declining anthracite industry and a prime candidate for preservation as an industrial heritage site. But alas, Reading Anthracite began officially tearing it down in January 2015 to get at the coal beneath it.

Ruins of the Old St. Nicholas Breaker in November 2013 (mile 4.2)

PA 54 bears off to right here. Continue ahead on SR 4030.

0.1 4.3 Enter Wiggan's Patch. Built in the 1860's and named after George Wiggan, co-owner of the Bear Run Colliery, it at was here in the early morning of 10 December 1875 that a party of 30 vigilantes raided the house of Charles McAllister, an alleged "Molly Maguire." McAllister himself escaped, but the thugs shot dead his pregnant wife, pistol whipped his mother-in-law, and shot and killed Charles O'Donnell, a boarder, one of three men who tried to escape. This brutality, never matched by the "Mollies" themselves, was perpetrated in retaliation for the murders of Thomas Sanger and William Uren, mine boss and miner, respectively, at Raven Run on September 1, 1875. No one was ever tried for the "Wiggans Patch Massacre." Reportedly, the house in which the murders took place is still standing.

		To left is "red dog" ash from the John B. Rich COGEN plant and numerous railroad tank cars. The assemblage of tank cars here is reputedly related to Saudi Arabia's recent dumping of the price of oil—not a great deal of foreign oil is being transported at the present time.
0.4	4.7	Remnant of patch town of Boston Run.
0.4	5.1	Gilberton Coal Co. operation mainly to left—breaker, washing plant, culm, coal, etc. The company—an affiliate of Reading Anthracite—operates the Rich COGEN plant.
0.7	5.8	To right, at end of Gilberton operation, is a the sloping highwall of an old strip mine.
0.2	6.0	Enter Gilberton, named for John Gilbert, a 19th century coal-mine operator.
0.5	6.5	After passing under bridge on PA 924, turn right on ramp to PA 924 (Frackville).
0.2	6.7	Cut in Llewellyn Formation to left.
0.1	6.8	Stop sign. Merge with PA 924 South.
0.6	7.4	To left is the beginning of a long cut in north-dipping Pottsville sandstone, conglomerate, etc. The north end of the cut in the Sharp Mountain Member is the site of serious, recurrent rockslides from the mid-1960's into the 1980's—not surprising caused by undercutting steeply inclined bedding planes.
0.6	8.0	PHMC Historical Marker to right reads:

> MAHANOY PLANE
> *Critical to the Pennsylvania anthracite industry, this inclined plane railroad transported coal from the Mahanoy Valley up the Broad Mountain to Frackville. Opened in 1862 as part of the Reading Railroad system, improvements in the early 20th century increased its size and capacity, making it an engineering marvel able to meet national demands. After hoisting hundreds of millions of tons of coal, it closed in 1932. Partial ruins remain nearby.*

0.1	8.1	Enter Frackville. First settled in the 1830s and '40s, Frackville was incorporated in 1876 with the merger of the villages of Frackville and Mountain City. It was founded by Daniel Frack, who had opened the first tavern in St. Clair, the Cross Keys, in 1829 to serve workers on the Danville & Pottsville Railroad. (He moved to found Frackville a few years later.)
0.3	8.4	At second traffic light in Frackville (end of PA 924), turn right on PA 61 North (West Oak Street).
1.0	9.4	Frackville Waste Water Facility to left.
1.4	10.8	Cut in Mauch Chunk Formation to right.
2.5	13.3	Village of Fountain Springs.
0.5	13.8	Stop sign. Turn right, keeping on PA 61.
0.2	14.0	St. Catherine Medical Center to left. This was the former Ashland State Hospital, founded in 1879 and completed in 1882 as the State Hospital for

		the Injured Persons of the Anthracite Coal Region. Originally built to treat only coal miners, it evolved over the years as a general hospital for everyone in the region. The current building was completed in 1967 and the name changed in 2006. The hospital closed in April 2012 after 130 years of operation.
0.4	14.4	Long cut in Mauch Chunk Formation on right.
0.2	14.6	Cut in Pottsville Formation on right.
0.3	14.9	Cross railroad and enter borough of Ashland, named after the plantation of Henry Clay in Kentucky.
0.1	15.0	Cross Mahanoy Creek.
0.1	15.1	To left is steeply north-dipping outcrop of Llewellyn sandstone exhibiting channel cut-outs, prominent joints, and spheroidal weathering. The metal plaque honors Dr. J. L. Hoffman, a physician and civic-minded citizen who contributed to the construction of the Ashland Reservoir and the erection of the Mothers' Memorial.

ASHLAND BOYS' ASSOCIATION
Widespread job loss in Pennsylvania's anthracite region in the late 19th century led many Ashland "boys" to seek employment elsewhere. Strong attachment to the miners' former hometown prompted formation of the A.B.A. c. 1900. Until 1976, the A.B.A. held Labor Day homecoming celebrations and during the Great Depression raised funds for the WPA-built Mothers' Memorial. It symbolizes abiding affection for family and community felt here and in the industrial US.

0.1	15.2	Traffic light at intersection with PA 54. Turn left on Centre Street, keeping on PA 61 (also PA 54). Directly ahead on the hillside is the famous Mothers' Memorial (Whistler's Mother Statue) as well as the Ashland War Memorial. The PHMC Historical Marker for the statue reads:
0.3	15.5	Traffic light in downtown Ashland. Ahead is a steep climb uphill on Centre Street.
0.7	16.2	S. 20th Street on left leads to Pioneer Tunnel Coal Mine Tour. (Thursday Preconference Field Trip).
0.1	16.3	Traffic light. Turn right on PA 61 (North Memorial Blvd.) Note that PA 54 continues straight ahead. TRICKY SPOT!
0.2	16.5	Enter Conyngham Township, Columbia County.
0.7	17.2	Bear right on rerouted PA 61.
0.2	17.4	Religious monument on left. This area was the former site of the village of Byrnesville, abandoned in the 1980s and '90s due to the Centralia Mine Fire. The village had been established in 1856, many of the early settlers coming from County Mayo in Ireland. Most of the men found employment at the nearby Locust Run Colliery. In its heyday, Byrnesville was home to more than 60 families.
0.7	18.1	Enter Centralia, formerly a borough, now largely abandoned because of a 53-year mine fire that is still burning. To the left is site of St. Ignatius Roman Catholic Church (demolished in the fall of 1997) and the St.

Ignatius Cemetery. The soil bank to the left blocks the former route of PA 61, abandoned in 1994 because of subsidences over the burning underground mine. Sometime before St. Ignatius was torn down, the author Bill Bryson passed through Centralia on his "trek" along the Appalachian Trail. In *A Walk in the Woods* (1998) he described a short walk along old PA 61:

> *I walked to the front of the church. A heavy metal crash barrier stood across the old road and a new highway curved off down a hillside away from the town. I stepped around the barrier and walked down old Highway 61. Clumps of weedy grass poked through the surface here and there, but it still looked like a serviceable road. All around on both sides for a considerable distance the land smoked broodingly, like the aftermath of a forest fire. About fifty yards along, a jagged crack appeared down the center of the highway and quickly grew into a severe gash several inches across, emitting still more smoke. In places, the road on one side of the gash had subsided a foot or more, or slumped into a shallow, bowl-shaped depression. From time to time I peered into the crack but couldn't gauge anything of its depth for the swirling smoke, which approved to be disagreeably acrid and sulphurous when the breeze pushed it over me.*

Centralia was founded as "Centerville" in the mid-1840s by Alexander Rea, a mining engineer for the Locust Mountain Coal and Iron Company. (The name was changed in 1865). The Mine Run Railroad was built in 1854, and the first mines opened in 1856. Centralia was incorporated as a borough in 1866, and two years later, on 17 October, Alexander Rea was murdered by the Molly Maguires along the road to Mine Run just to the east.

Continue down the hill on former Locust Avenue (PA 61).

0.1	18.2	Turn left into parking area.
0.1	18.3	Turn left into partially paved area.

STOP 1. Centralia Mine Fire

40.800078 N, -76.334113 W

Leave STOP 1, turning left on PA 61.

0.2	18.5	Stop sign. Turn left on former Centre Street, staying on PA 61. This was the center of Centralia.
0.2	18.7	Several of the few remaining houses in Centralia are on the left.
0.3	19.0	"Conyngham Township" sign on right marks the former limits of Centralia boro going west toward Mount Carmel.
0.3	19.3	Waste piles and strippings to right.
0.3	19.6	Entrance to stripping on right.
0.5	20.1	Turn right on paved road into stripping area.

STOP 2. Site 1 of Logan Surface Mine of Blaschak Coal Corporation. SMP #19950101

40.802778 N, -76.358611 W

STOP 3. Site 2 of Logan Surface Mine of Blaschak Coal Corporation

40.802778 N, -76.358611 W

Leave STOP 3. Return to entrance to strip-mine area and turn right on PA 61.

1.3	21.4	Enter Northumberland County, Mount Carmel Township.
0.5	21.9	Enter borough of Mount Carmel. The first permanent settler here was Lawrence Lamberson, a Revolutionary War veteran who surveyed the area in 1793 and became the first permanent settler in about 1800. Albert Bradford, an early sawmill operator, is said to have named the village after the holy mountain in Palestine because of its elevation and beautiful situation in the mountains. The Green Ridge Improvement Company opened the first coal mine and built the first breaker in the immediate area in 1854. Rapid development followed. Mount Carmel was incorporated as a borough in 1862. For a time in the 1970s and '80s it was feared that the Centralia Mine Fire would burn westward down the valley and threaten Mount Carmel. Such is no longer believed to be the case.
0.4	22.3	Traffic light. Turn right, staying on PA 61.
0.3	22.6	Turn left on West Avenue, staying on PA 61.
0.2	22.8	PHMC Historical Marker to right reads:

GEN. JAMES M. GAVIN (1907-1990)
U.S. Army officer: he rose to lieutenant general, 1955. Military tactician & strategist of airborne operations and limited wars. In World War II a paratrooper, regimental & division commander, 82nd Airborne Division; was in Sicily, Salerno, Normandy, Holland invasions. During Cold War he held high-level command and staff positions. Retired from Army, 1958. U.S. Ambassador to France, 1961-63. Author & businessman. In his boyhood he lived here in Mount Carmel.

0.2	23.0	Stop sign. Turn right, staying on PA 61.
0.1	23.1	Cross Shamokin Creek.
0.2	23.3	Enter village of Atlas.
0.8	24.1	Traffic light intersection with PA 54. Continue ahead on PA 61.
0.1	24.2	Enter village of Strong. Just to the right here are greenhouses heated by steam from the Foster Wheeler Mount Carmel COGEN Plant on the ridge to the north (see mile 55.8).
0.9	25.1	Enter borough of Kulpmont, incorporated in 1915.
0.6	25.7	Traffic light in Kulpmont.
0.8	26.5	Old textile factory to right.
0.6	27.1	South-dipping ledges of Llewellyn sandstone to right.
0.7	27.8	Traffic light in front of The Plaza at Coal Township.
0.2	28.0	Enter Ranshaw Township.
0.4	28.4	Sandstone outcrops to right.

0.2	28.6	Cut along road to right opposite Weis Market exhibits an excellent upright chevron fold (syncline) in the Llewellyn Formation (not visible from highway).
0.3	28.9	Llewellyn rock-cut along turnaround to right.
1.0	29.9	Enter city of Shamokin. Its name taken from the 18th century Amerindian village of "Shamokin" near Fort Augusta at the forks of the Susquehanna (now the city of Sunbury), Shamokin was incorporated as a borough in 1864 and as a city in 1949. It is bordered on the north by the world's largest man-made mountain, the Glen Burn-Cameron Colliery culm bank. The city once boasted numerous collieries—including the Cameron-Glen Burn (see STOP 4) and Luke Fidler on the north, the Henry Clay on the east and south, the Burnside on the south, and the Bear Valley on the south and west.
0.2	30.1	Traffic light. Bear left, staying on PA 61.
0.4	30.5	Trinity Evangelical Lutheran Church to right.
0.2	30.7	Traffic light. Turn left on PA 125 (Market Street).
0.1	30.8	Cross Shamokin Creek at start of boulevard, then turn right on Arch Street.
0.2	31.0	Turn right into parking area.

STOP

STOP 4 and LUNCH. Claude E. Kehler Park: History and fate of the Glen Burn Colliery

40.788889 N, -76.562500 W

End of LUNCH. Turn left on Arch Street and return to Market Street (PA 125).

0.2	31.2	Turn right on Market Street.
0.5	31.7	Bear right, staying on PA 125.
0.7	32.4	To left is the Sterling Mine from which issues a steady flow of "yellow boy" (acid-mine drainage). Continue straight ahead onto Bear Valley Patch Road. (PA 125 bends off to left.)

Sterling Mine at intersection of PA 125 and Bear Valley Road. The slope mine here was opened in 1934. The "yellow boy" feeds into Carbon Run just to the north (which flows past STOP 4) then into Shamokin Creek

0.1	32.5	Enter Bear Valley 1st Patch.
0.2	32.7	Recycling Center to right (on Venn Access). Enter Bear Valley 2nd Patch.

0.4	33.1	"NO MAINTENANCE BEYOND THIS POINT. ENTER AT YOUR OWN RISK." Road degenerates greatly beyond here. Many large potholes!
0.8	33.9	Stop at end of asphalt "paving" just before start of very rocky incline. Disembark. Buses turn around.

STOP 5. Bear Valley Strip Mine: "The Whaleback"

40.763137 N, -76.593375 W

		End of STOP 5. Walk back to buses and return to PA 125.
1.5	35.4	Stop sign. Continue straight ahead, now on PA 125.
0.7	36.1	Stop sign. Continue on PA 125 (Market Street).
0.4	36.5	Traffic light at Lincoln Avenue.
0.1	36.6	Traffic light. Turn right on PA 61 (Sunbury Street) and continue back east.
0.5	37.1	Traffic light. Bear right, staying on PA 61.
0.9	38.0	To left at traffic light is a cut (old stripping?) exposing a 5 ft± -thick coalbed, dipping steeply south.
4.7	42.7	To left are greenhouses of the Foster-Wheeler Mount Carmel COGEN Plant at Natalie.
0.5	43.2	Traffic light. Turn left on PA 54.
0.8	44.0	Visible through trees to left is the Foster-Wheeler Mount Carmel COGEN Plant (see mile 55.8).
0.3	44.3	Enter village of Natalie.
0.7	45.0	Cut in Pottsville Formation to left at crest of Big Mountain.
0.4	45.4	Sandstone ledges to left are in the Mauch Chunk Formation.
0.3	45.7	Ahead to right is Brush Valley between Big and Little Mountains, carved by South Branch Roaring Creek out of the Mauch Chunk Formation.
0.9	46.6	To left is AQUA Pennsylvania, a water and wastewater utility company serving 8 states.
0.3	46.9	Enter Bear Gap in Little Mountain and pass deep cut in the Pocono Formation to left.
0.2	47.1	Enter Ralpho Township.
1.2	48.3	Good view of Trimmers Rock "upland" ahead.
0.2	48.5	All Saints' Cemetery to right.
0.5	49.0	Turn right on Quarry Road.
0.7	49.7	Red metal gate—continue straight ahead on gravel road.
0.2	49.9	Offices of Bear Gap Quarry. Disembark.

STOP 6. Bear Gap Quarry

40.858867 N, -76.517310 W

		Leave STOP 6, returning to PA 54.
0.9	50.8	STOP sign. Turn left on PA 54, returning back to PA 61.
0.4	51.2	Good view of Bear Gap in Little Mountain, with Big Mountain behind.
0.5	51.7	Another good view of Bear Gap.
1.1	52.8	Pocono sandstone to right.
0.5	53.3	Cross Brush Valley again.
0.5	53.8	Enter Mt. Carmel Township.
0.5	54.3	Mauch Chunk ledges to right.
0.4	54.7	Pottsville ledges to right at crest of Big Mountain.
0.3	55.0	Enter village of Natalie.
0.8	55.8	Good view of Foster-Wheeler Mount Carmel COGEN Plant to right. Started up in February 1990, the plant has a net power output of 40 MW by the burning of "culm" that has a heat value of 3250 BTU/lb. At that time, it consumed about 840,000 tons/yr of this coal waste. Process steam is used to heat greenhouses located between the plant and PA 61 (see mile 24.2).
0.9	56.7	Strip mine to left in distance.
0.4	57.1	Traffic light. Turn left on PA 61. Continue on PA 61 through Mt. Carmel and Centralia to Ashland, Frackville, and Pottsville.
7.6	64.7	Stop sign entering Ashland. Turn left, staying on PA 61 (Market Street).
0.1	64.8	Scenic view east from Market Street in Ashland.

View east down Market Street in Ashland. "Nose" of Bear Ridge in the distance (mile 64.8)

1.0	65.8	Traffic light. Turn right, staying on PA 61.
6.7	72.5	Traffic light in Frackville. Turn right, staying on PA 61.
0.1	72.6	Holy Ascension Orthodox Church to left.

0.3	72.9	Dutch Kitchen Diner to left.
0.4	73.3	Bear right onto ramp for I-81 North.
0.4	73.7	Merge with I-81 North.
0.9	74.6	Frackville State Correctional Institution (SCI) Penitentiary to right.
0.6	75.2	John B. Rich COGEN plant on top of Broad Mountain to left.
0.4	75.6	To right are gas pipes from Wheelabrator-Frackville COGEN Plant to Frackville SCI.
0.6	76.2	Ahead to left is the Wheelabrator-Frackville COGEN Plant (see Day-2 roadlog, mile 4.2).
0.2	76.4	Deep cuts in Llewellyn Formation on both sides of road.
3.1	79.5	Cut in north-dipping Pottsville conglomerate.
1.5	81.0	Bear right onto exit ramp to PA 924 North (Mahanoy City).
0.3	81.3	Merge with PA 924.
0.2	81.5	Turn left onto SR 1008.
0.1	81.6	Turn left into MainStay Suites.
0.1	81.7	Parking lot of MainStay Suites.

End of Day 1 Field Trip!

REFERENCES

Abandoned Mine Research, Inc., St. Nicholas Breaker, http://www.undergroundminers.com/mahanoy.html (accessed 12 May 2015).

Arnold, Walter, photographer, The art of abandonment—the Old St. Nicholas Coal Breaker, http://artofabandonment.com/2010/07/the-old-st-nicholas-coal-breaker-mahanoy-pa/ (accessed 12 May 2015).

Bryson, B., 1998, A walk in the woods: New York, Broadway Books, 276 p.

Crown, H. T., and Major, M. T., 2003, A guide to the Molly Maguires—featuring the ORIGINAL Molly Maguire Tour: Frackville, PA, Broad Mountain Publishing Company, 234 p.

Dempsey, T., [no date], Schuylkill County Patch Towns: [Schuylkill County Historical Society].

Inners, J. D., Edmunds, W. E., and LaRegina, J. A., 1996, Independent steam-electric power plants in the Anthracite Region, NE Pennsylvania: site geology, coal-refuse bank utilization, and environmental benefits: Pennsylvania Geological Survey, 4th ser., Open-File Report 96-50, 22 p.

Johnson, D. B., 2004, Centralia: Charleston, SC, Arcadia Publishing, 128 p.

Kenny, Kevin, 1998, Making sense of the Molly Maguires: New York, Oxford University Press, 336 p.

Mahanoy Area Historical Society, 2004, Mahanoy area: Charleston, SC, Arcadia Publishing, 128 p.

Mahanoy Area Historical Society, Welcome to the Kaier page: www.mahanoyhistory.org/kaier.html (accessed 7 May 2015).

Morin, Bode, 2013, Last of the giants—coal breakers threatened: Society for Industrial Archeology Newsletter, v. 42, no. 4, p. 1-3.

Wallace, A. F. C., 1987, St. Clair—a nineteenth-century coal town's experience with a disaster-prone industry: New York, Alfred A. Knopf, 519 p.

Wikipedia, Pennsylvania Route 61, http://wikipedia.org/wiki/Pennsylvania_Route_61 (accessed 31 July 2014).

Wikipedia, Mahanoy City, Pennsylvania, http://en.wikipedia.org/wiki/Mahanoy_City,_Pennsylvania (accessed 7 May 2015).

Wikipedia, Shamokin, Pennsylvania, http://en.wikipedia.org/wiki/Shamokin,_Pennsylvania (accessed 2 June 2015).

STOP #1: CENTRALIA COAL MINE FIRE

Stop Leader – Jennifer Elick, Susquehanna University

SITE 1 Origin of Coal Mine Fire 40.80078° N/ 76.334113° W

Approaching Centralia from the south (Ashland), take PA-61 N to the St. Ignatius Cemetery (Figure 1-1). Turn left onto an unmarked road (across from the St Ignatius Cemetery) known as Second Street. Drive approximately 1000 ft on Second Street and park beyond the Odd Fellows Cemetery. From here you can see old mine vents. Walk east along an ATV path, to a wider road, (~ 1/8 of a mile). This location is adjacent to the dump where the Centralia coal fire was ignited on May 27, 1962 (Figure 1-2).

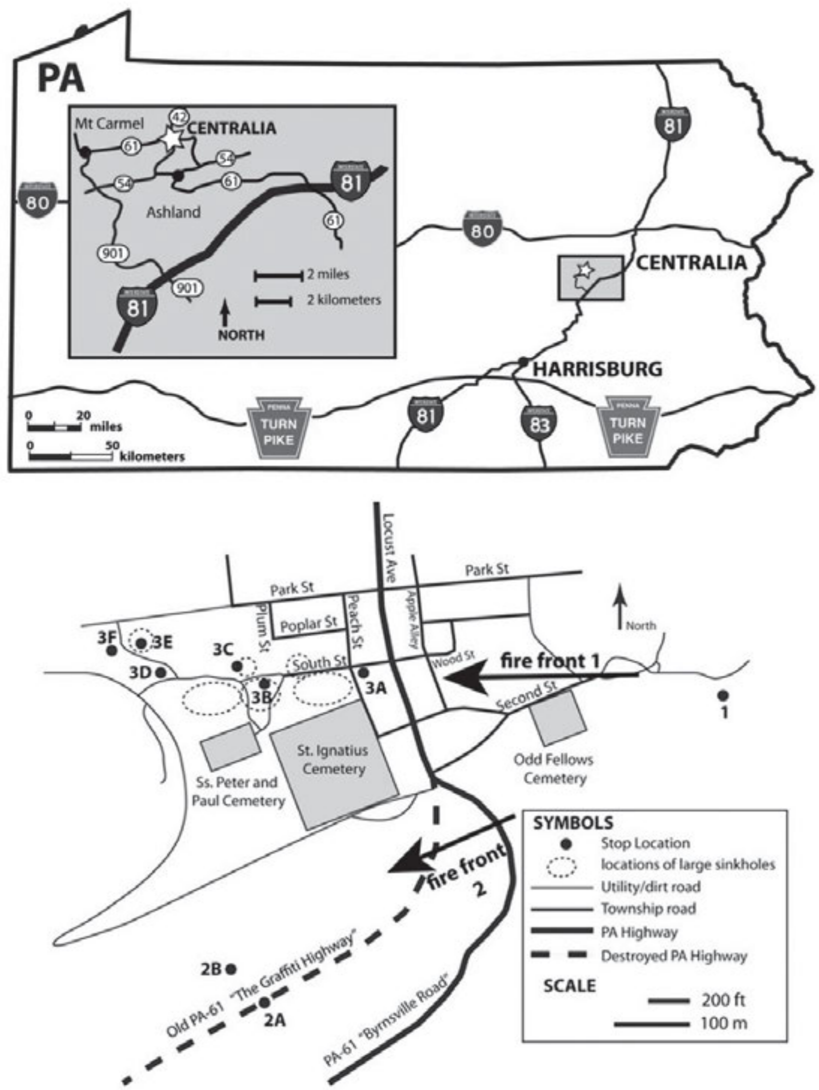


Figure 1-1. Map directions to Centralia with major PA highways (top) and sites in Stop 1(bottom). Site 1 is the origin of the coal fire, the location of the dump and a site for collecting Pennsylvanian plant fossils. Site 2 is Fire front 2, located along Graffiti Highway (Old PA 61). Site 3 is Fire Front 1, located alongside the St. Ignatius Cemetery

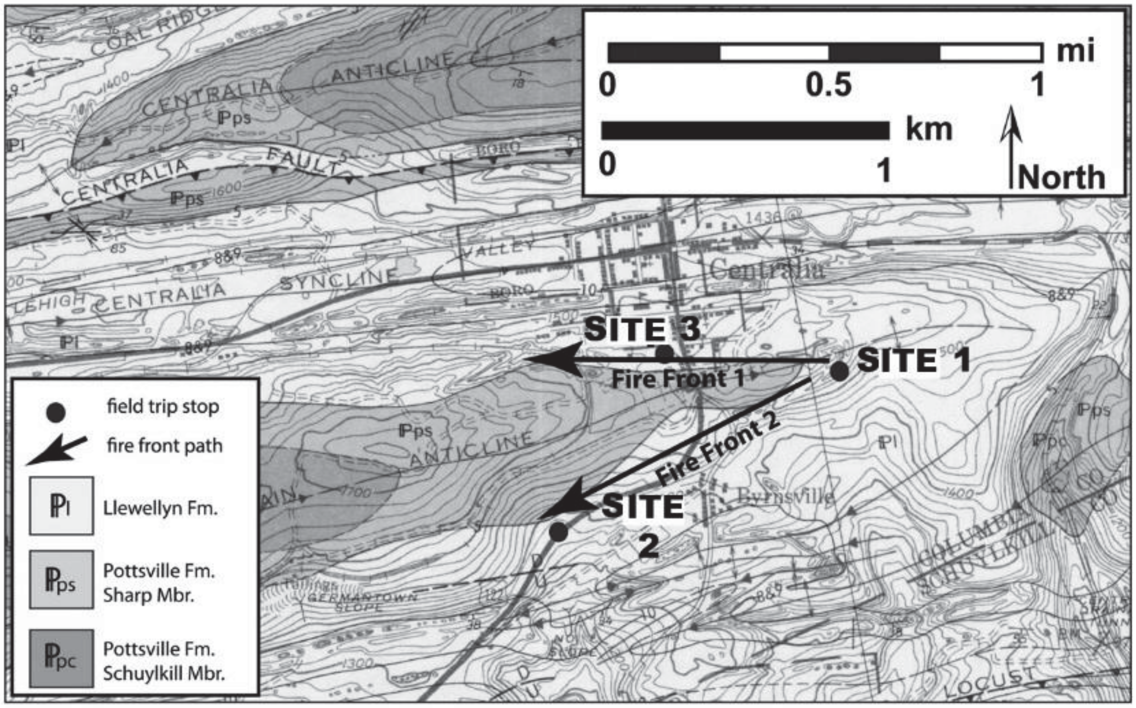


Figure 1-2. Geologic map of region around Centralia highlighting SITE 1 and the other 2 sites visited in Stop1. Black arrows identify locations and movement direction for fire fronts 1 &2. (modified from Arndt, 1971)

Caution should be used at this exposure due to the steep slope. The rock exposed along the nose of the anticline is interbedded carbonaceous black shale, with iron-stained quartz sandstone and dark gray shaly siltstone from the Buck Mountain coal succession (Llewellyn Formation) (Arndt, 1971) (Figure 1-3). Note the variance of strike (N37°E to N60°E) and dip (28 to 45° SE) due to the folding. These rocks are interpreted to represent a water-logged environment along a humid alluvial plain that contained coastal marsh peat swamps (Edmunds et al., 1999).

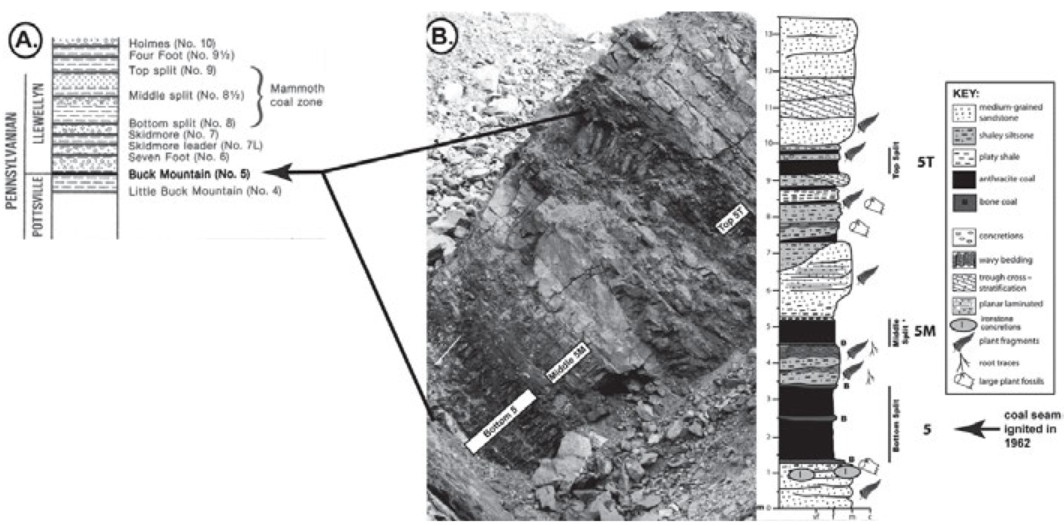


Figure 1-3. A). Stratigraphy of the Middle Pennsylvanian in eastern and central Pennsylvania (modified from Berg et al., 1983) The Buck Mountain coal succession is identified by a black arrow. B). Photograph and detailed measured section of Buck Mountain coal splits from Blaschak Surface mine (modified from Elick, 2013).

Here Pennsylvanian age plant fossils from the black shale near the base of the Buck Mountain coal succession are abundant. The shale contains abundant carbonized and coalified plant fossils, many of which are kaolinite and pyrophyllite coated or iron-stained. Some of the fossil plants found at this location include different species of Neuropteris, Lepidodendron, Alethopteris, Sphenopteris, Sphenophyllum, Sigilaria, and Calamites. Stigmaria were also identified extending from some Lepidodendron tree fossils. A cone from either a Lycopod (Lepidodendron, Sigillaria) or possibly Horsetail (Calamites) that came from St. Clair, Pennsylvania was also found. There are many unidentified plant fragments. Compressed, large tree trunks, up to 0.45-m, are located at the base of the hill. An exposure of quartz sandstone is discontinuous, iron-stained, and micaceous and undulates across the exposure. It contains ripples, and plant fragments. The shaly siltstone did not appear to contain as many plant fossils as the friable shale.

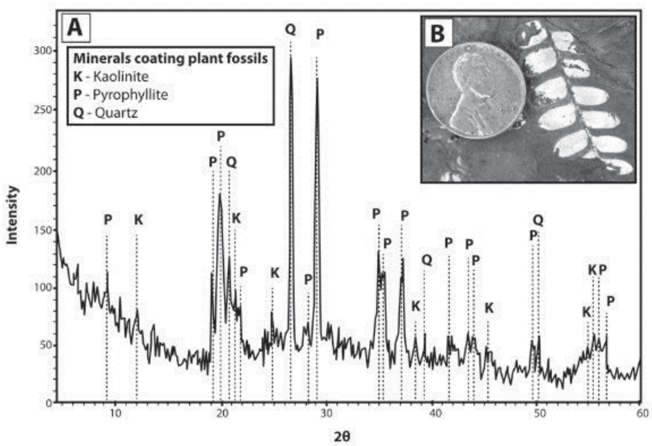


Figure 1-4. Middle Pennsylvanian pyrophyllite- and kaolinite-coated Neuropteris plant fossil from black shale

Many of the fossils at this location are coated by pyrophyllite and kaolinite, and likely formed under low-temperature metamorphic conditions, (approximately 275° C). They are similar to those described by Peterson et al. (2011), who studied alteration of fern fossils from the shale in the Buck Mountain coal succession in St. Clair, PA. The ferns died and were buried in a low-energy, low-oxygen environment, like a swamp, and the sediments eventually lithified into rock. During maximum burial, the unit was heated to between 250 and 300° C, allowing pyrophyllite to replace an early forming mineral phase, such as pyrite (Peterson et al., 2011) and also increasing the coal rank to anthracite (Figure1- 4).

The mine vents located near the Odd Fellows Cemetery were drilled down to the subsurface workings in order to draft the gases out of the town. For a short while, the vents provided some relief (DeKok, 2010). However, they likely accelerated the fire movement in the long-term by creating an updraft that circulated oxygen-rich air to the fire from other locations (Neubauer and Elick, 2013).

SITE 2 Fire Front 2 along Old PA 61 — 40.799655° N/ 76.339679° W

From South Street, return to PA Route 61 S and turn right. Drive 200 ft, and pull off the road to the right where "Old Route 61" is located (Figure 1-1). This particular stretch of PA-61, is also known as the "Graffiti Highway," and was closed to traffic in 1992 due to the fire. We will examine features at this stop that are within a 1500-ft walk down the road. Park in front of the St Ignatius Cemetery, along PA-61, and walk past and down the blocked road. Heat from the coal fire was released along vents from fire front 2 and under the road. The big crack in the road and vents in the trench delineate the path of the fire along the southern limb of the Locust Mountain Anticline (Figures 1-1, 1-2, and 1- 5).

SITE 2A, Big Crack on "Graffiti Highway" 40.796457 º N/ 76.342742 º W

A large crack, nearly 76-m long and 1.2- to 1.5-m wide, extends through the middle of Old PA-61 S (Figure 1-5). As the fire moved through the area, it caused the road to contort and buckle. After repairing the road several times between 1987 and 1992, this stretch of the road was closed to traffic (DeKok, 2010). The crack in the road is longer and wider than it was in 2006, suggesting renewed activity by the fire, however, crown vetch grows throughout the crack and the temperature in this location is not elevated. The highway endured stretching and subsidence from the heat, which produced large extensional features like en-echelon fractures and deformational structures that resemble normal faults (Figure 1-5).

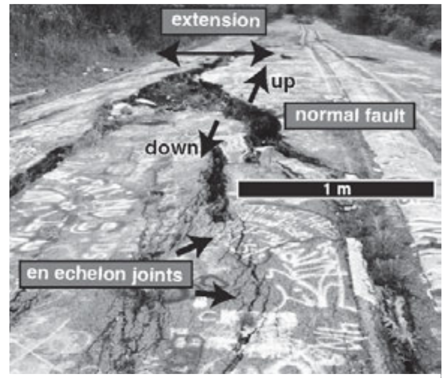


Figure 1-5. Crack in PA-61 reveal extensional features in the macadam. (Photo: Elick 2015)

SITE 2B, Excavation Trench on Hill 40.796688º N/ 76.343165º W

A short hike up the hill, along a footpath, north of the big crack in old PA-61, leads to one of the excavation trenches dug out as a means of extinguishing the fire. The trench exposes black shale and siltstone (N70°E; 40°SE). This is also the location of additional exhaust vents from fire front 2. The high temperatures from the fire burned off the organics in the shale, and the shale is now a bright reddish-orange color where gases were exhausted.

SITE 3 Fire front 1 40.800868º N/ 76.340456º W

From the Odd Fellows Cemetery, return to PA-61 N. Drive approximately 200 ft N and turn left onto South Street (Figures 1-1 and 1-2). Though many visitors drive across this landscape, it is recommend here that you park at the base of South Street, on the sandstone, and walk westward, along fire front 1. This area (Figure 1-6) contains numerous sinkholes, fractures, and exhaust vents and care should be taken while walking.

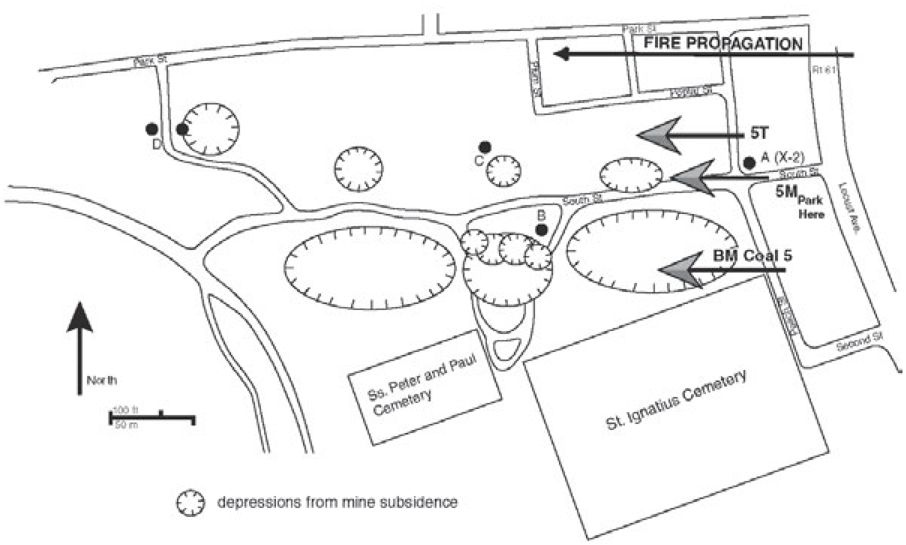


Figure 1-6. Map of locations of interest at fire front 1. A) PADEP borehole, B) sinkholes, C) N-S oriented fractures, and D) large sinkhole and birch forest.

SITE 3A, PA DEP Borehole 40.80107° N/ 76.34102° W

The orange-painted PADEP borehole (X-2) helps mark fire front 1. It is located at the intersection of Peach and South Streets (both are unmarked), west of the parking area. Borehole X-2 is one of 46 sealed holes that the PADEP continue to monitor on a monthly basis for temperature/depth. In July of 2011, the temperature of this particular borehole at a depth of 23 m depth was 137° C. Though this is high relative to the current surface exhaust vent temperatures of today, it is low in comparison to some record borehole temperatures in the past. The highest temperature recorded at a borehole in 2011 was 206° C; this borehole was located on Park Street, just east of PA-61 (PADEP, 2013). In the 1970's and 1980's, many boreholes commonly reached temperatures > 530° C (GAI Consultants, 1983). During this time interval, one particular borehole reached 732° C at depth, with corresponding surface exhaust vent temperatures of 482° C (PADEP, 2013).

SITE 3B, Sinkholes 40.800809° N/ 76. 342641° W

Continue walking westward, following South Street, up the hill, to the Ss. Peter and Paul Cemetery. The road leading to the cemetery exhibits 2 m of subsidence (Figure 1-7). This sunken road is part of a large sinkhole that formed as smaller sinkholes coalesced (Elick, 2013). The sinkholes began to form following heavy precipitation events in 2011 (the wettest year on record in central PA), when over 185 cm of precipitation fell in central PA, nearly twice the average for the state (Elick, 2013). The precipitation interacted with the hot rock from the fire, causing shale to turn to mud and quartz-cemented sandstone and conglomerate to crumble and fall apart. Steam interacting with the bedrock helped cause the surface bedrock to collapse, producing sinkholes that follow the bedrock orientation. In all, nine new sink holes formed in 2011, along the strike of 5, 5M, and 5T coal beds of the Buck Mountain coal succession. The large sinkhole at the top of the hill is 23 m wide and 26 m long and up to it 2 m deep (Elick, 2013).

Figure 1-7. Example of recent subsidence near Ss. Peter & Paul Cemetery. This sinkhole began to form in 2011. (Photo: Elick 2015)

SITE 3C, North-south oriented heat exchange 40.81294° N/ 76.343150° W

Approximately 300-ft north of the NE corner of the Ss. Peter and Paul Cemetery is a location where several N–S oriented fractures are venting heat from fire front 1 (Figure 1-8). Because the coal fire is known to have moved through the Buck Mountain coal succession (from 5 to 5M to 5T) (Elick, 2013), it therefore has potential to migrate to the next overlying coal bed, the Seven Foot coal (No. 6) (Figure 1-3).

Anthracite coal begins combustion at approximately 500° C under normal surface conditions (Schweinfurth, 2009). Under adiabatic conditions, the minimum temperature at which coal can combust may be lower (Kim, 2007). Coal fires can therefore migrate into successive coals by preheating the adjacent coals, commonly along a structural cracks or collapse features in the bedrock (Cao et al., 2007). In the recent past, borehole X-2 has reached temperatures in the range necessary to initiate combustion of adjacent coals in this manner. Elick (2013) measured fracture orientations, and identified a north-south oriented fracture set associated with the Appalachian Orogeny (Faill, 1999) and subsurface mining. Additionally, fractures from mine subsidence may influence the spread of the fire. Currently, north-south oriented vents are monitored to determine if the fire will migrate to the adjacent coal beds, such as the Seven Foot coal (No. 6).

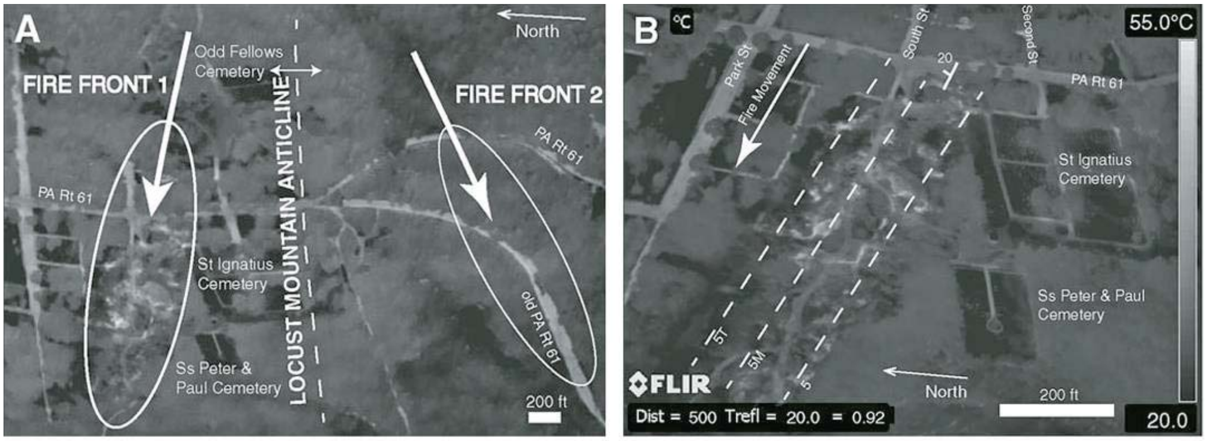


Figure 1-8. Aerial thermal infrared images of fi re fronts in Centralia taken 23 May 2015. (A) View showing variations in temperatures of the fire fronts relative to the Locust Mountain anticline, from 800 ft altitude. (B) View of fire front 1, from 500 ft altitude, showing variations in temperature and coal beds from the Buck Mountain coal succession (dashed lines)

SITE 3D, Succession 40.801391º N/ 76.345176º W

Continue walking west along the dirt road for another 100 ft, towards a **Y** in the road (Figure 1- 6). Turn west and follow the road to the right-hand fork for another 150 ft. The road then turns nearly 90° to the north. We will stop here to examine a large sinkhole, nearly 15-m wide and 3-m deep. To the left, on the other side of the road, is a field of birch trees. Between 2000 and 2007, heat and gases from the mine fire escaped from vents into the field, killing all of the large trees. By 2007, the surface temperatures began to decrease, and vegetation returned. Birch, a common successional tree in the coal regions and colonizer following environmental disruption, has thrived in this area and in other places where the ground temperatures have lowered. When soil temperatures and gas compositions returned to normal levels by 2012, it was concluded that the westward progression of the fire had ceased (Elick, 2013).

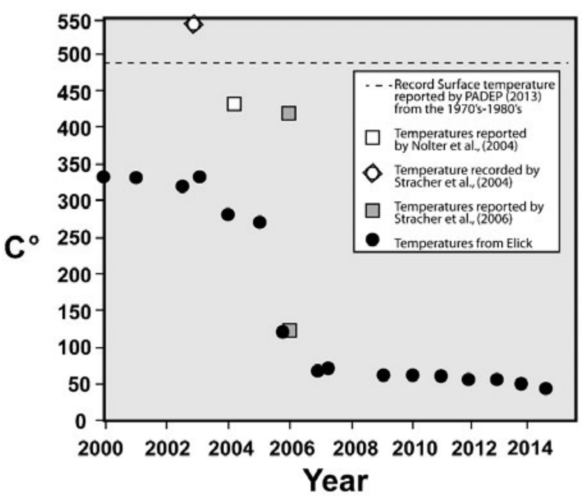


Figure 1-9. Graph of changing temperatures of the surface exhaust vents (°C) for the Centralia mine fire from 2000 to 2015. All of the data collected by Elick is from fire front 1.

The decline in temperatures throughout Centralia (Figure 1-9), indicates that the fire is currently diminishing. Martinez and Ressler (2001) predicted that coal fire gases would introduce nutrients to the soil, like ammonia, nitrate, and phosphate, which would aid in the regrowth of vegetation once the fire temperatures subsided. Today, birch, oak, and sumac trees are rapidly colonizing the once hot landscape.

REFERENCES

Elick, J.M., 2015, The Centralia coal mine fire (Centralia, Pennsylvania): A field guide for an evolving system, in Brezinski, D.K., Halka, J.P., and Ortt, R.A., Jr., eds., Tripping from the Fall Line: Field Excursions for the GSA Annual Meeting, Baltimore, 2015: Geological Society of America Field Guide 40, p. 485–497, doi:10.1130/2015.0040(12).

STOPS # 2 & 3: BLASCHAK OPERATIONS BETWEEN CENTRALIA AND MOUNT CARMEL

Structural geology of the Logan Main Mining Pit and the Logan West Pit

Stop Leader – Robin Koeberle

These STOPS in Logan Main Mining Pit (#2) and the Logan West Pit (#3) provide visual evidence of thrust faulting prior to major folding in the central portion of the Western Middle Anthracite field.

Geology

The Pennsylvania Anthracite region is divided into four fields: Northern, Eastern Middle, Western Middle, and Southern. The Logan pits of Blascak Coal Company are located in the central part of the Western Middle field in the Mount Carmel and Ashland 7½ -minute quadrangles. The geologic map of Figure 2-1 (Arndt, 1971a and b) shows the complex structure affecting the two rock units comprising bedrock of the mined area: the Llewellyn Formation and the underlying Pottsville Formation, ubiquitous in all four Anthracite fields.

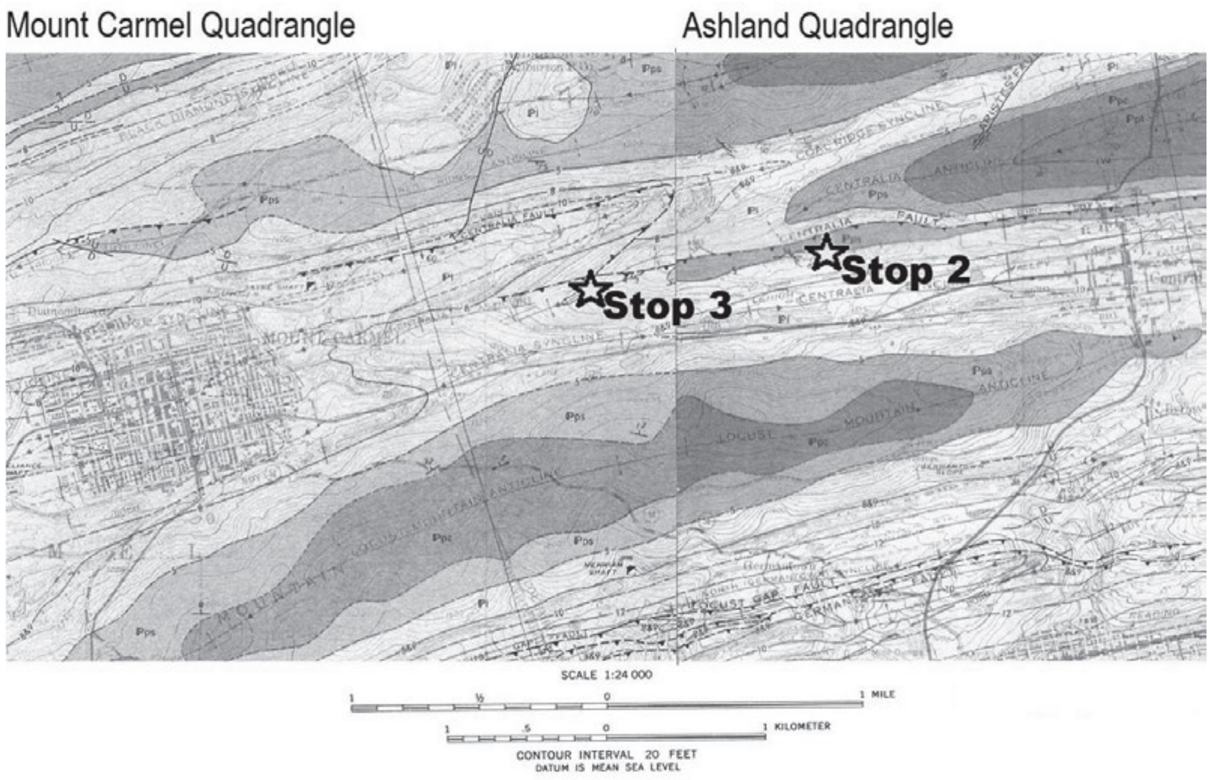


Figure 2-1. USGS Geologic Quadrangles showing the location of STOPS 2 and 3 (Arndt Wood, 1971a and b)

The dominant Llewellyn Formation is Middle to Late Pennsylvanian in age (Wood et al., 1962) and extends from the bottom rock of the Buck Mountain (No. 5) vein up to the present erosion surface. Prior to 1962, the Llewellyn was informally called the "Coal Measures," then assigned to the Allegheny and Conemaugh Formations and to the informal unit known as the "post-Pottsville." The Llewellyn is comprised of siltstone, shales, sandstones, conglomerates, and coal. The underlying Pottsville is largely conglomerate and sandstone, with a few coalbeds that are only locally mineable in the Western Middle field. Figure 2-2 is a composite stratigraphic section from Arndt (1971a and b).

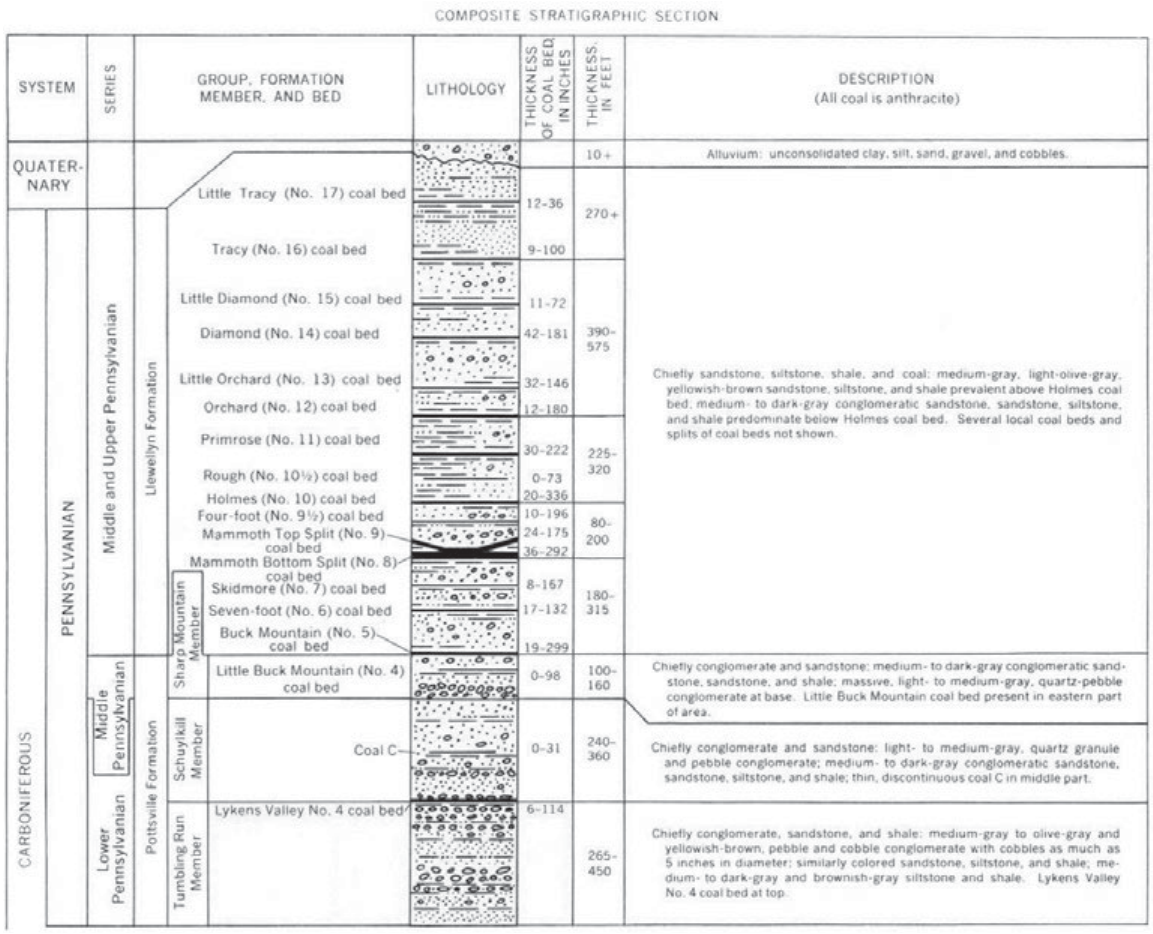


Figure 2-2. Composite stratigraphic section from Arndt, 1971a and b

The Llewellyn Formation in all four Anthracite fields is contorted into complexly folded and faulted synclinoria. These structural features formed during the various phases of the Appalachian Orogeny. Superimposed upon these complex fold systems are a multitude of low-angle thrust, high-angle reverse, underthrust, tear, and bedding-plane faults. Throughout the Anthracite region, advancing surface mining operations encounter visual geologic evidence of the chronological development of these various structures. This can supply a wealth of detailed information, giving actual "survey" data to the understanding of the geologic structures present in the area. Unfortunately, this visual evidence is lost and sometimes never recorded as operations advance or are backfilled. Locations like the Bear Valley "Whaleback" (STOP 5 of this Field Conference) are examples of structures that help us understand the complexity of this region. Numerous authors have discussed the sequences from detailed field investigations. Gordon Wood of the U.S.G.S. noted that few natural outcrops of the Llewellyn Formation exist. Most detailed information is supplied by underground mine maps and surface mine excavations, all centered on the coal veins; relatively little is known of the strata between these veins.

A detailed Lithotectonic Map of the Appalachian Orogen in Canada and the United States (Hibbard et al., 2006) combines much of the research on the salients and recesses associated with this Orogeny. Figure 2-3 shows these salients and recesses in the Appalachian-Ouachita orogenic belt as published somewhat earlier by Thomas (1983).

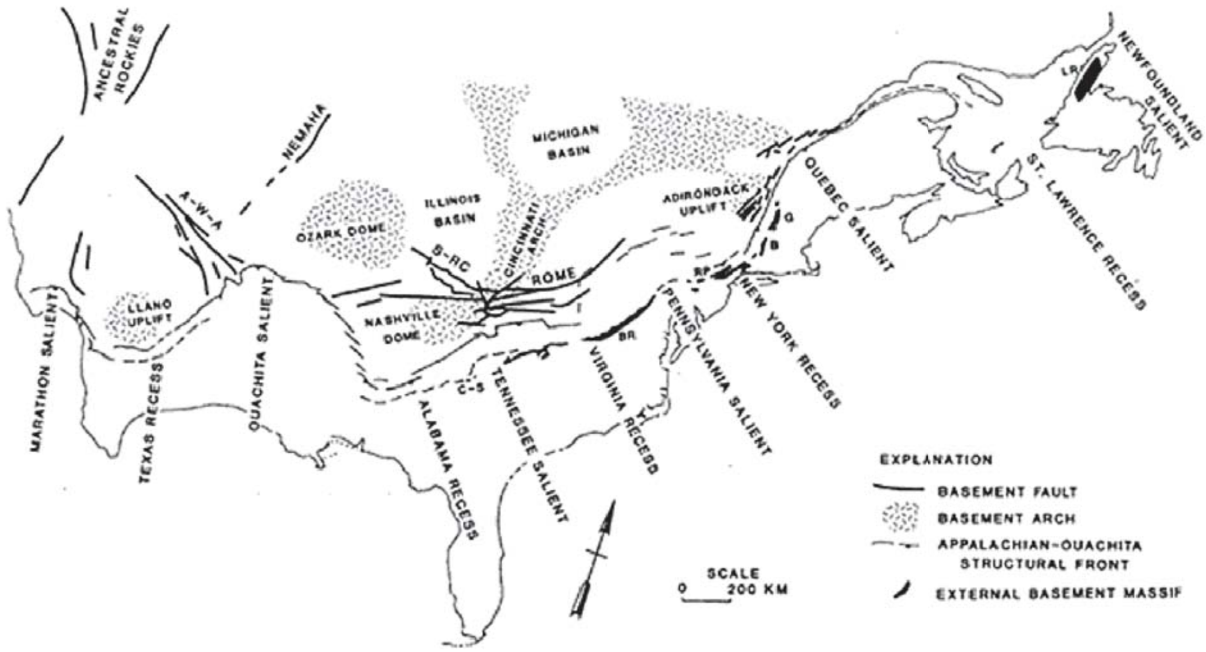


Figure 2-3. Structural geologic map of recesses and salients along the Appalachian-Ouachita orogenic belt during the late Paleozoic, showing basement faults and arches of the North American craton (Thomas, 1983). Appalachian external basement massifs: B = Berkshire; BR = Blue Ridge; C-S = Corbin-Salem Church; G = Green Mountain; LR = Long Range; RP = Reading Prong. Intracratonic basement faults: A-W-A = Arbuckle-Wichita-Amarillo; S-RC = Shawneetown-Rough Creek

Mine History

Three underground mines operated in this area and are generally named the Logan Colliery, Sayre Colliery, and Morris Ridge Colliery. Names and operators of these collieries have changed many times, and a book could be written on this aspect alone. Numerous other operators have mined on the properties—from underground independent miners to various surface mining operators. Mine maps for these various can be obtained from various sources and utilized for mine planning and development.

The Logan Colliery is located in the Centralia syncline between the boroughs of Mount Carmel and Centralia. To the north are the Morris Ridge and Sayre Collieries in the Coal Ridge syncline, which is between Mount Carmel and the village of Aristes. The Centralia anticline is the general dividing line between these three mine complexes.

STOP OVERVIEWS

STOP 2. Logan Mine Mining Pit

You will be viewing the bottom rock of the Buck Mountain vein on the north limb of the Centralia syncline. To the west is the Centralia fault, which cuts the Buck Mountain vein, causing an overturned fold and a repeat of the Buck Mountain vein (Figure 2-4, closeup in Figure 2-5). The Centralia fault runs east to west on the north limb of the Centralia syncline and extends past the village of Delano far to the east. It causes an overturned fold on the Buck Mountain vein. On the Mount Carmel quadrangle, the Centralia fault is shown to branch off and arc around in the Coal Ridge syncline (Arndt, 1971b)—whereas in actuality the fault there is a thrust fault separate from the Centralia fault. This is discussed later in **The Missing Evidence**.

Figure 2-4. Centralia fault on the north limb of the Centralia syncline looking west. On the right is the Centralia anticline exposed by mining

Figure 2-5. Close-up detail of the fault zone shown in Figure 2/3-4. Looking west.

The Centralia fault is well defined and was originally described in the underground mine mapping as a "roll." Later mine operators searched for the "Bubble" as they extended their underground operations. Figures 4 and 5 show how well defined the fault is once it is exposed in open pits and strippings. As we go 2000 feet farther west of this location, the fault disappears to a point where the bottom rock of the Buck Mountain vein is just beginning to overturn and fracture (Figure 2-6).

Figure 2-6. Overturned Buck Mountain vein top rock and the Centralia fault. Looking west.

STOP 3. Logan West Pit

Here we see an asymmetrical fold in the Seven-Foot (No. 6) vein (Figure 3-7). To the south, but no longer visible, was a trailing imbricate fan with the beginning of the Centralia fault (Figure 3-8). The southern portion of the fold is cause by compression folding that took place in the later stages of the orogeny in the area.

Figure 3-7. Here we see an asymmetrical fold caused by compression. Looking east.

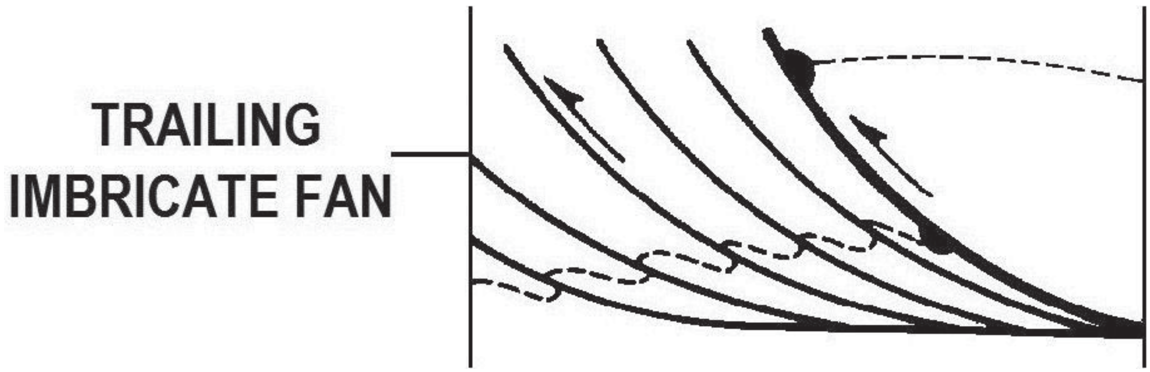


Figure 3-8. Trailing imbricate thrust (Boyer and Elliot, 1982)

The Missing Evidence

The Morris Ridge Colliery, located directly north of the Logan Colliery, is an active mining operation of Mallard Contracting. Here the Coal Ridge syncline is a tight fold, forming a chevron fold to the east (Figure 3-9) and broadening into two synclines as it progresses to the west.

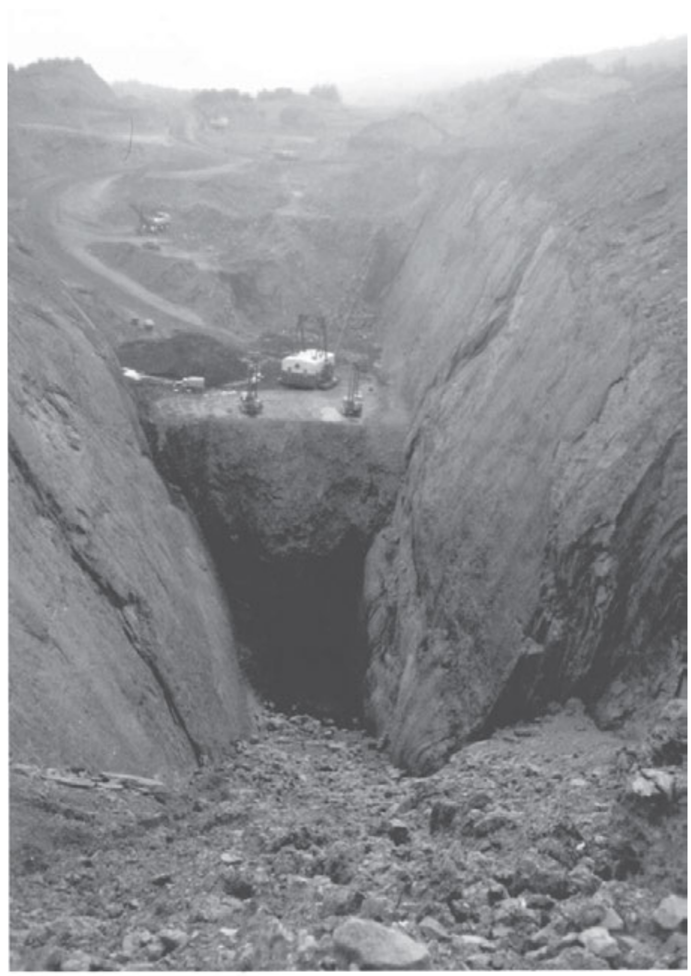


Figure 3-9. Coal Ridge syncline forming a chevron fold, looking west. Mining at the time of this photo (1980's) was being done by Kerris and Helfrick, Inc.

Looking at the mining cross sections it is evident that a number of thin-skinned thrusts occurred, one of which duplicated the Mammoth vein. This thrust is evident from the Morris Ridge Colliery westward and is, in essence, a klippe. On the U.S.G.S. Quadrangle Map the fault is assumed to be part of the Centralia fault (Arndt, 1971a), but is in reality a separate thrust fault that occurred prior to the major folding event. It is important to not that these thrusts are all dipping to the north and can be traced visually across the syncline to outcrop at the surface. This event is seen in the uppermost strata. The main questions are how far the map trace of this thrust extends to the west, and does this overthrust of the Mammoth vein tie into the overthrust that occurred to the south?

In the Centralia syncline, mining indicated that there was only one Mammoth vein. The Centralia fault begins just to the west, where the bottom rock of the Buck Mountain vein began to offset at the top of an anticline. To the north of this offset are three trailing imbricate thrusts. The Centralia fault came in at a later date than the flat decollement thrusts in the Mammoth vein, due to the fact that the Buck Mountain underlap had made a more complete syncline being cut off on its southern limb.

Figures 3-10 through 3-15 well illustrate the complex structural framework of the Coal Ridge syncline—its folds, thrusts, imbricate thrusts, folded thrusts, and overthrusts.

Figure 3-10. Coal Ridge synclinal axis at loader, and a Marion 7400 dragline mining the southern syncline. Thrust faults are evident at the top of the photo, with an imbricate thrust visible. Looking west.

Figure 3-11. Folded thrust sheet with imbricate thrust

Figure 3-12. North-dipping limb of the Mammoth vein, showing the Mammoth-vein bottom rock, upper right, over the Mammoth vein. Looking west.

Figure 3-13. Coal Ridge syncline, showing detail of the compression folding on the north-dipping limb of the Mammoth vein. Looking west.

Figure 3-14. Overthrust on the Holmes veins located on the north limb of the Coal Ridge syncline. Looking west.

Figure 3-15. Detail of the Holmes vein overthrust. Looking west.

REFERENCES FOR STOPS 2 AND 3

Arndt, H. H., 1971a, Geologic map of the Ashland quadrangle, Columbia and Schuylkill Counties, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ-918 (scale 1:24,000).

Arndt, H. H., 1971b, Geologic map of the Mount Carmel quadrangle, Columbia, Northumberland, and Schuylkill Counties, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ-919 (scale 1:24,000).

Boyer, S. E., and Elliott, D, 1982, Thrust systems: American Association of Petroleum Geologists Bulletin, v. 66, no. 9, p. 1196-1230.

Hibbard, J. P., van Staal, C. R., Rankin, D. W., and Williams, H., 2006, Lithotectonic map of the Appalachian Orogen, Canada-United States of America: Geological Survey of Canada, "A" Series Map 2096A, 2 sheets (1:1,500,0000), doi: 10.4095/221912.

Thomas, W. A., 1983, Continental margins, orogenic belts, and Intracratonic structures: Geology, v. 11, p. 270-272.

Wood, G. H., Jr., Trexler, J. P., Yelenosky, A., and Soren, J., 1962, Geology of rocks of Pennsylvanian age in the southern half of the Tremont quadrangle, Schuylkill County, Pennsylvania: U.S. Geological Survey Bulletin 1112F, P, F181-F208.

STOP #4 AND LUNCH: CLAUDE E. KEHLER PARK, SHAMOKIN

History and fate of the Lower Gap-Cameron-Glen Burn Colliery

Stop Leaders – Jon D. Inners and Michael Korb

Claude E. Kehler Park in Shamokin provides a good view of the gap cut though Big Mountain by Shamokin Creek, a tributary of the trunk Susquehanna River whose mouth is at the south edge of Sunbury, 13 miles to the west-northwest. Big Mountain is the bounding Pottsville ridge on the north side of the Western Middle Anthracite field, extending about 20 miles from west of Trevorton to northeast of Centralia (Figure 4-1). For more than 100 years, the gap was the site of one of the largest collieries in the Anthracite fields—the classic Cameron-Glen Burn Colliery, the final breaker of which was immortalized on many postcards from the mid-20th century (Figure 4-2).

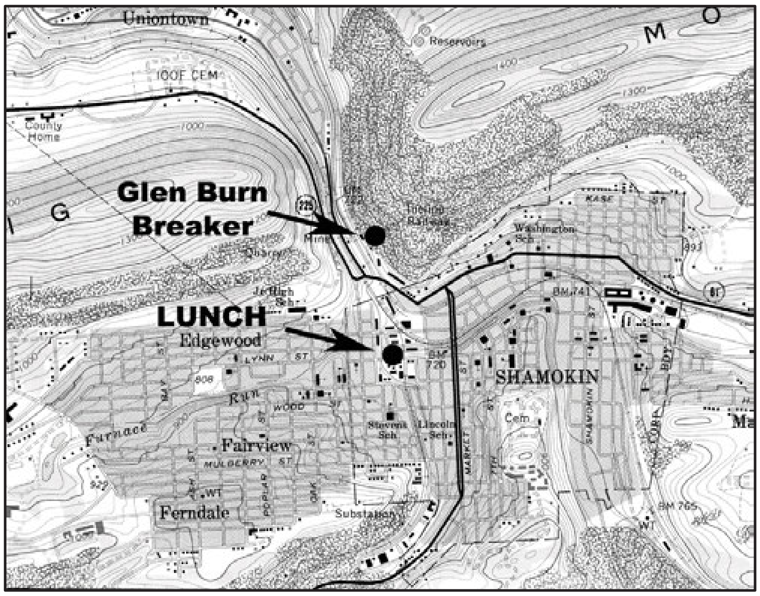


Figure 4-1. Location map for STOP 4 and Lunch—Claude E. Kehler Park, Shamokin

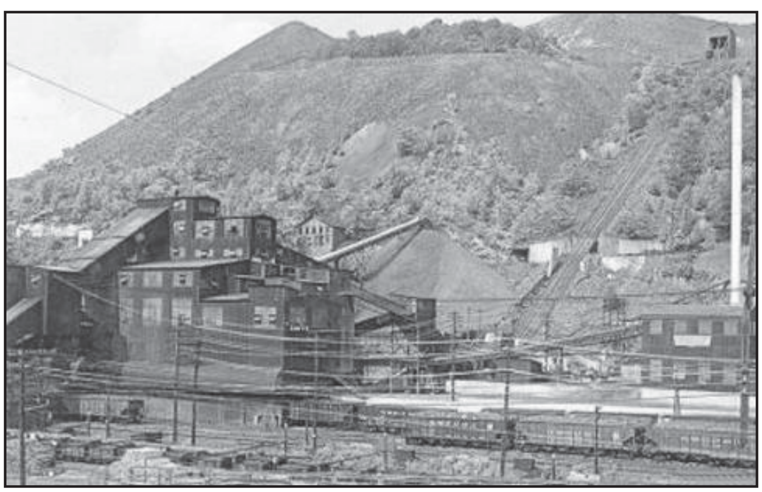


Figure 4-2. A postcard view of the Glen Burn breaker, probably from the 50's or 60's. The breaker was dismantled in 2000.

Mining and Geology

The Cameron-Glen Burn Colliery was situated at the extreme north edge of Shamokin. The Glen Burn mine lay entirely west of the gap, its western boundary about 3 miles distant, and the Cameron mine straddled the gap, extending 1.3 miles to the east. The combined mines were bounded on the east by the Hickory Swamp mine, on the south by the Luke Fidler, Neilson, Stirling, and Bear Valley mines, and on the west by the Bear Valley mine. Only the western part of the Cameron mine underlies a significant area of the city of Shamokin.

The roughly east-west axis of the Western Middle synclinorium is about a mile south of the mines. Folds in the northern part of the coal field are subsidiary folds on the north limb of the synclinorium, being doubly-plunging, parallel to subparallel folds, some broken by thrust faults trending subparallel to the folds. They trend N75°E and are mostly less than 1000 feet wide. Few persist more than a mile or two along strike before merging or overlapping an adjacent fold. The major structures affecting the Cameron-Glen Burn mines are the Hickory Swamp basin ("basin" being the miners' term for a coal-bearing syncline) and the Luke Fidler anticline, the Cameron basin, the Edgewood anticline, and the Glen Burn basin (proceeding east to west). Bounding the mines to the southwest of the gap is the south-dipping Furnace Run fault, which reaches the surface about 3000 feet south of the crest of Big Mountain.

The Llewellyn Formation at Shamokin has a maximum thickness of about 1900 feet and contains 18 persistent coal beds (i.e., beds that can be traced throughout a basin and can be correlated between adjacent basins). Eleven seams were mined at the Cameron-Glen Burn mines—Primrose (No. 11), Rough (No. 10½), Holmes (No. 10), Four-Foot (No. 9½), Mammoth Top Split (No. 9), Mammoth Middle Split (No. 8½), Mammoth Bottom Split (No. 8), Skidmore (No. 7), Skidmore Leader (No. 7L), Seven-Foot (No. 6), and Buck Mountain (No. 5). These coals were mined from to depths of more than 1000 feet east of the gap and 1200 feet west of the gap. The thickest of these beds were in the Mammoth Coal Zone—a maximum of 15.0 feet (av. 7.8) in the Top Split, 10.7 feet (av. 7.3) in the Middle Split, and 12.4 feet (av. 6.7) in the Bottom Split). The Seven-Foot—mined extensively in the Cameron—had a maximum thickness of 10.4 feet (av. 6.0). Coal beds younger than the Orchard (No. 12) underlie the city of Shamokin, where little mining was done.

History

Mining began at the future site of the Glen Burn Colliery in the Big Mountain gap of Shamokin Creek in 1836, the coal probably being cleaned and sized by hand-operated shakers. The first breaker was built in 1857 by W. L. Dewart at his "Lower Gap Colliery." It was renamed the Cameron Colliery in 1864. In 1871 a new large "double type" breaker was built to replace the original structure. As demand increased, the need for a still larger cleaning plant prompted erection of a new facility in 1888. This breaker was built in January of that year, but burned down that October. It was quickly replaced the next year.

In 1894 a "jig house," containing more sophisticated cleaning and sizing equipment and sizing equipment to process some smaller sizes of coal, was added to the breaker. Fifteen years later electric lighting was installed in the breaker, an update greatly inspired by the frequent visits to the area of Thomas Edison. Prior to that time the breaker was illuminated by oil lamps, which certainly contributed to the fire danger. The final breaker on the site, an all steel breaker considered at the time the most modern processing plant in the Anthracite region, was built in 1939 by the Stevens Coal Company. That same year the Susquehanna Colliery Co., based in Wilkes-Barre, took over operation of the Cameron and renamed it the Glen Burn Colliery in 1940. Susquehanna operated the mine and breaker until it was acquired by Kerris and Helfrick in the late 1960's.

The number of workers employed at the Cameron/Glen Burn Colliery peaked in 1899 at more than 1500 men and boys. Production at the Cameron Colliery was impressive in the 1880's: 175,000 tons in 1881, 164,000 tons in 1882, 220,094 tons, in 1884, 245,436 tons in 1885, and 193,931 tons in 1886. (Compare with that of the Pine Forest Colliery at STOP 10.) But the highest production occurred between 1934 and 1948, peaking at 627,158 tons in 1942. Daily production in that year averaged more than 2400 tons. Though mining ceased in 1970, Kerris and Helfrick continued to operate the breaker—processing up to 500 tons of coal per hour from other mines into the 1980's. Unfortunately the breaker was not equipped to handle the coal finer than Buckwheat #4 (i.e., through 3/32 to over 3/64 inch). A strike stopped production in 1986, and the breaker ceased operation the next year for an indefinite period. Then in 1990 it shut down permanently. The Glen Burn breaker was dismantled in 2000—and a classic landmark at the northern entrance to "The Region" along PA 61 was no more.

Over the 134-year life of the various named colliers in the gap, about 30,000,000 tons of coal was removed from the Glen Burn and Cameron mines beneath the north side of Shamokin. Recorded accidents claimed the lives of 217 workers during the colliery's years of operation. The worst was on 27 May 1911, when five men died in an explosion. Nearby mines also had their share of disasters. At the smaller Luke Fidler mine just to the southeast, five men died in a fire on 8 October 1894 and seven were killed in an explosion on 25 November 1902. A fire at the Neilson mine just to the south of the gap claimed ten lives on 1 April 1893.

Interestingly, the mine workings west of the gap were designated a fallout shelter in the 1950's and '60's. Hundreds of tins of crackers and water barrels, as well as much toilet paper and medicine, were still evident in 1997 when "explorers" entered deep into the west drift.

The Glen Burn Mine Fire

The immense tree-covered culm bank, extending about 1.5 miles down the southern slope of Big Mountain west of the gap, is evidence of the mine's production over more than a century and a quarter of time. It is the largest in the entire Anthracite region and claimed locally to be the "world's largest man-made mountain"—though it seems unclear whether Guinness recognizes it as such. Both an underground mine fire and an above-ground culm bank fire plagued the colliery for many years starting in the middle years of the past century; only the underground fire is still burning (Figure 4-3).

Figure 4-3. The Glen Burn Mine Fire in about 2010

The combined underground-culm bank extended eastward into adjoining problem areas and burned for more than 50 years. The once-burning refuse bank is situated over the outcrop of at least 13 coal seams. During periods of air inversion, the smoke from this area caused breathing difficulties in Shamokin. There was also the problem of the large areas of the refuse bank sliding and subsiding. At its maximum extent above ground fire covered an area of nearly 500 acres.

The Glen Burn Mine Fire is actually the combination of at least 5 separate fires. Two were extensive surface fires (New Bank and Old Bank at numerous locations, now extinguished), and three are deep mine fires (Cameron, Luke Fidler, and Hickory Swamp). Active burning of the fire in December 2011 was confirmed by surface venting that started a forest fire extinguished by the Coal Township Fire Department. The large fire zone is on uninhabited Big Mountain (Figure 4-4). The steeply dipping coal veins cause flushing materials to wash down-dip into the underground mine pools, making it necessary to "rubblize" in order to place flushing materials. Surface sealing and clearing may prevent future forest fires. The fire has been classified as "High Cost, Moderate Benefit, Low Worth" by PA DEP Bureau of Mining Reclamation. Estimated reclamation cost is $15,000,000<u>+</u>.

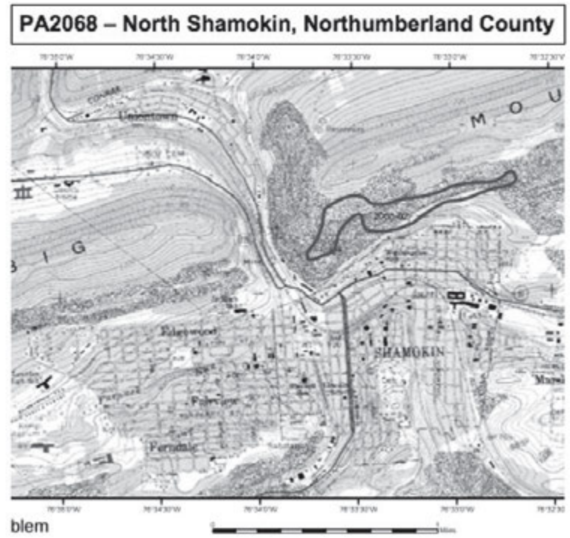


Figure 4-4. Map of the Glen Burn Mine Fire (outline)

REFERENCES

Arndt, H. H., Danilchik, W., and Wood, G. H., Jr., 1963, Geology of anthracite in the western part of the Shamokin quadrangle, Northumberland County, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-47, 2 sheets.

Ashburner, C. A., 1883, First report of progress in the Anthracite Coal Region—the geology of the Panther Creek basin or eastern end of the Southern field: Pennsylvania Geological Survey, 2nd ser., AA, 407 p.

Danilchik, W., Arndt, H. H., and Wood, G. H., Jr., 1962, Geology of anthracite in the eastern part of the Shamokin quadrangle, Northumberland County, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-46, 2 sheets.

x-Man, Abandoned coal mine—Glen Burn/Cameron colliery, http://www.uer.ca/forum_showthread_archive.asp?threadid=100548 (accessed 4 June 2015) (3)

Koeberle, R., Blaschak Coal Co., personnel communication, June 2015.

Lesley, J. P. 1887, Annual report of the Geological Survey of Pennsylvania for 1886: Pennsylvania Geological Survey, 2nd ser., Part III, p. 919-1329.

Moore, Chester A., 1982, Breaker near Shamokin will be replaced (Reading Eagle, 23 May), https://news.google.com/newspapers?nid=1955&dat=19820523&id=u9MxAAAAIBAJ&sjid=7OMFAAAAIBAJ&pg=5554,1040987&hl=en (accessed 4 June 2015). (4)

NEP Crossroads, Glen Burn Colliery/Shamokin, PA, http://nepacrossroads.com/about4273.html (accessed 4 June 2015). (1)

Pennsylvania Department of Environmental Resources—Bureau of Abandoned Mine Reclamation, 2012, PA2068—North Shamokin, Northumberland County, 2 p.

Pioneer Millworks and Cindy Inkrote, 1800's antique timbers reclaimed from the Cameron Colliery, Shamokin, PA, http://pioneermillworks.com/get-to-know-us/unearth-the-story/1800s-antique-timbers-reclaimed-cameron-colliery (accessed 4 June 2015). (2)

U.S. Department of Labor, Dist 1—coal mine safety and health fatality information: historical coal mine disasters in the Anthracite region, http://www.msha.gov/district/Dist_01/Fatals/histfat.htm (accessed 7 June 2015)

STOP # 5: IN MEMORIAM – RICHARD P NICKELSEN

Gary M. Fleeger, Pennsylvania Geological Survey

Of all of the outstanding geological work completed by Dick Nickelsen (Figure 1), Professor Emeritus at Bucknell University, in his 60+ year career, he is probably best known for his work at Bear Valley strip mine and the Whaleback near Shamokin, PA. It was the subject of a detailed article published in the American Journal of Science in 1979, culminating his 17-year-long, complete structural analysis of the site. In that study, he was able to define, based on cross-cutting relationships and orientation analysis, the sequence of 6 structural stages during the Alleghany Orogeny from pre-folding jointing to fold-related extension resulting in grabens (Nickelsen, 1979). He also documented clockwise stress axis orientation changes during the orogeny. Nick passed away in Lewisburg at age 89 on November 23, 2014.

Figure 1. Nick, leading a Pennsylvania Geological Survey staff field trip to Bear Valley in November, 2007

Nick studied under the tutelage of the world-famous Ernst Cloos at Johns Hopkins, where he mapped the Blue Ridge near Harper's Ferry, WV (Nickelsen, 1956). After graduation, he taught at Penn State, but decided that he preferred a smaller school where there was more emphasis on teaching. In 1959, he went to Bucknell, where he started the geology department. Nick was my structural geology professor, and also my senior thesis advisor at Bucknell in the mid 1970s.

Nick was a regular attendee of the annual Field Conference of Pennsylvania Geologists. From the at least 1955 (when he was a leader) through 2007, he attended many Field Conferences. I accompanied Nick and another Bucknell student on my first Field Conference in 1975, where we actually camped out on boulder colluvium in a cemetery, to avoid detection and eviction during the night.

Nick led his first Field Conference in 1955 while at Penn State. He and Gene Williams led a one-day trip on the structure and stratigraphy of Pennsylvanian units near Philipsburg and Clearfield, PA (Nickelsen and Williams, 1955). Nick demonstrated the jointing and faulting in that area in a number of strip mines. His work on the jointing became part of his more extensive work on joints on the plateau (Nickelsen and Hough, 1967).

Figure 2. Nick leading the 1996 Field Conference of Pennsylvania Geologists.

Nick later turned his attention to the Ridge and Valley. He and Rodger Faill co-led the 1973 Field Conference looking at Ridge and Valley structures (Faill and Nickelsen, 1973; Figure 2). They showed that folds were of various orders (sizes), frequently disharmonic, and largely kink folds. Penetrative deformation was much more extensive and significant to deformation than previously thought.

This year is the second visit to Bear Valley by the Field Conference. A few years after his AJS publication on Bear Valley, Nick led the 1983 Field Conference to demonstrate his work to the geologic public. Co-led with Ed Cotter, Professor Emeritus at Bucknell (Nickelsen and Cotter, 1983), it holds the record for the largest attendance on a Field Conference trip, with 278 participants. Bear Valley continues to be an incredible teaching laboratory, and is visited by geologists from around the world, still learning from Nick's work. In addition to the highlight of Bear Valley, other stops expanded upon the structures seen in 1973, especially penetrative deformation.

During his later years teaching at Bucknell, he studied folded thrusts and duplexes in the Kishacoquillas Valley region of the Ridge and Valley. He first recognized that the sequence of structures rotated counterclockwise on the SW limb of the Pennsylvania salient, opposite what he saw in the NE limb, such as here at Bear Valley. He led a PA Survey staff trip there in October, 1988. Much of that work was used as a basis for the Field Conference of PA Geologists in 2007, led by Tom McElroy and Don Hoskins, who were then mapping in the Kishacoquillas Valley area. Nick was the guest speaker at that year's banquet, which, after 52 years, was the last Field Conference that he attended.

After Nick's retirement from Bucknell in 1992, he continued to map and research the structural geology of the McConnellsburg area, looking at the sequence of deformation and the counterclockwise rotation of the structure. He compared the Tuscarora Fault to the Antes-Coburn detachment that he identified in his Kishacoquillas Valley work. He led the 1996 Field Conference to show the results his McConnellsburg work (Nickelsen, 1996).

Nick was very concerned with the preservation and enhancement of significant geological sites. Several times, he was involved with preservation attempts at Bear Valley, which continue today, but was concerned about any restriction of access that might occur as a result.

Nick was one who rarely turned down an opportunity to take people in the field. He led numerous field trips for various groups, including industry groups and non-geologists. The Pennsylvania Survey staff benefitted from a few Nick-led trips, the last being, appropriately, to Bear Valley in 2007 (Figure 1) at age 82.

References

Faill, R. T. and Nickelsen, R. P., 1973. Structural geology, pp. 9-38, in: Faill, R. T., et al., eds., Structure and Silurian-Devonian stratigraphy of the Valley and Ridge Province in central Pennsylvania Guidebook for the 38th Annual Field Conference of Pennsylvania Geologists, October 5-6, 1973, Bureau of Topographic and Geologic Survey, Department of Environmental Resources, Harrisburg, PA 17120.

Nickelsen, R. P., 1956. Geology of the Blue Ridge near Harpers Ferry, West Virginia: Bulletin of the Geological Society of America, v. 67, pp. 239-270.

Nickelsen, R. P., 1979. Sequence of structural stages of the Alleghany orogeny, Bear Valley Strip Mine, Shamokin, Pennsylvania: American Journal of Science, v. 279, pp. 225-271.

Nickelsen, R. P., 1996, Alleghanian Sequential Deformation on the SW limb of the Pennsylvania Salient in Fulton and Franklin Counties, south-central Pennsylvania, Guidebook for 61st Annual Field Conference of Pennsylvania Geologists, Pennsylvania Geological Survey, Harrisburg, PA.

Nickelsen, R. P. and Cotter, E., eds., 1983. Silurian depositional history and Alleghanian deformation in the Pennsylvania Valley and Ridge. Guidebook for 48th Annual Field Conference of Pennsylvania Geologists, Pennsylvania Geological Survey, Harrisburg, 192 p.

Nickelsen, R. P. and Hough, Van Ness, D., 1967a. Jointing in the Appalachian Plateau of Pennsylvania: Bulletin of the Geological Society of America, v. 78, pp. 609-630.

Nickelsen, R. P. and Williams, E. G., 1955. Structure and stratigraphy of Pennsylvania sediments of the Plateau area near Philipsburg and Clearfield, Pennsylvania, Guidebook 21st Annual Field Conference of Pennsylvania Geologists May 27, 28, and 29, 1955, pp. Sd 1-41.

This stop is dedicated to the memory of Richard P. Nickelsen

STOP #5: ALLEGHANIAN DEFORMATION AT THE BEAR VALLEY STRIP MINE

Stop Leader – Stephen Whisner
Bloomsburg University

Adapted from:

Field Trip Guidebook T166: Day 3

28th International Geological Congress

by

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***** PLEASE BE CAUTIOUS AS YOU MOVE AROUND THE SITE *****

– smooth slopes, precipitous drops, narrow paths, and wet leaves make for treacherous footing –

Summary

The Bear Valley strip mine, home of the Whaleback, lies at the west end of Pennsylvania's middle anthracite coal field in the Appalachian Valley and Ridge. Mining of Pennsylvanian coals has exposed beautiful, complex structures, making this one of the preeminent locations in eastern North America in which to view deformation in three dimensions. Nickelsen (1979, 1983) decrypted the overprinted structures to parse out six stages of deformation: extension jointing in coals followed by Alleghanian deformation that includes extension jointing in sandstones and ironstones, formation of spaced cleavage and small folds, faulting, larger-scale folding, and extension. In addition to providing evidence of progressive deformation, this is a superb locale for examining disharmonic folding, in which layer thickness and competency contrasts control deformation.

Introduction

The Bear Valley Strip Mine is situated along several faulted second order folds on the south limb of the first order Shamokin synclinorium (Figure 5-1). The mine area has been previously described by Nickelsen (1979, 1983) from whose work most of this stop description is derived (see Memoriam, this Guidebook)

The mine offers superb three-dimensional exposures of the structural elements of the northern Valley and Ridge province, and clear views of geometric relationships and sequential overprinting of structures that elucidate the stages and processes of deformation during the

Alleghanian orogeny. All of the stages displayed are Pennsylvanian or younger but no Mesozoic deformation is thought to have occurred here.

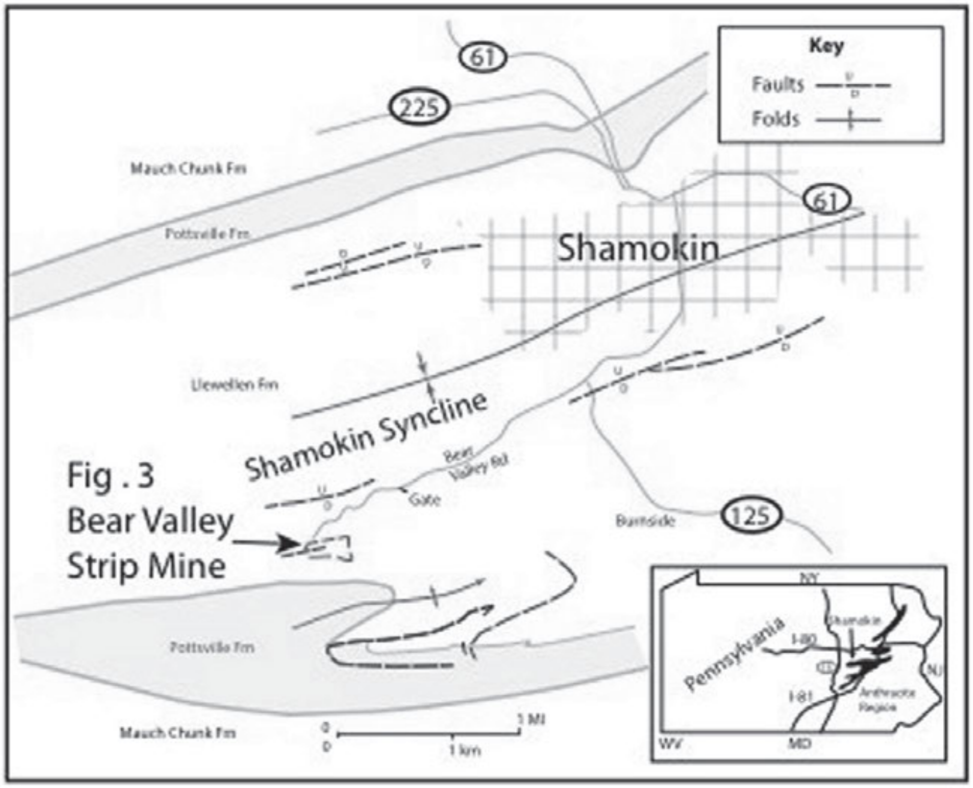


Figure 5-1. Index map and location map of Bear Valley Strip Mine.
Pennsylvania 225, 125, and 61; U.S. 15, I-80, and I-81 are labeled

All of this is visible within a 320,000 ft2 (30,000 m2) strip mine area that contains two disharmonically-folded, Pennsylvanian-age cycles of sedimentation exposed in cross section along highwalls and on unique bedding plane surfaces. Deformation mechanisms and the structural sequence of layer-parallel shortening (Stages II, III, IV) overprinted first by large-scale folding (Stage V) and later by layer-parallel extension (Stage VI) can be fully demonstrated at this locality (Figure 5-2).

The variety of structural elements and deformation mechanisms includes: Stage I joints in coal that are eastern extensions of the pre-Alleghanian Set I joints in coal observed on the Appalachian Plateau by Nickelsen and Hough (1967, Plate 3); hydraulic extensional joints with quartz-fiber fillings in ironstone and sandstone (Stage II); spaced cleavage in shales and silty shales formed by pressure solution, or grain rotation and sliding, or primary crenulation, accompanied by incipient recrystallization (Stage III), wrench (strike-slip) or wedge (thrust) faults with very obvious slickensides and slickenlines (Stage IV); third (size) order flexural slip folds showing disharmony between adjacent structural lithic units (Stage V); and extensional fault "grabens" or extensional joints formed by buckling or release fracturing (Stage VI). Elsewhere in the region Stage VII large scale strike-slip faults with horizontal slickenlines cut all other structures. Finally, it is apparent that ductility contrast between stiff ironstone and sandstone and weaker shale and coal controls the relative structural behavior of rock types.

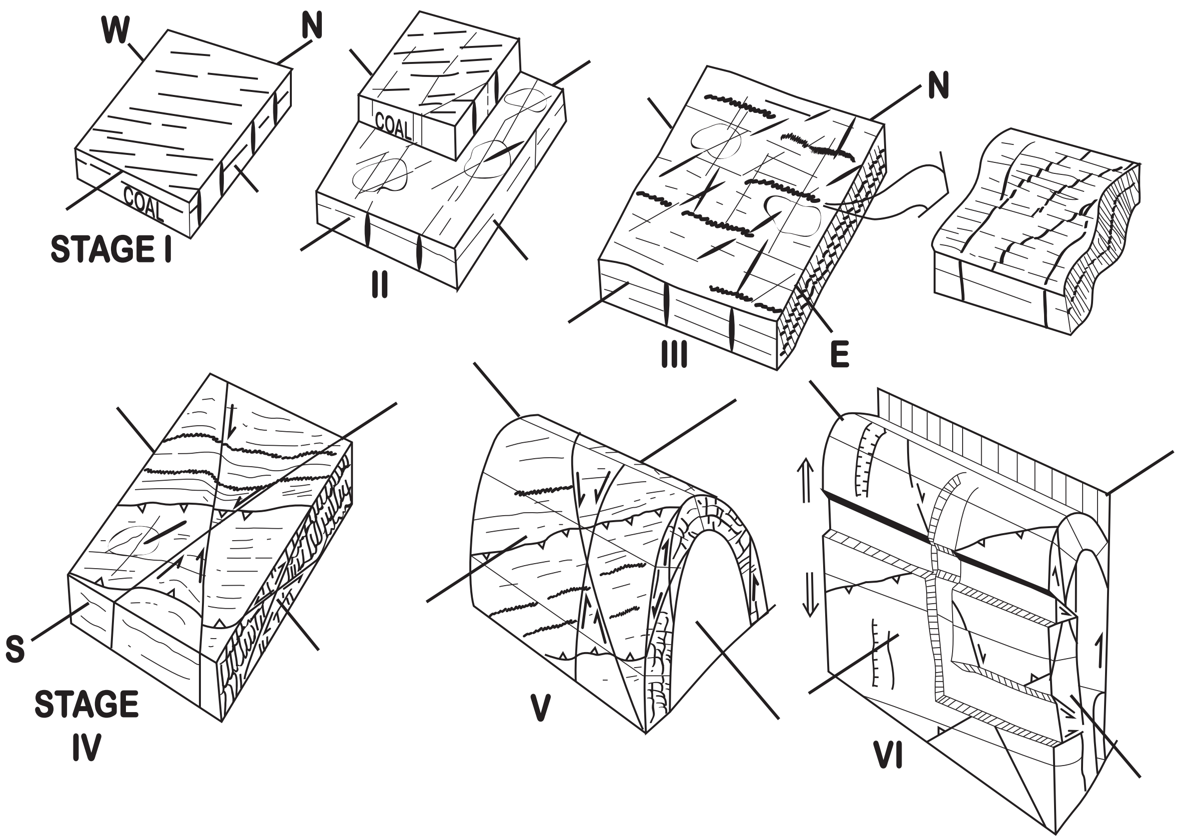
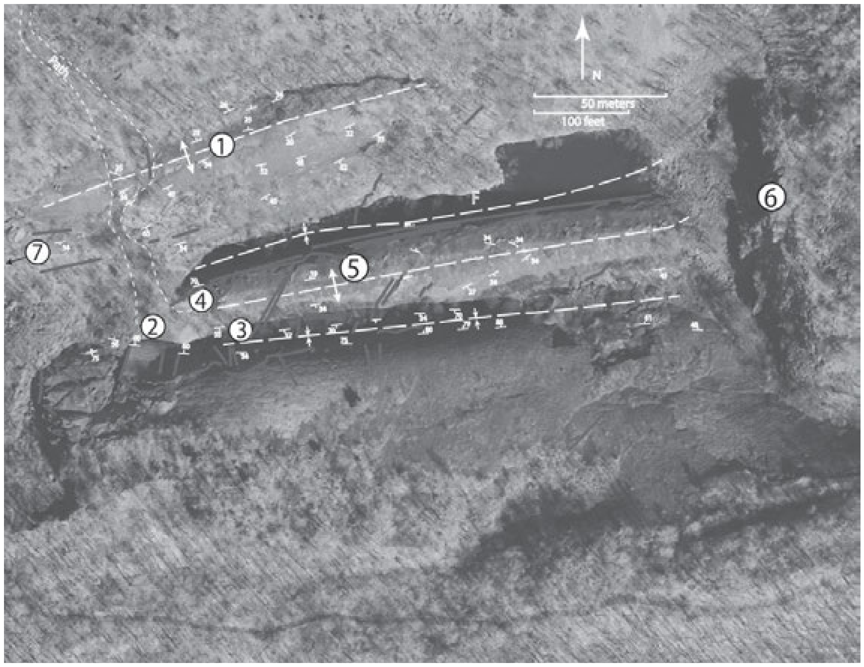


Figure 5-2. Cartoon depicting the sequence of development of structural stages of the Alleghany orogeny: Stage I. Orthogonal joint sets form in coal; Stage II. Several sets of hydraulic extensional joints form in sandstones and shales; Stage III. Pressure solution and primary crenulation cleavage and small-scale folds form; pressure solution of Stage II joint fillings occurs; Stage IV. Conjugate wrench and wedge faults deform Stage III cleavage; Stage V. Large-scale folding of all previous structures occurs; Stage VI. Extensional joints and faults produce flattening perpendicular to bedding and layer-parallel extension, both parallel and perpendicular to fold hinges. After Nickelsen, 1983.

Station 1

Turn left (east) off the entrance path and walk to the crest of the north anticline at Station 1 (Figure 5-3). The rocks beneath your feet represent the floor of the coal swamp and have impressions of large lycopsid trees and stigmaria (roots). From 1, the entire mine is visible, including third order folds, fold disharmonies, many faults, and ironstone concretions. The view of the southwest corner (Figure 5-4) shows overprinted Stage IV conjugate wrench fault systems (dihedral angle 35°) and a Stage IV thrust. To the east the disharmonic third order folding shown in Figure 5-5 is visible. Looking south is an excellent view to the north limb of the Whaleback anticline showing Stage IV thrusts and conjugate wrench faults, the Stage V anticline plunging east, and Stage VI extensional joints and faults (Figure 5-6). The north anticline on which you are standing has a chevron profile because the kink junction axis is inclined to bedding (Faill and Nickelsen, 1973, Fig. 20).

Figure 5-3. Map showing topography, geology and station localities 1 to 7, of the Bear Valley strip mine. After Nickelsen, 1983



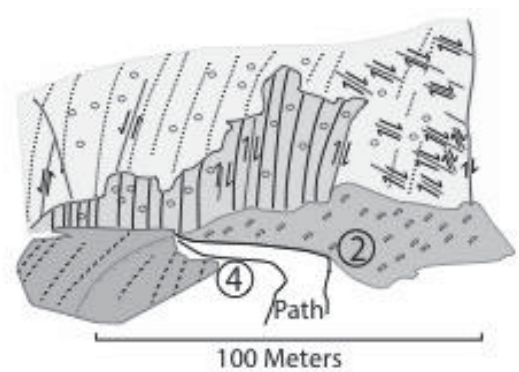


Figure 5-4. Conjugate wrench fault systems and a thrust fault between Stations 2 and 3 on the south wall, as viewed from Station 1. (Figures 5-4, 5-5 after Nickelsen, 1983)

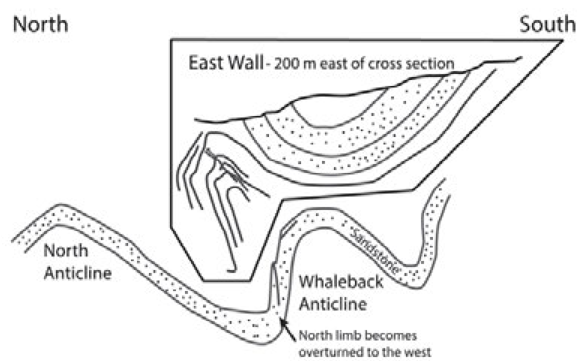


Figure 5-5. Diagram of Bear Valley strip mine structures as viewed from west end of the Whaleback. Bottom of sketch shows structure of sandstone bed viewed north-south through Station 1 of Figure 3. Top section shows east wall structures as visible from crest of Whaleback.

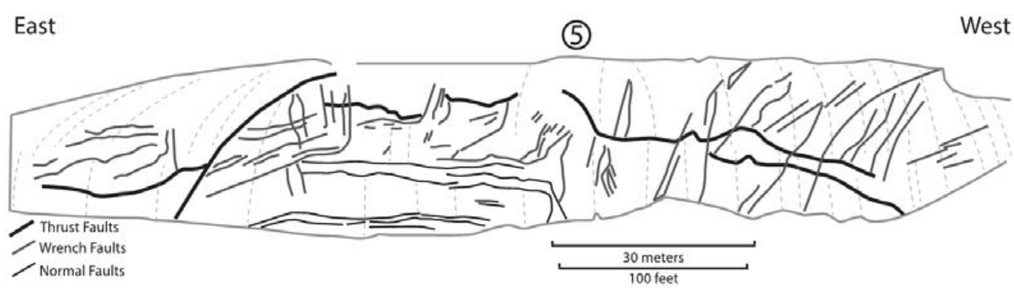


Figure 5-6. North limb of Whaleback anticline viewed from Station 1. Extensional faults (Stage VI) define "grabens" that are both parallel to and transverse to the fold hinge. The "grabens" overprint Stage IV wrench and thrust faults. Station 5 is labeled.

Station 2

The Stage IV wrench and wedge (thrust) faults of Figure 5-4 can be studied here. Note that slickenlines on wrench faults are parallel to the fault-bedding intersection, indicating that they formed prior to folding and were later folded to their present attitude during Stage V. Slickenlines on wedge faults bisect the dihedral angle between wrench faults and were formed at the same time. Spaced cleavage (primary crenulation and pressure solution mechanisms) occurs in shales upslope to the southwest. Ironstone concretions are the stiffest member of the sedimentary succession (McAleer, 2004) showing only Stage II joints and surface slickenlines that demonstrate how other strata have shortened and flowed around them. The contact between concretions and their enclosing rock are shear planes or boundary zones between different structural lithic units. The sequence of structural stages is established by offset of Stage II joints by Stage III pressure solution cleavage and by drag of Stage III cleavage-bedding intersections against Stage IV wrench faults. All of these structures formed by layer-parallel shortening in horizontal beds prior to folding.

While walking eastward between Stations 2 and 3, you can see Stage II joints in ironstone concretions, ductility contrast between ironstone and sandstone or shale, and a major wrench fault that is the west boundary of the thrust slice of Figure 5-4.

Station 3

The east end of the thrust slice illustrated in Figure 5-4 can been seen from here. On the Whaleback anticline to the north, wrench faults with intricate slickenline patterns indicate overlap between Stage IV faulting and Stage V folding. Stage VI strike and transverse extensional faults and "grabens" are also well exposed.

Station 4

Here, looking at the hinge of the Whaleback, you can observe extensional features such as filled veins and jointing surfaces, especially along the upper layers of the sandstone.

Station 5

The crest of the Whaleback anticline provides the best view of the fold disharmony to the east (Fig. 5-5), Stage II hydraulic joints on the whaleback and the Stage IV wrench and wedge faults and Stage VI strike joints (of release or buckling origin) on the south wall. Note that the Stage VI strike joints are not symmetrical with the acute bisectors and slickenlines of Stage IV wrench and wedge faults, indicating that the structural array formed in response to differently oriented strains - Stage IV layer parallel shortening, versus Stage VI extension due to fold buckling.

Station 6 *(Optional – please watch your step if you wish to visit Station 6.)*

Walking along the crest of the Whaleback from Station 5 towards Station 5-6, you pass over abundant pencil cleavage, (elongate pieces of rock formed by breakage along the intersection of bedding and cleavage surfaces). Pencil clevage is especially prominent to the southeast of the crest as the Whaleback plunges under the surface to the east. Station 6 provides a close-up view of disharmonic folding along the eastern wall where one can see clearly the concentric folding in the sandstones versus the faulted and more kink-shaped folds in shales and coals (Fig. 5-5).

Station 7

From Station 5, walk west along the crest of the Whaleback, and turn north along the path. Continue west into a small valley and walk to the area marked Station 7 on Figure 5-3, then proceed west for about 125 additional meters. At this locale we can find examples of Carboniferous “tree” trunks and root balls (probably *Lepidodendron* or *Sigillaria*) about 10 meters above the valley floor on the northern valley wall. There are also exposed fossilized root balls in the talus along the valley floor (Figure 5-7).

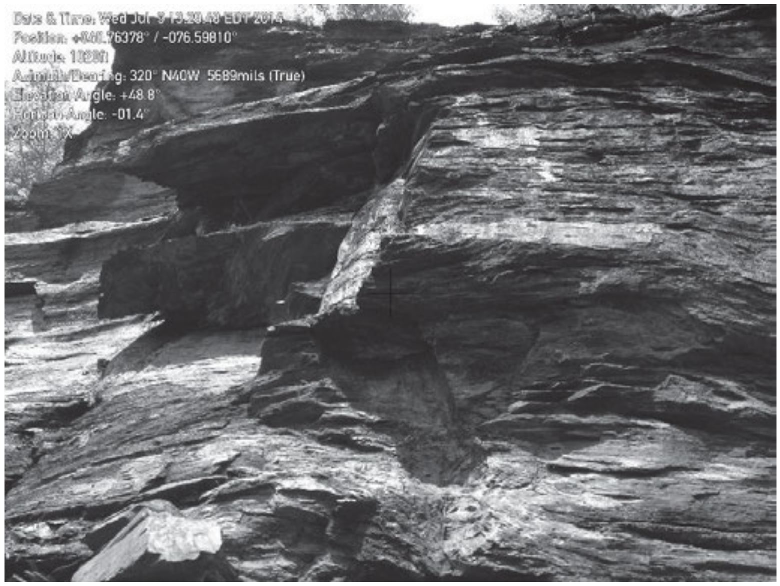


Figure 5-7. Oblique view of tree trunk at Station 7.

References

Faill, R. T. and Nickelsen, R. P., 1973. Structural geology, pp. 9-38, *in:* Faill, R. T., et al., eds., Structure and Silurian-Devonian stratigraphy of the Valley and Ridge Province in central Pennsylvania Guidebook for the 38th Annual Field Conference of Pennsylvania Geologists, October 5-6, 1973, Bureau of Topographic and Geologic Survey, Department of Environmental Resources, Harrisburg, PA 17120.

McAleer, R. J., 2004. Concretions in the Llewellyn Formation, Bear Valley Strip Mine, Shamokin, PA : Rigid Inclusions in a Deformable Matrix, Unpublished B.S. Thesis Penn. State University

Nickelsen, R. P., 1979. Sequence of structural stages of the Alleghany orogeny, Bear Valley Strip Mine, Shamokin, Pennsylvania: American Journal of Science, v. 279, pp. 225-271.

Nickelsen, R. P, 1983. Stop III- Bear Valley Strip Mine *in* Nickelsen, R. P. and Cotter, E., eds., 1983. Silurian depositional history and Alleghanian deformation in the Pennsylvania Valley and Ridge. Guidebook for 48th Annual Field Conference of Pennsylvania Geologists, Pennsylvania Geological Survey, Harrisburg, 192 p.

Nickelsen, R. P. and Hough, Van Ness, D., 1967a. Jointing in the Appalachian Plateau of Pennsylvania: Bulletin of the Geological Society of America, v. 78, pp. 609-630.

STOP # 6: BEAR GAP QUARRY

Stop Leader – Aaron Bierly, Pennsylvania Geological Survey

Introduction

Stop six is located in Ralpho Township, Northumberland County approximately 1.8 miles south east of Elysburg. The Bear Gap quarry has been open since 1968 and was purchased by the current owners, Corson Quarries, Inc., in 2006 (B. Corson, personal communication). The strata being quarried is the Devonian-aged, Trimmers Rock Formation which is crushed for aggregate. The area of the quarry was mapped by H. A. Arndt, G. H. Wood, Jr., and R. F. Schryver in 1973 though the quarry itself was apparently not investigated. Figure 6-1 shows the location of Bear Gap Quarry.

Figure 6-1. Location photo of Bear Gap Quarry

Structure

The Bear Gap quarry is located on the southern limb of the Selinsgrove Anticlinorium. Beds commonly strike from 053 to 082 with dips ranging from 23 to 53 degrees southeast. Small local folds are present and a previously unmapped anticline/syncline pair can be observed in the northwestern and northeastern corners of the quarry as seen in Figures 6-2 A and B.

Two major fracture patterns are well established in the Trimmers Rock. The first is a joint or cleavage that nearly parallels bedding strike, but dips 40 to 70 degrees to the northwest. This fractures is often well exposed in weathered road cuts and stream banks and commonly spaced from 1 to 12 inches apart. The second fracture is a joint running sub perpendicular to perpendicular to the prior fracture and commonly dips between 70 to 90 degrees.

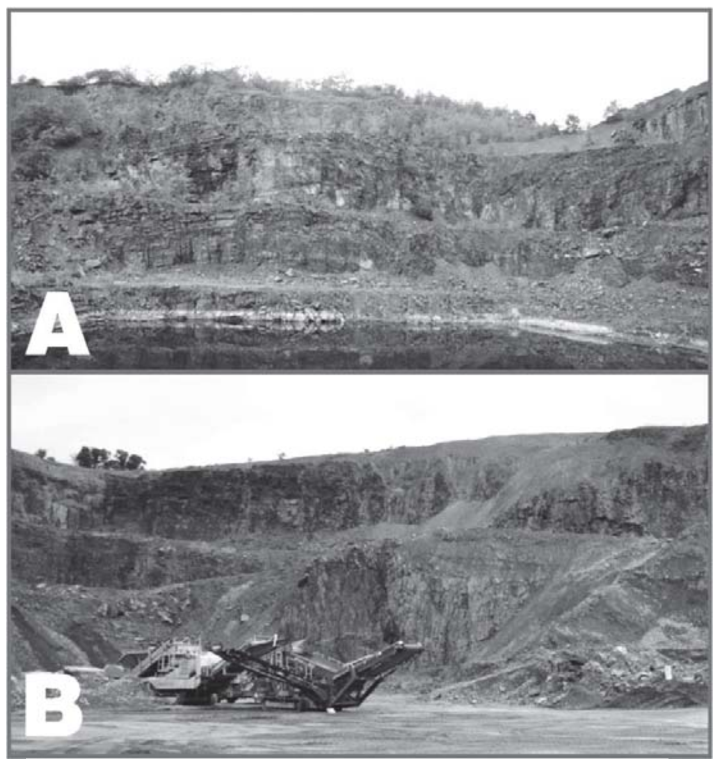


Figure 6-2. A). Anticline and syncline in NW corner of quarry; B). Syncline in NE corner of quarry

Figure 6-3 is a geologic map of the area surrounding Bear Gap Quarry. LIDAR illustrates the valley formed by the more easily eroded shales of the underlying Mahantango Formation on the South Selinsgrove anticline to the north of the quarry.

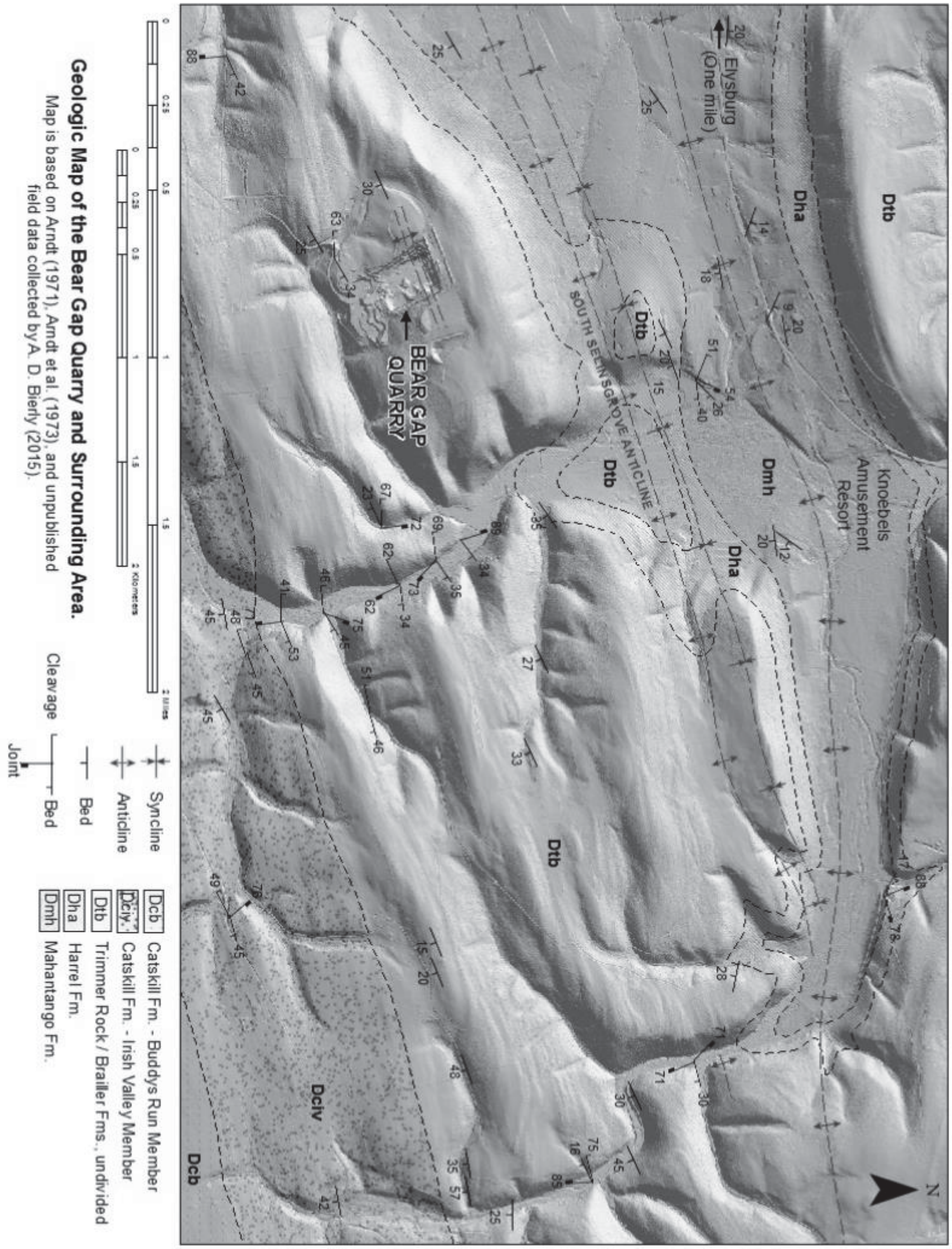


Figure 6-3. Geologic map using LIDAR image to highlight topography, showing Bear Gap Quarry and surrounding area.

Stratigraphy and Depositional Environment

The Trimmers Rock Formation in the immediate proximity of the quarry is dominantly a medium gray to light-olive gray siltstone to very-fine grained sandstone with subordinate interbeds of shale (Figure 6-4). Sedimentary features observed include laminations, cross laminations, and soft sediment deformation structures (Figure 6-5). The formation is approximately 2,120 feet thick.

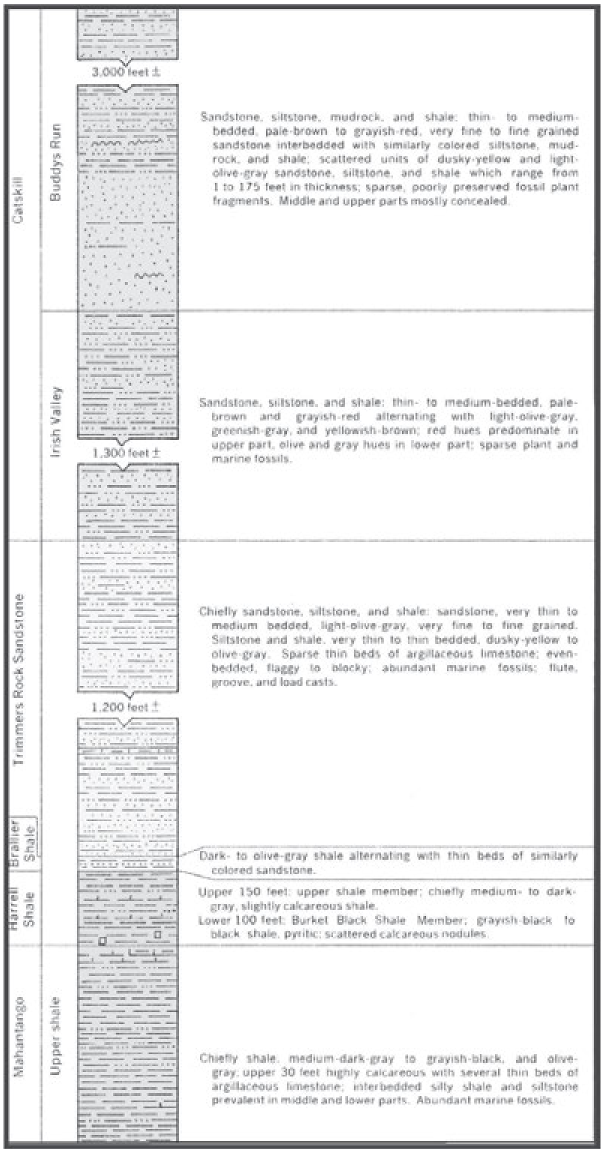


Figure 6-4. Geologic column of the Greater Bear Gap Area, modified from Arndt, et. al.,(1973)

This formation formed in a marine environment which is supported by the presence of fossil invertebrates (Figure 6-6) including brachiopods, crinoids, bivalves, bryozoans, and sponges (rare). The source of sediment was derived by deltaic and shore line currents (Harper 1999). Repetitious cycles of shale and siltstone were observed in the basal third of the formation and are interpreted by the author to be turbidites; possibly suggesting, at least locally, that the basal Trimmers Rock formation was deposited on the steeper slopes of a deltaic ramp. An excellent exposure of these turbidite deposits can be seen approximately 2.5 miles east-northeast along Pineswamp Road near the intersection of Keller School Road (Figure 6-7).

The upper contact of the Trimmer Rock Formation quickly grades into the Irish Valley Member of the Catskill Formation and occurs where the marine setting gives way to terrestrial environments. This change in environment is often mapped at the first occurrence of red beds but fossilized rootlets and plant debris may give hint in the changing of the formations. Periodically, marine zones reoccur within the Irish Valley Member. The Trimmers Rock Formation tends to be more resistant to erosion compared to the adjacent formations creating a more hilly terrain with deeply incised headwater ravines and hollows.

The lower contact with the Brailler Formation (also marine in origin) is transitional and is defined by a change in lithology from a dominantly siltstone and very fine grained sandstones sequence (Trimmers Rock Formation) downward to a dominantly dark gray to olive gray shale with thin sandstone interbeds (Brailler Formation). Lack of extensive exposures and the gradational nature of these two formation likely led to these formations being mapped together as one undivided unit in the 1971 and 1973 USGS geologic maps of the Mount Carmel Quadrangle and South Half of the Shamokin Quadrangle.

Figure 6-5 (left) - An exposure along Pineswamp Road bearing soft-sediment deformation features. Note Shale squeezing up between siltstone bed above rock hammer (arrow).

Figure 6-6 (below) - Marine fossils found in the Trimmers Rock Formation near the Bear Gap Quarry. Photo is in grayscale with brightness and saturation of the photo altered to bring out details. Left is a fossilized sponge, center contains a bryozoan and brachiopod, to right is a crinoid. Scale bar is in centimeters

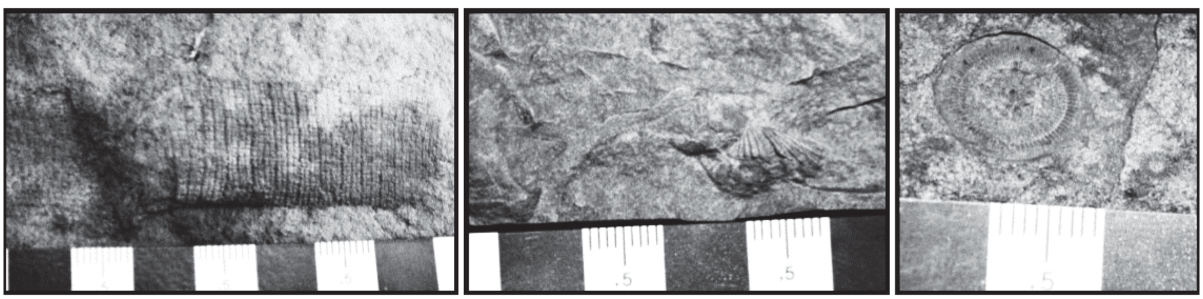


Figure 6-7. repetition of alternating shale and siltstone deposition in this exposure along Pineswamp Road are interpreted as delta ramp turbidites

References

Arndt, H. A., 1971, Geologic Map of the Mount Carmel Quadrangle, Columbia, Northumberland, and Schuykill Counties, Pennsylvania, U. S. Geological Survey Geologic Quadrangle GQ-919, scale 1:24000.

Anrdt, H.A., Wood W. H., and Schryver, R.F., 1973, Geologic Map of the South Half of the Shamokin Quadrangle, Northumberland and Columbia Counties, Pennsylvania, U.S. Geological Survey Miscellaneous Geologic Investigation Series, I-734, scale 1:24000.

Harper, J.A., 1999, The Geology of Pennsylvania, Stratigraphy and Sedimentary Tectonics, Devonian, in Shultz, C.H., Pennsylvania Geological Survey, 4th Ser., Special Publication 1, p. 117-121.

BONUS STOP: CENTRALIA MINE FIRE DRAINAGE TUNNEL

Stop Leader – Jennifer Elick, Susquehanna University

Location

40.793057° N/ 76.323603° W

Take PA-61 N to the intersection of PA-61 and PA-42 and turn right on to Big Mine Run Road. Follow this road for 1.5 miles and pull off to the right. Along the road is an ~100-ft-long footpath through the woods, which leads to the Centralia mine drainage tunnel (Fig. 1).

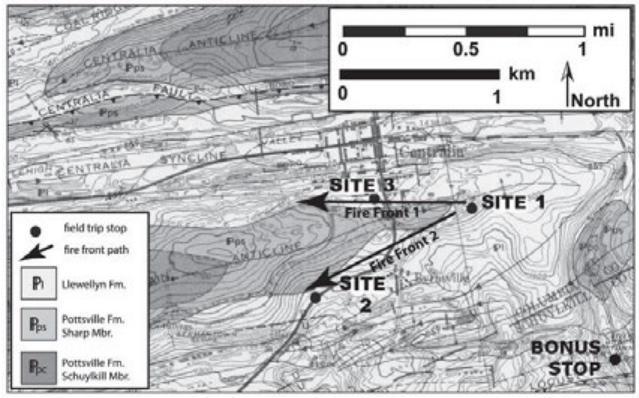


Figure 1. Map directions to Centralia mine fire drainage tunnel. Bonus Stop is located at the bottom right hand corner of the map. Centralia Mine Fire Stop #1 sites are shown as reference.

Centralia Mine Fire Drainage Tunnel

The tunnel was constructed to drain standing water from the mine so that the coal could be mined without pumping large quantities of water to the surface (PADEP, 2013). The tunnel discharges ~2300 gal/min on average (3.3 million gal/d) (PADEP, 2013). The groundwater emanating from the mine system is green in color, with a pH of 3.7–3.8 (Fear et al., 2010) and low dissolved oxygen content. The rim of the ponded area and shallow areas are orange and coated with iron oxide. The water draining the mine has a very high iron and sulfur content and is considered toxic to many forms of aquatic life (PADEP, 2013). The iron and sulfur are products of pyrite oxidation.

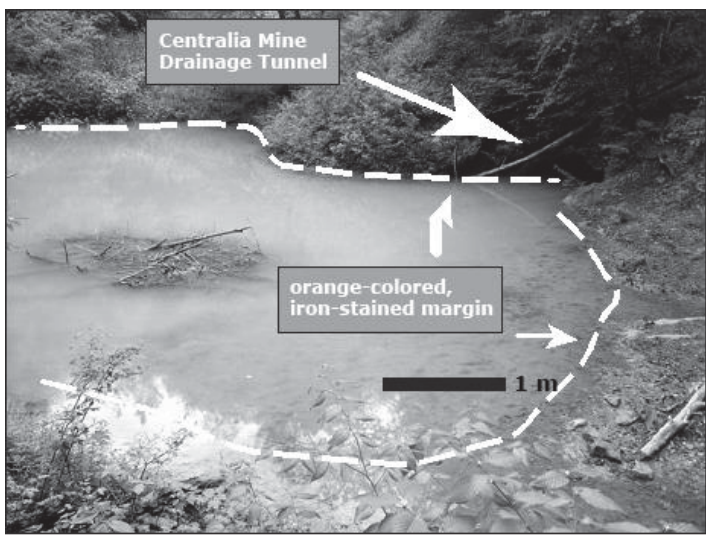


Figure 2. The Centralia mine drainage tunnel. The rim of the ponded area is orange form iron staining; the interior of the ponded area appears light green in color. This is an example of acid-mine drainage; this anthropogenic drainage system flows into Mahanoy Creek, which eventually makes its way into the Susquehanna River, north of Herndon, 10 miles south of Sunbury, PA (photo taken by Elick, 2015)

This stop serves as a reminder that many mine-related environmental issues still affect the region of Centralia, as well as other towns and cities in the anthracite coalfields. The coal fire is an important chapter in the mining history of Centralia, along with acid-mine drainage and polluted streams, coal tailings and culm heaps, forest removal and environmental displacement, and mined-out strip pits filled with garbage. It is a reminder of the adverse legacy of coal mining on the environment.

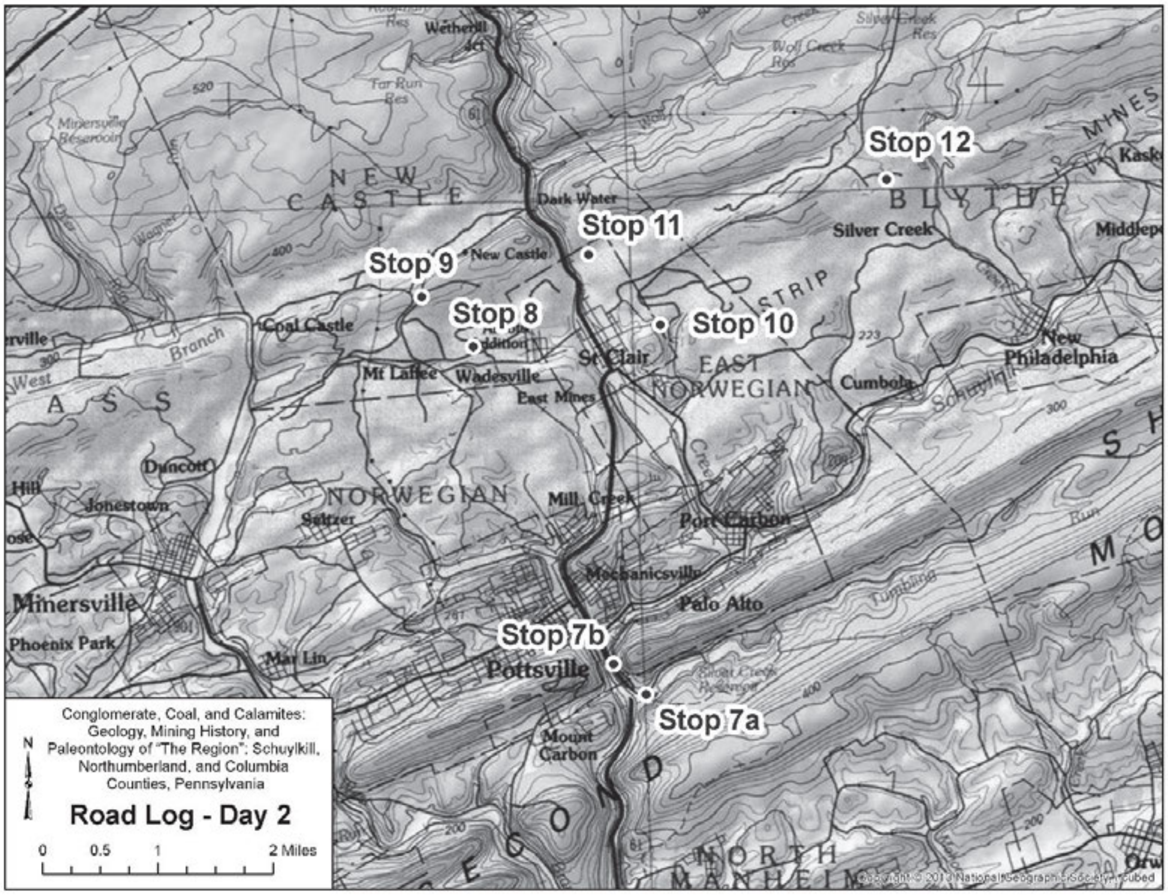
References

Elick, J.M., 2015, The Centralia coal mine fire (Centralia, Pennsylvania): A field guide for an evolving system, in Brezinski, D.K., Halka, J.P., and Ortt, R.A., Jr., eds., Tripping from the Fall Line: Field Excursions for the GSA Annual Meeting, Baltimore, 2015: Geological Society of America Field Guide 40, p. 485–497, doi:10.1130/2015.0040(12).

**Pennsylvany? Yep! It used ta be right over thar!
'Course, thet were 'fore the price o' coal went up!**

Reprinted from the 1980 Field Conference of Pennsylvania Geologists Field Trip Guidebook

DAY 2 ROADLOG



Day 2 Road Log route map with STOP locations

MILES		
Int.	**Cum.**	**Description**
0.0	0.0	Leave parking lot of MainStay Suites.
0.1	0.1	Stop sign. Turn right on SR 1008.
0.1	0.2	Turn right onto ramp to I-81 South.
0.1	0.3	Merge with I-81 South.
3.9	4.2	Excellent view of COGEN plants to right, John B. Rich Memorial Power Station on top of the distant ridge and Wheelabrator Frackville just off the Interstate. Wheelabrator Frackville went on line in May 1989. It has a net power output of about 42 MW and consumes about 550,000 tons/year of culm having a heat value of about 3500 BTU/lb. The Frackville State SCI uses the process steam.
0.4	4.6	Cut in Pottsville Formation.

1.6	6.4	Frackville SCI to left.
0.7	7.1	Bear right onto ramp for PA 61 South (St. Clair).
0.5	7.6	Merge with PA 61 South at south end of Frackville.
0.3	7.9	Schuylkill Mall overpass.
0.4	8.3	Enter Broad Mountain gap.
0.3	8.6	Deep cut in Pottsville conglomerate.
0.5	9.1	Deep cut in Mauch Chunk to right.
0.2	9.3	Enter New Castle Township.
0.1	9.4	First of several cuts in south-dipping Mauch Chunk to right.
0.6	10.0	Cut in Mauch Chunk sandstone to right.
0.2	10.2	Cut in Mauch Chunk behind fence.
0.3	10.5	Cut in Pottsville conglomerate to right
0.4	10.9	Dark Water.

Just to right is a shaft of the old Repplier Colliery north of the Mine Hill anticline. Opposite the shaft on the other side of Dark Water Road is the Repplier Water Level Tunnel (see Wood, 1972).

Shaft of the old Repplier Colliery at the intersection of PA 61 and Dark Water Road, mile (10.9)

0.7	11.6	Traffic light at Coal Creek Commerce Center (STOP 11 to left).
0.6	12.2	Traffic light—Hancock Street, St. Clair, to left, Wade Street to right.
0.4	12.6	Traffic light at Russell Street.

0.2	12.8	Traffic Light at Ann Street. Cut in south-dipping Llewellyn sandstone to right.
0.2	13.1	Long cut in Llewellyn Formation to right, with anticlinal kink fold at north end and south-dipping strata in southern part, where a folded and sheared coalbed crops out at the top.
0.3	13.4	Cut in south-dipping Llewellyn Formation to right exposes black shale and rusty-weathered sandstone at the north end, a 20-foot-thick black shale and coal interval in the middle, and thick-bedded, well-jointed, coarse-grained sandstone and conglomerate at the top.
0.1	13.5	Traffic light at Mall Drive and Tunnel Road.
0.1	13.6	Long "canyon" cut in south-dipping Llewellyn Formation. At the north end is a sheared coal bed, with mostly rusty weathered sandstone and a few thick, recessed intervals of black shale in the south part.
0.4	14.0	Traffic light at Pottsville Diner. Just beyond on the left is a cut in Llewellyn sandstone with a well-defined kink fold at the north end.
0.5	14.5	Long cut in south-dipping Llewellyn Formation at curve to left. The strata exposed are in the vicinity of the Peach Mountain (No. 18), Tunnel (No. 19), and Rabbit Hole (No. 20) coalbeds (Wood, 1972).
0.1	14.6	Grand view of Pottsville ahead. Note Yuengling Brewery; Sharp Mountain on horizon with Second Mountain visible through Schuylkill River gap.

Pottsville and Sharp Mountain, looking south from in front of the Schuylkill County Courthouse, west of PA 61 (mile 14.6)

Pottsville was established as a village in Norwegian Township in 1819 and incorporated as a borough on 19 February 1828. It became the county seat in 1851, replacing Orwigsburg. As the 19th century progressed Pottsville became an ever more significant iron-producing, anthracite-mining, and railroad hub—the most important town in the Southern

Anthracite field. In the early 1870's the Philadelphia and Reading Coal and Iron Company (predecessor of Reading Anthracite) established its headquarters on Centre Street (later moved to Mahantongo Street), and later in that decade several Molly Maguire trials and executions took place in the old courthouse and still-extant stone prison in the northern part of town. It was chartered as a third-class city on 22 March 1911.

It is immortalized in American literature as the "Gibbsville" of novelist and short-story writer John O'Hara (1905-1970).

0.1 14.7 Traffic light at Arch Street.

0.4 14.8 Traffic light at Norwegian Street.

0.2 15.0 On Bunker Hill to the right is a magnificent, but somewhat neglected, statue-monument honoring statesman Henry Clay (1777-1852), erected in the early 1850's by the powers-that-be of Schuylkill County in recognition of Clay's support of a high tariff on iron and iron products—a significant spur to the accelerating anthracite-iron industry of the time.

Henry Clay Monument on Bunker Hill (mile 15.0)

0.1 15.1 Traffic light at PA 209 intersection. Enter construction zone. Continue straight ahead.

0.3 15.4 Traffic light in construction zone. Directly ahead to left is the upper part of the reference section of the Pottsville Formation and the north end of STOP 7.

0.3 15.7 Long cut in Mauch Chunk Formation to left (part of STOP 7).

0.1 15.8 Turn left onto Reservoir Road.

0.1 15.9 Turn right into Tumbling Run Water Treatment Facility. Proceed to parking area, probably just to right of entrance. The dam here is the lower of two dams on Tumbling Run, a west-flowing tributary of the Schuylkill River that flows in the Mauch Chunk valley between Second Mountain (Pocono Formation) and Sharp Mountain (Pottsville Formation). The dams were originally built in the 1830's to supply the Schuylkill Canal. From 1890 to1914 the lake above the upper dam was the site of the Tumbling Run Amusement Park, the entertainment centerpiece of the Pottsville area. The park boasted a hotel, theater, dance pavilion, amusement hall, roller coaster, carousel, and skating rink—as well as dozens of boathouses along the shores of the lake. The characters in John O'Hara's *Ten North Frederick* (1955) and *The Lockwood Concern* (1965) spent many a pleasant day there.

During the 19th and early 20th centuries, ice was harvested from the two Tumbling Run lakes.

STOP 7. Pottsville and Mauch Chunk Formation in PA 61-cut through Sharp Mountain on PA 61

40.674444 N, -76.182778 W drop off point
40.678333 N, -76.188056 W main road cut

Leave STOP 7, turning left on Reservoir Road and proceeding back to PA 61.

0.1 16.0 Stop sign. Turn right on PA 61. (Not allowed during construction)

0.6 16.6 Traffic light at US 209 (Mauch Chunk Street).

0.1 16.7 Ledges to right are Llewellyn Formation.

0.1 16.8 Deep cuts to right behind buildings mark the site of a major railroad coal-loading facility dating back to the 19th century.

0.3 17.1 Cut in south-dipping Llewellyn Formation at curve on right.

0.6 17.7 Cut in kink-folded Llewellyn Formation on right, just before Pottsville Diner (on left).

0.3 18.0 Enter Norwegian Township.

0.1 18.1 "Canyon" in south- dipping Llewellyn Formation.

0.5 18.6 Directly ahead is the steep south slope of synclinal Broad Mountain, with anticlinal Mine Hill just in front of it.

0.3 18.9 Traffic light at Ann Street. Enter borough of Saint Clair, the downtown area being to the right. St. Clair was named for St. Clair Nichols, who co-owned the land and assisted in laying out the town in the early 1830s. (More on St. Clair at STOPS 10 and 11.)

0.6	19.5	PHMC Historical Marker to right reads:

> *JOHN SINEY (1831-1880)*
> *Pioneering labor organizer and leader of the Workingmen's Benevolent Association (WBA) of Schuylkill County, a union of anthracite mineworkers. Formed nearby in 1868, WBA had 20,000 members in 22 districts; secured state mine safety laws and the first labor contract in the industry. Siney was president of the Miners' National Association and was active in the Greenback labor Party.*

0.1	19.6	Traffic light. Turn left on Wade Street.
0.1	19.7	Enter Arnots Addition (part of St. Clair borough).
0.2	19.9	Enter New Castle Township and village of Wadesville.
0.1	20.0	St. Boniface and St. Mary's Cemeteries to left. John Siney is buried in the latter.

Grave of labor leader John Siney in St. Mary's Cemetery (mile 20.0)

0.6	20.6	Old stripping to right in distance.
0.1	20.7	Stop sign. Turn right on West Wade Street.
0.2	20.9	Old cemetery to left. Graves here date back nearly to 1800. Nearly all of the 19th century monument stones are marble and deeply weathered. Quite a few are inscribed in German, including one slate stone that is still quite legible. The few 20th century markers are granite.
0.2	21.1	Road to right (just before large abandoned house) leads into the upper south wall of the "Mammoth" Wadesville stripping. Continue ahead.
0.1	21.2	Another stripping access road to right.
0.1	21.3	Y-intersection; continue on road to right, East Darkwater Road.

1.2	22.5	Turn right into entrance to Pottsville Materials. Proceed back to Wadesville strip mine overlook.

STOP 8. Wadesville strip mine of Reading Anthracite Company

40.718576 N, -76.210149 W

STOP 9. Pottsville Materials Company quarry

40.724997 N, -76.218456 W

0.3	22.8	Exit taking left on Darkwater Road. Take second left onto haul road into Wadesville pit. Visit pit (weather permitting) that was discussed at Stop 8 and viewed from above at Stops 8 & 9
		Exit Wadesville pit. Turn left.
0.4	23.2	Y-intersection; stay left to stop sign, then continue straight on West Wade Road.
0.6	23.8	Turn left (blind intersection near transformer) onto E. Wade Road and continue on to PA 61.
0.6	24.4	Enter Wadesville.
0.2	24.6	Enter St. Clair.
0.3	24.9	Traffic light. Go straight on Hancock Street and enter "downtown" St. Clair.
0.2	25.1	Cross Mill Creek, then turn right on Nicholas Street.
0.1	25.2	To right, in the former St. John's Lutheran church, is the home of the St. Clair Community and Historical Society.
0.1	25.3	Stop sign. Turn left on Lawton Street.
0.4	25.7	Enter parking lot.

STOP 10 and LUNCH. St. Clair Fish and Game: Mining history, geology, and paleontology of the Pine Forest Shaft and Ravensdale Tunnel

40.720833 N, -76.179167 W

		End of LUNCH. Leave STOP 10, exit parking lot.
1.0	26.7	Return to PA 61 by same route on Lawton, Nicholas, and Hancock Streets. Turn right, north on PA 61.
0.5	27.2	Traffic light. Turn right on Terry Rich Road into Coal Creek Commerce Center. Continue ahead 0.1 mile, then turn left and proceed east along highwall past Home Depot 0.4 mi to "end" of paved road to parking area.

STOP 11. Coal Creek Commerce Center:
(A) Mammoth (No. 8) coalbed seatrock
(B) Lower Llewellyn/Pottsville stratigraphy
& St. Clair mining history
40.729876 N, -76.190776 W

0.5	27.4	End of STOP 11. Return to PA 61, turning left at traffic light back onto PA 61. Proceed south on PA 61.
0.6	28.0	Traffic light. Turn left on W. Hancock Street in St. Clair.
0.2	28.2	Cross Mill Creek.
0.4	28.6	Enter East Norwegian Township. We are now on what the locals call the "Burma Road."
0.4	29.0	Large reclaimed strippings on both sides of road.
0.4	29.4	Enter Blythe Township.
1.3	30.7	"Shooting Gallery" on right.
0.1	30.8	Turn right into parking area. Walk back a half mile through woods to old strippings.

STOP 12. St. Clair plant fossil site
(Reading Anthracite Company)
40.738439 N, -76.141556 W

		End of STOP 12. Return to "Burma Road"; continue northeast.
1.0	31.8	Abandoned stripping to right.
0.2	32.0	Another abandoned stripping to right.
1.6	33.6	Enter Ryan Township.
1.7	35.3	Mountain Valley Golf Course.
0.4	35.7	Enter Mahanoy Township.
0.1	35.8	Enter Ryan Township, cemetery to right.
0.3	36.1	Pass under I-81.
0.2	36.3	Coal operation to left.
0.5	36.8	Stop sign. Ahead is the German Protestant Cemetery. Turn right on Morea Road.
0.1	36.9	Far off to left is a large active stripping.
0.3	37.2	FABCON to right.
0.5	37.7	Turn right into MainStay Suites.

0.1 37.8 Parking lot of MainStay Suites.

End of Day 2 Field Trip! Have a safe trip home!

References

Dempsey, T., [no date], Schuylkill County Patch Towns: [Schuylkill County Historical Society].

Mac Arthur, P. C., 1999, John O'Hara's Anthracite Region: Charleston, SC, Arcadia Publishing, 128 p.

Schuylkill Haven History, Tumbling Run, http://schuylkillhavenhistory.com/TUMBLINGRUN.html (accessed 10 June 2015).

St. Clair Sesquicentennial Committee, 1999, Our town—Saint Clair's Sesquicentennial Commemorative Book, 132 p.

Wallace, A. F. C., 1987, St. Clair—a nineteenth-century coal town's experience with a disaster-prone industry: New York, Alfred A. Knopf, 519 p.

Wood, G. H., Jr., 1972, Geologic map of anthracite-bearing rocks in the Pottsville quadrangle, Schuylkill County, Pennsylvania: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-681, 2 sheets.

Wood, G. H., Jr., 1973, Geologic map of the Pottsville quadrangle, Schuylkill County, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ-1028.

Wood, G. H., Jr., and Arndt, H. H., 1969, Geologic map of the Shenandoah quadrangle, Schuylkill County, Pennsylvania: U.S. Geologic Survey Geologic Quadrangle Map GQ-781.

That reminds me, your deed includes the mineral rights - the Coal Company sold them back after they mined all the coal from under this area!

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STOP #7: UPPER MISSISSIPPIAN TO MIDDLE PENNSYLVANIAN STRATIGRAPHIC SECTION, POTTSVILLE, PENNSYLVANIA

Stop Leaders – Rudy Slingerland, The Pennsylvania State University,
Edward Simpson, Kutztown University

Introduction

The rocks at this site are exposed along a road cut on the eastern side of Pennsylvania 61, 0.3 to 0.5 mi (0.4 to 0.8 km) south of Pottsville, Pennsylvania (Figure 7-1), on the southern margin of the Southern Anthracite field where the Schuylkill River has cut a deep gap in Sharp Mountain. The outcrop exposes a 2,000-ft (600+-m)-thick section of upper Carboniferous molasse, representing the northwestward in-flux of clastic detritus into the Appalachian foreland basin from an orogenic source terrane formerly situated along the present Atlantic Coastal Plain. Subsequent to their deposition, these sediments were deeply buried, metamorphosed, technically deformed in the Alleghanian Orogeny, uplifted, and largely eroded. The Southern Anthracite field now preserves the thickest, coarsest-grained, most proximal to the source, and most stratigraphically continuous occurrence of upper Carboniferous molasse in the central Appalachians.

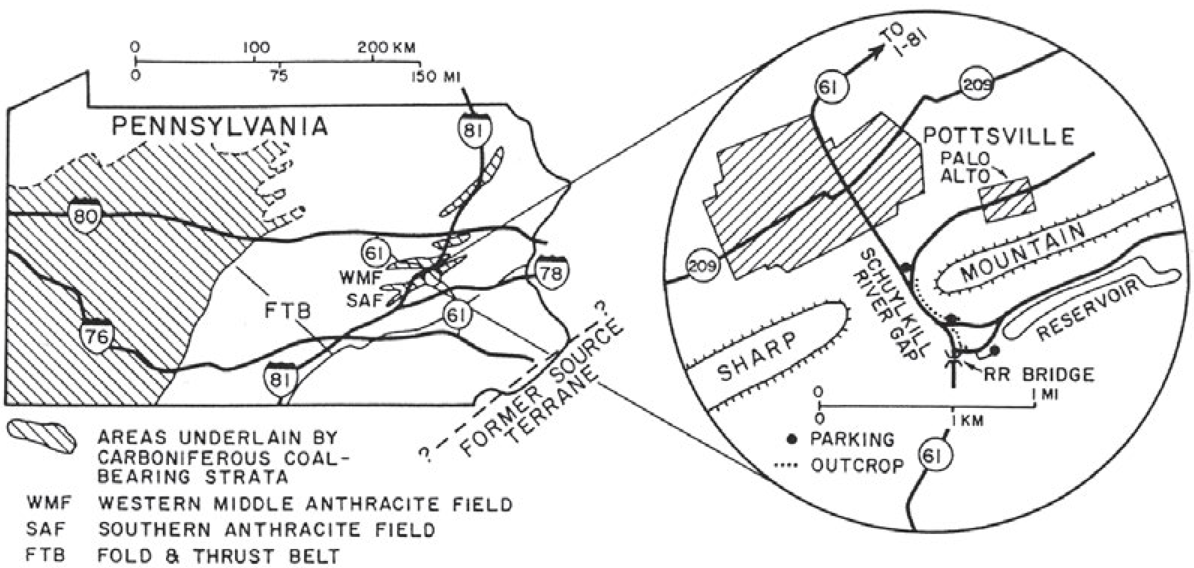


Figure 7-1. Key map of field locality

Of particular interest here is an alternation of facies that reflects a gradual but progressive evolution of depositional environments from a semi-arid alluvial plain (Mauch Chunk Formation), to a semi-humid alluvial plain (Pottsville Formation), to a humid alluvial plain dominated by peat swamps (Llewellyn Formation). This transition, documented by dramatic changes in sedimentary facies, facies sequences, and maximum clast sizes, clearly reflects incipient Alleghanian tectonism and regional (perhaps even world-wide) climatic changes occurring near the end of the Mississippian. Early investigators (e.g., Meckel, 1967) emphasized tectonics as the origin of the facies changes. Later Levine and Slingerland (1987) argued that the transition arises mainly from a change to more humid climatic conditions in the Pennsylvanian that produced larger sediment yields and stream discharges. At this stop we will reconsider these two hypotheses.

Stratigraphic And Geomorphic Overview

Molasse sediments of the Anthracite region are stratigraphically subdivided on the basis of grain size and predominant coloration (Wood and others, 1969). The fine-grained, red Mauch Chunk Formation (Middle to Upper Mississippian) intertongues with and is replaced by the coarse-grained, gray Pottsville Formation (Lower to Middle Pennsylvanian), which in turn gives way to the finer-grained, gray to black, coal-rich Llewellyn Formation (Middle Pennsylvanian), representing the youngest extant molasse in the region. The former presence of many miles (kilometers) of overlying rocks is implied by the high coal rank and compaction of the Llewellyn sediments (Paxton, 1983; Levine, 1986).

The Mauch Chunk Formation is informally subdivided into three members (Wood and others, 1969). The middle member represents the 'type' Mauch Chunk red bed lithofacies. The lower and upper members represent the zones of intertonguing with the underlying Pocono Formation and the overlying Pottsville Formation, respectively. The upper contact of the Mauch Chunk is defined as the top of the uppermost Mauch Chunk-type red bed (Figure 7-2).

The Pottsville Formation is formally subdivided into three members (Wood and others, 1956), each representing a crudely fining-upward megacycle. Of the three, the Tumbling Run and the Sharp Mountain members are the coarser-grained, while the intervening Schuylkill Member is finer-grained and contains a greater proportion of coal. The lower contacts of the Schuylkill and Sharp Mountain members are defined at the base of major conglomeratic units. The base of the Schuylkill Member is by no means obvious at the outcrop, but the "Great White Egg" quartz pebble conglomerate at the base of the Sharp Mountain Member is very distinctive. The contact between the Pottsville and Llewellyn Formations is placed at the base of the lowermost thick, stratigraphically persistent coal horizon, the Buck Mountain (#5), which has been correlated over large areas of the Anthracite fields (Wood and others, 1963).

Chronostratigraphic age designations in the Anthracite region, based upon the 13 upper Paleozoic floral zones defined by Read and Mamay (1964; also see Edmunds and others, 1979, Fig. 11), indicate the Pottsville section is conformable, extending from Zone 3 in the upper Mauch Chunk Formation (Chesterian Series) to Zone 10 in the lower Llewellyn Formation (Des Moinesian/Missourian Series), a duration of approximately 20 million years. The Mauch Chunk/Pottsville contact, occurring between Zones 3 and 4, corresponds roughly to the Mississippian/Pennsylvanian systemic boundary. In areas of the central Appalachians other than the Southern and Middle Anthracite fields, Zones 4, 5, and 6 are absent, suggesting the presence of a significant disconformity between the youngest Mississippian and oldest Pennsylvanian strata (see discussion in Edmunds and others, 1979).

The strata exposed at the site are slightly overturned and comprise part of the southern limb of the Minersville Synclinorium, forming the southern margin of the Southern Anthracite field. They attained their present attitude during the late Paleozoic Alleghanian Orogeny when northwest-directed tectonic forces produced a progression of deformational phases that migrated northwestward across the foreland basin. At the Pottsville site all structural phases are superposed (Wood and Bergin, 1970; Nickelsen, 1979).

The structure and stratigraphy of the upper Paleozoic molasse sequence are revealed geomorphically by the relative resistance to erosion of the near-vertical component units. The Pocono sandstone, subjacent to the Mauch Chunk Formation, upholds Second Mountain, the major ridge visible to the south of the Pottsville section. The Mauch Chunk Formation underlies the valley between Second and Sharp mountains. The distinctive double ridge of Sharp Mountain is formed by the Tumbling Run and Sharp Mountain members of the Pottsville Formation. The Schuylkill River, which excavated the gap in Sharp Mountain, flows southeasterly across the Valley and Ridge Province on its course to the Chesapeake Bay, opposite to the streams that originally deposited the Pottsville sediments.

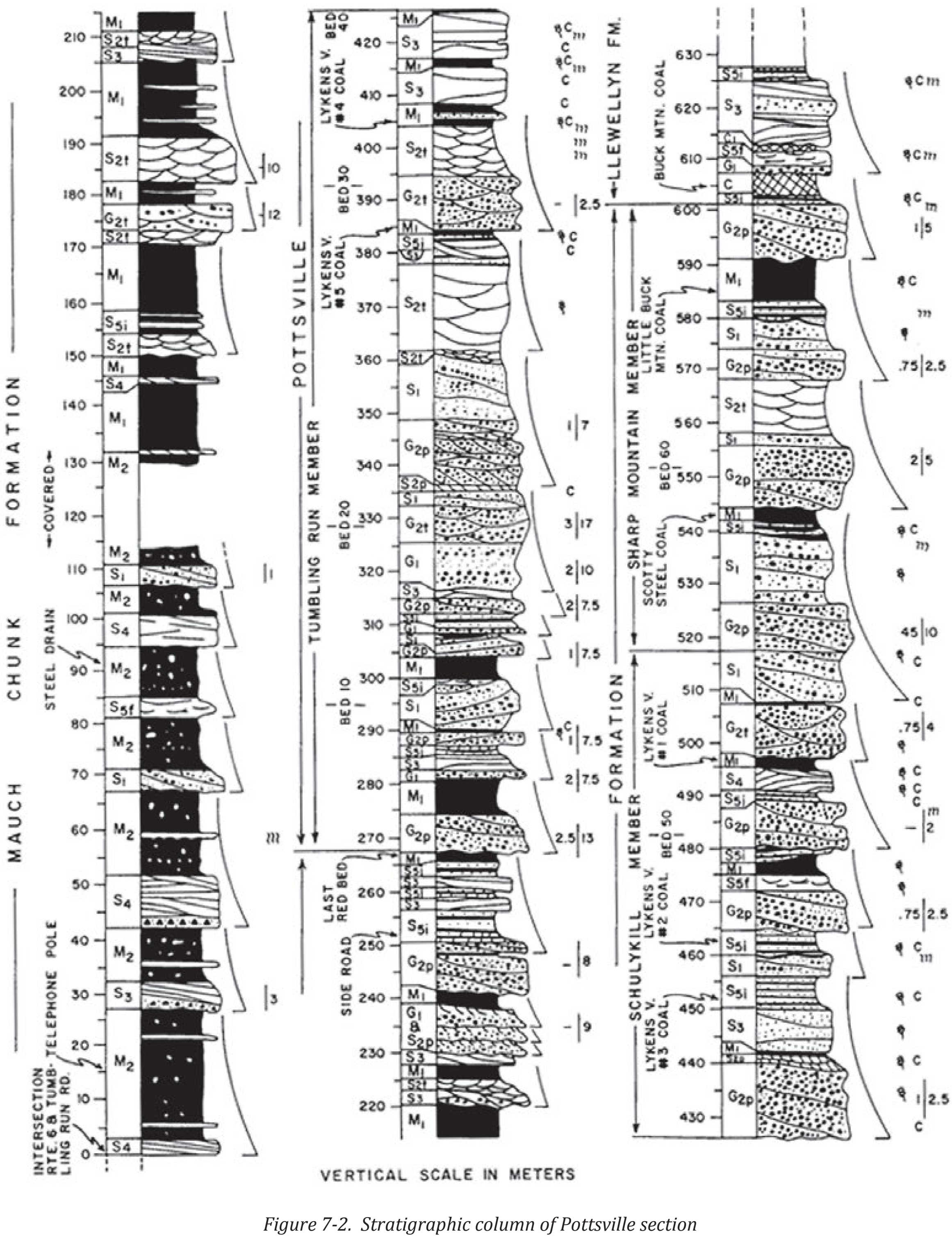


Figure 7-2. Stratigraphic column of Pottsville section

Sedimentology of the Pottsville Section — Facies States and Composition

Sedimentary bed forms, sediment composition, facies sequences, and paleobotany reveal a significant alteration in paleo-climatic conditions across the Pottsville section, ranging from generally semi-arid, poorly vegetated conditions at the base to perennially humid, lush conditions at the top. Ten general facies have been defined at this site and are described in Table 1. Transition matrix analysis reveals two repeating motifs, one characteristic of the Mauch Chunk and one of the Pottsville. When compared to facies sequences from modern environments of deposition, the Mauch Chunk sequence is similar to that of Bijou Creek, Colorado, a sandy, braided, ephemeral stream subject to catastrophic floods (Miall, 1977). Facies S3 and S4 probably comprised sand flats or shallow channel deposits; S5i and S2t comprised waning flow deposits or overbank deposits more removed from the active channel. M1 represents intra-channel, slack water deposits and M2 represents overbank soils.

The Pottsville sequence is similar to that produced by the Donjek River, Yukon Territory, a gravel-sand mixed bedload, perennial braided stream (Miall, 1977). Facies G2, S1, and S3 formed in the lower parts of the active channels by longitudinal braid bar migration. Facies S2t and S5t formed in the upper parts of active channels or minor channels and on the tops of braid bars. Facies S5i and M1 formed on bar tops, abandoned channels, and overbank areas, and facies C was deposited in inter-channel swamps. The channels forming the Pottsville Formation were deeper with greater cross-sectional areas, and lower width/depth ratios than those forming the Mauch Chunk Formation. In consequence, maximum clast size is greater as is the thickness of cross-bed sets.

Sandstone petrology, organic matter content, clay mineralogy, and features of the paleosols (Table 1) all show a progressive trend to more highly leaching, less oxidizing (i.e., more humid) conditions higher in the section. Sandstones are compositionally mature throughout the section but become even more mature up section. The Tumbling Run Member of the Pottsville Formation contains the highest variety and proportion of non-quartzose fragments while the Sharp Mountain Member contains the highest proportion of vein quartz (Meckel, 1967). Preservation of organic matter in the upper part of the section implies conditions of low Eh, maintained by continuous saturation by stagnant or slowly moving water. Clay minerals are enriched in alumina and depleted in iron higher in the section indicating a greater degree of chemical and biological leaching.

Paleosols occurring throughout the section are particularly useful in revealing paleo-environmental conditions. Most paleosols of the Pottsville and Llewellyn Formations formed as underclays beneath peat swamps and, therefore, must have been water-saturated during most of their development. In contrast, paleosols of the Mauch Chunk Formation, classified as vertisols by Holbrook (1970), exhibit a variety of features indicating episodic wetting/drying cycles (Table 1).

Caliche, occurring as thin, bed-parallel laminae or in nodular layers less than 3 ft (1 m) in thickness is common in the middle member of the Mauch Chunk (Figure 7-2) and occurs occasionally in the upper member. Caliche forms in seasonally arid conditions when surface evaporation produces supersaturation of dissolved salts, especially calcium carbonate and silica. The laminar caliche is interpreted to have formed at the sediment surface in shallow ponds during evaporative cycles (Holbrook, 1970). A surface or near-surface origin is indicated for the nodular caliche as well (Holbrook, 1970) based on: (1) sedimentary laminations that pass from the surrounding sediment into the concretions, (2) nodules occurring as intraformational clasts in conglomerates, (3) the presence of carbonate as nodules in the shales but not as cement in the adjacent sandstones, and (4) ball and pillow structures occurring between the nodules and the underlying (but not the overlying) sediments.

TABLE 1 — FACIES STATES, SEQUENCES, COMPOSITION, AND FEATURES OF POTTSVILLE SECTION.

CODE:	G_1	$G_{2T\&P}$	S_1	$S_{2T\&P}$	S_3	S_4	$S_{5F\&I}$	M_1	M_2	C
SYMBOL:		t / p		t / p			f / i			
NAME:	Crudely bedded sandy conglom.	Cross bedded sandy conglom.	Plane bedded pebbly sandst.	Cross bedded pebbly sandst.	Coarse, plane bedded sandst.	Fine, plane bedded sandst.	Flaser or interbedded sandst. & mudst.	Noncalcareous mudst.	Calcareous mudst.	Coal
COLOR:	Pale gray ss. with variegated conglom.	Dusky yellow conglom. with gray sandst.	Light olive gray	Grayish orange to pink	Pale red (Mauch Ch.) Pale olive (Pottsv.)	Grayish to pink	Gray red (Mauch Ch.) or dark gray (Pv.)	Ruddy (MC) to light brown to black (Pv.)	Ruddy to brown	Black as coal
GRAIN SIZE:	Coarse sand to pebble conglom.	Pebble conglom. to very coarse sand	Coarse to granule with pebbly stringers	Coarse to granule	Coarse to very coarse	Very fine to fine sand	Fine sand with interbed. mud	Fine clay to silt	Fine clay & silt with carbonate concretions	Finely macerated plant fragments
INTERNAL BED FORMS:	Subhoriz. interstat. coarse sand & pebble conglom. Lenticular medium - thick beds	Medium to very thick lensatic beds. Matrix supported conglom (Note 1.)	Low angle laterally contin. wedge sets Medium to thick, concave upward	Cross bedding Lg. scale trough (S_{2t}) or Sm. scale planar (S_{2p})	Decimeter - thick tabular or wedge sets. Lateral cont. to 10s of m. Mass. or par. laminated	Tab. or wedge - shape beds. Laterally extensive thin to thick parallel laminae	Small scale cross - strata with mud flasers (S_5f) or laminated w/ mud layers (S_5i)(Note 2.)	Finely laminated or rooted see Note 3.	Stratified or paleosol features (see Note 3.) M. C. only	Finely stratified but sheared during tectonic deform.
COMPOSITION MAUCH CHUNK TYPE:	(No specific data)		Maturity: mature	Monoxl quartz: 50%	Feldspar: < 1%	Rock fragments plus mica. Avg. 15% Generally sedimentary or low - grade metamorphic origin; primarily zircon & tourmaline.		90% of M. C. Shales are red beds (org. - void) Relatively Fe - rich. Clays: 80% illite; 20% chlorite; $CaCO_3$ & SiO_2 concretions in M_1.		None
PV.—LLEWELL.— TYPE:	Vein qtz > sandstone, chert, conglom., silt, and shale > low to med grade metamorph. incl. phyllite, slate and schist.		more mature	60%	< 1%	(3 - 38%) Med. to high - grade metamorphic minerals first appear in upper Mauch Chunk indicating unroofing of these rocks in source terrane.		All are grey to black org. - bearing Fe - poor, Al - rich. Primarily ill. & chlor. with → 40% kaol. & pyrophyllite. No caliche.		> 92% fixed carbon, dry mineral matter - free.
TYPICAL BASE:	Undulatory, sharp	Undulatory, sharp, erosive	Undulatory, sharp, erosive	Gradational from S_1 or erosive from M_1	Gradational or sharp	Sharp, planar dips to 15°	Gradational from S_1 or S_3	Gradational from S_3 or S_4	Gradational	Gradational from M_1
TOP:	Gradational	Grades to S_{21}	Sharp, undulatory, fine - gr.	Grad. to S_1i or M_1	Grad. to S_{21} or S_{5i}	Grad. to M_2	Grad. to S_1 or M_1	Sharp or erosive	Sharp or erosive	Eros. to G_1 Grad. to M_1

NOTES:

1. G_2 bed continuity ranges from 3m to across outcrop. Lenses subparallel to 2nd - order truncation surfaces; either laterally extensive tangential low angle (<15°) planar cross - strata (G_{2p}) or large - scale (2 - 4 m) cut - and - fill troughs (G_{2t})
2. S_5 unit contains abundant dark brown calcareous root traces, desiccation cracks, and raindrop impressions in Mauch Chunk or plant fragments in Pottsville.
3. Paleosol features of M_1 & M_2 : In Mauch Chunk, paleosols are "vertisols" with wetting/drying features, including wedge - shaped peds, blocky joints, mud cracks, raindrop impressions, pretectonic slickensides, & caliche.
   Paleosols in Pottsville Fm. are "underclays" with abundant root impressions, leached clay minerals, & no bedding.

OTHER SYMBOLS:

▲▲▲ Intraformational conglomerate; Calcareous concretions; Root traces; Plant fragments; C Carbonaceous; Erosional contact; 3|10 average (3) and maximum (10) clast size in centimeters; Fining and thinning upward cycle; Disconformity

TRANSITION MATRIX SUMMARY SEQUENCES:

Mauch Chunk No. 1: $S_4 \rightleftarrows M_2$

Mauch Chunk No. 2: $S_3 \rightarrow S_{2t} \rightarrow M_1$; $S_3 \rightarrow S_{5i} \rightarrow M_1$

Pottsville: $G_{1p} \rightarrow S_1 \rightarrow S_{2t} \rightarrow M_1$; $S_3 \rightarrow S_{5i}$; S_{5f}

(Compositional information from Meckel, 1967; Wood et al., 1969; Holbrook, 1970; Hosterman et al., 1970)

The composition of the organic matter and clay minerals has been strongly influenced by diagenetic conditions during burial. The coal has been elevated to anthracite rank. Expandable layer clays are not present and illite is of the highly ordered 2-M form, representing "anchizone" alteration. Pyrophyllite is an anchizone alteration product of kaolinite that forms only in Fe-depleted rocks (cf., Hosterman and others, 1970, Table 1). Ammonium illite is thought to form at high coal rank in organic matter-rich sediments by nitrogen released during late stages of coalification (Paxton, 1983). These transformations imply temperatures of ca. 225-275°C and 4 to 6 mi (6 to 9 km) of burial.

Tectonic and Climatic Significance of the Pottsville Section

During deposition of the Pottsville section the depositional margin of the basin lay in the vicinity of Philadelphia as indicated by paleocurrent directions and regional trends in maximum grain size (Pelletier, 1958; Meckel, 1967; Wood and others, 1969). Northeast-flowing streams carried sediments toward the basin axis, which trended northeast-southwest across western Pennsylvania. Time equivalent upper Carboniferous rocks are alluvial in eastern Pennsylvania and deltaic and shallow marine to the west (Edmunds and others, 1979). The Mauch Chunk Formation documents a relatively quiescent interval represented variously by fine-grained sedimentation and soil development in the east, an erosional disconformity toward the west, and shallow marine carbonate sedimentation along the basin axis. The influx of coarse clastics in the Pottsville interval has traditionally been ascribed to tectonic uplift in the source (e.g., Meckel, 1967), but while this might be partly true, it is neither a necessary nor sufficient explanation. It also is inconsistent with the flexural modeling of Beaumont et al. (1987; 1988) who used thicknesses of Appalachian basin fill at various times to back-calculate the magnitudes and locations of the necessary crustal loads. During the Early Pennsylvanian the loads were far south in Virginia and of modest thickness (Figure 7-3A); it was not until the Permian that the crust east of Pennsylvania was loaded (Figure 7-3B).

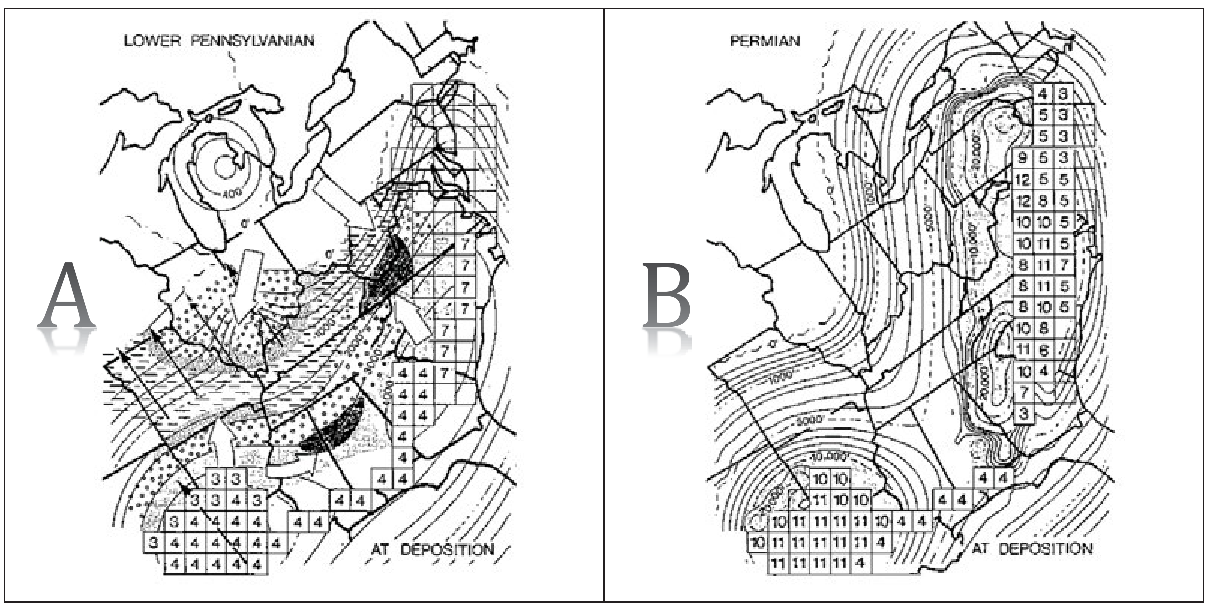


Figure 7-3. A) Lower Pennsylvanian isopach map (contours in feet). Model prediction at time of deposition showing the load thicknesses (km) necessary to produce the model subsidence in the Appalachian and Arkoma basins. Dash and dot patterns denote observed and restored shale, and fine and coarse sandstones. Light and dark shading represent coastal plain and coal swamp environments. Large arrows show the inferred major sediment dispersal directions. Fine arrows show the migration of the peripheral bulge during the advance of the overthrust loads in the Ouachita orogen;
B) Permian isopach map (contours in feet). Model prediction at time of deposition showing the load thicknesses (km) necessary to produce the model subsidence in the Appalachian and Arkoma basins. Shading represents regions deformed by thrusting in which the extra thickness of sediment may, in part, be occupied by older sediments that were shortened and thickened during thrusting.

The simplest explanation for the Mauch Chunk to Pottsville facies progression is a change to more humid climatic conditions in the Pennsylvanian that produced larger sediment yields and stream discharges. This climate change arose as eastern North America drifted northward from under the southern descending limb of the Hadley cell to under the equator.

The interpreted tectonic and paleoenvironmental setting during Mauch Chunk deposition would have resembled in many respects the current alluvial plain extending from the Zagros Mountains to the Persian Gulf where arid conditions produce little clastic influx from the technically active mountain belt. The adjacent foreland basin axis—lying parallel to the mountain belt—receives primarily carbonate sedimentation. Were a future global climatic change to transform the Middle East into a humid region, the margins of the Persian Gulf could perhaps evolve into a broad peat-forming environment such as existed in the Appalachian basin during Pottsville and Llewellyn times.

References

Beaumont, C., Quinlan, G., and Hamilton, J., 1987, The Alleghanian Orogeny and its Relationship to the Evolution of the Eastern Interior, North America In: Beaumont, C., and Tankard, A. J. (eds.). Sedimentary Basins and Basin-Forming Mechanisms. CSPG Memoir 12, p. 425-445.

Beaumont, C., Quinlan, G. and J. Hamilton, 1988, Orogeny and stratigraphy: Numerical models of the Paleozoic in the eastern interior of North America: Tectonics, v. 7, p. 389-416.

Edmunds, W. E., Berg, T. M., Sevon, W. D., Piotrowski, R. C., Heyman, L., and Rickard, L. V., 1979, The Mississippian and Pennsylvanian (Carboniferous) systems in the United States; Pennsylvania and New York: U.S. Geological Survey Professional Paper 1110-B, 33 p.

Holbrook, P. W., 1970, The sedimentology and pedology of the Mauch Chunk Formation at Pottsville, Pennsylvania, and their climatic implications [M.S. thesis]: Lancaster, Pennsylvania, Franklin and Marshall College, 111 p.

Hosterman, J. W., Wood, G. H., Jr., and Bergin, M. J., 1970, Mineralogy of underclays in the Pennsylvania Anthracite region: U.S. Geological Survey Professional Paper 700-C, p. C89-C97.

Levine, J. R., 1986, Deep burial of coal-bearing strata, Anthracite region, Pennsylvania—Sedimentation or tectonics?: Geology, v. 14, p. 577-580.

Meckel, L. D., 1967, Origin of Pottsville conglomerates (Pennsylvanian) in the central Appalachians: Geological Society of America Bulletin, v. 78, p. 223-258.

Miall, A. D., 1977, A review of the braided river depositional environment: Earth Science Review, v. 13, p. 1-62.

Nickelsen, R. P., 1979, Sequence of structural stages of the Alleghany orogeny at the Bear Valley strip mine, Shamokin, Pennsylvania: American Journal of Science, v. 279, p. 225-271.

Paxton, S. T., 1983, Relationships between Pennsylvanian-age lithic sandstone and mudrock diagenesis and coal rank in the central Appalachians [Ph.D. thesis]: University Park, Pennsylvania State University, 503 p.

Pelletier, B. R., 1958, Pocono paleocurrents in Pennsylvania and Maryland: Geological Society of America Bulletin, v. 69, p. 1033-1064.

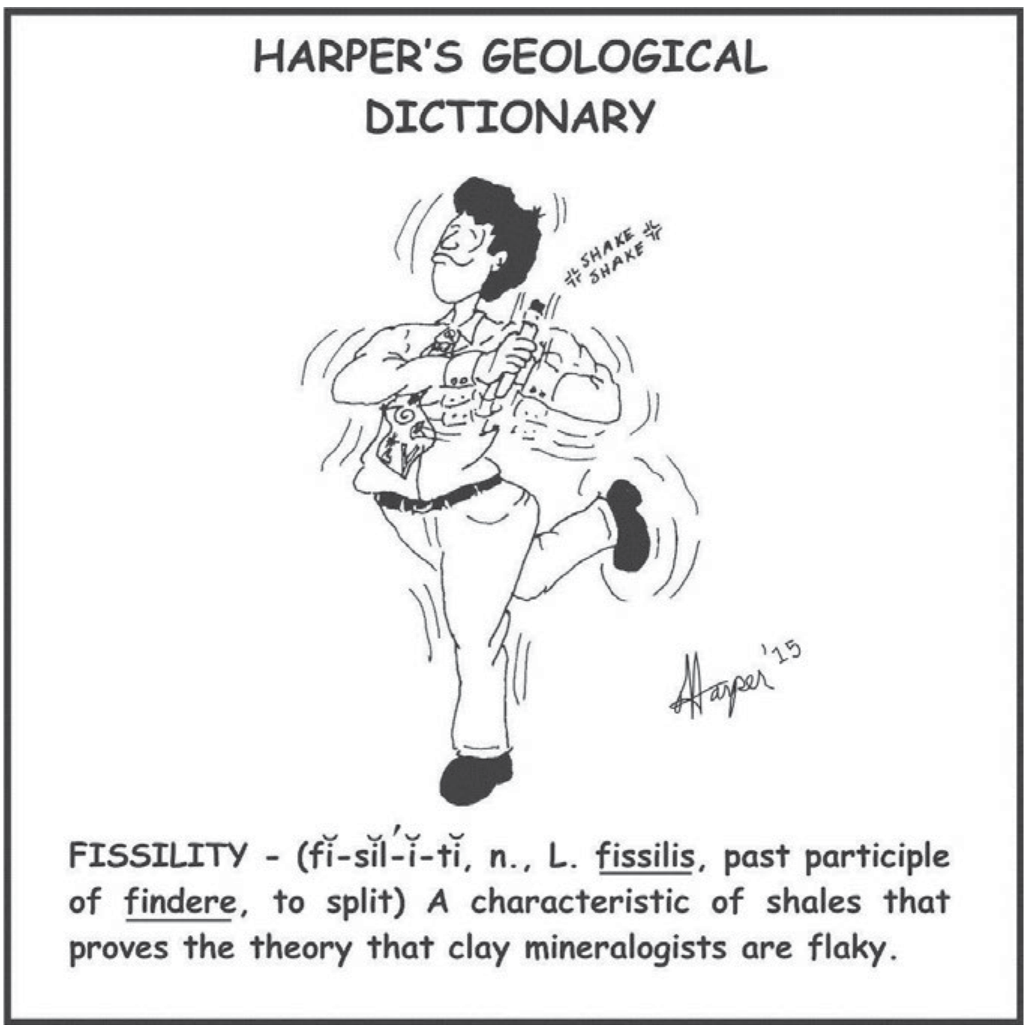
Read, C. B., and Mamay, S. H., 1964, Upper Paleozoic floral zones and floral provinces of the United States: U.S. Geological Survey Professional Paper 454-K, 35 p.

Wood, G. H., Jr., and Bergin, M. J., 1970, Structural controls of the Anthracite region, Pennsylvania, in Fisher, G. W., Pettijohn, F. J., Reed, J. C., Jr., and Weaver, K. N., eds., Studies of Appalachian tectonics; Central and southern: New York, John Wiley Interscience, p. 161-173.

Wood, G. H., Jr., Arndt, H. H., Yelonsky, A., and Soren, J., 1956, Subdivision of the Pottsville Formation in Southern Anthracite field, Pennsylvania: American Association of Petroleum Geologists Bulletin, v. 40, p. 2669-2688.

Wood, G. H., Jr., Arndt, H. H., and Hoskins, D. M., 1963, Geology of the southern part of the Pennsylvania anthracite region: Annual Meeting of the Geological Society of America, Field Trip Guide Book 4, U.S. and Pennsylvania Geologic Surveys, 84 p.

Wood, G. H,, Jr., Trexler, J. P., and Kehn, T. M., 1969, Geology of the west-central part of the Southern Anthracite field and adjoining areas, Pennsylvania: U.S. Geological Survey Professional Paper 602, 150 p.



STOP # 8: WADESVILLE ANTHRACITE SURFACE MINE – READING ANTHRACITE COMPANY

Stop Leaders – Daniel Koury and Nathan Houtz, Pennsylvania Department of Environmental Protection

Reading Anthracite Company is one of the oldest and largest mining companies in the Pennsylvania Anthracite Region. The company was founded in 1871 as The Philadelphia and Reading Coal and Iron Company by its parent company, The Philadelphia and Reading Railroad. The Company was formed in order to purchase coal lands in the Southern and Western Middle Anthracite fields and therefore insure revenue to the railroad. Although the company was originally formed to lease coal lands, as operators on these lands fell on hard times and were forced into bankruptcy, the company took over these operations and became a mining company.

Wadesville was originally developed by numerous collieries that worked in and around the area prior to 1828. The Wadesville shaft was formerly known as the Hickory shaft; which was dug beginning in 1864. In 1871 the mine was found to be on fire and water was turned into the mine from Mill Creek to drown it. The property was sold at sheriff sale in September 1876 to the Philadelphia and Reading Coal and Iron Company. On May 9th, 1877, an explosion of gas occurred, which resulted in the death of six men. After this, old workings again caught on fire and the mine was again flooded in1878. The deep mine operation at the Wadesville Colliery was discontinued in 1930, and with the cessation of pumping, the water pool within the mine increased to such a high level that the overflow discharged into Mill Creek at Saint Clair from an abandoned Saint Clair Colliery shaft. In 1949, the Philadelphia and Reading Company, now Reading Anthracite Company, began a surface mine at Wadesville and they installed deep well pumps in the Wadesville Shaft to allow access to lower coal reserves. The Wadesville Shaft is approximately 700 feet deep.

Over the years Reading Anthracite Company has developed the large surface mine at Wadesville which encompasses nearly 400 acres and is over 500 feet deep. The operation is one of Reading's largest, producing approximately 200,000 tons of coal per year. A 7800 Marion 35 cubic yard (cu yd) Walking Dragline removes the coal and a PC 4000 Kamatsu 29 cu yd Hydrologic Shovel removes the overburden. A Komatsu 18 cu yd Loader loads the coal into 150 ton Caterpillar trucks for transport to the New St. Nicholas coal breaker via a network of haulage roads. The excavation lies within a shallow syncline and is concentrated on splits of the Mammoth coal bed (Nos. 8 and 9) with a total thickness in excess of 40 feet (Figure 8-1). Three other coal beds are encountered and mined in pursuit of the Mammoth bed including the Four Foot (No. 9.5), Holmes (No. 10) and the Primrose (No. 11).

Figure 8-1. Drill location for the stratigraphic column

The Wadesville pit covers approximately 135 acres (Figures 8-2–8-7). In order to mine the Wadesville pit the minepool must be pumped. Exelon Generating, a nuclear power company, recognized that the minepool can be utilized as a reservoir. They pump up to 14.4 MGD at the Wadesville Shaft at certain times of the year to augment water from the Schuylkill River, to satisfy flow or temperature conditions of the river at the Limerick Generating Station 70 miles downstream.

Figure 8-2. View looking West. Shows the proximity to the town of Arnots Addition. Photo taken in 1999

Figure 8-3. View looking West/Southwest overview. Photo taken in 1999

Figure 8-4. View looking South. There has been substantial development since 1999. The large block of material in the mine against the south wall has been removed in recent years. Photo taken in 1999

Figure 8-5. View looking Southeast. Photo taken in 1999

Figure 8-6. Original photo of the Wadesville drill shown in closeup in Figure 8-1. View of the South wall near the southeast corner of the pit. Photo taken in 2002

Figure 8-7. View looking Southeast, as in Figure 8-5, above, 16 years later. Recent photo taken in 2015.

STOP #9: POTTSVILLE MATERIALS

Stop Leader – Susan K. Brown, H&K Group

Introduction

Pottsville Materials (Entrance Latitude = N40° 43' 29.99', Longitude = W 76° 13' 06.44"), owned by Pottsville Materials LLC, is a 179-acre area permitted by the Pennsylvania Department of Environmental Protection (PADEP) as a Large Noncoal Surface Mining Permit which produces construction aggregate and hot-mix asphalt (Figure 9-1). Prior to the initial permit date of October 14, 2009, the noncoal permitted area was part of the surrounding, larger Coal Mining Permit known as the Wadesville Mine, operated by Reading Anthracite Company. Through a partnership between The H&K Group and Reading Anthracite, the 179-acre site was carved out of the coal permit to form the non-coal permit in order to mine and process construction aggregates.

Figure 9-1. Panoramic view of Pottsville Materials quarry looking east

Geology

Pottsville Materials is located in the Anthracite Upland Section (previously part of the Appalachian Mountain Section) of the Ridge and Valley Physiographic Province of Pennsylvania. The dominant topography of the Anthracite Upland Section is that of low, linear to rounded hills formed by fluvial and glacial erosion acting upon the geologic structure that is characterized by narrow folds with steep limbs and numerous faults (Sevon, 2000).

More specifically, the site is situated on the Mine Hill Anticline, with the anticlinal axis trending northeast-southwest at approximately N 60-65°E. The site is underlain by the Pennsylvanian Period Llewellyn Formation (see Figures 9-7 & 9-8 at the end of Geology section), comprised of sandstone, conglomeratic sandstone, quartz pebble conglomerate, siltstone, shale, and numerous coal seams, and The Pottsville Formation, which is comprised of three members. The uppermost Sharp Mountain member, which consists of alternating beds of coarse-grained sandstone, conglomerate, minor siltstone and shale, and occasional thin coal seams, is found at the surface at the eastern most end of the permit area. The Sharp Member dips to the west beneath the Llewellyn Formation. Within the surface mining permit boundary, the main coal seams outcropping at the surface include the Buck Mountain (Coal No. 5), the Seven Foot (Coal No. 6) and the Skidmore (Coal Nos. 7 and 7L). The Buck Mountain seam marks the boundary between the Llewellyn and Pottsville Formations and outcrops at the far eastern end of the site where it dips to the southwest, reaching it's greatest depth at the western site boundary. The geology, along with the Permit boundary, surrounding roads, etc., is shown on Figure 9-2.

In 2006, The H&K Group's Engineering & Environmental Services Division drilled and logged three core holes, C-1, C-2 and C-3, along the axis of the Mine Hill Anticline to depths ranging from 300 to 400 feet below ground surface in order to map the geology and to collect samples for aggregate quality testing. The locations of the cores collected, logged, and photographed by an H&K geologist are shown on Figures 9-2 and 9-3.

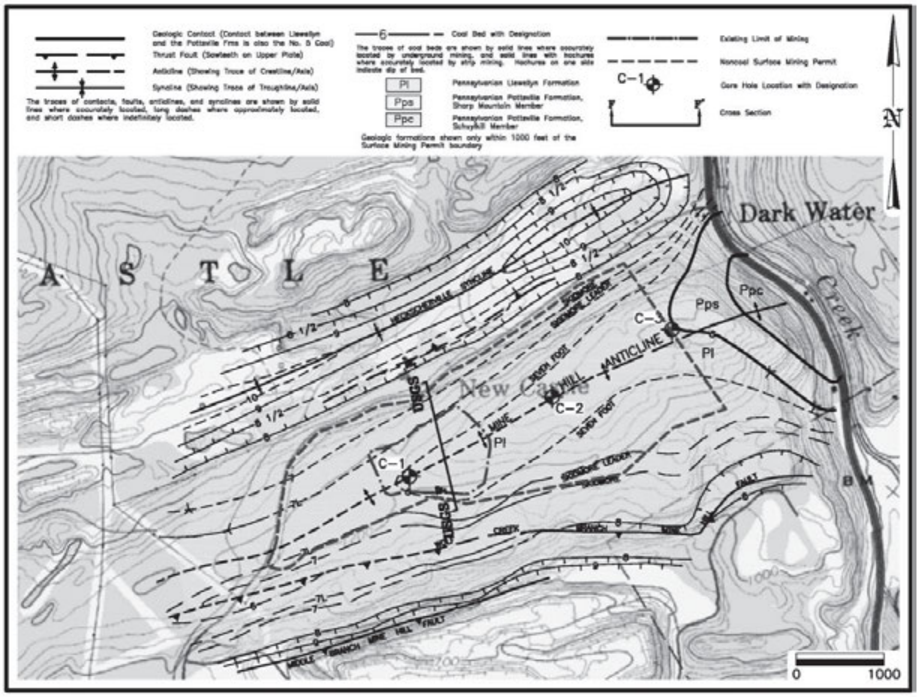


Figure 9-2. Pottsville Materials overview. Shows the location of the site and core holes relative to surrounding features

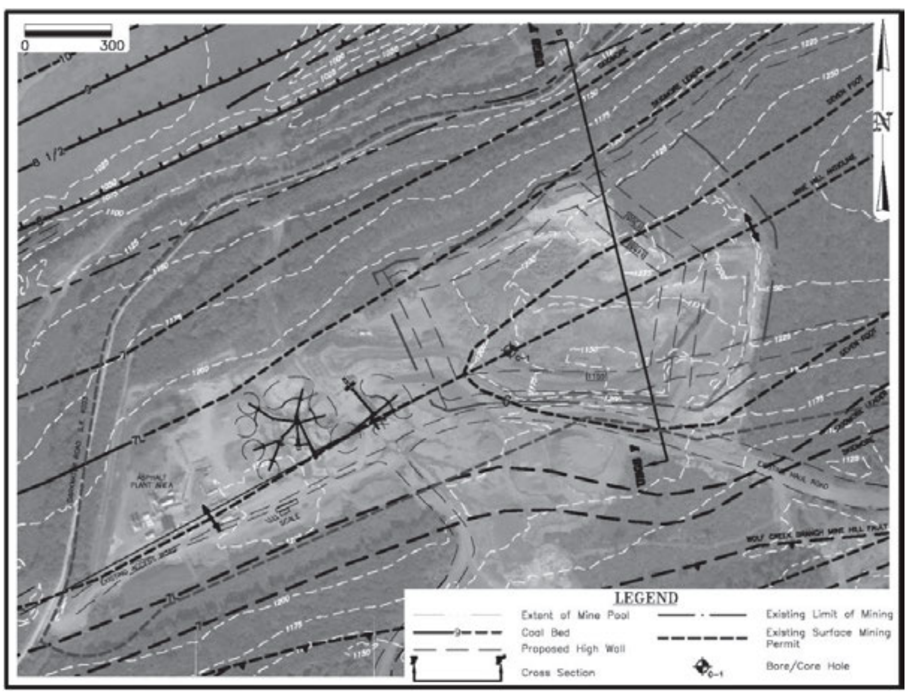


Figure 9-3. Map showing existing and proposed features within production area overlaid on aerial image (Google Earth)

Core profiles, depicting the subsurface stratigraphy as logged from the cores and correlation of the coal beds, are depicted on Figure 9-4. Historic mine maps and cross sections provided by Reading Anthracite, and a USGS cross section (Wood, 1972), shown as Figure 9-5, supplemented the core hole data to build detailed cross sections (Figure 9-6) for the mining permit application.

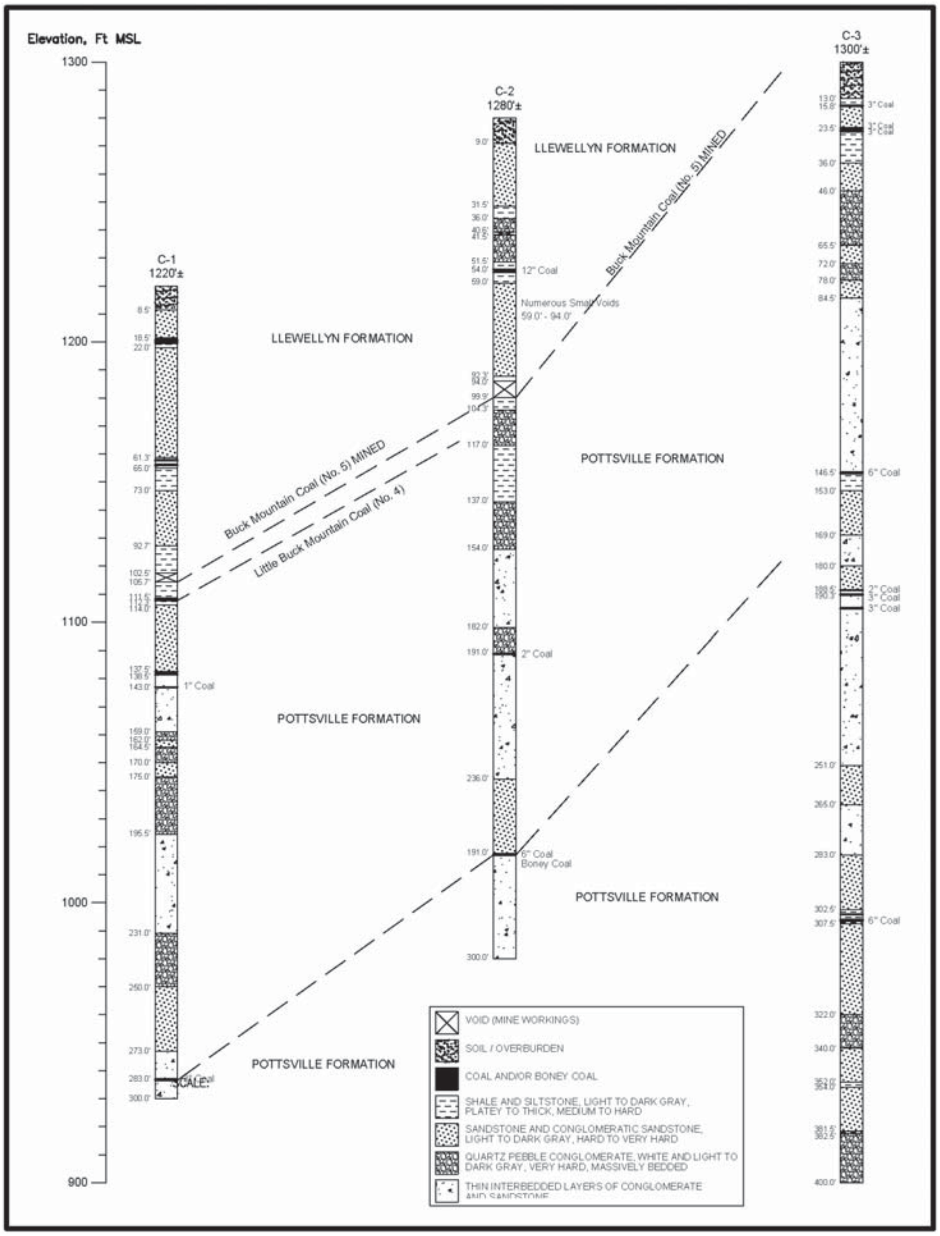


Figure 9-4. Core hole profiles developed by The H&K Group during the exploring and permitting phase of Pottsville Materials.

Based upon the results of the coring, it was estimated that the Llewellyn Formation extends to a maximum depth of approximately 110 feet below ground surface (bgs) within the permit area. The Sharp Mountain member of the Pottsville Formation is located beneath the Llewellyn Formation. It is expected that the Pottsville Formation (and the Buck Mountain coal which larks the contact) will be encountered throughout the quarry as mining progresses, however at varying depths due to the dip of the beds. Two prominent coal beds have been encountered during quarry excavation, one of which is exposed clearly in the southern highwall along the access ramp to the lower level of the pit (Figure 9-7). This coal seam extended across the pit along the surface of the upper bench, which has dictated the development of benches in a convex upward fashion (discussed further below). Geologic analysis of the site indicates that the coals encountered in the quarry are unnamed coal beds located between the Seven Foot and the Buck Mountain.

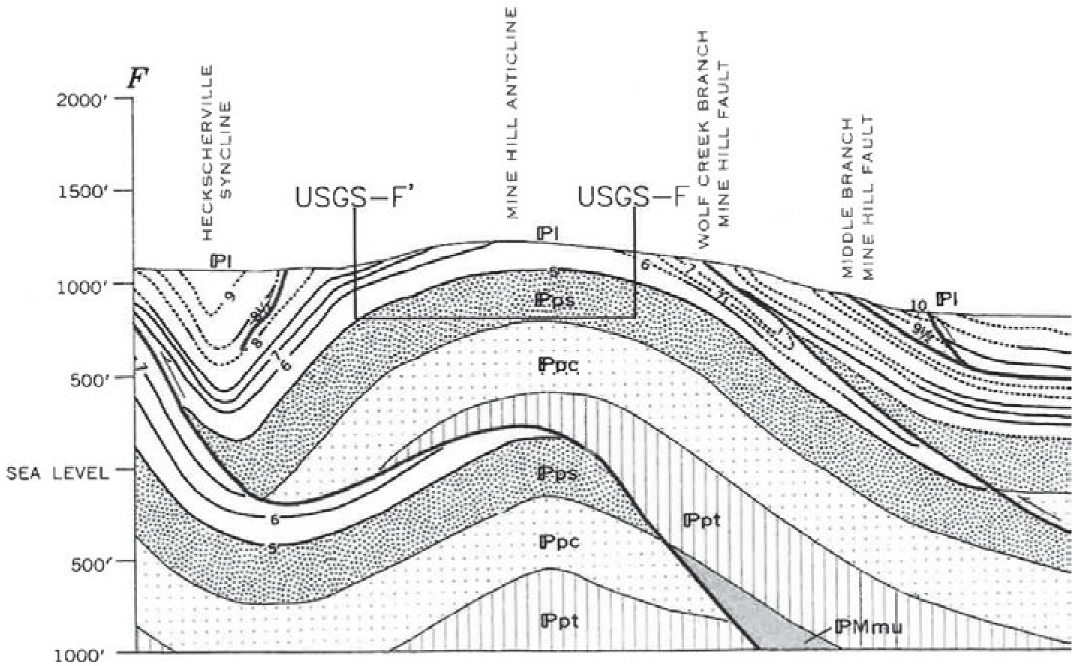


Figure 9-5. USGS Cross Section F–F', looking west. Location of cross section labeled on Figures 9-2 and 9-3. Stratigraphy depicted on the section (Wood, 1972) referenced to identify coal beds encountered in cores and in the pit.

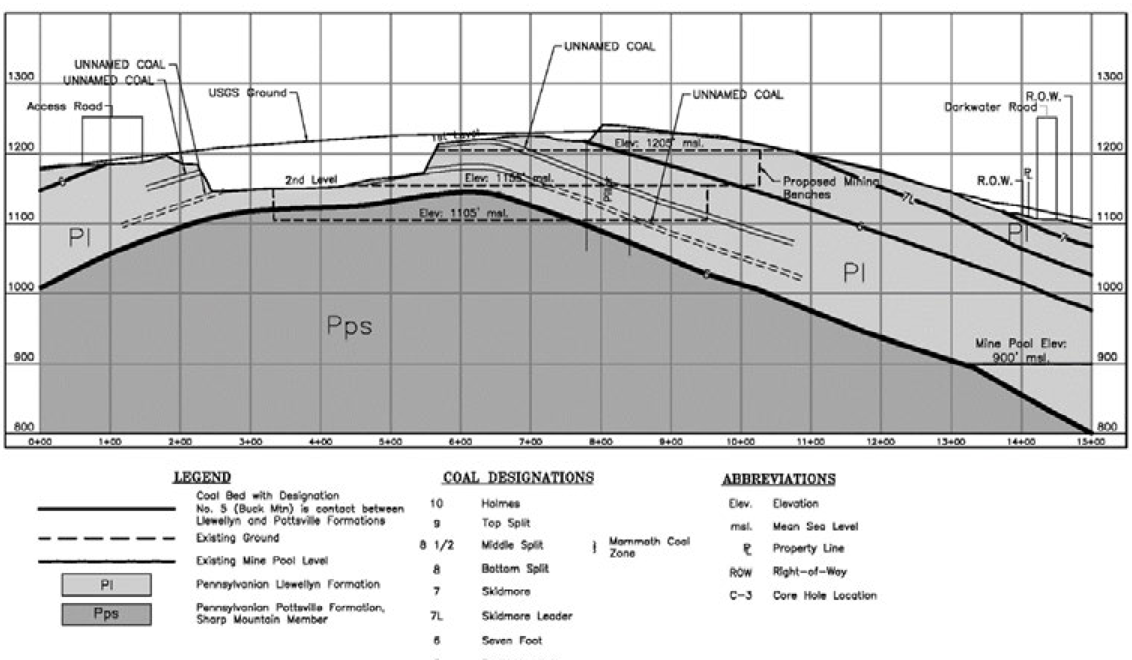


Figure 9-6. Cross Section USGS F – USGS F'. Cross section along same line developed for the USGS (Wood 1972) above in Figure 9-5, but showing quarry-specific details and re-interpretation of geology based on drilling and highwall exposures.

Historically, the site has been affected by coal mining both at the surface and underground. A site reconnaissance will reveal surface depressions where outcropping coal was removed. Surface coal extraction by coal mining entities has occurred to the north and south of the ridge on which Pottsville Materials quarry sits because thick coal beds are found at shallower depths at these locations. In the Wadesville pit to the south, the Mammoth Vein is still being mined with a dragline today. With three splits numbered 8, 8 ½, and 9 having a cumulative average coal thickness of nearly 35 feet, the Mammoth is one of the thickest anthracite coal beds in the region.

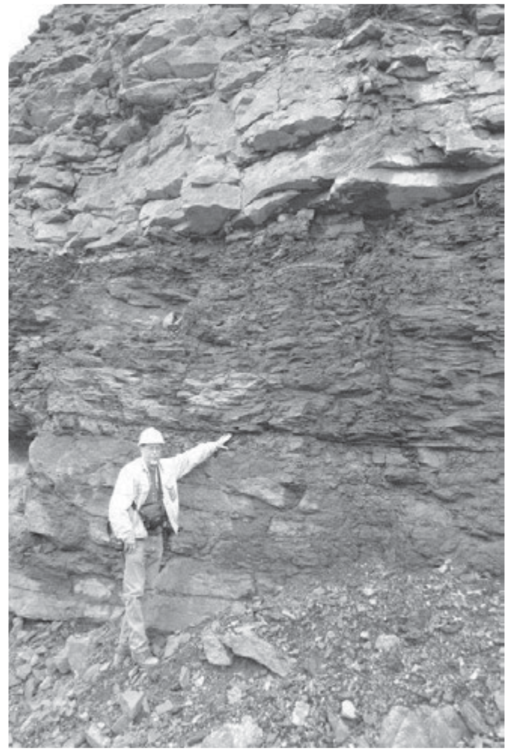


Figure 9-7. Identification of prominent coal seam in the southern highwall along the access ramp to the lower level.

The thickest coal-producing seam within the permit area is the Buck Mountain seam (No. 5). It is reported that the Buck Mountain bed thickness ranges from 1.0 to 17.3 feet, and the coal thickness ranges from 0 to 12.2 feet (Wood, 1972). Core holes drilled in December 2006 encountered mine workings in the form of voids associated with the Buck Mountain coal seam. The voids encountered at locations C-1 and C-2 measured 3 and 6 feet, respectively. Fragments of wooden support beams were also retrieved in the core sample. Due to mine subsidence, the measured thickness of the void is likely smaller than the original working. Published data, mine maps from Reading Anthracite Company's abandoned underground mine map archives, and the PADEP Pottsville Mining Office/Deep Mine Safety indicate that the Buck Mountain has been heavily mined by anthracite underground miners. Portions of the Skidmore and the Seven Foot have also been mined.

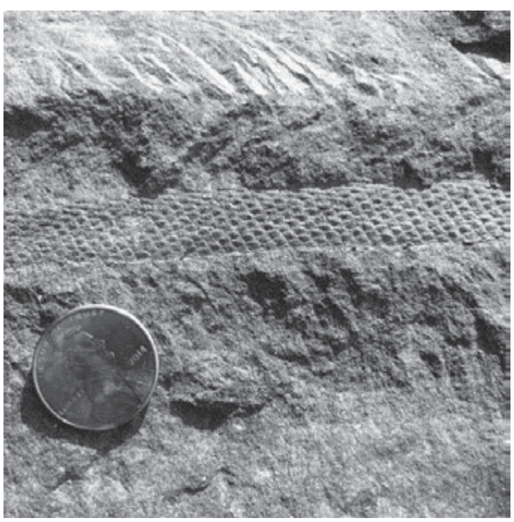


Figure 9-8. Fossil from Llewellyn Formation at Pottsville Materials. Believed to be Lepidodendron, also known as scale tree, it is one of the most common plant fossils found in Pennsylvanian age rocks.

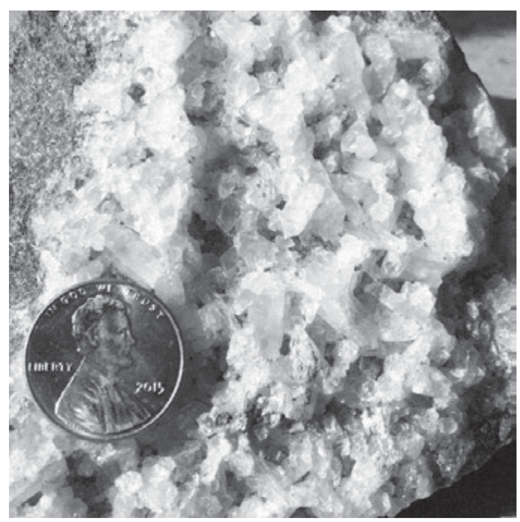


Figure 9-9. Well-formed quartz crystals found in sandstone of the Llewellyn Formation at Pottsville Materials.

Production – Aggregate

Pottsville Materials consists of an aggregate processing plant and a hot-mix asphalt plant. The processing plant crushes approximately 375 to 400 tons of Pottsville Formation conglomerate and sandstone per hour, and averages 425,000 tons per year. Production begins at the quarry face with drilling and blasting to produce shot rock (large boulders), which are then loaded in rock trucks with excavators and front-end loaders, for transport to the primary hopper/jaw. Through a series of conveyors and screens, different aggregate products are produced at the primary such as 2A modified, ballast, and rip-rap. Some of the stone is them conveyed to the surge pile and onto the secondary cone crusher, producing additional aggregate products including #8's (½-inch minus), screenings, and NY #2's. Again, a third, or tertiary, cone crusher produces #57 stone (1½-inch minus), a portion of which is run through a coarse material wash screw. A wash screw cleans the stone of fine silt and clay, producing clean #57 aggregate, also referred to as "plant material", which is typically used in concrete and asphalt production. Seven aggregate products produced at Pottsville Materials are approved for use in state roadways through an on-going series of testing by the Pennsylvania Department of Transportation (PADOT). Currently, the majority of the products are used in the construction of roadways, either as subgrade/subbase, or in the asphalt mixes produced at the on-site asphalt plant. Products such as #57's and #8's are sold for use in concrete at customer's concrete plants. Sand is also produced which may be used in concrete, asphalt, or, when tested and approved, as septic sand. Figures 9-8 and 9-9 on the opposite page are examples of rock found in the quarry.

Quality control is an important factor in aggregate production. Although the coal bed itself is relatively thin, and separation and recovery of this seam is not economically significant, the coal and its associated shale beds would contaminate aggregate products. For example, greater than 3% "deleterious shale" would prohibit a product from being PADOT approval. For this reason, mining along this seam in a convex upward fashion allows for easier segregation of the coal and shale from the sandstone and conglomerate.

Production – Hot Mix Asphalt

The hot-mix asphalt plant at Pottsville Materials is a stationary Astec Industries 400 ton per hour counter flow double barrel (a drum within a drum) drum mix plant equipped with three 300 ton capacity heated storage silos capable of producing up to 395,000 tons annually. On average, Pottsville produces 100,000 tons of asphalt. The hot mix asphalt process consists of introducing various aggregates from the quarry, including #7, #8, #57 stone, and B-3 sand, into the inner drum via five electronically metered cold feed bins through a conveyor system. The aggregate is dried and heated within the inner drum to approximately 300-350 degrees by means of a natural gas fired burner. The burner is also capable of firing No.2 fuel oil or recycled fuel oil as an alternative. Once the aggregate is thoroughly heated and dried within the inner drum aggregate is transferred to the outer drum at which point Recycled Asphalt Product (RAP; pavement that has been removed from road surfaces with a milling machine when preparing to re-pave a road), mineral filler (dust) and asphalt cement (AC) are added to the mix. Up to 25% of the total mix can be recycled asphalt products. RAP is processed on-site with a portable crusher and/or screen to specific sizes and gradations.

References

Wood, G.H., 1972, Geologic Map of Anthracite-Bearing Rocks in the Pottsville Quadrangle, Schuylkill County, Pennsylvania, U.S. Geologic Survey, Miscellaneous Geologic Investigations, Map I-681

Google Earth, New Castle, PA area. Imagery Date 9/12/2012; Downloaded 8/19/2015.

Sevon, W.D., 2000, Physiographic Provinces of Pennsylvania, Commonwealth of Pennsylvania, Department of Conservation and Natural Resources, Fourth Edition, Map 13.

STOP #10 AND LUNCH: PINE FOREST SHAFT, ST. CLAIR

PINE FOREST WORKINGS, RAVENSDALE TUNNEL, AND MARINE FOSSILS IN THE LLEWELLYN FORMATION

Stop Leaders – Jon D. Inners, Clifford H. Dodge, and Robert J. Scherr

Introduction

The grounds of St. Clair Fish and Game Club occupy part of the site of the former Pine Forest Colliery. The earlier deep mines and the later surface operations were off to the east and north, respectively, of the picnic pavilion where we will have lunch (see STOP 11 for location map). The latter are reclaimed and no long evident, whereas the Pine Forest Shaft and the drainage tunnel connected to the shaft are accessible and will be visited. About 2,500 ft east of the Club is the former location of the Ravensdale Tunnel—long removed by strip mining—where invertebrate fossils were reportedly found in 1857 (Figure 10-1).

Geology

The Pine Forest Shaft is located on the south-dipping north limb of the complexly faulted Pine Forest syncline between the surface trace of the Holmes (No. 10) coalbed to the north and the Primrose (No. 11) coalbed to the south; it is 550 ft south of the South Branch Mine Hill fault and 600 ft north of the Arnot fault (Wood, 1972, 1973) (Figure 10-1). As noted below, the shaft, sunk in 1864–66, penetrated the Mammoth coal zone at a depth of 362 ft. It encountered the 4 ft 4 in.-thick Holmes at 80 ft and the 7 ft 3 in.-thick "Seven-Foot" (now called the Lower Four-Foot) at 305 ft (Pennsylvania Geological Survey, 1889), and penetrated the south-dipping South Branch Mine Hill fault between the "Seven-Foot" and the top of the Mammoth zone (Figure 10-2).

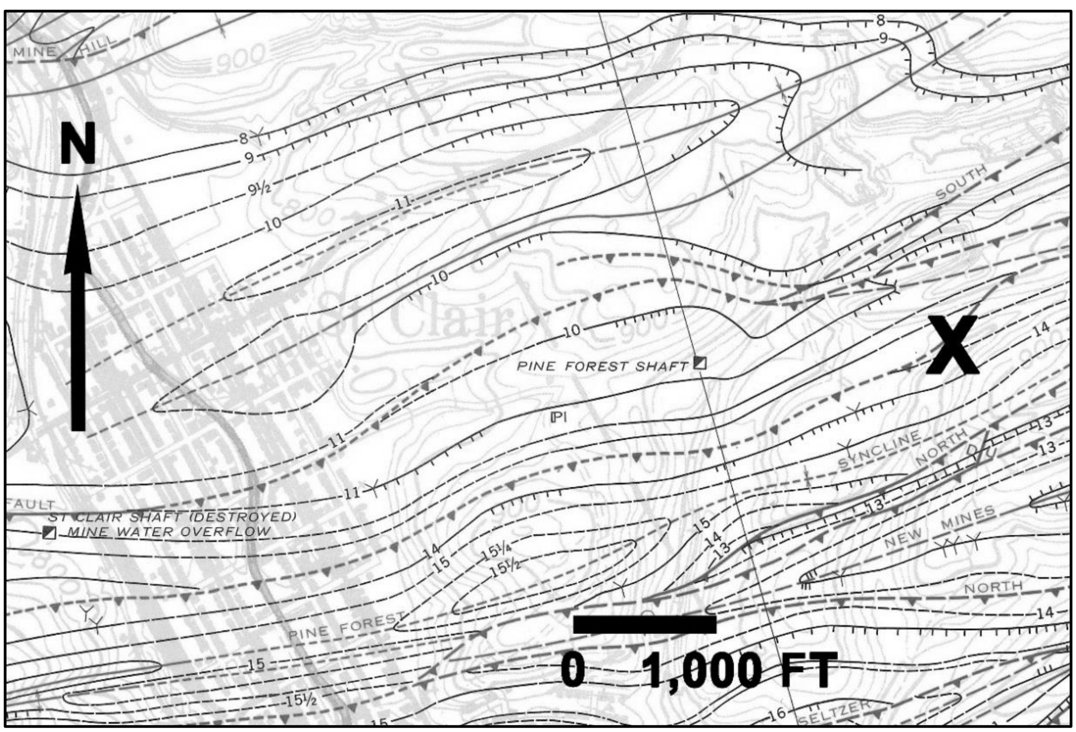


Figure 10-1. Detailed map of structure and coalbeds in the vicinity of the Pine Forest Shaft (modified from Wood, 1972). Bold letter "X" marks location of entrance to former Ravensdale Tunnel.

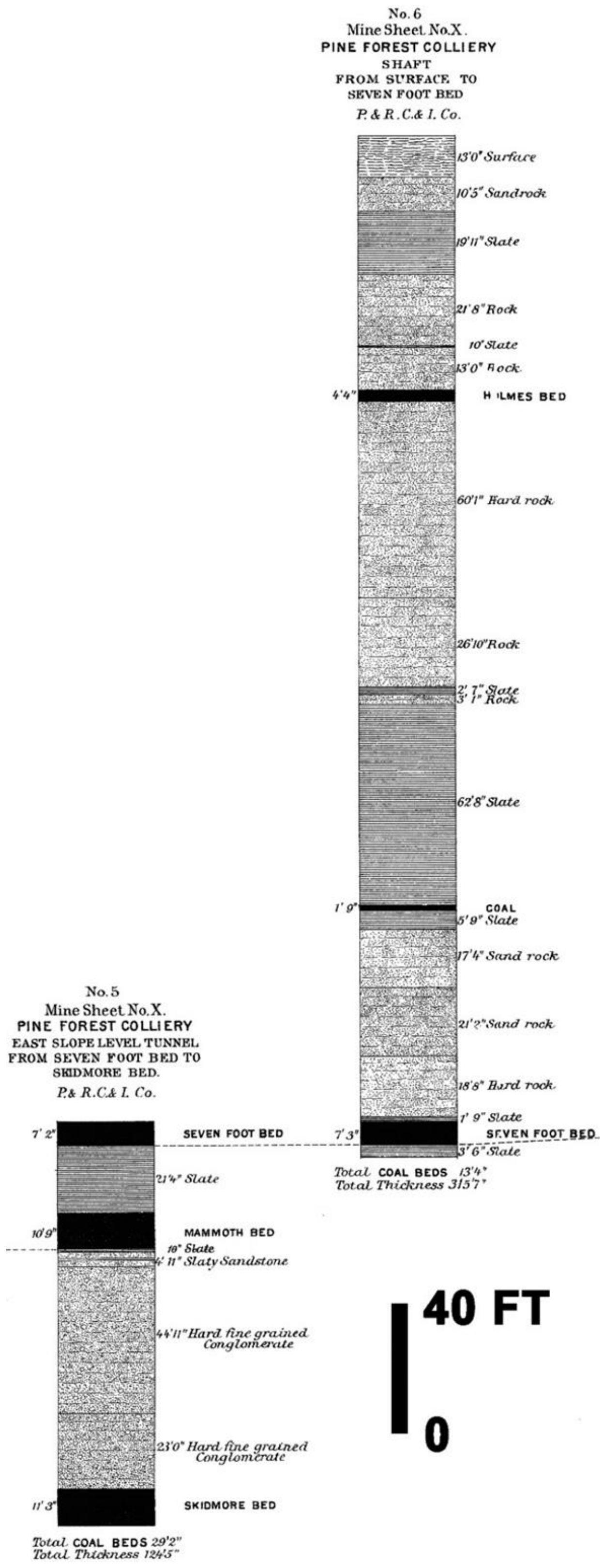


Figure 10-2. Columnar section of shaft at the Pine Forest Colliery from surface to base of "Seven-Foot" coal (right) and overlapping tunnel section from "Seven-Foot" coal to base of Skidmore coal (left). (modified from Second Geological Survey of Pennsylvania, 1889).

History of mining at the Pine Forest Slope and Shaft *(slightly modified from Wallace, 1988)*

In 1845, Benjamin Haywood and George W. Snyder sank the Pine Forest Slope in partnership with Benjamin Milnes, an experienced English miner who had come to the United States about 18 years earlier. The slope ran down along the eastern boundary of the St. Clair Tract, leaving a pillar of untouched coal along the property line and opening out gangways on the Mammoth and Seven-Foot veins that extended east for over a mile. Two nearby mine patches, Crow Hollow and Ravensdale, served the colliery established at Pine Forest.

All the machinery for the colliery—engines, pumps, and breaker—was constructed at Snyder and Haywood's machine shop and foundry in Pottsville, originally established by Snyder in 1835. By 1850, the colliery was employing 60 hands and producing about 15,000 gross tons per year; but after Haywood moved to California in 1850 to take advantage of the "gold rush" and Milnes left the firm in 1853 to take over the Hickory Colliery, Snyder took charge. He sank a second slope in 1857, and production increased rapidly to over 100,000 gross tons annually from three lifts below water level. By 1860, however, the operators needed to reach lower levels, and a vertical shaft was proposed. The sinking of the still extant, but long-flooded Pine Forest Shaft began late in 1864. Progress was delayed by water, and the work was not completed until November 1866 (Figure 10-3). This 12- by 20-ft shaft struck the Mammoth vein at 362 ft and a 43-ft tunnel south intercepted the Four-Foot (called the Seven-Foot at the time) and another tunnel, 270 ft north, reached the Skidmore.

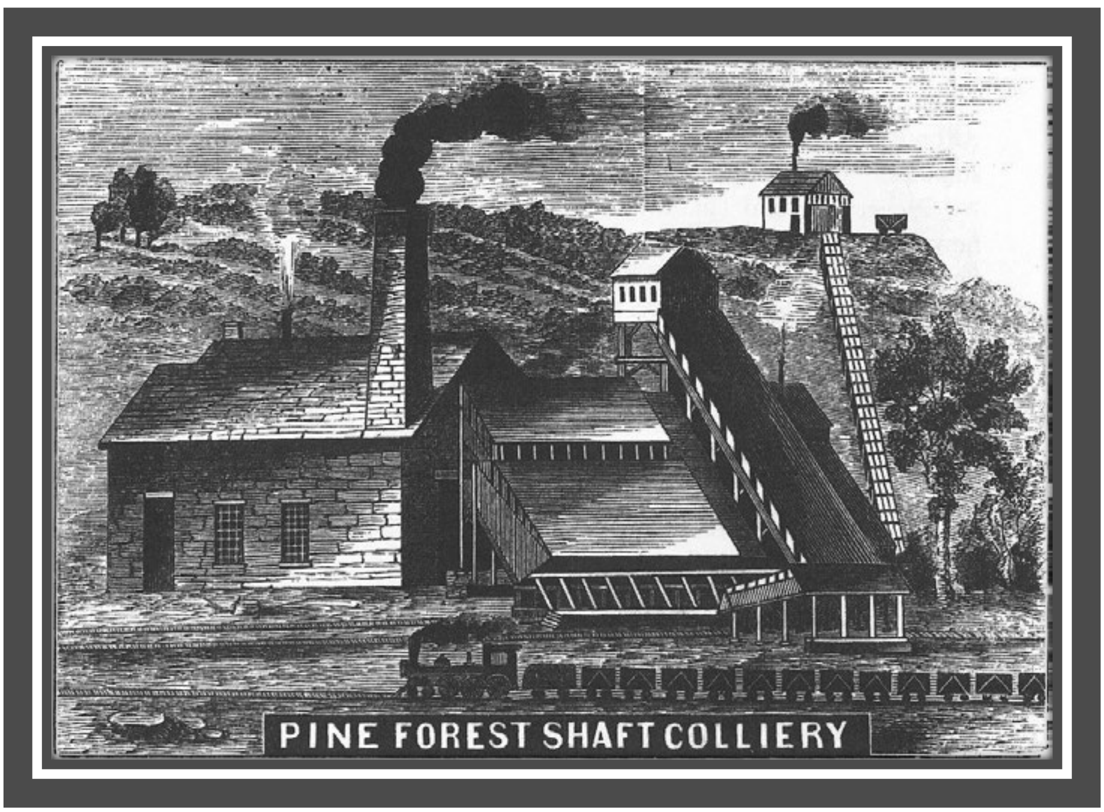


Figure 10-3. Pine Forest Shaft Colliery, 1866 (Wallace, 1988, p. 113)

In 1863, Snyder installed a steam fan to aid ventilation, probably the first in the vicinity. The aggregate steam power at the older Pine Forest Slope was 250 horses; at the new shaft it was over 500. As the first state mine inspector, John Eltringham, put it in 1869, "the machinery and engines, and the appurtenances of the colliery, cannot be excelled in the county" (Eltringham, 1870, p. 68–69). And again in 1870, "none but competent persons are in charge of engines and machinery" (McAndrew, 1871, p. 126). The breaker stood adjacent to the shaft, so that the cars ran up 80 ft to the top of the breaker and automatically unloaded the coal without leaving the cage; the cage was thoughtfully provided with a cover some time later to protect those riding in it.

Nevertheless, despite the mechanical sophistication displayed at the new mine, the Pine Forest Shaft Colliery turned out to be a failure. Tonnage figures in the mine inspectors' annual reports tell the story. Completed in 1866, the colliery suspended operations in 1884 and was finally abandoned in 1890. During its 24 years of existence, it was in condition to ship coal for only 12 years, and during even those 12 years, it produced only 626,112 gross tons, for an average annual production of 52,342 gross tons—merely half of what the old slope did back in the 1850s, and far below its estimated capacity of 150,000 gross tons per year. Statistics from the 1880s, by which time the colliery was under operation by the Philadelphia & Reading Coal & Iron Company (P&RC&I Co.), highlight the sad production story (Ashburner, 1883, 1885; Hill, 1887):

YEAR	GROSS TONS
1881	41,549
1882	42,486
1883	60,024
1884	31,090
1885	6,025
1886	0

The problem with the Pine Forest Shaft was its ventilation, which was ill-designed when the shaft first opened in 1866. It prevented effective production until 1872, when Snyder sold the colliery to the P&RC&I Co. and a professional operator took over the lease. Snyder chose as the inside boss an Irish immigrant, Thomas Maguire, who had worked for Snyder ever since the sinking of the shaft began. Maguire was a practical miner but illiterate and, as his son put it later in his autobiography, "did not want to be a boss, but they simply made him be one" (Patterson, 1914, p. 314). The elder Maguire depended on his son, then in his twenties, to keep the colliery account books and to maintain records of the inside air volume and velocity. Bad engineering resulted in a poor ventilation system that ran the downcast air from the foot of the shaft through the entire mine before returning to the surface at a fan located close to the breaker. Mine inspector Eltringham (1870, p. 69) observed that "there is a considerable quantity of gas evolved in the face of the gangway and breast, so that it is necessary and expedient to use no lamps but the Davy safety-lamps," and he was forced to issue detailed instructions on the use of lamps and other precautions for fire safety. Next year (1870), even after the upcast air shaft and fan were moved to a point 1,000 yds distant from the breaker, the condition was little better, as "the accumulation of carburetted hydrogen [methane] gas in the mine at present is considerable, and none but the most careful miners should be permitted to work in certain districts with or without safety lamps" (McAndrew, 1871, p. 126). At times, all production had to be halted because of rockfalls in the gangways that block the flow of air, and fires and explosions that closed down the mine for extended periods in the 1870s.

In 1872, William Kendrick took charge of the Pine Forest on behalf of the P&RC&I Co., but Thomas Maguire continued as inside boss until his death in 1877. Maguire's son John took his place for a time, before moving on in the employment of the company as superintendent, district superintendent, and finally division superintendent. But, despite the superior experience of Kendrick and better technical education of the younger Maguire, the mine never lived up to its promise, and in 1890 was left to fill up with water.

In 1961, when Reading Anthracite took over the P&RC&I Co., the renamed firm began employment of a Marion 7800 dragline (220-ft boom and 35-yd bucket) at the Pine Forest stripping just north of the old shaft. The shaft was converted to a pumping station draining water from the aquifer through which the open pit mine descended. The outlet of the drainage tunnel is about 200 ft south of the shaft entrance. (Figures 10.4–10.9). The big dragline is still operating at Wadesville (STOP 8).

Figure 10-4. Outlet of the drainage tunnel at the Pine Forest Shaft, November 2014

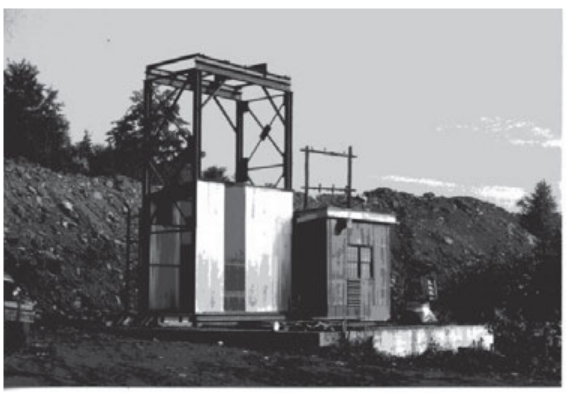


Figure 10-5. Pump at the Pine Forest Shaft, October 1971

Figure 10-6. *Entrance to Pine Forest Shaft, November 2014*

Figure 10-7. Looking down the Pine Forest Shaft. View to the water level about 15 ft below land surface, November 2014

Figure 10-8. Marion 7800 dragline at the Pine Forest surface stripping operation, May 1972

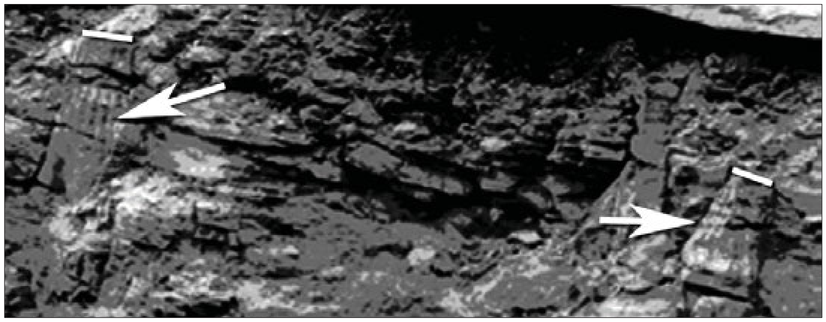


Figure 10-9. Arrows point to fossil tree trunks at the Pine Forest stripping operation in this contrast enhanced photo; white lines show trunk tops. April 1973

Ravensdale Tunnel

Located north of Ravensdale Hollow about 1 mi east of St. Clair, the former Ravensdale Tunnel is particularly noteworthy as the discovery site of the first-known "marine" invertebrate fossils from the coal measures in the Southern Anthracite coalfield. The fossils were found in the summer of 1857 by William B. Rogers, Jr., geological assistant of the First Geological Survey of Pennsylvania (1836–58) and nephew of the state geologist, who "discovered the casts of two or three (an *Avicula?* and a *Tellinomya?*) in coal-slate [inside] near the mouth of the Ravensdale tunnel" (Rogers, 1858, p. 833). Although the reported mollusk genera are now invalid, they correspond most likely to non-specific (at least) pectinid and nuculid bivalves, respectively, which are recognized as marine to restricted marine in origin. The description of the discovery site and cross section through the tunnel are sufficiently detailed to constrain the stratigraphic interval from which the fossils were collected as between (older to younger) the Orchard (No. 12) and Diamond (No. 14) coalbeds, which are separated by a vertical distance of about 200 ft (Figure 10-10).

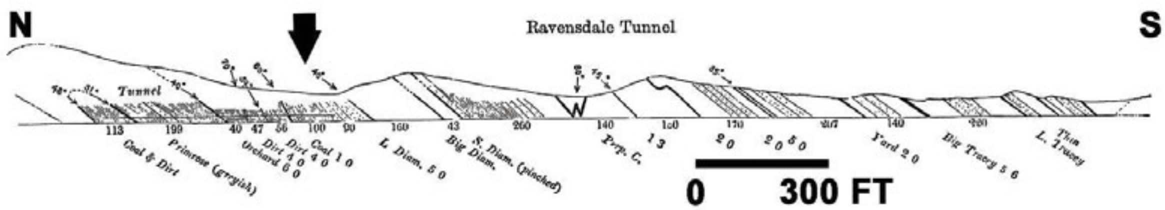


Figure 10-10. North-south cross section of south-dipping anthracite-coal measures at and in vicinity of former Ravensdale Tunnel (modified from Rogers, 1858, p. 130, Fig. 169). Downward-pointing arrow indicates approximate location and stratigraphic position at which marine fossils were found. Overturned fold at north end of tunnel was designated "Anticlinal F" by First Geological Survey of Pennsylvania (now called the Pine Forest anticline). Horizontal numbers on cross section are distances in feet between key points; diagonal numbers are coal thicknesses in feet and inches. It is highly likely that the survey and geologic section of the tunnel were made by P. W. Sheafer of the First Geological Survey (see Dodge, this guidebook)

The Little Diamond (L. Diam.) coal on the cross section is now recognized as the Diamond (Woods, 1972). Unfortunately, the fossil specimens that the younger Rogers collected are not known to have survived, but attempts are underway to verify this. Based on the present correlation scheme of coals throughout the several anthracite coalfields (despite acknowledged uncertainties) (see Eggleston and others, 1999, p. 460, and p. 461, Figure 36–2), it would appear that the marine fossils at Ravensdale represent one of the Glenshaw Formation (Conemaugh Group) marine zones of western Pennsylvania, though stratigraphically lower (older) than the Mill Creek limestone of Ashburner (1886) of the Northern Anthracite field, which is the probable equivalent of the Ames marine zone of western Pennsylvania (Chow 1951).

The former Ravensdale Tunnel operated in the mid-nineteenth century as a horizontal mine entry (access point) into the south-dipping anthracite-coal measures (Pennsylvanian lower Llewellyn Formation), between (older to younger) the Primrose (No. 11) and Little Orchard (No. 13) coalbeds. The tunnel trended northward into the hillside for a distance of about 555 ft, as of the late 1850s. It was subsequently removed by surface mining in the twentieth century and therefore is lost to science for further investigation. Nevertheless, plans are ongoing to search for invertebrate fossils elsewhere near St. Clair and Pottsville in the same stratigraphic interval as encountered at the former Ravensdale Tunnel. Even today, known occurrences of marine invertebrate fossils (i.e., marine zones), or any fossil faunae for that matter, in the Southern Anthracite coalfield are extremely rare—perhaps because they are absent or poorly preserved, or more likely (?), because they have never been systematically searched for in the black shales where they most probably occur but may be difficult to discern without careful examination. Recognition of marine zones here could lead to improved stratigraphic correlations with the bituminous coalfields of Pennsylvania, where the sequence of marine zones is well established, and to a better understanding of the stratigraphy and depositional history of the anthracite coalfields as a whole.

References

Ashburner, C. A., 1883, First report of progress in the Anthracite coal region—The geology of the Panther Creek basin or eastern end of the Southern field: Pennsylvania Geological Survey, 2nd ser., Report AA, 1–242 p.

____1885, Second report of progress in the Anthracite coal region, part 1—Statistics of production and shipment for 1883 and 1884: Pennsylvania Geological Survey, 2nd ser., Report AA, 21 p.

____1886, Report on the Wyoming Valley limestone-beds, *in* Lesley, J. P., Annual report of the Geological Survey of Pennsylvania for 1885, Pennsylvania Geological Survey, 2nd ser., Annual Report 1885, p. 437–450.

Chow, M. M., 1951, The Pennsylvanian Mill Creek limestone in Pennsylvania: Pennsylvania Geological Survey, 4th ser., General Geology Report 26, 36 p.

Eggleston, J. R., Kehn, T. M., and Wood, G. H., Jr., Anthracite, chap. 36 of Shultz, C. H., ed., The geology of Pennsylvania: Pennsylvania Geological Survey, 4th ser., Special Publication 1, p. 458–469. [Co-published with Pittsburgh Geological Society.]

Eltringham, John, 1870, Report of the inspector of mines of the county of Schuylkill, for the year ending December 31, 1869: Harrisburg, B Singerly, 200 p.

Hill, F. A., 1887, Third report of progress in the Anthracite coal region, *in* State Geologist, Annual report of the Geological Survey of Pennsylvania for 1886, part 3—Report on the Anthracite region: Pennsylvania Geological Survey, 2nd ser., Annual Report 1886, pt. 3, p. 919–1329.

McAndrew, P. F., ed., 1871, Reports of the inspectors of coal mines of the Anthracite coal regions of Pennsylvania, for the year 1870: Harrisburg, B Singerly, 250 p.

Patterson, J. F., 1914, Reminiscences of John Maquire after fifty years of mining: Pottsville, Pa., Schuylkill County Historical Society Publications, v. 4, p. 305–336.

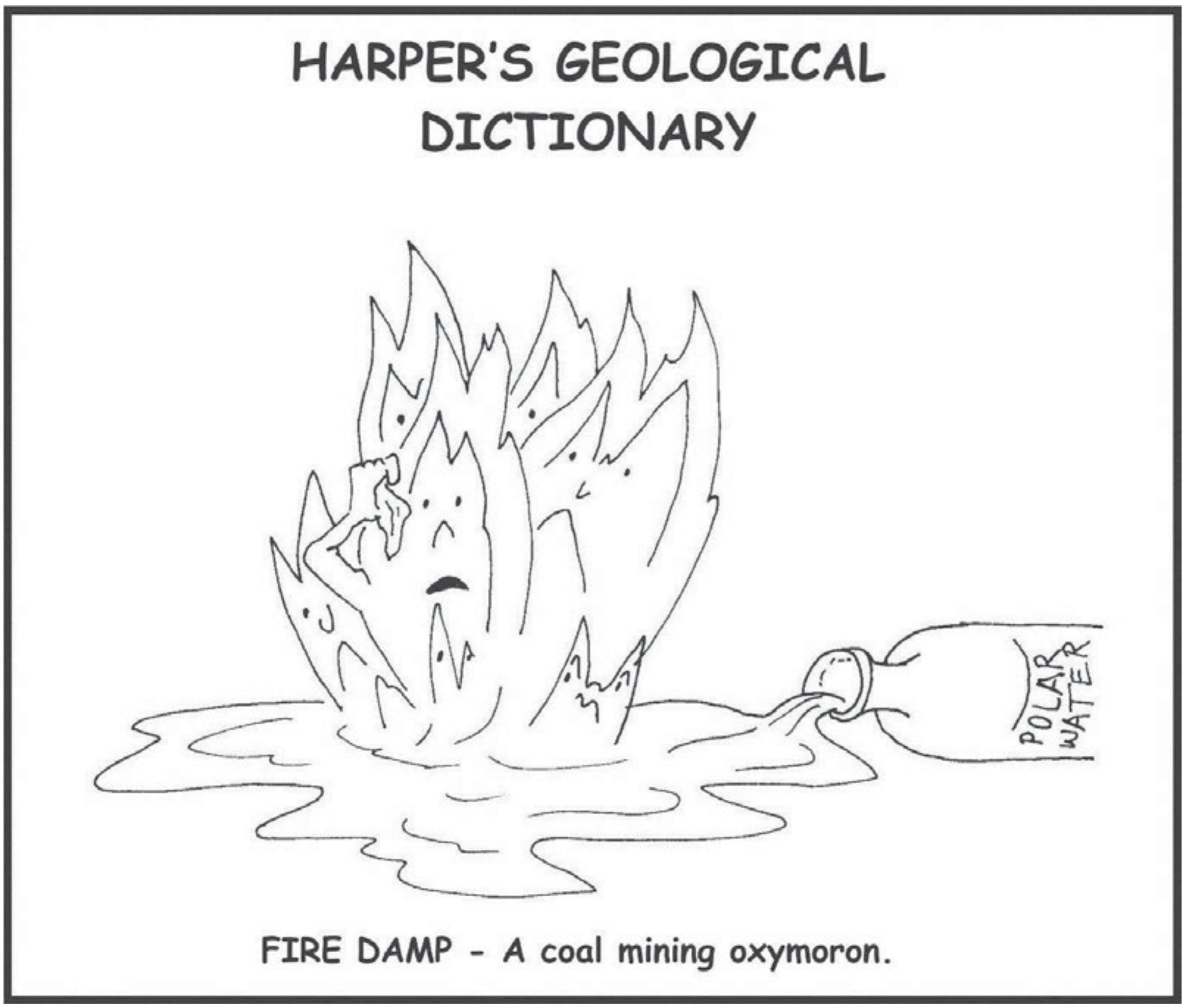
Rogers, H. D., 1858, The geology of Pennsylvania—A government survey: Edinburgh, William Blackwood and Sons [Philadelphia, J. B. Lippincott], v. 2, 1,045 p.

Second Geological Survey of Pennsylvania, 1889, Columnar section sheet no. 5, *in* Atlas of the Southern Anthracite field, part 4: Pennsylvania Geological Survey, 2nd ser., Atlas AA, 6 plates.

Wallace, A. F. C., 1988, St. Clair—a nineteenth-century coal town's experience with a disaster-prone industry: Ithaca, Cornell University Press, 519 p.

Wood, G. H., Jr., 1972, Geologic map of anthracite-bearing rocks in the Pottsville quadrangle, Schuylkill County, Pennsylvania: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–681, 2 plates, scale 1:12,000.

_____1973, Geologic map of the Pottsville quadrangle, Schuylkill County, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ–1028, 1 plate, scale 1:24,000.



STOP # 11:
COAL CREEK COMMERCE CENTER, ST. CLAIR
MAMMOTH (NO. 8) COALBED SEATROCK, LOWER LLEWELLYN/ POTTSVILLE STRATIGRAPHY, AND ST. CLAIR MINING HISTORY

STOP Leaders—Jon D. Inners, Robert J. Scherr, and Leonard J. Lentz

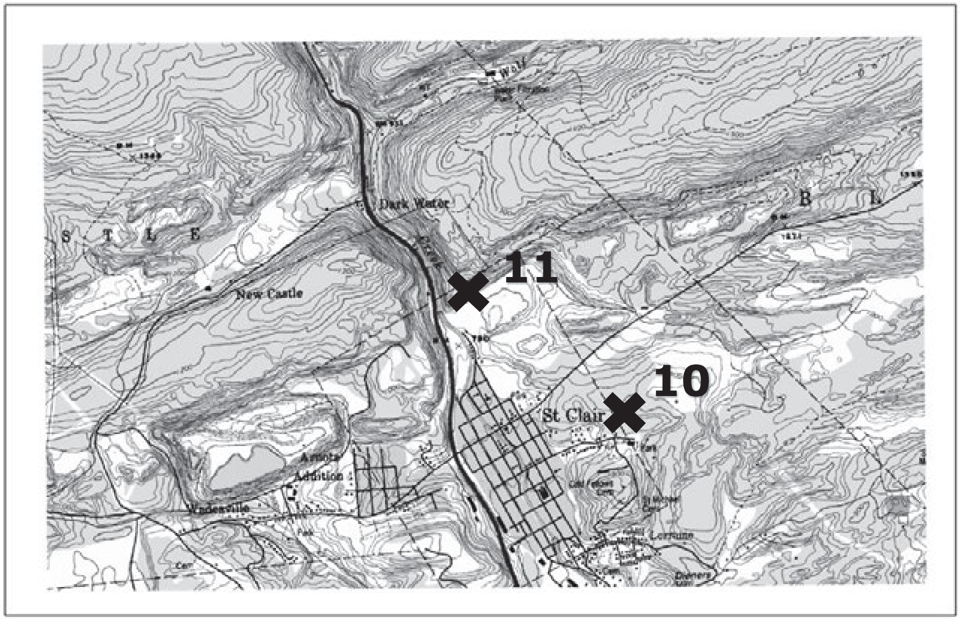


Figure 11-1. Location map of STOPS 10 (Lunch) and 11 (Pottsville 7 ½ quadrangle, 1995)

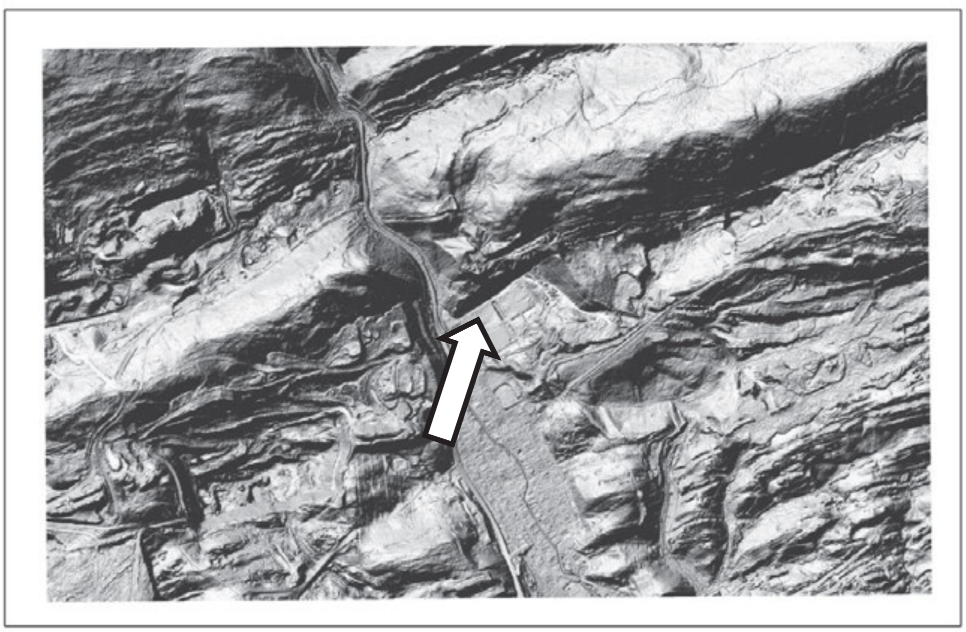


Figure 11-2. Lidar image of St. Clair area. Arrow points to Coal Creek Commerce Center.

Geology and Physiography

The borough of St. Clair is situated in the northern part of the complexly folded and faulted Minersville Synclinorium and is entirely underlain by the coal-bearing Middle to Late Pennsylvanian-age Llewellyn Formation. To the north and northeast the Mine Hill anticline—a west-plunging spur of the Broad Mountain anticlinorium—elevates the Early to Middle Pennsylvanian-age Pottsville Formation, as well as lower coal beds of the Llewellyn Formation (here non-productive) and separates the productive St. Clair-Wadesville tract from a narrow productive band extending from Dark Water on Mill Creek westward to New Castle and Coal Castle (the Heckscherville syncline). The most important Llewellyn coal beds mined in the St. Clair area are (in descending order) the Diamond (No. 14, Orchard (No.12), Primrose (No. 11), Holmes (No. 10), Mammoth Top, Middle, and Bottom Splits (Nos. 9, $8^{1/2}$,and 8), Skidmore (No. 7), and Buck Mountain (No. 8). Just south of St. Clair, the coals incline precipitously south into the basin, soon reaching uneconomical depths—a fact recognized as early as 1838 by H. D. Rogers of the First Pennsylvania Geological Survey (1836–58), but hotly contested for several decades by contemporary Pottsville boosters, such as Eli Bowen, Benjamin B. Bannon, and Samuel H. Daddow. (See Figures 11-1 through 11-4)

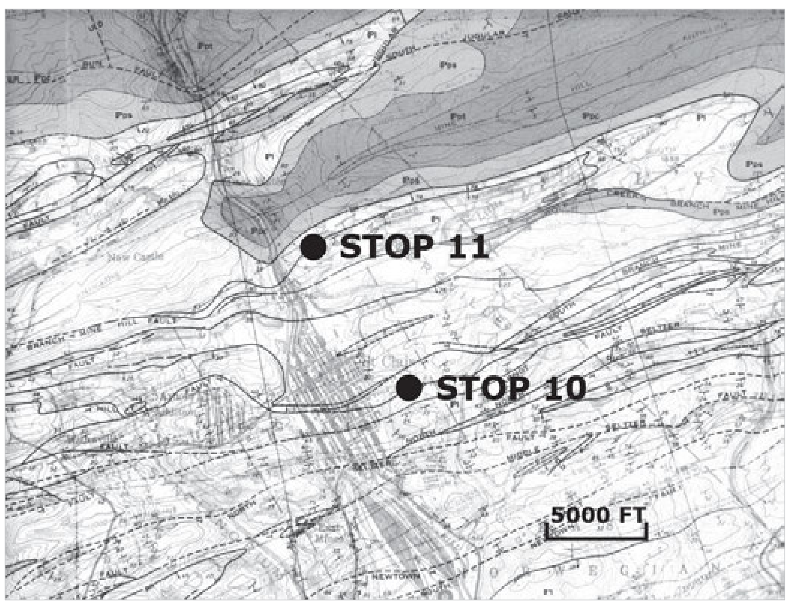


Figure 11-3. Geologic map in the vicinity of STOPS 11 and 10 (Lunch) (Wood, 1973).

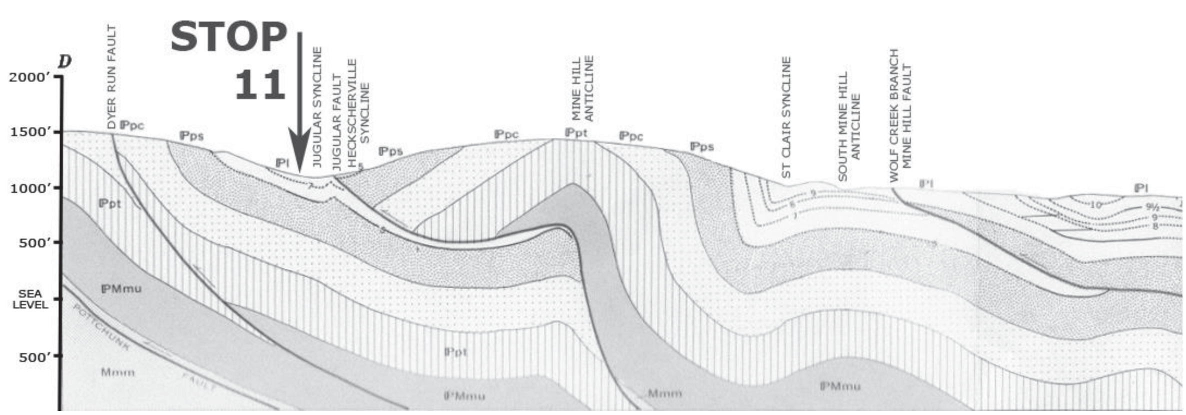


Figure 11-4. Geologic cross at STOP 11— Coal Creek Commerce Center (Wood, 1972)

The Coal Creek Commerce Center is situated at the north edge of the complexly folded and faulted Minersville synclinorium, which in the vicinity of Pottsville and St. Clair constitutes the entirety of the Southern Anthracite field, here about 5 miles wide (Wood, 1972, 1973). The entire synclinorium is underlain by the Upper Pennsylvanian Llewellyn Formation. Exposed for about a quarter mile along the north edge of the Commerce Center is the steeply dipping seatrock of the Mammoth Bottom Split (No. 8) coalbed (Walking Tour, **1**). About 400 feet north of the highwall along the old railroad grade (behind Dunkin' Donuts) is a water-level drift in the Buck Mountain (No. 5) coalbed (**3a**). Between the highwall and the drift is a partial stratigraphic section of the rocks between the drift and the highwall (**2**). Along the south side of the Commerce Center, exposures just south and southeast of Tractor Supply Co. exhibit gently folded beds in the lower Llewellyn Formation near the crest of the South Wolf Creek anticline. A coalbed exposed at the base of the cut directly south of Tractor Supply Co. exposes the Skidmore (No 7 coalbed ?) and an east-dipping, cross-cut thrust fault (Figures 11-5 and 11-6).

Figure 11-5. Gently folded beds in the lower Llewellyn Formation near the crest of the South Wolf Creek Anticline of Wood (1972), behind Tractor Supply Co. at the south end of the Coal Creek Commerce Center. A coalbed exposed at the base of the cut is probably the Skidmore (No.7).

Figure 11-6. East-dipping thrust fault at the west end of the folded beds behind Tractor Supply Co.

To the north of the Commerce Center is the unfaulted Mine Hill anticline, which plunges westward toward Mill Creek and the Pottsville Aggregates quarry (STOP 9). Mine Hill is underlain by the Pottsville Formation, the rock forming the core of the fold and underlying the high, central ridge being the Tumbling Run Member. The Schuylkill Member crops out and defines the anticline along the old railroad grade on the east side of Mill Creek (Walking Tour, **3c**).

Mining in St. Clair

(Modified from St. Clair Sesquicentennial Committee, 2000, p. 21-31; see also Wallace, 1987, p. 101-122.)

Anthracite was discovered in St. Clair in 1824. Outcrops of coal attracted some of the early miners. Many veins subsequently important in the Southern, Western Middle, and Eastern Middle fields were discovered and named in and around St. Clair, e.g. the Primrose, Holmes, Mammoth, Orchard, Seven-foot, and Skidmore. Lines of outcrop of the Primrose vein, named for the primroses that grew around the area, surfaced south of St. Clair. Several mine patches settled close by. Some of these were Mill Creek, Scalpington, East Mines, and Centreville. The vein was struck at 122 feet in 1830 and was about three feet thick.

To the north of St. Clair, the Mammoth vein outcropped at Mine Hill. Isaac Beck accidentally discovered this vein while washing his hands in Mill Creek in 1830. It was hit at 438 feet and was 22 feet thick. The Holmes vein was hit at 194½ feet and was 4½ . John Holmes was an Irishman who emigrated from Dublin around 1841. This vein is the next vein below the Primrose. Pinkerton and Company named the Orchard vein after Samuel Arnout's Apple Orchard where the vein was opened in 1850. John Pinkerton and Company also discovered the Skidmore and Buck Mountain veins while tunneling north through the Mammoth vein. These veins were the thinnest significant veins that ran under, generally being only ten to fourteen inches thick. The Seven-Foot vein was struck at 402 feet and was 8½ inches thick.

St. Clair was considered one of the principal coal towns of the Southern Anthracite field (Figure 11-7). Most of the land was owned by two large extended families from Philadelphia. They were the Carey Group and the Wetherill Group. Both families were interested in making money for their heirs and squeezed every penny from the operators, wanting their royalties paid promptly and in full. Over the years the groups would sell the land while retaining the mineral rights. Both groups sold their estates to the Philadelphia and Reading Coal and Iron Company in 1872. In the early mines, the miners paid a heavy price due to the greed of the owners and operators. Many of the operators ignored best mining practices and took shortcuts on such things as ventilation and timbering. This led to explosions, cave-ins, fires, and floods that killed and crippled many of the men who entered these mines. For years the owners rationalized the problems and disasters effecting the mines as caused by "the Careless Miner" and heedlessly kept producing anthracite to fuel the Industrial Revolution—and at the same time fatten their pockets.

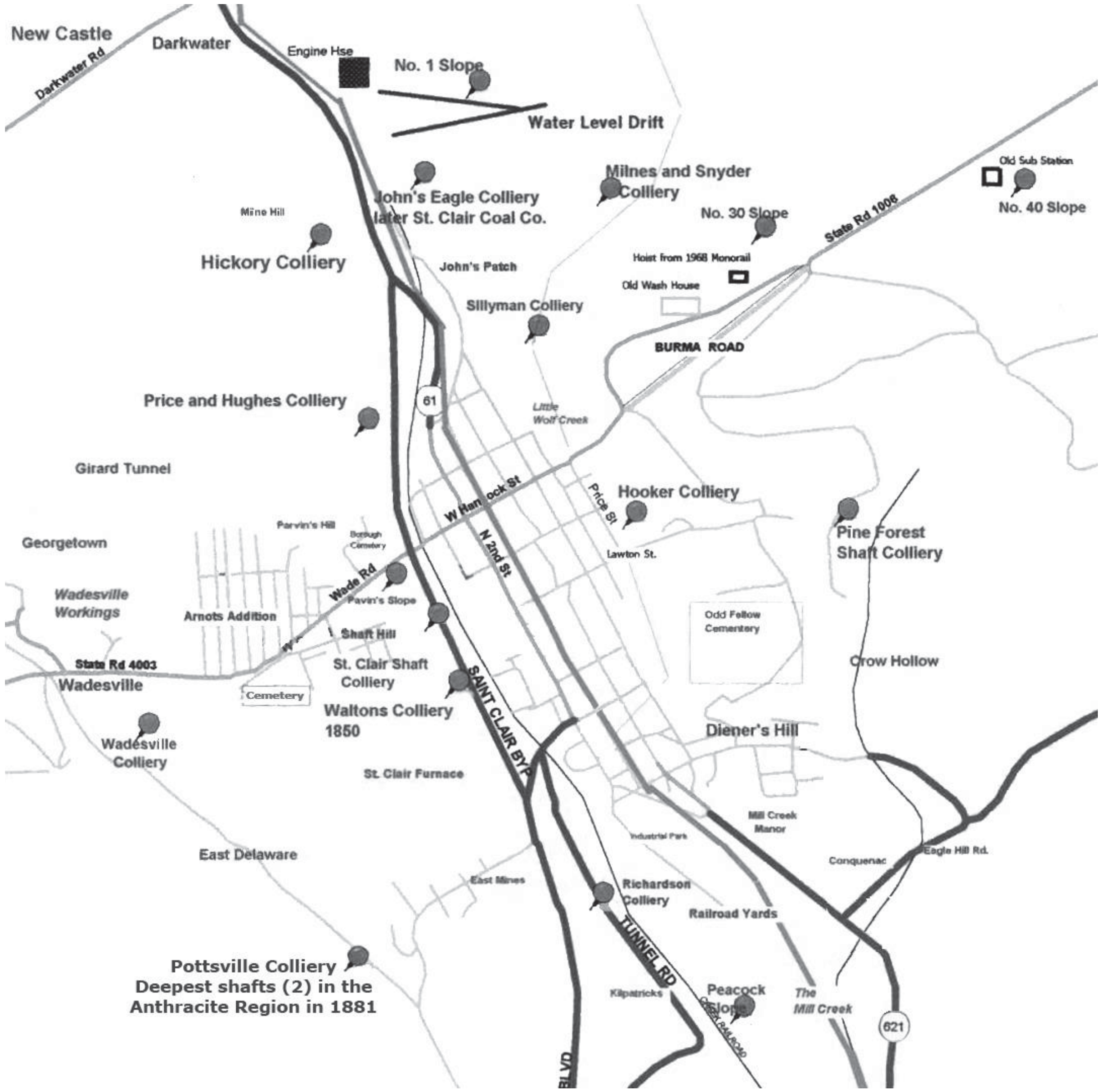


Figure 11-7. 19th-century deep mines in the St. Clair area

Collieries

Parvin's Colliery, opened by owner and operator Frank Nichols in 1825 on the Primrose vein, was the first colliery in St. Clair. This slope was located on Parvin's Hill, north of Wade Road on the west side of Mill Creek. Nicholas continued operation until 1829. Potts and Patterson worked the mine from 1829 to 1836. Joseph Lawton was in charge for the next ten years until 1846, when Frank Parvin and Company resumed operations. This slope slanted south from the outcrop and produced about 30,000 tons of coal per year. A fire damp explosion occurred in 1859 causing the mine to be flooded. Parvin and Company sold the mine to Andrew Russell, but after a few years the mine was abandoned in the early 1860's.

The second colliery was the ***Rainbow Colliery***, named for the color of the coal taken from this mine. This unusual color was due to its gaseous composition. The Rainbow colliery was located east of St. Clair at Crow Hollow. Ulrich and Schrader operated this colliery from 1826 to 1836. For the next four decades the mine continued to operate under a succession owners until Maurice and Rothermell abandoned it in 1868.

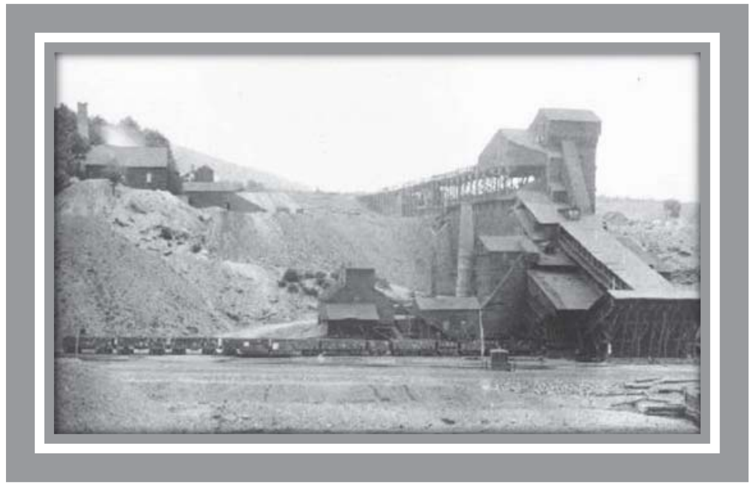


Figure 11-8. John's Eagle Colliery

The ***Eagle Colliery*** was located in the north end of St. Clair. It was constructed by Frank Hass in 1826 and operated until 1832. William and Thomas Johns began operations on Wetherill Lands in 1846. It then became known as ***Johns' Eagle Colliery*** (Figure 11-8) The first breaker was built in 1849 and continued in operation until it was replaced with a much larger one in 1857. This colliery had several fires. The first was in 1878; the big breaker burned on Decoration (Memorial) Day, allegedly by an arsonist. Within a few years, both the engine house and blacksmith shops were destroyed by fire. In fact, the breaker burned at least twice in 28 years. In 1872, when the Philadelphia and Reading Coal and Iron (P&RC&I) Company purchased the mineral rights, they renewed their lease and the Johns family continued operations until 1882. The P&RC&I Co. operated the mine from 1882 until the late 1880's or early '90's, after which the St. Clair Coal Company leased it.

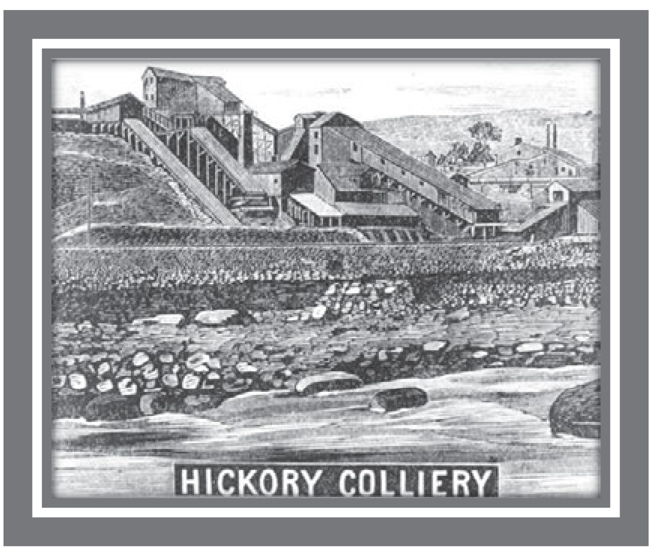


Figure 11-9. Hickory Colliery

The ***Hickory Colliery*** was located across Mill Creek from the Eagle Colliery and was operated by Beck and Woodside from 1828 to 1835 (Figure 11-9). John Pinkerton ran it from 1835 to 1844. He dug a tunnel north to an earlier drift making an air hole, and then continued west for about half a mile. This mine at its peak produced 10,000 tons per year. Benjamin and William Milnes purchased the mine from Pinkerton, sinking a new slope and continuing westward. By 1860 the mine was so large that it presented problems with ventilation. Also having problems with rotting timbers and cave-ins in the old workings, they sank a new slope—but in 1864 sold the operation to the Mammoth Vein Consolidated Coal Company. The company leased the land from the Wetherills, paying a royalty of 26 cents per ton. P. W. Shaefer (see Dodge, this Guidebook) was the directing engineer, and, in his opinion, the only way to save the colliery was to sink a vertical slope on the Mammoth at Wadesville. This was necessary because the timbers had been stolen from the Old Hickory workings. The colliery was abandoned in 1874.

West, Hudson, and Pinkerton opened the ***Pinkerton Tunnel Colliery***, located in the north end of town, in 1830. They operated it until 1841, after which John Pinkerton and Whitfield took over the operation from 1841 to 1853.

In 1845 Snyder and Haywood sank the ***Pine Forest Slope***. This colliery was to the east of St. Clair, where the patch of Crow Hollow grew up around it (see STOP 10). The colliery produced 15,000 tons per year and employed sixty men by 1850. After Haywood moved to California in 1857, Snyder sank a second slope and increased the tonnage to 100,000 tons. The operators needed to reach lower levels by 1860 and followed McGinness and Carey's example by sinking a vertical shaft in November 1866. As with many other collieries in the area, the ventilation presented a problem. After continually being plagued by gas, Snyder sold the colliery to the P&RC&I Co. in 1872. This brought about the use of the first Davy safety lamps. William Kendrick took charge for the "Coal and Iron," but despite his experience, the mine did not prosper and was abandoned in 1890. During its 24 years of operation, the shaft mine was productive for only 12 years and produced only 628,112 tons—far below the estimated capacity of 150,000 per year.

The ***St. Clair Slope and Shaft*** was built by Enoch McGinness in 1853 and 1854 to exploit the Mammoth vein. The slope was sunk first and then the vertical shaft—located at the end of Carroll Street beyond the railroad tracks, reaching several hundred feet to make lower coal accessible. This was of great importance, as it proved the 40-ft-thick white ash vein [Mammoth seam?] was at an easy accessible depth throughout the Broad Mountain range. His friends honored McGinness, for they believed he had opened a coalfield that would take generations to exhaust. The breaker was built in 1854 directly over the shaft. Pottsville inventor George Martz designed the hoisting system powered by a 40-horsepower engine designed by McGinness. This colliery mined underneath the entire town of St. Clair north of Lawton Street by the 1870's. The initial design of the mine, ventilation, bad workmanship, and flooding in the tunnel when it rained contributed to low and intermittent production. McGinness himself predicted 1,000 tons per day would be produced. However, the average tons per year was about 50,000. McGinness sold the mine to Kirk and Baum in July 1855. In August 1856 the breaker, along with most of the other buildings, burned and collapsed into the shaft. (A similar disaster at Avondale in the Northern Field in September 1869 killed 110 miners and led to first state-wide mine safety law and the prohibition of breakers being built over mine openings.) In 1860, Kirk and Baum gave up their lease. E. L. Hart worked the mine from 1862 to 1864. The St. Clair Coal Company of Boston took over the lease in July 1865. The breaker was again destroyed by fires, and by 1868 the mine was flooded and abandoned. A group of local operators started to refurbish and enlarge the shaft, but Carey gave up and sold the mine to the P&RC&I. Under the supervision of William Kendrick, the P&RC&I recognized the many problems of the mine and closed it in 1874.

The ***Hooker Colliery*** was located to east of Morris Street above Lawton Street. The Mount Hope Coal Company began operations in the early 1870's on the site known as the Jackson Colliery. They continued their operations until shortly after World War I.

A group of New York businessmen led by William H. Taylor and members of the Patterson family leased the former ***Herbine Colliery*** (originally the Eagle Colliery [see above]) in 1895, renaming it the ***St. Clair Coal Company***, Inc. (Figure 11-10). Mr. W. T. Smythe of Mahantongo Street in Pottsville came several years later and became general manager and superintendent. Coal was mined in several slopes near the colliery, which was located northeast of town. Slopes were also located on the Burma Road (SR 1006) and in Silver Creek. A drift was put in directly across from the breaker on the sight of the former Hickory Colliery. The veins encountered in the mine ranged from several inches thick to the 80-foot Mammoth vein.

The first fire that occurred under this ownership was on 4 August 1903. The machine shop was destroyed, causing $5,000 in damage. The shop was rebuilt and the colliery remained in operation. On St. Patrick's Day, 1911, a great fire destroyed the old wooden breaker. It was estimated at the time that $100,000 in damage was incurred. Reconstruction was started immediately, and a new breaker was erected. This was to be the fifth breaker on the site. At the time 1,050 men worked at the breaker, and they averaged $45.00 a month in pay. Harold M. Smythe, son of W. T. Smythe, took control of the St. Clair Coal Co., in 1933. He was president of the company until his death in 1956. He was well respected in the region, both by employees and contemporaries. He also served on the Anthracite Institute as a member of the board of directors in the 1940's.

1938 came and with it one of the worst disasters in St. Clair history. On 27 April, at approximately 7:30 in the morning, an explosion occurred 300 feet below the surface in the Buck Mountain No. 9 tunnel of the St. Clair Coal Co. Men working nearby sounded the alarm, and the rescue and subsequent recovery began. The entrance to No. 9 was blown shut, compelling the mine rescue team to carry the injured and dead through gangways a mile long to an emergency slope off the Mammoth vein. It was said that pillars under the gangway had crumbled and released gas from old workings, causing the explosion. Eight men were killed and eleven injured in this terrible disaster.

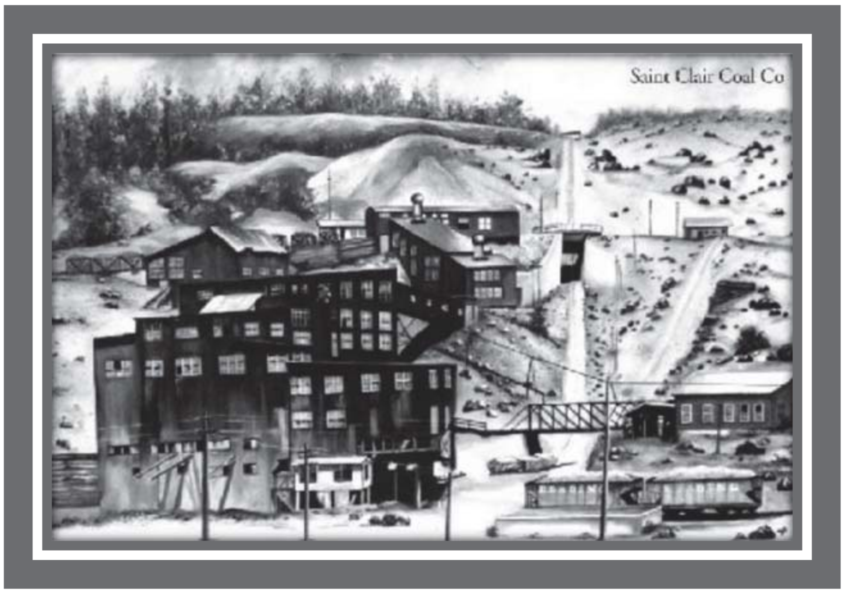


Figure 11-10. The St. Clair Coal Co. Colliery

The St. Clair Coal Co. employed 500 men with an annual payroll of $600,000 in 1938. The previous year 635,138 tons of coal were mined. An addition was added to the breaker in 1943. Wilmot Engineering Company of Hazleton constructed a new Hydrator plant. This increased plant feed capacity to 6,000 tons per 7-hour shift.

On 14 February 1948, two contract miners were killed on No. 30 slope near No. 10 tunnel north of Burma Road on the east side of St. Clair. They were caught under a heavy fall of top rock while working near a chute. Ironically, Nicholas Panko, age 53, survived the 1938 disaster sonly to be killed in this mishap. The St. Clair Coal Co. colliery was idled by a long strike lasting several months in 1949. The strike began over a firing of a contract miner for disciplinary reasons. Then all United Mine Workers of America (UMWA) miners east of the Mississippi went on strike. St. Clair miners returned to work on 30 September of that year.

When 1955 came it brought an end to an historic era. On 1 November the No. 30 and No. 40 slopes were closed. This was the first time in St. Clair's history that no deep mining was done.

Two hundred inside and 30 outside employees lost their jobs. The pump in the Pine Forest Shaft was kept running in hope of deep mining returning, but this never happened. The breaker and a strip-mining operation remained working. The colliery remained open for two years, with Mrs. Harold Smythe becoming president in 1956. On 12 September 1957 the P&RC&I denied renewal of the lease held by the St. Clair Coal Co. colliery. Pleas were heard from local clergy, businessmen, town officials and UMWA officials, but it was all to no avail. On 15 October 1957, the St. Clair Coal Co. closed its doors. Two hundred men lost their jobs. In 1956, the last full year of operation, 360,589 tons of coal were mined and processed at the breaker.

An independent operator reopened the No. 30 slope in 1968. An underground monorail, the first of its kind, was used to haul coal to the surface. This venture lasted only several years. Reading Anthracite (successor to the P&RC&I Co.) operated the Pine Forest stripping east of town until 1987 and continues to operate the Wadesville stripping. In 1999 Reading Anthracite leased the St. Clair Coal Co. tract between the borough and Mine Hill to Wal-Mart, with Coal Creek Commerce Center erected soon afterward.

Walking Tour of Significant Sites

1. Highwall of Mammoth Bottom Split (No. 8) coalbed.

The ~1/4-mile long highwall at the north edge of Commerce Center exposes the seatrock of the Mammoth Bottom Split (No. 8) coalbed), one of the major veins exploited in the old underground workings and in the later strippings here (Figure 11-11). On average, bedding strikes N65°E and dips 60°SE into the St. Clair syncline of Wood (1972, 1973). This is the same seatrock horizon that is so splendidly exposed on the south side of the Bear Valley stripping and over The Whaleback (STOP 5, this Guidebook). *Stigmaria* (lycopod roots) are abundant, and a few broken unidentified trunks are also evident (Figure 11-12). Unlike in the No. 8 seatrock exposed at Bear Valley, however, only a few weathered siderite concretions occur at the Commerce Center.

*Figure 11-11. Steeply inclined highwall exposing the seatrock of the Mammoth Bottom Split (No. 8) at **1**. On top of Mine Hill in the background are old culm banks of the St. Clair Coal Co. Colliery.*

The No. 8 seatrock exposed here is a silty, dark gray claystone. The *Stigmaria* are the in-place roots of the lycopods *Sigillaria* and *Lepidodendron*. (See Wnuk, 1988, for a discussion of the origin of seat-earth floras in the Anthracite fields.)

Figure 11-12. Stigmaria in the seatrock of the Mammoth Bottom Split (No. 8) coalbed at ***1***

2. Dunkin' Donuts stratigraphic section.

The construction cut at Dunkin' Donuts at the north end of the Commerce Center exposes 210 feet of rock section below the Mammoth Bottom Split (No. 8) coalbed, including four "coal" horizons—two of which probably represent the Seven-Foot (No. 6) and the Skidmore (No. 7) (Figure 11-13 and measured Lower Llewellyn section in Table 1).

About 60 percent of the rock exposed is sandstone, conglomeratic sandstone, and conglomerate. Bedding in the lower beds is generally relatively planar bedded, with abundant carbonized plant fossils in a massive, 20-foot thick bed near the base (unit 4). The upper 60 feet (units 25-31), below the 12-foot-thick Mammoth seatrock (unit 32), are conglomeratic and commonly current bedded. The 5-foot-thick Seven-Foot coalbed (unit 6) near the base would appear to be minable. The Skidmore (unit 11) is relatively thick, but shaly and bony. The other two horizons (units 14 and 23) are thin and bony. Attitude of bedding here is approximately N60°E/25°SE.

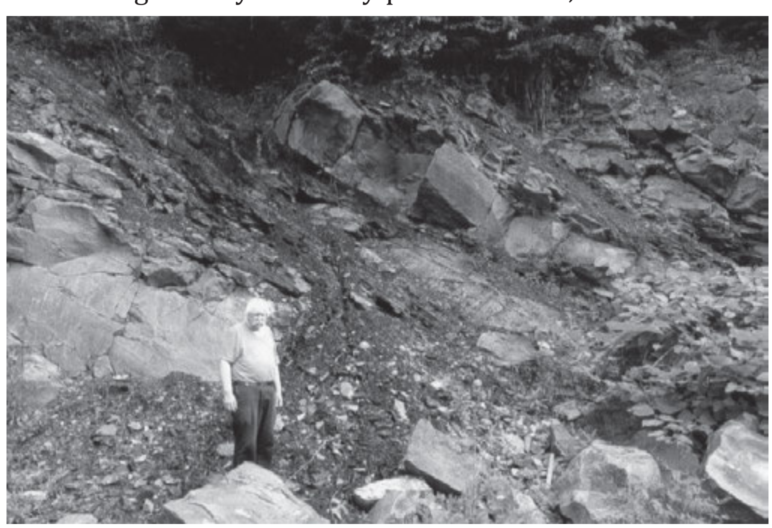


Figure 11-13. Lower beds of stratigraphic section exposed at ***2****. The coal bed in the Middle is probably the Seven-Foot (No. 6, unit 6 of measured section).*

TABLE 1

LOWER LLEWELLYN SECTION AT DUNKIN' DONUTS – COAL CREEK COMMERCE CENTER, ST. CLAIR, PA

33.	**Mammoth Bottom Split (No. 8) coalbed** (concealed)	
32.	Claystone, silty, dk gy, rootworked, especially in upper 5', *Stigmaria* common	12.0'
31.	Sandstone, fine to md grained, lt ol gy, rusty weathered	5.0'
30.	Qtz conglomerate, thick bedded, md dk gy to lt ol gy, rusty weathered	3.0'
29.	Qtz conglomerate, massive, md gy to md dk gy; pebbles to ½", mostly >1/4 in	4.0'
28.	Sandstone, md to thk bedded, coarse grained, md gy to md dk gy, rusty weathered, w/ bands of fine-pebbly qtz conglomerate to 6" thick	30.0'
27.	Qtz conglomerate, massive, rusty weathered; sharp contact at top	2.0'
26.	Sandstone, thick bedded, fine to md grained, md gy, poorly exposed at top	13.0'
25.	Qtz conglomerate, thk bedded, rusty weathered; pebbles to ½" mostly >1/4"	3.0'
24.	Shale, fissile, dk gy, rusty weathered	2.5'
23.	Bony coal, blk	1.0'
22.	Concealed interval	5.0'
21.	Sandstone, md bedded, fine to coarse grained, md dk gy, ol gy weathered, w/ some thin, fine pebbly beds; shaly at base, but poorly exposed	4.0'
20.	Concealed, rubbly interval	12.0'
19.	Sandstone, md bedded, current bedded, rusty weathered	10.0'
18.	Concealed interval	8.0'
17.	Sandstone, md bedded (2"-6"), current bedded, fine grained, md dk gy, rusty weathered	0.5'
16.	Concealed interval	6.0'
15.	Shale, fissile to platy, dk gy, rusty weathered; lower 0.5' hard and non-fissile	5.0'
14.	Bony coal. blk	0.5'
13.	Clay shale, fissile to splintery, md dk gy to gy blk; poorly exposed	4.0'
12.	Claystone, hard, dk gy, rootworked; poorly exposed	8.0'
11.	Shale and bony coal, blk, rootworked w/ plant fossils (pyrophyllite?); poorly exposed Horizon of **Skidmore (No. 7) coalbed** (?)	9.0'
10.	Sandstone, thk bedded to massive, fine grained, md gy to md dk gy, rusty weathered	5.0'
9.	Sandstone, thin to md bedded, fine grained, micaceous, md gy, ol gy and rusty weathered	3.5'
8.	Sandstone, thick bedded, md to coarse grained, lithic, md dk gy to dk gy, rusty weathered, rubbly; bd partings mostly ½" to 1"; probable channel	17.0'
7.	Shaly coal, dk gy to blk; upper part of underlying coalbed	1.2'
6.	Coal, thk bedded, blk; sheared at 2' intervals (shear planes at N30°W/47°SW) **Seven-Foot (No. 6) coalbed** (?)	5.0'
5.	Claystone, gy blk, rootworked; seatrock of No. 7 coalbed	1.7'
4.	Sandstone, massive, coarse grained, micaceous, lithic, md gy, rusty weathered; some intervals between in middle part w/ relatively even partings spaced 1-2" apart; carbonized plant fossils common.	20.0'
3.	Sandstone, md bedded, coarse grained, micaceous, lithic, md gy	5.0'
2.	Concealed interval	100.0±
1.	**Buck Mountain (No. 5) coalbed** (concealed at mine drift)	

3. Along the old Railroad Grade north of Dunkin' Donuts

(Note that permission to pass beyond the gate must be obtained from the Schuylkill County Municipal Authority, 221 S. Centre Street, Pottsville, PA, 570-622-8240)

North of the Llewellyn section at Dunkin' Donuts the old Reading Railroad grade extends north through the Mill Creek gap in Mine Hill and Broad Mountain. Built in the 1860's to ultimately connect with the Mahanoy Plane just northwest of Frackville, the Reading here became as important a transport route for anthracite as any in "The Region"—being one of the main reasons for the construction of the great St. Clair Railroad Yards that were completed south of the borough in 1913. We will walk north along the trail here to Darkwater (time permitting), observing several interesting features along the way.

a. Water-level drift on the Buck Mountain coalbed

Just beyond the gate on the right is a drift of the St. Clair Coal Co. on the Buck Mountain (No. 5) coalbed, probably dating from the early 1900's. The company's No. 1 Slope on the Buck is uphill and some distance east along the slope of Mine Hill (Figures 11-14 A, B & C).

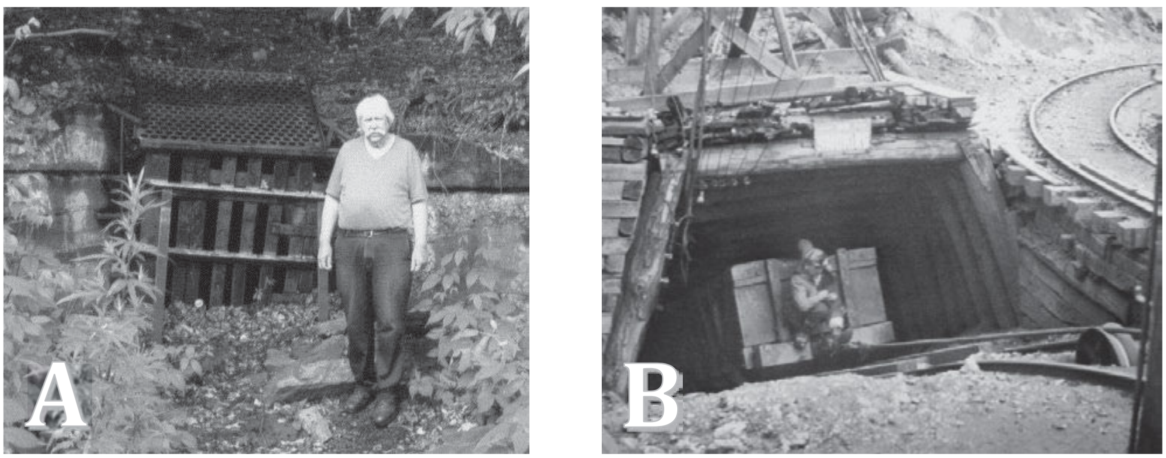
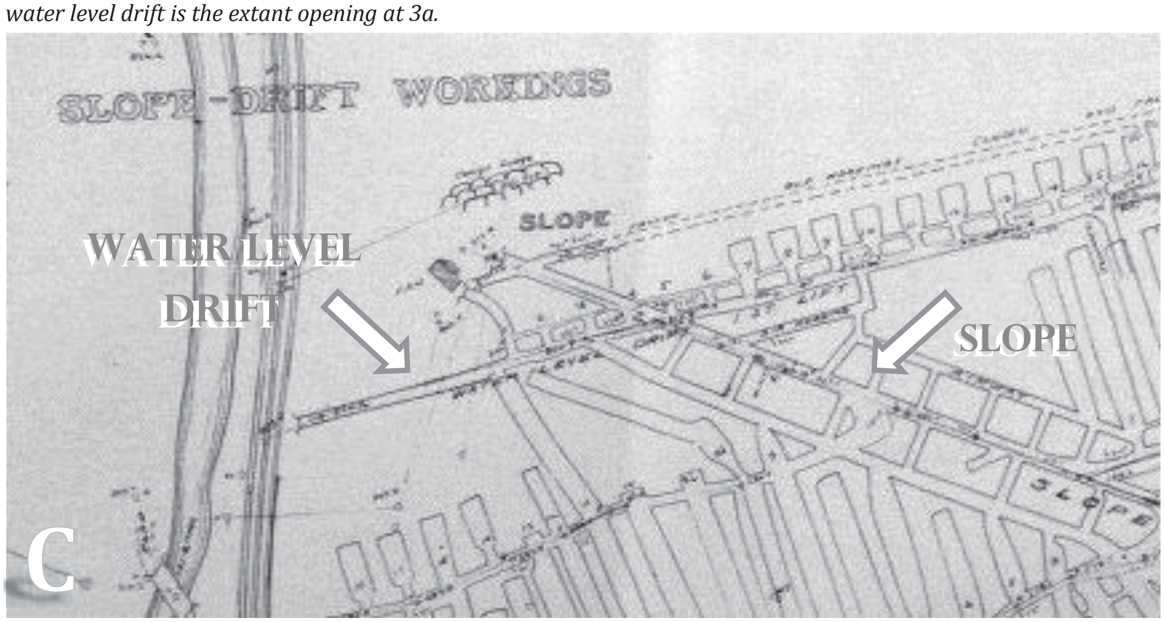


Figure 1114. A) Water-level drift on the Buck Mountain (No. 5) coal bed at 3a. B). No. 1 Slope in the Buck Mountain (No. 5) coalbed of the St. Clair Coal Co. C) Buck Mountain workings of the St. Clair Coal Co., November 1913. The water level drift is the extant opening at 3a.



b. Concrete engine-house ruins

High on the hillside west of the old railroad grade, about 275 feet north of the Buck Mountain drift, are the ruins of the concrete engine house for No. 1 slope of the St. Clair Coal Co. (Figure 11-15), constructed about 1900. This was about the time that concrete came into wide use in the Anthracite fields—highlighted by the building of the community of "Concrete City" at Nanticoke, Luzerne County, by the Delaware, Lackawanna, and Western Coal Company in 1911. The engine house operated until the closing of the mine in the 1950's.

*Figure 11-15. Ruins of the concrete engine house for the No. 1 slope of the St. Clair Coal Co. at **3**b.*

c. Pottsville conglomerate crags define the axial trace of the Mine Hill anticline

Farther up the trail, two prominent crags of gray conglomerate and sandstone, mapped as Schuylkill Member (Wood, 1973), define the west-plunging axis of the Mine Hill anticline. The southern crag dips about 21° south, and the northern on dips about 40° north. Between the two crags the slope is covered with large conglomerate boulders, and other ledges are visible higher on the slope, though mostly hidden in the trees.

d. Darkwater

At the north end of the traverse is a pump house of the Schuylkill County Water Authority. Prior to re-construction of PA 61 in the 1940's, the patch town of Darkwater was located in this vicinity. It was here in the late 1880's that the Pennsylvania Railroad built a high trestle (viaduct) that bridged the Mill Creek gorge (Figure 11-16), towering over the Reading track—wooden ties of which can still be seen along the old grade near the SCWA treatment plant. On the other side of the creek, just northwest of the intersection of Darkwater Road and PA 61, is a shaft of the old Repplier Colliery, now a pumping station and drainage pit (see Day-2 Roadlog, mile 10.9). Originally started as a drift mine far off to the west near the patch town of New Castle in about 1840, the Repplier (Figure 11-17) operated on and off into the 1950's—one of the last large deep mines to shut down.

Figure 11-16. The Pennsylvania Railroad trestle across the Mill Creek gorge at Darkwater (3d).

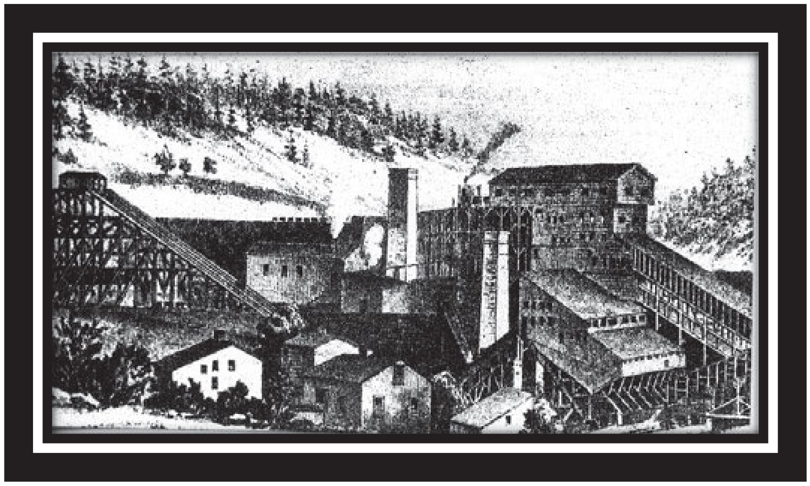


Figure 11-17. Repplier Colliery northwest of Darkwater in the 1800's. After the final closing of the colliery in the 1950's, the entire area was strip-mined (see Day-2 Roadlog, mile 10.9).

References

St. Clair Community and Historical Society, 2009, Around St. Clair: Charleston, SC, Arcadia Press, 127 p.

St. Clair Sesquicentennial Committee, 2000, St. Clair's our town sesquicentennial commemorative book, 132 p.

Wallace, A. F. C., 1987, St. Clair—a nineteenth-century coal town's experience with a disaster-prone industry: New York, Alfred A. Knopf, 519 p.

Wnuk, C., 1988, Carboniferous seat-earth floras in the Anthracite fields, in Inners, J. D., editor, Bedrock and glacial geology of the North Branch Susquehanna lowland and the Eastern Middle Anthracite field, northeastern Pennsylvania: Guidebook, 53rd Annual Field Conference of Pennsylvania Geologists, Hazleton, PA, p. 56-62.

Wood, G. H., Jr., 1972, Geologic map of anthracite-bearing rocks in the Pottsville quadrangle, Schuylkill County, Pennsylvania: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-681, 2 plates (scale 1:12,000).

Wood, G. H., Jr., 1973, Geologic map of the Pottsville quadrangle, Schuylkill County, Pennsylvania: U.S. Geological Survey Geologic Quadrangle Map GQ-1028 (scale 1:24,000).

STOP #12: PINE FOREST SHAFT, ST. CLAIR

Stop Leaders – Jeri L. Jones, Jones Geological Services, and
William E. Kochanov, Pennsylvania Geological Survey

THE SITE IS PRIVATE PROPERTY AND CAN ONLY BE ACCESSED WITH PERMISSION FROM READING ANTHRACITE COAL COMPANY

The site is located 0.34 mile east-southeast of Burma Road (SR 1006) or 0.5 mile west of the intersection of Tucker Hill Road (SR 527) and Silver Creek Road (SR 166) approximately 2.87 miles northeast of St. Clair. Coordinates 40.73843889, -76.14155556 (Figure 12-1).

There is a small pull off area on the east side of Burma Road approximately 0.2 mile northeast of the “shooting range” also on the east side of the road (note: the shooting range contains the same fossils found at the main site but collecting is discouraged here for obvious reasons). Access to the property is by following an unimproved road east off of Burma Road to the clearing. Outcrops are found along strike of the pit from the west edge eastward for about 120 feet. Elevation of the site is approximately 1383 feet.

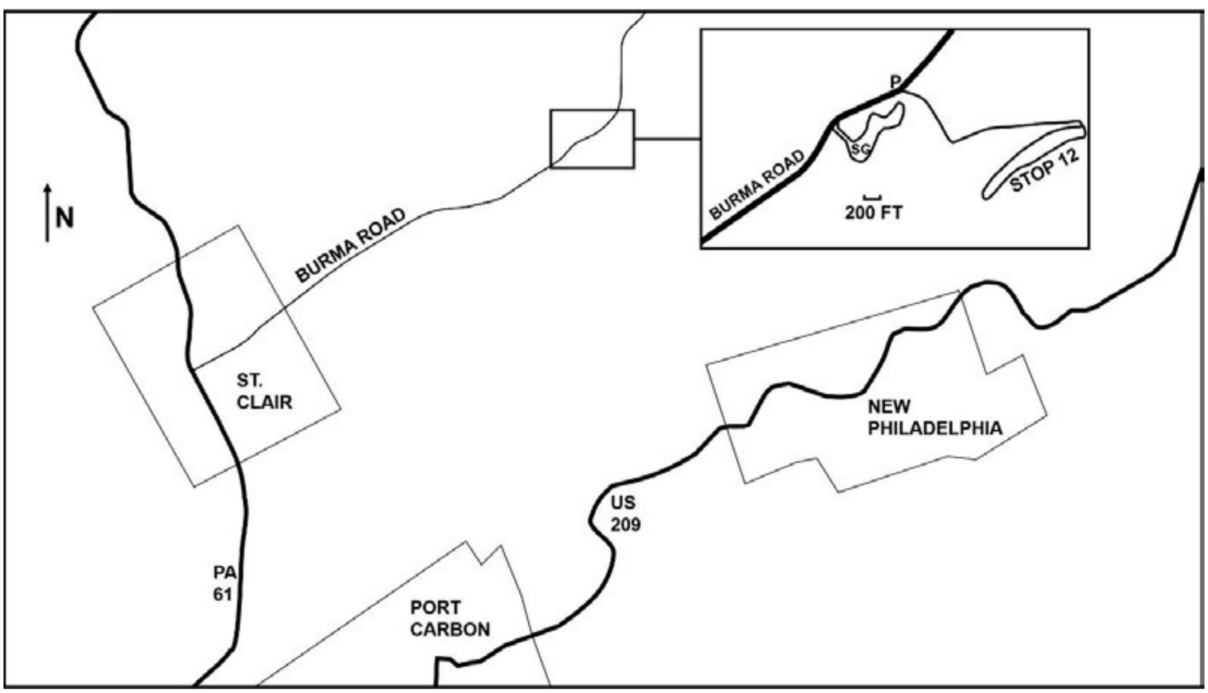


Figure 12-1. Location map for Stop 12. Pottsville, 7.5-minute quadrangle; north is up.

Introduction

Stop 12 has been included with several field trips within the Anthracite region primarily due to the unique occurrence of the St. Clair flora (e.g., Sevon and others, 1982; Inners, 1988; Levine and Eggleston, 1992; Pfefferkorn and others, 2006). The most thorough discussion comes from

Sevon and others (1982) where Inners and Smith (p. 16-22), discuss the regional stratigraphic and geologic setting as well as the mineralogical occurrence of the white pyrophyllite coating on the fossil flora. Much of the general background material for this stop is taken from their entry.

Stratigraphy and Geology

The site is representative of fossil plants associated with the Buck Mountain (No. 5) coal seam, the regional stratigraphic marker between the Llewellyn and underlying Pottsville Formations, Late Middle Pennsylvanian (Figure 12-2).

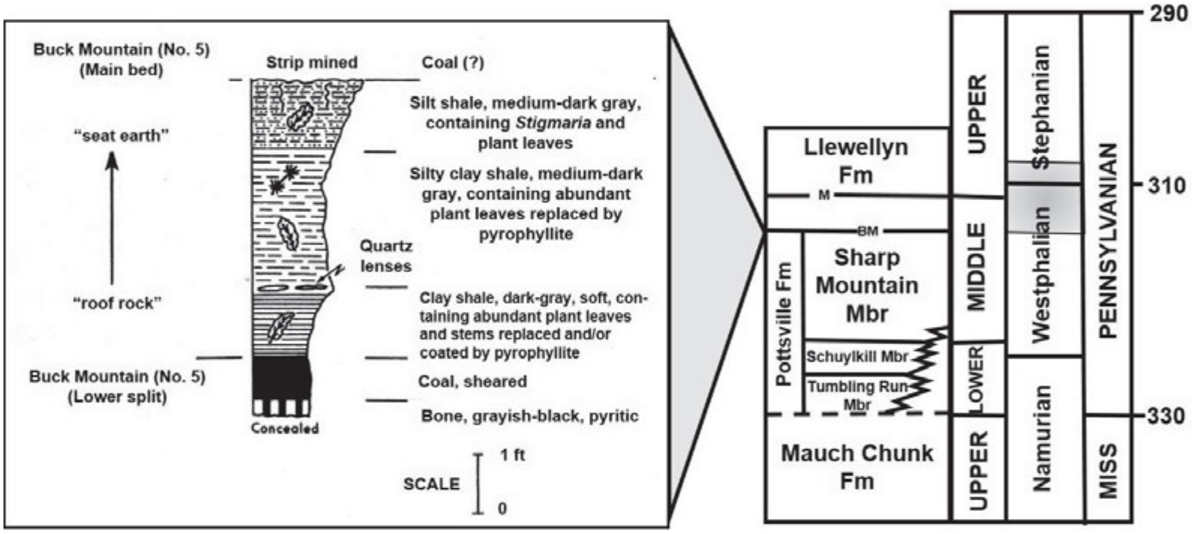


Figure 12-2. Stratigraphic section for the St. Clair fossil site modified from Sevon and others (1982), Berg and others (1983), and Edmunds, (1996). Note stratigraphic position of the Buck Mountain (BM) and Mammoth (M) coal seams and the biostratigraphic range for the Buck Mountain flora (shaded).

The fossil-bearing zones are the "roof rock" of a thin, un-mined lower split of the Buck Mountain coal seam and the "seat rock" of the main coal bed, which has been stripped away over a wide area. The contact between the Llewellyn Formation and the Sharp Mountain Member of the Pottsville Formation likely occurs only a few feet below the lower coal split (Sevon and others, 1982).

The site exposes a portion of the eastern limb of the South Mine Hill anticline. This anticline plunges toward the southwest and extends northeastward to the St. Clair-Mahoney City Road. The exposed shale and siltstone strikes approximately N80° E and with dips 12-15° to the southeast (Wood, 1973). The light gray conglomerate and conglomeratic sandstone boulders that are found in the woods to the north and in the "claimed" area of the mine to the east are derived from the Sharp Mountain Member in the core of the South Mine Hill anticline.

Roughly 300 feet south, a splay from the Wolf Creek branch of the South Mine Hill fault separates the Buck Mountain from the Skidmore (No. 7) and Mammoth Bottom Split (No. 8) coals. Approximately 0.3 mile to the east and northeast the two latter coals, as well as the Mammoth Middle Split (No. 8.5) and Top Split (No. 9), are part of an intricate maze of thrust faults and folds (Sevon and others, 1982).

A geologic map of the St. Clair area is shown in Figure 12-3.

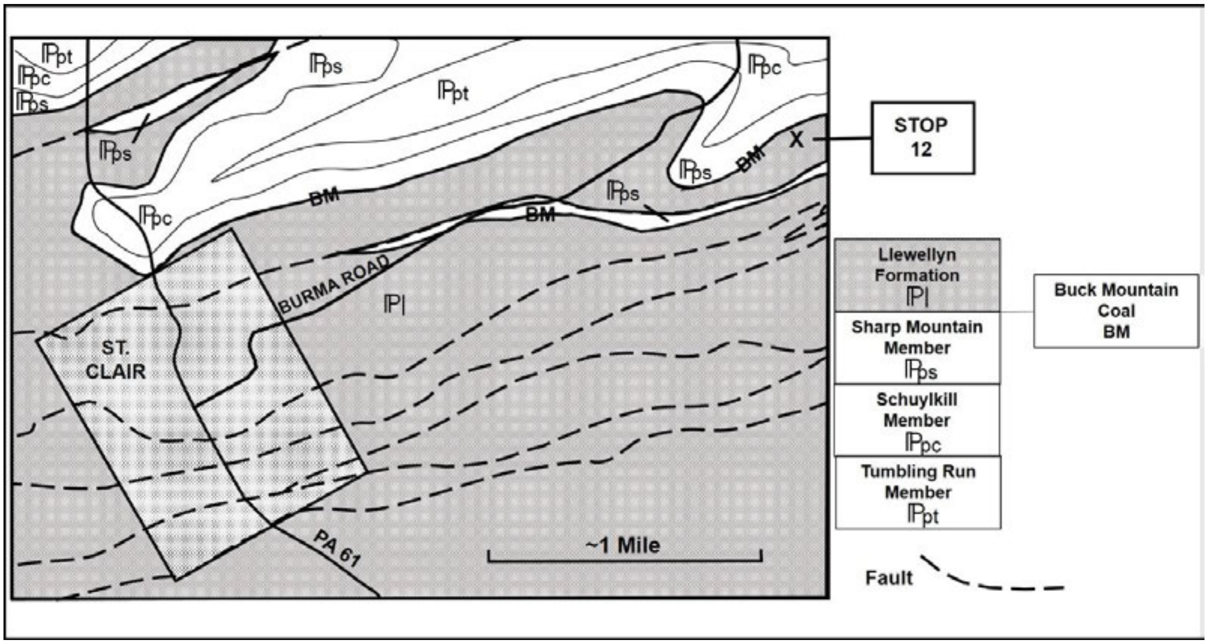


Figure 12-3. Geologic map of the St. Clair fossil site. Adapted from Wood (1973).

Paleontology

Fossil plants indicate two different environments. Some, like the seed plants (conifers and *Cordaites*) indicated an upland environment. The uplands had more erosion than deposition so plant fossils from this environment are rarer in the fossil record. In contrast, the second environment was the mud swamps, an area frequently flooded bringing with it silts and muds, burying the plants and plant debris. The Sphenopsids (such as *Calamites*) and pteridosperms (e.g., *Alethopteris, Nueropteris*) formed in this environment. This stop is an example of a mud swamp.

During global warming events and fluctuation of sea level, these environments would have been more ephemeral, shifting positions locally through larger-scale changes globally. Such fluctuations would have prevalent throughout the early Carboniferous into the Permian from episodic polar glacial periods (Gestaldo and others, 1997) and Alleghanian tectonic activity. The wet mud swamp of pteridosperms and Sphenosids is replaced by the drier peat swamp of the *Lepidodendron*.

It was once believed that these plants reflected the majority of plant life in diversity. Today, most paleobotanists think the coal measure plants are anachronistic – they represent primitive plants that have held on in their swampy realm because the climatic conditions were relatively more stable. With the rapidly changing environment in the uplands, flora was abundant, but the uplands did not produce many fossils (Phillips and Rose, 2001).

Our location is geologically unique. The fossiliferous rocks are both “seat” rocks and roof shales, depending upon how you look at the stratigraphic profile. Roof shale floras have been a major source of data for understanding Carboniferous vegetation. Gastaldo and others (1995) propose three levels at which preservation of plant parts can be viewed: 1) early taphonomic processes and earliest diagenesis can destroy or preserve plant parts in a given clastic depositional setting; 2) those plant parts that are preserved can be autochthonous, parautochthonous, or allochthonous in relationship to their original place of growth; 3) with respect to a peat layer (coal bed), the overlying clastic material can be deposited in a continuous transition, after a short temporal break (discontinuity), or after a significant hiatus of time.

In general, there are two broad groups associated with roof-shale floras. First, there are those that represent the final vegetation of the forest that formed the underlying peat (autochtonous or parautochthonous). Secondly, there are those from lowland habitats that were deposited in the same site after the cessation of peat formation. The former is a geologically instantaneous picture of the forest that has undergone either catastrophic burial, or death from edaphic stress (bad soil) followed by slow burial. Through clastic deposition, the final peat-swamp forest may be gradually replaced by clastic swamps resulting in a succession of autochthonous clastic-swamp accumulations in the shale above the coal bed (Gastaldo and others (1995).

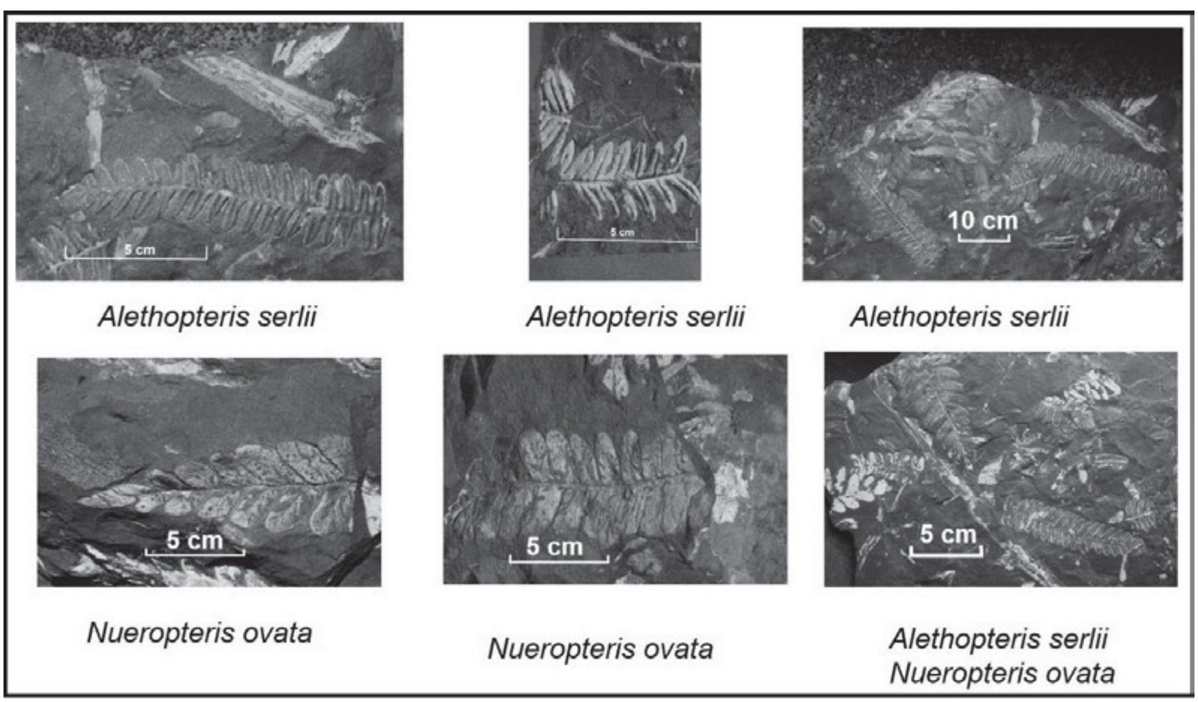
At the site….

David White (1900) collected fossil plants from the Pottsville Formation in the Southern Anthracite field at 41 localities and from the roof of the coal forming the dividing line between the Pottsville formation and the overlying "Productive Coal Measures." His Group 5 includes flora from the Buck Mountain coal (correlative Twin coal) at the "Pottsville Gap." He described the flora in the roof of the Buck Mountain coal as a "typical Coal Measures flora" very distinct from the floras typical of the Pottsville formation; although a few of its species do manage to creep into the upper parts of the overlying Llewellyn Formation. He bases the stratigraphic position as being slightly later than that of the basal beds of the ''Lower Coal Measures" in the Northern Anthracite field or of the Allegheny series in the northern bituminous basins.

Various regional studies make reference to the Buck Mountain flora in a stratigraphic context, linking the coal horizon to the Lower Kittanning of western Pennsylvania in what appears to be a case of following White's and Oleksyshyn's (1982) paleobotanical summaries (Read, 1954; Wood and others (1956), Eggleston and others (1988), Wagner and Lyons (1997)**,** Sevon and others (1982), Read and Mamay (1964); Edmunds, 1996).

More than 80 fossil plant species, as well as several arthropods, have been identified from the St. Clair fossil site. **Table 12-1** lists the more common and diagnostic genera and species, with photos of the two most prevalent at the site shown in **Plate 12-1** below:

Plate 12-1. Images of the two most common plant fossils at St. Clair, Stop 12.



The plant species are assigned to genera that include large stems and trunks (*Lepidodendon*, *Sigillaria* and *Calamites*); roots (*Stigmaria*), cones (*Macrostachya*); seeds (*Rhasbdocarpus* and *Trigonocarpus*); and leaves (*Asterophyllites*, *Annularia*, *Sphenophyllum, Pecopteris. Sphenopteris, Eusphenopteris, Mariopteris, Alethopteris* and *Neuropteris*). These are all typical members of the Middle Pennsylvanian coal swamp floras (Sevon, 1982; Phillips and Rose, 2001). Arthropod remains include wings of cockroaches (*Blatteria*), "ancestral" crickets (*Caloneurodea*) and "ancestral" dragonflies (*Protodonata*). Occasional specimens of legs and pleural segments of the long-bodied fresh-water trilobitomorph *Arthropleura* have also been reported (Sevon, 1982).

Table 12-1. List of fossil flora identified from the St. Clair fossil site (from Phillips and Rose, 2001).

Division: Lepidophyta	Division: Pteridophyta
Class: Lyncopsida	Class: Pteropsida
Order: Lepidodendrales	Order: Filicales
Lepidodendron lanceolatum	*Pecopteris arborescens*
Lepidostrobophyllum ovatifolium	*Pecopteris cyathea*
Sigillaria cf. elongate	*Pecopteris hemitelioides*
Stigmaria ficoides	*Pecopteris miltoni*
	Pecopteris unita
Division: Arthrophyta	Division: Pteridospermophyta
Class: Sphenopsida	Subdivision: Gymnospermae
Order: Calamitales	Order: Pteridospermales
Asterophyllites equisetiformis	*Sphenopteris missouriensis*
Asterophyllites longifolius	*Sphenopteris macilenta*
Annularia mucronata	*Sphenopteris spiniformis*
Annularia stellata	*Eusphenopteris nummularia*
	forma nummularia
	Mariopteris cf. inflata
	Mariopteris cf. lobata
Order: Sphenophyllales	*Diplothmema cheathasmi*
	Alethopteris decurrens
Sphenophyllum cuneifolium	*Alethopteris friedelli*
Sphenophyllum emarginatum	*Alethopteris lonchitica*
Sphenophyllum longifolium	***Alethopteris serlii***
Sphenophyllum majus	*Alethopteris sullivantii*
Sphenophyllum oblongifolium	*Neuropteris heterophylla*
Sphenophyllum verticillatum	*Neuropteris macrophylla*
	Neuropteris oblique
	Neuropteris ovata, forma typical
	Neuropteris ovata, forma flexuosia
	Neuropteris scheuchzeri
	Neuropteris tenuifolia
	Odobtopteris subcuneata

Discussion

Along with the Mazon Creek flora in Illinois, the St. Clair site has become a standard for collections worldwide of Pennsylvanian-age plant fossils. With its coating of the clay mineral pyrophyllite, the whitened fossils stand out in marked contrast with the dark-gray shaly background, providing an added aesthetic appeal to fossil specimens.

The first reported occurrence of pyrophyllite-coated flora is from Genth (1879). He analyzed specimens collected by Mr. Eli S. Reinhold finding "the purest specimens having a white to yellowish-white color, and a lustre between silky and pearly…the fibrous particles showing a somewhat laminated structure." He adds that the pyrophyllite bed (of the Buck Mountain) "is usually found in horizontal seams, parallel with the coal beds…it has not been found in any of the other beds of the same mine, and only this mine has furnished it…although the bed in which it occurs is worked in other mines."

However, in the opening paragraph, Genth begins, "One of the most interesting varieties of pyrophyllite is that from the coal slates of the "North Mahanoy Colliery" (old Silliman Colliery) near Mahanoy City, Schuylkill County, Pa." Research of the North Mahanoy Colliery places it just north of Mahanoy City along Mahanoy Creek (Thompson, 1899), approximately 5 miles NNE of Stop 12.

And with the final nail, Genth (1879) states, "This occurrence of pyrophyllite in coal slates and as the petrifying material of coal plants is exceedingly interesting, and I believe it to be <u>the first time that it has thus been observed.</u>" Apparently, it seems that the white pyrophyllite coating of the Buck Mountain flora had its "roots" outside of Mahanoy City courtesy of the North Mahanoy Colliery, Mr. Eli Reinhold, and Frederick Genth. The North Mahanoy Colliery by the way, mined the Buck Mountain coal (Abandoned Mine Research, Inc., 2013).

A review of the early fossil plant descriptions by Lesquereux (1858, 1880, and 1884) and White (1900) describe plant fossil sites just to the south of Stop 12 (approximately 0.5 miles) near New Philadelphia and Silver Creek but they are not in reference to the Buck Mountain coal horizon. White's (1900) collection of flora from the Buck Mountain horizon at the "Pottsville Gap" does not make any reference to the unique mineral preservation.

In Wood (1860) 30 new species were described; one locality being St. Clair. Specimen *Solenoula nobis* is listed as being from the Milnes Mine, St. Clair, but its position is with the Mammoth seam not Buck Mountain (p. 238).

The site at stop 12 was being mined during 1938 as determined by aerial imagery from that period (Figure 12-4) so it may be that the locality for what is now known as the St. Clair site, simply had not been exploited by White (or other researchers) prior to that time (David White died in 1935).

Darrah (1969), in tracking down plant fossil localities obtained from David White's collections, states that he (Darrah) collected specimens associated with the Buck Mountain from a locality "… at the east end of the old strippings 2.5 miles east of St. Clair." With a bit of inference, this just about matches the Stop 12 location, however, this is somewhat speculative as "east" is relative and there had been other seams mined in the vicinity. Unpublished records coming from amateur fossil enthusiasts, recall having visited and collected at the St. Clair site proper during the 1950's (Joe Dague, pers. comm.).

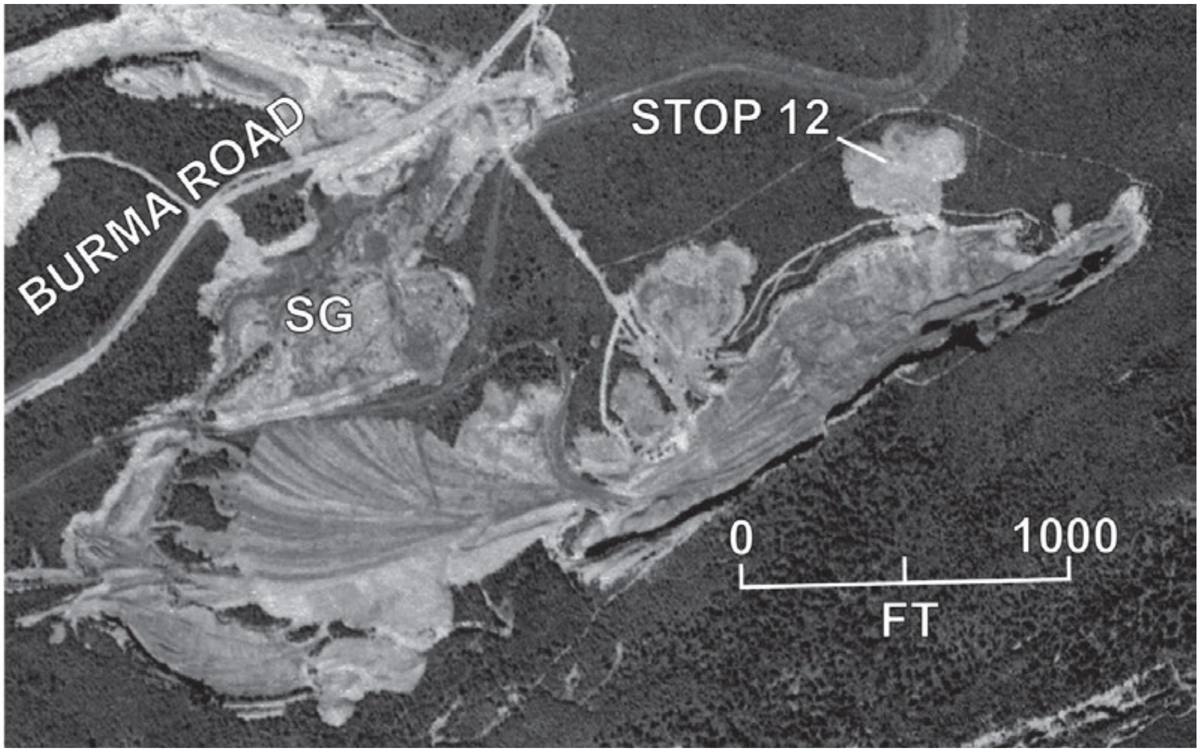


Figure 12-4. Aerial image of the St. Clair site from 1938. Image enlarged from original 1:20,000 scale. SG= shooting gallery. North is up. Photo AQS-26-113 obtained online from Penn Pilot, http://data.cei.psu.edu/pennpilot/).

Time and Time Again

Darrah (1969) referred the Buck Mountain coal bed (No. 5 of Wood et al, 1962) to the Westphalian D based on work by Oleksyshyn (1982), but he goes on to point out that due to the reported presence of *Sphenophtllum oblongifolium* (from Oleksyshyn), would make it basal Stephanian (Cantabrian); also the presence of *Alethopteris grandinioides* var. *subzeeilleri* also tends to suggest basal Cantabrian, whereas *Pecopteris monyi* and *Pecopteris nyranensis* would confirm either Westphalian D or lower Cantabrian. Ultimately, the Buck Mountain flora of Oleksyshyn (1982) contains elements of both Westphalian D and the overlying lower Spephanian. Oleksyshyn also compares the Buck Mountain with the Lower Kittanning horizon of western Pennsylvania.

A Bit on Pyrophyllite

Pyrophyllite is a hydrous aluminum silicate; chemically bearing a close resemblance to other clay minerals such as dickite and kaolinite.

Hosterman and others (1970) identified pyrophyllite in 24 of 76 samples taken from the underclays of various coals throughout the anthracite region. They found pyrophyllite to more prevalent in the Southern and the two Middle Fields than in the Northern Field and that the distribution of samples indicated that the pyrophyllite is concentrated in the upper part of the Pottsville and lower part of the Llewellyn.

Analyses of the pyrophyllite coating by Myer and others (1977) concluded that the growth of the pyrophyllite was controlled by the leaf structure; the entire leaf is generally preserved as pyrophyllite, the cuticle, and veins are occasionally preserved as graphite. Myer and others (1977) also suggest that the plant remains were first replaced by pyrite, which was then later replaced by pyrophyllite at higher temperatures and pressure. Woody structures such as the veins which resisted replacement by the initial low temperature phase were converted to graphite at that time.

Genth (1879) also made some interesting observations regarding the relationship between pyrite and pyrophyllite. He describes the occurrence in large cracks seeming to have crystallized "…from above and below…and that the two seams (of pyrophyllite)…are mostly separated by a thin layer of pyrite in minute crystalline masses, which leaves the impressions of their crystals upon the pyrophyllite…" - meaning that the pyrite came after the pyrophyllite. He goes on to state, however, that "…the fibrous pyrophyllite, as well as the pyrite, are coated with a very thin layer, not thicker than the finest tissue paper, of a scaly variety of pyrophyllite of an almost silver-white color" -inferring that the pyrophyllite came after the pyrite. It sounds as if the pyrophyllite/pyrite interaction went back and forth. This is corroborative with Myers and others (1977), at least in part, where they suggest the plant remains may have initially been replaced with pyrite then later by the pyrophyllite.

The pyrophyllitic coating has been observed at other localities in the anthracite fields. It has been observed in abandoned surface mines just southeast of Eckley Miner's Village near Hazleton and in an abandoned mine just north of Ashland (Kochanov and Inners, pers. observ.).

Analyses of selected coals and shale from the anthracite region by Daniels and Altaner (1990) interpreted the minerals to be formed in several stages of hydrothermal alteration, as evidenced by the presence of higher temperature clay minerals in the series soudite-tosudite-rectorite. Figure 5 shows the range of occurrence for some selected clay minerals and their temperatures. Pyrophyllite and tosudite would begin forming in the 200 C° range and higher (Ruiz-Cruz, 2007); kaolinite and dickite at lower temperatures. The transition of kaolin mineral to pyrophyllite approximately marks the transition from diagenesis to metamorphism (Ruiz-Cruz, 2007).

In a study of mineral matter content of anthracite coals, Spackman and Moses (1961,p. 10) also correlated pyrophyllite with the Buck Mountain and Seven Foot seams (the Seven Foot is the next seam lying stratigraphically above the Buck Mountain).

The bracketing of pyrophyllite at this particular stratigraphic level bears some parallels to the occurrence of another uncommon mineral, tosudite.

The presence of the clay mineral tosudite (Smith, 1982; Smith and Barnes, 1988) found within the basal Pottsville of the Eastern Middle Anthracite Field as well as interstitially within the Pottsville Sharp Mountain conglomerates and basal Llewellyn in the Northern Anthracite Field (Kochanov, 2012) adds another coincidental occurrence of a unique mineral species during this time-stratigraphic interval. Note its range of occurrence in Figure 12-5.

Harrison and others (2004) concluded that through field observations, illite-crystallinity studies and fluid-inclusion analysis indicate that coal-bearing Pottsville and Llewellyn Formations and the underlying Pottchunk Fault acted as a regional aquifer for the migration of hot fluids during the Alleghanian Orogeny. The presence of quartz veins, tosudite and pyrophyllite in the strata, among other indicators, suggest the migration of fluids though the sandstones and abundant fractures that developed in response to the Alleghanian Orogeny. The fluids achieved a minimum temperature of 270° C. at a depth of ~3.1-8.5 km. Anthracitization was likely the result of stratigraphically controlled hot fluid through the coal-bearing horizons at shallow depths equal to or less than 5 km.

One can presume a regional temperature gradient during the Alleghanian orogeny contributing towards the formation of specific clay minerals such as dickite and kaolinite. Amplification of temperatures by localized folding and faulting may have altered allochthonous clays that were deposited in the St. Clair swamps (and elsewhere) to pyrophyllite, emplacing them specifically along the Sharp Mountain/Lower Llewellyn timeline.

An interesting aside comes from western Pennsylvania in the form of euhedral zircons and biotite crystals from the Pine Creek marine horizon (Lower Stephanian), which suggest ash fallout from volcanic activity (Harper, 2000). It is plausible that the volcanic fallout, concurrent with tectonic activity, was widespread in distribution, suggesting that these minerals could also be found along similar timelines within the anthracite fields and perhaps introducing a unique "clayseed" along the Pottsville/Llewellyn timeline.

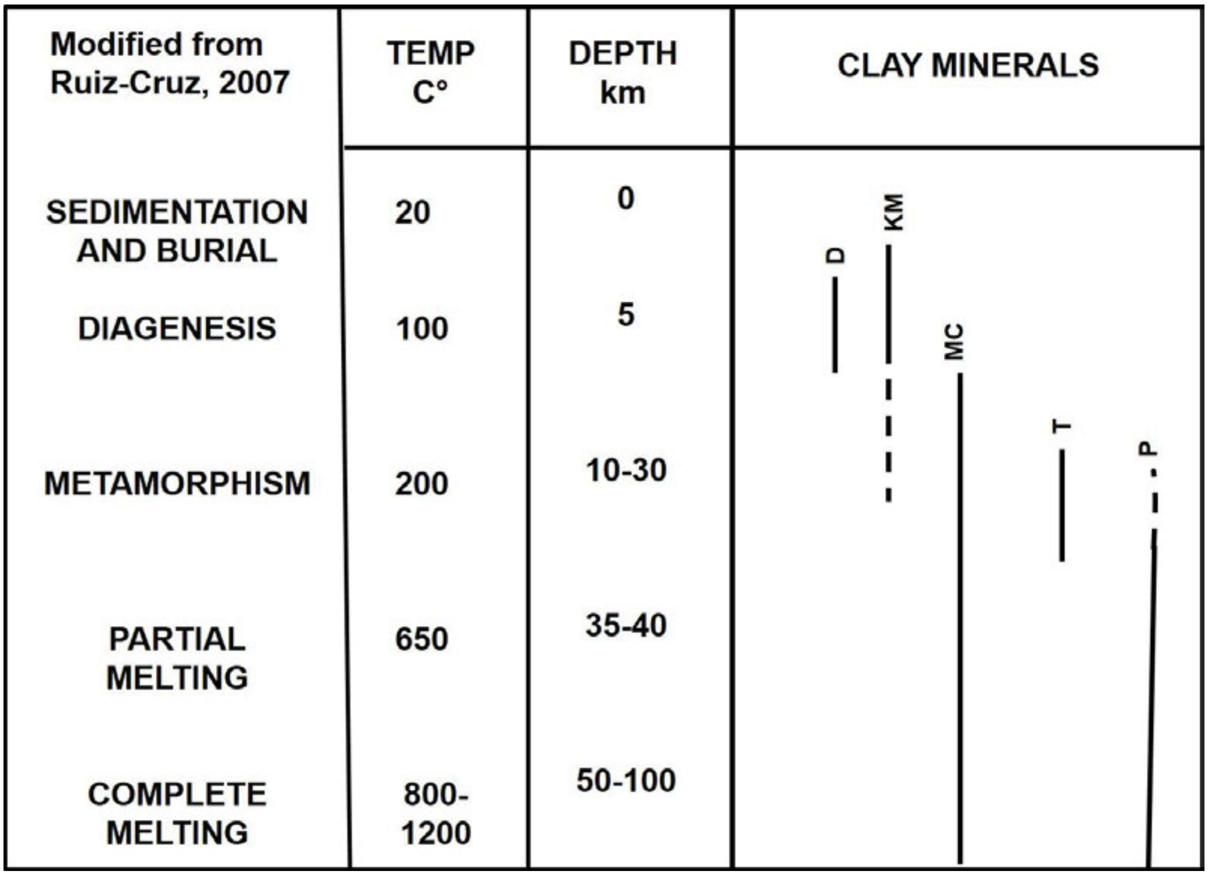


Figure 12-5. Temperature of formation and burial depths for selected clays. Kaolinite mineral (KM), tosudite (T), muscovite/chlorite (MC), pyrophyllite (P), dickite (D). Modified from Ruiz-Cruz (2007).

Localized structural complexes of multiple folds and faulting at the St Clair site may have helped focus various mineral end members through hydrothermal alteration of detrital clays derived from eroded Pennsylvanian highland (paleosols) that were then deposited into the St. Clair swamps. Subsequent alteration of clays as a result of hydrothermal fluids following permeable, interstitial pore spaces, faults and joint pathways help to define areas of the unique clay mineralogy prevalent in the anthracite region.

References

Abandoned Mine Research, Inc., 2013, Springdale (Silliman) Shaft: Mine Images, photos and brief text, http://www.undergroundminers.com/sillimans.html.

Berg, T.M., McInerney, M.K., Way, J.H., and MacLachlan, D.B., 1983 (revised 1993), Stratigraphic correlation chart of Pennsylvania: Pennsylvania Geological Survey, 4th series, General Geology Report 75, 2 p., 1 chart.

Daniels, E. J. and Altaner, S. P., 1990, Clay mineral authigenesis in coal and shale from the Anthracite region, Pennsylvania: American Mineralogist, Volume 75, p. 825-839.

Darrah, W.C., 1969, A critical review of the Upper Pennsylvanian floras of eastern United States with notes on the Mazon Creek flora of Illinois: Gettysburg, PA, 220 p., (privately printed).

Edmunds, W.E., 1996, Correlation chart showing suggested revisions of uppermost Devonian through Permian stratigraphy, Pennsylvania: Pennsylvania Geological Survey, 4th Series, Open-File Report 96-49, 8 p., 1 chart.

Gastaldo, R. A., DiMichele, W. A. and Pfefferkorn, H. W. Out of the Icehouse into the greenhouse: A Late Paleozoic analog for modern global vegetational change. Geological Society of America, GSA Today, v. 6, no. 10, p. 1 – 7.

Gastaldo, R. A., Pfefferkorn, H. W., and DiMichele, W. A., 1995. Taphonomic and sedimentologic characterization of roof-shale floras. Geol. Soc. America Memoir 185, p. 341-352.

Harper, J.A. and Shultz, C.H., 2000, Stop 7, Fall Run Park, Substop F – Pine Creek Marine Zone: in Harper, J.A., ed., Pittsburgh at the Millenium: The impact of geoscience on a changing metropolitan area: 65th Annual Field Conference of Pennsylvania Geologists Guidebook, p. 122.

Harrison, M. J., Marshaka, S., and Onaschb, C. M., 2004. Stratigraphic control of hot fluids on anthracitization, Lackawanna synclinorium, Pennsylvania. Tectonophysics, v. 378, issue, 1-2, p. 85-103.

Inners, J.D. and Smith, R.C., II, St. Clair plant fossil and pyrophyllite locality, Blythe Township, Schuylkill County: in Sevon, W.D., Berg, T.M., Inners, J.D., and Smith, R.C., II, 1982, Geology of the southern part of the anthracite coal fields of Pennsylvania, Guidebook for the 74th Annual Meeting of the American Association of State Geologists, Stop 2., p. 16-22.

Kochanov, W.E., 2012, Occurrences of tosudite and associated sulfide minerals in the Anthracite Fields of Pennsylvania: Friends of Mineralogy Symposium, unpublished abstract with Program.

Levine, J. P., 1993. The distribution of Eurasiatic late Paleozoic floras: A main tool for paleogeographic relationships. Biostratigraphy of Mainland Southeast Asia. Facies and Paleontology, v. 2, p 347-359.

Levine, J.R. and Eggleston, J.R., 1992, The Anthracite Basin of Eastern Pennsylvania: U.S. Geological Survey Open-File Report 92-568, Guidebook for the joint meeting of the International Committee for Coal and Organic Petrology and the Society for Organic Petrology, 72 p.

Lesquereux, L., 1858, Fossil plants of the Coal Strata of Pennsylvania: in Rogers, H.D., ed., The Geology of Pennsylvania, II (part II), p. 835-884.

___________, 1880, Description of the Coal Flora of the Carboniferous Formation in Pennsylvania and throughout the United States: 2nd Geological Survey of Pennsylvania, Report of Progress P., v. 1 (p. 1-354), v. 2, (p. 355-694).

___________, 1884, Description of the Coal Flora of the Carboniferous Formation in Pennsylvania and throughout the United States: 2nd Geological Survey of Pennsylvania, Report of Progress P. v. 3, p. 695-977).

Myer, G.H., De Santis, J., Grandstaff, B.E., and Grandstaff, D.E., 1977, A multistage model of preservation in some fossil plants: Geological Society of America, Abstracts with Programs, v. 9, no. 3, p. 304.

Oleksyshyn, J., 1982, Fossil plants from the Anthracite coal fields of eastern Pennsylvania: Pennsylvania Geological Survey, 4th Series, General Geology Report 72, 157 p.

Pfefferkorn, H., Slingerland, R., and Kochanov, W.E., 2006, Plant Paleoecology and Geology of the Southern Anthracite Field, Pennsylvania: Pre Conference Field Trip, Geological Society of America, Annual Meeting, Philadelphia.

Phillips, D. and Rose, E., 2001. Carboniferous fossil plants of the Southern Anthracite Coal Field, Saint Clair, Pennsylvania and Marine invertebrates of the Devonian Mahantango Formation, Deer Lake, Pennsylvania. Joint Spring Fieldtrip between the New York Paleontological Society and Polytechnic University.

Read, C.B., 1947, Pennsylvania floral zones and floral provinces: Journal of Geology, v. 55, no. 3, p. 271-279.

Read, C.B. and Mamay, S.H., 1964, Upper Paleozoic floral zones and floral provinces of the United States: U.S. Geological Survey professional Paper 454-K, 35 p., 19 plates.

Sevon, W.D., Berg, T.M., Inners, J.D., and Smith, R.C., II, 1982, Geology of the southern part of the anthracite coal fields of Pennsylvania, Guidebook for the 74th Annual Meeting of the American Association of State Geologists, p. 16-22.

Smith, R.C., II, and Barnes, J.H., 1988, Tosudite: Déjà vu intermittent blue: in Inners, J.D., ed., Bedrock and glacial geology of the North Branch Susquehanna Lowland and the Eastern Middle Anthracite Field, Guidebook for the 53rd Annual Field Conference of Pennsylvania Geologists, p. 51-55.

Spackman, W. and Moses, R.G., 1961, The nature and occurrence of ash forming minerals in anthracite: Proceedings of the Anthracite Conference, Mineral Industries Experiment Station Bulletin 75, p. 1-15.

Wagner, R.H. and Lyons, P.C., 1997, A critical analysis of the higher Pennsylvanian megafloras of the Appalachian region: Review of Palaeobotany and Palynology, v. 95, p. 255-283.

White, D., 1900, The stratigraphic succession of the fossil floras of the Pottsville formation in the southern anthracite coal field, Pennsylvania: U.S. Geological Survey 20th Annual Report, Part 2, p. 751-930, plates 180-193.

White, C. D., 1904, Deposition of the Appalachian Pottsville: Geological Society of America Bulletin, v. 15, p. 267-282.

Wood, H.C., Jr., 1860, Contributions to the Carboniferous Flora of the United States: Proc. Acad. Nat. Sci. Phil. V. 12, p. 236-240, 519-522.

Wood, G.H., Jr., 1973, Geologic map of the Pottsville quadrangle, Schuylkill County, Pennsylvania: U.S. Geological Survey, Geologic Quadrangle Map GQ-1028.

Wood, G.H., Jr., Trexler, J. P., Arndt, H.H., Yelenosky, A. and Soren, J., 1956, Subdivision of Pottsville Formation in southern Anthracite Field, Pennsylvania: AAPG Bulletin, v. 40, no. 11, p. 2669-2688.)

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