Quality of Water in Mines in the Western Middle Coal Field, Anthracite Region, East-Central Pennsylvania

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 85-4038

Prepared in cooperation with
U.S. BUREAU OF MINES

QUALITY OF WATER IN MINES IN THE WESTERN MIDDLE COAL FIELD, ANTHRACITE REGION, EAST-CENTRAL PENNSYLVANIA

By Lloyd A. Reed, Mark M. Beard, and Douglas J. Growitz

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FACTORS FOR CONVERTING INCH-POUND UNITS TO

INTERNATIONAL SYSTEM UNITS (SI)

Multiply inch-pound units	By	To obtain SI units
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	0.4047	hectare (ha)
ton (short)	0.9072	tonne (t)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
grains per gallon (gr/gal)	17.12	milligrams per liter (mg/L)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
ton per square mile (ton/mi^2)	0.3502	megagram per square kilometer (Mg/km^2)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
micromhos per centimeter at 25° Celsius (µmhos/cm at 25°C)	1	microsiemens per centimeter at 25° Celsius (µS/cm at 25°C)
degree Fahrenheit (°F)	-32 x 5/9	degree Celsius (°C)

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ABSTRACT

The quality of mine water in the 75 square-mile Western Middle anthracite field was determined by sampling discharges and boreholes at about 60 abandoned and flooded mines during 1975-78. Geologically, the field is a synclinal basin, divided by parallel faults into more than a score of smaller basins that contain the coal deposits. An estimated 1.6 billion (1,600,000,000) tons of anthracite were mined. Most of the deep mines are now closed and flooded.

The Vulcan-Buck Mountain mine, east-northeast of Mahanoy City, contains an estimated 6,100 acre-feet of water with a specific conductance of from 380 to 460 μS/cm (microsiemens), and a pH of from 4.4 to 4.6 units. Twenty-two mines are in the Mahanoy basin and the Shenandoah complex--a 15-square mile area between Mahanoy City and Girardville. Seven of these mines, located in the Mahanoy basin, may contain 30,000 acre-feet of water. Specific conductance ranges from 630 μS/cm in the Tunnel mine to 1,800 μS/cm in the Gilberton mine. Fifteen of these mines are in the Shenandoah complex. Specific conductance ranges from 240 to 310 μS/cm in mines in the eastern end of the complex to 2,400 μS/cm in the western end.

The specific conductance of water in eight mines near Mount Carmel ranges from 460 to 980 μS/cm. Seventeen mines are located near Shamokin; water from at least 12 mines drains into other mines before discharging at the surface. Water from the largest single discharge, 11 cubic feet per second, had a specific conductance of 950 μS/cm. The North Franklin mine near Trevorton, contains about 4,900 acre-ft of water with a specific conductance of about 1,100 μS/cm.

INTRODUCTION

This report presents information on the quality of water available from abandoned and flooded coal mines in the Western Middle anthracite field in east-central Pennsylvania, one of four anthracite fields where coal was extensively mined from about 1840 through 1950 (fig. 1). The Western Middle field is about 35 miles long in a generally east-west direction, from 2 to 5 miles wide, and includes the towns of Shamokin (about 45 miles northeast of Harrisburg) and Mahanoy City (about 36 miles southwest of Wilkes-Barre). Large quantities of ground water are available in mine voids, much of it of good chemical quality suitable for most uses.

The investigation was made by the U.S. Geological Survey, in cooperation with the Pennsylvania Department of Environmental Resources, Office of Resources Management. The study was sponsored by the U.S. Bureau of Mines. The report does not necessarily reflect official views or policies of the U.S. Bureau of Mines or the Pennsylvania Department of Environmental Resources.

Purpose and Scope

The purpose of the report is to describe the quality of ground water in the Western Middle coal field of east-central Pennsylvania. The description of the quality was expanded to include the quantity and movement of ground water in the mined areas.

Data for this report were collected between April 1975 and August 1978. Individual mine discharges were measured and sampled in April 1975; the larger discharges were sampled monthly from September 1975 to April 1976. Water samples were collected also from mine shafts and boreholes, in many of which temperature, specific conductance, and caliper logs were made; the caliper logs were to determine the depth of mine voids and other openings.

The samples were analyzed for temperature, pH, specific conductance, sulfate, acidity, and dissolved iron. The data are presented in tables that accompany the discussions of specific mines or groups of mines. Comments in the text focus primarily on temperature and specific conductance--temperature because it may be a clue to the depth of circulation in the mine (the deeper the source the warmer the water), and specific conductance[1/] because it is a good index of the total mineralization, or dissolved solids content, of the water.

[1/] Specific conductance is the measure of a solution to conduct an electrical current. The conductance of a solution is temperature dependent, increasing approximately 2 percent for each increase of 1°C. For consistency, it is referred to a temperature standard of 25°C.

Wherever possible, the report gives information on the altitude of water in the mines and estimates of the amount of water in storage, reported in acre-feet[1]. Water levels are based usually on the levels of the mine discharges or direct measurements in shafts or boreholes that terminate in mine openings. Estimates of water in storage are mostly from previous reports, chiefly that by Ash and others (1949).

With the discussions of mines in specific areas, maps are presented showing the locations of individual mines, usually with respect to nearby towns, and including other features such as barrier pillars that separate the mines from one another. Also shown are lines designated by letters indicating the location of the geologic sections presented on plates 3-8 (figs. 20 to 36).

Finally, the report gives information on the probable movement of water between mines, or from one mine to another. This information is based on older reports as well as newly acquired data relative to the location and altitude of breached barrier pillars and current mine-water levels.

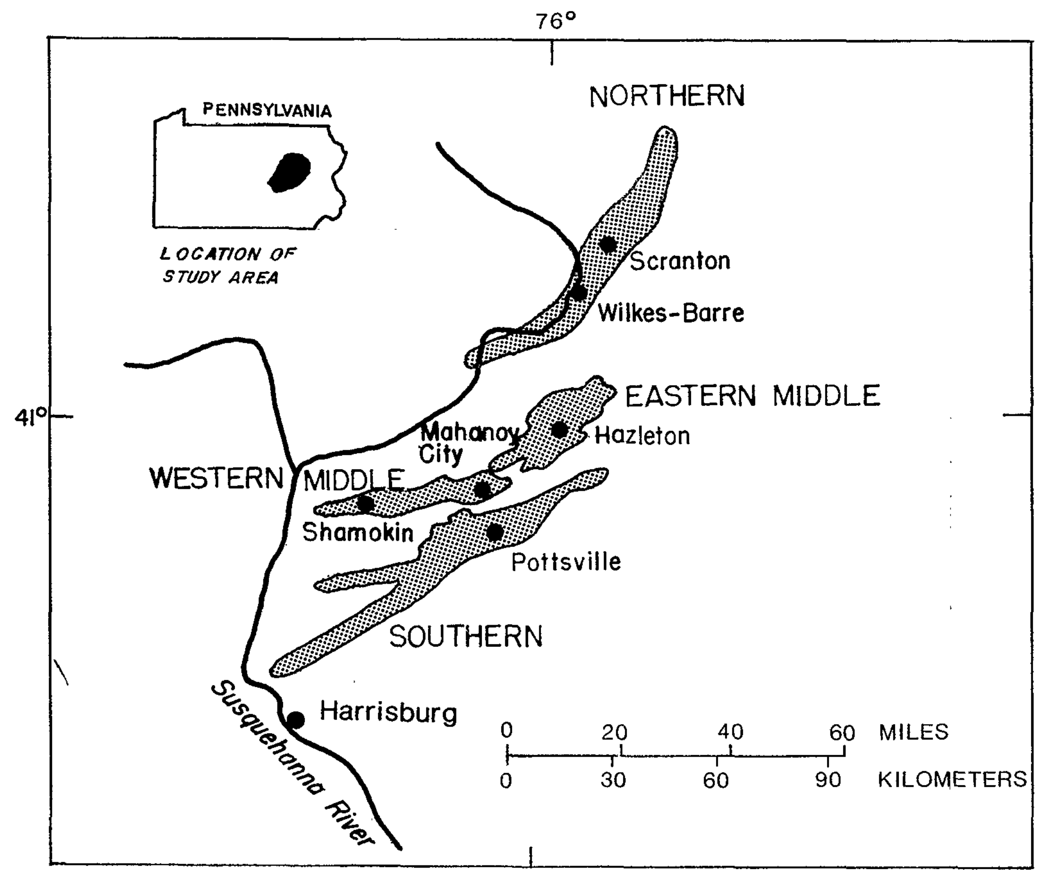


Figure 1.--Four anthracite fields in east-central Pennsylvania.

[1] An acre-foot of water is the amount required to cover one acre to the depth of one foot. It is equivalent to approximately 326,000 gal.

Geologic Setting

Geologically, the Western Middle anthracite field is a synclinal basin that is divided by parallel faults into 26 smaller basins that contain the coal deposits (figs. 2 and 3 on plate 1 at back of book).

The most prominent of the coal basins is the 25-mile-long Mahanoy basin, which extends along the southern boundary of the Western Middle field from a point 5 miles east of Mahanoy City to about the same distance west of Locust Gap. The Mahanoy basin is separated from the rest of the basins that comprise the Western Middle field by the Suffolk fault, which extends from east of Mahanoy City to Girardville, and by the Locust Gap fault, which extends from Girardville to west of Locust Gap.

North and northwest of Mahanoy City are eight basins that will be referred to collectively as the Shenandoah complex. They are the Mahanoy City, Delano, Ellangowan, Knickerbocker, Maple Hill, Shenandoah, William Penn, and Locust Mountain basins. Of the remaining 18 basins in the Western Middle field, some of the more important coal bearers are the Girardville, North, Centralia, Coal Ridge, and Black Diamond basins, north of Ashland; and the Natalie and Hickory Swamp basins north of Mount Carmel. Names of the other basins are given on figure 2.

Twenty-four coal beds have been identified in the Western Middle field, extending from 700 to 1,400 ft above sea level to as deep as 2,500 ft below sea level. Near Shamokin, where an estimated 77 ft of coal is in the top 1,700 ft of strata, individual beds range in thickness from 0.5 to 7.8 ft and average 4.6 ft (table 1).

An estimated 1.6 billion (1,600,000,000) tons of anthracite were mined from the coal basins, leaving about 3.6 billion tons unmined. Most of the coal was removed by deep-mining methods that created about 25 billion cubic feet of underground space. This is equivalent to an area of nearly 75 square miles excavated to a depth of 12 ft.

Origin of Mine Water

Underground mining was done in two steps called "first mining" and "robbing" (second mining). During first mining, shafts and airways were driven from the surface to the closest workable bed, and coal was removed by the room-and-pillar or similar method. About half the coal was left in place as pillars to support the roof. After the coal bed had been first mined, the pillars were removed by working from near the property line toward the mine shaft. Removal of the pillars was called robbing, and it allowed the mine roof to collapse. The coal bed usually was not mined closer than 120 ft to any property line. These unmined areas, called "barrier pillars", were left for two purposes: (1) to prevent disasters, such as explosions and fires, from affecting adjacent mines and (2) to control flooding. After a mine was closed, the barrier pillars acted as dams, preventing the flow of mine water, derived from the perculation of ground water, from abandoned to active mines. In some places where the barrier pillars had been partially robbed, abandoned mines had to be pumped to maintain safe working conditions in adjacent active mines.

Table 1.--Average thickness of coal beds in the western part of the Shamokin quadrangle (Arndt and others, 1963)
[A dash indicates no information]

Coal bed		Average thickness, in feet	
Name	No.	Bed (coal plus shale partings)	Coal
Post-Pottsville rocks			
Rabbit Hole	20	4.6	--
Tunnel	19	5.5	--
Spahn or Peach Mountain	18	6.2	6.2
Little Tracy	17	4.8	4.8
Tracy	16	5.2	4.1
Little Diamond	15	5.3	3.6
Diamond	14	3.2	2.5
Little Orchard	13	5.7	4.5
Orchard	12	3.1	2.3
Primrose	11	6.6	6.1
Rough	10 1/2	6.5	5.3
Holmes	10	8.2	7.4
Four-Foot	9 1/2	5.5	4.3
Mammoth Top Split Leader	9L	7.5	5.7
Mammoth Top Split	9	8.3	7.8
Mammoth Bottom Split	8	8.3	7.3
Mammoth Bottom Split Leader	8L	4.0	--
Skidmore	7	4.3	3.4
Skidmore Leader	7L	3.7	2.4
Seven-Foot	6	8.0	6.0
Buck Mountain Bottom Split	5	5.2	3.8
Pottsville Formation			
D	--	2.5	2.5
C	--	.6	.6
Lykens Valley No. 4	--	6.6	5.4

Most of the deep mines are now closed and flooded. One factor contributing to the closing of many mines was the cost of pumping to keep the mines dewatered. Where the workings were at a high enough altitude, water was removed by drainage tunnels; pumping was required if the workings were below the level of nearby streams. The bottoms of many of the mines are 800 to 1,000 ft below the land surface, requiring extensive pumping system to keep the mines dewatered. Data indicate that 70 percent or more of the annual precipitation precolated to the mines and had to be removed to prevent flooding. Where the mines were pumped, it is estimated that an average of 1,000 gal/min had to be pumped for each square mile of surface area underlain by mine workings.

When pumping ceased, the mines filled with water, which eventually overflowed at the surface, and a new water table was established. Water moves through the mines from points of higher to points of lower elevation, generally in the same direction as the ground water would move if the mines did not exist. Travel time of water through the mines, although highly variable depending on depth, volume, and the degree of interconnection of the mines, is generally much less than the equivalent movement of ground water through undisturbed rocks.

Discharge from a mine may be from the mine shaft, a borehole, drainage tunnel, or by seepage. Because all mine openings are connected to the mine shaft, directly or by horizontal tunnels, the water-surface altitudes are generally uniform within a mine complex. In many places adjacent mine complexes are connected through breached barrier pillars.

Previous Reports

A list of selected reports on the geology of the coal deposits and the quantity and quality of the mine waters is given in the References. Most reports on the quantity and quality of the water are based on data collected from 1941 through 1950 when many deep mines were still operating. One of the early reports by Felegy and others (1948) presents data collected chiefly in 1941 and 1946. In that study, at least one sample was collected from every known mine discharge in the four anthracite fields, as well as from selected streams. The report states that discharge from drainage tunnels and mine discharges, in the Western Middle field in 1941 was about 120 ft^3/s. Total acid load was 226 ton/d as H_2SO_4. Discharge in 1946 was 61 ft^3/s--about half that in 1941--and the total acid load was 96 ton/d as H_2SO_4.

A report by Ash and others (1949) presents data collected in 1945 and 1946 on the quantity of water in the mines in the Western Middle field. Fifty-eight mines contained 118,000 acre-ft of water.

Other pertinent reports are those by Ash, Eaton, and others (1950) and by Ash, Hower, and others (1953), which give data on mine-pumping systems and pumpage, and by Ash, Eaton and others (1951) on problems caused by acid mine-drainage. Another report by Ash, Eaton and others (1953) discusses the adequacy of barrier pillars to act as dams in the deep mines.

DRAINAGE AND MINE-WATER MOVEMENT

The Western Middle anthracite field is drained by Mahanoy and Shamokin Creeks and Zerbe Run, a tributary of Mahanoy Creek, all of which flow generally from east to west (fig. 4, plate 1). Mahanoy Creek, with a total drainage area at Ashland of 46 mi^2, drains the eastern and most of the central parts of the coal field. Some of its tributaries flow across the mined area in defined channels; others disappear into the mine workings before reemerging as the discharges from mine openings. Shamokin Creek drains about 26 mi^2 in the central and western parts of the coal field, and Zerbe Run drains about 3 mi^2 in the extreme western part.

For this report the coal field has been arbitrarily divided into five drainage areas, in each of which all known mine discharges, as well as selected streams, were measured and sampled. The drainage areas, shown in figure 4, are listed below from east to west and identified by the principal streams or outlets that control the drainage.

(1) Mahanoy Creek at Ashland. Includes 33 mi^2 east and northeast of Ashland and 4 mi^2 in the vicinity of Centralia. The area contains at least 45 mines, of which three are in the environs of Mahanoy City, 36 are between Mahanoy City and Girardville, and six are between Girardville and Ashland. In April 1975, total discharge from 16 mine openings was 104 ft^3/s; the discharge of Mahanoy Creek at Ashland was 126 ft^3/s.

(2) Unnamed tributary to Mahanoy Creek at Locustdale. Drainage area 2 mi^2; discharge, chiefly from the Potts mine, was 3.5 ft^3/s in April 1975.

(3) Tunnels near Locust Gap, discharging beneath Mahanoy Mountain into Mahanoy Creek. Drainage area of about 7 mi^2 extends from 3 miles southwest of Locust Gap to 1.5 miles north of Ashland. Discharge, primarily from the Locust Gap mine via the Doutyville and Locust Gap drainage tunnels, was 17.4 ft^3/s in April 1975.

(4) Shamokin Creek at Shamokin. Drainage area of 26 mi^2, extends from Mount Carmel to Shamokin (fig. 4) and includes at least 11 mines in the vicinity of Mount Carmel and 17 mines near Shamokin. In April 1975, discharge from mine openings was 69.5 ft^3/s and the discharge of Shamokin Creek, below Shamokin, was 117 ft^3/s. The large difference probably was due to the fact that not all streamflow originates from mine openings.

(5) Zerbe Run near Trevorton. Drainage area 3 mi^2. Discharge, in April 1975, was 8.3 ft^3/s from two mine openings in the North Franklin mine; the discharge of Zerbe Run below Trevorton was 17.4 ft^3/s.

Mine-water movement, is generally from east to west, the same as the surface-water drainage. However, because water in the mines is largely controlled by shafts and other openings and by barrier pillars, movement of the mine water locally may be virtually in any direction. As this investigation shows, the water being discharged from the mines becomes generally more mineralized as it moves from one mine to the next, suggesting progressively longer travel time and longer contact with rocks. Water that enters the mines in all parts of the field moves through one or more mines and is discharged, and this process goes on more or less continuously.

QUALITY OF MINE WATERS IN SPECIFIC AREAS

Drainage Area 1

Mines Near Mahanoy City

The area east-northeast of Mahanoy City, within about 1 mile of the town, includes three mines--the Vulcan-Buck Mountain, Primrose, and Park (fig. 5). The Vulcan-Buck Mountain mine contains an estimated 6,100 acre-ft of water (Ash and others, 1949). Discharge from the Vulcan-Buck Mountain boreholes (63) was measured and sampled monthly from July 1975 through March 1976 (table 2). During those 9 months, discharge ranged from 3.7 to 12.0 ft^3/s and averaged 7.4 ft^3/s. Temperature ranged from 9.5°C to 10.5°C, specific conductance from 380 to 460 µS/cm and pH from 4.4 to 4.7 units (table 2).

Borehole SC-300, in the Vulcan-Buck Mountain mine was drilled from an altitude of 1,259 to 1,106 ft, and cased to 1,215 ft (see fig. 17, plate 2). From December 1975 through December 1977, the water level ranged from altitudes of 1,256 to 1,249 ft (3 to 10 ft below the land surface). The caliper log indicated a 1-ft opening at an altitude of 1,141 ft, and brine trace logs indicated upward movement of water, at 2 ft/min, between altitudes of 1,128 and 1,140 ft. Temperature was about 10.0°C and specific conductance ranged from 345 to 440 µS/cm, which was about the same as that of the discharge from the mine.

Water in the Primrose and Park mines is not discharged locally at the surface but moves through breached barrier pillars into mines northwest of Mahanoy City, from which it ultimately discharges. The water level in the Primrose mine evidently is independent of that in the Vulcan-Buck Mountain mine, because the mine workings do not appear to be connected across the Suffolk fault. The estimated altitude of the water level in the Primrose mine (about 1,120-ft altitude), is controlled by a breach in barrier pillar II (fig. 5). Ash and others (1949) estimated that the Primrose mine contained 500 acre-ft of water when the altitude of the water level was 1,000 ft; present estimate is 700 acre-ft, based on a water level of 1,120 ft. No water-quality data were collected from the Primrose mine in this investigation.

The Park mine (No. 1 and No. 2 mines in table 2) contained 750 acre-ft of water, as estimated by Ash and others (1949), with the water level at altitude 1,172 ft. Based on the 1977 water-level altitude of about 1,250 ft, the mine contained an estimated 1,000 acre-ft of water.

Borehole SC-298, in the Park Mine, was drilled from a land-surface altitude of 1,333 ft to an opening in the Little Buck Mountain (No. 5) coal at altitudes of between 1,180 and 1,170 ft. Temperature and specific conductance logs were made in the borehole four times between August 1976 and August 1978 and none showed an increase in conductance in the mine void. Samples were collected at an altitude of 1,193 ft, 13 ft above the mine on four occasions. The specific conductance of three of the samples ranged from 105 to 140 µS/cm. The fourth sample had a specific conductance of 455 µS/cm. The water temperature, at the bottom of the mine, measured twice with seven months between the measurements, was about 10.0°C. Water-level altitudes ranged from 1,272 to 1,244 ft.

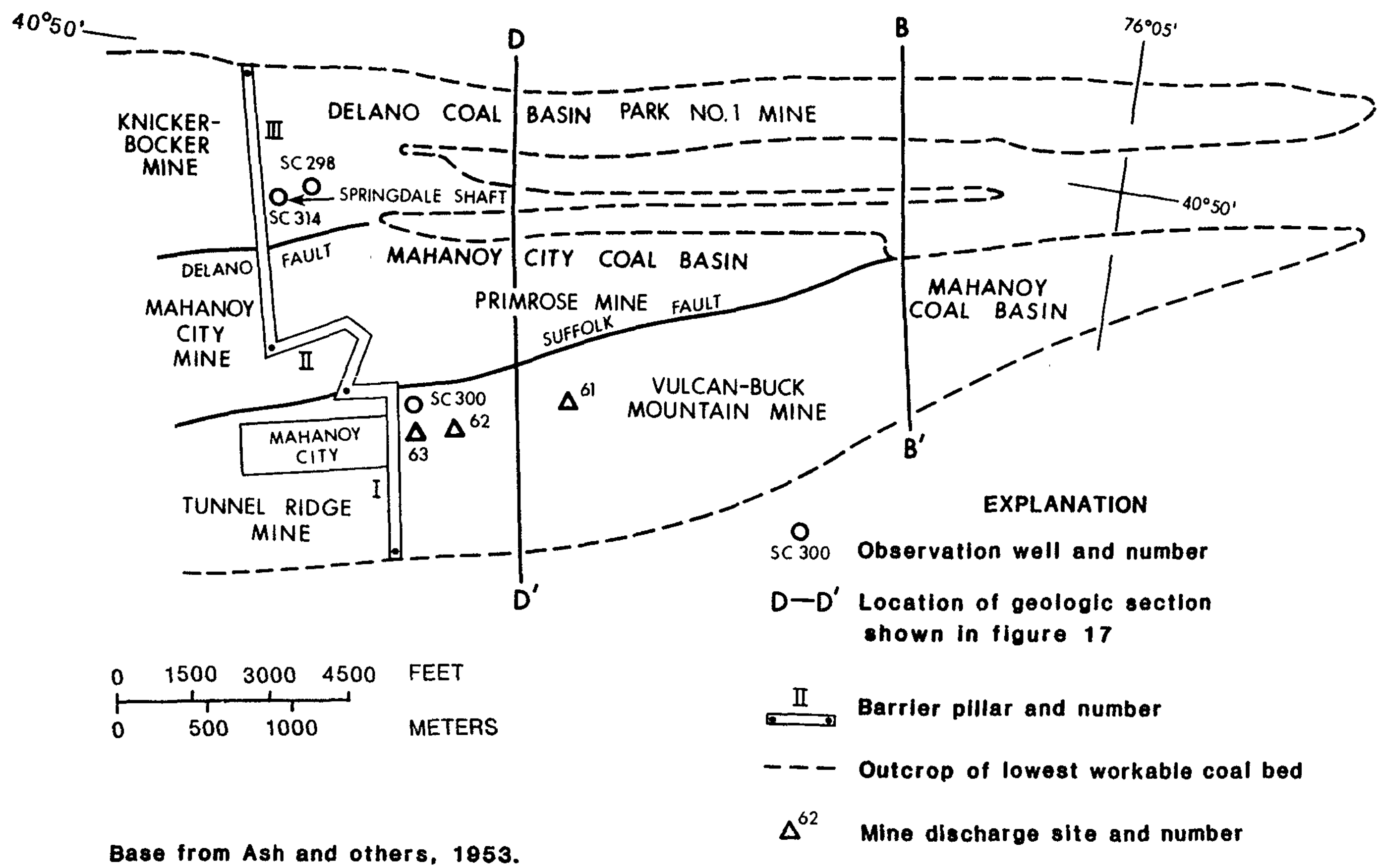


Figure 5.--Deep-mine complexes east of Mahanoy City.

Table 2--Water quality of boreholes and mine discharges east of Mahanoy City

MINE DISCHARGES

Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	pH	Concentration, in mg/L: sulfate	Concentration, in mg/L: iron	Loads, in tons per day: sulfate	Loads, in tons per day: iron	Acidity to indicated pH, as $CaCO_3$ (mg/L): 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L): 8.3
61	Vulcan-Buck Mountain mine	Morris Tunnel	40°49'16" 76°07'17"	4-18-75	0.3	9.5	440	3.3	140	2.0	0.11	0.0016	105	110
62	Vulcan-Buck Mountain mine	seepage	40°48'58" 76°07'25"	4-18-75	.6	10.0	460	4.0	160	8.0	.26	.013	80	90
63	Vulcan-Buck Mountain mine	Vulcan-Buck Mountain boreholes	40°48'55" 76°07'35"	4-16-75	9.8	9.5	380	4.4	160	10	4.2	.26	63	68
				7-1-75	7.1	10.5	380	4.5	---	7.5	---	.14	76	88
				7-31-75	12.0	---	---	---	---	---	---	---	---	---
				9-3-75	3.7	10.0	460	4.5	---	---	---	---	---	---
				10-1-75	10.8	10.0	460	4.7	---	10	---	.29	70	82
				11-5-75	6.2	9.5	460	4.6	---	8	---	.13	70	80
													58	66
				12-30-75	6.1	9.5	440	4.6	---	10	---	.16	50	58
				2-11-76	6.5	9.5	430	4.6	---	10	---	.18	54	68
				3-3-76	6.5	9.5	420	4.6	---	10.5	---	.18	56	66

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No.: USGS	Borehole No.: PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)	Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Specific conductance (µS/cm at 25°C)	Dissolved iron (mg/L)
Vulcan-Buck Mountain (1932)	670	SC-300	3	1,259	1,106	1,256-1,249	Mammoth (void)	8-4-76	430-440	10-12
								3-24-77	345	20
								8-14-78	420	10
Park Nos. 1 and 2 (1953)	880	SC-298	18	1,333	1,170	1,272-1,244	Little Buck Mountain (void)	8-4-76	140	1.0
								3-23-77	125	3.0
								7-21-77	105	1.4
								8-14-78	455	8.6
Park Nos. 1 and 2	880	SC-314	Springdale shaft	1,340	---	1,274-1,244	Seven-Foot (void)	3-23-77	415	1.5
								8-14-78	560	2.4

1/Voids are areas that have been mined out.

2/Pennsylvania Department of Environmental Resources

Logs were made and samples collected also from the Park mine Springdale shaft (SC-314). The water-level altitude, which was about the same as that in borehole SC-298, ranged from 1,274 to 1,244 ft above sea level from December 1975 through December 1976. The specific conductance was 415 µS/cm in March 1977 and 560 µS/cm in August 1978. The logs indicated little or no movement of water in the shaft.

Mines between Mahanoy City and Girardville

Twenty-two mines are in a 15-mi^2 area between Mahanoy City and Girardville, all of which were closed prior to 1958. Seven of these mines are in the Mahanoy coal basin, which forms the southern boundary of the area, and 15 are in the eight basins called the Shenandoah complex which lie north of the Mahanoy basin and are separated from it by the east-west trending Suffolk fault (figs. 6 and 7, plate 1).

Mines in the Mahanoy Basin

Water levels in boreholes and shafts in the seven mines in the Mahanoy basin ranged in altitude from 1,100 to 1,175 ft near Mahanoy City and from 1,056 to 1,082 ft near Girardville (about 8 mi to the west), reflecting the regional gradient and general movement of ground water from east to west.

Movement of mine water in this part of the Mahanoy basin is partially controlled by barrier pillars, four of which are between Mahanoy City and Gilberton (halfway between Mahanoy City and Girardville), and all of which reportedly were breached at about 600 ft altitude. Of three barrier pillars between Gilberton and Girardville, two were reportedly intact in 1950; the third was breached, but the altitude of the breach was unknown (Ash and others, 1953).

Ash and others (1949) estimated that the seven mines contain 24,800 acre-ft of water, based on water levels that ranged in altitude from 971 ft near Mahanoy City to 986 ft near Girardville. Based on the subsequent rise in water levels, the mines contained an estimated 30,000 acre-ft of water in 1978.

Discharge was measured at two sites--at the Gilberton mine (fig. 6, site 64) from a pump that operates 40 percent of the time to control water levels and prevent the flooding of basements in Gilberton, and at the Girard mine (site 70) from a mine opening. In April 1975, discharge was 8.0 ft^3/s from the Girard mine and 23 ft^3/s from the Gilberton mine pump. Water temperature at the Girard mine was 12.0°C, only slightly higher than the temperature of water from the mines east of Mahanoy City. However, temperature of water from the Gilberton mine pump was 14.0°C, indicating that at least part of the water came from relatively deep sources where earth temperatures are higher. The Gilberton mine is the deepest mine in this part of the Mahanoy basin, reaching 66 ft below sea level, almost 200 ft lower than the next deepest mine.

There are other differences, besides temperature, in the waters from the Girard and Gilberton mines. Specific conductance was 1,800 μS/cm in water from the Gilberton mine and 825 μS/cm in Girard mine water. Concentrations of sulfate and iron were also much higher in the water from the Gilberton mine, as shown in table 3. These differences in chemical quality may be due to differences in depth of the contributing zones in the respective mines or possibly in the residence time of the water; water from the Gilberton mine was in the mine longer and, hence, more mineralized than water from Girard mine.

Specific conductance and temperature logs were made in five boreholes, SC-299, SC-302, SC-316, SC-304, and SC-305, located as shown in figure 6. Samples also were collected from the boreholes for chemical analyses. The chemical data, depths of the boreholes, and other information, are given in table 3.

Borehole SC-299, in the Tunnel Ridge mine (fig. 6), was drilled from a land surface altitude of 1,199 ft to an opening in the Bottom Split Mammoth (No. 8) coal at 1,010 ft. The Mammoth coal out crops about 300 ft north of the borehole. In August 1976, the range in specific conductance was 590 to 630 μS/cm; in February 1977, the range was 360 to 390 μS/cm. Temperature was 12.0°C in August 1976 and 11.0°C in February 1977, measured both times near the bottom of the hole. The temperature, each time, was about 2.0°C higher near the water surface. These seasonal differences probably were caused by water entering the voids left where the Mammoth coal was mined to the surface.

Borehole SC-302, in the St. Nicholas mine, was drilled from a land-surface altitude of 1,161 ft to a void in the Little Buck Mountain (No. 5) coal at 879 ft. The borehole was cased through the Mammoth coals. Bottom temperature was 11.5°C in August 1976 and 10.0°C in March 1977, specific conductance was 870 μS/cm in August 1976 and 1,350 μS/cm in March 1977. The change in specific conductance was opposite that recorded in borehole SC-299 for essentially the same period.

Borehole SC-316, in the Gilberton mine near the Gilberton shaft was drilled from a land-surface altitude of 1,148 ft to an opening in the Top Split Mammoth (No. 9) coal at 873-ft altitude. The borehole was cased to within 5 ft of the bottom. The water temperature (14.0°C) and specific conductance (1,400 μS/cm) at the opening in the Top Split Mammoth in March 1977 were about the same as for the water in the nearby shaft, as would be expected. Specific-conductance logs made in the Gilberton shaft indicate highest values (1,400 μS/cm) at altitudes of 700 ft (the second lift) and at 400 ft (the Top Split Mammoth coal). The dip of the Top Split Mammoth coal is about 45° in the area of the shaft and borehole, which accounts for the difference in altitudes.

Borehole SC-304, in the Lawrence mine, was drilled from a land-surface altitude of 1,154 ft to 958 ft. The borehole contains an opening at 1,064 ft and terminates near the Top Split Mammoth coal. Water-level altitudes ranged from 1,110 to 1,093 ft. The temperature and specific conductance near the bottom of the borehole in August 1976 and March 1977, were 14.0°C and 900 μS/cm, and 13.0°C and 775 μS/cm, respectively. Despite the fact that slow upward flow was detected in the borehole in May 1977, the small seasonal

Table 3.--Water quality of boreholes and mine discharges in the Mahanoy coal basin between Mahanoy City and Girardville

MINE DISCHARGES

Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (µs/m at 25°C)	pH	Concentration, in mg/L: sulfate	Concentration, in mg/L: iron	Loads, in tons per day: sulfate	Loads, in tons per day: iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L): 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L): 8.3
64	Gilberton mine	Gilberton Pump (operates 40 percent of the time)	40°48'01" 76°12'34"	4-18-75	23 9.2	14.0	1,800	6.1	1,000	54	62 24.8	3.4 1.36	102	108	240
70	Girard mine	seepage	40°47'30" 76°16'26"	4-16-75	8.0	12.0	825	5.9	460	20	9.9	.43	71	105	155

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No.: USGS	Borehole No.: PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)	Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Specific conductance (µS/cm at 25°C)	Dissolved iron (mg/L)
Tunnel Ridge (1931)	368	SC-299	4	1,199	999	1,175-1,100	Mammoth (void)	8-4-76 3-24-77 7-20-77 5-14-78	590-630 470 590 530	40-45 10 35 25
St. Nickolas (1928)	128	SC-302	5	1,161	879	1,130-1,103	Little Buck Mountain (void)	8-16-76 3-30-77	870 1,350	50 3.5
Gilberton (1938)	-66	SC-311	USBM-4 Gilberton shaft	1,139	48	1,108-1,095	Buck Mountain (void)	12-2-76 12-9-76	810 1,380	100 100
Gilberton (1938)	-66	SC-316	8	1,148	863	1,108-1,095	Mammoth (void)	3-31-77 8-14-78	1,400 910	25 38
Lawrence (1938)	147	SC-304	46	1,154	958	1,110-1,093	Four-Foot	8-19-75 3-31-77	900 775	15 6.2
West Bear Ridge (1938)	370	SC-305	9	1,138	898	1,082-1,056	Mammoth (void)	8-20-76 4-7-77 7-19-77	600 575 560	50 21 33

1/Voids are areas that have been mined out.

2/Pennsylvania Department of Environmental Resources

Table 4.--Data from selected mines in the Shenandoah complex

[A dash indicates no information]

Mine	Surface altitude of mine pool, in feet above sea level	Estimated contents of mine pool, in acre-feet	Specific conductance of mine water, in microsiemens at 25°C
Knickerbocher	1,104	1,000	240-300
North Mahanoy	1,104	1,000	-
Mahanoy City	1,104	3,000	1,090
Kebley Run	1,110E	200	-
Indian Ridge	1,094	5,000	960
Maple Hill	1,109	10,000	1,700
Kohinoor	1,106	10,000	1,100
West Shenandoah	1,018	-	-
Weston	1,018	5,000	-
William Penn	1,018	4,000	1,450
East Bear Ridge	1,140	1,460	-
Raven Run	1,366	1,170	-
Hammond	1,004	3,000	1,680
Packer No. 5	955	5,000	2,400
	TOTAL	49,830	

changes suggest less water movement in this part of the Lawrence mine than in some of the other mines investigated. Drainage from the Lawrence mine is into the West Bear Ridge mine and then into the Girard mine from which it discharges to the surface.

Borehole SC-305, in the West Bear Ridge mine, was drilled from a land-surface altitude of 1,138 ft to an opening in the Mammoth coal (No. 8) at 898 ft. Water levels and specific conductance ranged from 1,082 to 1,056 ft and from 560 to 600 µS/cm, respectively.

Mines in the Shenandoah Complex

The Shenandoah complex consists of eight basins totaling 11.3 mi^2 that bound the Mahanoy basin on the north (fig. 7, plate 1). Fourteen mines in the complex were closed by 1959. Water from the mines, which includes that from the Primrose and Park mines in the Mahanoy basin, moves westward through breached barrier pillars from one mine to another to discharge at points near Girardville. Water-level altitudes generally decline from east to west--from 1,140 to 1,094 ft in six boreholes east of Shenandoah, and from 1,023 to 1,004 feet in four boreholes west of the town, measured from December 1975 through December 1977.

In 1977, 13 mines were estimated to contain approximately 50,000 acre-ft of water (table 4). Discharge in April 1975 at five sites near Girardville totaled 52 ft^3/s; the largest flow from a borehole near a breached barrier pillar in the Packer No. 5 mine (71, fig. 7) was 45 ft^3/s. Discharge from the Packer No. 5 mine, measured monthly from June 1975 through March 1976, ranged from 38 to 49 ft^3/s and averaged 42.8 ft^3/s.

Total water discharge in April 1975 was 52 ft^3/s. If this represents the mean annual discharge, 38 ft^3/s may be from direct infiltration of 37 in. on 13.9 mi^2 (including 2.6 mi^2 in the Mahanoy basin) directly underlain by mines, and 14 ft^3/s may be from infiltration and runoff of 19 in. that enter the mines from 10 mi^2 of unmined area, chiefly along the south side of Locust Mountain. Infiltration from mined and unmined areas is an estimated 25 percent higher here than in the Mahanoy basin.

Discharges from all five sites in the Shenandoah complex were sampled in April 1975. The specific conductance of water from the Packer No. 5 mine (71) was 2,400 µS/cm and the temperature was 15.0°C. At two other discharge points (66 and 67), near Lost Creek, with total discharge of 4.7 ft^3/s, the average specific conductance was 1,950 µS/cm. Average temperature was a relatively warm 15.0°C, indicating that water is coming from deep sources. The discharge at Lost Creek is from the northern half of the William Penn basin, probably from the Weston mine.

The mine waters become increasingly mineralized from east to west, the direction of movement (table 5). The specific conductance of water discharged from the Packer No. 5 mine, in the western part of the Shenandoah complex, ranged from 2,000 to 2,700 µS/cm, based on samples collected monthly from

Table 5.--Water quality of boreholes and mine discharges in the Shenandoah complex between Mahony City and Giradville

MINE DISCHARGES

Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)
66	Weston mine	Weston surface areas seepage	40°48'30" 76°14'49"	4-16-75	3.7	15.0
67	Weston mine	Lost Creek borehole	40°48'25" 76°14'49"	4-16-75	1.0	16.0
68	Hammond mine	Connerton Village boreholes	40°48'06" 76°16'04"	4-16-75	1.7	15.0
69	Hammond mine	Seepage	40°48'05" 76°16'20"	4-17-75	.20	13.0
71	Packer No. 5 mine	breach and boreholds	40°47'40" 76°16'22"	4-18-75	45	15.0
				6-25-75	49	16.5
				7-30-75	47	--
				9-4-75	41	16.0
				10-1-75	44	15.5
				11-5-75	44	15.0
				12-3-75	39	15.0
				12-30-75	38	15.5
				2-11-76	40	14.0
				3-4-76	41	15.5

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No. USGS	Borehole No. PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)
Tunnel Ridge (1931)	368	SC-301	USBM-2	1,253	731	1,130-1,120
Knickerbacher (1953)	503	SC-297	21	1,479	1,028	1,138-1,104
Mahanoy City (1953)	427	SC-319	1	1,232	1,075	1,140-1,104
Indian Ridge and Shenandoah City (1932)	476	SC-303	11	1,283	928	1,117-1,094
Maple Hill (1954)	150(west) 503(east)	SC-317	2	1,205	1,062	1,135-1,109
Kohinoor (1953)	244	SC-315	7	1,243	1,093	1,125-1,106
Weston (1959)	--	SC-318	6	1,023	731	1,023-1,018
William Penn (1946)	50	SC-312	57	1,050	754	1,045-1,018
Hammond (1954)	--	SC-307	47	1,060	858	1,022-1,004
Packer No. 5 (1959)	250	SC-313	10	972	724	956-958

1/Voids are areas that have been mined out.

2/Pennsylvania Department of Environmental Resources

MINE DISCHARGES

Specific conductance (μS/cm at 25°C)	pH	Concentration, in mg/L sulfate	Concentration, in mg/L iron	Loads, in tons per day sulfate	Loads, in tons per day iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L) 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L) 8.3
1,900	6.1	1,200	20	12	0.20	62	65	118
2,150	6.1	1,300	20	3.51	.05	177	132	230
1,950	6.3	1,200	40	5.5	.18	205	88	210
2,200	6.3	1,100	20	.59	.011	138	5	19
2,400	5.8	1,300	40	158	4.9	167	68	174
2,250	6.2	--	35	--	4.6	218	40	170
--	--	--	--	--	--	--	--	--
2,300	6.3	--	--	--	--	174	82	136
2,300	6.1	--	20	--	2.4	210	106	160
2,700	6.1	--	30	--	3.6	198	118	172
2,200	6.0	--	40	--	4.2	204	78	122
2,150	6.1	--	30	--	3.1	204	85	154
2,000	6.0	--	35	--	3.8	182	68	116
2,050	6.1	--	25	--	2.8	204	95	164

BOREHOLES

Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Specific conductance (μS/cm at 25°C)	Dissolved iron (mg/L)
Mammoth (void)	8-16-76	1,030	100
	12-6-76	760	100
	3-23-77	1,090	76
Buck Mountain (void)	8-3-76	240	7.5
	3-24-77	310	3.5
Skidmore (void)	4-21-77	760	25
Mammoth (void)	9-23-77	400	25
Orchard	4-7-77	1,700	--
Mammoth (void)	3-24-77	1,100	1.5
Diamond (void)	2-10-77	2,000	--
Primrose (void)	6-24-76	1,450	35
	12-8-76	1,275	35
	2-11-77	--	50
	3-25-77	1,300	22
	7-19-77	1,175	26
	9-14-78	940	15
Skidmore Leader (void)	9-2-76	1,600	60
	4-1-77	1,450	160
Four-Foot (void)	3-9-77	2,000	31
	4-1-77	2,000	27

June 1975 to March 1976, compared with values of 240 and 310 μS/cm, respectively, for samples collected in August 1976 and March 1977 from borehole SC-297 in the Knickerbocker mine, the most easterly of the mines in the Shenandoah complex.

Borehole SC-297, near the north side of the Knickerbocker basin, was drilled from a land-surface altitude of 1,479 ft to an altitude of 1,028 ft. The borehole was drilled through a void between 1,109 and 1,079 ft in the Buck Mountain coal (No. 5), which has been mined to the outcrop. Water in the mine void close to the borehole consists, in part, of water that infiltrates from the nearby out crop, which probably accounts for the low specific conductance values of 240 and 310 μS/cm, that were determined by logging in August 1976 and March 1977, respectively. Water temperature in the borehole was about 11.5°C when the specific-conductance logs were made.

Borehole SC-319, in the Mahanoy City mine, was drilled from a land-surface altitude of 1,232 ft to an opening in the Skidmore coal (No. 7) at an altitude of 1,075 ft. The borehole is not close to an out crop. Logs were run in April 1977 and specific conductance ranged from 510 to 760 μS/cm, and water temperature ranged from 13.0°C at an altitude of 1,125 ft to 12.0°C at an altitude of 1,080 ft. From December 1975 to December 1977, water levels ranged from 1,140 to 1,104 ft.

Borehole SC-301, was drilled from a land-surface altitude of 1,253 ft at the Tunnel Ridge mine through the Suffolk Fault to a void in the Bottom Split Mammoth coal (No. 8) at 744 ft in the Mahanoy City mine. The borehole is located about a half mile west of Mahanoy City. Temperature logs made in August 1976 and March 1977 are shown in figure 8. The temperature range from the water surface, at an altitude of 1,130 ft, to an altitude of 850 ft was from 16.5°C to 17.5°C.

Temperatures decrease dramatically below an altitude of 850 ft--from 17.5°C to 12.0°C. The lower temperatures are associated with an opening in the Bottom Split Mammoth (No. 8) coal below an altitude of 744 ft. The water cooled dramatically in the interval occupied by the Bottom Split Mammoth coal, through which circulation of mine water evidently occurs. The specific conductance in borehole SC-301 ranged from 130 to 335 μS/cm near the top to 760 to 1,090 μS/cm near the bottom, based on water samples collected when the logs were made.

Borehole SC-303, in the Indian Ridge mine at Shenandoah, was drilled from a land-surface altitude of 1,283 ft to 981 ft. The borehole is near the middle of the Shenandoah complex (fig. 7) and terminates at the top of a 53-ft opening in the Bottom Split Mammoth coal (No. 8). (See fig. 19, plate 2). The coal has been nearly all mined out and the mine may contain as much as 5,000 acre-ft of water. A sample collected from the mine void had a low specific conductance of 400 μS/cm but was high in dissolved iron (about 25 mg/L). This may be a general characteristic of water in the mine. Temperature near the top of the borehole (15.0°C) was higher than that in the mine void (13.5°C), probably due to circulation in the mine.

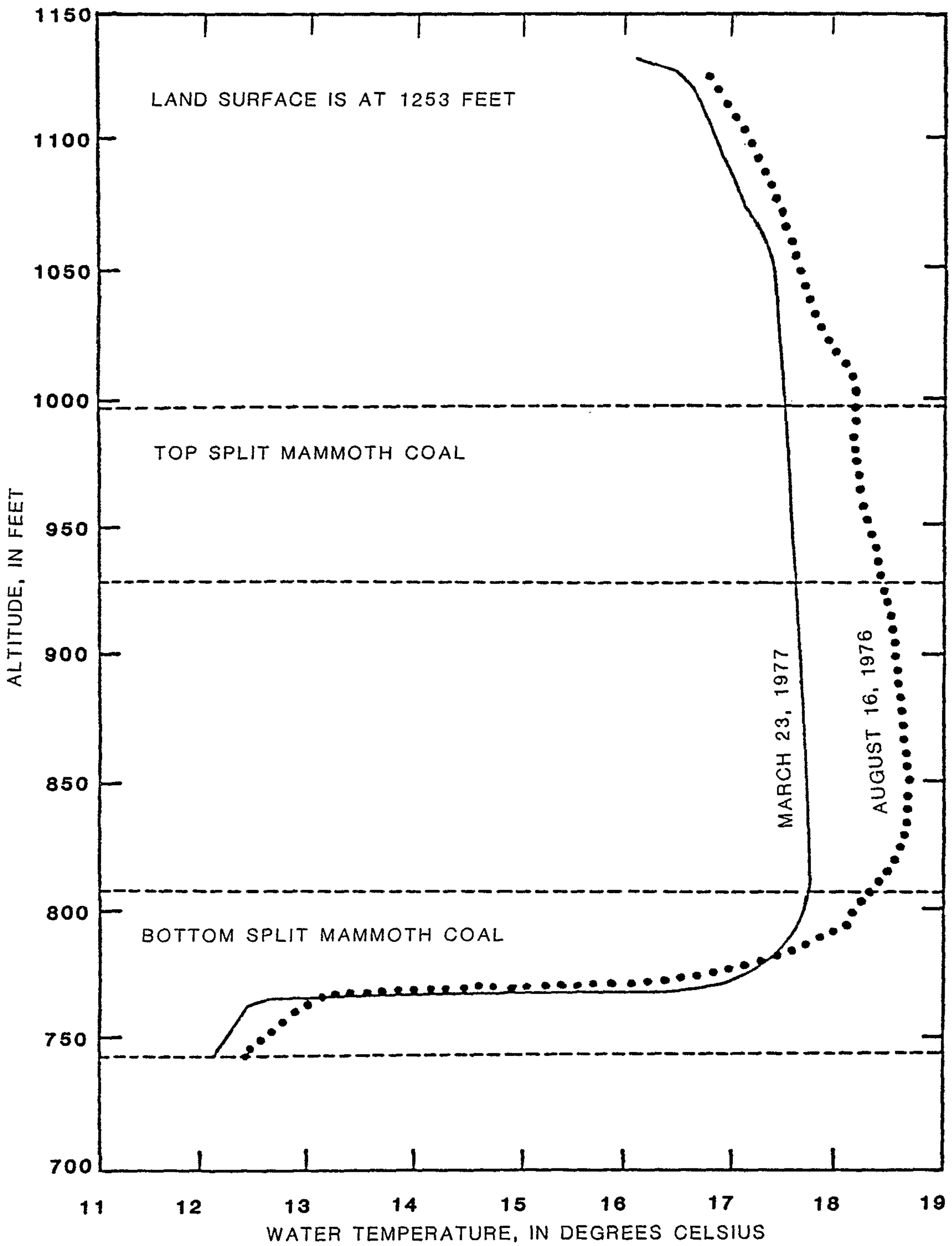


Figure 8.--Temperature logs from borehole SC-301.

Borehole SC-317, in the Maple Hill mine, was drilled from a land-surface altitude of 1,205 ft to an opening in the Orchard coal (No. 12) at 1,062 ft. The borehole is located about a mile southeast of Shenandoah. The specific conductance and temperature increased with depth from 900 µS/cm and 11.5°C near the water surface to 1,700 µS/cm and 12.0°C near the bottom of the borehole. No circulation was detected in the borehole.

Borehole SC-315 in the Kohinoor mine at Shenandoah was drilled from a land-surface altitude of 1,243 ft to 1,093 ft. Casing was placed to an altitude of 1,109 ft. The lower part of the borehole penetrates highly fractured material that had collapsed into the mine after removal of the Mammoth coal. Logs were made and samples were collected from the borehole in March 1977; near the bottom of the borehole, the specific conductance was 1,100 µS/cm and temperature was 13.0°C. Temperature logging indicated that water was circulating near the bottom of the borehole.

Borehole SC-312, in the William Penn mine, about 1.75 mi south-west of Shenandoah, was drilled from a land-surface altitude of 1,050 ft to an altitude of 754 ft. The borehole was cased to an altitude of 821 feet. A 26-foot fractured zone is present from an altitude of 795 to 769 ft. Temperature in the borehole was 15.0°C above the fractured zone and 12.5°C within the zone. Specific conductance ranged from 1,275 above to 1,450 µS/cm within the fractured zone.

Borehole SC-318, in the Weston mine, was drilled from a land-surface altitude of 1,023 ft to an opening in the Diamond coal at an altitude of 731 ft. The borehole is near mine discharge 67 (the Lost Creek borehole) at the Weston mine (fig. 9). The water level is near land surface and the borehole sometimes overflows. In February 1977, temperature and specific conductance in the borehole ranged from 15.0°C and 1,900 µS/cm near the surface to 16.0°C and 1,200 µS/cm near the bottom.

Borehole SC-307, in the Hammond mine near Girardville, was drilled from a land-surface altitude of 1,060 ft to an opening in the Skidmore (No. 7) coal at an altitude of 858 ft. The borehole is cased to an altitude of 920 ft. Temperature and specific conductance logs were made in September 1976 and April 1977. Both times the average temperature was 10.5°C and the range in specific conductance was from 1,450 to 1,600 µS/cm. The logs indicated little or no circulation in the borehole.

Borehole SC-313, in the Packer No. 5 mine at Girardville, was drilled from a land-surface altitude of 972 ft to an altitude of 724 ft. The borehole penetrates a section between altitudes of 850 and 840 ft that had caved after removal of the Holmes (No. 10) coal. Small voids were reported between 763- and 752-ft altitudes in the Mammoth (No. 8 and 9) coals. Based on temperature logs made in the borehole in March and April 1977, about 10 gal/min of water was flowing upward from the openings in the Mammoth coal to the openings in the Holmes coal. A specific conductance of 2,000 µS/cm indicated that the quality of the water was about the same as that of the discharge from the Packer No. 5 mine.

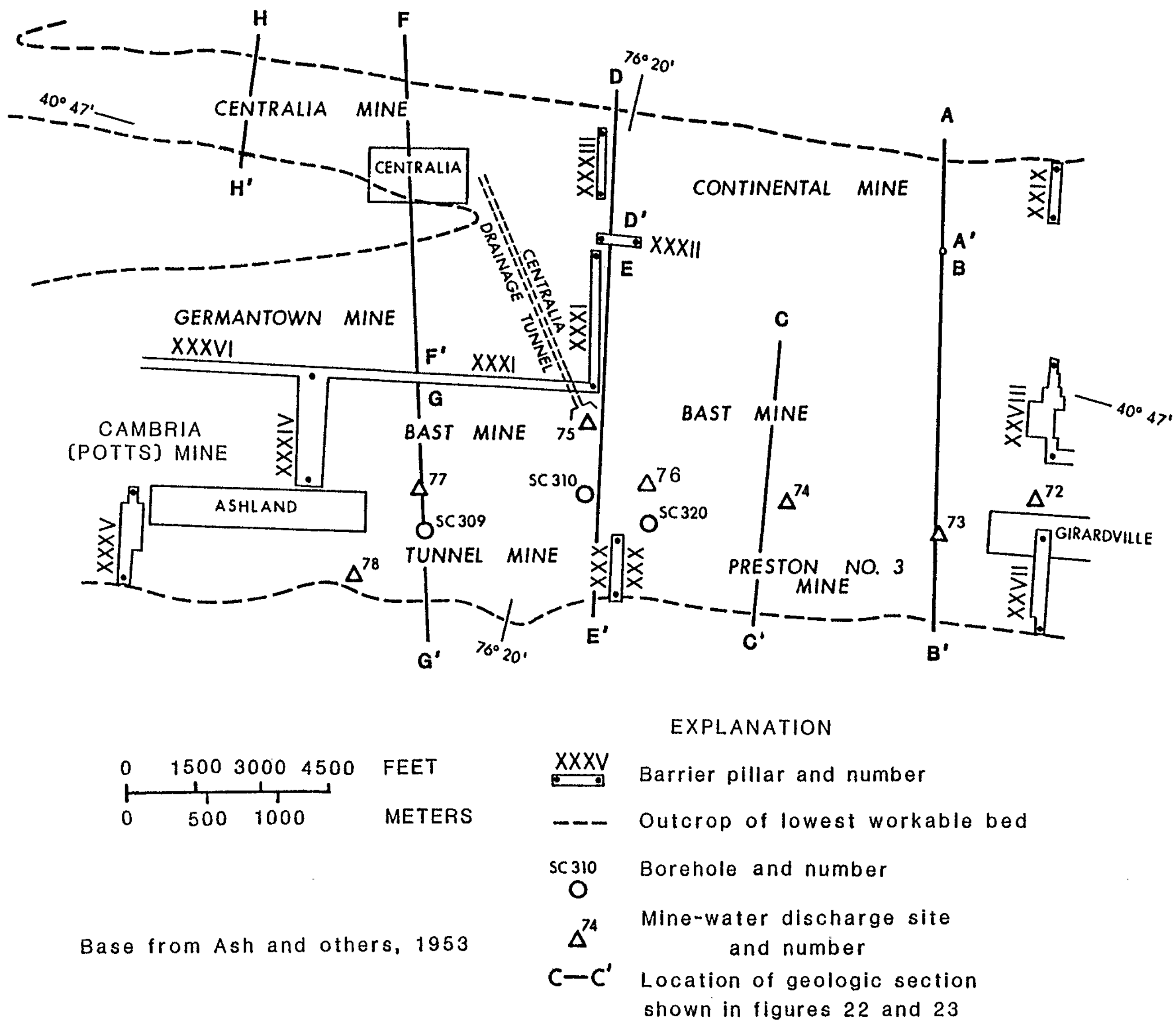


Figure 9.--Deep-mine complexes between Girardville and Ashland.

Mines Between Girardville and Ashland

Mines between Girardville and Ashland, including those in the Centralia area, are shown in figure 9. Four mines--the Centralia, Preston No. 3, Bast, and Tunnel--were estimated to contain 17,500 acre-ft of water in April 1977. Mine-water levels decline from an altitude of 960 ft near Girardville to 880 ft near Ashland. Water levels are much higher in the northern part of the area near Centralia; the altitude of the Centralia drainage tunnel outlet is 986 ft. The present water levels in the Centralia, Preston No. 3, and Tunnel mines are not known but, at water-level altitudes of 1,000, 948, and 872 ft, the mines contained 924, 1,750, and 1,894 acre-ft of water (Ash and others, 1949), respectively. The Bast mine contained 11,300 acre-ft of water at a water-level altitude of 757 ft; at a water level of 906 ft, measured in 1975, the mine may contain 13,000 acre-ft of water. No information is available for the Continental mine.

Discharge from six outlets draining an estimated 9 mi^2 of mined area between Girardville and Ashland was 22.4 ft^3/s. The largest discharge 11.0 ft^3/s, was from the Centralia drainage tunnel, which drains 4 mi^2 near Centralia.

The water-quality data from mine discharges and boreholes have wide ranges in specific conductance and other constituents. As listed in table 6, the specific conductance ranged from 2,050 µS/cm near Girardville (site 72) to 1,250 µS/cm near Ashland. Between these points, values at seven other discharges and boreholes ranged from 400 to 1,800 µS/cm. At the Centralia tunnel outlet, the point of largest discharge, the specific conductance was 950 µS/cm. Water temperature ranged from 10.0°C at the Preston No. 3 mine tunnel (site 73) to 14.0°C at the Bast mine (site 77). Water discharge from the Preston drift (site 72) is small, and water discharge from the Tunnel mine is from a strip pool overflow; and their temperatures may not represent temperatures in the mines.

Borehole SC-320, in the Bast mine, was drilled from a land-surface altitude of 913 ft to 633 ft. The borehole penetrated an opening in the Diamond coal (No. 14) at an altitude of 656 ft and was cased to an altitude of 671 ft. Logs made in the borehole in September 1977 indicate that water temperature and specific conductance at the opening in the Diamond coal were 11.0°C and 570 µS/cm, respectively. Borehole SC-310 was drilled in the Bast mine and borehole SC-309 was drilled in the Tunnel mine. No voids were encountered by either borehole, and the relation between the water in the boreholes and the water in the mines is not known.

Drainage Area 2, Mines Near Locustdale

Drainage to an unnamed tributary to Mahanoy Creek from a 2-mi^2 area near Locustdale is principally from the Potts mine, part of which is also called the Cambria mine (fig. 10). Evidence suggests that water does not move freely between the north and south part of the Potts mine.

Table 6.--Water quality of boreholes and mine discharges between Girardville and Ashland

MINE DISCHARGES

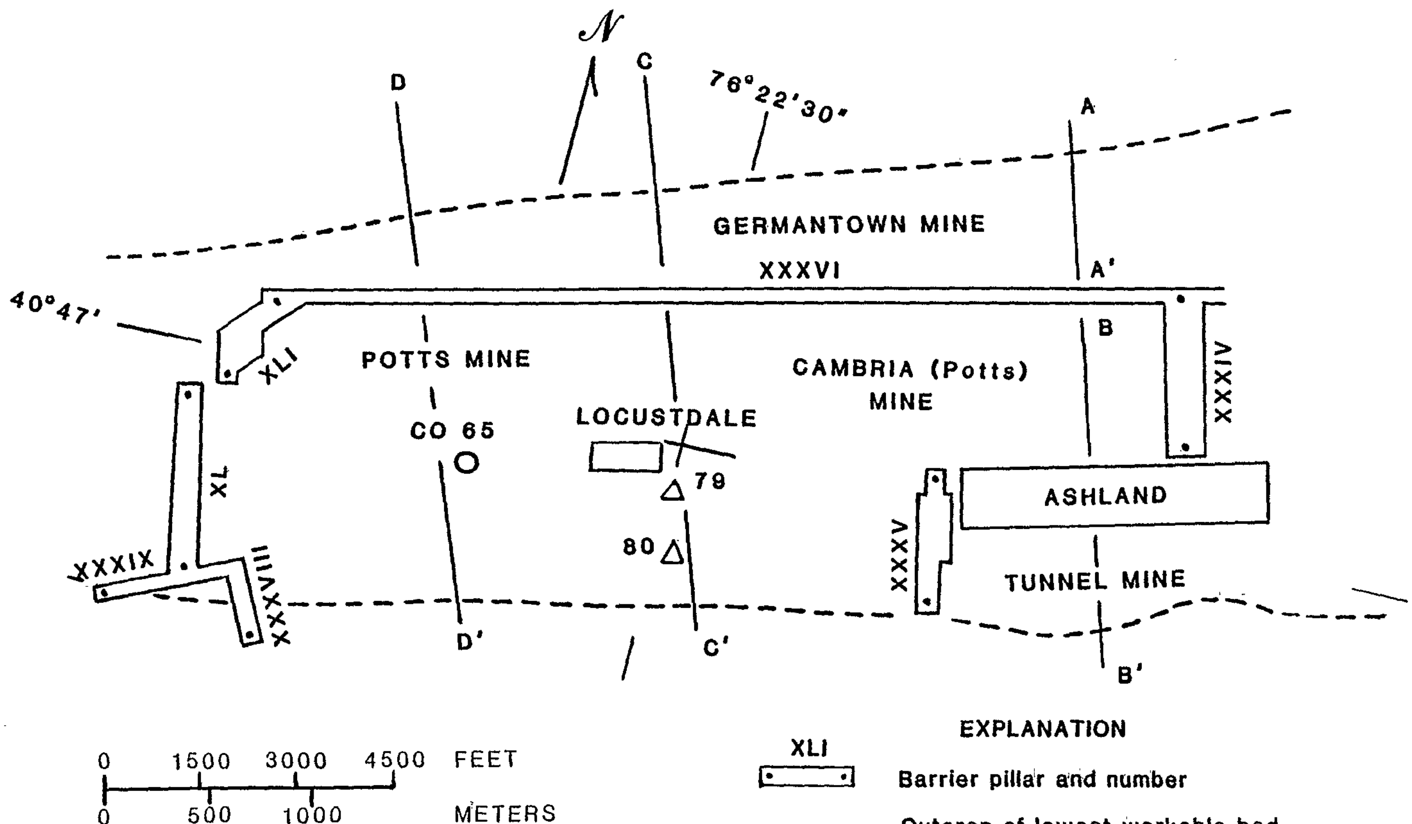
Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	pH	Concentration, in mg/L: sulfate	Concentration, in mg/L: iron	Loads, in tons per day: sulfate	Loads, in tons per day: iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L): 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L): 8.3
72	Preston mine	Preston No. 3 water-level drift	40°47'44" 76°16'13"	4-16-75	0.4	16.5	2,050	6.3	1,300	30	1.4	0.03	153	83	177
73	Preston mine	tunnel	40°27'25" 76°17'34"	4-17-75	2.2	10.0	520	5.6	200	20	1.2	.12	46	40	80
74	Bast mine	tunnel	40°47'29" 76°18'08"	4-17-75	.9	12.0	1,800	3.4	930	40	2.3	.10	--	174	213
75	Centralia mine	Centralia drainage tunnel	40°47'27" 76°19'26"	4-16-75	11.	11.0	950	3.5	580	10	17	.30	--	133	145
76	Bast mine	Overflow site	40°47'11" 76°19'09"	4-17-75	.00	--	--	--	--	--	--	--	--	--	--
77	Bast mine	Oakland tunnel	40°47'06" 76°19'54"	4-17-75	6.6	14.0	1,400	6.3	660	20	12	.36	118	58	110
78	Tunnel mine	drain pool area and seepage	40°46'45" 76°20'12"	4-17-75	1.3	17.0	1,250	6.5	640	30	2.2	.11	98	23	48

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No.: USGS	Borehole No.: PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)	Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Specific conductance (µS/cm at 25°C)	Dissolved iron (mg/L)
Bast (1934)	16	SC-320	25	913	633	910-906	Diamond	9-23-77	570	--
Bast (1934)	16	SC-310	87	911	630	901-886	Little Diamond (no void)	9-13-76 2-11-77	760 400	30 30
Tunnel (1891)	11	SC-309	26	897	622	888-885	Little Tracy (no void)	9-13-76	1,490	90

1/Voids are areas that have been mined out.

2/Pennsylvania Department of Environmental Resources



Base from Ash and others, 1953.

10.--Deep-mine complexes near Locustdale.

Discharge was sampled at two sites (79 and 80), both at an altitude of about 1,000 feet, in April 1975; total discharge was 3.5 ft^3/s. Water from the largest discharge, 3.2 ft^3/s, had a temperature of 15.0°C and a specific conductance of 2,400 µS/cm (table 7). The relatively high temperature suggest that the water is a mixture of water from levels between the surface and the deepest reported mining level. The mine contains about 5,000 acre-ft of water.

Borehole CO-65 in the Potts mine, was drilled from a land-surface altitude of 1,045 ft to an altitude of 655 ft. The borehole terminates a few feet above the Little Diamond (No. 15) coal, which was not mined in the area. No openings were detected. Specific conductance and temperature logs were made in the borehole in September 1976. The temperature ranged from 11.5°C to 12.5°C, and the specific conductance from 1,090 to 1,120 µS/cm

Drainage Area 3, Mines Near Locust Gap

Drainage from the Locust Gap mine and, possibly, the Germantown mine discharges from the Locust Gap (Helfenstein) and Doutyville tunnels (sites 92 and 94, fig. 11), and two other sites (91 and 93), into Mahanoy Creek. If the Germantown mine is included, the total drainage area is 7 mi^2.

The water level in both the Locust Gap and Germantown mines is about 700 ft in altitude, based on the altitudes of the drainage tunnel outlets (Doutyville, 694 ft; and Locust Gap, 711 ft). The Locust Gap mine may contain as much as 5,000 acre-ft of water. The quantity of water in the Germantown mine is not known. Discharge from the Locust Gap mine in April 1975 was 13 ft^3/s from the Doutyville tunnel and 3.9 ft^3/s from the Locust Gap tunnel. Discharges from sites 91 and 93 were 0.3 and 0.2 ft^3/s, respectively (table 8).

The quality of the water from both drainage tunnels was about the same. Water from the Doutyville tunnel had a temperature of 13.0°C and a specific conductance of 1,280 µS/cm; water from the Locust Gap tunnel had a temperature of 13.0°C and a specific conductance of 1,200 µS/cm. Temperature and specific conductance of water from drainage outlets 91 and 93, 10.5°C and 12.0°C, and 460 and 530 µS/cm, respectively, were lower than those of water from tunnels.

Two boreholes were logged and sampled, and the water level in each was significantly higher than the assumed water level in the mines, suggesting that the water in the boreholes does not represent the water in the mines. Borehole SC-308 in the southeastern corner of the Germantown mine, near Ashland, is shown on figure 11. The water level in the borehole was at an altitude of 978 ft in September 1976, and at an altitude of 973 ft in August 1978--about 275 feet higher than the assumed altitude (700 feet) of the water generally in the Locust Gap and Germantown mines. The borehole was drilled to an altitude of 836 ft, but penetrates no known mine voids. Temperature in September 1976 ranged from 11.0°C near the top to 12.5°C near the bottom. Specific conductance was 850 µS/cm in September 1976 and 895 µS/cm in August 1978. Water was not moving in the borehole, based on brine tracing.

Table 7--Water quality of boreholes and mine discharges near Locustdale

MINE DISCHARGES

Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	pH	Concentration, in mg/L: sulfate	Concentration, in mg/L: iron	Loads, in tons per day: sulfate	Loads, in tons per day: iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L): 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L): 8.3
79	Potts mine	West breach	40°46'34" 76°22'19"	4-17-75	0.3	12.0	950	6.8	240	2	0.19	0.0016	46	3	18
80	Potts mine	East breach	40°46'24" 76°22'15"	4-17-75	3.2	15.0	2,400	6.6	960	40	8.3	.35	328	38	170

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No.: USGS	Borehole No.: PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)	Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Water quality in borehole below casing: Specific conductance (µS/cm at 25°C)	Water quality in borehole below casing: Dissolved iron (mg/L)
Potts (1934)	9	CO-65	28	1,045	655	1,009-988	Little Diamond (no void)	9-15-76	1,120	60

[1]/Voids are areas that have been mined out.

[2]/Pennsylvania Department of Environmental Resources

Table 8.--Water quality of boreholes and mine discharges near Locust Gap

MINE DISCHARGES

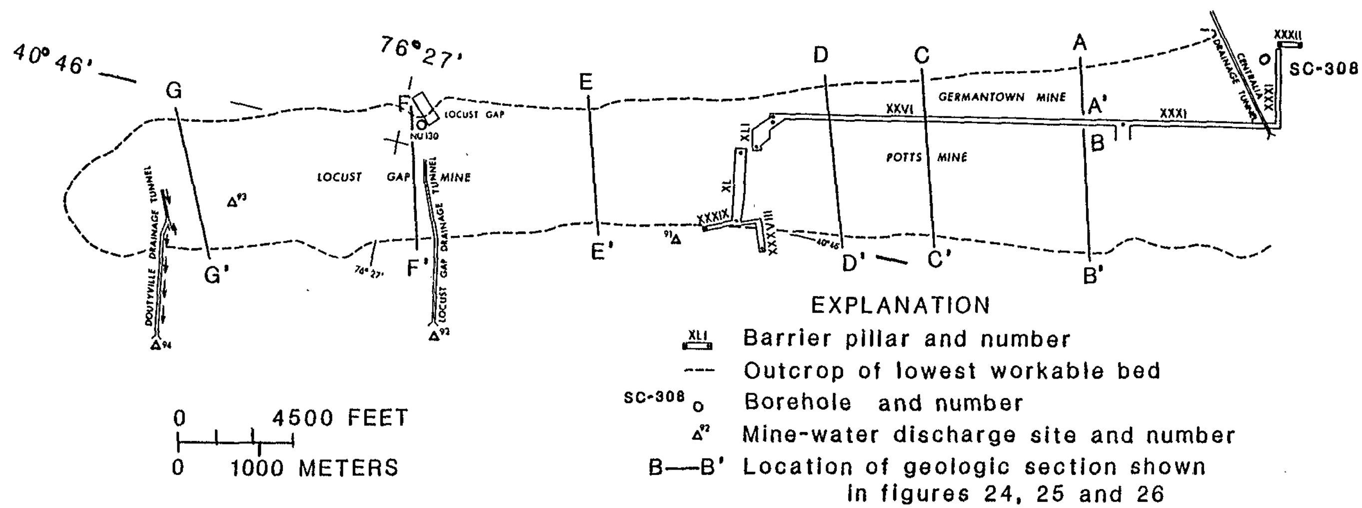
Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft³/s)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	pH	Concentration, in mg/L: sulfate	Concentration, in mg/L: iron	Loads, in tons per day: sulfate	Loads, in tons per day: iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L): 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L): 8.3
91	Lavelle mine	Lavelle slope	40°45'58" 76°24'05"	4-17-75	0.3	10.5	460	3.3	230	2	0.19	0.0016	--	45	50
92	Locust Gap mine	Locust Gap tunnel	40°45'04" 76°26'12"	4-17-75	3.9	13.5	1,200	7.2	670	10	7.1	.11	54	--	45
93	Locust Gap mine	strip pool overflow	40°45'31" 76°28'29"	4-21-75	.2	12.0	530	3.6	250	2	.14	.0011	--	90	100
94	Locust Gap mine	Doutyville tunnel	40°44'35" 76°28'38"	4-18-75	13	13.0	1,280	3.6	700	12	25	.42	--	106	135

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No.: USGS	Borehole No.: PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)	Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Water quality in borehole below casing: Specific conductance (µS/cm at 25°C)	Water quality in borehole below casing: Dissolved iron (mg/L)
Germantown (1960)	100	SC-308	24	986	836	978-973	Mammoth (no void)	9-2-76 8-15-78	850 895	20 25
Locust Gap (1955)	250	NU-130	USBM-34	1,198	686	900-884	Skidmore (void)	9-27-77	180 at 868 ft 50 at 708 ft	8 --

1/Voids are areas that have been mined out.

2/Pennsylvania Department of Environmental Resources



Base from Ash and others, 1953

Figure 11.--Deep-mine complexes near Locust Gap.

Borehole NU-130 (U.S. Bureau of Mines No. 34), in the Locust Gap mine was drilled from a land-surface altitude of 1,198 ft to an altitude of 686 ft. The driller's log indicated the presence of a void from altitudes of 969 ft to 965 ft in the Middle Split Mammoth coal. Broken rock was reported between altitudes of 910 ft and 885 ft--an interval that includes the Bottom Split Mammoth coal.

The water level in borehole NU-130 was at an altitude of 884 feet when logs were made in September 1977; this level is equivalent to levels 1 ft below the floor of the mined out Bottom Split Mammoth coal, and 184 ft above the assumed water level in the Locust Gap mine. Temperature in borehole NU-130 was 12.0°C near the water surface and increased to 12.5°C near the bottom. Specific conductance decreased from 180 µS/cm near the water surface to about 50 µS/cm near the bottom. The water in the borehole is not in contact with a flooded mine void and apparently does not represent the water in the mine.

Drainage Area 4

Mines Northeast of Mount Carmel

Midvalley No. 3 mine in the Coal Ridge basin discharges through a tunnel to Midvalley mines Nos. 1 and 2 in the Black Diamond basin (fig. 12). The Midvalley mines have been estimated to contain 1,500 acre-feet of water (Ash and others, 1949). Drainage area of all three mines is 3.5 mi^2.

The water level in Midvalley No. 1 and No. 2 mines is maintained at about altitude 1,163 ft by drainage tunnel outlet 83. The altitude of the outlet from Midvalley No. 3 mine is 1,212 ft (Ash and others, 1953) and the water level in the mine is probably near this level. If barrier pillar XXXVII (fig. 14) were removed, the water in Midvalley No. 3 mine would merge with that in the Sayre-Sioux mine, and the common water level would be about at an alitude of 1,000 ft.

The principal discharge from the Midvalley mines from drainage tunnel outlet 83 in April 1975 was 5.9 ft^3/s. Discharge from tunnel No. 4 (site 82) and a seepage point (site 81) was 0.4 and 0.2 ft^3/s, respectively. Temperature of water from the main drainage tunnel (site 83) was 10.5°C and the specific conductance was 600 µS/cm (table 9).

Mines Near Mount Carmel

Eight mines in the vicinity of Mount Carmel are connected in different degrees through breached barrier pillars and drainage tunnels (fig. 13). Water from the Richards Shaft mine, north of Mount Carmel, flows westward through breached barrier pillars into the Sayre-Sioux mine, thence through the Pennsylvania mine into the Scott mine. The Scott mine also receives water from three other mines--the Richards Water Level, Natalie, and Greenough--by way of drainage tunnels.

From the Scott mine water moves through mine workings into the Scott Ridge mine. Water from the Scott Ridge mine discharges to the surface,

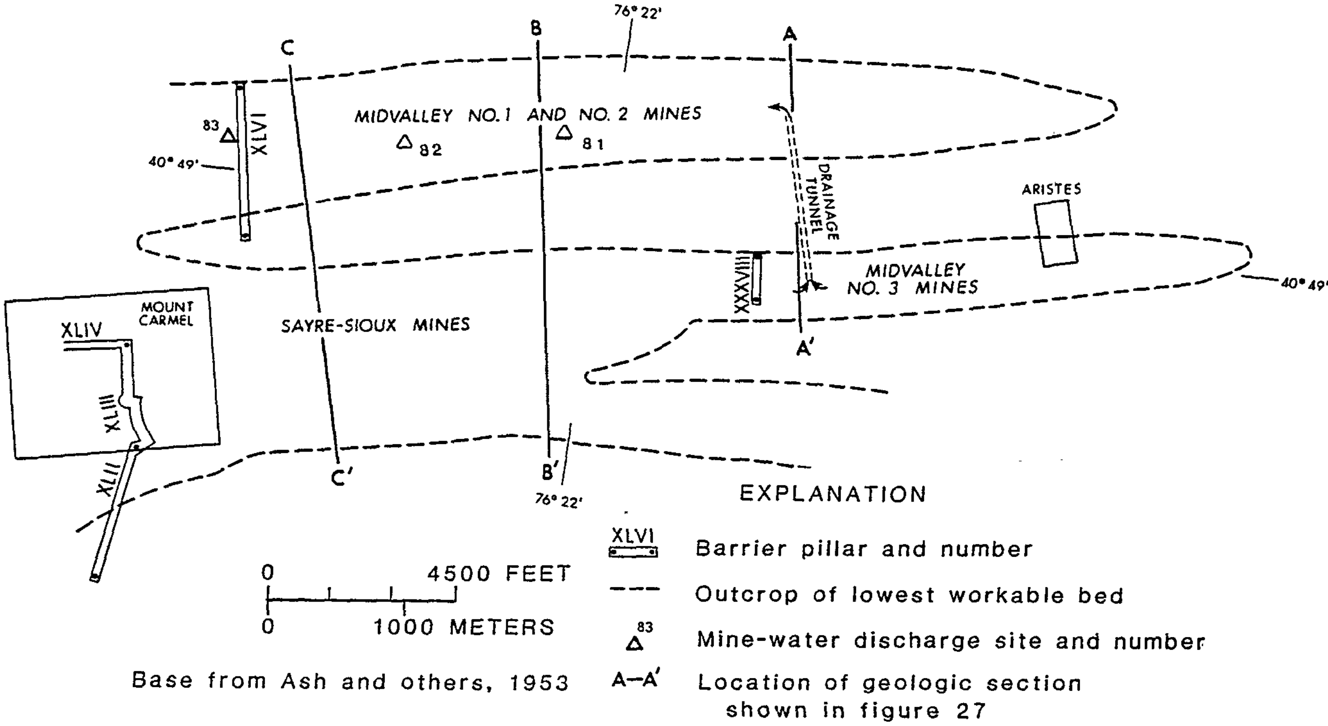


Figure 12.--Deep-mine complexes east of Mount Carmel.

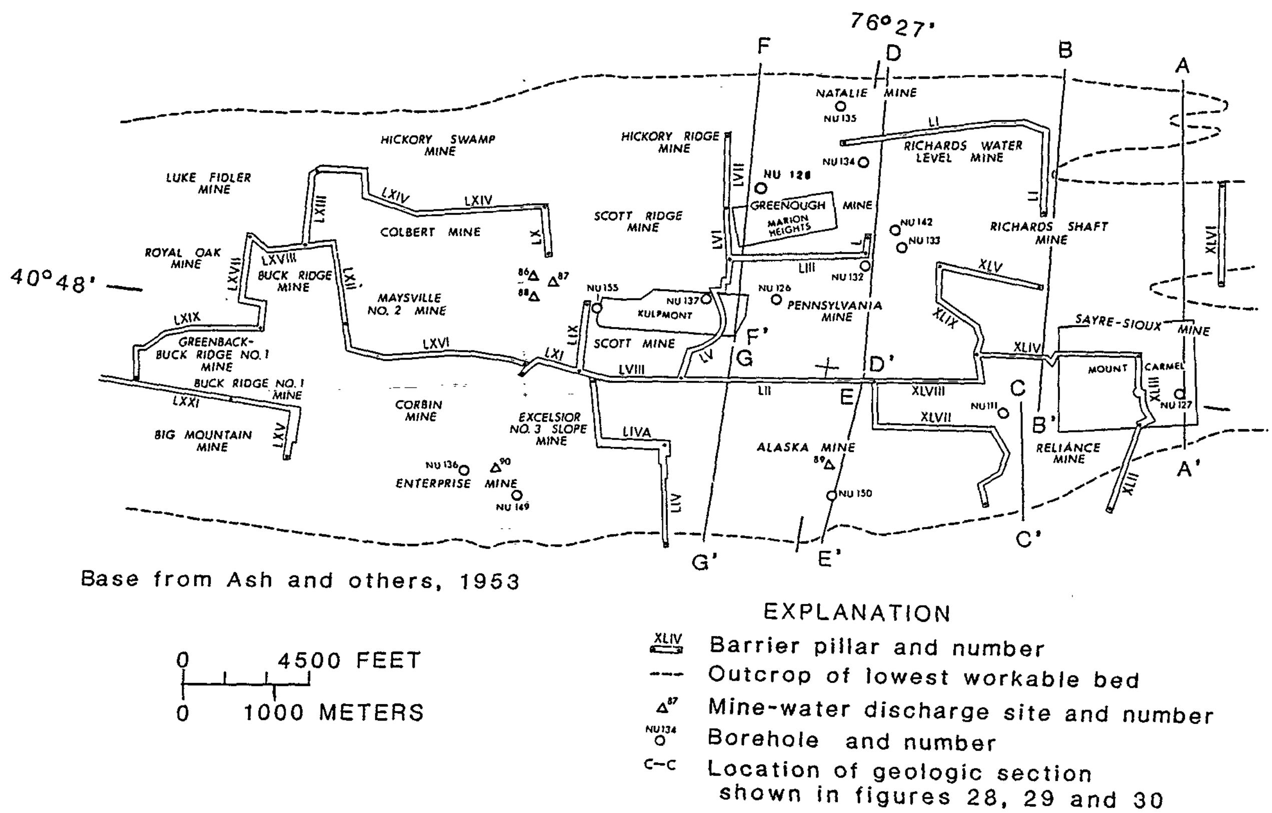


Figure 13.--Deep-mine complexes in the vicinity of Mount Carmel.

Table 9.--Water quality of mire discharges east of Mount Carmel

Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	pH	Concentration, in mg/L sulfate	Concentration, in mg/L iron	Loads, in tons per day sulfate	Loads, in tons per day iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L) 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L) 8.3
81	Mid-Valley mine	seepage	40°49'17" 76°22'21"	4-17-75	0.2	17.5	1,600	2.8	870	10	0.47	0.0054	--	395	429
82	Mid-Valley mine	Mid-Valley tunnel No. 4	40°49'05" 76°23'55"	4-17-75	.4	12.5	280	3.3	264	1	.29	.0011	--	40	48
83	Mid-Valley mine	tunnel	40°48'48" 76°24'24"	4-17-75	5.9	10.5	600	3.3	280	15	4.5	.24	--	140	155

chiefly through a tunnel (site 87), with a smaller amount coming from a mine opening (site 86). Discharge in April 1975 was 15.0 ft^3/s from the tunnel and 2.8 ft^3/s from the mine opening.

Water levels decrease from an altitude of 1,076 ft in the Richards Shaft mine to an altitude of 990 ft at the Scott Ridge mine-discharge tunnel (site 87). The range in water-level altitude was from 995 to 1,021 ft in the Sayre-Sioux mine, from 992 to 1,005 ft in the Pennsylvania mine, and from 992 to 1,005 ft in the Scott mine. Water levels in the Richards Water Level, Natalie, and Greenough mines were about 80 ft higher than the water level in the Scott mine, based on borehole evidence. However, some of the boreholes may not have been in free contact with the main mine openings, and perhaps did not reflect accurately the general water level in the mines.

The mines contain a large amount of water in storage. Ash and others (1949) estimated that the Richards Shaft mine contained 5,025 acre-ft of water when the water level was at an altitude of 1,076 ft; the Sayre-Sioux mine contained 3,490 acre-ft when the water level was at an altitude of 920 ft, and the Pennsylvania mine to contain 6,550 acre-ft when the water level was at an altitude of 888 ft. They also estimated that the Scott and Scott Ridge mines, together, contained 3,710 acre-ft of water when the water level was at an altitude of 886 ft. They estimated that the Richards Water Level, Natalie, and Greenough mines contained 3,140 acre-ft of water, based on water levels at an altitude of 1,070 ft in the Richards Water Level and Greenough mines, and 1,083 ft in the Natalie mine.

Mine water levels are higher now than when Ash and others made their estimates, and significantly more water is in storage now than then. For example, the water level in the Scott and Scott Ridge mines was about 100 feet higher in 1977 than it was when the earlier estimates were made. The Scott and Scott Ridge mines may have contained as much as 4,500 acre-ft of water in 1977, rather than the 3,710 acre-ft of the earlier estimate.

The quality of the water in the eight mines, based on the water from mine discharges and in boreholes, is generally similar, as shown by the data in table 10. The specific conductance ranges from 460 µS/cm in borehole NU-128, in the Greenough mine, to 980 µS/cm for water from the Scott Ridge mine discharge. The ranges in other constituents are also fairly narrow.

Data were collected from one mine shaft and one borehole at the Richards Shaft mine. Mine shaft NU-133--the Richards shaft--was excavated from a land-surface altitude of 1,164 ft through nine coal beds to a bottom altitude of 315 ft. Temperature and specific-conductance logs showed that water was moving from the 350 ft level upward to a tunnel at 950 ft altitude. The temperature ranged from 10.5°C near the water surface (1,074- to 1,077-ft altitude) to 13.0°C near the bottom. Specific conductance ranged from 320 µS/cm near the surface, to 350 µS/cm at 954-ft altitude, to 520 µS/cm at 364 ft, and to 1,450 µS/cm at 334 ft.

Borehole (NU-142) is about 1,500 ft northwest of NU-133 and was drilled from a land-surface altitude of 1,287 ft to 825 ft. The borehole is in an unmined area between the Richards shaft and the Richards Water Level mine. Casing was installed to 1,029 ft altitude. Logs were made on October 5,

Table 10.--Water quality of boreholes and mine discharges near Mount Carmel

MINE DISCHARGES

Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (μS/cm at 25°C)	pH	Concentration, in mg/L sulfate	Concentration, in mg/L iron	Loads, in tons per day sulfate	Loads, in tons per day iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L) 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L) 8.3
86	Scott Ridge mine	breach	40°47'39" 76°29'19"	4-17-75	2.8	12.7	980	5.3	1,190	50	9.0	0.38	16	165	210
87	Scott Ridge mine	rock tunnel	40°47'39" 76°29'19"	4-17-75	15	12.7	980	5.3	490	45	20	1.8	16	115	165
89	Alaska mine	seepage	40°46'56" 76°26'50"	4-17-75	.1	8.0	900	2.7	380	5	.1	.0014	--	183	203
90	Excelsior mine	strip pool overflow	40°46'25" 76°29'37"	4-18-75	13	12.0	810	4.9	400	44	14	1.5	5	158	185

Table 10.--Water quality of boreholes and mine discharges near Mount Carmel--(continued)

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No. USGS	Borehole No. PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)	Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Specific conductance (μS/cm at 25°C)	Dissolved iron (mg/L)
Sayre-Sioux (1940)	580	NU-127	17	1,089	871	1,021-995	Mammoth (void)	8-16-77	660	25
Richards Shaft (1938)	154	NU-133	Richards shaft	1,164	315	1,077-1,074	Little Buck Mountain (void)	11-30-77 8-15-78	520 475	32 29
Richards Shaft (1938)	154	NU-142	30	1,287	825	1,212-1,112	Buck Mountain (no void)	10-5-77	650	45
Pennsylvania (1940)	80	NU-132	Pennsylvania shaft	1,140	615	1,005-992	Little Buck Mountain (void)	12-1-77 4-26-78 8-15-78	830 740 720	46 -- 33
Pennsylvania (1940)	80	NU-126	60	1,117	950	1,005-992	Four-foot (void)	6-2-77	820	50
Natalie (1929)	750	NU-135	49	1,503	970	1,104-1,088	Lykens Valley (void)	10-6-77	320	20
Richards Water Level (1929)	650	NU-134	48	1,435	980	1,201-1,174	Whites (no void)	10-5-77	780	20
Greenough (1926)	453	NU-128	31	1,394	944	1,104-1,074	Whites (void)	8-16-77	460	35
Scott (1928)	-73	NU-137	32	1,143	814	1,004-992	Bottom Split Mammoth (no void)	11-10-77	760	35
Scott (1928)	-73	NU-155	15	1,061	938	1,005-993	Top Split Mammoth (void)	6-2-77	680	50
Reliance (1953)	200	NU-111	16	1,063	856	1,006-984	Holmes (void)	9-15-76	840	80
Alaska (1954)	450	NU-150	33	1,077	853	1,015-991	Four-Foot (no void)	5-27-77	520	1.0
Enterprise (1935)	449	NU-149	36	1,020	----	959-957	Skidmore (no void)	--	--	--
Excelsior (1935)	449	NU-136	55	982	----	956-940	Top Split Mammoth (no void)	1-11-77	240	3.0

1/Voids are areas that have been mined out.

2 Pennsylvania Department of Environmental Resources

1977, and they indicate that the bottom 100 ft of the hole has filled with debris. No mine openings were penetrated by the borehole and water movement could not be detected. Temperatures in the borehole ranged from 10.5 to 11.5°C, and specific conductance ranged from 600 to 700 µS/cm. Water levels ranged from altitudes of 1,112 to 1,212 ft.

Borehole NU-127, in the Sayre-Sioux mine, was drilled from a land-surface altitude of 1,089 ft to 871 ft, and cased to 914 ft altitude. Temperature logs made in the borehole showed large changes below about 940 ft altitude--the temperature declined from about 14.0°C in the casing to 11.5°C in the void in the Top Split Mammoth coal. Specific conductance increased from about 400 µS/cm in the upper part of the casing to 1,000 µS/cm near the bottom of the casing and to 660 µS/cm in the void in the Top Split Mammoth coal.

Borehole NU-126 and shaft NU-132, in the Pennsylvania mine, were logged in June 1977. The borehole was drilled from a land-surface altitude of 1,117 ft, through an opening in the Four-Foot (No. 9 1/2) coal between 992 and 987 ft, to 950 ft. Water temperature was 12.0°C and the specific conductance was 820 µS/cm when logs were made in June 1977. The Pennsylvania shaft, NU-132, which was constructed from a land-surface altitude of 1,140 ft to 615 ft, penetrates several coals--from the Holmes (No. 10) at 1,060 ft, to the Little Buck Mountain (No. 5) at 615 ft. The temperature in the shaft ranged from 12.5°C near the water surface to 14.0°C at the 620 ft level, the maximum depth logged. The specific conductance ranged from 720 to 850 µS/cm in the same interval. Deepest reported mining in the Pennsylvania mine was at an altitude of 80 ft, and the quality of the water deep in the mine may be significantly different from the quality of the water sampled.

Data were collected from two boreholes in the Scott mine--NU-137 in the eastern part of the mine and from NU-155, in the western part. Water levels in both boreholes are virtually the same, as shown by the hydrographs in figure 14.

Borehole NU-137 was drilled from a land-surface altitude of 1,143 ft to an opening in one of the Mammoth coals at 814 ft altitude. The borehole was reported cased to 833 ft altitude. Logs made in November 1977 showed a temperature of 12.5°C near the bottom, and a specific conductance of about 700 µS/cm. Borehole NU-155 was drilled from a land-surface altitude of 1,061 ft to a 3-ft opening in the Top Split Mammoth (No. 9) coal at 938 ft altitude. The borehole was cased to 941 ft altitude. Based on logs made and samples collected in June 1977, the temperature was 15.0°C and the specific conductance near the bottom was 680 µS/cm.

In the Richards Water Level mine, borehole NU-134 penetrates three coal beds but no mine voids. Logs made in October 1977 showed water temperature of 10.5°C and specific conductance of 780 µS/cm. As no openings were reported, the water quality in the borehole may not represent the water quality in the mine. No water movement was detected in the borehole.

Borehole NU-135, in the Natalie mine, was drilled from a land-surface altitude of 1,503 ft to 970 ft, and was cased to 1,038 ft altitude. The borehole terminates in a 6-ft opening in the Lykens Valley (No. 1) coal--the oldest coal bed in the Western Middle field. The specific conductance ranged

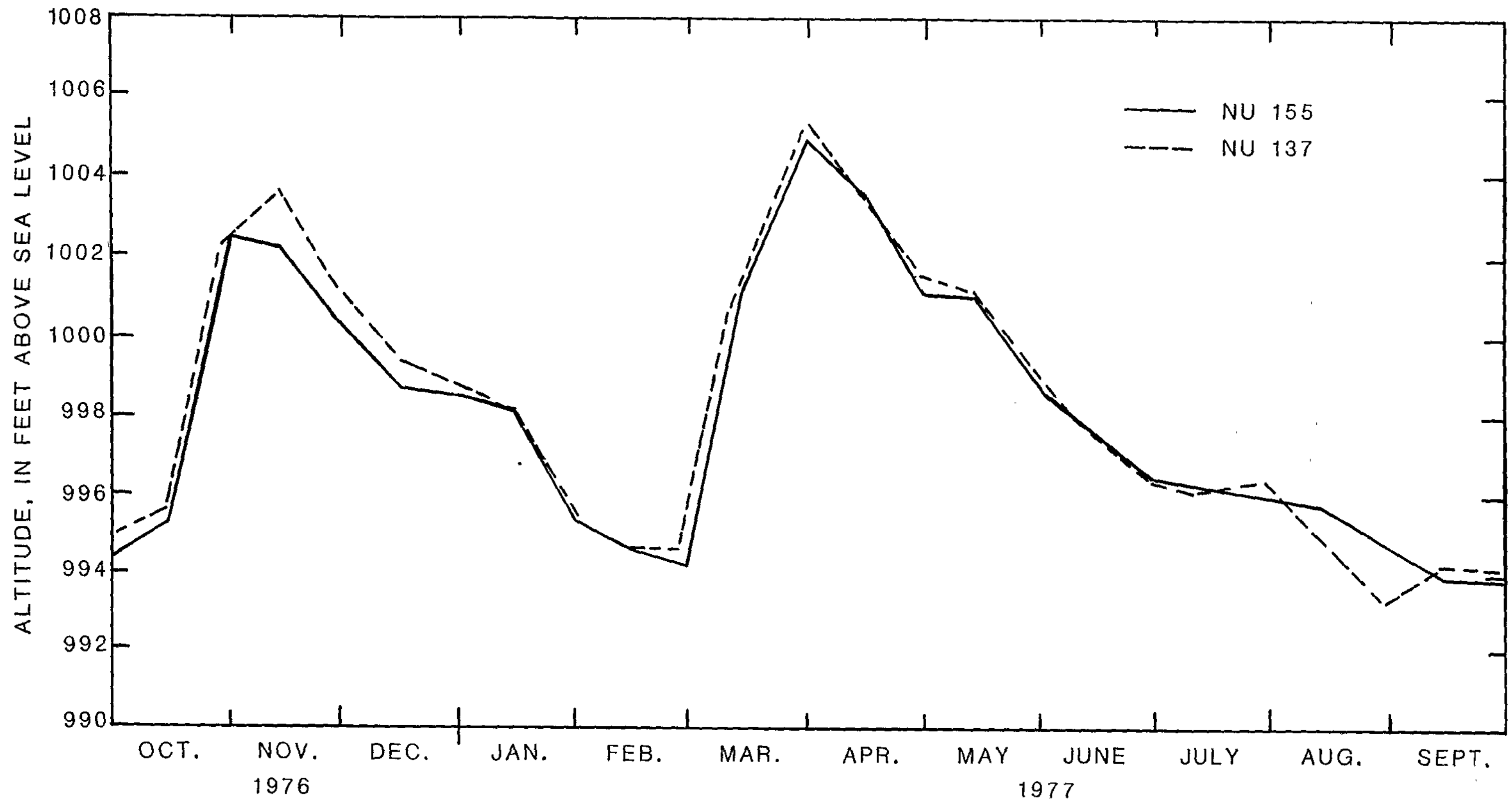


Figure 14.--Water levels in boreholes NU-137 and 155, 1977.

from 100 μS/cm near the water surface (at an altitude of 1,091 ft) to 320 μS/cm near the bottom. Temperature of the water in the mine void was 11.0°C. Water quality is relatively good, probably because the borehole is near the out crop and the detention time of the water in this part of the mine is relatively short.

Borehole NU-128, in the Greenough mine, was drilled from a land-surface altitude of 1,394 ft to 944 ft. The borehole transects an opening in the Whites (No. 3) coal between 991 and 985 ft altitude. Based on logs made in August 1977, temperature ranged from 11.5°C at the water surface (1,076 ft altitude), to 11.0°C in the mine opening. Specific conductance ranged from 200 to 460 μS/cm in the same interval.

Four mines west of Mount Carmel, in the southern part of the area shown in figure 13, are not in hydraulic connection with the eight mines discussed in the above paragraphs. Water flows west through breached barrier pillars from the Reliance mine, just south of Mount Carmel, into the Alaska mine. The Alaska mine is connected to the Enterprise and Excelsior mine, also through breached barrier pillars. Discharge is chiefly by overflow from the Excelsior mine (site 90) and includes drainage from the Reliance, most of the Alaska, and the eastern parts of the Enterprise and Excelsior mines--an area of 5.1 mi^2. Parts of the Alaska (site 89) and Enterprise mines also discharge to the surface locally. Discharge from the Excelsior mine (site 90) in April 1975 was 13.0 ft^3/s, and the specific conductance was 810 μS/cm. Seepage from the Alaska mine (site 89) was 0.1 ft^3/s.

Water levels in the Reliance mine, measured in borehole NU-111, which reaches an 8-ft opening in the Holmes (No. 10) coal at an altitude of 856 ft, ranged from altitudes of 1,006 to 984 ft during this investigation. The specific conductance of the water at the opening in the Holmes coal was 840 μS/cm when logs were made in September 1976. The altitude of the discharge point (site 90) from the Excelsior mine is 970 ft. Intervening water levels in the Alaska, Enterprise, and Excelsior mines could not be determined with confidence because none of the boreholes in these mines penetrated mine voids, and it was not known whether water levels measured in the boreholes were the same as those in the mines.

The volume of water stored in the Enterprise and Excelsior mines was estimated by Ash and others (1949) to total 2,600 acre-ft when the water level was at an altitude of 865 ft. The present water level is 100 ft higher, based on the altitude (970 ft) of the discharge (site 90) from the Excelsior mine. The volumes of water stored in the Reliance and Alaska mines are not known, but based on the extensive mining that has occurred, both mines together may hold 6,000 acre-feet of water.

Quality of water in the Reliance, Alaska, Enterprise, and Excelsior mines is similar to that in the eight mines discussed earlier in this section, as shown by the chemical-quality data in table 10.

Water discharged from the Excelsior mine (site 90) had a temperature of 12.0°C and a specific conductance of 810 μS/cm. The temperature of water from the Alaska mine (site 89) was 8.0°C, but the discharge was only 0.1 ft^3/s and the temperature is probably not representative of the temperatures in the mine.

The water temperature near the bottom of borehole NU-111, described earlier in the Reliance mine, was 12.°C. The specific conductance from 975 to 855 ft was about 300 µS/cm but increased to 840 µS/cm at 855 ft (the opening in the Holmes (No. 10) coal). Boreholes NU-136, NU-149, and NU-150, in the Excelsior, Enterprise, and Alaska mines, respectively, do not intersect mine openings and the reported chemical constitutents in table 10 may not be representative of the water generally in the mines.

Mines Near Shamokin

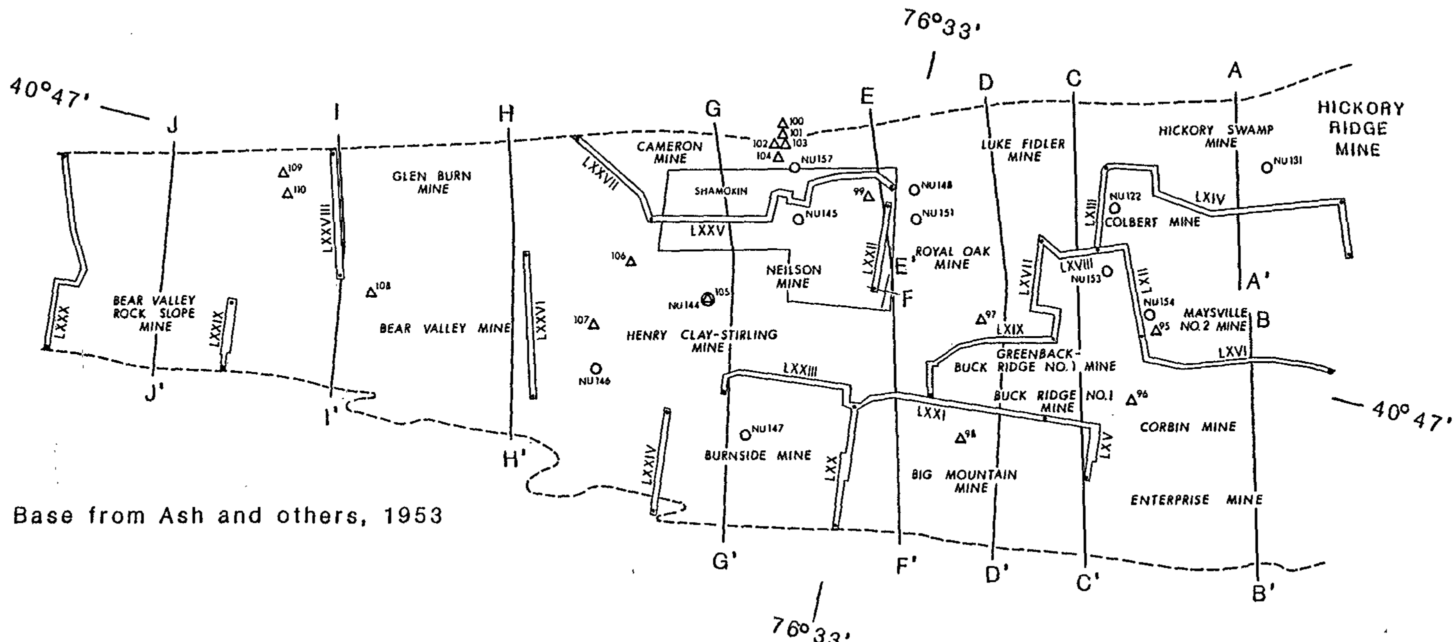
Seventeen mines in this area, shown in figure 15, were investigated; water from at least 12 of these mines drains into other mines before discharging at the surface. Total discharge measured in April 1975 was 31.8 ft^3/s from 17 shafts, tunnels, and seepage points; the largest single discharge was 11.0 ft^3/s from one of two discharge points (site 105) in the Henry Clay-Stirling mine about 0.25 mi south of Shamokin.

Beginning with the easternmost mines and proceeding generally westward, water from the Hickory Ridge mine flows into the Hickory Swamp mine and thence into the Luke Fidler mine, which receives water also from the Colbert mine. Water from the Luke Fidler mine flows into the Cameron mine, which also receives water from five other mines--the Buck Ridge, Greenback-Buck Ridge, Royal Oak, Neilson, and Glen Burn mines--before discharging into Shamokin Creek. Water in two mines southeast of Shamokin--the Maysville (site 95) and Big Mountain (site 98)--discharges directly to the surface. The Henry Clay-Stirling mine receives water from the Burnside mine and also from the Bear Valley mine, from which mine water also discharges by seepage. The Bear Valley mine also receives water from the Bear Valley Rock Slope mine to the west. The total area that drains to the Henry Clay-Stirling mine is about 7.5 mi^2.

Water levels in the Hickory Ridge, Hickory Swamp, and Luke Fidler mines are probably about 750 ft in altitude; the water level in the Cameron mine is probably close to 723 ft, which is the altitude of the discharge to Shamokin Creek. Water levels in the Maysville and Big Mountain mines, each of which discharges directly to the surface, are approximately at altitudes 860 and 869 ft, based on the altitudes of their respective discharge points, sites 95 and 98. Water levels in the Bear Valley, Burnside, and Henry Clay-Stirling mines are all about 770 ft in altitude.

Water in storage in many of the mines was estimated by Ash and others (1949) based on mine water levels that prevailed in the late 1940's. For some mines where water levels are controlled by the altitude of the discharge points, water levels are essentially the same now (1985) as they were then and these early estimates probably are valid. In other mines, water levels may be tens of feet higher now than in the 1940's.

For mines whose water levels are essentially unchanged, Ash and others (1949) estimated water in storage as follows: Big Mountain mine, 2,530 acre-ft; Bear Valley and Bear Valley Rock Slope mines combined, 4,060 acre-ft; Burnside mine, 3,390 acre-ft; and Henry Clay-Stirling mine, 8,250 acre-ft. Other estimates by Ash and others (1949) for mines in which water



Base from Ash and others, 1953

0 4500 FEET
0 1000 METERS

EXPLANATION

- LXV — Barrier pillar and number
- --- — Outcrop of lowest workable bed
- NU144 o — Borehole and number
- △108 — Mine-water discharge site and number
- A—A' — Location of geologic section shown in figures 31, 32, 33 and 34

Figure 15.--Deep-mine complexes near Shamokin.

levels may or may not be the same now as when the estimates were made are: Colbert mine, 727 acre-ft at a water-level altitude of 800-ft; Buck Ridge mine, 712 acre-ft at 824-ft altitude; Greenback-Buck Ridge mine, 916 acre-ft at 775-ft altitude; Royal Oak mine, 287 acre-ft at 770-ft altitude; and Neilson mine, 127 acre-ft at 730-ft altitude.

Mines for which the estimates by Ash and others (1949) are based on water levels lower than those that occur now are as follows: Cameron mine, 3,570 acre-ft at 430 ft altitude; the Luke Fidler mine, 1,890 acre-feet at 542 ft altitude; the Hickory Ridge mine, 58 acre-ft at 690 ft altitude; and the Hickory Swamp mine, 322 acre-ft at 650 ft altitude. For the present water levels, storage is estimated to be 7,000 acre-ft in the Cameron mine, 2,500 acre-ft in the Luke Fidler mine, 150 acre-ft in the Hickory Ridge mine, and 400 acre-ft in the Hickory Swamp mine. No data were given for the Glen Burn mine, which may contain 1,000 acre-ft of water at the present water-level altitude of 720 ft.

The specific conductance of water from the mine discharges near Shamokin (table 11) ranges from 160 µS/cm at the Bear Valley mine (site 109) to 1,700 µS/cm at the Cameron mine (site 101). If data from boreholes are included, the range is even larger--from 85 µS/cm in borehole NU-131, in the Hickory Ridge mine, to 5,000 µS/cm in borehole NU-122, in the Colbert mine. Generally, mine-water quality probably does not differ as much as these ranges suggest. Some values in table 11 are clearly seen to be anamolous, either because the local discharges are not representative of general water quality in the mines, or because samples were taken from isolated or plugged-up boreholes, or because of other factors. Most generally representative of mine-water quality are concentrations of chemical constituents associated with the larger mine discharges.

Water from the largest single discharge, 11.0 ft^3/s from the Henry Clay-Stirling mine (site 105), had a specific conductance of 950 µS/cm. The specific conductance of water from four minor discharges (sites 107, 108, 109, 110) from the Bear Valley mine--one of the mines that drains to the Henry Clay-Stirling mine--ranged from 160 to 800 µS/cm. However, total discharge from the four sampling points was only 0.85 ft^3/s, and it is doubtful that any of the specific conductance values is representative of the water generally in the mine.

Water from the Cameron mine, which receives water directly from six mines and indirectly from two others, shows, not unexpectedly, the highest specific conductance, which ranges from 1,000 to 1,700 µS/cm from four discharges (sites 100, 101, 103, 104), that total 9.81 ft^3/s.

Water from the Maysville mine discharges from a borehole (site 95) at altitude 860 ft. In April 1975, discharge was 3.3 ft^3/s. The water had a specific conductance of 1,000 µS/cm and a temperature of 11.0°C. Most of the mine waters from the more significant discharges are highly mineralized, with specific conductances that generally exceed 900 µS/cm. Exceptions are waters from the Big Mountain and Neilson mines where specific conductances were somewhat lower--700 and 600 µS/cm, respectively--from discharge points 98 and 99. The specific conductance of water from the Corbin mine (site 96) also was relatively low (810 µS/cm).

Table 11.--Water quality of boreholes and mine discharges near Shamokin

MINE DISCHARGES

Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (μS/cm at 25°C)	pH	Concentration, in mg/L: sulfate	Concentration, in mg/L: iron	Loads, in tons per day: sulfate	Loads, in tons per day: iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L): 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L): 8.3
88	Colbert mine	breach	40°47'26" 76°29'41"	4-17-75	0.9	12.0	900	5.3	510	40	1.2	0.10	13	118	138
95	Maysville mine	borehole	40°47'03" 76°30'52"	4-16-75	3.3	11.2	1,000	6.3	460	50	4.1	.45	133	125	200
96	Corbin mine	Corbin water level drift	40°46'46" 76°30'53"	4-16-75	1.0	12.0	810	4.1	490	40	1.3	.11	--	210	230
97	Royal Oak mine	seepage	40°46'57" 76°32'05"	4-16-75	.1	12.5	720	5.3	370	30	.10	.0081	35	115	135
98	Big Mountain mine	No. 1 slope	40°46'19" 76°32'19"	4-16-75	2.0	11.5	700	3.4	300	20	1.6	.11	--	150	160
99	Neilson mine	Shamokin City drainage tunnel	40°47'28" 76°34'09"	4-16-75	2.6	10.5	600	6.1	230	5	1.6	.035	33	20	35
100	Cameron mine	air shaft	40°47'44" 76°33'59"	4-16-75	4.0	12.2	1,470	3.4	790	60	8.5	.65	--	355	385
101	Cameron mine	drift	40°47'37" 76°33'55"	4-16-75	4.7	14.0	1,700	4.1	1,100	150	14	1.9	--	420	474
102	Cameron mine	intermittent pump	40°47'35" 76°33'34"	4-16-75	.00	--	--	--	--	--	--	--	--	-	--
103	Cameron mine	seepage	40°47'30" 76°33'52"	4-16-75	.01	12.5	1,000	4.7	550	60	.00	.0000	5	230	255
104	Cameron mine	drift and tunnel	40°47'31" 76°33'46"	4-16-75	1.1	14.5	1,300	5.5	920	60	2.7	.18	38	185	210
105	Henry Clay Stirling mine	pump slope	40°40'37" 76°34'07"	4-16-75	11	13.0	950	5.6	470	50	14	1.5	43	145	170
106	Henry Clay Stirling mine	collapsed drift	40°46'43" 76°34'47"	4-16-75	.2	11.0	355	6.1	91	10	.05	.0054	79	33	65
107	Bear Valley mine	seepage	40°46'14" 76°35'11"	4-16-75	.1	11.0	800	3.3	380	1	.10	.0003	--	120	123
108	Bear Valley mine	North Mountain tunnel collapsed	40°46'18" 76°36'59"	4-15-75	.6	9.5	405	5.6	180	20	.29	.032	28	90	105
109	Bear Valley mine	seepage	40°47'54" 76°37'28"	4-15-75	.1	7.0	160	5.7	61	1	.02	.0003	3	5	8
110	Bear Valley mine	strip pool overflow	40°46'42" 76°37'30"	4-15-75	.05	9.0	180	5.5	78	1	.01	.0001	7	5	8

Table 11.--Water quality of boreholes and mine discharges near Shamokin--(continued)

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No. USGS	Borehole No. PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)	Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Specific conductance (µS/cm at 25°C)	Dissolved iron (mg/L)
Burnside (1932)	200	NU-147	12	976	676	844-781	Primrose (no void)	--	--	--
Bear Valley (1939)	400	NU-146	42	946	610	789-783	Rough (no void)	5-25-77	1,100	35
Henry-Clay-Sterling (1932)	250	NU-144	40	780	500	779-777	Little Orchard (no void)	5-24-77 8-15-78	650 770	1.5 14
Colbert (1929)	206	NU-122	35	917	687	760-721	Buck Mountain (no void)	5-31-77	5,000	40
Maysville (1966)	500	NU-154	37	873	502	858-851	Orchard (no void)	6-1-77 8-15-78	540 540	1.0 1.6
Buck Ridge (1900)	257	NU-153	13	939	550	839-819	Little Orchard	5-1-77	830	35
Hickory Ridge (1929)	670	NU-131	50	1,139	779	1,057-1,052	Buck Mountain (no void)	9-28-77 8-15-78	120 85	15 1.8
Royal Oak (1906)	364	NU-151	52	774	449	765-758	Orchard (no void)	5-31-77	950	10
Luke Fidler (1929)	-788	NU-148	38	804	354	755-748	Primrose (no void)	5-26-77	875	1.0
Neilson (1900)	200	NU-145	53	739	562	730-725	Orchard (no void)	5-24-77 8-15-78	1,200 1,060	1.0 0.77
Cameron (1928)	-300	NU-157	Cameron shaft	734	415	714	Holmes	11-15-77 12-6-77 8-15-78	2,900 2,800 2,080	70 56 18

1/Voids are areas that have been mined out.

2/Pennsylvania Department of Environmental Resources

Borehole NU-144, in the Henry Clay-Stirling mine, was drilled from a land-surface altitude of 780 ft to 500 ft. No mine openings were penetrated and the water quality probably is not representative of the general quality in the mine. The specific conductance in May 1977 ranged from 250 µS/cm near the water surface (about two feet below the land surface) to 650 µS/cm near the bottom of the borehole.

Borehole NU-146, in the Bear Valley mine, was drilled from a land-surface altitude of 946 ft to 610 ft. One mine void was penetrated at an altitude of 835 ft--50 ft above the water surface. Specific conductance ranged from 450 µS/cm at 725 ft to 1,200 µS/cm at 618-ft altitude. Temperature ranged from 11.6°C near the water surface to 12.0°C in the bottom 40 feet of the borehole. Borehole NU-147, in the Burnside mine, could not be sampled because of an obstruction.

Borehole NU-154, in the Maysville mine, was drilled from a land-surface altitude of 873 ft to 502 ft. The uppermost 300-ft section was cased. No mine voids were encountered in the drilling and water in the borehole is probably not representative of that in the mine. In June 1977, water temperature was 12.0°C. Specific conductance was 540 µS/cm, about half that of water discharged from the borehole at site 95.

Six of the boreholes listed in table 11 are in mines that drain, directly or indirectly, into the Cameron mine. The mines (and boreholes) are the Neilson (NU-145), Royal Oak (NU-151), Buck Ridge (NU-153), Luke Fidler (NU-148), Colbert (NU-122), and Hickory Ridge (NU-131).

Borehole NU-145, in the Neilson mine, was drilled from a land-surface altitude of 739 ft to 562 ft. It was cased to an altitude of 593 ft. No openings were reported, but caliper logs made in May 1977 indicated a possible fracture at 579 ft. The water-level altitude of 727 ft may be approximately the same as the general water level in the mine. The specific conductance ranged from 600 µS/cm near the water surface to 1,200 µS/cm near the bottom. The temperature ranged from 13.0°C to 14.0°C over about the same interval.

Borehole NU-151, in the Royal Oak mine, was drilled from a land-surface altitude of 774 ft to 449 ft and cased to an altitude of 582 ft. No mine openings were reported when the borehole was drilled. Specific conductance ranged from 600 µS/cm near the water surface (about 760 ft) to 950 µS/cm near the bottom. Temperature was 10.0°C near the water surface and 12.0°C near the bottom.

Borehole NU-153, in the Buck Ridge mine, was drilled from a land-surface altitude of 939 ft to 550 ft, and cased to an altitude of 571 ft. The borehole penetrates the Little Orchard (No. 13) coal between an altitude of 574 and 554 ft. It is not known if the Little Orchard coal had been mined in the area. The water level ranged between altitudes of 839 and 819 ft. The specific conductance of a sample collected near the bottom of the borehole was 830 µS/cm.

Borehole NU-148, in the Luke Fidler mine, was drilled from a land-surface altitude of 804 ft to 354 ft, and cased to an altitude of 504 ft. No mine openings were reported when the borehole was drilled; however, temperature, specific conductance, and brine-trace logs made in May 1977 indicated a downward flow of water of about 5 gal/min originating behind the casing at an altitude of 604 ft, and downward to an opening at an altitude of 436 ft. A sample collected at an altitude of 474 ft had a specific conductance of 875 µS/cm; the temperature was 14.5°C. The deepest mining reported in the Luke Fidler mine was at an altitude of -788 ft (788 ft below sea level).

Borehole NU-122, in the Colbert mine, was drilled from a land-surface altitude of 917 ft to 687 ft, and cased to an altitude of 708 ft. No mine openings were reported when the borehole was drilled; the lowest coal bed in the borehole is the Buck Mountain (from altitudes of 720 to 710 ft), and it was not mined in the area. When logs were made in May 31, 1977, the water level was at an altitude of 743 ft, and the borehole was filled with debris below an altitude of 713 ft. Temperature of water ranged from 12.6°C near the surface to 15.2°C near the bottom. Specific conductance ranged from 1,000 µS/cm near the water surface to 5,000 µS/cm near the bottom.

Borehole NU-131, in the Hickory Ridge mine, was drilled from a land-surface altitude of 1,139 ft to 779 ft, and cased to an altitude of 829 ft. An opening was encountered from altitudes 1,073 to 1,067 ft; the opening was above the water level and was cased. No other openings or coal beds were encountered. Water levels in the borehole ranged from altitudes of 1,052 to 1,057 ft; however, the water level in the mine is probably at an altitude of 750 ft, which is 30 ft below the bottom of the borehole. Logs were made in September 1977; temperature was 10.8°C and specific conductance was 120 µS/cm.

Drainage Area 5

The North Franklin Mine Near Trevorton

The North Franklin mine, at the west end of the Western Middle coal field, is separated from the other mines in the Shamokin area by an intact barrier pillar (fig. 16) and drains into Zerbe Run, a tributary of Mahanoy Creek. If the outlet to Zerbe Run were blocked and the water level in the mine allowed to rise 5 or 10 ft, drainage from the North Franklin mine would be to the Bear Valley Rock Slope mine and ultimately into Shamokin Creek.

The water level in the North Franklin mine is about at an altitude of 870 ft, based on the altitude of the discharge points (sites 111, and 112). At this level, the mine contains an estimated 4,900 acre-ft of water (Ash and others, 1949). Discharge from the mine in April 1975 from sites 111 and 112 (table 12) was 8.3 ft^3/s. The discharge of Zerbe Run, below Trevorton, was 17.4 ft^3/s. The specific conductance of the water from site 112 was 1,100 µS/cm.

Borehole NU-129, in the North Franklin mine, was drilled from a land-surface altitude of 872 ft to an opening in the Bottom Split Mammoth (No. 8) coal at an altitude of 530 ft. Based on logs made in September 1977, the specific conductance ranged from 700 to 790 µS/cm, which is significantly different from that of the water at the mine discharge. Temperature in the borehole was 11.5°C.

Table 12--Water quality of boreholes and mine discharges near Trevorton

MINE DISCHARGES

Site number	Name	Description	Location (Lat-Long.)	Sampling date (mo-d-yr)	Discharge (ft^3/s)	Water temperature (°C)	Specific conductance (µS/cm at 25°C)	pH	Concentration, in mg/L: sulfate	Concentration, in mg/L: iron	Loads, in tons per day: sulfate	Loads, in tons per day: iron	Alkalinity to pH 4.5 as $CaCO_3$ (mg/L)	Acidity to indicated pH, as $CaCO_3$ (mg/L): 7.0	Acidity to indicated pH, as $CaCO_3$ (mg/L): 8.3
111	North Franklin mine	drift and borehole	40°46'17" 76°40'44"	4-18-75	7.3	12.5	980	3.7	580	25	11	0.49	--	150	175
112	North Franklin mine	includes 111 and additional seeps	40°46'36" 76°40'58"	4-18-75	8.3	12.5	1,100	3.5	560	22	13	.49	--	225	250

BOREHOLES

Mine complex and year closed	Minimum altitude of mine voids[1] in feet above mean sea level	Borehole No.: USGS	Borehole No.: PaDER[2]	Altitude of land surface (In feet above mean sea level)	Altitude of bottom of borehole (In feet above mean sea level)	Range in water levels Dec. 1975 to Dec. 1977 (In feet above mean sea level)	Lowest coal bed in borehole	Water quality in borehole below casing: Date sampled (mo-d-yr)	Water quality in borehole below casing: Specific conductance (µS/cm at 25°C)	Water quality in borehole below casing: Dissolved iron (mg/L)
North Franklin (1929)	315	NU-129	43	872	530	871-869	Bottom Split Mammoth (void)	9-23-77	700	8.0

[1]/Voids are areas that have been mined out.

[2]/Pennsylvania Department of Environmental Resources

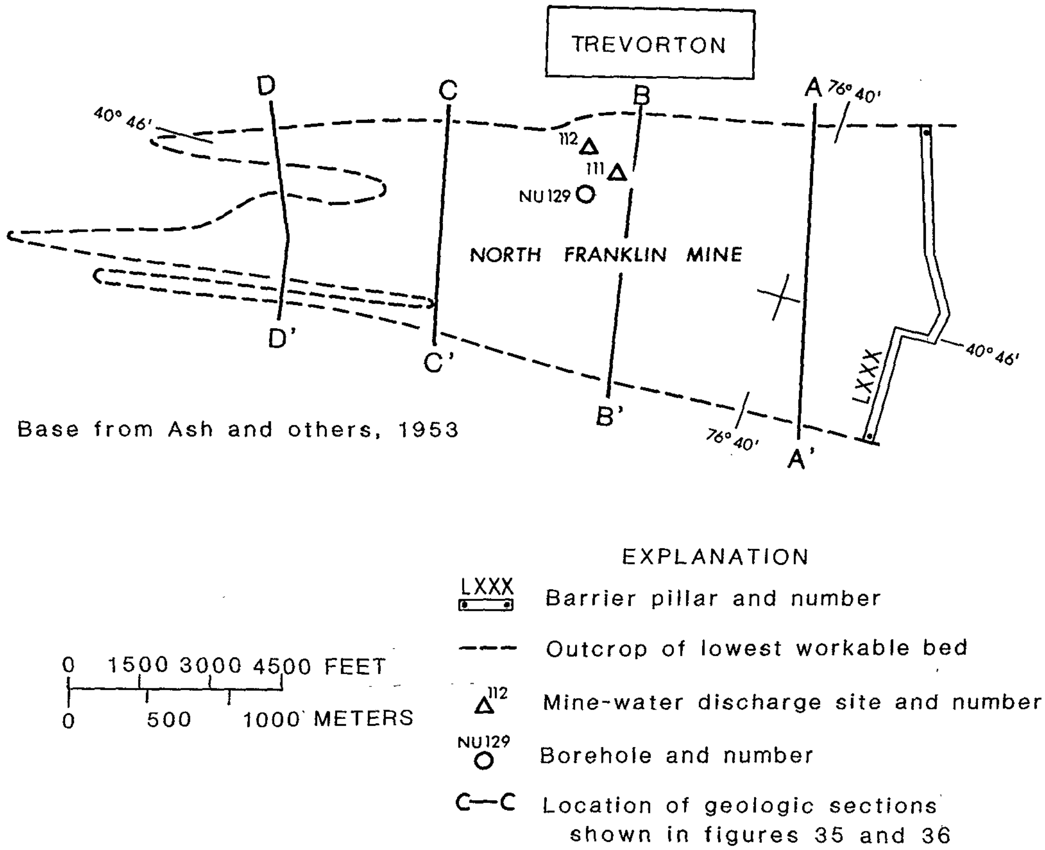


Figure 16.--The North Franklin mine near Trevorton.

COMPARISON OF MINE DISCHARGES FROM 1941 TO 1975

In the Western Middle field mine, water levels were higher and discharges larger in 1975-78 than they were in the 1940's when previous investigations were made. As a result, the water in the mines and water discharged at the surface are of significantly better quality now (1985), than in earlier years.

The mines were estimated to contain 218,000 acre-ft of water in 1975, which is nearly twice the 118,000 acre-ft estimated by Ash and others (1949) based on studies made in 1945 and 1946. Discharge in 1975 was 206 ft^3/s or 72 percent more than that determined in 1941 by Felegy and others (1948). Total acid load in 1975 was 102 ton/d, as H_2SO_4, or 55 percent less than in 1941. The improvement in water quality is due partly to greater dilution afforded by the increased volume of water being discharged, and also to the fact that the generally higher water levels (and consequent mine flooding) has resulted in less exposure and oxidation of acid-producing minerals in the mines. Direct comparisons between individual mines from 1941 to 1975 can not be made because the report by Felegy and others (1948) did not list discharges by mine name or location.

SUMMARY

This report presents information on the quality of water available from abandoned and flooded coal mines in the Western Middle anthracite field in east-central Pennsylvania--one of four anthracite fields where coal was extensively mined from about 1840 through 1950. Data were collected between April 1975 and April 1976. Individual mine discharges were measured and sampled in April 1975; the larger discharges were sampled monthly from September 1975 to April 1976. Water samples also were collected from mine shafts and boreholes.

Geologically, the Western Middle anthracite field is a synclinal basin that is divided by parallel faults into 26 smaller basins that contain the coal deposits. About 1.6 billion (1,600,000,000) tons of anthracite were mined from the coal basins, leaving unmined about 3.6 billion tons. Most of the coal was removed by deep mining methods that created about 25 billion cubic feet of subsurface voids. Most of the deep mines are now closed and flooded. Because all mine openings are connected to the mine shaft, directly or by horizontal tunnels, the water-surface altitudes are generally uniform within a mine complex. In many places, adjacent mine complexes are connected through breached barrier pillars.

The Vulcan-Buck Mountain mine, east-northeast of Mahanoy City, contains an estimated 6,100 acre-ft of water. Discharge was measured and sampled monthly from July 1975 through March 1976. During those 9 months, discharge ranged from 3.7 to 12.0 ft^3/s (average 7.4 ft^3/s), specific conductance from 380 to 460 µS/cm and pH from 4.5 to 4.7 units. Water in the Primrose and Park mines is not discharged locally at the surface, but moves through breached barrier pillars into mines northwest of Mahanoy City, from which it is ultimately discharged. The Primrose mine may contain 700 acre-ft, based on the 1977 water-level altitude of 1,120 ft. The Park mine (No. 1 and No. 2 mines) may contain 1,000 acre-ft of water, and logs made March 1977 and August 1978 showed the specific conductance was 415 and 560 µS/cm, respectively.

Twenty-two mines are in a 15 mi^2 area between Mahanoy City and Girardville, all of which closed prior to 1958. Seven of these mines are in the Mahanoy coal basin, and 15 are in the eight basins known as the Shenandoah complex. The seven mines in the Mahanoy basin may contain 30,000 acre-ft of water. Discharge from the Mahanoy basin is at two sites--a pump at the Gilberton mine that operates 40 percent of the time and from a mine opening at the Girard mine. Water discharge was 8.0 ft^3/s from the Girard mine and the average discharge from the Gilberton mine pump was 9.2 ft^3/s. Specific conductance was 825 µS/cm from the Girard mine and 1,800 µS/cm in water from the Gilberton mine.

Water in the Tunnel Ridge mine was sampled at an opening in the Bottom Split Mammoth (No. 8) coal. The Mammoth coal crops out about 300 ft north of the borehole. In August 1976, the specific conductance was 630 µS/cm and in February 1977 was 390 µS/cm. These seasonal differences may be caused by water entering the voids left after the Mammoth coal was mined to the surface. Water in the St. Nicholas mine was sampled at a void in the Little Buck Mountain (No. 5) coal; specific conductance was 870 µS/cm in August 1976 and

1,350 μS/cm in March 1977. Water in the Gilberton mine was sampled at an opening in the Top Split Mammoth (No. 9) coal; the specific conductance was 1,400 μS/cm. Water in the West Bear Ridge mine was sampled at an opening in the Mammoth coal (No. 8); specific conductance was 600 μS/cm.

Water from the mines in the Shenandoah complex, including water from the Primrose and Park mines in the Mahanoy basin, moves westward through breached barrier pillars from one mine to another and discharges at points near Girardville. Most of the water discharged from the Shenandoah complex is discharged at the Packer No. 5 mine. In April 1975, the water discharge was 45 ft^3/s, the specific conductance was 2,400 μS/cm, and the temperature was 15.0°C. The relatively warm water temperature indicates that the water is coming from deep sources.

The mine waters in the Shenandoah complex become increasingly mineralized from east to west--the direction of movement. On the north side of the Knickerbocker basin, water was sampled at an opening in the Buck Mountain coal (No. 5), which was mined to the surface. The specific-conductance values were 240 and 310 μS/cm in August 1976 and March 1977, respectively. In the Mahanoy City mine, a water sample collected from an opening in the Skidmore coal (No. 7) had a specific conductance of 760 μS/cm. A water sample collected from the Bottom Split Mammoth coal at the Indian Ridge mine near the middle of the Shenandoah complex had a low specific conductance, 400 μS/cm but was high in dissolved iron (about 25 mg/L).

Two water samples were collected from an opening in the Skidmore coal in the Hammond mine near Girardville. The specific conductance ranged from 1,450 to 1,600 μS/cm. Water samples collected from a borehole in the Packer No. 5 mine at Girardville had a specific conductance of 2,000 μS/cm, about the same as that of the discharge from the mine.

The Midvalley mines contain an estimated 1,500 acre-feet of water. No borehole data are available from the Midvalley mines, but water discharge was 5.9 ft^3/s in April 1975 and the specific conductance was 600 μS/cm. Eight mines near Mount Carmel are connected in various degree through breached barrier pillars and drainage tunnels. The mines contain a large amount of water in storage. The Richards Shaft, the Sayre-Sioux, the Pennsylvania, the Scott and the Scott Ridge mines together, and the Richards Water Level, the Natalie, and the Greenough mines together contained 5,025, 3,490, 6,550, 3,710, and 3,140 acre-ft of water, respectively, when water levels were about 100 ft lower than those in 1975. The quality of the water in the eight mines, based on the water from mine discharges and in boreholes, is generally uniform. The specific conductance ranges from 460 μS/cm in the Greenough mine to 980 μS/cm for water from the Scott Ridge mine discharge.

Seventeen mines near Shamokin were investigated; water from at least 12 drains into other mines before discharging at the surface. Total discharge measured in April 1975 was 31.8 ft^3/s from 17 shafts, tunnels, and seepage points. Water from the largest single discharge--11.0 ft^3/s from the Henry Clay-Stirling mine (site 105), had a specific conductance of 950 μS/cm.

The water level in the North Franklin mine, near Trevorton, is about at an altitude of 870 ft, based on the altitude of the discharge points (site 111 and 112). The mine contains about 4,900 acre-ft of water. Discharge from the mine in April 1975 was 8.3 ft^3/s, and the specific conductance was 1,100 μS/cm. A sample collected from an opening in the Bottom Split Mammoth coal in the North Franklin mine had a specific conductance of 790 μS/cm, which is significantly different from that of the water at the mine discharge.

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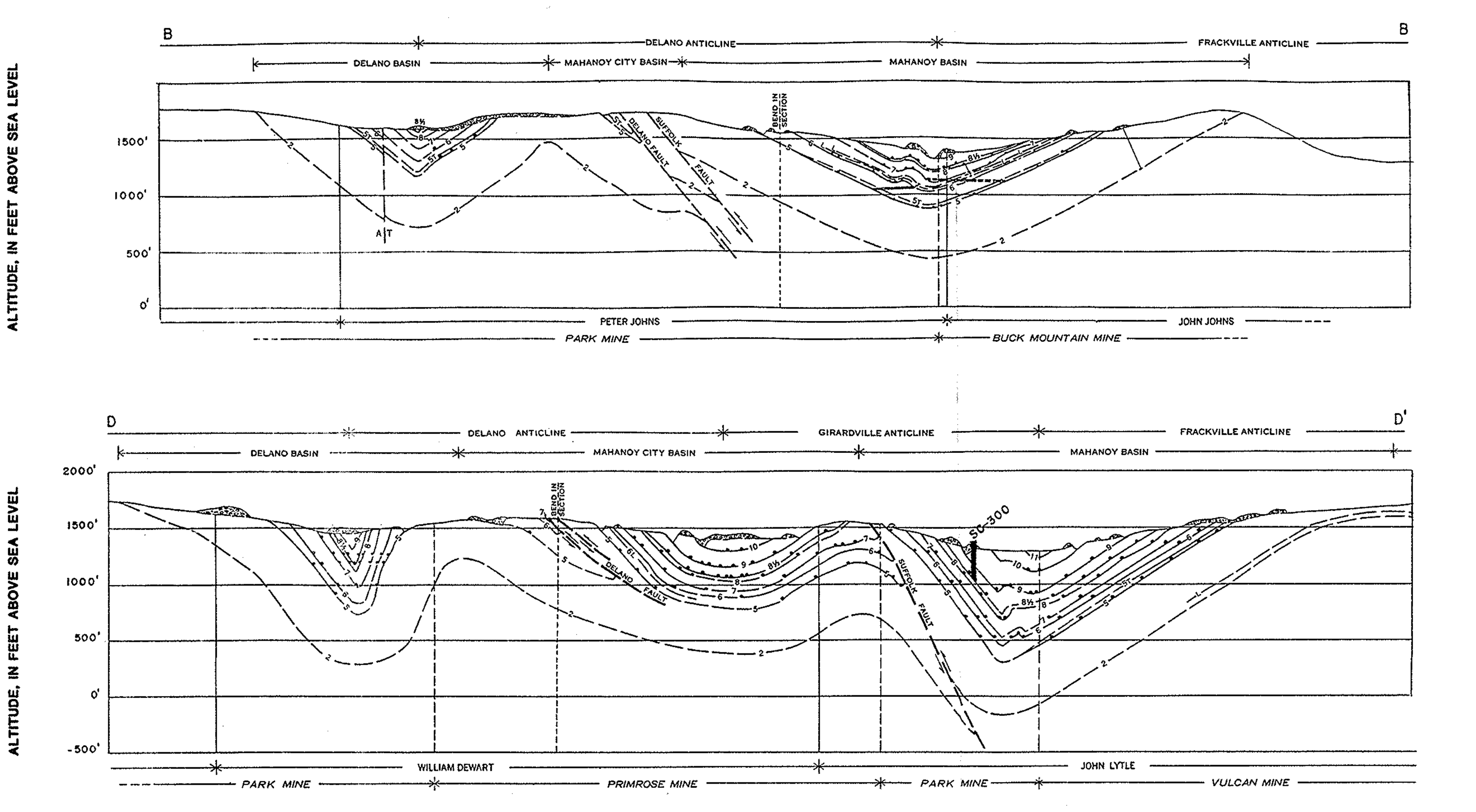
------1951b, Geology of anthracite in the east-central part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-10.

------1953, Geology of anthracite in the southeastern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-12.

U.S. Bureau of Mines, 1979, Site selection and financial analysis of deep surface mining of anthracite coal: U.S. Department of Energy Technical Report FE-9006-TI, 607 p.



EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

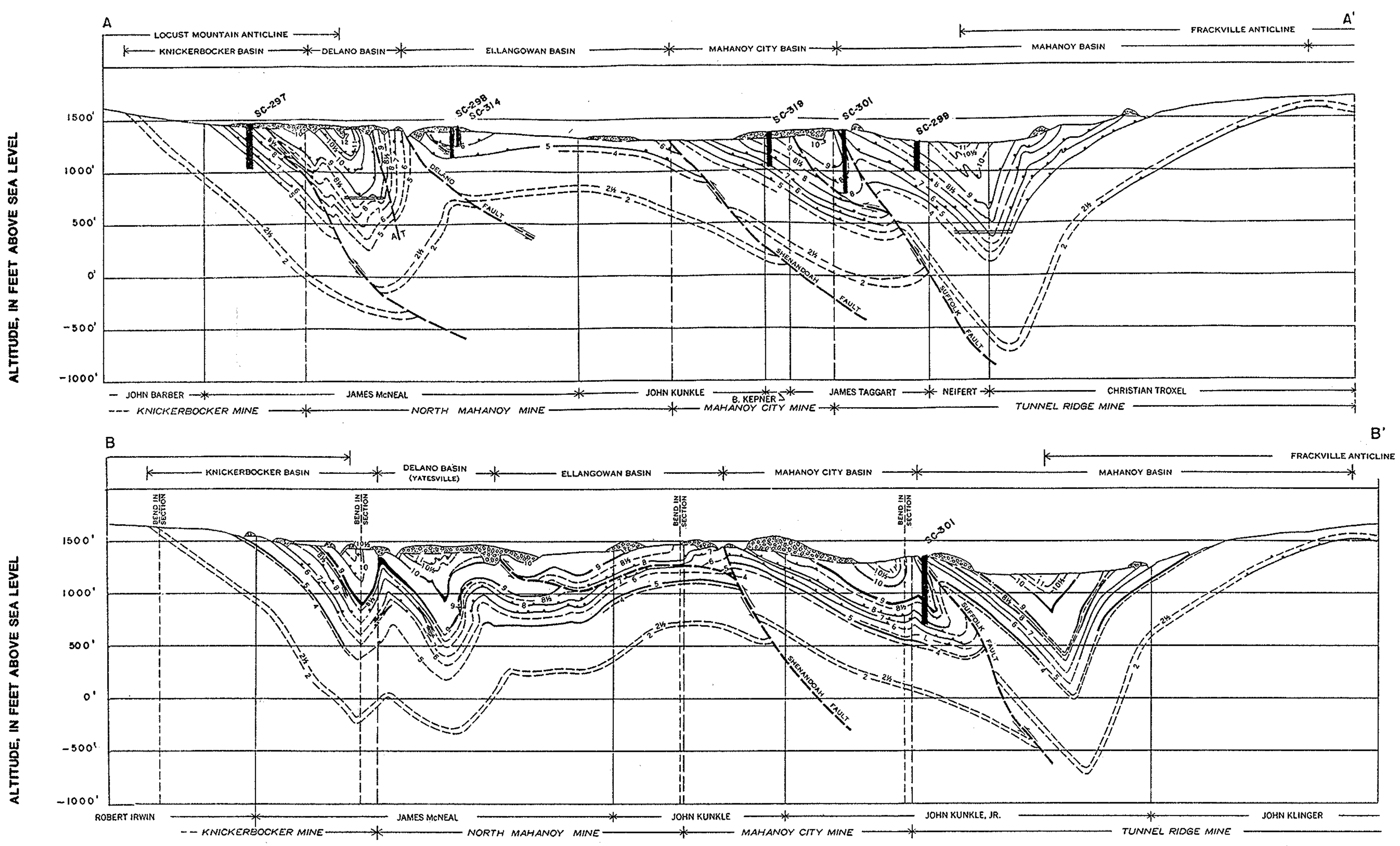
MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-121
Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Maxwell, J.A., and Rothrock, H.E., 1955, Geology of anthracite in the western part of the Delano quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-25.

Figure 17.--Structural geologic sections in the coal basins east of Mahanoy City.



EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

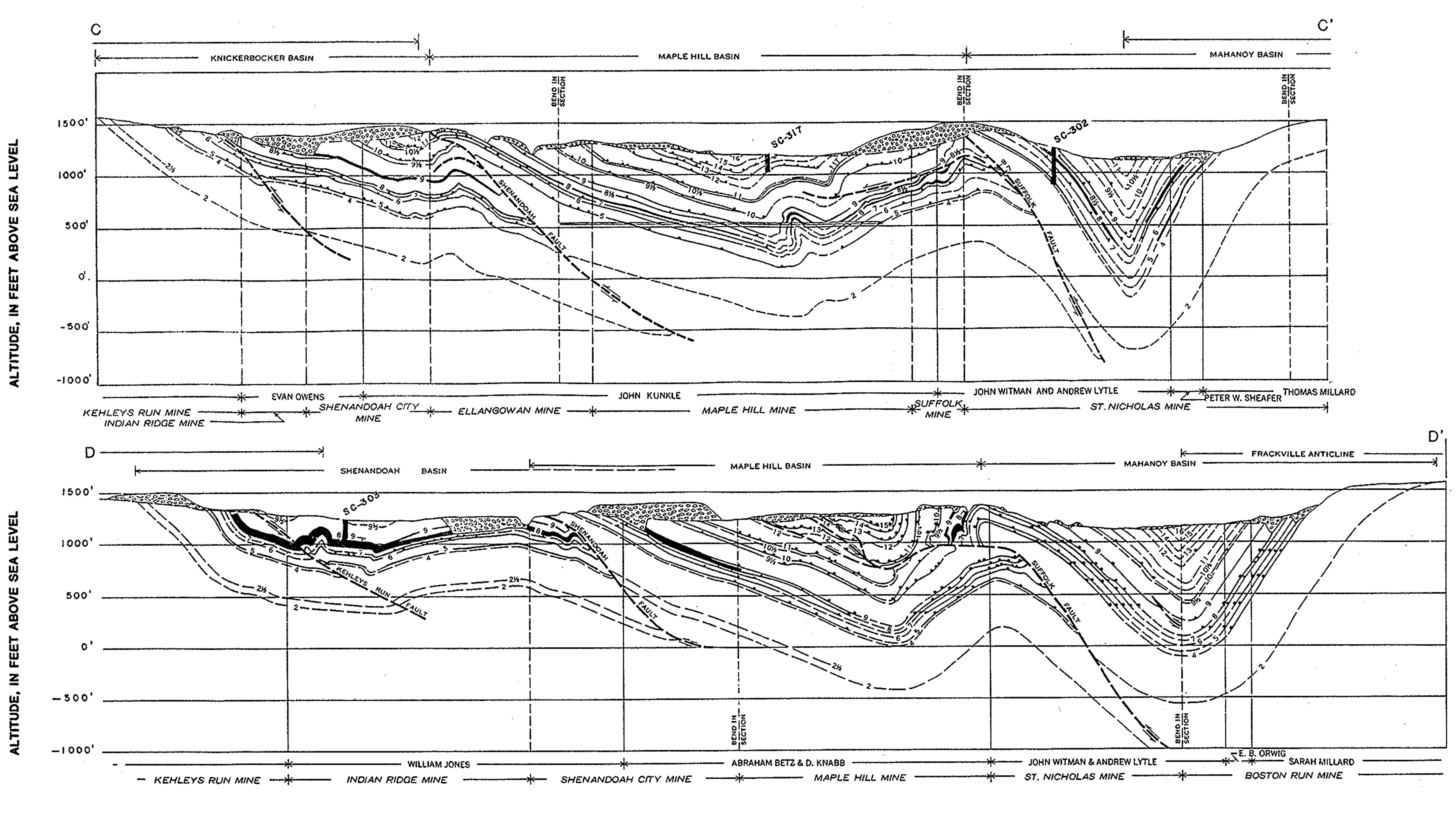
MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-121
Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Kehn, T.M., and Wagner, H.C., 1955, Geology of anthracite in the eastern part of the Shenandoah quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-19.

Figure 18.--Structural geologic sections in the Mahanoy basin and in the Shenandoah complex near Mahanoy City.



EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-121
Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Danilchik, Walter, Rothrock, H.E., and Wagner, H.C., 1955, Geology of anthracite in the western part of the Shenandoah quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-21.

Figure 19.--Structural geologic sections in the Mahanoy basin and the Shenandoah complex west of Mahanoy City.

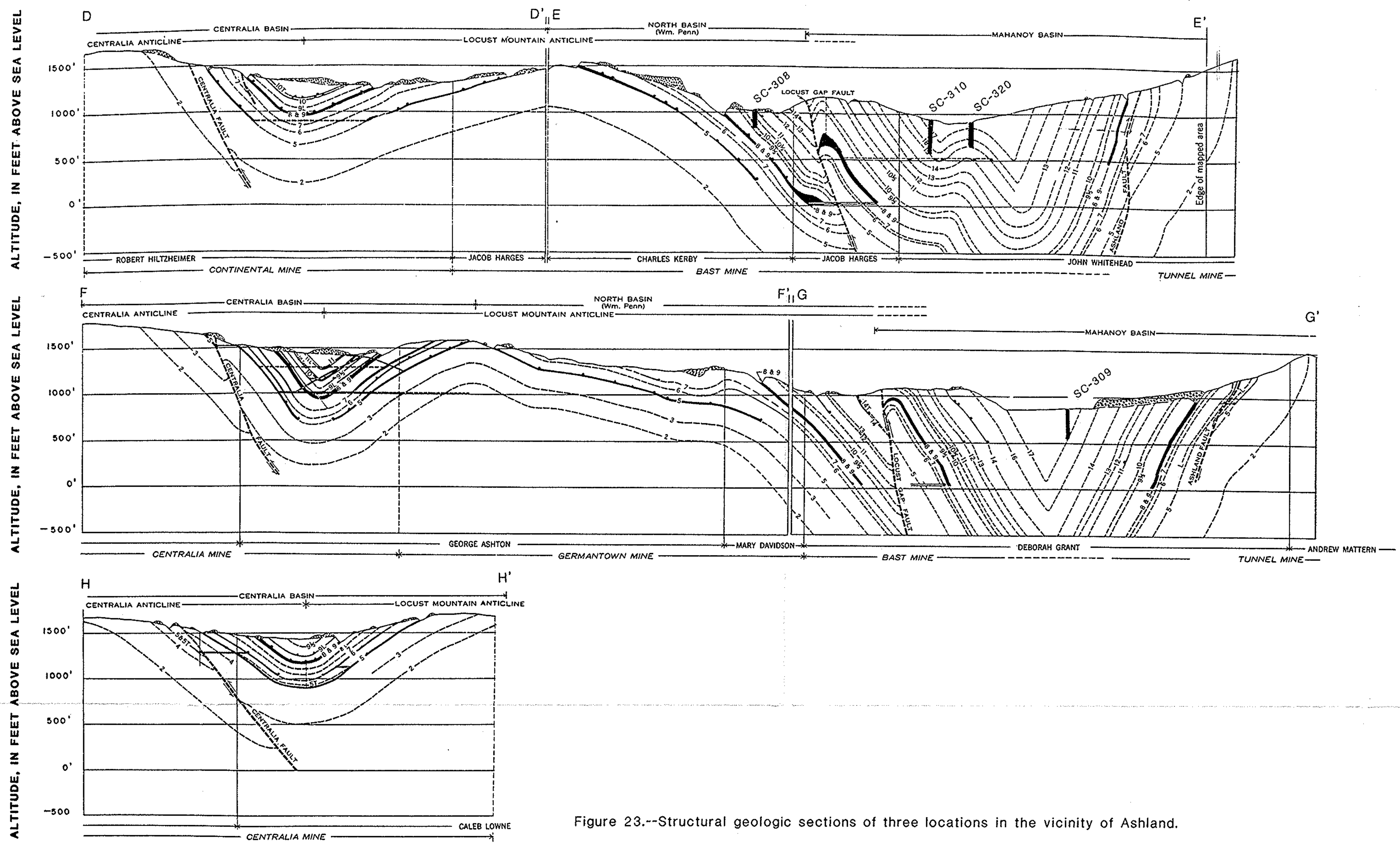


Figure 23.--Structural geologic sections of three locations in the vicinity of Ashland.

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

SC-309 Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Haley, B.R., Arndt, H.H., Rothrock, H.E., and Wagner, H.C., 1953, Geology of anthracite in the western part of the Ashland quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-13.

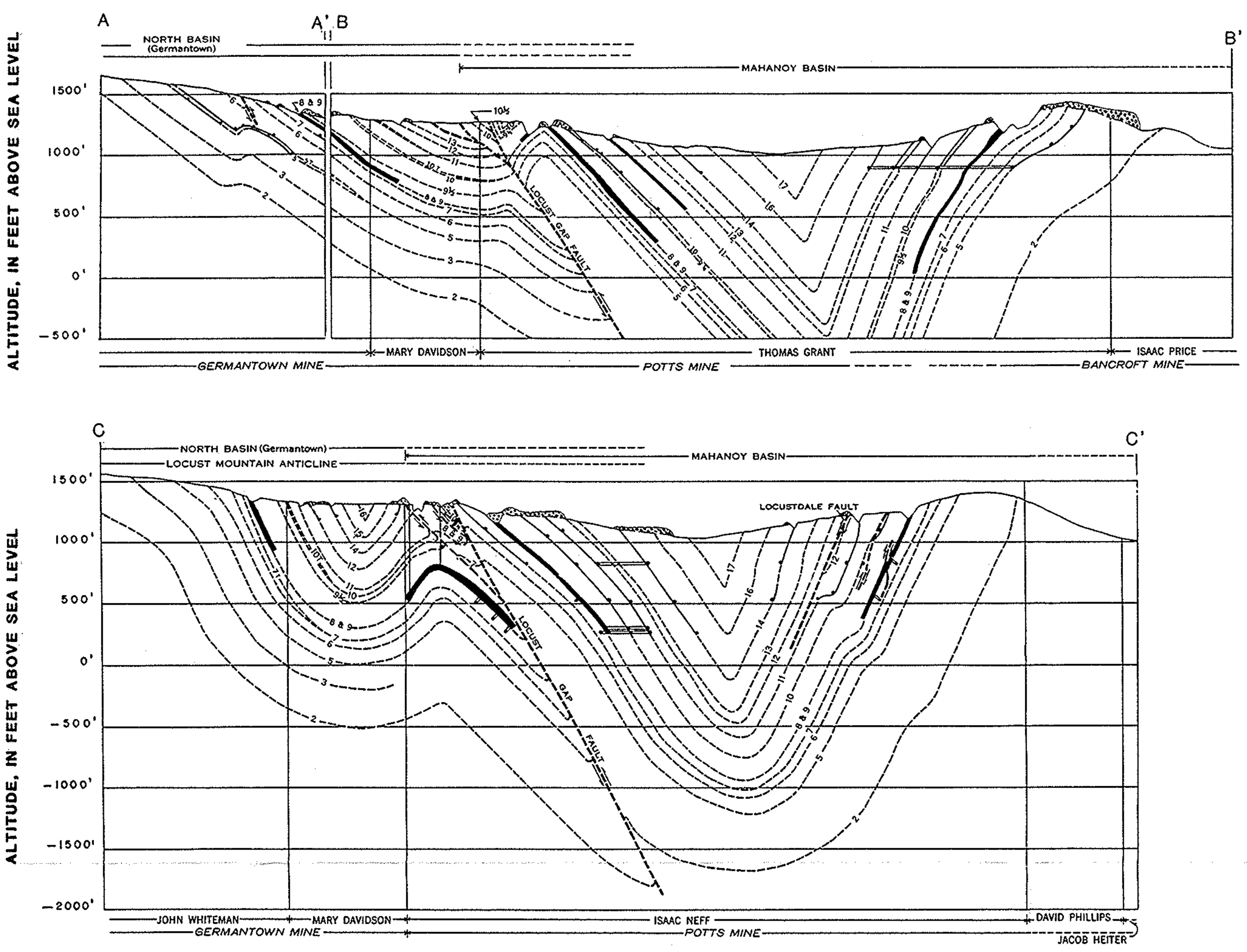


Figure 24.--Structural geologic sections east of Locustdale.

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Haley, B.R., Arndt, H.H., Rothrock, H.E., and Wagner, H.C., 1953, Geology of anthracite in the western part of the Ashland quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-13.

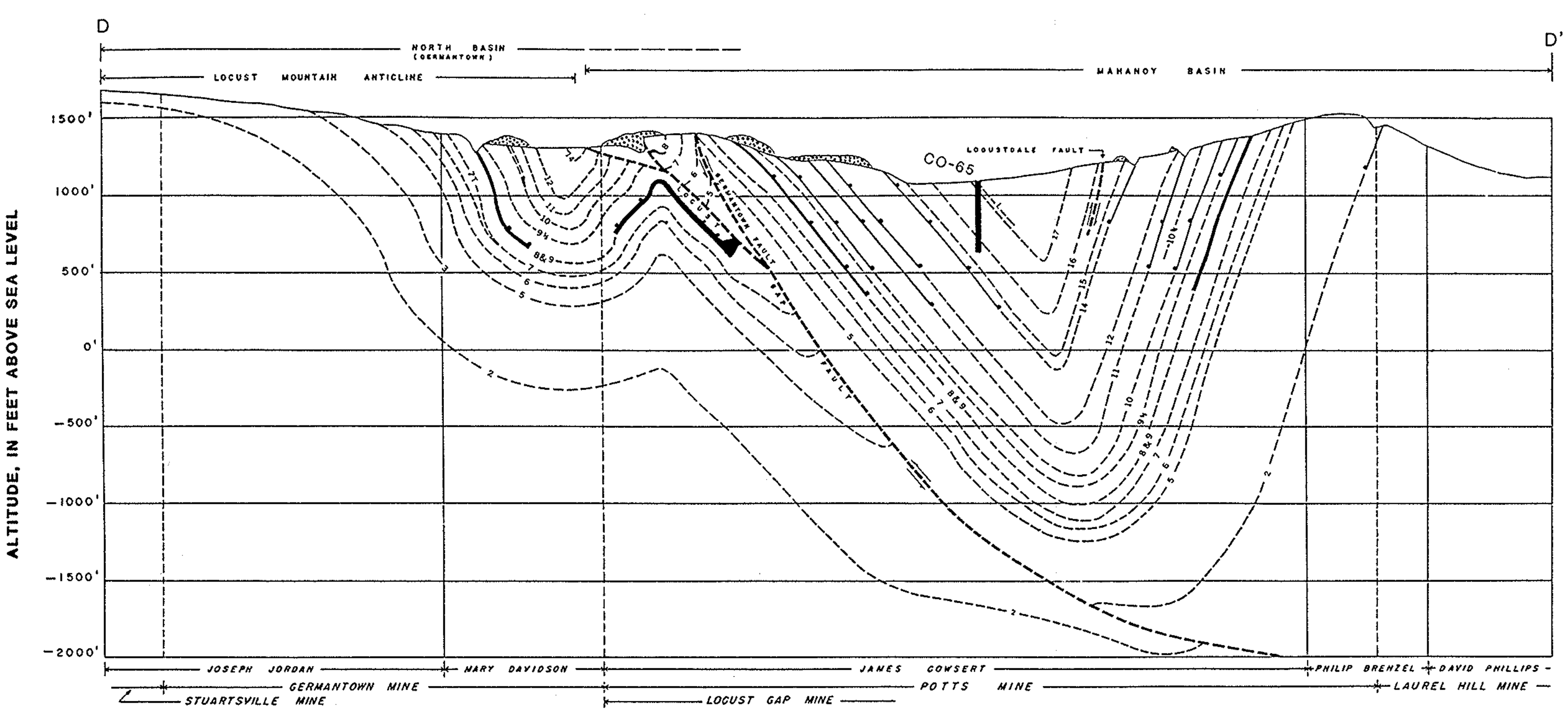


Figure 25.--Structural geologic section near Locustdale.

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

CO-65 Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1953, Geology of anthracite in the southeastern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-12.

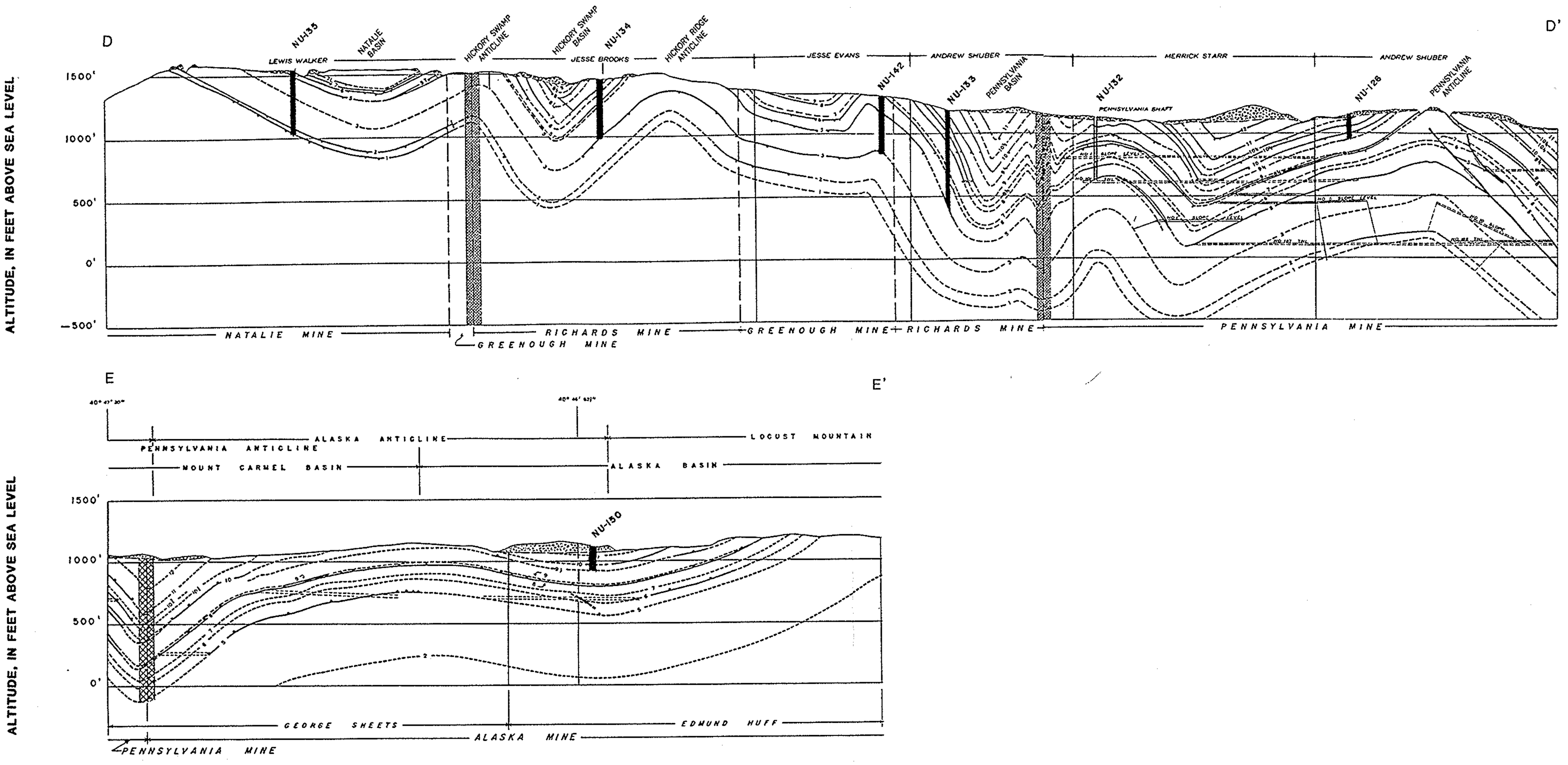


Figure 29.--Structural geologic sections near Mount Carmel.

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-130 Approximate location of borehole and number

Contact Dashed where approximately located

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1950. Geology of anthracite in the west-central part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-3.

Geology by:
Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1951a, Geology of anthracite in the southwestern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-7.

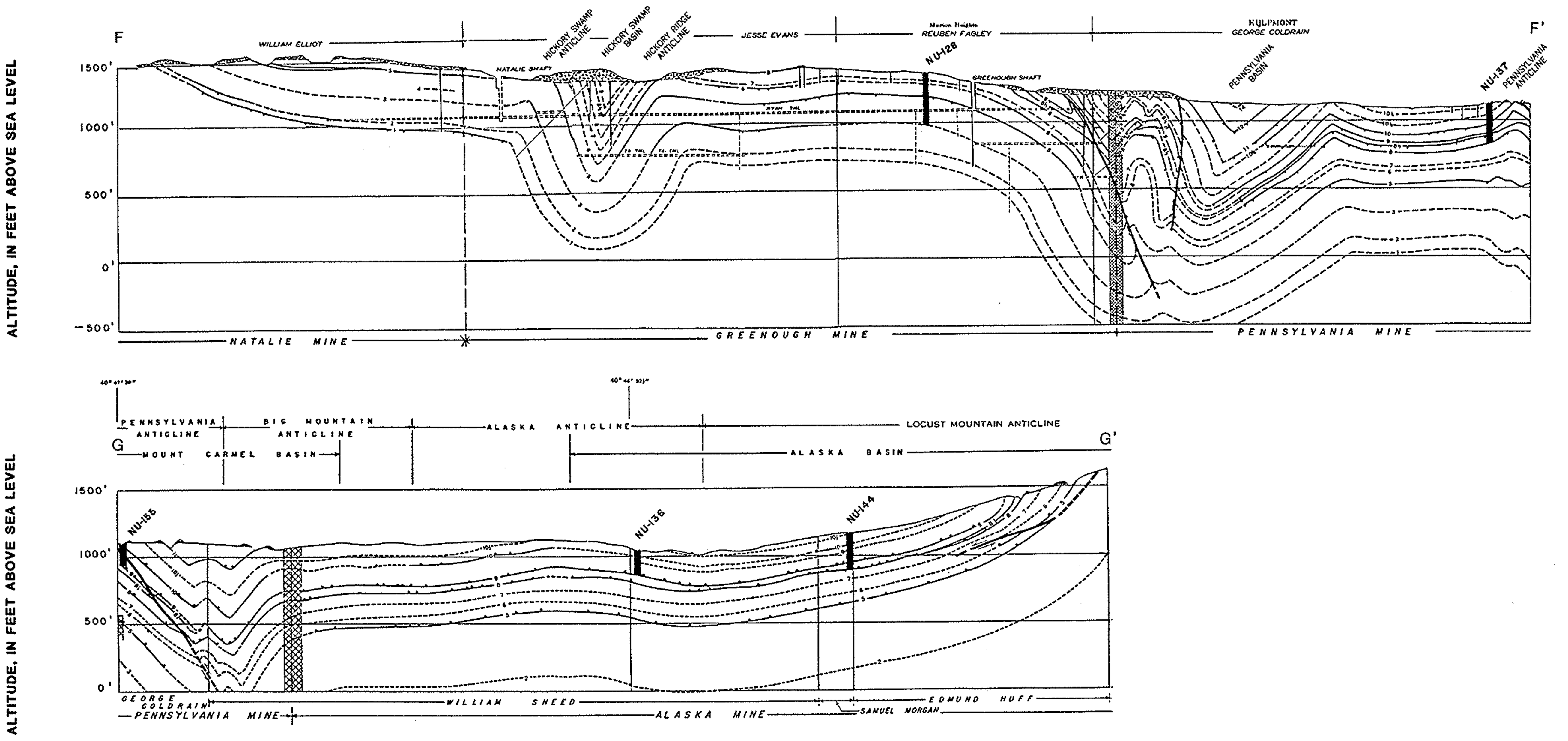


Figure 30.--Structural geologic sections near Mount Carmel.

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-130 Approximate location of borehole and number

Contact Dashed where approximately located

Geology by:
Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1950. Geology of anthracite in the west-central part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-3.

Geology by:
Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1951a, Geology of anthracite in the southwestern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-7.

0 500 1000 2000 FEET
0 300 600 METERS

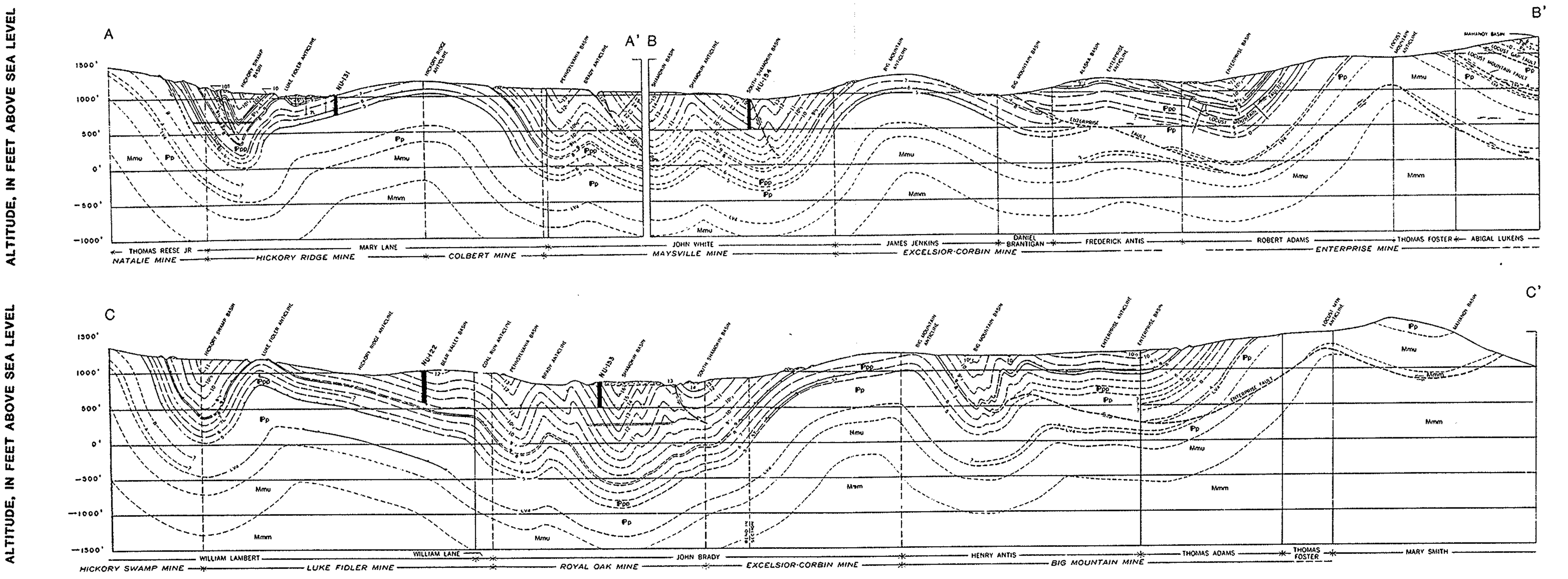


Figure 31.--Structural geologic sections east of Shamokin.

PENNSYLVANIAN
- Ppp, Post Pottsville rocks
- Pp, Pottsville Formation

MISSISSIPPIAN
- Mauch Chunk Formation
- Mmu, Upper member
- Mmm, Middle member

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

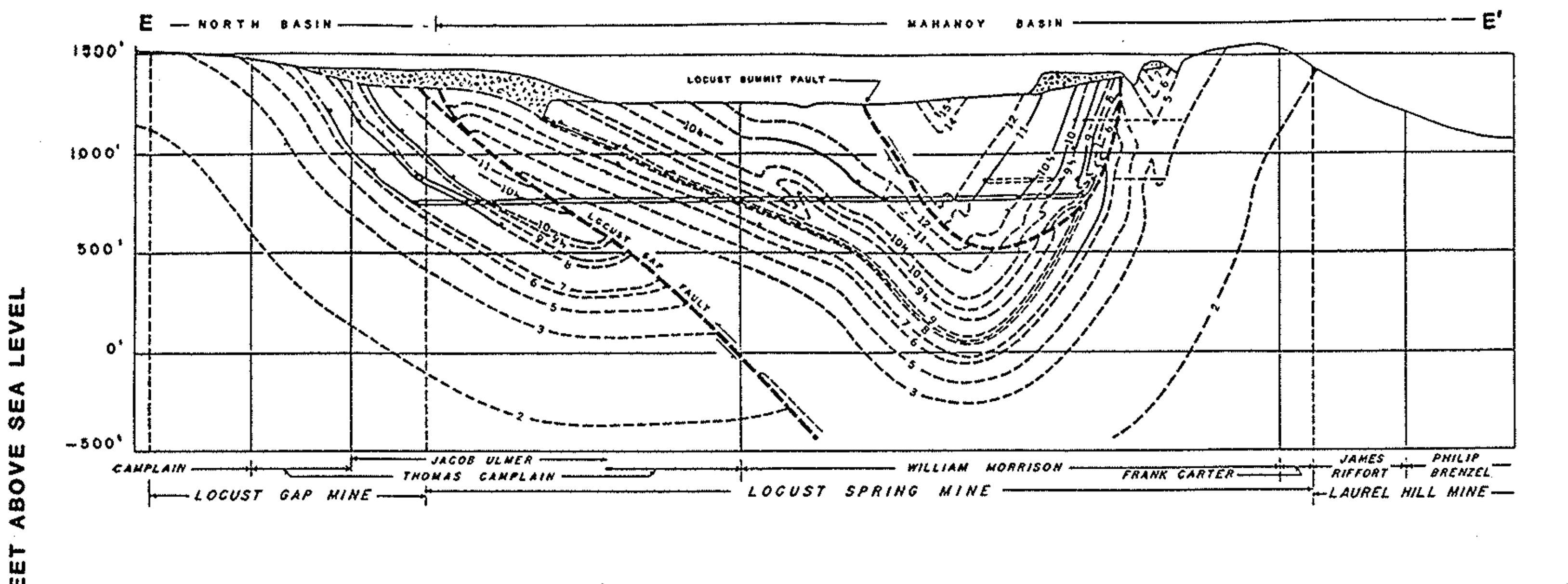
MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

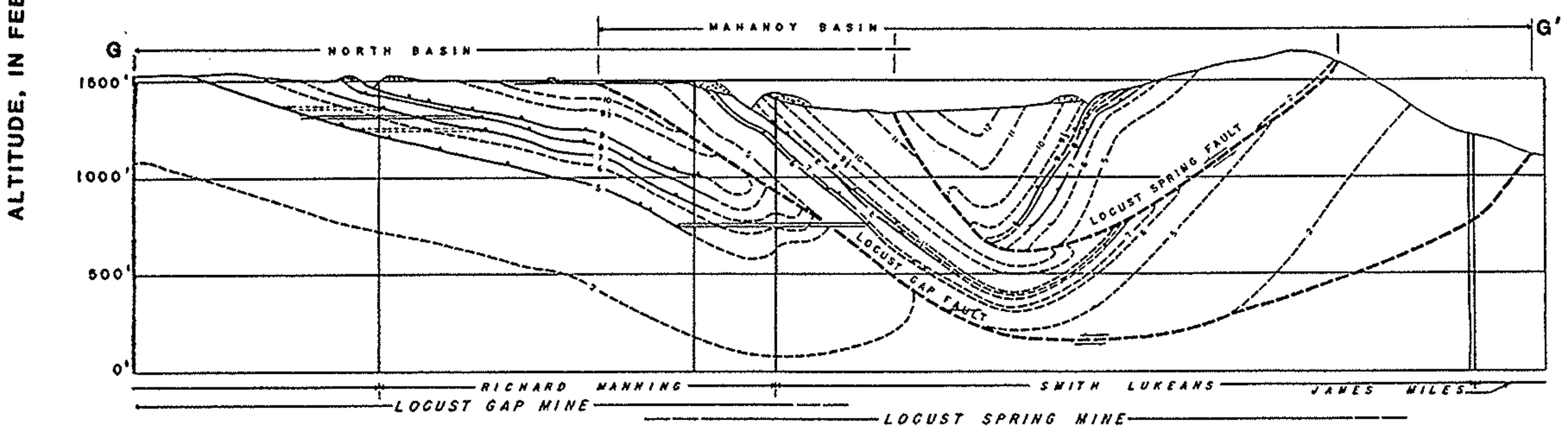
NU-130 Approximate location of borehole and number

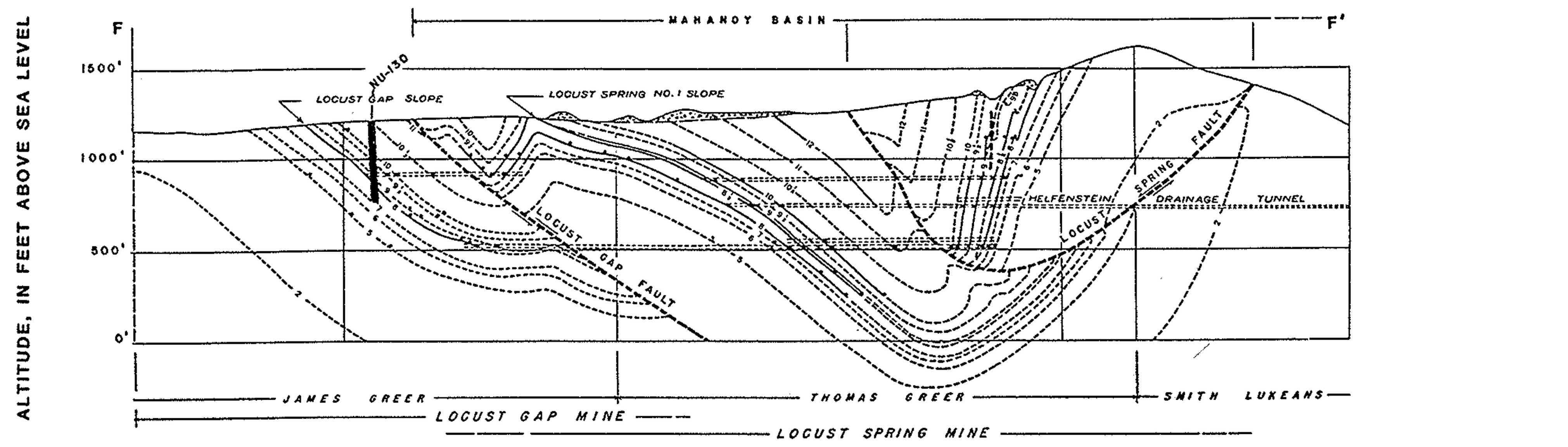
Contact Dashed where approximately located

0 500 1000 2000 FEET
0 300 600 METERS

Geology :
Danilchik, Walter, 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.







EXPLANATION

Contact
Dashed where approximately located

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement
Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

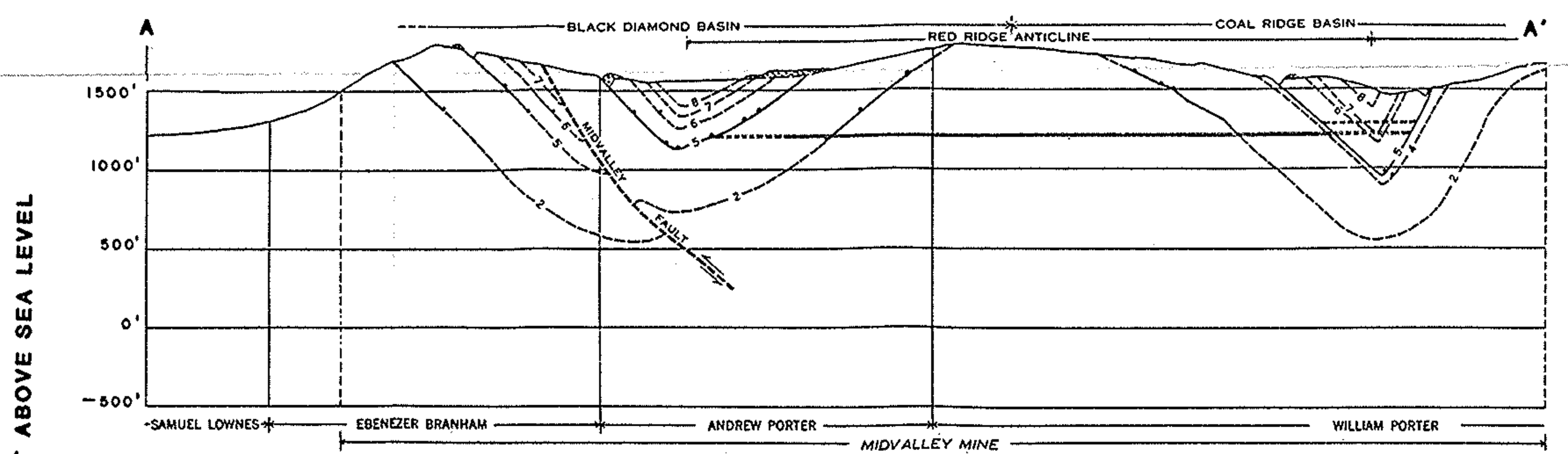
NU-130
Approximate location of borehole and number

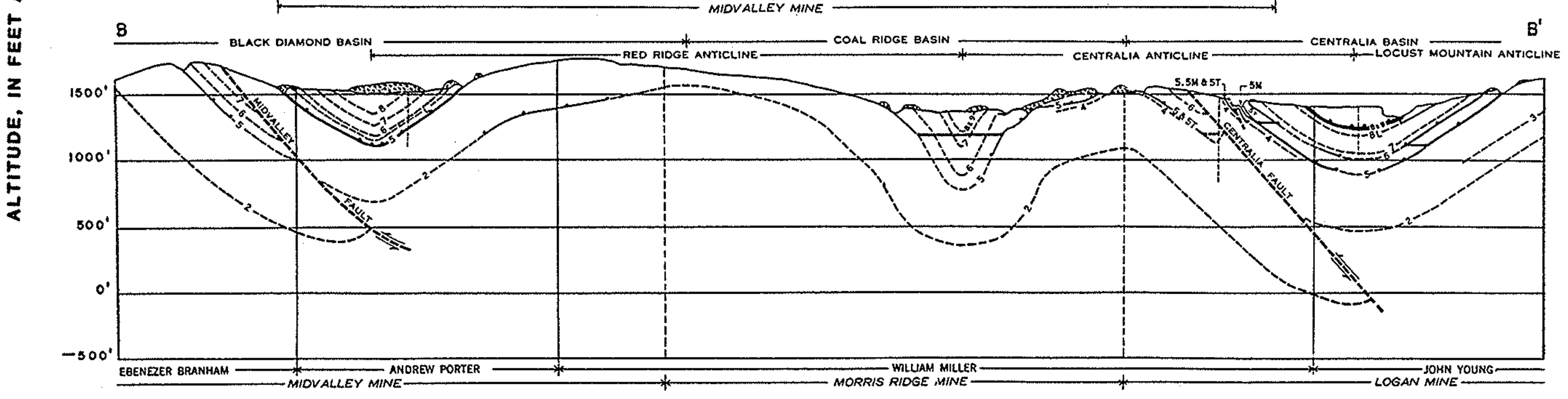
0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1951a, Geology of anthracite in the southwestern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-7.

-----1953, Geology of anthracite in the southeastern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-12.

Figure 26.--Structural geologic sections in the vicinity of Locust Gap.





EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement
Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

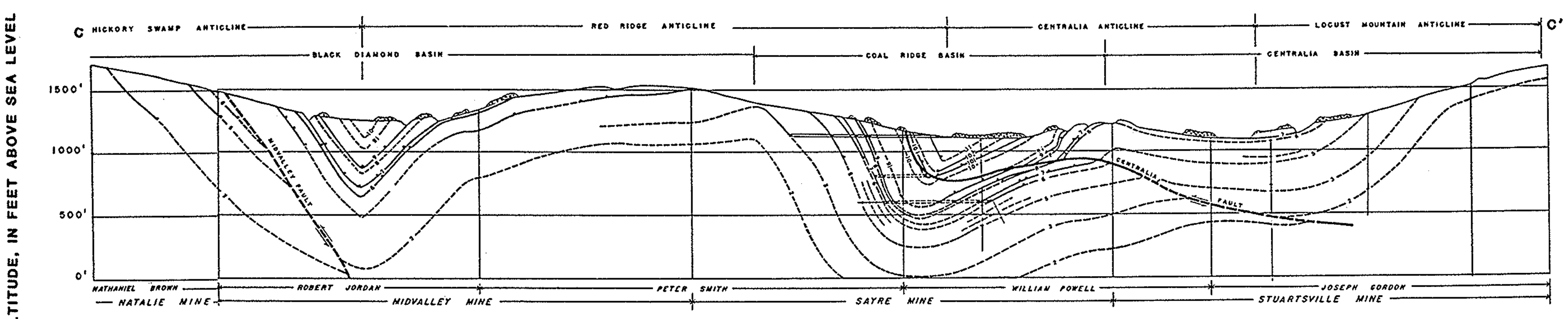
Cross section of gangway

MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

Tunnel, showing position of intersection

Geology by:
Haley, B. R., Arndt, H. H., Rothrock, H. E., and Wagner, H. C., 1953, Geology of anthracite in the western part of the Ashland quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-13.

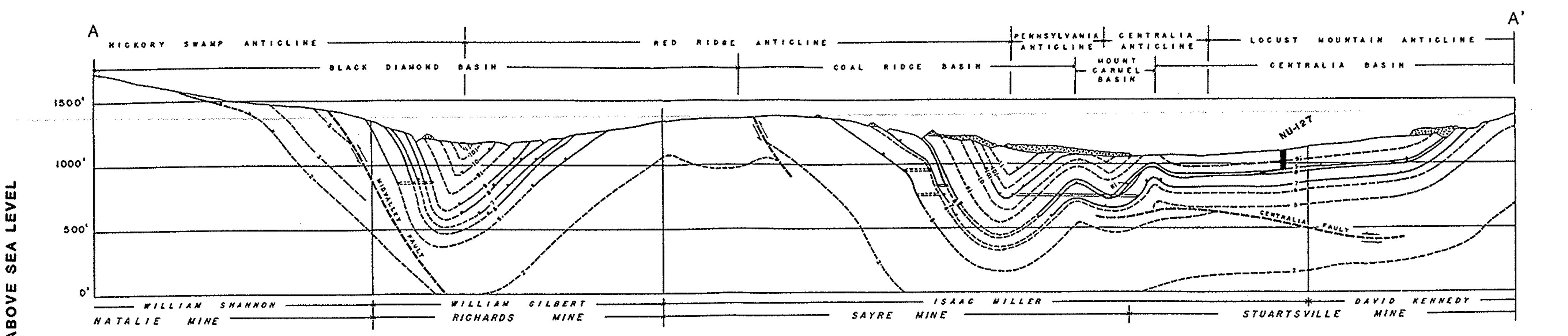
0 500 1000 2000 FEET
0 300 600 METERS

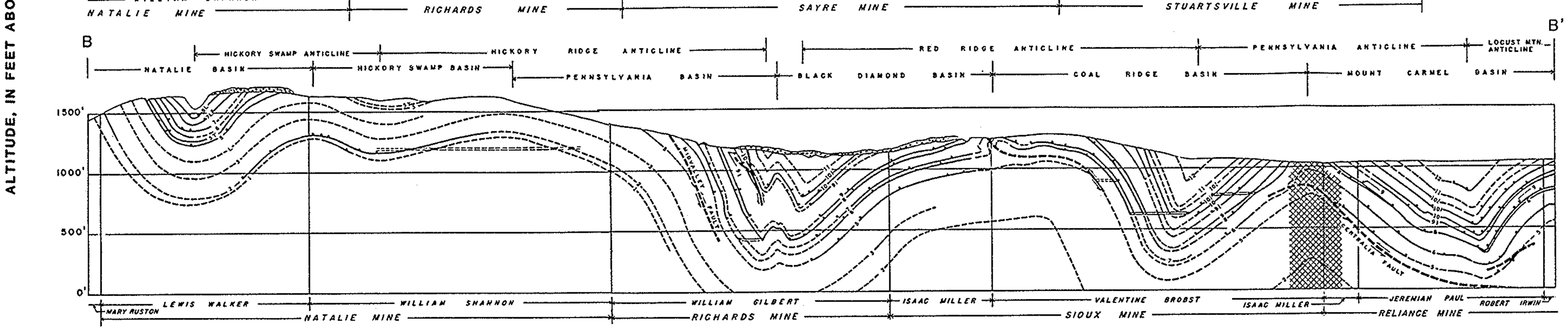


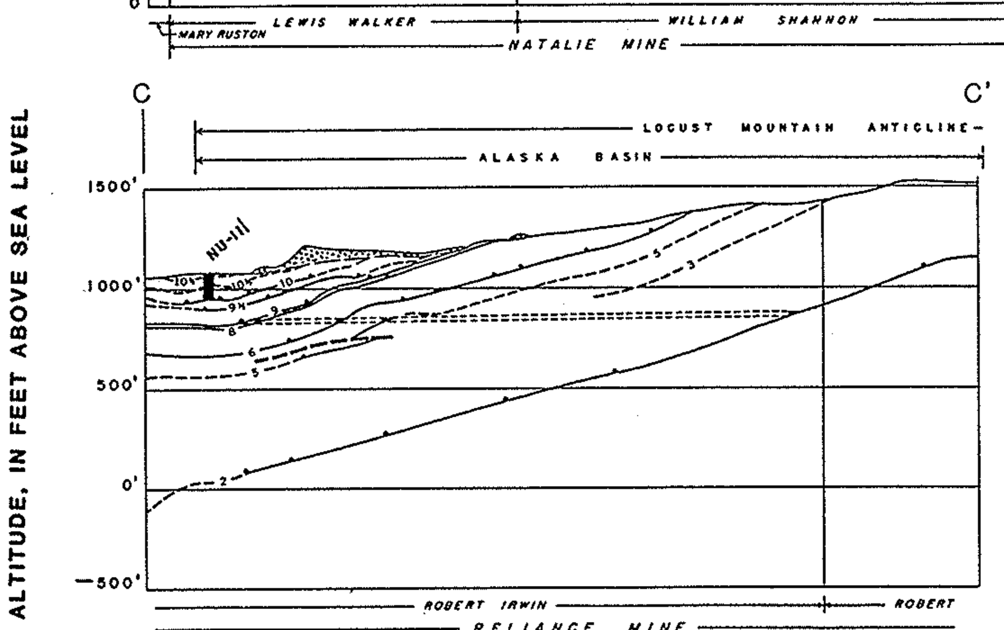
Geology by:
Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1951b, Geology of anthracite in the east-central part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-10.

0 500 1000 2000 FEET
0 300 600 METERS

Figure 27.--Structural geologic sections east of Mount Carmel.







EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement
Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-121
Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1951b, Geology of anthracite in the east-central part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-10.

-----1953, Geology of anthracite in the southeastern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-12.

Figure 28.--Structural geologic sections at Mount Carmel.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Prepared in cooperation with the
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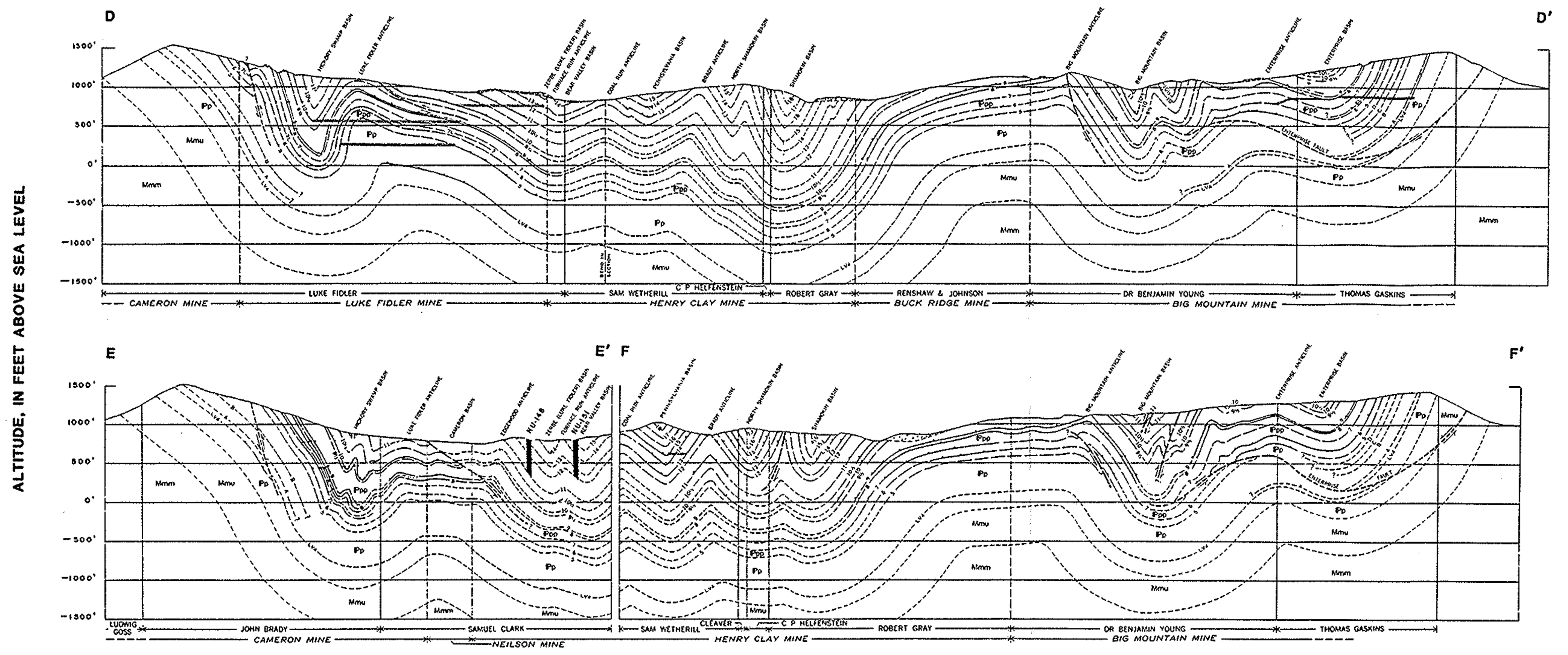
WATER-RESOURCES INVESTIGATIONS REPORT
85-4038
Plate 7



PENNSYL-VANIAN
- Ppp, Post Pottsville rocks
- Pp, Pottsville Formation

MISSISS-IPPIAN
- Mauch Chunk Formation
- Mmu, Upper member
- Mmm, Middle member

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Danilchik, Walter, 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.

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

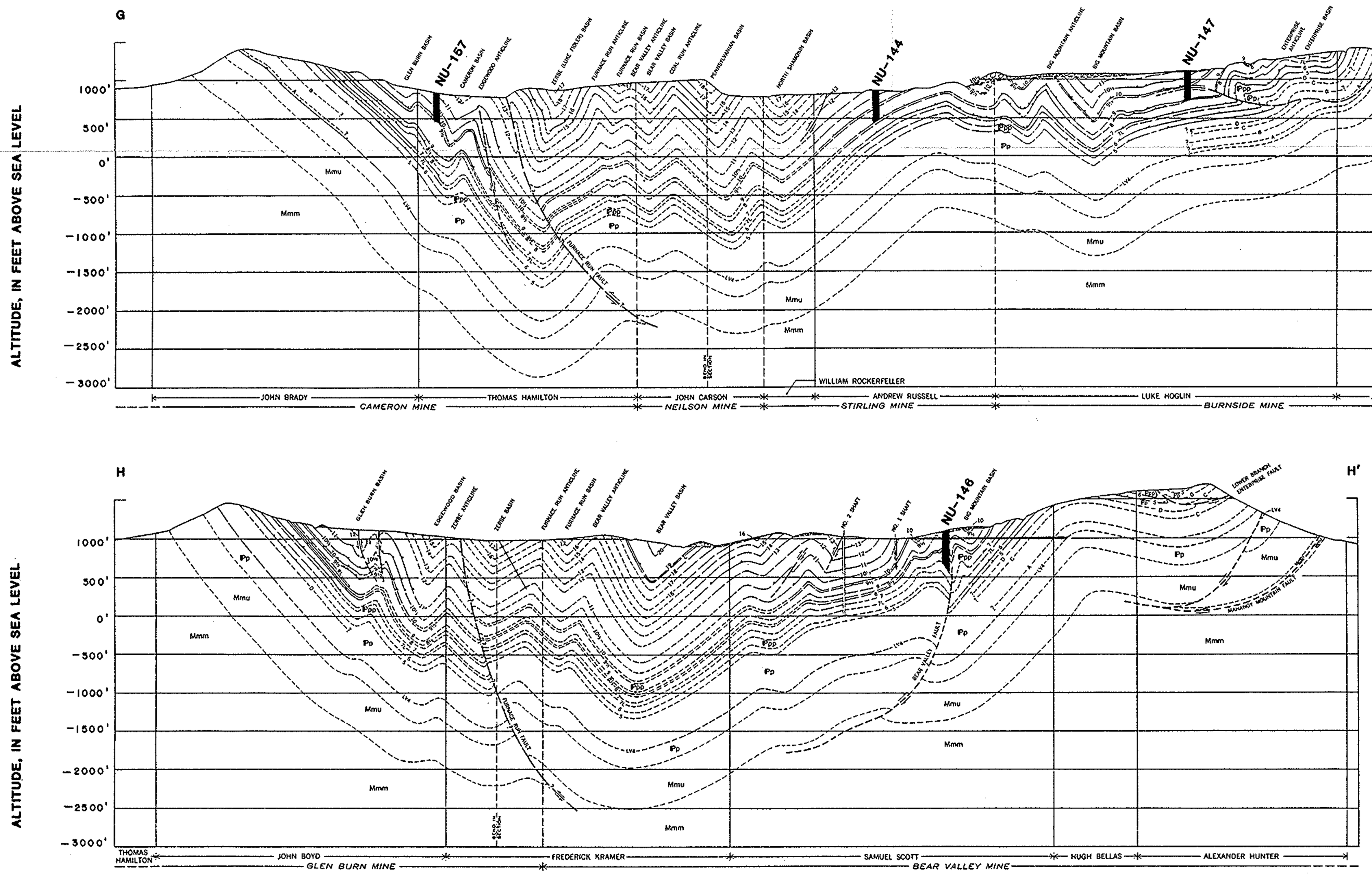
Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-130 Approximate location of borehole and number

Contact Dashed where approximately located

Figure 32.--Structural geologic sections east of Shamokin.



EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-130 Approximate location of borehole and number

Contact Dashed where approximately located

PENNSYL-VANIAN
- Ppp, Post Pottsville rocks
- Pp, Pottsville Formation

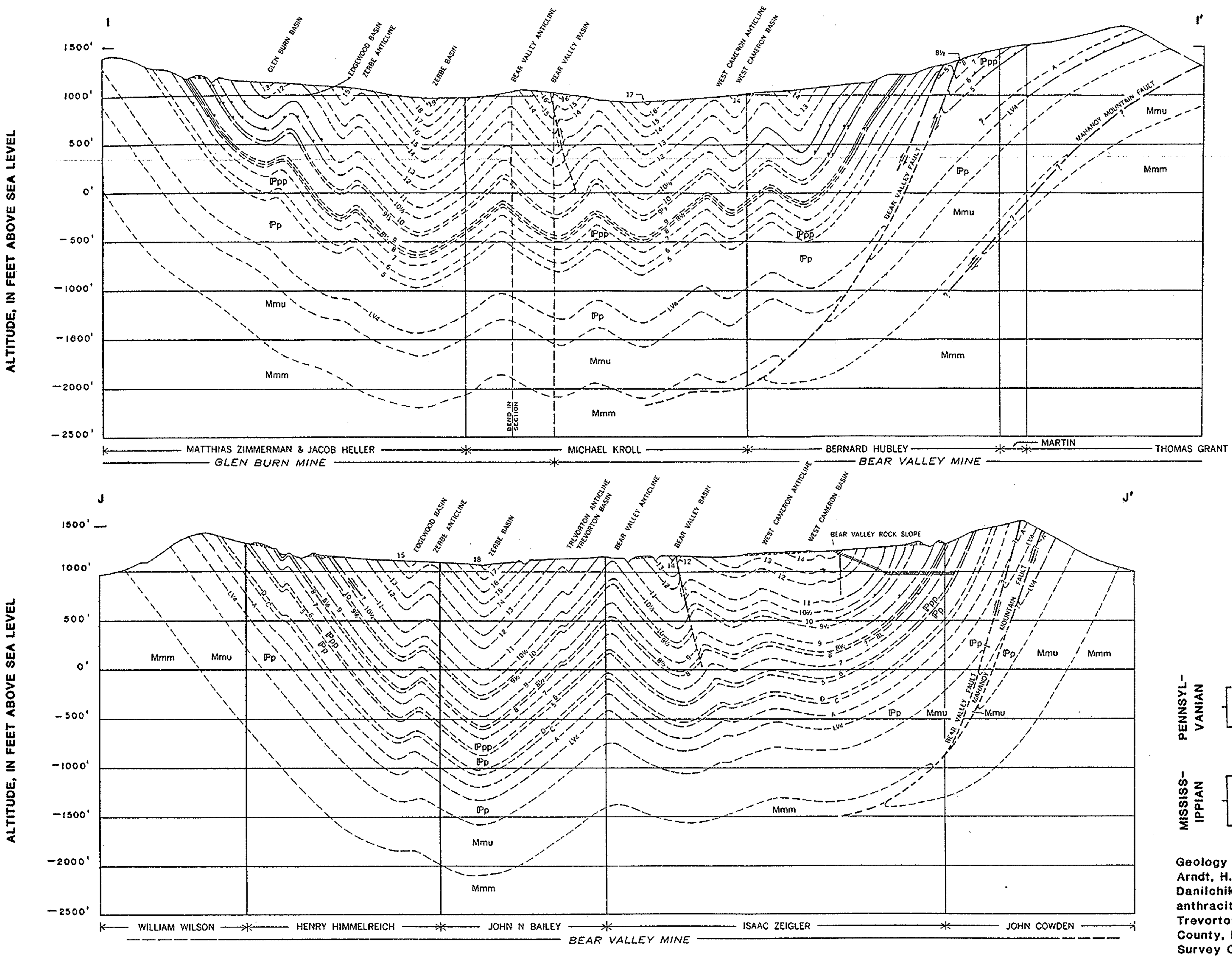
MISSISS-IPPIAN
- Mauch Chunk Formation
- Mmu, Upper member
- Mmm, Middle member

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Arndt, H.H., Wood, G.H. Jr., and Danilchik, Walter, 1963, Geology of anthracite in the southern part of the Trevorton quadrangle, Northumberland County, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-48.

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

Figure 33.--Structural geologic sections near Shamokin.



EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE– Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-130 Approximate location of borehole and number

Contact Dashed where approximately located

PENNSYL-VANIAN
- Ppp, Post Pottsville rocks
- Pp, Pottsville Formation

MISSISS-IPPIAN
- Mauch Chunk Formation
- Mmu, Upper member
- Mmm, Middle member

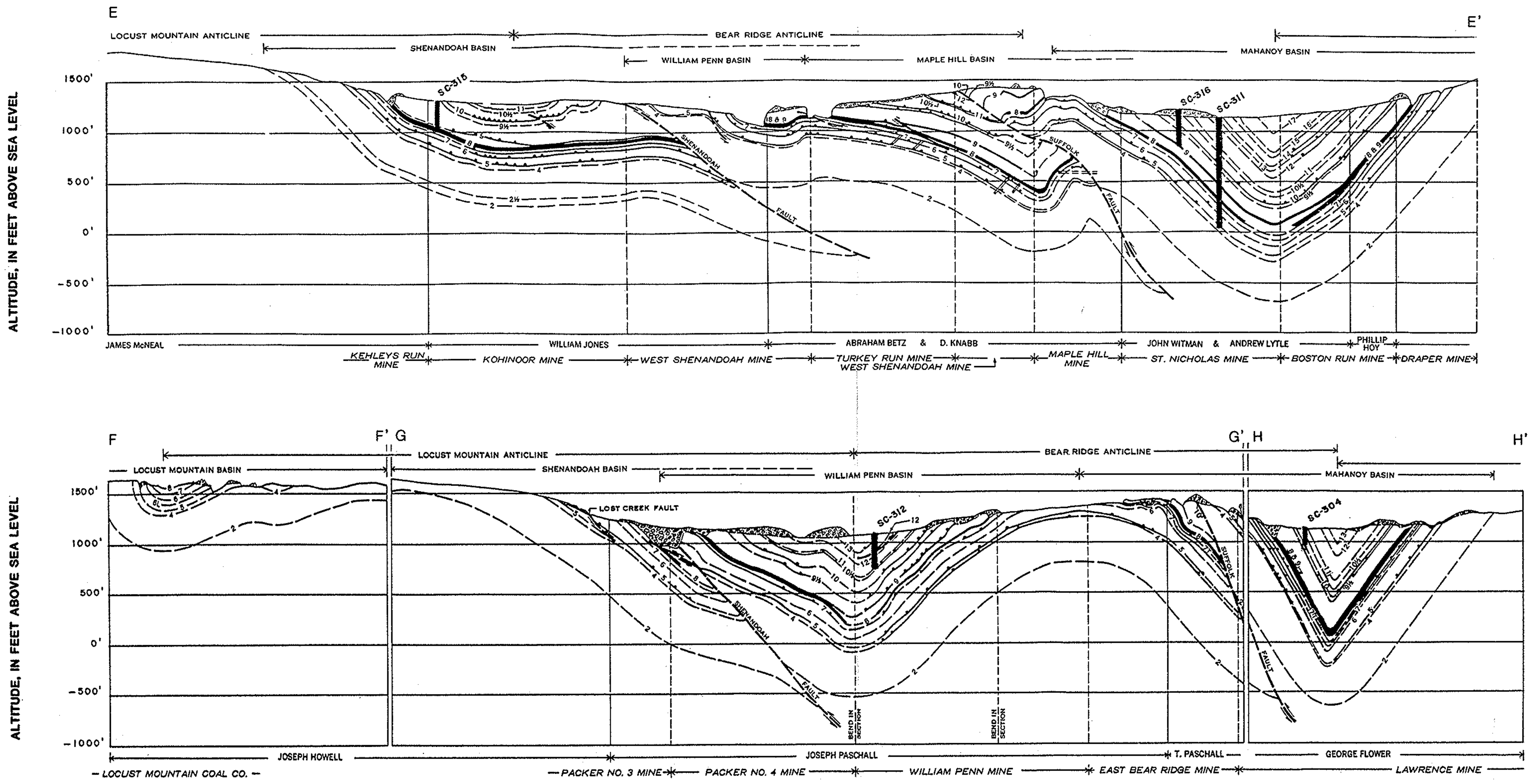
Geology by:
Arndt, H.H., Wood, G.H. Jr., and Danilchik, Walter, 1963, Geology of anthracite in the southern part of the Trevorton quadrangle, Northumberland County, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-48.

0 500 1000 2000 FEET
0 300 600 METERS

PENNSYL-VANIAN
- Ppp, Post Pottsville rocks
- Pp, Pottsville Formation

MISSISS-IPPIAN
- Mauch Chunk Formation
- Mmu, Upper member
- Mmm, Middle member

Figure 34.--Structural geologic sections west of Shamokin.



EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

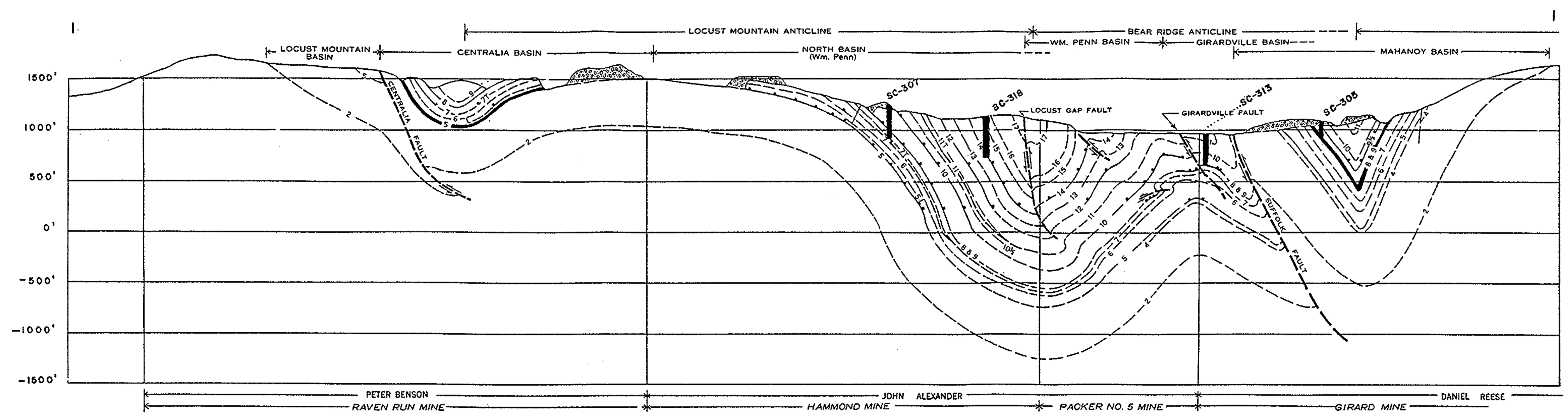
MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-121
Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Danilchik, Walter, Rothrock, H.E., and Wagner, H.C., 1955, Geology of anthracite in the western part of the Shenandoah quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-21.

Figure 20.--Structural geologic sections in the Mahanoy basin and the Shenandoah complex near Shenandoah.



EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

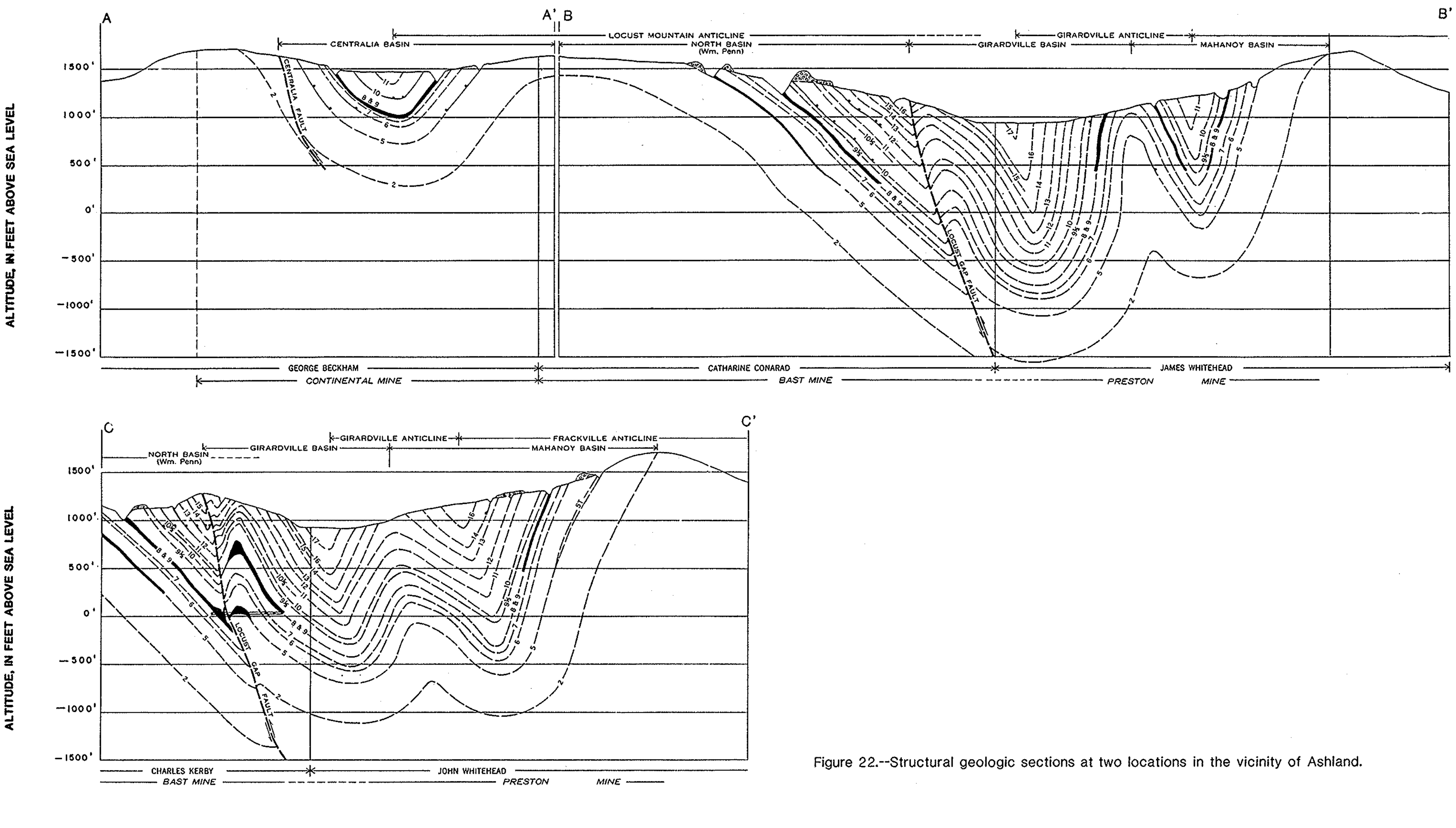
MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-121
Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

Figure 21.--Structural geologic sections in Mahanoy basin and the Shenandoah complex near Girardville.

Geology by:
Haley, B.R., Arndt, H.H., Rothrock, H.E., and Wagner, H.C., 1954, Geology of anthracite in the eastern part of the Ashland quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-14.



EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-121
Approximate location of borehole and number

0 500 1000 2000 FEET
0 300 600 METERS

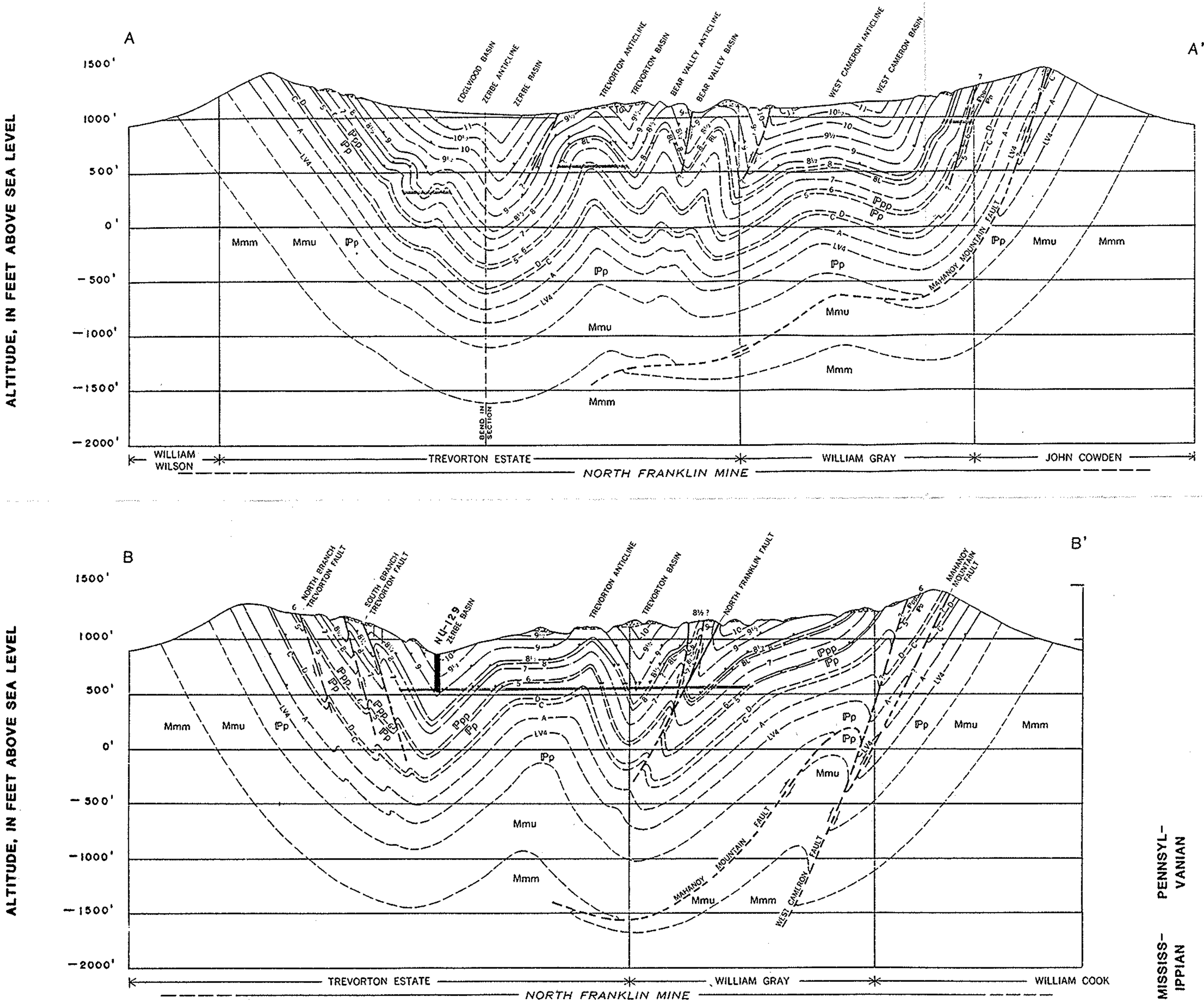
Figure 22.--Structural geologic sections at two locations in the vicinity of Ashland.

Geology by:
Haley, B.R., Arndt, H.H., Rothrock, H.E., and Wagner, H.C., 1954, Geology of anthracite in the eastern part of the Ashland quadrangle, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-14.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Prepared in cooperation with the
U.S. BUREAU OF MINES

WATER-RESOURCES INVESTIGATIONS REPORT
85-4038
Plate 8



PENNSYLVANIAN
Ppp, Post Pottsville rocks
Pp, Pottsville Formation

MISSISSIPPIAN
Mauch Chunk Formation
Mmu, Upper member
Mmm, Middle member

Figure 35.--Structural geologic sections near Trevorton.

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

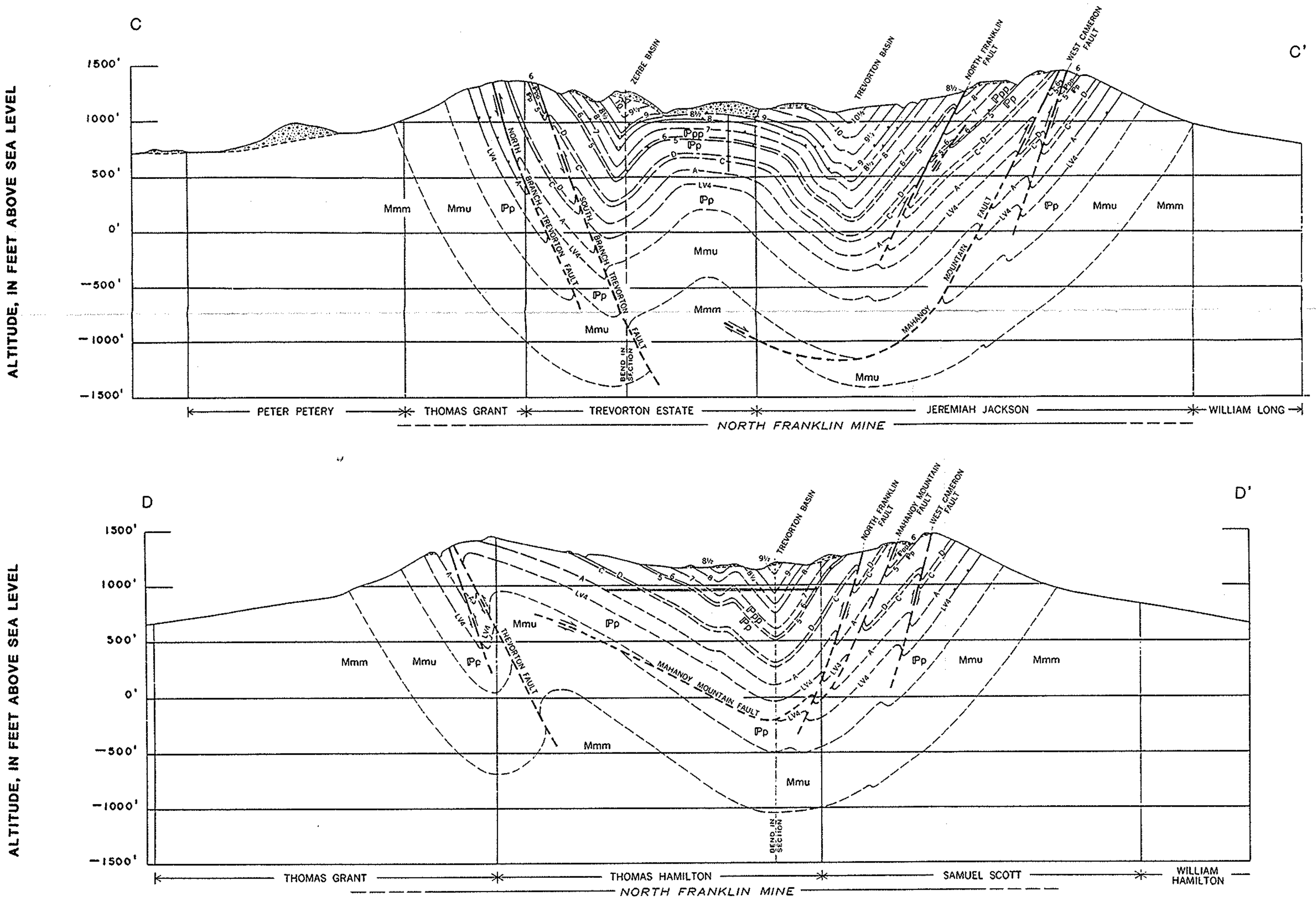
MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-130
Approximate location of borehole and number

Contact
Dashed where approximately located

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Arndt, H.H., Wood, G.H. Jr., and Danilchik, Walter, 1963, Geology of anthracite in the southern part of the Trevorton quadrangle, Northumberland County, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-48.



PENNSYLVANIAN
Ppp, Post Pottsville rocks
Pp, Pottsville Formation

MISSISSIPPIAN
Mauch Chunk Formation
Mmu, Upper member
Mmm, Middle member

Figure 36.--Structural geologic sections near Trevorton.

EXPLANATION

Coal bed, with designating letter or number solid where mined: long dashed where approximately located: short dashed where inferred ? correlation or extension of coal bed is uncertain.

Fault, showing relative movement Long dashed where approximately located: short dashed where inferred. ? probable fault or extension of fault is uncertain.

Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

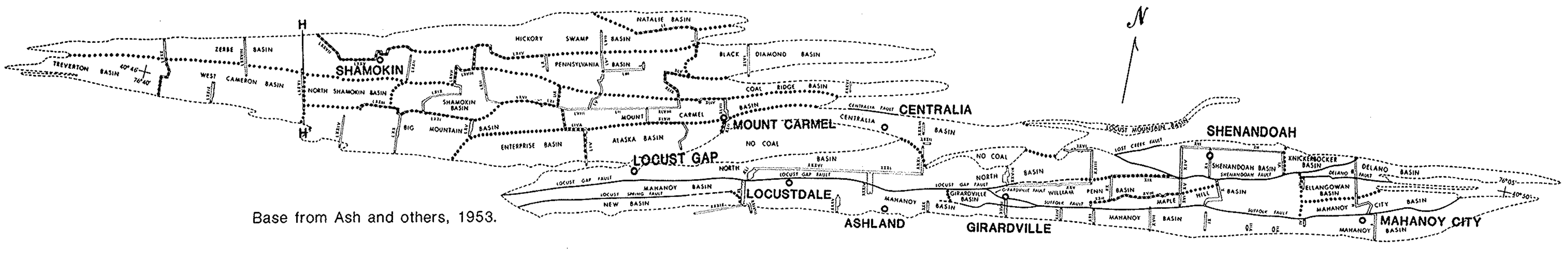
MINE WASTE–
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

NU-130
Approximate location of borehole and number

Contact
Dashed where approximately located

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Arndt, H.H., Wood, G.H. Jr., and Danilchik, Walter, 1963, Geology of anthracite in the southern part of the Trevorton quadrangle, Northumberland County, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-48.



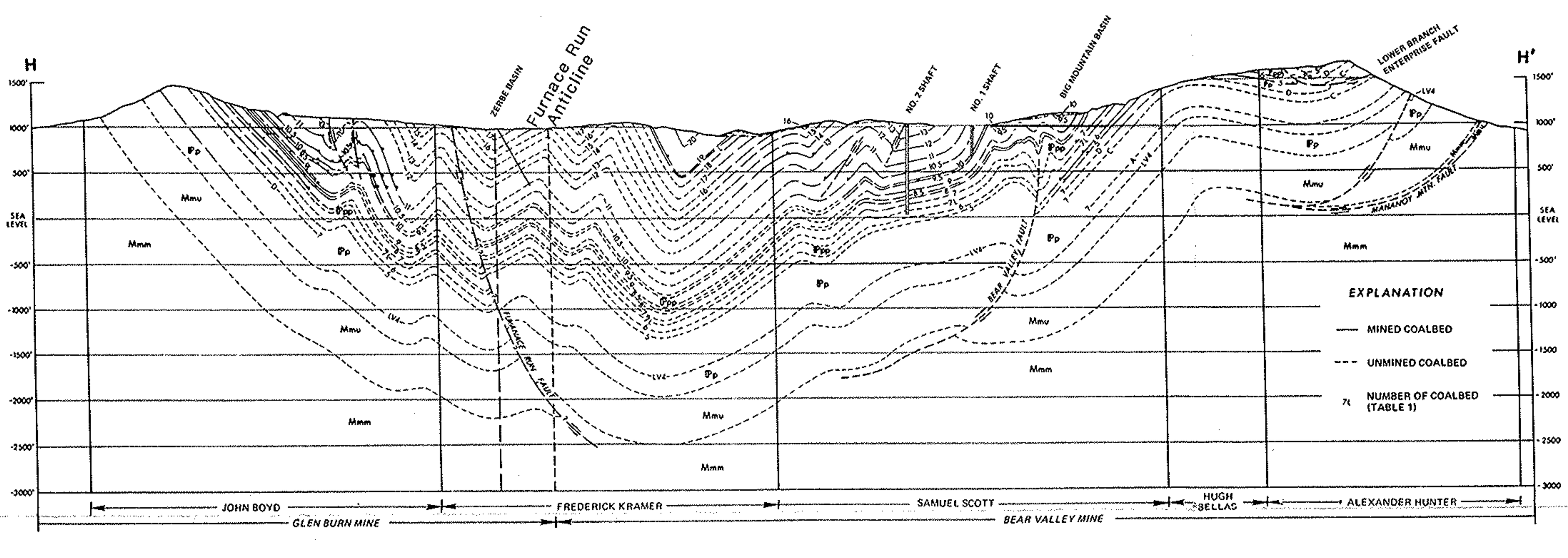
Base from Ash and others, 1953.

EXPLANATION

Outcrop of lowest workable coal bed
Barrier pillar and number
Boundary between coal basins
Major fault and name
H——H′ Geologic section

0 1 2 3 4 MILES
0 2 4 6 KILOMETERS

Figure 2.--The Western Middle anthracite field.



EXPLANATION

0 500 1000 2000 FEET
0 300 600 METERS

Geology by:
Arndt, H.H., Wood, G.H. Jr., and Danilchik, Walter, 1963, Geology of anthracite in the southern part of the Trevorton quadrangle, Northumberland County, Pennsylvania: U.S. Geological Survey Coal Investigations Map C-48.

Contact
Dashed where approximately located

Fault, showing relative movement
Long dashed where approximately located; short dashed where inferred. ? probable fault or extension of fault is uncertain.

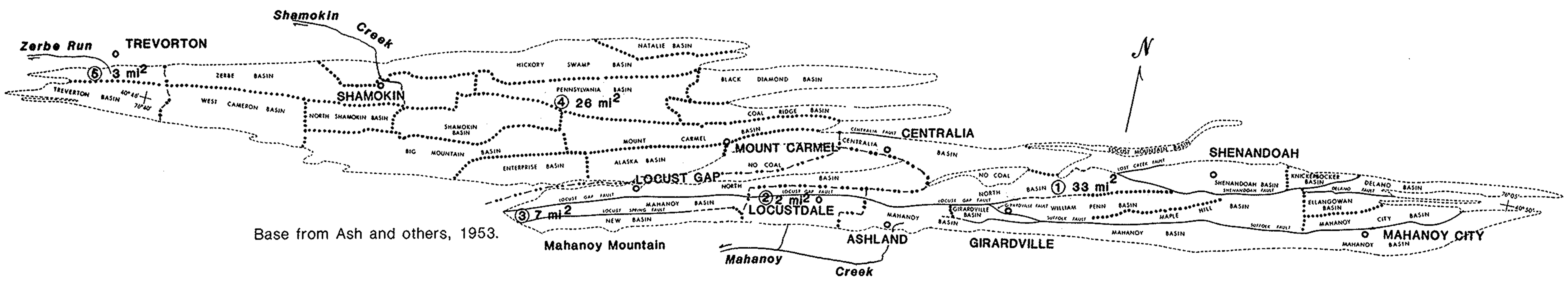
Cross section of gangway

Tunnel, showing position of intersection

Drill hole, showing position of coal beds found in core or cuttings

Mine waste
Includes such waste from mining and breaker operations as culm, rock banks, cast piles, back fill, and silt in settling basins.

Figure 3.--Structural geologic section west of Shamokin.



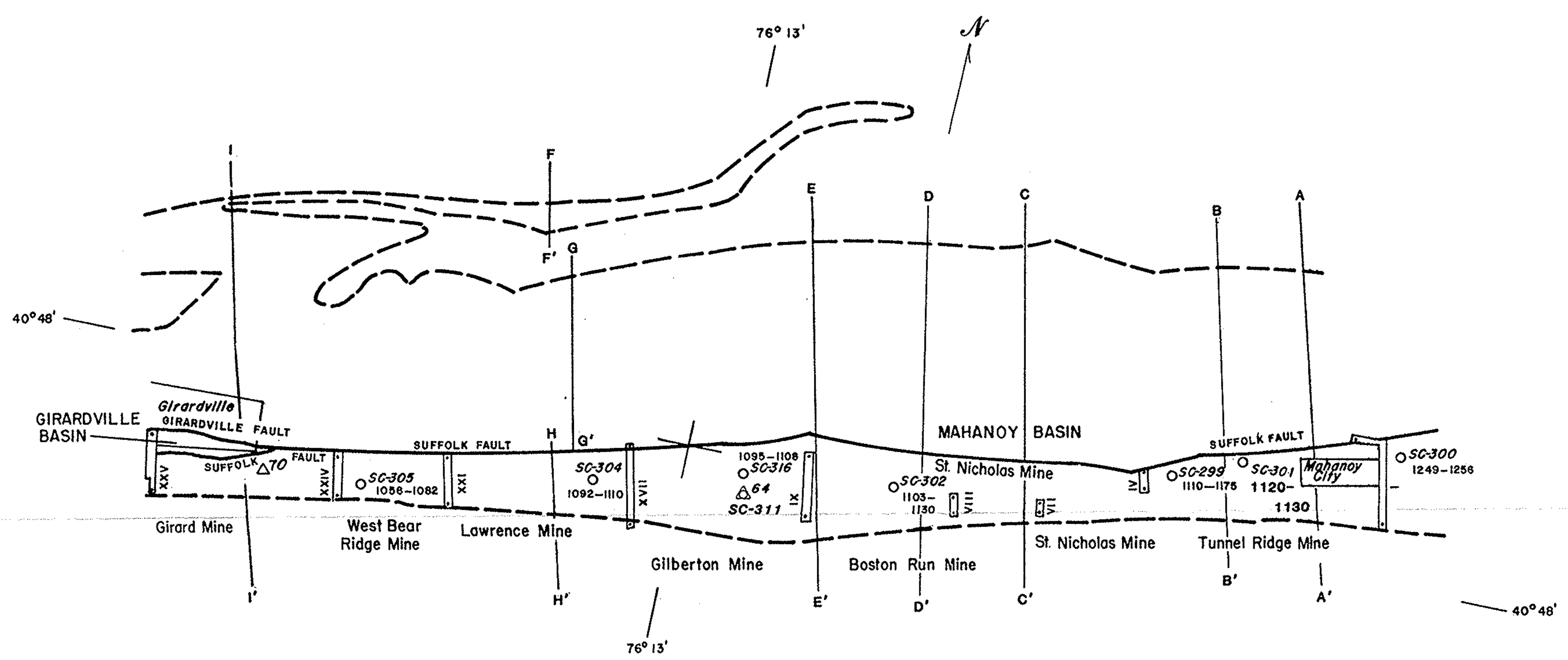
Base from Ash and others, 1953.

EXPLANATION

Outcrop of lowest workable coal bed
Drainage divide
Boundary between coal basins
Major fault and name
④ Number of drainage area
26 mi² Size of drainage area

0 1 2 3 4 MILES
0 2 4 6 KILOMETERS

Figure 4.--Drainage areas in the Middle Western field.



EXPLANATION

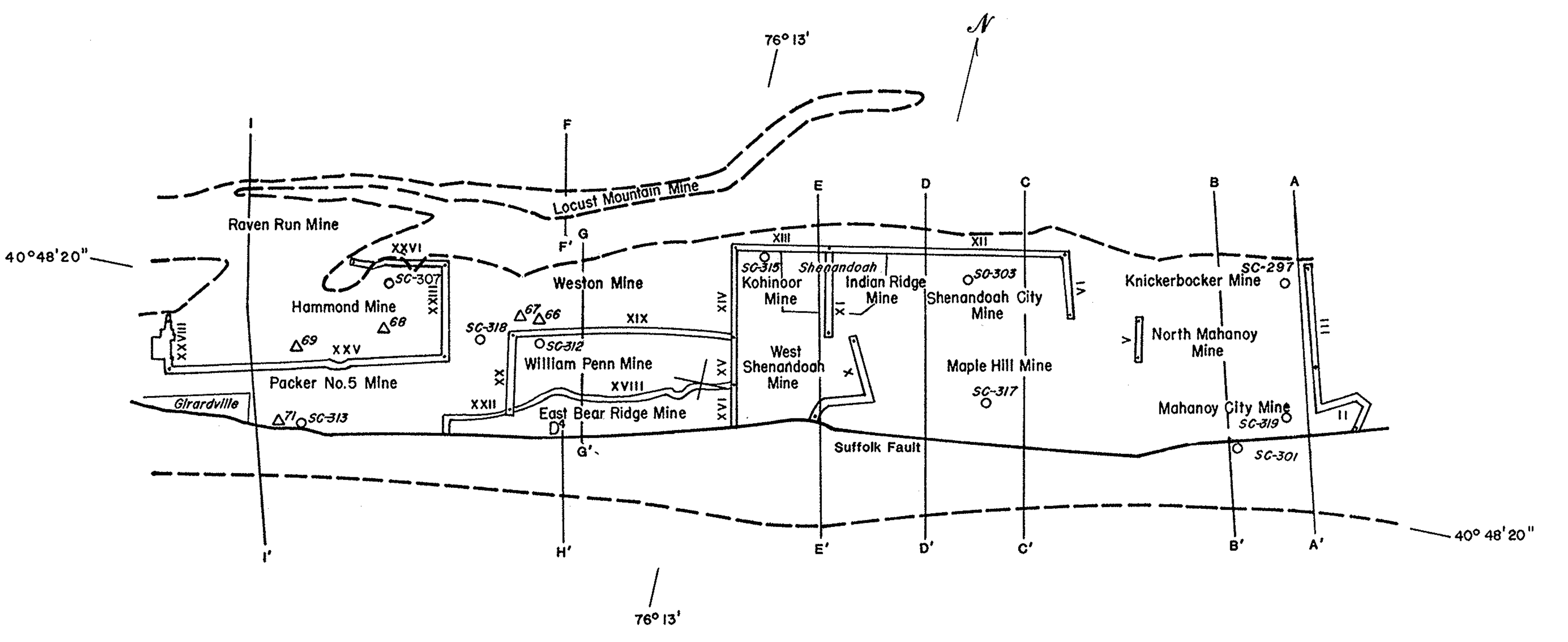
Outcrop of lowest workable coal bed
VII Barrier pillar and number
○SC306 Borehole and number
△72 Mine-water discharge site and number
C——C′ Location of geologic sections shown in figures 18, 19, 20, and 21.
1103–1130 Range in altitudes of water levels in boreholes

Note: Borehole SC-301 terminates on the north side of the Suffolk Fault in the Mahanoy City mine.

Base from Ash and others, 1953.

0 1500 3000 4500 FEET
0 500 1000 METERS

Figure 6.--Mahanoy Coal basin between Mahanoy City and Girardville.



EXPLANATION

Outcrop of lowest workable coal bed
XVI Barrier pillar and number
○SC-303 Observation well and number
△72 Mine discharge site and number
A——A′ Location of geologic section

Note: Borehole SC-301 terminates on the north side of the Suffolk Fault in the Mahanoy City mine.

Base from Ash and others, 1953.

0 1500 3000 4500 FEET
0 500 1000 METERS

Figure 7.--Deep mine complexes in the Shenandoah complex.