

Geology of Rocks of Pennsylvanian Age
in the Southern Half of the
Tremont Quadrangle
Schuylkill County, Pennsylvania

GEOLOGICAL SURVEY BULLETIN 1112-F



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By GORDON H. WOOD, JR., J. PETER TREXLER,
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CONTRIBUTIONS TO ECONOMIC GEOLOGY

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*A description of Pennsylvanian
stratigraphy, anthracite beds, and
structural features of a part of the
Southern anthracite field*



UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

	Page
Abstract	181
Introduction	182
Stratigraphy	185
Devonian rocks	185
Catskill formation	185
Mississippian rocks	186
Pocono formation	186
Mauch Chunk formation	187
Pennsylvanian rocks	189
Pottsville formation	189
Tumbling Run member	190
Schuylkill member	192
Sharp Mountain member	193
Post-Pottsville rocks	195
Quaternary rocks	197
Structure	197
Folds	198
Faults	199
Folded thrust faults	199
Other faults	200
Effect of structure on the mining of coal	201
Coal beds	202
Coal beds of the Pottsville formation	203
Coal beds of post-Pottsville rocks	204
Uranium prospecting	206
References	207

ILLUSTRATIONS

[Plates are in pocket]

<p>PLATE 13. Geologic map. 14. Structure sections <i>A-A'</i> to <i>H-H'</i>. 15. Graphic sections 1 to 7.</p>	Page
<p>FIGURE 22. Index map of the Southern and Western Middle anthracite fields</p>	183
<p>23. Index map showing the location of anthracite fields in eastern Pennsylvania</p>	184

TABLES

	Page
TABLE 1. Floral zones in rocks of Pennsylvanian and Mississippian age in the Appalachian region.....	190
2. Average thickness and range in thickness of the economically more important Pottsville and post-Pottsville coal beds.....	204

CONTRIBUTIONS TO ECONOMIC GEOLOGY

GEOLOGY OF ROCKS OF PENNSYLVANIAN AGE IN THE SOUTHERN HALF OF THE TREMONT QUAD- RANGLE, SCHUYLKILL COUNTY, PENNSYLVANIA

By GORDON H. WOOD, JR., J. PETER TREXLER, ANDY YELENOSKY, and
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ABSTRACT

A sequence of rocks of Late Devonian, Mississippian, and Pennsylvanian age, more than 11,000 feet thick, is exposed in an area of about 27 square miles in west-central Schuylkill County, Pa. These Paleozoic rocks are overlain at many localities by a varying thickness of unconsolidated, sediments of Quaternary age. The entire sequence of rocks accumulated in a continental environment.

The upper part of the Catskill formation of Late Devonian age, 500 to 1,000 feet thick, crops out in the northwestern part of the report area. This unit consists of red, brown, and gray sandstone, siltstone, and shale. The Catskill formation is overlain unconformably by 1,050 to 1,100 feet of strata assigned to the Pocono formation of Mississippian age. The Pocono consists largely of gray to brown quartz conglomerate, conglomeratic quartzose sandstone, and quartzose sandstone. The Mauch Chunk formation of Mississippian age, 2,500 to 6,000 feet thick, succeeds the Pocono with apparent conformity. It consists largely of red sandstone, siltstone, and shale, but contains some interbedded gray conglomerate, sandstone, siltstone, and shale in its basal and upper parts. The overlying Pottsville formation of Early Pennsylvanian age consists of about 1,100 feet of predominantly gray quartz conglomerate, conglomeratic quartzose sandstone, quartzose sandstone, subgraywacke, siltstone, shale, and a few coal beds; its basal beds intertongue with the red beds of the Mauch Chunk. The Pottsville is divided into the Tumbling Run, Schuylkill, and Sharp Mountain members, in ascending order. Post-Pottsville rocks of later Pennsylvanian age rest with apparent conformity on the Pottsville formation. They consist of about 2,150 feet of light-to dark-gray quartz conglomerate, conglomeratic quartzose sandstone, quartzose sandstone, subgraywacke, siltstone, shale, and many coal beds.

The report area, which is in the Southern anthracite field, is on the north limb of the arcuate and completely deformed Minersville synclinorium. The limb of the synclinorium is folded into many doubly plunging anticlines and synclines and is broken by thrust, tear, and bedding faults. The trend of the folds ranges from N. 65°E. to N. 85°E. The fault system within the Pennsylvanian rocks is dominated by a series of low-angle folded thrust faults that are truncated by later high-angle thrust and tear faults and paralleled by bedding faults. The

folded faults developed before or during an early episode of folding. The other faults developed near the end of this folding or during a later episode of deformation.

The coal of the report area is anthracite containing from slightly less than 92 percent to slightly more than 94 percent fixed carbon. The economically more important coal beds are the Middle Split (No. 8½), Holmes (No. 10), Orchard (No. 12), Diamond (No. 14), Tracy (No. 16), and Peach Mountain (No. 18).

INTRODUCTION

The geology of the Pennsylvanian and uppermost Mississippian rocks and the anthracite beds in the south half of the Tremont quadrangle in the Southern anthracite field of Pennsylvania (fig. 22) is described and illustrated in this report. The stratigraphy of the exposed older Mississippian and Devonian rocks is also described briefly. The Southern anthracite field is one of four fields in eastern Pennsylvania that contain coal of anthracite rank (fig. 23). The mapped area is a small part of the Valley and Ridge physiographic province of the Appalachian Highlands (Fenneman, 1946). The only large towns within the area are Tremont, Donaldson, and the eastern part of Hegins.

The geologic map (pl. 13) shows the topography and culture of the area and also outcrops of anthracite beds; the location of mine portals and strip mines; the probable correlation of anthracite beds across faults and between outcrops; the outcrop belts of formations and members; and the geologic structure of the area, including folds and faults, which have controlled the mining of coal and the circulation of underground water. The stratigraphy is shown on 7 graphic sections (pl. 15); and the geologic structure is shown on 8 structure sections (pl. 14).

The fieldwork and the office compilation for this report were done during parts of 1954, 1955, and 1956 at the same time that a much larger area was mapped and studied. Because of the complexity of the geology and the small size of the report area, many of the geologic interpretations and conclusions reached are based upon field mapping and mining-company data from the larger area.

The Reading Anthracite Division of the Philadelphia and Reading Co., The Indian Head Coal Co., other companies, and several individuals furnished mine maps, drill-hole records, sections showing structural features and stratigraphy along tunnels, and similar factual data. The cooperation of these companies and individuals is appreciated.

The authors are responsible for all theoretical interpretations such as the location and correlation of unmined and intermittently mined coal beds, the amount of displacement and direction of movement

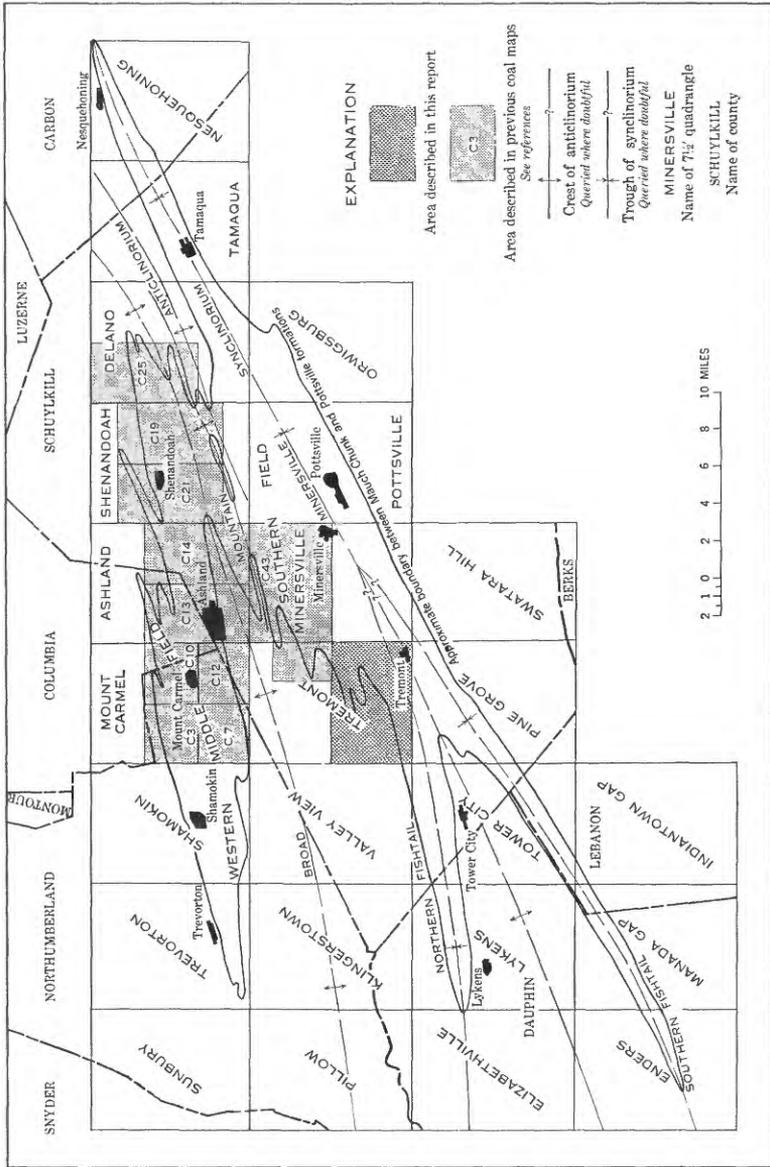


FIGURE 22.—Index map of the Southern and Western Middle anthracite fields showing the location of the mapped area and major structural features.

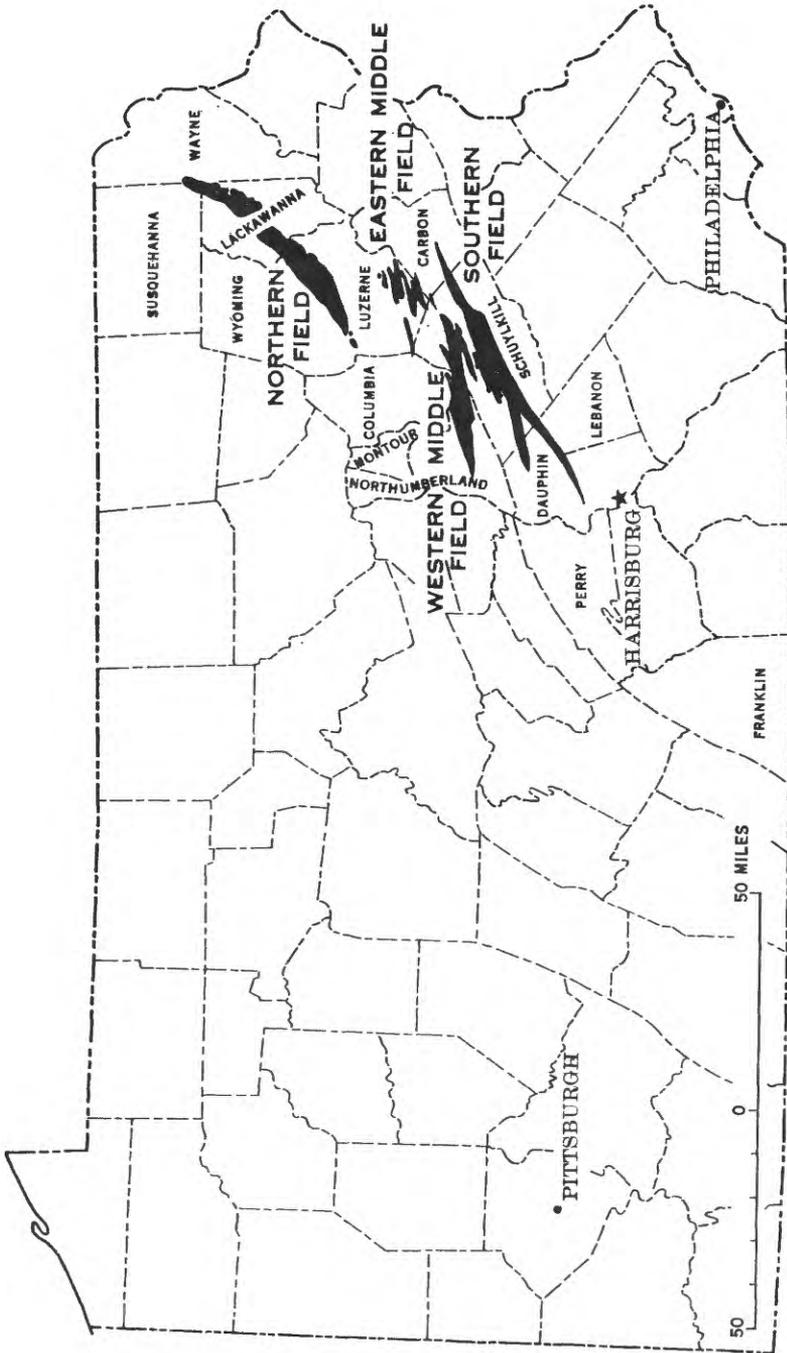


FIGURE 23.—Index map showing the location of anthracite fields in eastern Pennsylvania.

along faults, the correlation of coal beds and other strata across faults, and the subsurface projection of strata below faults in areas where there has been little or no mining. They are also responsible for interpreting the surface location of faults and their projection to depth, the surface location of the traces of crest and trough lines of anticlines and synclines, and the stratigraphic division of the Pottsville formation into three members.

It is suggested that readers who are not acquainted with the techniques of using geologic maps refer to the section entitled "How to Use This Geologic Report" in U.S. Geological Survey Coal Investigations Map C-43 (Wood and others, 1958).

STRATIGRAPHY

Continental rocks of Devonian, Mississippian, and Pennsylvanian age and unconsolidated sediments of Quaternary age crop out in the mapped area. This report is concerned primarily with the Pennsylvanian and youngest Mississippian rocks and secondarily with the older rocks. The Catskill formation of Devonian age and the Pocono formation of Mississippian age are poorly exposed in the northwestern part of the area. The Mauch Chunk formation of Mississippian age is poorly exposed in valleys in the northern, western, and central parts of the area, and the Pottsville formation and post-Pottsville rocks of Pennsylvanian age are exposed in most of the remainder of the area. Unconsolidated deposits of clay, silt, sand, and granule to boulder gravel of Quaternary age locally cover the Pennsylvanian, Mississippian, and Devonian rocks as soil, stream alluvium, and talus.

Graphic sections of the Devonian and Mississippian formations in the mapped area are not included because outcrops are poor and widely scattered, and because a precise description of these formations is not an objective of this report. These formations were described and their thicknesses were estimated from exposures and by lateral tracing of stratigraphic units across covered intervals, using float and topographic expression as guides.

DEVONIAN ROCKS

CATSKILL FORMATION

The upper part of the Catskill formation, 500 to 1,000 feet thick, is intermittently and poorly exposed in the northwestern part of the mapped area north of the crest of Mahantango Mountain. The beds in this part of the formation are divisible into the following two units, but these are not shown separately on the geologic map (pl. 13): (a) 250 to 700 feet of red, grayish-red, and reddish-brown shale, silt-

stone, and sandstone overlain by (b) $250\pm$ feet of light-brown, olive-brown, yellowish-brown, and light-gray shale, siltstone, and quartzose sandstone. (The term "shale" is used in this report for all consolidated clastic sediments whose grain size is less than $1/250$ mm in diameter.)

The contact between the Catskill and Pocono formations, which is difficult to locate in mapping because of poor exposures, is placed at the base of the lowest conglomerate bed of definite Pocono lithology. The authors recognize that the upper unit of the Catskill formation as defined above may represent locally the basal part of the Pocono formation as identified by others elsewhere in eastern Pennsylvania. Nevertheless, they have placed this unit in the Catskill because it resembles the upper part of the Catskill formation to the south and east that was assigned by Willard (1936, p. 571, 581-584, 606) to the Honesdale sandstone of I. C. White (1881, p. 66-68), and it thins to less than 50 feet beneath the lowest conglomerate of definite Pocono lithology northeast of the mapped area in the northern part of the Tremont quadrangle. It is not possible to determine from the exposures in the mapped area if the northeastward thinning is due to pre-Pocono erosion or to shearing along bedding planes that separated rocks of differing structural competency; however, the authors believe the thinning is due to erosion.

MISSISSIPPIAN ROCKS

POCONO FORMATION

The Pocono formation, which is composed of gray conglomerate and sandstone 1,050 to 1,100 feet thick, crops out on the crest and south flank of Mahantango Mountain. The formation is divisible into four units in the field but these units are not distinguished on the geologic map (p. 13). The following is a description of these units, from base to top: (a) 250 to 300 feet of interbedded light-gray and yellowish-brown quartz-pebble and granule conglomerate and sandstone, (b) $400\pm$ feet of gray coarse-grained quartzose sandstone, (c) about 100 feet of grayish-orange and light-gray fine quartz-pebble and granule conglomerate and sandstone, and (d) $300\pm$ feet of yellowish-orange, yellowish-brown, or gray sandstone and conglomeratic sandstone. Several thin beds of carbonaceous shale and coal are intercalated in the sandstone units.

In the conglomerate sequences, the percentage of coarse sandstone and conglomeratic sandstone is several times greater than that of conglomerate. Throughout the formation, pebbles are locally as much as 2 inches in diameter but average $1/4$ to $1/2$ inch; they are subrounded to well rounded. The fine- to coarse-grained sandstone matrix is poorly to well cemented by silica, and the rocks range from friable to quartzitic. Bedding ranges from thin to massive but is largely medium or

massive. (Bedding-thickness terms as used in this report are "massive," more than 4 feet; "medium," 1 to 4 feet; "thin," less than 1 foot.)

The contact of the Pocono formation with the overlying Mauch Chunk formation is obscured at most localities by soil and talus, but a study of the few exposures suggests that the rocks near the contact are conformable. The base of the lowest reddish-brown sandstone, siltstone, or shale typical of the Mauch Chunk has been chosen arbitrarily as the contact between these formations.

MAUCH CHUNK FORMATION

The Mauch Chunk formation consists predominantly of red beds with minor amounts of gray conglomerate, sandstone, siltstone, and shale in the lower and upper few hundred feet. It crops out in wide valleys that were eroded by Deep, Pine, and Hans Yost Creeks. Exposures of the formation generally are poor, and most of the information concerning the various parts of the formation was obtained by lateral tracing of locally distinctive units, which are not shown on the geologic map.

The original thickness of the Mauch Chunk formation is unknown because the shale and siltstone units locally have been greatly thinned or thickened by bedding and thrust faults, by shear zones of small displacement, and by much rock flowage. The faults and shear zones in the outcrop belt of the Mauch Chunk formation are not shown on the geologic map because the main objective of this report is to describe and illustrate the large-scale structure and stratigraphy of the Pennsylvanian rocks of the map area. The apparent thickness of the formation in the area ranges from about 2,500 to 6,000 feet.

The basal 250 to 500+ feet of the formation consists mainly of thick units of red and reddish-brown shale, siltstone, and sandstone. Interbedded with these red units are 2 units ranging in thickness from 10 to 50 feet and composed of thin- to medium-bedded gray, yellowish-brown, and brownish-gray, and olive-gray shale, siltstone, and sandstone containing lenses of granule conglomerate. Sandstone beds in the nonred units are composed largely of fine to coarse grains of clear, rose, and smoky quartz, together with minor quantities of chert, mica, feldspar, and hematite. The rock types in the nonred units closely resemble those of the Pocono formation, and it is possible that these units are tongues of the Pocono or that they represent a recurrence of similar sedimentation.

The medial 1,500 to 5,000 feet of the Mauch Chunk formation consists of many laterally persistent zones of red, reddish-brown, and grayish-red siltstone and sandstone. The beds range in thickness from 0 to more than 10 feet and vary from tabular to wedge shaped.

Crossbedding and cross-lamination are common. The sandstone beds are chiefly fine to medium grained and consist largely of well-sorted subrounded to well-rounded quartz grains with minor amounts of chert, mica, feldspar, and other accessory minerals. The sandstone is moderately well cemented by hematite and silica. In some localities green or grayish-green streaks are conspicuous in the red shale, siltstone, and sandstone beds. These streaks commonly are parallel to the bedding but some follow joints, indicating that they may be due to the reduction of iron oxide. Mud cracks, ripple marks, and rain prints are locally abundant in shale units where the bedding planes are not obscured by fracture cleavage.

The outcrop belt of the upper 300 to 600 feet of the Mauch Chunk formation is largely covered by talus. This part of the formation is composed of red and reddish-brown shale, siltstone, and sandstone beds that alternate with several persistent zones of gray, grayish-green, olive-gray, and yellowish-brown pebble and cobble conglomerate, conglomeratic sandstone, sandstone, shale, and siltstone. The nonred beds are commonly parallel laminated and cross laminated; lenticular, irregular, wedge shaped; and are thin to massive. Pebbles and cobbles of quartz, quartzite, gneiss, granite, schist, red shale, siltstone, and sandstone range from $\frac{1}{4}$ inch to 7 inches in diameter. They are sporadically embedded in a matrix of moderately to well-cemented fine- to coarse-grained sandstone. The beds in the nonred zones are similar to those in the basal part of the overlying Pottsville formation, and the red beds resemble those lower in the Mauch Chunk. These two distinctively different suites of rocks in the upper 300 to 600 feet of the Mauch Chunk clearly record the alternation of depositional environments in which rocks typical of Mauch Chunk sedimentation and those typical of Pottsville sedimentation accumulated.

Although field mapping and stratigraphic studies in the Southern anthracite field show an intertonguing relationship, the authors, following White (1900, p. 832), have placed the contact between the Mauch Chunk and the Pottsville formations at the top of the uppermost red or brownish-red bed of shale, siltstone, or sandstone. The basal conglomerate beds of the Pottsville are progressively replaced northward by red beds of the Mauch Chunk formation at the rate of 10 to 15 feet per mile.

About 5 miles southeast of the mapped area, at the type and reference sections of the Pottsville formation (Wood and others, 1956) at Pottsville, the contact between the Pottsville and Mauch Chunk formations has been considered for many years to be the type locality of the base of the Pennsylvanian system (Moore and others, 1944, p. 665). The Mississippian-Pennsylvanian time boundary, as defined at the

type and reference sections of the Pottsville formation, probably is in the uppermost part of the Mauch Chunk formation in the mapped area because of the northward replacement of the basal conglomerate of the Pottsville by red beds of the Mauch Chunk.

PENNSYLVANIAN ROCKS

Rocks of the Pennsylvanian system are assigned to the Pottsville formation of Early and Middle Pennsylvanian age and to a sequence of post-Pottsville rocks of Middle and possibly, in part, of Late Pennsylvanian age. The Pottsville has been divided into three members, which have been traced over much of the anthracite region (Wood and others, 1956). Post-Pottsville rocks have not been divided because distinct lithologic units other than coal beds have not yet been identified or traced for more than a few miles.

The formations and members of Pennsylvanian age described in this report are not correlated by the authors with Pennsylvanian formations in western Pennsylvania because of the distance involved and the dissimilarity of the rocks. Table 1, however, shows tentative regional rock correlations (C. B. Read, written communication, 1955) between formations in the Southern anthracite field and elsewhere in the Appalachian region as based on floral zones.

POTTSVILLE FORMATION

The Pottsville formation, composed mainly of conglomerate, sandstone, siltstone, shale, and coal, crops out on Broad and Little Mountains in Barry, Foster, Frailey, and Hegins Townships. Exposures are mainly near the tops of the mountains. The topography of most of the area underlain by the Pottsville is that of a rolling highland; however, along the margins of the coal field it is rough and steep.

The Tumbling Run, Schuylkill, and Sharp Mountain members of the Pottsville formation were named and described from exposures at the type and reference sections in the water gap through Sharp Mountain, which is a short distance south of Pottsville, Pa. (Wood and others, 1956). Some of the variations in Pottsville stratigraphy and the local variations in thickness of its upper members are shown in the structure sections (pl. 14) and graphic diagrams (pl. 15). Thickness data for the upper part of the formation are plentiful, but similar data for the lower part are sparse owing to the lack of exposures and mining data and to numerous structural complications. The formation averages about 1,100 feet in thickness in the mapped area.

The named and numbered coal beds of the Pottsville formation are, in ascending order, the Lykens Valley No. 6, No. 5, No. 4, No. 3 $\frac{3}{4}$,

TABLE 1.—*Floral zones in rocks of Pennsylvanian and Mississippian age in the Appalachian region, with reference to the Southern anthracite region*¹

System	Floral zone	Rock unit in—	
		Appalachian region except Southern anthracite field	Southern anthracite field
Permian	<i>Callipteris conferta</i>	Lowest part of Permian	Not known.
Pennsylvanian ²	<i>Danaeites</i> spp.	Monongahela formation, upper part.	Not known.
	<i>Lesuropteris</i> spp.	Monongahela formation, lower part, and Conemaugh formation, upper part.	Not known.
	<i>Neuropteris flexuosa</i> and <i>Pecopteris</i> spp.	Conemaugh formation, lower part, and Allegheny formation, upper part.	Post-Pottsville rocks, undifferentiated.
	<i>Neuropteris rarinervis</i>	Allegheny formation, lower part	Sharp Mountain member, upper part.
	<i>Neuropteris tenuifolia</i>	Kanawha formation, major part	Not known.
	<i>Megalopteris</i> (formerly <i>Cannophyllites</i>)	Kanawha formation, base	Schuykill member.
	<i>Mariopteris pygmaea</i> and <i>Neuropteris tennesseana</i>	New River formation, upper part, and Lee formation, upper part	Tumbling Run member, Lykens Valley No. 4 coal bed and adjacent strata.
	<i>Mariopteris pottsvillea</i> and <i>Aneimites</i> spp.	New River formation, lower part	Tumbling Run member, Lykens Valley No. 5 and No. 6 coal beds and adjacent strata.
	<i>Neuropteris pocahontas</i> and <i>Mariopteris eremopteroides</i>	Pocahontas formation	Mauch Chunk formation.
	Mississippian ³	<i>Cardiopteris</i> spp. and <i>Sphenopteridium</i> spp.	Mauch Chunk formation
<i>Triphylopteris</i> spp.		Pocono formation, upper part	Pocono formation, lower part.
<i>Adiantites</i> spp.		Pocono formation, lower part	Upper part of Devonian sequence of rocks.
Devonian	<i>Archaeopteris</i> spp.	Upper part of Devonian sequence of rocks	

¹ Charles B. Read, written communication, 1955.² Boundary between Pennsylvanian and Mississippian rocks was incorrectly shown in an earlier report by Wood and others (1958, table 1).

No. 3, No. 2, No. 1½, and No. 1; the Scotty Steel No. 2 and No. 3; and the Little Buck Mountain (No. 4). Several thin and nonpersistent leader coal beds are locally present, but to date they have not proved to be economical to mine.

TUMBLING RUN MEMBER

The Tumbling Run member is composed largely of thin to thick beds of gray, grayish-brown, olive-gray, grayish-green, and yellowish-brown pebble and cobble conglomerate, conglomeratic sandstone, sub-graywacke, and quartzose sandstone intercalated with thin to thick beds of gray, grayish-green, and dark-gray shale and siltstone, and coal.

Most of the coarse clastic rocks are concentrated in the lower part of the member; conglomerate and conglomeratic sandstone make up about half. Conglomerate beds at most places are parallel laminated to cross laminated; tabular, lenticular, or wedge shaped; and thin to massively bedded. The quartzose sandstone and subgraywacke beds are also parallel laminated to cross laminated; tabular, lenticular, or irregular; and are thin to massively bedded. The conglomerate and sandstone are generally cemented by silica and limonite, but to a small extent by calcite. Most of the coarse clastic rocks are well cemented, and some are sedimentary quartzite.

At most localities slightly more than 75 percent of the cobbles and pebbles are white or pink vein quartz and quartzite; the remainder are principally chert and slightly metamorphosed gray, red, and dark-brown sandstone, siltstone, and shale. A few pebbles of granite, gneiss, and schist were found in several places. The pebbles and cobbles, which are predominantly rounded, range in diameter from about $\frac{1}{4}$ inch to 6 inches and average about 1 inch. In many localities the cobbles and pebbles are fractured by joints; in a few places they are distorted or squeezed, probably as the result of folding and thrust faulting.

The finer clastic rocks and coal are concentrated largely in the upper part of the member. Megascopically, most of the siltstone is quartzose, but it contains varying amounts of mica, clay, and carbonaceous material. The shale is clayey to silty and commonly contains a high percentage of carbonaceous material. Ironstone nodules locally are abundant in the shale. The rocks beneath the coal beds commonly vary from siltstone to shale along the strike and in fresh exposures do not appear to be laminated or fissile; however, where weathered these rocks commonly are distinctively laminated and some have poor to excellent fissility. The rocks beneath the coal beds locally contain *Stigmaria*.

Three coal beds in the upper part of the Tumbling Run member are persistent and of economic and stratigraphic importance. In ascending order these are the Lykens Valley No. 6, No. 5, and No. 4 coal beds (table 1 and pl. 15). They underlie most of the coal field in the mapped area and their outcrops are shown on the geologic map (pl. 13) and in structure sections (pl. 14) where their thickness is known or inferred to be more than 14 inches. At most places these coal beds are underlain by shale or siltstone and are overlain by conglomerate and sandstone or shale and siltstone which locally contain well-preserved plant fossils. At many localities the Lykens Valley No. 6 and No. 5 coal beds and the adjacent shale and siltstone contain a fossil flora consisting largely of plant species from

Read's zone of *Neuropteris pocahontas* and *Mariopteris eremopteroides* (oral communication, 1955) with a few species from the succeeding zone of *Mariopteris pottsvillea* and *Aneimites* spp. The flora of the Lykens Valley No. 4 coal bed is largely from the zone of *Mariopteris pottsvillea* and *Aneimites* spp. and to a lesser extent from the zone of *Neuropteris pocahontas* and *Mariopteris eremopteroides*.

The thickness of the Tumbling Run member is difficult to determine because of structural complications, but it appears to average about 500 feet and to range from about 280 to 800 feet. The member seems to thin slightly to the east, and the percentage of fine clastic material increases to the west and north.

SCHUYLKILL MEMBER

The Schuylkill member consists of pebble conglomerate, conglomeratic sandstone, sandstone, siltstone, shale, and coal beds. Regionally it intertongues with the Tumbling Run member, although locally it appears to rest conformably on the Tumbling Run. The contact between these members is at the base of a sequence of quartz-pebble conglomerate beds and at the top of a sequence of quartzose sandstone, conglomeratic sandstone, siltstone, or shale beds. The average diameter and range in size of the pebbles is slightly less in the conglomerate of the Schuylkill member than in the conglomerate of either the Tumbling Run or Sharp Mountain members; the Schuylkill member is consistently grayer in color than the Tumbling Run member and does not contain distorted or squeezed pebbles.

The basal unit of the Schuylkill member is composed of lenticular and irregularly bedded conglomerate containing pebbles of white to gray vein quartz and quartzite. It ranges in thickness from about 50 feet to slightly more than 70 feet. At most localities the pebbles weather out and form a fine gravel. They range in diameter from slightly less than $\frac{1}{4}$ inch to about 2 inches, their average diameter is about $\frac{3}{8}$ inch, and most of them are rounded. The beds of the Schuylkill member are well jointed at many localities; however, the joints usually have developed around the pebbles rather than through them.

Above its basal unit, the Schuylkill member consists of light- to dark-gray, grayish-green, and olive-brown quartz and quartzite-pebble conglomerate, conglomeratic quartzose sandstone, quartzose sandstone, and subgraywacke interbedded with gray, grayish-green, and dark-gray siltstone and shale, and thin to thick beds of coal. The pebbles in the conglomeratic rocks are smaller than those in the basal unit, averaging about $\frac{1}{4}$ inch in diameter and ranging from less than $\frac{1}{4}$ inch to about $1\frac{1}{2}$ inches. Most of the pebbles are rounded and are composed of white and gray vein quartz and to a lesser extent white

or gray quartzite. In many localities the sandstone is well jointed and the joints are heavily stained by limonite. The subgraywacke and some of the quartzose sandstone are characterized by an abundance of carbonaceous material, most of which megascopically appears to be finely divided vegetable matter. The siltstone is quartzose and micaceous and contains varying amounts of clay and carbonaceous material. Shale is more common in the Schuylkill member than in the other members of the formation. It is either clayey or silty and generally contains a high percentage of carbonaceous material. Ironstone nodules are common in the shale. Fissility and discernible laminations seem to be related in many places to weathering (see description of Tumbling Run member).

Three coal beds are economically and stratigraphically important throughout the outcrop area of the Schuylkill member. In ascending order these are the Lykens Valley No. 3, No. 2, and No. 1 coal beds. The Lykens Valley No. 1½ coal bed has been mined locally and is shown on the geologic map (pl. 13), structure sections (pl. 14), and graphic sections (pl. 15) where it is known or interpreted to exceed 14 inches in thickness. At most localities the coal beds of the Schuylkill member are underlain by siltstone and shale. The roof rocks are commonly conglomerate and sandstone but locally are shale and siltstone that contain a fossil flora characteristic of the zone of *Mariopteris pygmaea* and *Neuropteris tennesseana* (table 1). The floor rocks of the coal beds contain *Stigmaria* in many places.

The beds of the Schuylkill member are tabular, lenticular, irregular, and wedge shaped and range in thickness from less than 1 inch to slightly more than 5 feet. Beds of the finer clastic rocks are mainly parallel-laminated and the beds of the coarser clastic rocks are principally cross-laminated. Cementation by silica, calcite, and hematite is moderate to strong. The sandstone and subgraywacke are commonly cemented more firmly than the conglomerate.

The thickness of the Schuylkill member is difficult to determine because of structural complications such as bedding and low-angle thrust faulting and squeezing of strata. The member ranges in thickness between 210 and 575 feet and averages about 410 feet.

SHARP MOUNTAIN MEMBER

The Sharp Mountain member consists of conglomerate, sandstone, siltstone, shale, and coal beds. It ranges in thickness from about 100 to 270 feet and averages about 190 feet. The contact between the Sharp Mountain and Schuylkill members is placed at the base of a thick sequence of light-gray quartz-pebble and cobble-conglomerate beds and at the top of a sequence of light-gray, grayish-green, and yellowish-

green conglomeratic quartzose sandstone, siltstone, and shale, and coal beds. The regional stratigraphic and paleobotanical relations above and below the contact strongly suggest either a considerable hiatus during which there was little if any erosion or a regional disconformity of small erosional relief between these members. There is little local evidence of an unconformity.

The basal conglomerate of the Sharp Mountain member is 80 to 120 feet thick and contains rounded pebbles and cobbles composed chiefly of white to medium-gray vein quartz and quartzite. The pebbles and cobbles range from about $\frac{1}{4}$ inch to 5 inches in diameter and average about 1 inch. In some localities, a few elongate pebbles and cobbles of sandstone, siltstone, shale, schist, gneiss, and granite have been found. The degree of rounding of the larger pebbles and cobbles is commonly greater than that of the smaller ones. The matrix of the conglomerate beds is at most localities poorly to moderately well cemented fine- to coarse-grained quartzose sandstone and subgraywacke. Upon weathering, the cobbles and pebbles stand out in relief. The basal conglomerate is concealed at most places by a thick mantle of residual gravel; however, in many places it forms a series of massive steeply dipping ledges characterized by protruding cobbles and pebbles.

The upper part of the Sharp Mountain member ranges in thickness from about 20 to 150 feet. It is composed of light- to medium-gray quartz-pebble conglomerate, conglomeratic quartzose sandstone, subgraywacke, and quartzose sandstone; medium- to dark-gray shale and quartzose siltstone; and two or more beds of coal. Tabular, lenticular, and wedge-shaped beds are common in this part of the member. Most beds of coarse clastic rocks are crossbedded and cross-laminated, but a few are parallel-laminated. The cementation of the beds of finer clastic rocks is moderate to strong and that of the coarse clastic rocks is weak to strong. The quartzose rock contains chert, mica, and rock fragments as accessory constituents. The shale units are silty or clayey. They contain a fossil flora characteristic of the zones of *Neuropteris tenuifolia* and *Neuropteris rarinervis* (table 1). Plants representative of the zone of *Megalopteris* (formerly *Cannophyllites*) have not been found.

Most of the pebbles in the upper part of the member are rounded. They consist chiefly of white to medium-gray vein quartz and quartzite and rarely of sandstone, shale, siltstone, granite, gneiss, and schist. Their average diameter is about $\frac{1}{2}$ inch, but they range from slightly less than $\frac{1}{4}$ inch to about $1\frac{1}{2}$ inches in diameter.

The coal beds of the Sharp Mountains are confined to the upper 20 to 100 feet of the member. They commonly are underlain by shale

and siltstone and in most places are overlain by conglomerate or sandstone. The Scotty Steel No. 2 and No. 3 coal beds, where they are known or are inferred to be more than 14 inches thick, are shown on the geologic map (pl. 13) structure sections (pl. 14), and graphic sections (pl. 15). The Little Buck Mountain (No. 4) coal bed is shown on the geologic map and structure sections, but it is not shown on the graphic sections because it does not occur at the places where the sections were measured. It lies about 175 feet above the base of the Sharp Mountain member and 50 feet above the stratigraphic position of the Scotty Steel No. 3 coal bed in adjacent areas. The Little Buck Mountain (No. 4) coal bed has not been recognized in the mapped area south of the northernmost trace of the Lower Mine Hill fault and the Peaked Mountain anticline, and the Scotty Steel coal beds have not been identified north of these same structural features. The shale beds adjacent to the Little Buck Mountain (No. 4) coal bed in the Little Mountain syncline contain a fossil flora of the *Neuropteris rarinerervis* zone (C. B. Read, oral communication, 1955; see table 1.) Those adjacent to the Scotty Steel No. 3 coal bed in the Dam syncline and between the traces of the Lower and Middle Mine Hill faults contain a slightly older flora that consists of fossils representative of both the *Neuropteris rarinerervis* zone and the *Neuropteris tenuifolia* zone.

The contact between the Sharp Mountain member of the Pottsville formation and post-Pottsville rocks is at the base of the Buck Mountain (No. 5) coal bed. The field relations of strata near this contact suggest that it is conformable; however, the absence of the Little Buck Mountain (No. 4) coal bed in the southern part of the mapped area may be due to a period of erosion that preceded the deposition of the Buck Mountain (No. 5) coal bed and its underlying shale bed. If a period of erosion did precede the deposition of the Buck Mountain (No. 5) coal bed, about 100 feet of strata was locally eroded (Wood and others, 1958; compare composite stratigraphic section of that report with pl. 15 of this report).

POST-POTTSVILLE ROCKS

Post-Pottsville rocks crop out in the deeply downwarped parts of the Donaldson and Tremont synclines along Good Spring and Middle Creeks and Coal Run, and the lower several hundred feet of these beds is also preserved on Broad Mountain in the Fisher, Dam, and Little Mountain synclines (pl. 13). The upper part of this rock sequence has been irregularly eroded so that its full thickness is not preserved in the Southern anthracite field. Post-Pottsville strata slightly younger than those found in the mapped area are preserved, however, to the south and east in the most deeply depressed part of the field.

The post-Pottsville rocks are composed of shale, siltstone, quartzose sandstone, subgraywacke, conglomeratic quartzose sandstone, quartz-pebble conglomerate, and coal beds. Coarse clastic sediments such as sandstone, subgraywacke, and granule and small-pebble conglomerate predominate over the finer clastic sediments such as shale and siltstone. Conglomerate and coarse sandstone are more common between the Buck Mountain (No. 5) and Bottom Split (No. 8) coal beds, between the Holmes (No. 10) and Orchard (No. 12) coal beds, and above the Little Diamond (No. 15) coal bed, than they are in the other parts of the post-Pottsville sequence.

The beds between the Buck Mountain (No. 5) coal bed and the Top Split (No. 9) coal bed are chiefly somber gray or grayish brown, whereas the beds above the Top Split coal bed are either yellowish gray or light grayish brown. The beds of the post-Pottsville sequence are tabular, lenticular, irregular, and wedge shaped, thin to massive, and contain both parallel-laminations and cross-laminations. The quartz-pebble conglomerate, conglomeratic sandstone, coarse quartzose sandstone, and subgraywacke are mainly thick to massively bedded and cross-laminated. Beds of fine clastic rocks are principally thin bedded and parallel-laminated.

Most of the economically important and intensively mined coal beds are in post-Pottsville rocks. The thicker, more persistent, and more intensively mined of these coal beds are the Bottom Split (No. 8), Middle Split (No. 8 $\frac{1}{2}$), and Top Split (No. 9), which constitute the Mammoth coal zone; and the Holmes (No. 10), the Primrose (No. 11), the Orchard (No. 12), the Little Orchard (No. 13), the Diamond (No. 14), the Tracy (No. 16), and the Peach Mountain (No. 18). Several less important coal beds are mined where they thicken locally. These coal beds are the Buck Mountain (No. 5), Skidmore (No. 7), Little Diamond (No. 15), and Little Tracy (No. 17). The Seven Foot (No. 6), Upper Four Foot (No. 16 $\frac{1}{2}$), Tunnel (No. 19), Rabbit Hole (No. 20), Faust (No. 21), and Salem (No. 22) coal beds are mined only in a few places and are also known elsewhere from prospects. Several leader and rider coal beds have been found locally in prospects, strip mines, and underground mines.

The Buck Mountain (No. 5) and Seven Foot (No. 6) coal beds contain a fossil flora of the *Neuropteris rarinervis* zone (C. B. Read, oral communications, 1954-55). The strata between the Seven Foot (No. 6) coal bed and the base of the Bottom Split (No. 8) coal bed contain a mixed flora from the *Neuropteris rarinervis* zone and the zone of *Neuropteris flexuosa* and *Pecopteris* spp. (table 1). Coal beds above the Bottom Split (No. 8) coal bed contain a fossil flora of the zone of *Neuropteris flexuosa* and *Pecopteris* spp. None of the coal beds in the

Southern anthracite field are known to contain fossil plants as young as the zone of *Lesuropteris* spp.

According to Read (oral communications, 1954-55), the youngest rocks in the post-Pottsville sequence contain a flora that suggests they are correlative with the upper part of the Allegheny formation or the lower part of the Conemaugh formation of western Pennsylvania.

The original thickness of the post-Pottsville sequence is unknown because it has been eroded, and the youngest beds are not preserved. Within the mapped area an average of about 2,150 feet of post-Pottsville rocks is preserved in the Tremont syncline, where the youngest coal bed, the Salem (No. 22), is overlain by about 100 feet of rock.

QUATERNARY ROCKS

Surficial deposits of unconsolidated clay, silt, sand, and granule to boulder gravel of Quaternary age cover the Paleozoic rocks along stream courses and on the steeper hillsides. Since the areal extent of most of the surficial deposits is small, and most deposits are thin, they are not shown on the geologic map.

The debris from underground and strip mines has been dumped wherever coal beds are mined. As a result, channels of many streams are choked locally by waterlaid accumulations of mine debris. Deposits of mine debris are not shown on the geologic map because their thickness and areal extents are constantly changing.

STRUCTURE

The mapped area (fig. 22) is on the complexly deformed north limb of the Minersville synclinorium (Wood and others, 1958). This limb, which is much larger than the mapped area, has been folded into many doubly plunging enechelon anticlines and synclines and has been broken by many thrust and bedding faults. That part of the Minersville synclinorium underlain by coal-bearing rocks of Pennsylvanian age is the Southern anthracite field.

The Minersville synclinorium is overturned to the north throughout much of its extent. The north limb is relatively broad in outcrop, and its component folds, although locally symmetrical, are generally asymmetrical with their axial planes vertical or inclined to the north or to the south. The south synclinorial limb is not as broad in outcrop and in most places it is overturned to the north, as are many of its component folds.

In the vicinity of the mapped area the synclinorium consists of two deeply downwarped elongate and complexly folded areas or troughs. The northern trough trends about N. 75°-80° E. through the southern part of the mapped area where it locally follows the trough of the Don-

aldson syncline. The southern trough trends about N. 66° E., 1 to 2 miles south of the south edge of the mapped area. These troughs are known informally as the "northern and southern fishtails." They are separated in the southern part of the mapped area and to the west and south of the area by an unnamed anticlinorium which plunges eastward and dies out in the adjacent Minersville quadrangle. Where the anticlinorium dies out the troughs appear to unite to form the most deeply depressed part of the synclinorium. The anticlinorium and the 2 troughs extend southwest from the mapped area for about 65 to 70 miles.

FOLDS

The principal synclines containing beds of anthracite are called "basins" by the mining industry. Smaller anthracite-bearing synclines on the flanks of the larger folds are termed "local basins." Locally, limbs of folds that are truncated by thrust faults but which appear, because of the lack of mining data, to be parts of synclines have also been called "basins." The term "basin" is not used in this report for a syncline or a truncated limb.

The larger synclines in the mapped area from north to south are Little Mountain, Dam, Donaldson, and Tremont. The larger anticlines are the Peaked Mountain, West West Falls, and Big Lick Mountain anticlines. Each of these folds is doubly plunging but not within the mapped area; however, many smaller folds do plunge within the area. The trends of crest axes range from about N. 65° to 85° E., and most of the axial planes are slightly inclined to the south. The amplitude of the folds generally ranges from 2 inches to 5,000 feet, and the wavelength from 2 inches to slightly more than 2 miles. The type of folding varies from disharmonic to parallel; the synclines usually are more tightly folded than the adjacent anticlines. Small folds tend to be more disharmonic in their pattern and their limbs proportionately more attenuated.

East of section *A-A'* on Broad Mountain the West West Falls anticline splits eastward into the Crystal Run and Swatara anticlines, separated by the Forestville syncline. In the southeastern part of the area near section *C-C'* the Tremont syncline splits westward into the Tremont and South Tremont synclines, separated by the Little Lick Mountain anticline.

Field mapping and subsurface mining data show that the larger anticlines and synclines affect the rocks to depths of many thousands of feet. These data also show that the smaller flexures die out rapidly with depth and most of them do not affect strata far below the present ground surface.

FAULTS

The fault system in the mapped area is dominated by a series of low-angle folded thrust faults; high-angle thrust, bedding, and tear faults are present but are of less importance. The folded thrust faults may have developed before the deformation that resulted in the present folded aspect of the Valley and Ridge physiographic province or they may have developed during the folding. Other types of faults seem to have developed during a later state of folding or near the end of folding.

FOLDED THRUST FAULTS

The principal folded thrust faults are the Lower, Middle, and Upper Mine Hill, and Hentzes faults. Their individual displacement, as determined from data obtained in field mapping, from mine data, and from the synthesis of these data into a series of cross sections, seems to exceed 1,000 feet and locally to be as much as or slightly more than 2,500 feet. These faults broke through the bedding at low angles and in many places are nearly parallel to it. The Lower and Middle Mine Hill faults and the Hentzes fault join in the west half of the mapped area (pl. 13) between sections *E-E'* and *F-F'* in the outcrop belt of the Tumbling Run member of the Pottsville formation. West of the fault junction the fault cuts downward into the upper part of the Mauch Chunk formation and cannot be traced because of overlying talus.

The strata of the Schuylkill member of the Pottsville formation above the Upper Mine Hill fault in the Dam syncline are believed to be a klippe. The area of the probable klippe is poorly exposed, and a fault was not found during field mapping; however, the rocks exposed in the axial part of the syncline are similiar to those of the Schuylkill member rather than to those of the post-Pottsville sequence. The log of an old borehole substantiates this difference in lithology. The exact surface location of the borehole was not found, but as nearly as can be determined it was near the axis of the syncline and about 1,000 to 2,000 feet east of section *A-A'*. The log shows about 250 feet of pebble conglomerate, shale, and sandstone above the Buck Mountain (No. 5) coal bed. The lithology of the beds penetrated and the absence of thick coal beds such as the Bottom Split (No. 8) coal bed of the Mammoth coal zone and other post-Pottsville coal beds indicates that part of the rocks above the Buck Mountain (No. 5) coal bed are anomalous in lithology and stratigraphic position and were probably emplaced by a fault.

As shown by paleobotanical data (Read, oral communication, 1955), the strata of the Sharp Mountain member of the Pottsville formation in the plat of the Hentzes fault on the south limb of the Dam syn-

cline rest on beds above the Lykens Valley (No. 4) coal bed of the Tumbling Run member. This structural relation suggests that the Hentzes fault either developed at a time when the strata, now preserved in the sole of the fault on the south limb of the Dam syncline, were flexed so that they were on the limb or crest of an anticline now obscured by subsequent folding, or that the fault locally furrowed completely through the Schuylkill member and into the upper beds of the Tumbling Run member. In either interpretation, the direction of net slip of the Hentzes fault appears to have been from the east or southeast, rather than from the south. The direction of net slip is indicated by the absence of Sharp Mountain and post-Pottsville strata at the surface south of the crest of the West West Falls anticline between the traces of the Hentzes and Middle Mine Hill faults.

In the western part of the Dam syncline between sections *B-B'* and *D-D'*, beds of the Tumbling Run and Schuylkill members have been repeated four times on both limbs of the syncline by the Lower and Middle Mine Hill faults and the Hentzes fault. Evidence for this is (a) the presence of the Lykens Valley No. 5 coal bed in the thrust plate of the Lower Mine Hill fault and of the Lykens Valley No. 5 and No. 4 coal beds in the sole of the fault, (b) presence of the Lykens Valley No. 3 coal bed in the thrust plate of the Middle Mine Hill fault, (c) repetition of the floral zone of *Neuropteris pocahontas* and *Mariopteris eremopteroides* and the Lykens Valley No. 5 and No. 4 coal beds, (d) occurrence of Schuylkill beds below Tumbling Run beds in the sole of the Middle Mine Hill fault, and (e) the fact that the Schuylkill beds are stratigraphically from the top or middle part of the member and not from the base; therefore, the basal contact of the Schuylkill is a fault (Hentzes fault). Farther east near section *A-A'*, on the north limb of the Dam syncline, beds in the upper part of the Schuylkill and the Sharp Mountain members of the Pottsville formation and the lower part of the post-Pottsville rocks are repeated three times by the Lower and Middle Mine Hill faults. These are shown by the repetition of the Sharp Mountain member of the Pottsville formation, of floral assemblages, and of the Lykens Valley No. 1, Scotty Steel No. 3, and Buck Mountain (No. 5) coal beds.

OTHER FAULTS

The high-angle thrust faults are not folded. They have displacements generally ranging from 1 inch to 300 feet and are inclined either to the south or north. They seem to have developed as the result of compressional squeezing in the central parts of synclines that caused uplift of these parts by faulting.

Bedding faults are numerous but are extremely difficult to trace and correlate. Although movement along some faults was probably sev-

eral hundred feet, movement along most ranged from 1 inch to 6 feet. The cumulative effect of movement along bedding faults, however, may be almost as great as that along the folded faults.

Only one tear fault is shown on the geologic map (pl. 13); but many hundreds of tear faults that are too small to show at the scale of the map are present throughout the area. The mapped tear fault is on Broad Mountain between sections *B-B'* and *C-C'*. The Lykens No. 2 and No. 3 coal beds on the south side of the fault have been moved relatively westward so that they almost join the Lykens Valley No. 4 and No. 5 coal beds on the north side of the fault. The displacement is proved by the differing stratigraphy of beds on opposite sides of the fault and by plant fossils studied by C. B. Read (oral communication, 1955).

Although there are many faults, only the Red Mountain fault is visible at the surface; the location of all other faults is based on stratigraphical, paleobotanical, and mining data. In most mine exposures the faults are represented by a narrow zone of crushed and broken rock.

EFFECT OF STRUCTURE ON THE MINING OF COAL

The amount of coal available for mining in the anthracite fields has been increased locally by folding and repetition of strata by thrust faulting. The anthracite beds of eastern Pennsylvania probably would have been eroded away had they not been protected in the structural depressions which contain the anthracite fields.

Parts of many anthracite beds in the troughs of synclines are below the present limit of mining. Mining operations have greatly benefited from the fault duplication of thick economically important anthracite beds at or near the surface. It is likely that many anthracite beds are also duplicated by thrust faults at depths below existing mine workings. The unmined parts of coal beds preserved in the plates and soles of thrust faults form valuable reserves of anthracite for possible future operations.

The mining of coal is adversely affected by (a) bedding, tear, or thrust faults whose displacements are smaller or slightly greater than the thickness of the respective coal beds ("rock faults"); (b) large faults that have macerated the coal; (c) large faults that displace coal beds so that the location of the beds in the subsurface is unknown or so that they cannot be effectively mined by tunnels from existing mine workings; (d) the squeezing of coal from between the roof and floor of the coal bed ("pinches"); (e) small folds in which the coal has been sheared, thinned, or thickened ("rolls"); (f) areas of macerated or broken coal on crests, in troughs, or on limbs of folds where the

coal cannot be profitably or safely mined ("shear zones"); (g) areas where the coal in troughs of large synclines is too deep to be mined by present methods and equipment.

COAL BEDS

The coal in the mapped area meets the standard specifications for anthracite (American Society for Testing Materials, 1954). On a dry mineral-matter-free basis the percentage of fixed carbon ranges from slightly more than 92 percent to slightly more than 94 percent, and the volatile matter ranges from about 5 to 8 percent (Cooper and others, 1944). On an as-received basis the ash content ranges from about 7 percent to about 24 percent, with the average about 12 percent. The sulfur content averages about 0.7 percent and ranges from about 0.5 percent to about 2 percent.

The coal beds of the mapped area are referred to by a name and number where they are relatively persistent and by a number where they are of local occurrence. Leader coal beds are referred to by the letter "L," and rider coal beds by the letter "R." In many localities the names and numbers used in this report do not agree with those used by the Second Geological Survey of Pennsylvania (Ashburner, 1883; Ashburner and others, 1883-85, parts 1-6), the mining companies, and individuals for the following reasons: (a) Coal beds in isolated mines were frequently correlated and named years before the workings were connected with those of adjacent mines, and when connected, many coal beds were found to be incorrectly correlated and named; (b) many gaps still exist between areas of mining; (c) the structure and stratigraphy of the mapped area are complex and were not thoroughly investigated in the past; and (d) the various companies and individuals do not always use the same nomenclature.

The authors of this report are responsible for the location on the geologic map (pl. 13) of all coal-bed outcrops, for all correlations, and for all names and numbers assigned to coal beds. Thus, in areas where the coal beds have not been mined or only intermittently mined, or where the nomenclature differs between mined localities, the authors have studied all available field and mining-company data and have arrived at the interpretations shown on the geologic map, structure sections, and graphic sections regarding the local and regional correlations and the names and numbers of coal beds.

The floor rocks of coal beds in the Pottsville formation and in the post-Pottsville rocks are chiefly shale and siltstone. The roof rocks of the Pottsville coal beds are mainly conglomerate and sandstone; however, at some places they are shale and siltstone. The roof rocks of post-Pottsville coal beds are mostly shale and siltstone. The strata

adjacent to the coal beds in both formations change rapidly in many places along the strike and down the dip because of structural adjustments due to squeezing. Thus it is not advisable for those engaged in mining to rely on a particular type of roof or floor rock at all localities when planning mining operations.

COAL BEDS OF THE POTTSVILLE FORMATION

The Lykens Valley No. 6 coal bed is exposed in several prospects and trenches in the northern and western parts of the area. At these localities the coal bed, which is not thick enough to mine economically, ranges in thickness from about 6 inches to 2 feet.

The Lykens Valley No. 5 coal bed has been infrequently strip mined and mined underground in the eastern part of the mapped area. It contains many thin shale partings, and local pyritic partings are abundant. Commonly the ash content of this coal is high because of included clay and silt. The average thickness of the coal bed, based on a few measurements from mining data, is about $7\frac{1}{2}$ feet (table 2), and the bed seems to thin gradually to the northeast.

The Lykens Valley No. 4 coal bed is not mined in as many places as the Lykens Valley No. 5 coal bed because it is thinner. On the basis of a few measurements obtained from mining data it seems to average about 4 feet in thickness, and it thins gradually to the northeast. Because the coal from this bed generally does not contain as much ash as the coal from the Lykens Valley No. 5 coal bed, it is much in demand, and mining activity by small operators is intense where the bed is thick enough to mine economically. Shale and pyritic partings are not as common as in Lykens Valley No. 5 coal bed.

Locally the Lykens Valley No. 1, No. $1\frac{1}{2}$, No. 2, and No. 3 coal beds have been strip mined and mined underground in the central and southern parts of the mapped area, but these coal beds are known only from a few prospects, trenches, and small mines in the northern part. The Lykens Valley No. 3 coal bed has not been observed at enough places to determine its characteristics and average thickness. The average thickness of the Lykens Valley No. 2 bed is about 12 feet in the southern and central parts of the mapped area, of which about $11\frac{1}{4}$ feet is coal. This bed is characterized by numerous thin shale partings, and the coal is impure at many localities. The authors were not able to obtain sufficient measures to determine the average thickness of the Lykens Valley No. 1 coal bed in the mapped area, but locally it averages about $3\frac{1}{2}$ feet, of which 1 foot is coal. The remaining $2\frac{1}{2}$ feet is chiefly shale. The bed is usually thin and dirty and has not been economically important.

The Scotty Steel No. 2 coal bed is known only in the southwestern part of the mapped area, and its average thickness, purity, and num-

TABLE 2.—Average thickness and range in thickness of the economically more important Pottsville and post-Pottsville coal beds in the southern half of the Tremont quadrangle

[Thicknesses obtained from mining company data]

Coal bed	Bed thickness (feet)			Coal thickness (feet)			Average amount of refuse (percent)
	Average	Maximum	Minimum	Average	Maximum	Minimum	
22							
21							
20							
19							
18	7.5	10.0	4.9	5.5	10.0	1.0	27
17	6.4	12.0	2.0	4.7	9.0	1.0	26
16½							
16	7.8	17.8	2.7	5.9	17.8	1.7	24
15	14.5	4.8	4.2	12.4	2.4	2.4	47
14	14.3	4.9	3.0	14.0			
13	14.5	5.0	4.0				
12	8.8	14.0	3.7	6.4	12.0	2.0	27
11	10.6	15.1	2.6	7.3	15.0	.0	31
10	9.3	13.4	2.0	7.0	16.4	.0	25
9	4.8	8.6	.5	3.5	6.0	.0	27
8½	11.4	30.0	2.0	8.4	14.1	.0	26
8¼	6.6	9.0	4.0				
8	7.0	19.0	2.0	6.1	15.4	.9	13
7	6.4	11.7	.0	4.5	11.0	.0	30
6	6.1	14.1	1.4	4.8	11.5	.1	21
5	6.6	13.3	1.1	4.2	8.2	.4	36
4							
3	11.0	18.0	1.7	8.3	12.6	.9	25
2							
Lykens Valley :							
1	13.5	4.3	2.5	11.0	1.0	1.0	61
1½							
2	12.0	14.5	9.6	11.2	14.5	7.7	7
3							
4	4.1	6.0	3.5				
5	7.6	18.0	3.0				
6							

¹ Thickness data concentrated in small area and not widespread enough to adequately determine average thickness for map area.

ber of partings have not been determined because of the sparsity of data. The Scotty Steel No. 3 coal bed, which locally has been intensively mined underground and strip mined as far north as the Dam syncline, is not known north of the Lower Mine Hill fault. At various places in the southern part of the mapped area this coal bed has been correlated erroneously with the overlying Buck Mountain (No. 5) coal bed of the post-Pottsville rock sequence. The available mining evidence indicates that this coal bed averages 11 feet in thickness, of which 8.3 feet commonly is coal. The Little Buck Mountain (No. 4) coal bed was strip mined at 2 localities in the Little Mountain syncline where it consists of about 1½ feet of impure coal.

COAL BEDS OF POST-POTTSVILLE ROCKS

The named coal beds of the post-Pottsville rock sequence are, in ascending order, the Buck Mountain (No. 5); Seven Foot (No. 6); Skidmore (No. 7); Bottom Split (No. 8), Middle Split (No. 8½), and Top Split (No. 9) of the Mammoth coal zone; Holmes (No. 10); Primrose (No. 11); Orchard (No. 12); Little Orchard (No. 13);

Diamond (No. 14); Little Diamond (No. 15); Tracy (No. 16); Upper Four Foot (No. 16½); Little Tracy (No. 17); Peach Mountain (No. 18); Tunnel (No. 19); Rabbit Hole (No. 20); Faust (No. 21); and Salem (No. 22). The No. 8¼ and the No. 15½ coal beds, and several thin and nonpersistent leader and rider coal beds have been mined locally, but to date they have not proved to be of regional economic importance.

The Buck Mountain (No. 5) coal bed has been strip mined and mined underground in the Little Mountain syncline and mined underground in a small area in the Dam syncline. It has been infrequently strip mined and mined underground in the southern part of the area and has been intensively mined underground in the vicinity of the Penag tunnel and Good Spring No. 3 hoisting slope. The average thickness of the Buck Mountain coal bed, as obtained from mining data, is 6.6 feet of which 4.2 feet is coal. Throughout most of the Southern anthracite field this coal bed has been intensively mined and is economically important. However, in most localities in the mapped area the Buck Mountain coal bed is not as important as the underlying Scotty Steel No. 3 coal bed or the coal beds of the Mammoth coal zone.

The thicker, laterally persistent, and more intensively mined coal beds are commonly composed of thick benches of coal and thick to thin shale and pyritic partings. The partings at most localities are either thick enough to be mined separately or they are discarded when the coal is washed and sized. The only important exception is the Bottom Split (No. 8) coal bed, which in many places consists of thin partings intercalated with thin benches of coal. This coal bed averages 7 feet in thickness, of which an average of 6.1 feet is impure coal. The Middle Split (No. 8½) coal bed, the most intensively mined bed in the mapped area, averages 11.4 feet in thickness, of which 8.4 feet is coal. The Top Split (No. 9) coal bed, which has been extensively strip mined because of its proximity to the Middle Split coal bed, averages 4.8 feet in thickness, of which an average of 3.5 feet is coal. The Holmes (No. 10) and Primrose (No. 11) coal beds are, with the exception of the Middle Split coal bed, the most intensively mined in the area. The Holmes coal bed averages 9.3 feet in thickness, of which 7 feet is pure coal. The thickness of the Primrose (No. 11) coal bed averages 10.6 feet, of which 7.3 feet is usually coal. The Orchard (No. 12), Little Orchard (No. 13), and Diamond (No. 14) coal beds have been extensively strip mined but only locally mined underground. Although the Orchard (No. 12) coal bed averages 8.8 feet in thickness, of which 6.4 feet is coal, it has not been as valuable as the underlying Holmes and Primrose coal beds. Sufficient data

are not available to determine the average thickness of either the Little Orchard or Diamond coal beds in the mapped area, but, where mined, these beds consist of about 4 feet of impure coal, which is not thick enough for economical large-scale underground mining at the present time. The Tracy (No. 16) and Peach Mountain (No. 18) coal beds are the most important of the younger coal beds in the mapped area. Both have been extensively strip mined and locally mined underground. The Tracy coal bed averages 7.8 feet in thickness, of which 5.9 feet is coal. The Peach Mountain coal bed averages 7.5 feet, of which 5.5 feet is coal.

Locally several other coal beds have been economically important. These coal beds are not as persistent laterally as the coal beds previously described, and their thickness varies greatly within a short distance. At the few localities where the Seven Foot (No. 6) coal bed is mined, it averages 6.1 feet in thickness, of which 4.8 feet is coal. The Skidmore (No. 7) coal bed, where mined, averages 6.4 feet, of which 4.5 feet is coal; however, the average thickness of this coal bed throughout the mapped area is less than 6.4 feet. Similarly, the Little Diamond (No. 15) and Little Tracy (No. 17) coal beds, where mined, average 4.5 and 6.4 feet in thickness, respectively, of which 2.4 and 4.7 feet are coal, but the average thickness of these coal beds elsewhere in the mapped area seems to be less than the averages cited. All four beds contain many thin shale partings.

The lateral persistence and variations in thickness of the Upper Four Foot (No. 16½), Tunnel (No. 19), Rabbit Hole (No. 20), Faust (No. 21), and Salem (No. 22) coal beds are unknown because of the sparsity of mining and surface data. It is not feasible to describe these coal beds as to their purity or partings because of the lack of information.

URANIUM PROSPECTING

Uranium minerals have not been reported in the mapped area, although small deposits have been found to the east (Klemic and Baker, 1954; Dyson, 1954) and north in sandstone and conglomerate beds of the upper part of the Mauch Chunk formation, in the lower part of the Tumbling Run member of the Pottsville formation, in the Pocono formation, and in the Catskill formation.

Inasmuch as all known potentially economic occurrences of uranium minerals in the surrounding region are within these stratigraphic sequences, any search for uranium in the mapped area should be carried out first in these sequences and then expanded to the rocks above and below.

REFERENCES

- American Society for Testing Materials, 1954, Standard specifications for classification of coals by rank, in A.S.T.M. standards on coal and coke, D388-38, p. 79-84.
- Ashburner, C. A., 1883, First report of progress in the anthracite coal region; the geology of the Panther Creek basin or eastern end of the Southern field: Pennsylvania Geol. Survey, 2d, AA, p. 84.
- Ashburner, C. A., and others, 1883-85, Atlas of anthracite fields; Southern anthracite field, parts 1-6: Pennsylvania Geol. Survey, 2d.
- Cooper, H. M., Abernethy, R. F., Tarpley, E. C., Snyder, N. H., and Swingle, R. J., 1944, Analyses of mine, breaker and delivered samples in Analyses of Pennsylvania anthracite coals 1944: U.S. Bur. Mines Tech. Paper 659, p. 140-169.
- Danilchik, Walter, Rothrock, H. E., and Wagner, H. C., 1955, Geology of anthracite in the western part of the Shenandoah quadrangle, Pennsylvania: U.S. Geol. Survey Inv. Map C-21.
- Dyson, J. L., 1954, Relation of stratigraphy and structure to uranium occurrences near Mauch Chunk, Pennsylvania: Pennsylvania Acad. Sci. Proc., v. 28, p. 124-134.
- Fenneman, N. M., and Johnson, D. W., 1946, Physical divisions of the United States: U.S. Geol. Survey.
- 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. Geol. Survey Coal Inv. Map C-13.
- 1954, Geology of anthracite in the eastern part of the Ashland quadrangle, Pennsylvania: U.S. Geol. Survey Coal Inv. Map C-14.
- Kehn, T. M., and Wagner, H. C., 1955, Geology of anthracite in the eastern part of the Shenandoah quadrangle, Pennsylvania: U.S. Geol. Survey Coal Inv. Map C-19.
- Klemic, Harry, and Baker, R. C., 1954, Occurrences of uranium in Carbon County, Pennsylvania: U.S. Geol. Survey Circ. 350, 8 p.
- Maxwell, J. A., and Rothrock, H. E., 1955, Geology of anthracite in the western part of the Delano quadrangle, Pennsylvania: U.S. Geol. Survey Coal Inv. Map C-25.
- Moore, R. C., and others, 1944, Correlation of Pennsylvania formations of North America: Geol. Soc. America Bull., v. 55, p. 657-706.
- Rothrock, H. E., Wagner, H. C., and Haley, B. R., 1951, Geology of anthracite in the west-central part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geol. Survey Coal Inv. Map C-3.
- Rothrock, H. E., Wagner, H. C., Haley, B. R., and Arndt, H. H., 1951, Geology of anthracite in the southwestern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geol. Survey Coal Inv. Map C-7.
- 1951, Geology of anthracite in the east-central part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geol. Survey Coal Inv. Map C-10.
- 1953, Geology of anthracite in the southeastern part of the Mount Carmel quadrangle, Pennsylvania: U.S. Geol. Survey Coal Inv. Map C-12.
- White, C. D., 1900, The stratigraphic succession of the fossil floras of the Pottsville formation in the Southern anthracite coal field, Pennsylvania: U.S. Geol. Survey 20th Ann. Rept., pt. 2 (1898-99), p. 749-930.
- White, I. C., 1881, The Geology of Susquehanna County and Wayne County: Pennsylvania Geol. Survey, 2d, v. G5, p. 66-68, 132, 140.
- Willard, Bradford, 1936, Continental Upper Devonian of northeastern Pennsylvania: Geol. Soc. America Bull., v. 47, p. 565-608.

- Wood, G. H., Jr., Trexler, J. P., Arndt, H. H. Yelenosky, Andy, and Soren, Julian, 1956, Subdivision of Pottsville formation in Southern anthracite field, Pennsylvania : Am. Assoc. Petroleum Geologists Bull., v. 40, p. 2669-2688.
- Wood, G. H., Jr., Trexler, J. P., Yeleonsky, Andy, and Soren, Julian, 1958, Geology of the northern half of the Minersville quadrangle and a part of the northern half of the Tremont quadrangle, Schuylkill County, Pennsylvania : U.S. Geol. Survey Coal Inv. Map C-43.

