Geology of the Ransom Quadrangle Lackawanna, Luzerne, and Wyoming Counties Pennsylvania

GEOLOGICAL SURVEY BULLETIN 1213

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By THOMAS M. KEHN, ERNEST E. GLICK, *and* WILLIAM C. CULBERTSON

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Description of the outcropping and subsurface strata of Devonian, Mississippian, and Pennsylvanian age and of the unconsolidated sediments of Quaternary age

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GEOLOGY OF THE RANSOM QUADRANGLE, LACKAWANNA, LUZERNE, AND WYOMING COUNTIES, PENNSYLVANIA

By THOMAS M. KEHN, ERNEST E. GLICK, and WILLIAM C. CULBERTSON

ABSTRACT

The Ransom 7½-minute quadrangle is about 56 square miles in area. Most of the quadrangle is in the Allegheny Plateau; the southeasternmost part is underlain by the Northern Anthracite field of the Valley and Ridge province.

The outcropping bedrock in most of the quadrangle is the Catskill Formation of Late Devonian age. The Pocono Formation of Early Mississippian age and the Pottsville Formation and post-Pottsville rocks of Pennsylvanian age crop out in the southeastern part of the quadrangle. Eleven formations of Devonian age in the subsurface are provisionally recognized from the study of cuttings of the Richards 1 well. They range downward from the Catskill Formation of the Susquehanna Group to the Kalkberg Limestone of the Helderberg Group. The sedimentary strata studied in the Ransom quadrangle have a total stratigraphic thickness of about 12,000 feet and constitute one of the most complete sections of undeformed Devonian, Mississippian, and Pennsylvanian rock in northeastern Pennsylvania.

The Lower Devonian consists of marine limestones and shales that have been assigned—from the base upward—to the Kalkberg Limestone, New Scotland Limestone equivalent, Becraft Limestone, and Port Ewen Limestone equivalent of the Helderberg Group; the Shriver Chert of the Oriskany Group; and the Esopus Shale. In this study the Ridgeley Sandstone of the Oriskany Group was not recognized in the well cuttings, but the uppermost beds of limestone included in the Shriver Chert may be its stratigraphic equivalent.

The Middle Devonian strata consist of marine limestone, shale, and siltstone. Most limestone in the sequence is in the Onondaga Limestone, which also contains chert and bentonite. The shale and siltstone strata have been assigned to the Marcellus Shale and Mahantango Formation. Rocks of early Late Devonian age are assigned to the Trimmers Rock Formation. The lower part of the formation is a shale and siltstone sequence that was probably deposited in a marine environment. The upper part, which is a sequence of siltstone and sandstone that contains a few pyritized plant fossils, probably represents deltaic deposition. The sandstone is the oldest rock of Devonian age in which quartz granules were noted.

The rocks of Late Devonian age (consisting of beds of shale, sandstone, and conglomerate of the Catskill Formation) are informally subdivided into five zones on the basis of the size of the constituent quartz sand and quartz pebbles. The two lower zones are marine and are more shaly than the three upper zones. The three upper zones are nonmarine and contain grayish-brown "red" beds. A local conglomerate that caps Bald Mountain interfingers along strike with beds of shale and conglomeratic sandstone in the upper zone of the Catskill Formation.

At the top of the upper zone, a claystone sequence about 138 feet thick contains scattered grains and pebbles of quartz and pebbles and boulders of sandstone.

Rocks of Early Mississippian age (which constitute the Pocono Formation) locally fill shallow channels in the underlying Catskill Formation, but at most places the contact of the formations appears to be conformable. Coarse sandstone and conglomerate are the predominant rocks of the Griswold Gap Member of the Pocono. The upper part of the Pocono consists of interbedded shale, siltstone, sandstone, and conglomerate. The grayish-brown "red" beds near the top of the formation at localities adjacent to the Ransom quadrangle may be a transition zone between the Pocono and the Mauch Chunk Formation of Late Mississippian and Early Pennsylvanian age.

Strata of Pennsylvanian age unconformably overlie the Pocono Formation in the Ransom quadrangle. These strata consist of coarse sandstone and conglomerate and a few beds of carbonaceous shale in the Pottsville Formation.

A thin bed of carbonaceous shale at or near the base of the Pottsville is here designated as the Campbell Ledge Shale Member. The rest of the Pottsville is assigned to the Sharp Mountain Member. Above the Pottsville are the Pennsylvanian post-Pottsville rocks—a sequence of conglomerate, sandstone, carbonaceous shale, and coal beds.

Deposits of Pleistocene and Recent ages are present as terraces and alluvium along the Susquehanna River. A mantle of soil containing many rock fragments covers much of the gently sloping area above the flood plain. Part of that mantle is probably weathered glacial till.

After deposition of the post-Pottsville rocks, the area was uplifted and gently folded. As a result the dominant structural feature in the quadrangle is the asymmetrical gently northeast-plunging White Deer anticline. Several small faults were found adjacent to the area during this investigation; however, none were observed in the quadrangle.

Twelve wells have been drilled for gas in the quadrangle. Shows of gas below the upper part of the Trimmers Rock Formation were not reported. The gas shows probably were primarily from joints and fractures rather than from porous and permeable strata.

Anthracite has been mined from the five coal beds in the southeastern part of the quadrangle; production was low during 1957–1960.

INTRODUCTION

LOCATION AND EXTENT OF AREA

The Ransom 7½-minute quadrangle of east-central Pennsylvania comprises about 56 square miles of Lackawanna, Luzerne, and Wyoming Counties, Pa. It is about 5 miles west of Scranton and 10 miles northeast of Wilkes-Barre, Pa. (fig. 1).

The Ransom quadrangle encompasses no large cities; however, the towns of West Falls, Falls, and Ransom, and several smaller communities, are popular vacation areas along the Susquehanna River. Mill City, in the northwestern part of the quadrangle, and Milwaukee and Austin Heights, in the southeastern part, are business and recreational centers.

The Ransom quadrangle has a good system of paved roads. The northeastern part is traversed by U.S. Highway 6; the southeastern part, by State Highway 92; the east-central part, by State Highway

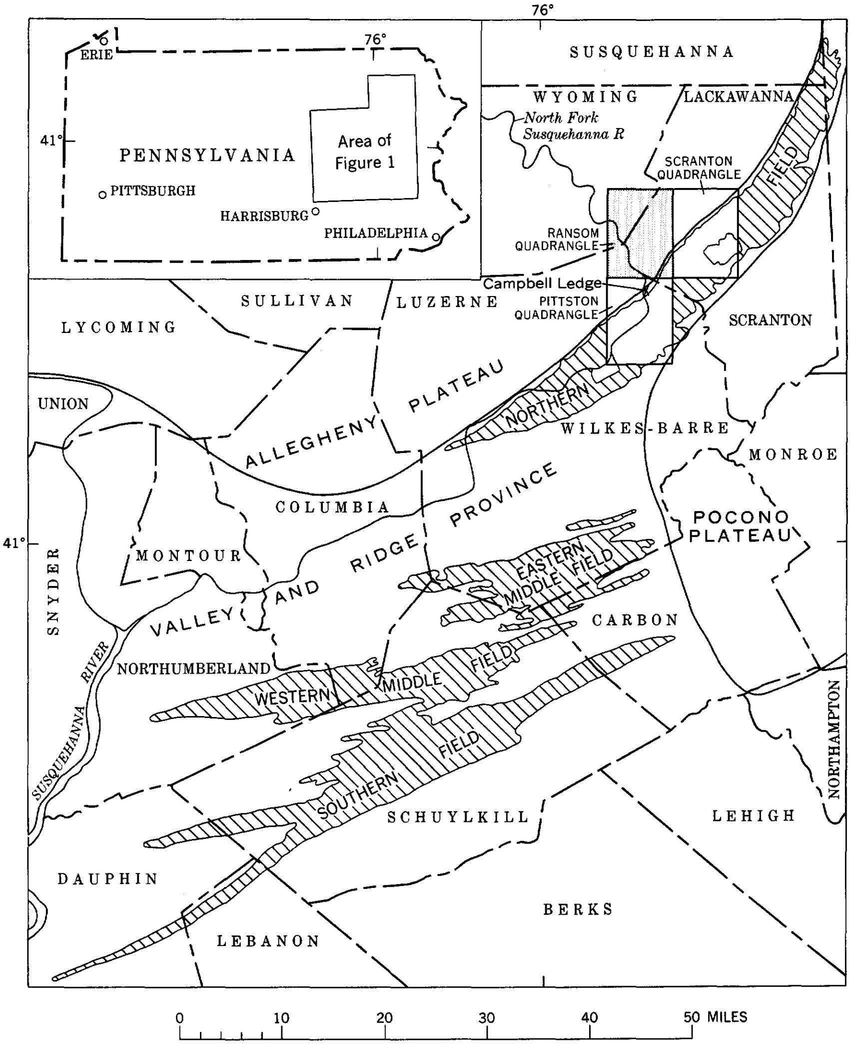

FIGURE 1.—The Ransom quadrangle (stippled area, upper right) shown relative to the anthracite fields and to the physiographic subdivisions of east-central Pennsylvania.

629; and the west-central part, by State Highway 292. In addition to these highways, many secondary roads in the area are paved. The quadrangle is served by the Lehigh Valley Railroad, whose tracks border the east bank of the Susquehanna River in the quadrangle, and by the Scranton Airport, which is near Schultzville in the northeastern part.

PURPOSE AND SCOPE OF REPORT

This report presents the results of a geologic study of the Ransom quadrangle, which was mapped as a part of the stratigraphic and structural studies made by the U.S. Geological Survey in and adjacent to the anthracite fields of Pennsylvania. The results of studies made in the Western Middle and Southern Anthracite fields have been published in the Coal Investigation Map and Bulletin series of the U.S. Geological Survey.

Although the bedrock in much of the Ransom quadrangle is poorly exposed, the cliffs along the Susquehanna River provide a readily accessible, well-exposed sequence of rocks of Devonian, Mississippian, and Pennsylvanian age. This sequence overlies the strata of Devonian age which were penetrated by the Transcontinental Production Co. Richards 1 well—the deepest well in the quadrangle. Thus, one of the longest and least structurally complicated rock sections in east-central Pennsylvania can be studied by piecing together data from outcrops and the log of the Richards 1 well. This report accordingly presents the detailed description, stratigraphic interpretation, and geologic setting of this 12,000-foot-thick measured section of Devonian, Mississippian, and Pennsylvanian rocks and thus provides information by which these same rock sequences in more deformed areas can be more easily interpreted.

The report also describes, and includes maps of, the surficial deposits of Pleistocene and Recent age, the topography, and the structure; and it discusses the economic geology of the quadrangle.

FIELDWORK AND EXAMINATION OF WELL CUTTINGS

Most fieldwork for this report was done by the authors during the spring of 1960. The senior author mapped the area underlain by post-Pottsville rocks in 1957, while preparing a report for the Anthracite Mine Drainage program.

The geology was plotted in the field on aerial photographs at a scale of approximately 1:20,000 or directly on a topographic base map. Data on the aerial photographs were transferred to the topographic base map by use of a universal projector. The stratigraphic sections were measured by use of tape and hand level. Corrections for dip, where necessary, were made in the field.

Samples of cuttings from the Richards 1 well were examined by use of a binocular microscope. A few fragments from each sample were submerged in 6*N* hydrochloric acid; if a significant part went into solution, the insoluble fraction was then described separately as insoluble residue.

Color terms used throughout the report for the rock descriptions follow the "Rock-Color Chart" (Goddard and others, 1948); lithologic symbols used in the illustrations are those suggested by Maher (1959, pl. 1); and grain sizes were classified according to the grade scale of Wentworth (1922).

ACKNOWLEDGMENTS

The Bureau of Topographic and Geologic Survey of Pennsylvania loaned well cuttings, drillers' logs, and other data on the Richards 1 well, and drillers' logs of other wells in the quadrangle. The authors appreciate the field visit made by Richard R. Conlin of the Bureau of Topographic and Geologic Survey of Pennsylvania and by John E. Johnston and George W. Colton of the U.S. Geological Survey.

PREVIOUS WORK

Of the previous investigations of the geology of the area, the most detailed was reported by I. C. White (1883) as a part of a six-county report in which a measured section along the Susquehanna River in and south of the Ransom quadrangle and other measured sections nearby were described. The Ransom quadrangle was included in statewide or regional studies of the Devonian, Mississippian, and Pennsylvanian rocks by Rogers (1858), Lesley (1892), Willard (1936, 1939), Swartz (1939), and Cleaves (1939). Studies of the Pennsylvanian rocks in the Northern Anthracite field were made by Hill (1887) and Smith (1895).

TOPOGRAPHY AND DRAINAGE

Most of the Ransom quadrangle is in the Allegheny Plateau physiographic province (fig. 1) which is a maturely dissected and glaciated plateau of moderate relief. The southeastern part of the quadrangle is in the Ridge and Valley physiographic province and includes part of the northwest side of the Northern Anthracite field. Land surface in the quadrangle ranges in altitude from 540 feet above mean sea level at the Susquehanna River to 2,280 feet on Bald Mountain at the east edge of the quadrangle. A major part of the land surface lies between 1,000 and 1,400 feet above sea level.

The area is drained by the Susquehanna River, which flows southeastward through the quadrangle in a valley that has retained the gentle meanders of preglacial time but whose walls have locally been oversteepened by glacial action. The flood plain consists of a series of isolated asymmetrical alluvial areas—some as much as 2,000 feet wide—that has formed inside the meander loops of the postglacial Susquehanna River.

Tributaries of the Susquehanna locally flow across falls-forming ledges of bedrock in narrow steep-sided valleys; however, in many parts of their courses, the tributaries are still reexcavating their preglacial valleys. Buttermilk and Gardner Creeks are the only perennial tributaries in the quadrangle. The others are intermittent streams that lose their water in the porous alluvium near the Susquehanna River during periods of low streamflow.

The preglacial topography of the Ransom quadrangle was modified by at least two ice advances during the Illinoian and Wisconsin Glaciations (Peltier, 1949, p. 15–16). Because the direction of ice movement differed from the strike of the bedrock by about 40° in much of the quadrangle, glacial erosion truncated or modified preglacial strike ridges to such an extent that in many places the present topography is not indicative of the lithology and competence of the underlying rocks. Ice rounded off many hills and covered them with a layer of ground moraine; it plucked or quarried the well-jointed rock from some hill slopes and locally oversteepened the cliffs along glacial valleys. Valleys transverse to the direction of ice movement were filled with ground moraine, whereas those parallel to the direction of movement

<table>
<tr><th colspan="2">ROGERS
(1858)</th><th colspan="4">PENNSYLVANIA SECOND GEOLOGICAL SURVEY
(1874-92)</th></tr>
<tr><th>System</th><th>Series</th><th>System</th><th colspan="2">Formation</th><th>Member</th></tr>
<tr><td rowspan="2">PENNSYLVANIAN</td><td rowspan="2">Serial</td><td rowspan="2">PENNSYLVANIAN</td><td colspan="2">Coal measures[1]</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Pottsville No. XII</td></tr>
<tr><td rowspan="2">MISSISSIPPIAN</td><td>Umbral</td><td rowspan="2">MISSISSIPPIAN</td><td colspan="2">Mauch Chunk No. XI</td></tr>
<tr><td>Vespertine</td><td colspan="2">Pocono No. X</td><td>Griswold Gap conglomerate</td></tr>
<tr><td rowspan="8">DEVONIAN</td><td>Ponent</td><td rowspan="8">DEVONIAN</td><td colspan="2">Catskill No. IX
?</td><td>Mount Pleasant red shale
Elk Mountain transition group
Cherry Ridge group
Honesdale sandstone group
Montrose red shale
New Milford sandstone
Starrucca shale
?</td></tr>
<tr><td>Vergent</td><td rowspan="3">Formation VIII</td><td>Hamilton VIII c</td><td rowspan="7"></td></tr>
<tr><td>Cadent</td><td>Marcellus VIII b[2]</td></tr>
<tr><td>Post-Meridian</td><td>Carniferous VIII a</td></tr>
<tr><td rowspan="2">Meridian</td><td rowspan="2">Formation VII</td><td>Cauda-Galli VII b</td></tr>
<tr><td>Oriskany shale and sandstone VII a</td></tr>
<tr><td rowspan="2">Pre-Meridian</td><td rowspan="2">Formation VI</td><td>Stormville shale</td></tr>
<tr><td>Stormville limestone</td></tr>
</table>

[1] Probably includes formation XIII, XIV, and XVI of the bituminous fields.
[2] Formation divided into several members in area of outcrop.

FIGURE 2.—Classification of Devonian, Mississippian, and

were deepened by scour and were then partly refilled with outwash material when the ice melted.

STRATIGRAPHY

The outcropping sedimentary rocks, excluding the deposits of Quaternary age, are about 4,000 feet thick and range in age from Late Devonian to Middle Pennsylvanian. They include the upper part of the Catskill Formation, the Pocono and Pottsville Formations, and part of the post-Pottsville rocks (pls. 1 and 3). The Transcontinental Production Co. Richards 1 well, drilled about 1 mile north of the town of Ransom, penetrated about 8,618 feet of strata. In this report those strata tentatively assigned to or correlated with 11 Devonian formations (fig. 2, pl. 2) extend downward from the Catskill For-

WILLARD (1935, 1936, 1939)				THIS REPORT			
System	Facies or group	Formation	Member	System	Group	Stratigraphic unit	
		Not studied		PENNSYLVANIAN		Post-Pottsville rocks	
				PENNSYLVANIAN		Pottsville Formation	Sharp Mountain Member Campbell Ledge Shale Member
MISSISSIPPIAN				MISSISSIPPIAN			
MISSISSIPPIAN		Pocono	Griswold Gap conglomerate	MISSISSIPPIAN		Pocono Formation	Griswold Gap Member
DEVONIAN	Catskill	Mount Pleasant red shale Elk Mountain sandstone Cherry Ridge red beds Honesdale sandstone Damascus red shale New Milford	Dyberry glomerate Lanesboro Kingsley red shale	DEVONIAN	Susquehanna	Catskill Formation	
DEVONIAN	Portage	Fort Littleton	Trimmers Rock sandstone Losh Run shale	DEVONIAN	Susquehanna	Trimmers Rock Formation	
DEVONIAN	Hamilton	Mahantango[2]		DEVONIAN	Hamilton	Mahantango Formation	
DEVONIAN	Hamilton	Marcellus[2]		DEVONIAN	Hamilton	Marcellus Shale	
DEVONIAN	Onondaga	Buttermilk Falls limestone Esopus shale		DEVONIAN		Onondaga Limestone and Esopus Shale	
DEVONIAN	Oriskany	Ridgeley sandstone Shriver chert		DEVONIAN	Oriskany	Shriver Chert	
DEVONIAN	Helderberg	Port Ewen shale Becraft limestone New Scotland limestone		DEVONIAN	Helderberg	Port Ewen Limestone equivalent, Becraft Limestone, New Scotland Limestone equivalent, and Kalkberg Limestone	

[2] Formation divided into several members in area of outcrop.

Pennsylvanian rocks in the Ransom quadrangle, Pennsylvania.

mation of the Susquehanna Group to the Kalkberg Limestone of the Helderberg Group. This well has apparently penetrated all but the lowermost few feet of rocks of the Devonian System that underlie the quadrangle.

DEVONIAN SYSTEM

LOWER DEVONIAN SERIES

HELDERBERG GROUP

The name Helderberg was used by Vanuxem (1842, p. 111) for the strata prominently exposed in the Helderberg Mountains of New York. Some years later Hall (1851, p. 162) divided the formation into the Upper Helderberg and the Lower Helderberg. The Helderberg Group of present usage is largely equivalent to Hall's Lower Helderberg, except that the Manlius Limestone of Clarke and Schuchert (1899) and of later geologists is no longer included.

In much of northeastern Pennsylvania the Helderberg is divided, in ascending stratigraphic order, into the Coeymans Limestone, Kalkberg Limestone, New Scotland Limestone equivalent, Becraft Limestone, and Port Ewen Limestone equivalent. The lower 300 feet of rock in the Richards 1 well is assigned to these formations (pl. 2), with the exception of the Coeymans Limestone, which (if present) presumably lies below the bottom of the hole.

Jones and Cate (1957, pl. 1) reported that the Helderberg Group is more than 200 feet thick in this part of the State. Furthermore, their data show that the Helderberg should consist mostly of shale in this area; data from the Richards 1 well show this too.

KALKBERG LIMESTONE

Name and age.—The name Kalkberg Limestone was proposed by Chadwick (1908, p. 348) for the limestone strata containing chert nodules that lie below the New Scotland Limestone in Greene County, N.Y. The impure siliceous limestone containing dark chert nodules and lying at the base of the New Scotland Limestone in Pennsylvania was considered by Swartz (1939, p. 55, 56) to be correlative with the Kalkberg Limestone of New York. The lower 35 feet of strata penetrated by the Richards 1 well is here provisionally assigned to the Kalkberg Limestone of Early Devonian age.

Distribution and thickness.—The Kalkberg Limestone crops out in eastern Pennsylvania, where its thickness is reported to range from 25 to 30 feet (Swartz, 1939, p. 58). Thus the lower 35 feet of strata in the Richards 1 well probably represents nearly the full thickness of the formation. The lower part of this sequence may also represent the upper part of the Coeymans Limestone, but only if the Stormville

Conglomerate of I. C. White (1882, p. 132) is missing from the top of the Coeymans in this area.

Lithology.—The Kalkberg, as determined from the cuttings from the Richards 1 well, consists of medium-gray to medium-light-gray very silty fine-grained limestone. It contains about 5 percent medium-gray to light-brownish-gray dense chert and a trace of pyrite. The limestone contains a few brachiopods and ostracodes.

NEW SCOTLAND LIMESTONE EQUIVALENT

Name and age.—The name New Scotland Limestone was proposed by Clarke and Schuchert (1899, p. 877) for rock exposures near New Scotland, Albany County, N.Y., where these rocks overlie the Kalkberg Limestone and underlie the Becraft Limestone. In this report the unit is referred to as the New Scotland Limestone equivalent, because in the Ransom quadrangle the lithology of this unit is mainly limy shale. Swartz (1939, p. 55–62) considered the New Scotland to be of Early Devonian age and correlated it with the New Scotland Limestone or equivalent strata in adjacent States.

Distribution and thickness.—The New Scotland Limestone is probably present throughout most of the Valley and Ridge province of Pennsylvania, but it has not been observed in the western part of Schuylkill County (Swartz, 1939, p. 55). Swartz (1939, p. 58) reported that the New Scotland Limestone is about 80 feet thick in the eastern part of Monroe County and that it varies in thickness from 10 to 30 feet in central Pennsylvania. Approximately 66 feet of strata penetrated by the Richards 1 well is tentatively assigned to the New Scotland Limestone equivalent.

Lithology.—In outcrops in eastern Pennsylvania the New Scotland consists of dark-gray calcareous shale and dark-gray thick-bedded argillaceous limestone that locally contains lenses and nodules of dark-gray to black chert that weathers white (Swartz, 1939, p. 55–56). The strata assigned to the New Scotland Limestone equivalent in the Richards 1 well consist of dark-gray finely micaceous very limy shale, part of which is silty, and a few beds of very silty limestone that contain traces of pyrite and a few ostracodes.

Stratigraphic relations.—In outcrops the contact of the New Scotland Limestone with the underlying Kalkberg Limestone is apparently transitional (Swartz, 1939, p. 55–60). Well cuttings at this interval also give no evidence of a hiatus.

BECRAFT LIMESTONE

Name and age.—The name Becraft Limestone was proposed by Darton (1894, p. 212) for the strata exposed near Becraft Mountain, N.Y. The unit had previously been referred to by Vanuxem (1840, p. 377) as the Scutella Limestone. Swartz (1939, p. 62–65) applied the name Becraft Limestone to rocks in northeastern Pennsylvania that are similar in lithology, stratigraphic position, and faunal content to the type Becraft in New York. The Becraft is of Early Devonian age in Pennsylvania.

Distribution and thickness.—The Becraft Limestone is about 20 feet thick at the northeast border of Pennsylvania in Monroe County; 10 miles southwest the strata tentatively referred to as the Becraft (Swartz, 1939, p. 62–63) are 14 feet thick and pinch out westward, in the eastern part of Monroe County. On the basis of lithologic similarity and stratigraphic position, 18 feet of the strata penetrated in the Richards 1 well is tentatively assigned to the Becraft Limestone.

Lithology.—In outcrops the Becraft consists of dark-gray to bluish-gray medium- to thick-bedded finely to coarsely crystalline limestone containing some shale or siltstone and dark-gray chert. It is highly fossiliferous in some areas and nearly unfossiliferous in others (Swartz and Swartz, 1941, p. 1162–1174). The Becraft, as determined from the cuttings from the Richards 1 well, consists of medium- to dark-gray finely micaceous pyritic very silty fine-grained limestone containing brachiopods, bryozoans(?), crinoids, and ostracodes. In the lower part of the formation the limestone has interbeds of dark-gray very limy shale.

Stratigraphic relations.—Where it is present in outcrops, the Becraft Limestone apparently rests conformably on the New Scotland Limestone. Data obtained from the Richards 1 well suggest that the Becraft Limestone and the New Scotland Limestone equivalent are conformable and that the contact may be gradational.

PORT EWEN LIMESTONE EQUIVALENT

Name and age.—The Port Ewen Limestone of Early Devonian Age was named by Clarke (1903, p. 21) for exposures near Port Ewen, N.Y. Southward, the Port Ewen Limestone loses its calcareous character, and in southeastern New York and northeastern Pennsylvania it is referred to as the Port Ewen Shale (Swartz, 1939, p. 62). The limy shale in the Richards 1 well occupies the same stratigraphic position as the Port Ewen of other areas; hence, in this report the limy shale is referred to as the Port Ewen Limestone equivalent.

Distribution and thickness.—Strata equivalent to the Port Ewen Limestone crop out in narrow belts in northeastern Pennsylvania and extend into central and south-central Pennsylvania, where they are represented in part by the Mandata Shale of Swartz (1939, p. 63). The Port Ewen strata are reported to be about 200 feet thick near the

New York–New Jersey boundary and are about 150 feet thick near the Pennsylvania–New Jersey boundary (Swartz, 1939, p. 62). In the Ransom quadrangle the Port Ewan Limestone equivalent is about 179 feet thick.

Lithology.—At most exposures in northeastern and central Pennsylvania, the Port Ewen Limestone has been described as ash-gray to black siliceous and calcareous shale (Swartz, 1939, p. 62; Swartz and Swartz, 1941, p. 1168–1174). In the Richards 1 well, strata equivalent to the Port Ewen Limestone are medium-gray to grayish-black finely micaceous slightly pyritic very limy shale and siltstone.

Stratigraphic relations.—In the northeastern part of the State, the Port Ewen Limestone equivalent can be differentiated easily from the underlying Becraft Limestone (Swartz, 1939, p. 62). In the Richards 1 well the contact of the Port Ewen Limestone equivalent with the Becraft Limestone is arbitrarily placed at the top of the limestone sequence.

ORISKANY GROUP

The name Oriskany was first applied by Vanuxem (1839, p. 273) to the white sandstone exposed at Oriskany Falls, N.Y. Rogers (1858, p. 107) introduced the name Meridian Sandstone for the strata in Pennsylvania that he correlated with the Oriskany Sandstone of New York. Platt and Platt (1877, p. XXIV) substituted the name Oriskany for the Meridian of Rogers. Cleaves (1939, p. 96–97) raised the Oriskany to group status and divided it into the Shriver Chert and the overlying Ridgeley Sandstone.

Rocks of the Oriskany Group crop out in many narrow belts in the Valley and Ridge province. The group may be as much as 350 feet thick in south-central Pennsylvania (Jones and Cate, 1957, pls. 2, 3). The sandstone of the Oriskany Group is reported to be absent from the outcrop and subsurface in a narrow belt that extends from Harrisburg (in the south-central part of the State) to the northeast corner along the "Adirondack-Harrisburg axis" of Woodward (1957, p. 1431–1432).

Sandstone is absent in the strata assigned to the Oriskany Group in the Richards 1 well; hence, only the Shriver Chert of the Oriskany Group is inferred to be present in the Ransom quadrangle (pl. 2). Cleaves (1939, p. 97) reported that the Ridgeley Sandstone is of variable lithology and locally grades to a silty limestone; accordingly, the 28-foot-thick upper unit of the Oriskany in the Richards 1 well may be a thin equivalent of the Ridgeley.

SHRIVER CHERT

Name and age.—The name Shriver Chert Member of the Oriskany Formation was proposed for a unit composed of dark-gray siliceous shale and chert exposed on Shriver Ridge, Cumberland, Md. (Swartz and others, 1913, p. 91). In Pennsylvania the Shriver was raised to the rank of formation by Cleaves (1939, p. 96–97). He considered it to be of late Early Devonian age (1939, p. 109). It comprises the cherty and siliceous limestone and shale in the lower part of the Oriskany Group.

Distribution and thickness.—The Shriver Chert has been traced from Maryland into south-central and central Pennsylvania (Cleaves, 1939, p. 96). In the Delaware Water Gap, Swartz and Swartz (1941, p. 1161, 1180) discovered a siliceous shale 54 feet thick between the Oriskany Sandstone and the calcareous Port Ewen Shale. Because it is similar in lithology and stratigraphic position, it is probably the Shriver Chert. In this quadrangle the strata tentatively assigned to the Shriver Chert are about 128 feet thick.

Lithology.—In the Richards 1 well the sequence assigned to the Shriver Chert consists of an upper 28-foot-thick unit of silty and cherty limestone, a middle 20-foot-thick chert sequence, and a lower 80-foot-thick shale and limestone sequence.

The lower 80 feet of the Shriver is made up of dark-gray very silty very siliceous finely granular limestone interbedded with dark-gray very limy shale. The limestone and shale grade downward into the very limy shale of the underlying strata. A few brachipod fragments were found in the well cuttings from near the base of the formation. The insoluble residue is a dark-gray aggregate of silt particles that is cherty in part.

The chert of the middle unit is brownish gray to dark gray, silty, very limy, and dense to finely granular. Interbeds of medium-gray mottled siliceous limestone grade into a thin dark-gray shale at the base of the unit. The insoluble residue ranges from hard siliceous silt to dense chert.

The upper unit consists of finely granular to finely crystalline medium-gray to brownish-gray silty and cherty limestone. The upper 18 feet of the unit contains some limestone beds that are nearly 50 percent chert and has a few calcareous siltstone partings near the top. The chert has a conchoidal fracture and is light brownish gray and subtranslucent to translucent; but when it is immersed in water, it shows "cloudy" limestone inclusions. The lower 10 feet of his unit is a siliceous silty finely granular limestone that contains a few brachiopods.

Stratigraphic relations.—In some areas of the State, the Shriver Chert apparently rests unconformably on strata of Helderberg age, but in other areas there is evidently no hiatus (Cleaves, 1939, p. 109; Willard, 1952, p. 76). In the Ransom quadrangle the boundary of the Shriver Chert with the underlying strata is apparently gradational.

ESOPUS SHALE

Name and age.—Darton (1894, p. 209–210) named rocks exposed near Esopus, N.Y., and along Esopus Creek the Esopus Shale. Previously, this shale had been referred to as the Cauda-galli Grit by Vanuxem (1842, p. 127–130) in his New York reports; the equivalent strata exposed in Pennsylvania was referred to as the Post-Meridian grits by Rogers (1858, p. 107). According to Willard (1939, p. 145–146) the Esopus Shale is of early Middle Devonian age. The Esopus Shale was assigned an Early Devonian age by Oliver (1964).

Distribution and thickness.—The Esopus Shale can be seen in outcrops throughout the eastern and northeastern parts of Pennsylvania. West of the Susquehanna River the Esopus has not been recognized in surface exposures, apparently because it has lost its lithologic character. The strata that in central Pennsylvania occupy virtually the same stratigraphic position as the Esopus have been referred to as the Needmore Shale (Willard, 1939, p. 149). The maximum thickness of the Esopus in outcrops in the eastern part of the State is about 300 feet in Monroe County (Swartz and Swartz, 1941, pl. 1). The thickness of the formation, as determined from cuttings from the Richards 1 well, is about 465 feet.

Lithology.—In the Richards 1 well the Esopus is subfissile medium-dark-gray to grayish-black nonlimy to very limy shale that contains minor amounts of mica and pyrite. The upper 35 feet of the formation seems to be composed of as much as 50 percent calcite, which suggests a gradational contact between Esopus and the overlying Onondaga Limestone. The upper 300 feet of strata contains a few brachiopods. The insoluble residue of the more limy beds is a light- to dark-gray aggregate of silt.

Stratigraphic relations.—The Esopus Shale reportedly (Willard, 1939, p. 154) rests disconformably on strata of Oriskany age. A disconformity may be present in the strata penetrated by the Richards 1 well, for the change from limestone to shale is abrupt.

MIDDLE DEVONIAN SERIES

ONONDAGA LIMESTONE

Name and age.—Hall (1839, p. 293) applied the name Onondaga to the gray crinoidal limestone in New York that underlies the Seneca Limestone and overlies the Oriskany Sandstone. Later, Emmons (1846, p. 174) included in the Onondaga Limestone the strata previously referred to as the Seneca Limestone, Selenurus Limestone, and Corniferous Limestone. He thus included in the formation all the strata between the Marcellus and the Oriskany. In northeastern Pennsylvania the calcareous rocks that lie at approximately the same stratigraphic position as the Onondaga Limestone in New York were designated the Selinsgrove Lower Limestone by I. C. White (1883, p. 80). Willard (1939, p. 142–144), in his study of formations of Devonian age of Pennsylvania, raised the Onondaga to group status and included in it the Buttermilk Falls Limestone and Esopus Shale of the eastern part of the State and the Selinsgrove Limestone and Needmore Shale of the central part of the State. The name Buttermilk Falls Limestone was proposed earlier by Willard (1938, p. 14) for the cherty limestone exposed at Buttermilk Falls on Marshall Creek, Monroe County, Pa. These strata are early Middle Devonian in age (Willard, 1939, p. 137–141). The Onondaga Limestone of this report is a formation that includes all strata from the top of the Esopus Shale to the base of the Hamilton Group. It includes strata previously assigned to the Buttermilk Falls Limestone and the Selinsgrove Limestone of Willard (1939).

Distribution and thickness.—The cherty facies of the Onondaga Limestone is confined to eastern Pennsylvania (Willard, 1939, p. 144). In central and southern Pennsylvania the limestone loses its cherty characteristic and is named the Selinsgrove Limestone (White, I. C., 1883; Willard, 1939). Lesley (1892, p. 1171) reported a maximum thickness of 250 feet for the Onondaga, and Willard (1939, p. 144) reported a maximum of 200 feet for his Buttermilk Falls Limestone, which is the Onondaga of this report. In the Richards 1 well the Onondaga Limestone is about 315 feet thick.

Lithology.—In the Richards 1 well the Onondaga Limestone consists of medium-gray to medium-dark-gray micaceous silty clayey limestone that is cherty in part (pl. 2). The strata can be subdivided into three lithologic zones. The lower 155 feet consists of medium-dark-gray limestone that grades into the underlying Esopus Shale. Traces of pyrite are present in this lower unit. The insoluble residue from the limestone is light- to dark-gray silt.

The middle 120 feet of the formation consists of medium-gray to medium-dark-gray limestone, interbedded in part with as much as 20 percent medium-gray slightly limy chert. The insoluble residue from the limestone is mostly clay and fine silt; however, some coarse silt is present near the base. Light-gray nonlimy soft finely granular bentonite beds, some of which contain light-brown mica, are present in the upper 90 feet of the middle unit.

The upper 40 feet of the formation is interbedded clayey limestone and grayish-black very limy shale, which is probably transitional with the overlying Marcellus Shale. This upper unit also contains grayish-black limy chert, a trace of pyrite, and a few gastropods.

Stratigraphic relations.—On the basis of determinations made from the well cuttings, the Onondaga Limestone seemingly grades to or intertongues with the underlying Esopus Shale. In outcrops, also, a similar relationship has been reported (Willard, 1939, p. 145–146).

HAMILTON GROUP

The name Hamilton Group was applied by Vanuxem (1842, p. 150) to strata exposed near Hamilton, N.Y., that extend from the top of the Marcellus Shale to the base of the Tully Limestone. Later, most investigators referred to these strata as the Hamilton Formation, and a few revised the group to include the Marcellus Shale. Cooper (1930, p. 116–134) redefined the Hamilton as a group that included the Marcellus Shale as the lowest of its four formations. For eastern Pennsylvania, Willard and Cleaves (1933, p. 757) used this classification, but for central Pennsylvania, Willard (1935b, p. 202) divided the Hamilton Group into the Marcellus and Mahantango Formations because he was unable to recognize some of the equivalents to Cooper's New York units. In the Ransom quadrangle about 2,165 feet of strata penetrated by the Richards 1 well is assigned by the authors to the Hamilton Group, which is divided, from the base upward, into the Marcellus Shale and Mahantango Formation (pl. 2).

MARCELLUS SHALE

Name and age.—Hall (1839, p. 295) proposed the name Marcellus Shales for rocks exposed near Marcellus, N.Y. Rogers (1858, p. 107, 138–140) recognized the Marcellus in Pennsylvania and designated it the Cadent Lower Black Slate—the lowest member of his Cadent Series. The Pennsylvania Second Geological Survey introduced both the numerical system, VIIIb (fig. 2), and the terminology used in New York—the Marcellus Formation—for these rocks and divided the Marcellus into three members: a lower black shale, a middle gray slate, and an upper black shale (Lesley, 1892, p. 1203–1208). Willard (1939, p. 168–173) retained the name Marcellus in his study of the Middle Devonian and divided the formation into four members. In the Ransom area these members cannot be recognized; but, because the rock is of a single lithologic type, it is referred to as the Marcellus Shale.

On the basis of both age determinations of fossils and stratigraphic position, the Marcellus Shale of Pennsylvania is correlated with the Marcellus of New York and is considered to be the lowest formation of the Hamilton Group of Middle Devonian age (Willard, 1939, p. 167–168).

Distribution and thickness.—The Marcellus Shale crops out in continuous and discontinuous narrow bands in the folded belt from northeastern to south-central Pennsylvania. Willard (1939, p. 168) reported that the Marcellus Shale is the most widespread unit of Devonian age in the State.

In Pennsylvania the formation ranges in thickness from 50 to 880 feet (Willard, 1939, p. 169). It is about 790 feet thick in the Ransom quadrangle (pl. 2).

Lithology.—In the Richards 1 well the Marcellus Shale consists of dark-gray to grayish-black slightly limy to very limy shale that is micaceous, silty, and soft in part, and that contains traces of pyrite and white vein calcite. The lower part contains traces of silty limestone. The upper 400 feet is ver fossiliferous, containing a crinoid, gastropod, and pelecypod fauna.

Willard (1939, p. 168) found that the middle gray slate of the Marcellus VIIIb of the Pennsylvania Second Geological Survey is, in outcrops, the most extensive of the three units described and that gray shaly sandstone is the predominant lithology for the formation in eastern Pennsylvania. Willard (1939, p. 173) reported that the formation in central Pennsylvania contains a sequence of fine- to coarse-grained sandstone and shale.

Stratigraphic relations.—Willard (1935b, p. 199–200; 1939, p. 148, 172) reported a disconformity at the contact between the Marcellus and the underlying Onondaga Limestone in central Pennsylvania and a thin sandstone in the basal part of the Marcellus in some areas. In the rest of the State the two formations appear to interfinger, and the contact appears to be transitional. In the Richards 1 well in the Ransom area, the contact is probably transitional; an alternating shale and limestone sequence about 40 feet thick was arbitrarily included in the Onondaga as a result of the contact being placed at the top of the youngest limestone bed in this sequence.

MAHANTANGO FORMATION

Name and age.—The name Mahantango Formation was proposed by Willard (1935b, p. 202, 205) for strata between the Marcellus Shale and the Tully Limestone exposed along Mahantango Creek in Juniata and Snyder Counties, Pa., where these strata are lithologically indivisible.

The Mahantango Formation is of late Middle Devonian age. According to Willard (1935b, p. 205), the Mahantango in central Pennsylvania contains about the same fauna as equivalent strata in Maryland, but it contains a less diverse fauna than the equivalent strata in New York.

Distribution and thickness.—The Mahantango Formation crops out in narrow zigzag bands and belts from northeastern Pennsylvania southwestward to the south border of the State, along part of the

Allegheny Front, and in many of the ridges of the Valley and Ridge province.

As determined from the cuttings in the Richards 1 well, the Mahantango Formation is about 1,373 feet thick in the Ransom quadrangle; this thickness corresponds to the thicknesses reported by Willard (1939, p. 134, 191).

Lithology.—In the Ransom quadrangle the Mahantango Formation is more than 90 percent shale and less than 10 percent siltstone. The shale is medium gray to medium dark gray, slightly to moderately limy, and micaceous, and contains traces of pyrite and some white vein calcite. The siltstone is medium dark gray, finely micaceous, and limy, and contains white calcite and clear quartz crystals. Part of the formation is very fossiliferous and contains brachiopods, crinoids, and fragments of unidentified fossils.

The Mahantango in the Ransom area is lithologically similar to the equivalent strata described in northeastern Pennsylvania by Fettke (1933, p. 640–641) and Willard (1935b, p. 205). The three shale facies reported by Willard (1939, p. 138, 176–179), however, were not recognized in the Richards 1 well, nor was the Montebello Sandstone Member of Claypole (1885, p. 67–68), which is present in the lower part of the Mahantango in some areas.

Stratigraphic relations.—The Mahantango Formation is apparently conformable with the underlying Marcellus Shale throughout most of Pennsylvania. Where the Montebello Sandstone of Claypole (1885, p. 67–68) is absent, the boundary of the Marcellus and Mahantango reportedly is transitional or conformable (Willard, 1939, p. 164, 191). In the Richards 1 well the formations are separated arbitrarily on the bases of color and slight lithologic differences. The contact is placed at the change from grayish-black strata to a medium-dark-gray silty shale.

UPPER DEVONIAN SERIES

SUSQUEHANNA GROUP

The name Susquehanna Series was proposed by Ashley (1923, p. 1106) for all strata from the base of the Tully Limestone to the top of the Catskill Formation. Recently these strata, which are predominantly of Late Devonian age, were redefined as a rock-stratigraphic unit of group rank in Pennsylvania (Miller and Conlin, 1959; 1961, p. 785–786).

In the Ransom quadrangle the Susquehanna Group includes all strata from the top of the Hamilton Group to the base of the Pocono Formation and is divided, from the base upward, into the Trimmers Rock and Catskill Formations. The group is about 7,750 feet thick in this area. Miller and Conlin (1961, p. 786) reported that the group is about 7,500 feet thick in their proposed type area.

TRIMMERS ROCK FORMATION

Name and age.—Willard (1935a, p. 1200) applied the name Trimmers Rock Member (of his Fort Littleton Formation) to exposures along the Juniata River near Newport, in Perry County. Previously, geologists of the Pennsylvania Second Geological Survey and other geologists referred to this rock sequence as a part of the Portage Group. The Trimmers Rock is now considered by most geologists to be of formational rank because of its great areal extent, ease of recognition, and varying lithology. It is of early Late Devonian age; Willard (1935a, p. 1201) considered it to be correlative with part of the Sherburne, Ithaca, and Enfield of New York.

Distribution and thickness.—The Trimmers Rock Formation is present in much of central and eastern Pennsylvania. Willard (1939, fig. 65) reported that the Trimmers Rock attains a maximum thickness of about 3,000 feet in western Luzerne County, about 35 miles southwest of the Ransom area (fig. 1). The formation does not crop out in the Ransom quadrangle but is about 1,900 feet thick in the subsurface, as determined from the cuttings from the Richards 1 well.

Lithology.—In the Richards 1 well the Trimmers Rock Formation is composed of shale, siltstone, and sandstone; it can be divided into three lithologic zones on the basis of the general upward increase in maximum grain size.

The lower zone of the Trimmers Rock Formation (depth 4,350–5,247 ft), nearly 900 feet thick, consists of alternating sequences of medium-light-gray to medium-dark-gray slightly limy shale and siltstone. A few marine fossils and pyritized plant fossils are present near the bottom and top of the zone. The Tully Limestone was reported to be near the base of this zone in the driller's log but was not definitely recognized in the well cuttings. It could be represented, however, by all or part of the 62 feet of fossiliferous limy siltstone at the base of this lower zone. The Harrell Shale and the Brallier Shale in other parts of Pennsylvania may also be represented in this zone (Butts, 1918; Willard, 1935a).

The middle zone (depth 4,000–4,350 ft), about 350 feet thick, consists of interbedded slightly calcareous shale, siltstone, and sandstone. The shale and siltstone are medium light gray to medium gray. The sandstone is medium light gray, silty, and very fine grained. Pyritized plants are present in the lower part, and a few crinoid plates are present near the top. Part of this zone may be the Brallier Shale. Willard (1935a, p. 1207), however, reported that the Brallier thins eastward and that the Susquehanna River approximately marks its east boundary.

The upper zone of the Trimmers Rock Formation (depth 3,340–4,000 ft), about 660 feet thick, consists of medium-light-gray calcareous very fine to very coarse grained sandstone interbedded with medium-light-gray slightly calcareous shale and siltstone, which make up about 30 percent of the zone. Medium to coarse quartz sand, milky and clear quartz granules, and small white vein-calcite crystals are scattered through 50 percent of the beds. Sand-sized grains of dark rock and pyritized plant fragments are present in the cuttings from several depths.

Stratigraphic relations.—Willard (1939, p. 208–209) reported that the contact between the Trimmers Rock Formation and the underlying Mahantango Formation is gradational and that the lithologies of the two formations are so similar in some areas that the contact could be determined only with difficulty. In some areas where the Tully Limestone was recognized, the contact between the Trimmers Rock Formation and the underlying Mahantango is marked by a disconformity (Willard, 1939, p. 209). The contact in the Richards 1 well was chosen on the basis of the slight change downward from medium gray to medium dark gray and the change downward from shale and siltstone to mainly shale.

CATSKILL FORMATION

Name and age.—The name Catskill Mountain Group (or Series) was first used by Mather (1840, p. 212–213, 227–233) for the sequence of strata of Devonian age in the Catskill Mountains of New York that "lies between the Helderberg limestone series and the coal-bearing rocks of Carbondale in Pennsylvania." In the Catskill Mountains the strata consist of white, gray, and red sandstone and conglomerate interbedded with gray, red, olive, and black siltstone and shale.

Rogers (1844, p. 154–156), in his study of the geology of Pennsylvania, proposed the name Ponent Series for the rocks between the base of the thick sequence of alternating red shale and sandstone and the top of the overlying light-gray conglomerate. As defined by Rogers, the Ponent Series included all the red shale and sandstone of the Catskill Formation, as well as some of the lower part of the Pocono Formation. Platt (1875, p. 8) restricted application of the name to the sequence of predominantly red rocks between the olive shales of the Chemung below and the Pocono (Vespertine of Rogers) above. Two years later Platt and Platt (1877, p. XXVI) substituted the term Catskill Formation for the Ponent Series of Rogers. I. C. White (1881, p. 59–73), in his study of the geology of Susquehanna and Wayne Counties, divided the Catskill into eight members. He recognized many of these members along the Susquehanna River in and adjacent to the Ransom quadrangle (1883, p. 157–162). In a study of the Upper Devonian of northeastern Pennsylvania, Willard (1936, p. 573) considered Catskill as a facies group that included all Upper Devonian rocks of nonmarine origin. Most of White's names and units were retained by Willard (1936, p. 574–593) for the six formations and three members included in the Catskill Facies Group. In the present study the authors were unable to recognize with certainty the subdivisions proposed by other geologists, and the strata are here referred to as the Catskill Formation.

Distribution and thickness.—The Catskill Formation is about 5,840 feet thick in the Ransom quadrangle; however, only the upper 3,000 feet is exposed. It forms the surface bedrock in all the Ransom quadrangle except about 3 square miles in the southeastern part (pl. 1). The base of the Catskill Formation does not crop out near the Ransom quadrangle, but it was reached by test wells drilled on the White Deer anticline. The deepest well, the Richards 1, started approximately 2,500 feet below the top of the Catskill and reached the base of the formation at a depth of 3,340 feet. Willard (1939, p. 260) reported that the maximum thickness of the Catskill is about 6,200 feet in Carbon County and that the formation thins to a featheredge in the western and northwestern parts of the State.

The oldest part of the formation exposed in the quadrangle—approximately 3,000 feet stratigraphically below the formation's top—crops out along the Susquehanna River on the crest of the White Deer anticline, about half a mile northwest of the town of Ransom, Pa. The best exposures are in glacially oversteepened cliffs along the Susquehanna River and in isolated benches on the sides of glacially rounded hills. Some tributaries to the Susquehanna River, such as Buttermilk Creek, cascade over a series of resistant layers in the Catskill in their lower reaches where the glacial debris has been washed away. Elsewhere in the quadrangle the Catskill Formation is poorly exposed, as it is generally covered by glacial and alluvial deposits.

Lithology.—In the Ransom quadrangle the Catskill Formation is made up of slightly more than 50 percent shale and siltstone and of slightly less than 50 percent sandstone and conglomerate. Outcrops and cuttings from the Richards 1 well show that the upper 4,100 feet of the formation—the more sandy part—contains grayish-brown ("red") beds and no known marine fossils. Cuttings from the Richards 1 well show that the lower 1,740 feet of the formation—the more shaly part—contains a few marine fossils (crinoids, brachiopods, gastropods, and a few pelecypods) and no "red" beds. These fossiliferous strata may be equivalent to the New Milford Formation of Willard (1935), exposed in the northern part of Wyoming County and much of Susquehanna County (1936, p. 589). The New Milford consists of alternating beds of red and gray to olive-green continental and marine sandstone and shale that underlie the Catskill Facies Group of Willard (1936, p. 588–589).

Other geologists (White, I. C., 1883; Willard, 1936; Cooper and others, 1942) have divided the Catskill Formation in northeastern Pennsylvania, but their units are unrecognizable in the Ransom quadrangle, even though the upper half of the formation is well exposed along the Susquehanna River. During the present investigation the authors made many attempts to trace specific horizons, such as the base of a prominent sandstone, or zones of specific color, such as one of the thicker "red" shale sequences. None of these units could be traced or mapped, however, in the glaciated area adjacent to exposures along the river. The sandstone units and "red" shale sequences seem to interfinger, which precludes tracing specific horizons for any distance. Nonetheless, the authors divided the Catskill Formation into generalized zones on the basis of size of quartz grains (pl. 3); the resulting informal units were used in mapping the Ransom quadrangle.

Using a combination of surface and subsurface data, the authors divided the Catskill Formation of the Ransom quadrangle into five zones:

A. From base to 1,075 feet above the base—no quartz grains present larger than medium sand.

B. 1,075–1,728 feet above the base—quartz grains as large as granules present; scattered in mostly fine-grained rocks.

C. 1,728–4,380 feet above the base—no quartz grains present larger than medium sand.

D. 4,380–4,804 feet above the base—a few widely scattered lenses present containing coarse quartz sand and sparse quartz granules and pebbles.

E. 4,804 feet to the top, which is 5,840 feet above the base—coarse grains, granules, and pebbles of quartz abundant.

The approximate limit of each zone is sketched on plate 1; but, technically, the zones are not mappable because their contacts are vague and probably highly variable. Only the upper part of zone C and zones D and E are exposed in the Ransom quadrangle. The following descriptions of zones A and B and of the lower part of zone C are based on the study of cuttings from the Richards 1 well.

Zone A.—Zone A is the fine-grained basal unit of the Catskill Formation, overlying the coarse-grained Trimmers Rock Formation and underlying the coarse-grained zone B of the Catskill. It is 1,075 feet thick in the Richards 1 well. Zone A, the least sandy part of the Catskill, is about 90 percent siltstone and shale and about 10 percent sandstone. The sandstone, which occurs mainly in the upper half of the zone, is medium light gray, silty, limy, and very fine to fine grained. The siltstone and shale are medium light gray to medium dark gray, finely micaceous, and nonlimy to very limy. The limy upper part grades downward to the very limy lower part, which contains crinoids, brachiopods, and gastropods.

Zone B.—Zone B extends from 1,075 feet to 1,728 feet above the base of the Catskill. In the Ransom quadrangle zone B is the only part of the lower part of the Catskill that contains coarse grains and granules of quartz. About 45 percent of the unit is sandstone; the rest is medium-gray slightly limy siltstone and shale. A few pelecypods are present in the shale of the lower half of the zone, and numerous crinoids are present in the sandstone of the upper half. These crinoids are the youngest marine fossils that were found in the formation.

Zone C.—Zone C extends from 1,728 feet to 4,380 feet above the base of the Catskill. Zone C is separable from the overlying and underlying coarse-grained units because its quartz grains are no larger than medium-sand size. The zone is made up of 60 percent mostly crossbedded very fine grained to fine-grained sandstone and a few beds of medium-grained sandstone, 30 percent medium-gray to greenish-gray siltsone and shale, and 10 percent brownish-gray to grayish-brown siltstone and shale. The brownish rocks, the "red" rocks of previous writers, occur mostly in the upper half of zone C. One of the thickest units of siltstone and shale, about 800–900 feet above the base of zone C, is grayish brown in the lower one-third and medium gray in the upper two-thirds. It contains nodules and lenses of light-brownish-gray silty siderite, the only siderite that was noted in the formation.

One minor but notable constituent of zone C and of the overlying zones is the medium-gray to brownish-gray very limy very silty sandy conglomerate that has been referred to in previous reports as "glomerate" (Willard, 1936; 1939). It forms beds and lenses, seldom more than 5 feet thick, and probably constitutes less than 5 percent of this interval. Willard (1936, p. 578) named one of these calcareous beds near the base of the Cherry Ridge Formation the Dyberry Glomerate. Many "pebbles" in these "glomerates" are algal(?) masses, and some are fish scales and bones. The subrounded pebbles in the "glomerate" of zone C appear to be locally derived and are probably a residual coarse fraction left in depressions by the cut-and-fill process. Similar "glomerates" in the overlying coarse-grained units contain quartz granules and pebbles. Thus, the coarsest pebbles available apparently tended to be concentrated in these lenses, and the calcareous cement was probably introduced by ground water that contained dissolved carbonate, which came in part from the surrounding rocks and in part from the pebbles of algal(?) limestone. Outcrops of "glomerate" have a highly "pock-marked" or "worm-eaten" appearance. The rock is porous and ironstained where decalcified by weathering. "Glomerate" is hard and resistant to mechanical abrasion when fresh; angular boulders of it are locally present in glacial debris. Brown ironstained porous lightweight decalcified rounded pebbles and cobbles of this rock are common in the fluvial gravel along the Susquehanna River.

Crossbedding in zone C, as well as that in the overlying zones of the Catskill, is conspicuous in outcrops of the Ransom quadrangle. Although some layers are much more crossbedded than others, the degree of crossbedding does not seem to be a criterion by which the Catskill can be zoned in the Ransom quadrangle. Both tabular and lenticular crossbedded units are abundant; the lenticular units are more common (fig. 3) and were probably formed by the scouring and filling action of meandering streams. The tabular units may have been deposited in a similar way but by larger streams.

Zone D.—Zone D extends from 4,380 feet to 4,804 feet above the base of the Catskill. It is transitional between zones C and E in that it contains only a few lenses in which coarse grains, granules, and pebbles of quartz are present. About 60 percent of the zone is mostly crossbedded and very fine grained to medium-grained sandstone; the remaining 40 percent is mostly limy grayish-brown "red" shale, claystone, and siltstone. Beds and lenses of limy rock, including "glomerates" similar to those in zone C, and calcite-filled vugs are common.

Zone E.—Zone E extends from 4,804 feet to 5,840 feet above the base of the Catskill. It consists of about 55 percent mostly crossbedded fine- to coarse-grained sandstone, containing scattered pebbles and granules of quartz, and about 45 percent mostly grayish-brown claystone, shale, and siltstone. The abundance of coarse quartz sand distinguishes zone E more definitely from other zones in the Catskill Formation than from the overlying Pocono sandstone, which also contains abundant coarse quartz sand. Beds and lenses of "glomerate" are less common in this unit than in zones C and D.

A local conglomerate that caps the upper 400 feet of Bald Mountain consists of about 40 percent pebble-and-cobble conglomerate, about 60 percent fine- to coarse-grained conglomerate sandstone, and minor amounts of siltstone and shale. The pebbles are mostly sandstone, quartzite, and white to pink quartz; a few pebbles are black chert that weathers white and medium- to dark-gray metamorphic rock. At Pinnacle Rock on Bald Mountain, however, some sandstone cobbles, as much as 6 inches long, and quartz, quartzite, and other rock fragments, as much as 3 inches long, were found. Most of the cobbles and

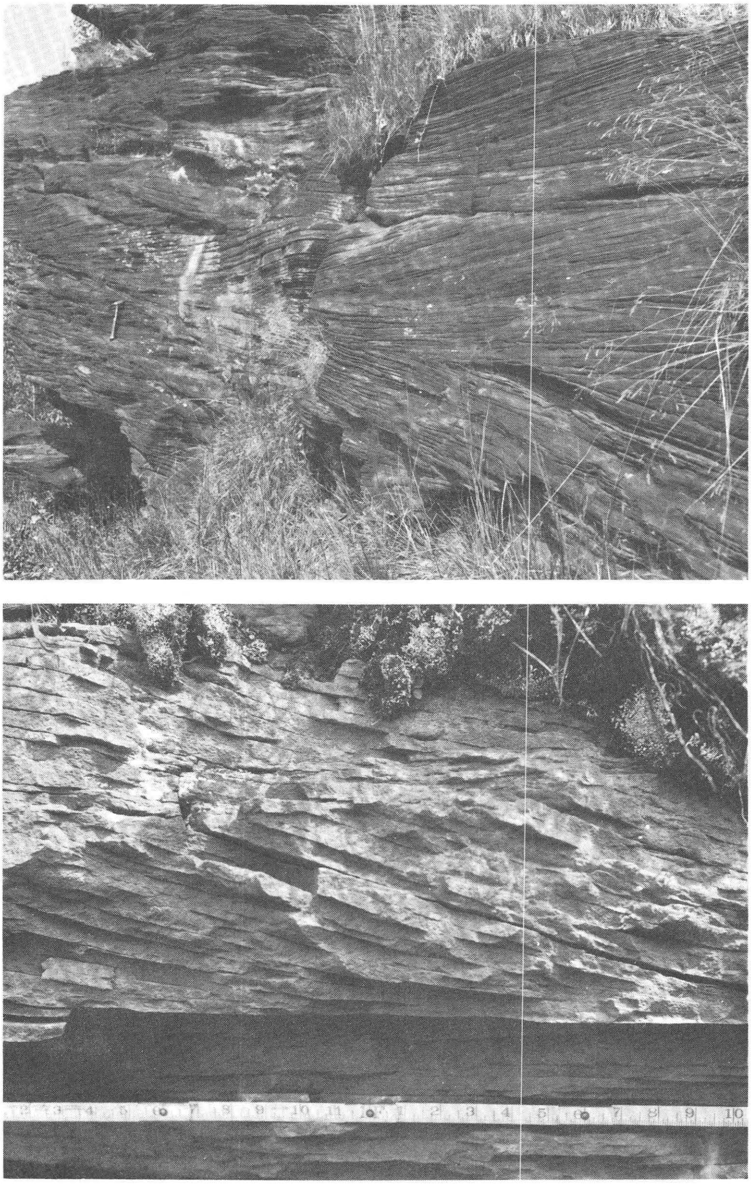

FIGURE 3.—Typical crossbedding in the Catskill Formation. Upper: Long and short lenticular crossbedding in zone E, near the outlet of the tributary to Falling Springs Reservoir. Lower: Short lenticular crossbedding in zone C in a cliff about half a mile south of Falls, Pa.

pebbles are well rounded, although some are subrounded to subangular. The long axes of some cobbles and pebbles seemingly have a preferred northwest-southeast orientation; however, most have random orientation. The conglomerate is bedded in lenses and tongues that are from 2 inches to 2 feet thick, although a few are as much as 5–6 feet thick. The conglomerate lenses and the sandstone tongues can be traced along the cliff face for distances of not more than 50 feet. A claystone parting $\frac{1}{4}$–2 inches thick was traced for a distance of 30 feet. Fluting, channeling, and other surface features, though scarce, are generally oriented northwest-southeast. The conglomerate was probably deposited in the channel of the main stream, which flowed northwestward across a broad delta. The authors found, by tracing the individual rock units in detail, that the conglomerate sequence on Bald Mountain interfingers northeastward and southwestward along the strike with the more typical sandstone, siltstone, and shale sequence of the upper part of zone E of the Catskill Formation (fig. 4).

The uppermost sequence of zone E is about 138 feet thick and consists of greenish-gray, grayish-brown, and dusky-yellow claystone that contains medium quartz sand, quartz pebbles as much as 2 inches long, and sandstone pebbles, cobbles, and boulders as much as 3 feet long. Sand grains, pebbles, cobbles, and boulders are randomly scattered in the claystone. Sand grains are abundant, but cobbles and boulders are scarce. The entire sequence has almost no bedding, except for lenses of poorly sorted sandstone in the lower part.

The best exposure of this pebbly claystone sequence is at the outlet of Falling Springs Reservoir. (See Powerline B section, units 5–13, p. 48.) Similar rock is exposed along strike to the northeast and southwest just outside the Ransom quadrangle, and a pebble-bearing claystone is present at about the same stratigraphic position in a roadcut south of Wilkes-Barre, Pa. In several other areas along strike

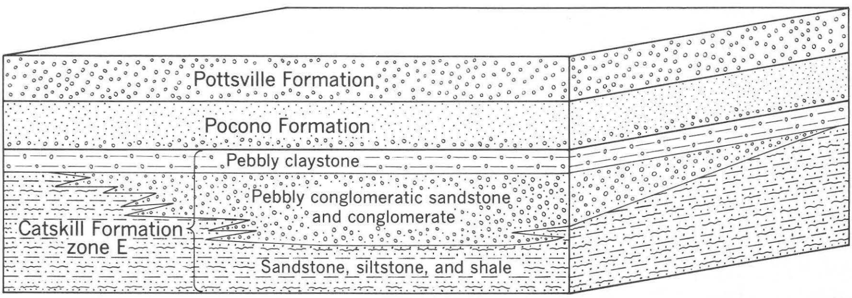

FIGURE 4.—Probable relation of the conglomerate exposed on Bald Mountain to other strata.

in and near the Ransom quadrangle, this sequence could not be found beneath the Pocono because is is either covered or absent. The lack of both bedding and sorting in the pebble-bearing claystone suggests that this claystone was deposited as a mudflow, but the unit's apparent widespread distribution leaves the exact mode of deposition largely to speculation.

Stratigraphic relations.—The Catskill Formation is apparently conformable and interfingers with the underlying strata. Willard (1939, p. 261–269) described an offlap or interfingering of the Catskill continental facies with marine facies of Late Devonian age. The basal part of the Catskill continental facies ranges in age from early Late Devonian in the eastern part of the State to late Late Devonian in the northwestern part (Willard, 1939, p. 268–269). It interfingers with the Trimmers Rock Formation to the east and with younger marine strata to the northwest. Thus, the basal contact is vague—not always easily recognizable—and transgresses time boundaries. In the Richards 1 well the contact of the Catskill Formation with the underlying Trimmers Rock Formation was arbitrarily placed at the change from medium-dark-gray shale and siltstone (Catskill Formation) to medium-light-gray very fine grained to fine-grained sandstone that contains scattered granules of clear quartz (Trimmers Rock Formation).

MISSISSIPPIAN SYSTEM

POCONO FORMATION

Name and age.—The name Pocono Sandstone was introduced by Lesley in 1876 (p. 221) for the gray sandstone and conglomerate of Early Mississippian age lying below the Mauch Chunk Formation and above the Catskill red beds; it replaced the term Vespertine Series of Rogers (1858, p. 141–146). Apparently Lesley had intended to establish the Pocono Plateau as the type section, but I. C. White (1882) found that most of the Pocono Plateau was underlain by rocks older than the Pocono. Thus, Lesley (in White, I. C., 1882, p. 15) revised the description of the type area for the Pocono Sandstone and implied that the type area was Moosic Mountain on the northwest border of the Pocono Plateau. The Pocono, now called a formation, is considered to be of Early Mississippian age (White, C. D., 1934, p. 269; Read, 1955, p. 1–14).

Griswold Gap Member.—I. C. White (1881, p. 57) recognized a persistent conglomeratic zone in the lower part of the Pocono Formation to which he gave the name Griswold Gap Conglomerate from exposures at Griswold Gap, just east of Forest City, Pa. He traced this conglomerate zone from Griswold Gap to an exposure on the

Susquehanna River about 1½ miles south of the Ransom quadrangle (White, I. C., 1883, p. 160–161).

The 152-foot-thick conglomerate and conglomeratic sandstone at the base of the Pocono in the Ransom quadrangle is referred to in this report as the Griswold Gap Member of the Pocono Formation.

In other areas of Pennsylvania, Willard (1939, p. 280) recognized two other members of the Pocono. His members were not recognized in the Ransom quadrangle.

Distribution and thickness.—The Pocono Formation underlies the crest of ridges around the edge of the Northern Anthracite field. It crops out, but is poorly exposed, in a narrow band across the southeast corner of the Ransom quadrangle. About 1½ miles southwest of the Ransom quadrangle, at the Campbell Ledge locality, the formation is approximately 570 feet thick (pl. 3). In the Ransom quadrangle the thickness of the Pocono decreases northward from approximately 500 feet to 400 feet in a distance of 2 miles. The decrease in thickness of the formation from south to north is probably due to erosion that took place prior to the deposition of the overlying Pottsville Formation. This decrease, in general, corresponds to the regional thinning of the formation to the north and northwest.

The Griswold Gap Member is about 150 feet thick along the Susquehanna River north of Campbell Ledge. Although it is so poorly exposed in the Ransom quadrangle that no complete section could be measured, the Griswold Gap Member seems to have about the same thickness there. The sequence of Pocono strata overlying the Griswold Gap Member is about 250–350 feet thick in the quadrangle and about 420 feet thick at Campbell Ledge.

Lithology.—In the map area about 25 percent of the Griswold Gap Member is a conglomerate that consists of subrounded to rounded cobbles and pebbles of quartz, quartzite, sandstone, and shale in a coarse sand matrix. Most of the quartz and quartzite is white, but a few pink quartz pebbles were observed. The base of the member is locally marked by a single layer of semioblate cobbles that lies parallel to the bedding. The other 75 percent of the member consists of conglomeratic sandstone, sandy siltstone, and claystone that are interbedded with the conglomerate. The sandstone is generally micaceous, fine to coarse grained, well sorted, and slightly to moderately crossbedded. The siltstone and claystone are micaceous and generally less crossbedded than the sandstone. The lower beds of this sequence contain well-preserved ripple marks near the Falling Springs Reservoir dam (fig. 5). Where fresh, the rock matrix of the Griswold Gap Member is yellow gray to light gray; where weathered, it is light olive gray to light brown. The prominent pebbles and cobbles generally impart a milky-white appearance to the outcrop.

FIGURE 5.—Ripple marks in basal part of Griswold Gap Member of Pocono Formation near the Falling Springs Reservoir dam.

The rest of the Pocono Formation consists of interbedded shale, siltstone, sandstone, and conglomerate that is here informally subdivided into three units. Data used as the bases for this division were obtained from outcrops along the Susquehanna River north of Campbell Ledge.

The lowest unit (Powerline A section, units 11–13, p. 46–47) is about 65 feet thick and overlies the Griswold Gap Member. It is poorly exposed—only 10 feet of siltstone was visible in this interval when this study was made. The covered layers in the lowest unit are probably made up of shale, siltstone, and fine-grained sandstone. I. C. White (1883, p. 157) reported observing a sandy red shale about 5 feet above the Griswold Gap Conglomerate in the Campbell Ledge area; however, the authors did not see this shale.

The middle unit (Powerline A section, units 14–32, p. 45–46), which is approximately 240 feet thick, consists of light-olive-gray to light-gray poorly sorted angular to subangular micaceous slightly to moderately crossbedded massive conglomerate, conglomeratic sandstone, sandstone, and siltstone. The sandstone and siltstone are generally calcareous and contain lenses and nodules of limestone that weather brown. The conglomerate, which is restricted to the lower 80 feet of this middle unit, contains subrounded pebbles as much as 1½ inches in diameter of metamorphic rock, quartzite, milky quartz, sandstone, siltstone, and claystone. A few black chert pebbles that weather white are also present. The pebbles make up a maximum of 20 percent of the conglomerate.

The uppermost unit of the Pocono Formation (Powerline A section, units 33–45, p. 44–45), which is about 110 feet thick, consists mainly of light-olive-gray and greenish-gray siltstone and claystone and greenish-gray and light-brown very fine grained to fine-grained sandstone. The siltstone and sandstone are micaceous, clayey, limy in part, and contain scattered limy nodules as much as 4 inches in diameter that weather grayish brown to grayish red. The beds are generally ¼–2 inches thick and slightly to moderately crossbedded; some are lenticular.

I. C. White (1883, p. 157) considered the upper 150 feet of strata here assigned to the Pocono as a part of the Mauch Chunk Formation of Mississippian age, even though he (1883, p. 160) stated that no red shale was seen in this interval. The Mauch Chunk Formation consists of greenish-gray and grayish-brown "red" shale and siltstone and fine- to coarse-grained light- to dark-gray sandstone, conglomeratic sandstone, and conglomerate. The beds of greenish-gray and grayish-brown "red" shale and siltstone generally constitute most of the Mauch Chunk interval. South of Wilkes-Barre the sandstone and conglomeratic sandstone beds make up about 30 percent of the Mauch Chunk and underlie the crest of Moosic Mountain. The formation is about 1,000 feet thick near Wilkes-Barre and thins toward the Ransom area. Strata containing a few feet of thin "red" beds were observed beneath the Pottsville Formation near Campbell Ledge in the Pittston quadrangle; to the east, in the Scranton quadrangle, "red" beds several feet thick were observed in a faulted zone beneath the Pottsville. The authors consider that the rocks beneath the Pottsville in the Ransom quadrangle are more typical of the Pocono Formation than of the Mauch Chunk, but they recognize that the upper few feet may be a transition zone between the Pocono and Mauch Chunk Formations.

Stratigraphic relations.—The relation between the Pocono Formation and the underlying Catskill Formation is not entirely clear. The change upward from shale of the Catskill to conglomerate of the Pocono is abrupt, and evidence of channeling in the upper surface of the Catskill suggests an unconformity. The presence of the relatively thin pebbly claystone at the top of the Catskill Formation in the Ransom quadrangle and along strike in adjacent areas indicates to the authors that pre-Pocono erosion was minor.

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PENNSYLVANIAN SYSTEM

POTTSVILLE FORMATION

Name and age.—Lesley in 1876 (p. 221, 226) substituted the name Pottsville Conglomerate for the Seral Conglomerate of Rogers (1844, p. 156), which included the sequence of sandstone and conglomerate of Pennsylvanian age that lies between the "red" beds of the Mauch Chunk Formation and the Lower Productive Coal Measures in the anthracite region. Lesley did not designate a type locality. Platt and Platt (1877, p. XXVI) listed Schuylkill Gap at Pottsville, Pa., as the locality chosen for the Pottsville Conglomerate by Lesley. C. D. White (1900, p. 756) proposed that the term formation be used—in preference to series or conglomerate—because the lithology of the sequences differs from place to place.

Campbell Ledge Shale Member.—I. C. White (1883, p. 39) gave the name Campbell's Ledge Black Slate to the dark-gray to black carbonaceous shale at or near the base of the Pottsville Formation. The exposure that he described is at Campbell Ledge, near Coxton, in Lackawanna County, Pa., about 1½ miles south of the Ransom quadrangle (fig. 8). This carbonaceous and coaly shale is here designated as the Campbell Ledge Shale Member of the Pottsville Formation. Plant fossils described by C. D. White (1900, p. 819) indicate that the member is younger than the Lykens Valley No. 1 coal bed of the Lower Pennsylvanian Schuylkill Member of the Pottsville Formation in the Southern Anthracite field. The member is assigned a Middle Pennsylvanian age.

Sharp Mountain Member.—The Pottsville Formation in the Southern Anthracite field was recently divided from the base upward into the Lower Pennsylvanian Tumbling Run and Schuylkill Members, and Middle Pennsylvanian Sharp Mountain Member (Wood and others, 1956, p. 2671). The sandstone and conglomerate in the Ransom quadrangle and in the Northern Anthracite field were tentatively correlated with the Sharp Mountain Member (Wood and others, 1956, p. 2688) (fig. 6). The thin sandstone below the conglomerate and black shale at the Campbell Ledge locality may correlate with the Schuylkill Member.

Distribution and thickness.—The Pottsville Formation is about 200 feet thick in the map area; along the margins of the Northern Anthracite field it is 75 feet to about 250 feet thick. The lower 25–50 feet of the formation is exposed as an almost continuous ridge across the southeastern part of the Ransom quadrangle and along the south flank of Bald Mountain, to the east in the Scranton quadrangle. The upper part of the formation and the basal contact are poorly exposed in the quadrangle, but the basal contact is well exposed along

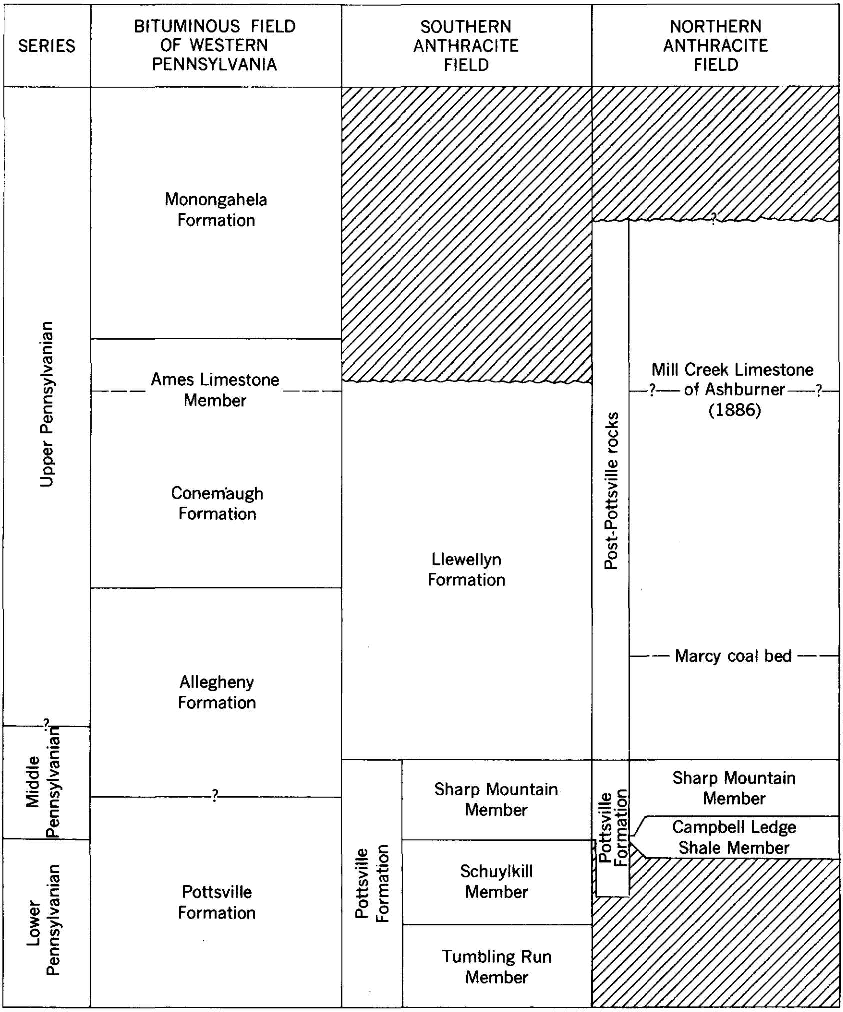

FIGURE 6.—Correlation of Pennsylvanian rocks of the bituminous and anthracite fields of Pennsylvania.

the east bank of the Susquehanna River at Campbell Ledge, about 1½ miles south of the Ransom quadrangle.

The Campbell Ledge Shale Member ranges from 0 to 10 feet in thickness. At the Campbell Ledge locality it occurs as lenses and has a maximum thickness of about 5 feet; and at a locality east of Falling Springs Reservoir (pl. 1), it is also about 5 feet thick. The member has been observed at most localities in the Northern Anthracite field where the basal part of the Pottsville is exposed.

A thin sandstone, 0–5 feet thick, lies below the Campbell Ledge Shale Member at some localities where the base is well exposed. It may be present throughout most of the Northern Anthracite field; but where the Campbell Ledge Shale Member is missing, the sandstone cannot be distinguished from younger Pottsville strata. This sandstone was not recognized in exposures in the Ransom quadrangle.

Lithology.—The Campbell Ledge Shale Member consists of dark-gray to black carbonaceous and coaly shale and thin coal lenses. It is massive where fresh but is fissile or platy where slightly weathered. At Campbell Ledge many species of plant fossils, as well as several species of insects, were found in the member (White, I. C., 1883, p. 39–41).

The Sharp Mountain Member is light- to dark-gray medium-bedded to massive very coarse grained sandstone and cobble conglomerate, containing a few lenses of siltstone, carbonaceous shale, and coaly shale. The sandstone is composed of grains of quartz and quartzite, and small amounts of mica, feldspar, garnet, and zircon. The conglomerate is composed of pebbles and cobbles of milky quartz and quartzite as much as 4 inches in diameter and a few pebbles of chert, siltstone, and shale. The lower part of the Sharp Mountain Member contains coarser grained rocks and is generally more conspicuous topographically than the upper part. In mining operations a few thin beds of coal and coaly shale have been found above the Campbell Ledge Shale Member; however, no outcrops of these beds have been found in the quadrangle.

Stratigraphic relations.—In the Ransom quadrangle the Pottsville rests discordantly on the Pocono Formation, as indicated by the thinning of the upper part of the Pocono. The stratigraphic break between the Pocono and the Pottsville is large here, because in other parts of the Northern Anthracite field, as much as 1,000 feet of the Mauch Chunk Formation is present between the Pottsville and Pocono Formations.

POST-POTTSVILLE ROCKS

Name and age.—Rocks of Pennsylvanian age above the Pottsville Formation in the Northern Anthracite field are informally referred to here as post-Pottsville rocks. The formal names for the Pennsylvanian strata above the Pottsville Formation in the bituminous coal fields of western Pennsylvania have not been applied to these rocks in the anthracite region (fig. 6). Correlation of the units of the two regions has been hampered by the dissimilarity of the rocks, the great distance between the regions, and the lack of a precise method for dating the beds. The name Llewellyn Formation has recently been applied to the Middle and Upper Pennsylvanian strata above the Pottsville Formation in the Southern and Western Middle Anthracite fields (Wood and others, 1962, p. C41–C42).

Paleobotanical dating by C. D. White (1900, p. 830) and correlation by Moore and others (1944, p. 680–681) indicate that the post-Pottsville rocks in this quadrangle may be equivalent to beds near the middle and upper parts of the Middle and Upper Pennsylvanian Allegheny Formation in the central and western parts of the State. A thin limestone near Wilkes-Barre—the Mill Creek Limestone of Ashburner (1886)—that lies about 500 feet stratigraphically above the Marcy coal bed was correlated with the Ames Limestone Member of the Upper Pennsylvanian Conemaugh Formation by I. C. White (1903, p. 259) and by Chow (1951, p. 14). If this correlation is correct, about two-thirds of the post-Pottsville strata in the Northern Anthracite field is younger than the Ames Limestone Member.

Distribution and thickness.—More than 2,000 feet of post-Pottsville rocks is preserved in the more deeply folded synclines of the four anthracite fields of eastern Pennsylvania (fig. 1). About 250 feet of post-Pottsville strata is present in the southeastern part of the Ransom quadrangle, but these beds are poorly exposed because they underlie areas of relatively gentle relief that are covered by soil mantle and glacial debris. The more resistant sandstone and conglomeratic beds locally project through the surficial deposits. The positions of the outcrops and exposures of the coal beds (pl. 1) are outlined on land surface by strip pits, subsidence of underground mine workings, and exploration trenches.

Lithology.—The post-Pottsville strata in this area consists of interbedded sandstone, conglomerate, shale, siltstone, carbonaceous shale, and five named coal beds (pl. 3). Medium- to coarse-grained thin- to thick-bedded light- to dark-gray quartzose sandstone and fine- to medium-grained medium- to thick-bedded light- to dark-gray quartz-pebble conglomerate make up the bulk of the sequence. The sandstone and conglomerate—except the coarsest conglomerate—are commonly crossbedded. Thin beds of light- to dark-gray shale and light-gray to yellow-brown siltstone are interbedded with the coarser grained rocks. Coaly and carbonaceous shale beds generally lie directly below or directly above the coal beds.

Coal beds.—The five named coal beds in the Ransom quadrangle, in ascending order, are the Lower Red Ash, the Middle Red Ash, the Upper Red Ash, the Clark, and the Marcy. The Lower Red Ash coal bed is apparently thin or impure and has been mined only in a few places in the area. The Middle and Upper Red Ash, Marcy, and Clark coal beds have been intensely mined underground and extensively strip mined in the quadrangle. Hill (1888) reported that in this general area the Upper Red Ash coal bed is more than 8 feet thick. The average thickness of each of the upper four coal beds is about 5 feet. Thin unnamed coal beds are locally present in the map area (pl. 3); however, the authors could not correlate them with coal beds in other parts of the anthracite field because of the paucity of outcrops and because of the limited mining data available.

Stratigraphic relations.—The contact between the post-Pottsville rocks and the underlying Pottsville Formation is arbitrarily placed at the base of the Lower Red Ash coal bed or at the base of the carbonaceous shale beneath the Lower Red Ash coal bed. This contact corresponds to that used by other geologists (White, C. D., 1900, p. 763; Wood and others, 1956, p. 2678).

QUATERNARY SYSTEM

PLEISTOCENE AND RECENT SERIES

GLACIAL TERRACE DEPOSITS

Scattered glacial terrace deposits of Pleistocene age are present adjacent to the Susquehanna River in the Ransom quadrangle (pl. 1). Terminal glacial deposits of Illinoian and Wisconsin glaciers are present near Berwick, about 20 miles southwest of the Ransom quadrangle. The deposits of Illinoian age reportedly consist of pebbles of black shale and siltstone, gray and red siltstone and sandstone, white sandstone, and quartzite, and a few cobbles of igneous and metamorphic rocks (Peltier, 1949, table 3). Peltier (1949, p. 26) reported that no Illinoian deposits had been found in areas north of the limit of the Wisconsin terminal deposits in Pennsylvania. The Illinoian deposits that may have been present in the Ransom quadrangle were either removed by the advancing Wisconsin ice sheet or so thoroughly mixed with material carried by the Wisconsin ice that their diagnostic features cannot be recognized. In areas where they can be recognized, Illinoian glacial deposits are distinguishable from younger Wisconsin glacial deposits by their more thoroughly leached condition and by the red and red-brown weathering of the sediments (Peltier, 1949, p. 4).

Glacial terrace deposits in the Ransom quadrangle have been assigned to the Olean Substage of Wisconsin age by Peltier (1949, p. 20). The terrace deposits are present in irregular and isolated patches adjacent to the Susquehanna River. Most deposits occur at an approximate altitude of 720 feet above mean sea level. West of West Falls, well-rounded pebbles and boulders are present at an altitude of about 1,000 feet above mean sea level and apparently constitute the highest terrace deposit preserved in the quadrangle. I. C. White (1883), Itter (1938), Peltier (1949), and others recognized terrace deposits at altitudes other than those cited for this area and for adjacent areas to the south, but the deposits are not readily apparent in the quadrangle. Those that are well exposed in the area are not strongly leached or oxidized.

The deposits consist mostly of quartz sand and gravel; 2–5 percent is igneous and metamorphic rock, limestone, and "glomerate." Pink, gray, and green granite and gneiss; white, gray, and pink quartzite; and other igneous and metamorphic rocks occur in these gravels. The sedimentary rocks include "red" and gray siltstones and sandstones, limestones, calcareous "glomerates," and black chert. With the exception of the black chert, the sedimentary rocks could be locally derived from the Catskill Formation. Peltier (1949, p. 18, 20) considered the Mohawk River valley and Adirondack Mountains of New York as the sources of the igneous and metamorphic rocks.

The deposit west of the Susquehanna River near the south edge of the quadrangle and like deposits elsewhere may be more than 100 feet thick.

ALLUVIUM

Alluvial deposits on the flood plain of the Susquehanna River (pl. 1) consist of poorly stratified well-rounded boulders, pebbles, and sand. The boulders and pebbles are not as large as those in the higher terrace deposits; this fact supports the authors' conclusion that the flood-plain deposits were derived partly from glacial terrace deposits. Also, the lower percentage of igneous and metamorphic rocks in the alluvial deposits indicates that these deposits were derived from terraces and from other sources comparatively lacking in igneous and metamorphic rocks.

Crossbedding, ripple marks (probably interference type), and some filled scour channels were observed in alluvial deposits a few miles south and west of the Ransom quadrangle. Most of these features show that the depositing currents flowed approximately parallel to the direction of flow of the present Susquehanna River. A few crossbeds face the opposite general direction; the course of the depositing stream may, therefore, have meandered.

Much flat-lying and gently sloping area above the flood plain is covered by a mantle of soil containing many rock fragments. The fragments consist of angular to subangular blocks, boulders, and pebbles of siltstone, sandstone, and conglomerate, and subrounded calcareous "glomerate" from the underlying strata. The matrix of this mantle is mostly fine sand but contains some silt and clay. No igneous and metamorphic rocks were found in this mantle; however, the authors believe that it is, at least in part, weathered glacial till.

STRUCTURE

The southeastern part of the mapped area contains the common limb of the Wyoming synclinorium (Wyoming Basin, or Lackawanna Basin, of other reports) of the Northern Anthracite field and the White Deer (Milton?) anticline. The northwestern part of the mapped area contains the gently dipping north limb of the White Deer anticline.

Structure contours on the map (pl. 1) were drawn on the base of the Pottsville Formation but were controlled largely by stratigraphic intervals of the underlying units. Many of the dip-and-strike data used in determining the trend and spacing of these contour lines may not represent the true attitude of beds, because complete elimination of the crossbedding component of dip readings was seldom possible. Furthermore, where the Pottsville has been removed by erosion the attitude of the base, shown by structure contours, is hypothetical and probably different, to some extent, from the attitude before erosion. The dominant structural feature of the quadrangle—the White Deer anticline—is apparently relatively uncomplicated; thus, the attitude of the rock in the quadrangle is approximately that shown on plate 1 by the structure contours and by the geologic section.

The White Deer anticline trends about N. 60° E. in the southwest corner of the quadrangle, but its trend changes to about N. 40° E. where the anticline extends past the east edge of the quadrangle. These trends correspond to the strike of rocks in the anthracite field to the southwest and northeast. The White Deer anticline, which plunges about 1° NE. (about 100 ft per mile), is asymmetric. The northwest flank dips about 3° locally, but the dip gradually diminishes away from the crest until it is about 1° in the northwestern part of the quadrangle. The dip of the southeast flank increases southeastward to about 27° in and adjacent to the Pennsylvanian strata. The anticline probably dies out a few miles northeast of the mapped area. To the southwest the anticline may be the Milton anticline shown by I. C. White (1883, sheet A) on his map of Wyoming, Lackawanna, and Luzerne Counties, Pa.

No faults were found in the mapped area; however three small thrust faults, involving the Catskill, Pocono, and Pottsville Formations, were observed in nearby areas.

ROCKFALL AT BALD MOUNTAIN

A combination rockfall and rockslide involving the upper part of the Catskill Formation has occurred south of Pinnacle Rock along the west side of the crest of Bald Mountain, in the east-central part of the Ransom quadrangle (pl. 1). The resultant rock debris, estimated to be about 250,000 cubic yards in volume, occupies an area about 250 feet wide that extends from Pinnacle Trail southward for a distance of about 1,000 feet. The upper surface of the debris slopes irregularly from an altitude of 2,045 feet to about 2,150 feet above mean sea level. A cliff projects 100 feet above the upper edge of the talus (fig. 7).

The debris consists of rectangular tabular blocks, most of which are about 2 feet square and 6 inches thick; however, some are as much as 8 feet wide, 15 feet long, and 4 feet thick. All the debris is sandstone and conglomerate that is readily identified as having come from the adjacent cliff. Glacial oversteepening of the cliff probably caused the eventual breaking away of the rock along well-developed joints that parallel the cliff face.

The most notable feature of the rockfall is the shape of its upper surface. The lower half tends to be a well-defined ridge that is separated by a depression from the steeply sloping (35°) upper half. (See fig. 7.) The depression, which is offset in at least one place, is slightly flattened in its deepest part, which is about 12 feet below the crest of the outer ridge. At the surface the largest blocks in the talus lie along the slope common to both the depression and the outer ridge.

Observers of similar rockfalls disagree in their interpretations of rate and manner of accumulation of debris. Howe (1909, p. 52–54) concluded that much of the debris in rockfalls in the San Juan Mountains of Colorado reached its present position "with a sudden violent rush that ended as quickly as it started," and that the concentric wrinkles formed as a result of the violent forward rush of debris. Sharpe (1938, p. 43–46) concluded, conversely, that the same "rock-glaciers" are fed by a constant source of material at their head and that concentric rings formed because of the slow forward flowage of the mass.

A rock slab falling from the top of the Bald Mountain cliff cannot roll or slide to the outer ridge of the talus; accordingly, the authors infer that the debris reached its present position through mass movement or by means of some special conveyance, such as a snowbank down which the blocks could slide. The present configuration of the cliff face suggests to the authors that most of the detached rock broke away during a single fall. The already jointed rock shattered on impact, and the debris probably came to rest essentially in its present position. Individual blocks are still being added to the talus; most of them lodge at the head of the slope (except, perhaps, when there is enough snow to lubricate their path down the 35° slope to the pit at the base).

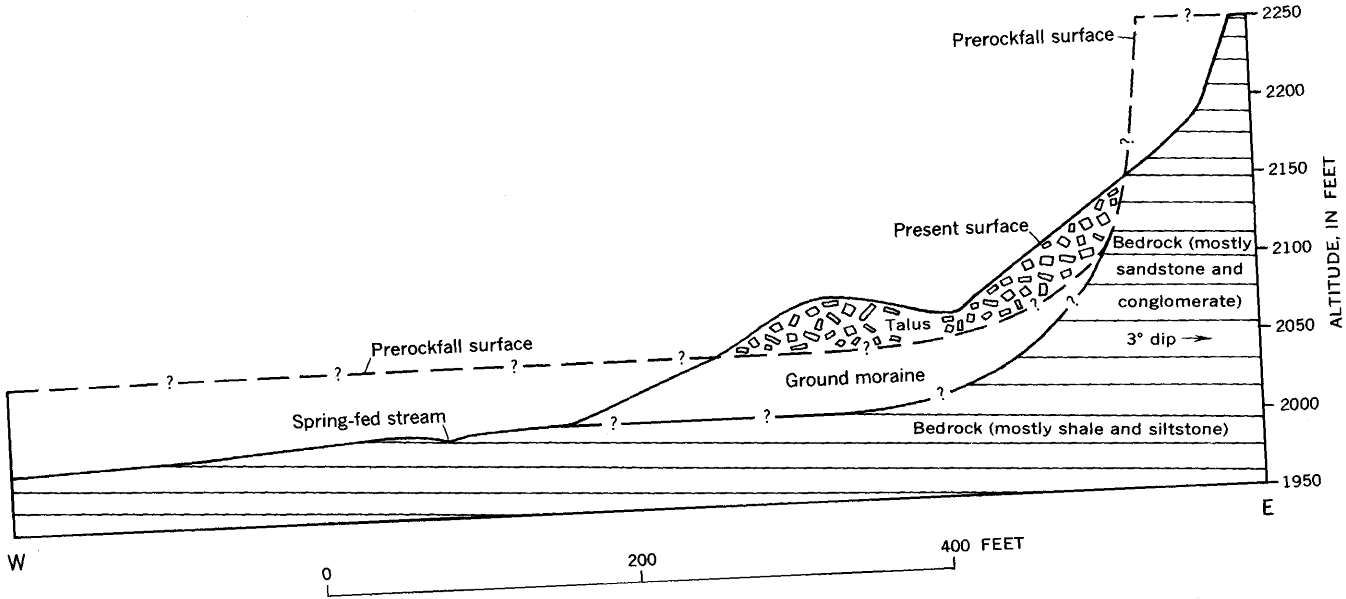

FIGURE 7.—Rockfall at Bald Mountain.

GEOLOGIC HISTORY

At the beginning of the Devonian Period, east-central Pennsylvania was a part of the Appalachian geosyncline. This trough, covered by an open sea, received a nearly unbroken sequence of deposits of Devonian, Mississippian, and Pennsylvanian age in this area. A highland that lay to the southeast at about the position of the present Atlantic coast supplied clastic sediments to the geosyncline. In Pennsylvania, marine rocks of Devonian age interfinger to the southeast and east with continental rocks of Devonian age.

During early and middle Helderberg time, the Ransom quadrangle received relatively small amounts of terrigenous sediments. A clear sea provided conditions that were favorable for brachiopods, crinoids, and ostracodes. During late Helderberg time a greater influx of terrigenous sediments resulted in the deposition of limy muds, and gastropods and pelecypods were the main inhabitants of the muddy bottom.

The sea began to clear when the sediment load of the westward-flowing streams began to diminish or be deflected from this area, and deposition of limy mud consequently gave way to deposition of sediments now represented by the silty limestone and limy chert of the Oriskany strata. Rocks of Oriskany age were probably deposited in a near-shore environment in part of the State, as they consist of quartz sandstone that locally contains pebbles. In the Ransom area the Oriskany is abruptly overlain by gray shale of Esopus age. The abrupt change in lithology indicates either a temporary cessation of sedimentation or a sudden change in the type of sediments supplied to this part of the trough. The introduction of a large amount of muddy sediment was probably the result of some modification of the sea currents or the extension of rivers across an encroaching land surface. During Esopus time subsidence accelerated, and larger quantities of fine-grained clastics poured into the trough. The increase in the carbonate content toward the top of the Esopus indicates that the marine environment again became favorable for the support of life.

During Onondaga time marine life probably flourished and indirectly contributed to the formation of limestone. In the upper part of the Onondaga, several layers of bentonite formed from volcanic ash which fell in the area. The volcanic ash may have contributed some of the silica that is now present as chert. During Marcellus and Mahantango time, subsidence of the trough again accelerated, and several thousand feet of sparsely fossiliferous gray and black shale and siltstone accumulated.

In Late Devonian time, uplift in the source area increased the amount of sediment carried into the geosyncline, and rivers built a series of deltas westward into the shallowing sea. As the trough filled, continental sediments were deposited over shallow-water marine sediments. Rivers carried coarse-grained clastics—including quartz granules—into the sea of the Ransom area in late Trimmers Rock time.

During early Catskill time the sea advanced and retreated several times in this area. The source area continued to rise, and the sediment-laden streams filled the embayments almost as fast as they formed. As the embayments filled, small swamps formed, and plants flourished and thus provided the organic debris preserved as plant fossils and coaly material in the Catskill strata. Rivers continued to build up the Catskill delta, and the sea was gradually pushed westward, beyond the Ransom quadrangle. The conglomerate capping Bald Mountain probably occupies one of the old river channels that existed near the close of Catskill time.

The coarse sandstone and conglomerate in the basal part of the Pocono Formation probably resulted from a major uplift in the source area during Early Mississippian time. Minor fluctuations in environment during Pocono time are indicated by lenses and tongues of both finer and coarser material throughout the Pocono interval and by lenses and nodules of limestone near the top of the formation. The absence of the Mauch Chunk Formation of Late Mississippian and Early Pennsylvanian age in the Ransom area indicates that a positive area existed there prior to deposition of the Pottsville Formation.

Another major period of uplift of the source area in Early Pennsylvanian time is indicated by the presence of coarse sandstone and conglomerate in the Pottsville Formation. The sediments gradually spread westward over the flood plain and intertongued with the Mauch Chunk sediments throughout much of eastern Pennsylvania. Only the upper part of the Pottsville sediments extended as far northwest as the Ransom area. Coal beds and carbonaceous shales in the Pottsville Formation indicate the beginning of a new cycle of quiescence in the highland to the east and of a climate favorable to the formation of extensive swamps during post-Pottsville time. From time to time these swamps were covered by great influxes of sand, gravel, and mud. Coalification of plant material into anthracite thus began.

At some time between the deposition of the post-Pottsville rocks and the Triassic, the Ransom area was gently folded. The deformation cannot be precisely dated because there are no younger undeformed strata overlying the deformed rocks of the region. After this deformation a long period of erosion (briefly interrupted in some areas by deposition in Late Triassic time) prevailed throughout much of the eastern part of the United States. Absence of Triassic rocks in the anthracite areas indicates that ridges of Paleozoic strata formed a barrier to the westward encroachment of the Triassic deposits.

Ice sheets covered the Ransom area during the Illinoian and Wisconsin Glaciations. Modification of the topography by these ice sheets is still evident.

ECONOMIC GEOLOGY

COAL

Coal was discovered in the Northern Anthracite field in 1762; the first large shipments from the region were made by boat in 1807 (Stoek, 1902, p. 74–75). Production of coal gradually increased until 1917, when more than 49 million tons was produced from the Northern Anthracite field, and then decreased. Coal has been mined from all five of the named coal beds in the Ransom quadrangle. No large-scale mining operations were in progress in 1960, and future production will probably be from small strip mines or from small underground mines.

The Lower Red Ash coal bed (pl. 3) has been mined only locally in the Ransom area because it is thin and impure at most places. Elsewhere in the Northern field the Lower Red Ash has been one of the more productive coal beds. The Middle and Upper Red Ash, the Clark, and the Marcy coal beds are thicker and of better quality than the Lower Red Ash coal bed. These beds were mined underground about 40 years ago and, in recent years, have been strip mined locally (Ash, 1954, p. 234). The extent of the underground mining in the Ransom quadrangle is not known; however, it is unlikely that large tonnages of recoverable coal remain in the quadrangle.

GAS

Commercial quantities of gas or liquid hydrocarbons have not been found in the Ransom quadrangle. The area has recently been tested by 12 wells (pl. 1). Eleven wells reportedly had two or more shows of gas in the lower 2,600 feet of the Catskill Formation, and 2 of these reportedly had shows of gas in the upper 300 feet of the Trimmers Rock Formation (Grow, 1964, p. 79–81). Only one show of gas was reported in the other well. The deepest test of the 12, the Richards 1 well, stopped at a total depth of 8,618 feet in rocks of probable Early Devonian age. Shows of gas were not reported below a depth of 2,970 feet, 370 feet above the base of the Catskill Formation. Eight of the other wells stopped in the upper part of the Trimmers Rock Formation, and the other three stopped in the lower part of the Catskill Formation.

The shows of gas, as reported, occurred at random depths in a 2,900-foot stratigraphic interval. The gas-producing zones are not definitely traceable from one well to another. Some gas is reportedly from zones of low primary permeability, as observed from the Richards 1 well cuttings; fractures and joints probably greatly facilitated the flow of gas to the test holes. Shows of gas are restricted to the lower partly marine rocks of the Catskill and the upper, entirely marine part of the Trimmers Rock Formation. The cover, however, is probably too thin and too fractured by jointing to confine gas that might have been present prior to truncation of the "red" upper part of the Catskill Formation.

Gas was produced from seven of the wells; however, the total volume obtained was small (Grow, 1964, p. 80). At the time of the authors' fieldwork (1960), all the wells were shut in.

SAND AND GRAVEL

Sand and gravel are present as discontinuous bodies along the flood plain of the Susquehanna River and as terrace deposits adjacent to the river. Other sand and gravel deposits may be present on higher ground, but none were observed.

The glacial terrace deposits are made up largely of sand and gravel but contain small amounts of silt and clay. In contrast, the flood-plain deposits contain larger amounts of sand, silt, and clay; and, in general, the gravel and pebble sizes are smaller than in the glacial terrace deposits.

In 1960 the flood-plain sand and gravel deposits were being mined at two places in the area for use in road building and for other construction purposes. No data on the annual production or on the estimated reserves of these deposits are available.

STRATIGRAPHIC SECTIONS

The following stratigraphic sections describe in detail one complete section of the exposed Pocono Formation and the lower part of the Pottsville Formation (powerline A) and six partial sections of the exposed Catskill Formation. All stratigraphic sections were measured within the Ransom quadrangle except powerline A and parts of powerlines B and C; these were measured just south of the Ransom quadrangle along or near the Susquehanna River. Figure 8 shows the stratigraphic relations of these sections and their locations. The sections are described downward, from youngest to oldest rocks, and are arranged in order of decreasing age. (See pl. 3 for a graphic composite section.)

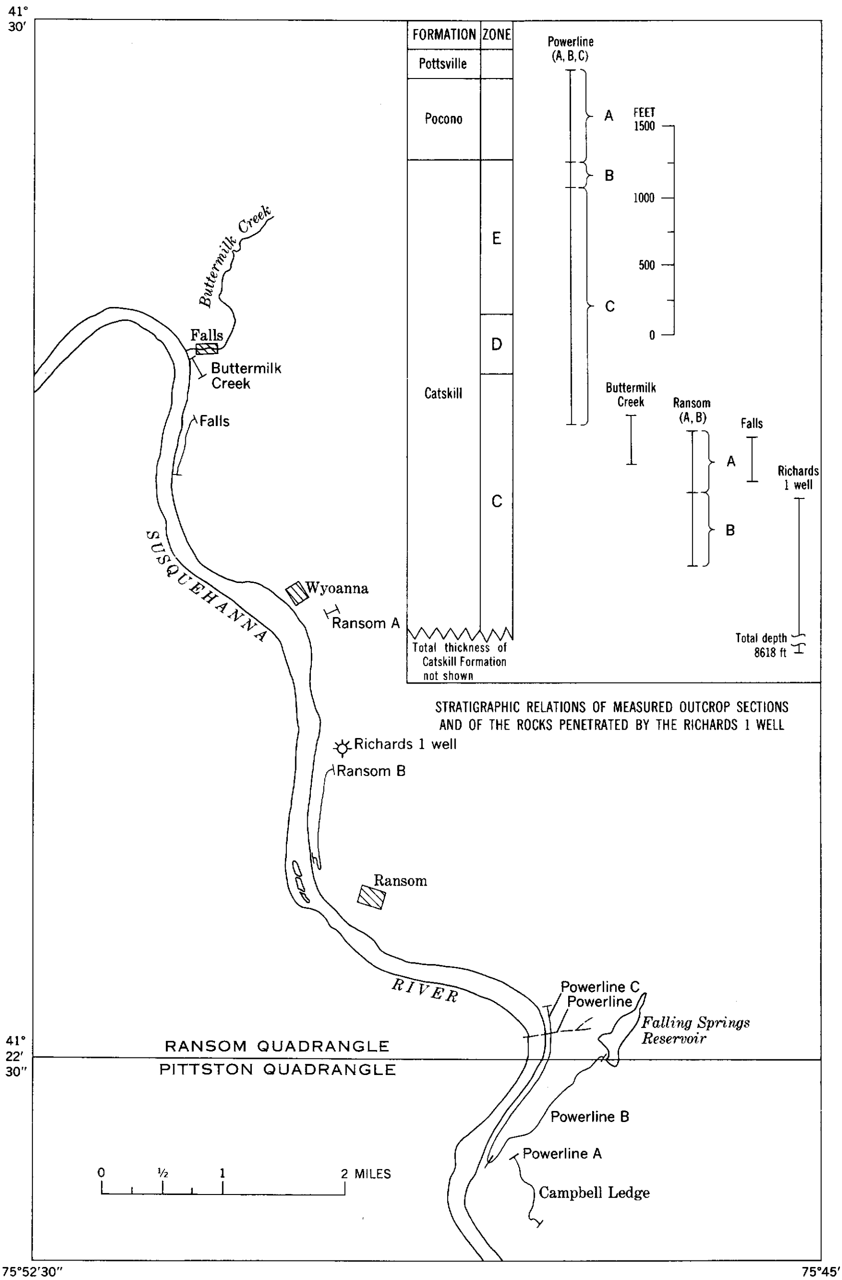

FIGURE 8.—Location and designation of sections measured in the Ransom and Pittston quadrangles.

POWERLINE A

The powerline A section extends from top of Campbell Ledge, on east bank of the Susquehanna River about 1½ miles south of Ransom quadrangle, northward along cliff face to base of the Pocono Formation, which caps the cliff just south of creek draining Falling Springs Reservoir.

	Feet
Pottsville Formation:	
Sharp Mountain Member:	
47. Conglomerate, medium-light-gray; massive lenses; quartz pebbles as much as 2½ in. long, and some quartzite, siltstone, and chert pebbles in medium to very coarse sand matrix; pebbles concentrated mostly in certain lenses; large plant fossils; exposures fair. Thickness measurement may not be exact because of folding and faulting, as indicated by abundant slickensides	75
Campbell Ledge Shale Member:	
46. Shale, dark-gray, micaceous, fissile; small pieces of plant fossils and (reportedly) fossil insects; lenticular, thickness ranges from 0 to 5 ft along 100 yd of outcrop; exposure fair; shale unit locally underlain by lens of Pottsville conglomerate as much as 5 ft thick	1
Part of Pottsville Formation measured	76
Pocono Formation:	
Upper part:	
45. Sandstone, light-brown, very fine to fine-grained, clayey, poorly sorted, massive; forms wedge-shaped blocks 2 in. thick on weathering; top contact sharp, basal contact gradational	3
44. Siltstone; weathers light brown; finely micaceous, well exposed; beds ¼–½ in. thick; moderately crossbedded; basal contact sharp	24
43. Sandstone, medium-light-gray, very fine grained, micaceous, clayey, silty, poorly sorted; forms wedge-shaped blocks 2 in. thick on weathering; well exposed in rounded cliff	9
42. Siltstone, greenish-gray to medium-light-gray; weathers light brown; finely micaceous; beds ¼–½ in. thick; moderately crossbedded	14
41. Claystone, greenish-gray, and siltstone in alternating beds; upper 4 ft of unit is siltstone; grayish-brown claystone lenses as much as 6 in. thick 1–2 ft above base; locally limy near base	21
40. Covered interval	1
39. Sandstone, greenish-gray, very fine grained, silty, slightly limy; limestone nodules in upper 1 ft; greenish-gray siltstone lens replaces sandstone in upper 3 ft. Small fault at top of unit	5
38. Claystone, greenish-gray, silty, subfissile, lenticular; limy grayish-red nodules as much as 2 in. thick and 1 ft long in upper 2 ft of unit; basal contact irregular	6

Pocono Formation—Continued

Upper part—Continued

	Feet
37. Siltstone, greenish-gray, very slightly limy, well-exposed, massive; lenticular bed; grades laterally into adjacent claystone units	2
36. Claystone, greenish-gray, and alternating greenish-gray siltstone; laminae to beds 4 in. thick 2–5 ft above base; contorted greenish-gray claystone grades laterally to grayish-brown claystone; ironstained limestone nodules as much as 1 in. thick and 3 in. long	6
35. Sandstone, greenish-gray, very fine to fine-grained, well exposed, massive; basal contact gradational	2
34. Siltstone, greenish-gray, clayey; beds ½–2 in. thick; grayish-red ironstained limestone nodules as much as 2 in. thick and 6 in. long in upper 5 ft; basal contact covered (unit assumedly rests on unit 33 equivalent)	12
33. Sandstone, light-brown, medium-grained, nonlimy (leached?); forms dip slope 100 ft long on southeast side of Campbell Ledge	4
32. Sandstone, light-olive-gray; greenish gray on slightly weathered surface; fine to medium grained; limy; poorly sorted; beds 3 in.–1 ft thick; limy lenses that weather brown	15
31. Sandstone, light-olive-gray, fine-grained; some medium grains; clayey; micaceous; beds 2–4 in. thick; poorly crossbedded; well sorted; fairly quartzose; grades upward to coarse-grained siltstone in upper 8 ft; basal contact gradational	12
30. Sandstone, light-olive-gray, limy, fine-grained, well-sorted, massive, well-exposed, slightly crossbedded; limy lenses as much as 2 in. thick and 3 ft long, weather back to outcrop	9
29. Sandstone, medium-light-gray, medium-grained, limy, massive, well-sorted, crossbedded (limy layers parallel some crossbeds); limestone nodules in basal 1 in	5
28. Siltstone, olive-gray, well-sorted, limy, subfissile	1
27. Sandstone, light-gray, fine- to medium-grained (fine-grained in upper 6 ft), limy, well sorted; in beds 1 ft thick; crossbedded; limy beds have brown pitted surfaces where weathered; basal contact sharp, irregular	10
26. Claystone, medium-light-gray, micaceous, limy, lenticular; lenses 2 in. thick (and possibly a vertical dike) of limy fine- to medium-grained sandstone; nearly continuous layer of limestone nodules in upper 2 in; basal contact sharp	1
25. Sandstone, medium-light-gray, fine-grained, partly micaceous, limy; beds 2 ft thick	7
24. Sandstone, light-gray; weathers brownish gray; medium to coarse grained; fine grained in upper 4 ft; limy, micaceous; beds 1–4 ft thick; well exposed subfriable where leached; sandy (fine-grained) limestone nodules as much as 1 in. in diameter in 3-ft-thick zone 6 ft above base of unit; nodules weather back into outcrop; basal contact sharp	10

Pocono Formation—Continued

Upper part—Continued	*Feet*
23. Sandstone, medium-light-gray, medium-grained, limy; subangular grains; beds 1–4 ft thick; very slightly crossbedded; medium-gray clayey sandy siltstone lens locally replaces sandstone in upper 10 in.; basal contact gradational	18
22. Siltstone, light-olive-gray to medium-light-gray; weathers brownish gray; slightly micaceous, limy, well sorted, massive. Basal 2 ft of unit is ironstained fine-grained (scattered medium grains) limy sandstone that weathers to beds 6 in. thick; basal contact gradational	12
21. Sandstone, light-gray, limy, fine-grained, well-sorted limestone nodules in middle half of unit; upper third contains medium sand; crossbedded in long sweeps; conchoidal fracture on fresh quarry face; basal contact sharp	18
20. Sandstone, medium-light-gray, very fine grained, limy, well-sorted; angular to subangular grains; massive; basal contact sharp	14
19. Sandstone, light-olive-gray, fine-grained, limy; some beds contain medium to coarse grains; conchoidal fracture; limy siltstone lenses as much as 6 in. long in zone 4 ft thick 20 ft above base; basal contact sharp	31
18. Sandstone, light-olive-gray, limy, micaceous, medium- to coarse-grained, poorly sorted, massive, scattered quartz granules; shale pebbles as much as 2 in. long in upper 2 ft of unit; basal contact sharp	9
17. Sandstone, light-olive-gray, limy, very micaceous, coarse-grained to very coarse grained, poorly sorted; angular to subangular grains; quartz granules and pebbles scattered throughout unit; discrete calcite grains in bed in middle of unit; channeled into underlying unit	19
16. Sandstone, light-gray; weathers light brown; locally micaceous; medium to coarse grained; poorly sorted; siliceous; angular to subangular grains; crossbedded in part; scattered thin layers of conglomerate composed of subrounded pebbles as much as 1 in. long of white quartz, green metamorphic rock with quartz veins, and quartzite; larger clay pebbles, especially at base	28
15. Conglomerate, light-gray; 20 percent subrounded white quartz pebbles as much as 1½ in. long; scattered pebbles of green metamorphic rock with quartz veins; quartzite pebbles; poorly sorted	7
14. Sandstone, medium-light-gray, medium-grained to very coarse grained, poorly sorted; angular to subangular grains; siliceous; white quartz pebbles as much as 1 in. in diameter; scattered black chert pebbles (weathered white); slightly coarser grained in upper part of unit; slightly crossbedded with large lenses	17
13. Covered interval	40
12. Siltstone, greenish-gray, micaceous, clayey, moderately well sorted; some fine sand; beds 1/16–½ in. thick; crossbedded	10

	Feet
Pocono Formation—Continued	
Upper part—Continued	
11. Covered interval	13
Total upper part	415
Griswold Gap Member:	
10. Sandstone, moderate-yellowish-brown, medium-grained to very coarse grained; clayey matrix; angular to subangular grains, 1–5 percent angular white quartz pebbles as much as 1 in. long. Unit is softer (probably because of the clay matrix) than sandstone below. One of the quarries in this area mentioned by I. C. White (1883, p. 157) is in this unit	15
9. Covered interval	14
8. Conglomerate, light-gray; weathers light brown; 10–50 percent white quartz pebbles as much as 2 in. long and a few pink quartz pebbles in coarse to very coarse sand matrix; siliceous; medium grained sandstone lens about 2 ft below top. Base channeled into unit 7. Unit 8 has been quarried locally	13
7. Sandstone, light-olive-gray; weathers light brown; medium to coarse grained; well crossbedded in layers 2–3 in. thick in upper half of unit; scattered white quartz pebbles as much as 1 in. long in upper half of unit	25
6. Covered interval	5
5. Sandstone, yellowish-gray; weathers light brown; medium to very coarse grained; poorly sorted, micaceous; subangular to subrounded grains; beds 1 in–2 ft thick; some crossbeds; subrounded to subangular white and a few pink quartz pebbles as much as 2 in. long; 10–25 percent pebbles in lower 20 ft of unit; basal contact sharp	31
4. Sandstone, light-gray; weathers light brown; fine grained, very micacous, siliceous; highly crossbedded in layers ½–1 in. thick. Only 6 ft of middle part of unit is well exposed; the rest includes some shale, 1 ft of which is exposed	20
3. Sandstone, light-gray; weathers light brown; fine grained, siliceous, well sorted; subangular to subrounded grains; coarse grained in basal part; quartz granules; grades upward to fine-grained sandstone; breaks into large white boulders on weathering; basal contact sharp	10
2. Sandstone, yellowish-gray; weathers light brown; medium to coarse grained, poorly sorted, siliceous; beds ½–4 in. thick; basal contact sharp	8
1. Sandstone, yellowish-gray; weathers light olive gray; coarse grained, poorly sorted; subangular to subrounded grains; beds 4 in–2 ft thick; slightly crossbedded; abundant quartz granules and pebbles as much as 1 in. long in upper 2 ft of unit; quartz and sandstone pebbles as much as 3 in. long at base of unit; basal contact sharp; channeled into underlying unit	11
Base of Pocono Formation and Griswold Gap Member:	
Total Griswold Gap Member	152
Total Pocono Formation	567

POWERLINE B

The Powerline B section was measured along the creek that flows southwestward from Falling Springs Reservoir dam. The base of the section is at the top of the cliff overlooking the Susquehanna River; the top of the section is at the dam. No break is apparent between the base of Powerline A and the top of Powerline B.

Susquehanna Group:	
Catskill Formation:	
Zone E (top of formation):	*Feet*
13. Claystone, dusky-yellow, slightly fissile; a few quartz pebbles as much as ¾ in. long; medium sand scattered throughout; basal 14 ft exposed; top 6 ft covered except for 6 in. of greenish-gray claystone containing medium sand; unit directly underlies the Griswold Gap Member of the Pocono Formation	20
12. Claystone, grayish-brown, micaceous; beds almost indistinct; medium sand, scattered quartz pebbles as much as 1 in. long, sandstone pebbles as much as 3 in. long; a 6-in. well-rounded cobble of very fine grained sandstone containing many dark grains; a few sandstone boulders as much as 3 ft long	37
11. Claystone, greenish-gray, micaceous; medium sand; pebbles of white and pink quartz and of conglomerate, all as much as 2 in. long; pebbles as much as 1 in. long (but no sand) in upper 6 ft	38
10. Claystone, greenish-gray, silty; fine to coarse sand, and siltstone pebbles; beds indistinct	20
9. Covered interval	7
8. Sandstone, medium-light-gray, very fine to coarse-grained; subangular to subrounded grains; ironstained; pebbles of white and pink quartz and of metamorphic rock, as much as 2 in. long; basal contact sharp	1
7. Claystone, greenish-gray, subfissile; scattered subangular subrounded pebbles as much as 2 in. long of white and pink quartz and of metamorphic rock; medium sand	9
6. Claystone, brownish-gray; silty, micaceous, poorly sorted, nonbedded; lower 2 ft covered	6
5. Sandstone, medium-light-gray; white and pink quartz pebbles as much as ¾ in. long; poorly sorted. Base of pebble claystone of zone E	3
4. Shale, brownish-gray; beds indistinct, about 1 in. thick	3
3. Sandstone, medium-light-gray, fine-grained to very coarse grained, clayey, dirty, micaceous; basal contact sharp. Unit thickens to 6 ft within a distance of 50 ft westward	3
2. Shale, brownish-gray; beds indistinct, about 1 in. thick; upper surface slightly fluted	4

Susquehanna Group—Continued
Catskill Formation—Continued
Zone E—Continued

	Feet
1. Sandstone, medium-light-gray, fine-grained to very coarse grained, poorly sorted, micaceous; pebbles of quartz, black chert, and shale scattered throughout; widespread crossbedding	25
Part of zone E measured	176

POWERLINE C

This section extends from the base of the powerline B section, along the creek draining Falling Springs Reservoir to the highway along the east side of the Susquehanna River. From there it extends northward along the highway to a point approximately 2,000 feet north of the powerline that crosses the river from the Electric Generating station. (See fig. 8.) Powerlines B and C are continuous.

Susquehanna Group:
Catskill Formation:
Zone E:

	Feet
124. Sandstone, greenish-gray, fine- to medium-grained, crossbedded, poorly exposed	25
123. Sandstone, brownish-gray; grades upward to greenish gray; fine to coarse grained; crossbedded; a few shale pebbles	24
122. Sandstone, brownish-gray, fine- to coarse-grained; quartz and black chert pebbles	12
121. Sandstone, brownish-gray, fine- to medium-grained, slightly micaceous; bed 1–6 in. thick; slightly crossbedded; fissile to nonbedded siltstone lens 8 in. thick 11 ft above base; shale pebbles and plates as much as 8 in. long reworked into the overlying sandstone	12
120. Covered interval	20
119. Sandstone, brownish-gray, medium-grained	12
118. Sandstone, brownish-gray, medium- to coarse-grained; quartz and shale pebbles as much as ½ in. long	12
117. Sandstone, brownish-gray, medium- to coarse-grained, poorly sorted, slightly crossbedded; "glomerate" of sandstone and black chert pebbles as much as 2 in. long and shale pebbles as much as 4 in. long in upper 1 ft	17
116. Sandstone, brownish-gray, coarse-grained, poorly sorted; quartz pebbles at base; black chert pebbles as much as 2 in. long throughout the unit; beds 1–6 in. thick; slightly crossbedded in long sweeps (single beds cut through as much as 10 ft of rock); basal contact sharp	30
115. Shale, grayish-brown, fissile to indistinctly bedded; siltstone lenses; grayish yellow green in upper part of unit, directly below unit 116; upper surface fluted	15
114. Covered interval; probably shale, as in unit 115	25

Susquehanna Group—Continued
Catskill Formation—Continued
Zone E—Continued

		Feet
113.	Sandstone, greenish-gray, very fine to medium-grained, micaceous; coarse-grained sandstone 3 ft thick containing scattered quartz pebbles 22 ft above base; very fine to fine-grained in upper 27 ft; beds 1–2 in. thick	52
112.	Interval, poorly exposed to covered; mostly shale, as indicated by float and by limited exposures	40
111.	Siltstone, grayish-brown; parallel beds ½–2 in. thick	5
110.	Sandstone, brownish-gray, fine-grained	3
109.	Sandstone, greenish-gray, fine-grained	1
108.	Claystone, grayish-brown, poorly exposed to covered	61
107.	Claystone, grayish-brown, fissile, and interbeds of brownish-gray very fine to fine-grained massive slightly crossbedded very micaceous sandstone	10
106.	Sandstone, greenish-gray, medium-grained; trace of coarse grains; angular to subangular grains; micaceous, especially along bedding planes; beds ½ in. thick to massive; crossbedded; grain size decreases upward; brownish gray in upper 1 ft; shale pebbles throughout, especially on bedding planes	23
105.	Covered interval; probably shale	21
104.	Sandstone, light-brownish-gray, medium-grained, crossbedded; abundant mica on bedding planes; poorly exposed	10
103.	Covered interval	8
102.	Sandstone, greenish-gray, fine- to coarse-grained. Top of unit at top of waterfall (adjacent to highway) on creek draining the Falling Springs Reservoir. Base of falls at unit 96	30
101.	Sandstone, greenish-gray, coarse-grained, and "glomerate"; some cleaned shale chips in "glomerate"	1
100.	Sandstone, greenish-gray, fine- to coarse-grained, crossbedded; beds 1–6 in. thick; crossbeds dip northeast and southeast (mostly northeast)	31
99.	Shale, greenish-gray; pinches out within 50 ft, then reappears; apparently sheared and brecciated in places	1
98.	Sandstone, greenish-gray, medium- to coarse-grained; angular to subangular quartz grains; crossbedded; micaceous along bedding planes	5
97.	Shale, greenish-gray, silty	1
96.	Sandstone, greenish-gray, medium- to coarse-grained; angular to subangular grains; sparse quartz and clay pebbles as much as 2 in. in diameter at base of waterfall adjacent to highway	8
95.	Siltstone, greenish-gray, slightly crossbedded; siltstone narrows to 1 ft thick 100 ft to the east; weak unit	3
94.	Sandstone, grayish-brown; fine-grained at base; grades upward to siltstone at top; grades eastward to siltstone, except for basal 1 ft; forms ledge	6

Susquehanna Group—Continued

Catskill Formation—Continued

Zone E—Continued

	Feet
93. Claystone, grayish-brown, silty, fissile to indistinctly bedded; weak unit	33
92. Sandstone, brownish-gray, fine-grained to very fine grained; parallel beds ¼–1 in. thick	16
91. Sandstone, greenish-gray, medium- to coarse-grained; scattered quartz pebbles as much as ¼ in. in diameter; crossbedded in part, mostly in long sweeps; many accessory minerals	35
90. Siltstone, greenish-gray; pinches out 100 ft to the south	5
89. Sandstone, greenish-gray, fine- to coarse-grained; scattered quartz pebbles as much as ¼ in. in diameter; shale lenses near top; beds ½–4 in. thick; slightly crossbedded; basal contact sharp	15
88. Claystone, grayish-brown, silty to nonsilty, fissile to indistinctly bedded; sandstone and "glomerate" lenses 15 ft above base; greenish-gray claystone lenses 18 ft above base; greenish gray in top 6 in.; weak unit; upper surface fluted	79
87. Sandstone, brownish-gray, very fine grained, silty; limy sandstone balls in upper 3 ft	5
86. Sandstone, greenish-gray, fine- to medium-grained, micaceous	5
85. Sandstone, brownish-gray, very fine grained, very micaceous	2
84. Sandstone, brownish-gray, medium-grained, micaceous	3
83. Sandstone, greenish-gray, medium- to coarse-grained, micaceous	2
82. Sandstone, greenish-gray, fine- to medium-grained; beds ¼–1 in. thick; slightly crossbedded in long sweeps; basal contact sharp	10
81. Claystone, grayish-brown, fissile; weak unit; upper surface fluted	6
80. Sandstone, brownish-gray, fine-grained to very fine-grained; a few claystone lenses; grades laterally to claystone	6
79. Sandstone, greenish-gray, fine- to medium-grained, micaceous; beds ½ in.–2 ft thick; crossbedded	7
78. Sandstone, greenish-gray, fine- to coarse-grained; sparse quartz pebbles as much as ½ in. long; beds ½ in.–2 ft thick; crossbedded in long sweeps	12
77. Conglomerate, greenish-gray; pink quartz pebbles as much as 1½ in. long; clay pebbles as much as 2½ in. long; angular to subangular sand in matrix; claystone lenses; beds ½ in.–2 ft thick; slightly crossbedded; basal contact sharp	6
76. Claystone, brownish-gray micaceous, fissile to indistinctly bedded; probably lenticular; becomes greenish-gray in top 2 ft within a distance of 50 ft; upper surface fluted	11

Susquehanna Group—Continued

Catskill Formation—Continued

Zone E—Continued	*Feet*
75. Sandstone, brownish-gray, fine-grained, micaceous, limy, poorly sorted	1
74. Claystone, brownish-gray; basal contact sharp, even	1
73. Sandstone, greenish-gray, fine-grained	7
72. Sandstone, greenish-gray, medium-grained, crossbedded; some grayish-red mica	3
71. Sandstone, greenish-gray, fine-grained, micaceous, crossbedded	10
70. Sandstone, greenish-gray, medium-grained, poorly sorted; conglomerate lenses containing quartz pebbles as much as ½ in. long	7
69. Sandstone, greenish-gray, medium-grained; grades upward to coarse-grained sandstone containing clay pebbles	9
68. Sandstone, greenish-gray, limy; fine-grained at base, grading upward to coarse grained; quartz pebbles as much as ½ in. in diameter	30
Part of zone E measured	850

Zone D:	
67. Sandstone, greenish-gray, fine-grained to very fine grained, crossbedded; contains limy "glomerate" lenses in upper part; basal contact sharp	19
66. Siltstone, grayish-brown, micaceous, clayey, subfissile; beds as much as 2 in. thick; plant debris; several limy sandstone lenses; locally crossbedded "glomerate" bed at base; upper surface fluted	10
65. Sandstone, greenish-gray, very fine to fine-grained, very micaceous, locally ironstained; beds ¾–2 in. thick; slightly crossbedded in long sweeps; grades to grayish brown in upper 1½ ft; basal contact sharp, conformable	20
64. Claystone, grayish-brown, fissile to indistinctly bedded; sandstone lenses	7
63. Claystone, greenish-gray, fissile to indistinctly bedded, micaceous; weak unit	3
62. Sandstone, greenish-gray, fine-grained micaceous, well-sorted; beds 1 in. thick; incipient crossbeds; about one-third of beds in lower 20 ft are lenticular, limy, "pock marked"	48
61. Claystone, grayish-brown, silty, micaceous, locally limy; 1 or 2 "glomerate" lenses; 2 lenticular sandstone beds; grades downward to very fine grained sandstone in lower 2 ft	30
60. Claystone, grayish-brown, silty, locally limy; basal contact gradational	5
59. Sandstone, grayish-brown, very fine grained, micaceous; limy zone 2 ft thick at base; lenticular; resistant to weathering	8

Susquehanna Group—Continued

Catskill Formation—Continued

Zone D—Continued

	Feet
58. Claystone, grayish-brown, silty, micaceous; limy in part; very fine grained brownish-gray sandstone lenses	8
57. Claystone, grayish-brown, silty, poorly bedded; several lenticular "pock-marked" limy zones; basal contact gradational	23
56. Sandstone; greenish gray in lower 5 ft, brownish gray in upper 9 ft; very fine grained; sparse incipient crossbeds	14
55. Claystone, grayish-brown, and grayish-brown siltstone interfingering with greenish-gray very fine grained sandstone and long "glomerate" lenses that contain a few clay pebbles	8
54. Sandstone; greenish gray in basal 5 ft grading upward to grayish brown in upper 6 ft; very fine grained; beds flaggy; some crossbedding	11
53. Claystone, grayish-brown, silty, fissile; limestone nodules as much as 1 in. in diameter in several "pock-marked" limy zones; limy "glomerate" bed 2 ft thick	17
52. Sandstone, greenish-gray, fine-grained, crossbedded; beds 1–8 in. thick; limy lenses in upper half; two fissile shale lenses as much as 6 in. thick	12
51. Claystone, grayish-brown, silty, indistinctly bedded, micaceous; limy and "pock-marked" in upper 8 in	3
50. Sandstone, brownish-gray, very fine grained, micaceous; beds 6–18 in. thick; slightly crossbedded	4
49. Claystone, grayish-brown, silty, fissile to indistinctly bedded, locally slightly limy; siltstone lenses	6
48. Siltstone, brownish-gray, coarse-grained, hard, massive	4
47. Claystone, grayish-brown, silty, fissile to indistinctly bedded, locally slightly limy; limy "worm-eaten" siltstone in upper 1 ft; "wormholes" result from leaching of limestone grains that average about 5 mm long	8
46. Claystone, greenish-gray, silty, fissile, micaceous; grades upward to brownish-gray siltstone in upper 1 ft	5
45. Sandstone, brownish-gray, very fine grained, clayey, micaceous, well-sorted; beds 2–12 in. thick; basal contact gradational	4
44. Sandstone, greenish-gray to slightly grayish-brown, fine-grained, clayey; abundant coarse-grained mica; beds 2–12 in. thick	10
43. Claystone, grayish-brown, silty; grades upward and laterally to limy fine-grained crossbedded sandstone that contains pebbles of shale; grades to greenish-gray claystone in places	3
42. Sandstone, greenish-gray, fine-grained, micaceous; a few long sweeping crossbeds; contains 2 greenish-gray claystone lenses	17
41. Claystone, grayish-brown, silty, indistinctly bedded; some interbeds of greenish-gray siltstone; limy zones	3

Susquehanna Group—Continued
Catskill Formation—Continued
Zone D—Continued

	Feet
40. Sandstone, greenish-gray, medium-grained, micaceous; beds indistinct, 2–6 in. thick; slightly crossbedded; angular to subrounded grains	5
39. Claystone, grayish-brown, silty; grades upward to very fine grained sandstone; slightly limy; 2 limy fine-grained sandstone lenses about 4 in. thick; weak unit	11
38. Sandstone, grayish-brown, fine-grained; beds 1–4 in. thick; moderately crossbedded; slightly limy; basal contact gradational	4
37. Sandstone, greenish-gray, slightly limy; medium grained in basal 5 ft, fine grained above; beds 1–4 in. thick; moderately crossbedded; several limy and clayey "pock-marked" zones; shale chips as much as 1½ in. long and poorly preserved plant debris in basal 1 ft	14
36. Sandstone, greenish-gray, fine- to medium-grained; grades upward to silty claystone in upper 1½ ft; beds 3 in. thick; moderately crossbedded; limy "pock-marked" very fine grained sandstone lens as much as 8 ft thick; a few clay pebbles; resistant to weathering; flute casts at base	20
35. Sandstone, greenish-gray, fine- to coarse-grained, micaceous, poorly sorted; beds 4 in. thick; incipient crossbeds; greenish-gray shale lenses 1 in.—1 ft thick; fluted casts at base; basal contact sharp, irregular	7
34. Claystone, grayish-brown; grades upward to greenish gray at top; silty, sandy, coarsely micaceous; beds fissile to indistinct; limy lens 6 ft below top; grades laterally to siltstone lenses and very fine grained sandstone lenses; weak unit; basal contact gradational	9
33. Sandstone, brownish-gray; fine grained at base, grades upward to massive grayish-brown siltstone; basal contact gradational	4
32. Sandstone, greenish-gray, fine-grained; crossbedded in both long and short sweeps; angular to subangular grains; greenish-gray shale lens as much as 1 ft thick 5 ft above base; limy sandstone lens 8 in. thick containing clay pebbles about 3 ft above base of unit; basal contact gradational	19
31. Sandstone, greenish-gray, coarsely micaceous; scattered white quartz granules and pebbles as much as ¾ in. long in a predominantly fine-grained matrix; beds indistinct, 1–4 in. thick; crossbedded in both long and short sweeps; poorly sorted; angular to subangular grains ;ironstains give unit "salt-and-pepper" appearance; limestone and shale pebbles as much as 1 in. long in basal 1 ft; shale lens 1 ft thick 8 ft above base. County-line marker on west side of highway, at base of unit, in Ransom quadrangle	20
Total zone D	423

Susquehanna Group—Continued
Catskill Formation—Continued

Zone C:	Feet
30. Sandstone, greenish-gray, fine-grained, slightly crossbedded; beds 1–4 in. thick; grades into fissile siltstone in upper 1 ft; weak unit	20
29. Sandstone, greenish-gray, fine-grained, nonbedded; weathers to knobby yellowish-green surface; coalified-plant beds as much as ½ in. thick. Unit is lens 30 ft long that is equivalent, laterally, to a "glomerate"	3
28. Claystone, greenish-gray, silty, fissile to indistinctly bedded	2
27. Sandstone, greenish-gray, very fine grained, micaceous; beds 1–3 in. thick; crossbedded in lower 15 ft; forms ledge	23
26. Claystone, grayish-brown, silty, indistinctly bedded; "glomerate" lens 2–3 ft thick at top weak unit	9
25. Sandstone, greenish-gray; grades to brownish gray in upper 3 ft; very fine grained	9
24. Siltstone, grayish-brown, fissile to distinctly bedded	4
23. Sandstone, greenish-gray, slightly limy, fine-grained; beds 1–6 in. thick; slightly crossbedded; "glomerate" 5 ft thick 5 ft above base. Base of unit is at road level beneath powerline that crosses river to powerplant	32
22. Siltstone and claystone, grayish brown; greenish gray in upper 2 ft; "glomerate" lenses locally in upper 2 ft	14
21. Sandstone, light-brownish-gray, fine-grained	3
20. Claystone, grayish-brown, silty; "glomerate" lens 6 in. thick in middle of unit	6
19. Sandstone, grayish-brown, fine-grained	2
18. Claystone, grayish-brown, silty	3
17. Siltstone, greenish-gray; basal contact irregular	3
16. Sandstone, greenish-gray, fine-grained well-sorted; many accessory minerals; massive when fresh; beds 1–4 ft thick; basal contact sharp	37
15. Claystone, grayish-brown, silty, fissile to indistinctly bedded	4
14. Siltstone, greenish-gray; "blobs" of grayish-brown clay; partly crossbedded	3
13. Sandstone, greenish-gray, very fine to fine-grained; beds 1–4 in. thick; shale and "glomerate" lens 3 ft thick 8 ft above base; "glomerates" also at 14 and 27 ft above base; crossbedded and more flaggy in upper 3 ft	50
12. Claystone, grayish-brown, silty; "glomerate" lens 1 ft thick at top; weak but persistent unit	5
11. Sandstone, greenish-gray, very fine grained and brownish-gray siltstone; beds ¼–1 in. thick; micaceous, well sorted; brownish gray in upper 4 ft; basal contact sharp	15
10. Siltstone, grayish-brown, fissile to indistinctly bedded; few crossbeds	11

Susquehanna Group—Continued
Catskill Formation—Continued
Zone C—Continued

	Feet
9. Sandstone, greenish-gray, very fine grained, well-sorted, micaceous; beds 1–6 in. thick; forms slope	11
8. Covered interval	23
7. Shale, brownish-gray, and interbeds of greenish-gray sandstone; beds 1 in–1 ft thick; 1 shale bed 3 ft thick 3 ft below top; forms slope; partly covered	20
6. Covered Interval	22
5. Sandstone, olive-gray, very fine to fine-grained; beds ¼ in. thick to massive; slightly crossbedded, micaceous, clayey, dirty	27
4. Covered interval	27
3. Sandstone, as in unit 5 above	21
2. Covered interval	13
1. Sandstone, greenish-gray, very fine to fine-grained, slightly micaceous, well-sorted; beds ¼–2 in. thick; slightly crossbedded; most crossbedding in upper part; "glomerate" beds in middle; shale lenses near base, middle, and top; forms isolated ledges along slope. Unit is 50–75 percent covered in lower 25 ft. Top of unit is approximately the top of Buttermilk Creek section	60
Part of zone C measured	482
Part of Catskill Formation measured	1,755

BUTTERMILK CREEK

The Buttermilk Creek section begins at road level on the east side of the Susquehanna River at the north end of the cliff about 600 ft south of the bridge over Buttermilk Creek at Falls, Pa. The section extends up the steepest accessible part of the north end of the cliff. The upper 60 feet is the approximate stratigraphic equivalent of the lower 60 feet of the Powerline C section.

Susquehanna Group:
Catskill Formation:
Zone C:

	Feet
24. Sandstone, greenish-gray to olive-gray, fine-grained to very fine grained; beds ¼–2 in. thick; slightly crossbedded in long sweeps; "glomerate" beds at 15 to 20 ft above base; 4-ft-thick grayish-brown siltstone unit in ¼-in.-thick beds 35 ft above base; poorly exposed to partly covered in upper 20 ft	64
23. Covered interval; forms slope	20
22. Sandstone, olive-gray, fine-grained, micaceous; some medium grains in lower part; angular to subangular grains; beds ¼–1 in. thick; abundant crossbedding; basal surface fluted; basal contact sharp. Base is approximate stratigraphic top of Ransom A section	13

	Feet
Susquehanna Group—Continued	
Catskill Formation—Continued	
Zone C—Continued	
21. Siltstone, grayish-brown; beds fissile to ¼ in. thick; sandstone lens 0–4 ft thick 7 ft from top; limy sandstone lenses	16
20. Sandstone, greenish-gray, very fine to fine-grained; well crossbedded in sweeps shorter and steeper than those of unit 19	19
19. Sandstone, greenish-gray, very fine to fine-grained; moderately crossbedded in long sweeps; "glomerate" lenses as much as 2 ft thick 10 ft above base and at top of unit; resistant; forms top of main cliff along river. Middle of unit approximate stratigraphic top of Falls section	30
18. Claystone, grayish-brown; fissile to indistinctly bedded; silty in lower half, clay shale in upper half; lenticular	3
17. Sandstone, brownish-gray, fine-grained; beds ⅛–2 in. thick; thin "glomerate" layer at top; lenticular	4
16. Shale and claystone, grayish brown, fissile to indistinctly bedded	6
15. Sandstone, greenish-gray, very fine to fine-grained, moderately crossbedded; several "glomerate" beds mostly in the lower 15 ft; grayish-brown shale beds, 1 foot thick 15 and 5 ft below top; upper 12 ft of sandstone forms persistent cliff traceable as "white bed" 4,000 ft southward on cliff face. "White bed" thins from 12 to 3 ft to south and is the "white bed" of unit 21 of Falls section. Comparison of altitude of "white bed" in both sections indicates apparent dip of 1° N	28
14. Claystone, grayish-brown, silty, limy; greenish gray in upper 1 ft; indistinctly bedded	5
13. Sandstone, greenish-gray to brownish-gray, fine-grained; abundant crossbedding in middle 5 ft; flaggy beds in lower half	15
12. Sandstone, greenish-gray, very fine grained, moderately crossbedded; beds 2–6 in. thick; greenish-gray shale 1 ft thick 6 ft above base; "glomerate" beds 5 ft above base and in upper 2 ft of unit	10
11. Claystone, greenish-gray, silty; interfingers with overlying sandstone	2
10. Sandstone, brownish-gray, very fine grained, platy to fissile	3
9. Sandstone, greenish-gray, very fine to fine-grained, massive, very slightly crossbedded; a few lenses of gray shale	13
8. Sandstone, greenish-gray, fine-grained; beds resistant, 1–4 in. thick; a few crossbeds; "wormholes"	11
7. Siltstone, brownish-gray; beds ⅛–2 in. thick; lenticular unit	3
6. Sandstone, brownish-gray, fine-grained, limy, massive; not crossbedded	3
5. Shale, grayish-brown, clayey, ripple-marked; plant fossils	3

Susquehanna Group—Continued
Catskill Formation—Continued
Zone C—Continued

	Feet
4. Sandstone, greenish-gray; grades to brownish gray in upper 5 ft; well sorted very fine angular grains; micaceous; crossbedded in long sweeps, but tends to be massive; medium-gray shale bed 1 ft thick 5 ft below top	23
3. Shale, dark-greenish-gray, fissile, interbedded with greenish-gray fine-grained limy sandstone; beds ½ in.–1 ft thick; shale and sandstone contacts sharp; clay shale in middle has microripple marks; "glomerate" bed near base; "glomerate," sandstone, and shale mixture in upper 4 ft	20
2. Sandstone, greenish-gray, fine-grained, well-sorted, relatively clean; limy in lower 2 ft; abundant crossbeds in long sweeps, ½–2 in. thick; closely spaced crossbeds in upper part; forms cliffs	15
1. Siltstone, grayish-brown, interbedded with grayish-brown very fine grained sandstone; beds as much as 6 in. thick; indistinctly crossbedded; locally limy; shale and "glomerate" lenses; grades laterally to greenish-gray siltstone in upper 2 ft	17
Part of zone C measured	346

RANSOM A

The base of this section is approximately 100 feet above road level about 1,500 feet south of the center of Wyoanna, Pa., on the east side of the Susquehanna River in the Ransom quadrangle, Lackawanna County, Pa. The section extends up the steepest accessible part of the cliff. The top of the section is equivalent to base of unit 23 of Buttermilk Creek section.

Susquehanna Group:
Catskill Formation:
Zone C:

	Feet
21. Sandstone, greenish-gray, very fine to fine-grained, well-sorted, crossbedded; beds ⅛–2 in. thick; 2 lenses of sandy limestone "glomerate" 1–2 ft thick near top; lower lens fills a channel	55
20. Sandstone, greenish-gray, very fine to fine-grained, well-sorted, finely micaceous; abundant crossbeds; limy at base	11
19. Claystone; grades from brownish gray at top to greenish gray at base; beds fissile to indistinct; channels at top filled with overlying sandstone	6
18. Covered interval	6
17. Sandstone, greenish-gray, very fine to fine-grained, well-sorted, micaceous; beds ⅛–2 in. thick, crossbedded in long sweeps of laminae dipping 12° S.; forms cliff	13

Susquehanna Group—Continued
Catskill Formation—Continued
Zone C—Continued

	Feet
16. Sandstone, light-brownish-gray, "red" to medium-gray, very fine to fine-grained, well-sorted, clayey, slightly micaceous; consists of sandstone sequences 10 ft thick separated by fissile greenish-gray shale lenses 5 ft thick; "red" sandstone and interbedded hard siltstone; crossbedding in long sweeps, more abundant in upper part	62
15. Siltstone, and interbeds of brownish-gray to greenish-gray very fine grained well-sorted micaceous sandstone; beds ¼ in. to 2 ft thick; some crossbedding, mostly near base; persistent; plant fossils in base of upper half in "red" beds	20
14. Sandstone, greenish-gray, fine-grained, well-sorted, micaceous, limonitic; limy in basal 1 foot; "glomerate" bed 4–18 in. thick in middle of unit; unit fills scour channels of the underlying siltstone to depth of 4 ft; persistent; forms cliffs	27
13. Siltstone, brownish-gray to greenish-gray; beds as much as 4 in. thick; no crossbedding; thins 4 ft within 20 ft (laterally) because of channels in upper surface	11
12. Covered interval; probably brownish-gray "red" siltstone	12
11. Siltstone, brownish-gray, clayey; beds fissile to ½ in. thick; massive "red" siltstone in upper 7 ft; steel-gray very fine grained sandstone bed 6 in. thick 20 ft above base; plant fossils in "red" shaly strata; forms cliff; persistent to the north; grades to sandstone to the south	36
10. Sandstone, greenish-gray to brownish-gray, very fine to fine-grained; beds 1–6 in. thick; no crossbedding; unit thins to the north, thickens to the south	2
9. Siltstone, grayish-brown. laminated to indistinctly bedded, no crossbedding; interbeds of 40 percent grayish-green very fine to fine-grained sandstone; sandstone slightly crossbedded, beds ½–3 in. thick; persistent; basal contact sharp	13
8. Sandstone, greenish-gray, very fine to fine-grained, well-sorted; trace of mica; limonitic and calcareous in lower 6 in.; abundant long crossbeds dip in many directions, many are crescent shaped (with both ends truncated); persistent; forms ledges; basal contact sharp	14
7. Interval, mostly covered; some gray siltstone exposed at top	12
6. Sandstone, greenish-gray, very fine to fine-grained, well-sorted; trace of mica and limonite; calcareous in part; ¼–3 in. thick	10
5. Covered interval	10
4. Sandstone, greenish-gray, very fine to fine-grained, well-sorted; trace of mica and limonite; calcareous in part; beds ¼–3 in. thick	10

Susquehanna Group—Continued
Catskill Formation—Continued

Zone C—Continued	Feet
3. Covered interval	13
2. Sandstone, greenish-gray, very fine to fine-grained, well-sorted; trace of mica and limonite; calcareous in part; beds ¼–3 in. thick, some beds 1–2 in. thick contain abundant microcrossbeds	55
1. Covered interval to top of Ransom B section	40
Part of zone C measured	438

RANSOM B

The base of the Ransom B section is at road level about 2,500 feet northwest of the center of Ransom, Pa., on the east side of the Susquehanna River in the Ransom quadrangle. The section extends up the steepest accessible part of the south end of the cliff. The top of Ransom Bis 40 feet below the lowest rock described in Ransom A.

Susquehanna Group:
Catskill Formation:

Zone C:	Feet
25. Sandstone, light-olive-gray, very fine to fine-grained, well-sorted, micaceous; beds ⅛–6 in. thick; flaggy, more so in basal part; slightly crossbedded; persistent; caps top of hill	33
24. Covered interval	30
23. Sandstone, greenish-gray, fine-grained, well-sorted, micaceous; angular to subangular grains; limonitic specks; beds ¼–1 in. thick; no crossbeds; persistent; forms cliff	11
22. Sandstone, greenish-gray, fine-grained, well-sorted, micaceous, calcareous; limonite-filled vugs; beds mostly parallel; a few crossbeds; interbeds of 40 percent "glomerate" as much as 2 ft thick; persistent; forms recess. Top of unit approximately top of Richards 1 well	5
21. Covered interval	47
20. Sandstone, greenish-gray, very fine to fine-grained, well-sorted, massive; trace of mica; forms beds ⅛–½ in. thick on weathering; a few incipient crossbeds; weak unit; forms slopes	25
19. Covered interval	42
18. Sandstone, greenish-gray, fine-grained, micaceous; angular to subangular grains; green and black mineral grains common; beds ¼–1½ in. thick; crossbedded; limy sandy "glomerate" 2 ft thick 10 ft above base; a few siltstone beds; upper and lower parts form ridges, middle part forms steep slope	61
17. Covered interval	15
16. Sandstone, greenish-gray, very fine grained, well-sorted, micaceous, massive; persistent	2

Susquehanna Group—Continued
Catskill Formation—Continued
Zone C—Continued

		Feet
15.	Siltstone, greenish-gray; some crossbedding	4
14.	Siltstone, grayish-brown, micaceous; beds indistinct, horizontal on weathering	8
13.	Claystone, grayish-brown, silty, fissile to indistinctly bedded; persistent; basal contact sharp. This is the oldest "red" unit in this section	3
12.	Siltstone, greenish-gray; beds indistinct, ¼–½ in. thick; interbeds of sandstone lenses 4–6 in. thick; indistinctly crossbedded	3
11.	Sandstone, greenish-gray, silty, very fine to fine-grained, well-sorted, micaceous, slightly clayey; beds ¼–½ in. thick; slightly crossbedded	13
10.	Sandstone, olive-gray to greenish-gray, fine-grained, well-sorted, micaceous, slightly clayey, slightly crossbedded; beds ¼–2 in. thick; limy layers in a zone 5 ft thick 32 ft above base	63
9.	"Glomerate"; medium sand and shale pebbles in silty matrix; calcite vein fillings 2 mm thick; very fine to fine-grained limy sandstone lenses in upper 5 ft	8
8.	Sandstone, greenish-gray, fine-grained, micaceous, clayey; very limy in part; laminae to beds ¼ in. thick; very slightly crossbedded; limy sandstone lenses containing shale chips that weather deeply and form pockets 1 in.–3 ft wide	35
7.	Sandstone, greenish-gray, fine-grained, well-sorted, clayey, micaceous; beds ½–2 in. thick; crossbedded in long sweeps; 4 interbeds 2–6 in. thick of limy sandstone and shale in upper 10 ft; uppermost limy zone is 1 in.–1 ft thick and lenticular	64
6.	Sandstone, greenish-gray, fine-grained, slightly micaceous; beds indistinct to ¼ in. thick. About 40 percent of unit consists of light-olive-gray shale and siltstone in beds as much as 6 in. thick, interbedded with the sandstone	10
5.	Covered interval	15
4.	Sandstone, greenish-gray, fine-grained, well-sorted, clayey, micaceous; beds ½–1 in. thick; crossbedded; forms persistent ledge; basal contact sharp, undulating	15
3.	Sandstone, greenish-gray, very fine to fine-grained; trace of mica; a few ironstained vugs; beds ¼–½ in. thick; no crossbedding; gray shale lenses as much as 1 ft thick in upper part of unit. Upper half may be more shaly than poor exposures indicate	40
2.	Siltstone, greenish-gray, finely sandy, micaceous, clayey; bedding not apparent; unit pinches out 50 ft to the south and extends at least 100 yd to north; weathers back from cliff face; basal contact sharp	3
1.	Sandstone, greenish-gray, fine-grained, well-sorted, clayey, micaceous; beds 2–4 ft thick; weathers to crossbeds ¼–½ in. thick	8
	Part of zone C measured	563

FALLS

The base of the Falls section is at road level, about 0.9 mile south of the Buttermilk Creek section and about 1 mile south of Falls, Pa., on the east side of the Susquehanna River. The section extends up the steepest accessible part of the south end of the cliff.

	Feet
Susquehanna Group:	
Catskill Formation:	
Zone C:	
23. Sandstone, brownish-gray; grades to greenish gray in top 4 ft; very fine to fine-grained; beds ¼–2 in. thick; moderately crossbedded; interbeds of grayish-brown fissile shale. Top of unit is approximately the middle of unit 19 of Buttermilk Creek section	18
22. Sandstone, brownish-gray, very fine grained; beds ¾ in. thick; moderately crossbedded; 2 beds of grayish-brown silty fissile to platy shale about 4 ft thick	22
21. Sandstone, greenish-gray, very fine to fine-grained, micaceous, ironstained; beds ¼–1 in. thick; abundant crossbedding; forms cliffs; 3 grayish-brown shale lenses 1 ft thick 20–30 ft above base; 3 similar lenses in the upper half; 3 greenish-gray shale lenses 1 ft thick in upper half of unit. A "white bed" 3 ft thick 40 ft above base, is the "white bed" of unit 15 of Buttermilk Creek section. Comparison of altitude of "white bed" at both sections indicates apparent dip of 1° N	62
20. Sandstone, light-brownish-gray, fine-grained; flaggy beds ¼–2 in. thick; no crossbedding	3
19. "Glomerate," greenish-gray, limy, ferruginous; weathers brown; clay pebbles as much as 1½ in. long; small red shale lens at top	3
18. Shale, medium-dark-gray; weathers to very light gray; thin limy "glomerate" lenses; lenticular, grades laterally to underlying shale	3
17. Shale, grayish-brown, silty	4
16. Shale, greenish-gray, silty, fissile to platy, lenticular; grades laterally to sandstone; limy nodules as much as 6 in. long	7
15. Sandstone, greenish-gray, very fine grained, well-sorted; beds ½ in. thick to massive; slightly crossbedded; lenticular	4
14. Claystone, grayish-brown, silty; beds ¼ in. thick	17
13. Sandstone, brownish-gray, very fine grained; beds as much as 2 in. thick	14
12. Shale, grayish-brown, silty; lenticular unit 0–4 ft thick	2
11. Sandstone, olive-gray, very fine grained, well-sorted; beds ⅛ in.–1 ft thick; moderately crossbedded; limy and "worm eaten"; sandy "glomerate" lens 1–6 ft thick at base	3
10. Shale, grayish-brown, silty, micaceous; beds as much as ¼ in. thick; locally limy; unit is 4–8 ft thick	5

Susquehanna Group—Continued
Catskill Formation—Continued
Zone C—Continued

	Feet
9. Sandstone, greenish-gray to light-brownish-gray, very fine to fine-grained, well-sorted, ironstained, slightly limy; thin laminae to beds 4 in. thick; crossbedded; dark-greenish-gray shale lens 1 ft thick 5 ft above base	24
8. Sandstone, very fine grained, siltstone, and claystone, in alternating beds; greenish gray; poorly exposed; sandstone beds ½–4 in. thick; crossbedded in lower part of unit	24
7. Claystone; grayish brown in upper and lower parts, greenish gray in middle 4 ft; silty; beds as much as 4 in. thick; limy sandstone lens overlain by "glomerate" lens in upper part	8
6. Sandstone, greenish-gray, very fine to fine-grained, micaceous, ironstained; beds ¼ in.–2 ft thick; slightly crossbedded; 2 "glomerate" lenses, each 1 ft thick—1 at base and 1 in middle of unit	30
5. Sandstone, mostly greenish-gray; brownish gray at base; very fine grained; massive; slightly crossbedded	4
4. Claystone, brownish-gray; beds as much as ⅛ in. thick	3
3. Sandstone, greenish-gray, very fine to fine-grained, well-sorted, micaceous; beds ¼ in.–2 ft thick; slightly crossbedded; dark-gray silty claystone lenses as much as 3 ft thick, 6 and 15 ft above base; bedding in lenses is disturbed or crumpled; "glomerate" at base and 2 ft below top of unit	28
2. Sandstone, greenish-gray to light-olive-gray, fine-grained, well-sorted, micaceous; beds 1–2 in. thick; abundant crossbeds; several "glomerate" lenses about 1 ft thick; dark-gray claystone lens 2½ ft thick near top; unbedded coal-bearing very fine to fine-grained sandstone in irregular lenses as much as 4 ft thick; coal lenses from individual plants as much 8 in. wide and ½ in. thick. Weathered coal-bearing sandstone is "pock marked" and rusty yellow; shows abundant channeling	30
1. In descending order: Claystone, greenish-gray, silty, slightly limy, fissile to indistinctly bedded; grades laterally to "glomerate" 1 ft thick. Greenish-gray to light-brownish-gray fine-grained sandstone 2 ft thick in middle of unit; angular to subangular grains; crossbeds 1 in. thick. Greenish-gray silty slightly limy fissile to indistinctly bedded claystone 3 ft thick. Greenish-gray very fine grained massive lenticular sandstone 1 ft thick at base of unit	7
Part of zone C measured	325

LOG OF RICHARDS 1 WELL

The Richards 1 well was completed on November 10, 1956, by the Transcontinental Production Co. It is approximately 2,050 feet south of lat 41°25′0″ N. and 8,850 feet west of long 75°47′30″ W. in the Ransom 7½-minute quadrangle, Lackawanna County, Pa. The top of the well is 1,030 feet above mean sea level; its depth is 8,618 feet. It was started about 2,500 feet below the top of the Catskill Formation and about 3,060 feet below the base of the Pottsville Formation.

Cuttings from the well were borrowed from the Pennsylvania Bureau of Topographic and Geologic Survey, Pittsburgh. The well was drilled by cable tool. Samples were clean and were taken mostly at 3–5 foot intervals; they were examined by E. E. Glick of the U.S. Geological Survey. (See pl. 2 for a graphic section of the rocks penetrated by the Richards 1 well; pl. 1 for the location of the well; and fig. 8 for the stratigraphic relations of the penetrated rocks to those described in the stratigraphic sections.)

Susquehanna Group:
Catskill Formation (3,340 ft):
Zone C (lower part):

	Depth (feet)
Sandstone, greenish-gray, very fine to fine-grained, slightly limy, very clayey; may be ground moraine in part	0–34
Sandstone, medium-light-gray, fine-grained, slightly micaceous, very limy; coalified plants	34–40
Siltstone, medium-light-gray, very finely micaceous	40–45
Sandstone, light-gray to light-brownish-gray, fine-grained, slightly micaceous, clayey	45–50
Shale, medium-gray and light-brownish-gray, very finely micaceous	50–53
Sandstone, light-gray, very fine to fine-grained, slightly limy, micaceous; coalified plants; 20 percent interbedded medium-gray finely micaceous siltstone	53–60
Sandstone, medium-light-gray, very fine to fine-grained, slightly limy, micaceous, clayey	60–70
Sandstone (as above), and 20 percent medium-gray micaceous siltstone beds	70–75
Sandstone, medium-gray, very fine grained, silty, clayey, finely micaceous	75–80
Shale, medium-light-gray, and 20 percent light-brownish-gray hard finely micaceous shale in a few silty layers	80–100
Siltstone, medium-gray, slightly micaceous, very finely sandy	100–112
Sandstone, light-gray, fine-grained, slightly limy, micaceous; angular to subangular quartz grains are well sorted; grains of dark rock—sandstone breaks across rather than around these	112–130

Susquehanna Group—Continued

Catskill Formation—Continued

Zone C—Continued

	Depth (feet)
Sandstone (as above, but more limy); some subrounded medium quartz grains; plant fossils, partly pyritized	130–140
Sandstone (as above), and 50 percent medium-gray shale and siltstone	140–155
Shale, medium-gray (trace light-brownish-gray); abundant mica, only as tiny grains	155–162
Sandstone, medium-gray, fine-grained, limy, micaceous, silty; thin medium-gray shale beds	162–172
Siltstone, medium-gray, very micaceous, finely sandy	172–179
Sandstone, medium-gray, fine-grained, silty, limy	179–185
Siltstone, medium-gray, finely micaceous	185–190
Sandstone, medium-light-gray, very fine grained, micaceous, limy	190–195
Shale, medium-gray, very finely micaceous	195–204
Sandstone, medium-light-gray, fine-grained, limy, silty, finely micaceous; medium-gray shale bed at base	204–209
Sandstone, medium-light-gray, fine-grained, micaceous, silty	209–230
Sandstone, light-gray to light-brownish-gray, very fine to medium-grained, micaceous, silty, very limy to slightly limy; "glomerate"? in part	230–235
Siltstone, medium-light-gray, coarse-grained, slightly limy, finely micaceous	235–245
Claystone, light-brownish-gray to grayish-brown,[1] very slightly limy, finely micaceous; greenish gray in lower 2 ft	245–258
Sandstone, medium-light-gray, very fine to fine-grained, finely micaceous, slightly limy; grain size increases downward	258–270
Sandstone, medium-light-gray, fine- to medium-grained, micaceous, limy to very limy; abundant dark grains in the sandstone give it "salt-and-pepper" appearance; coal fragments at 285 ft	270–290
Sandstone, medium-light-gray, very fine grained, finely micaceous, silty, limy	290–305
Shale, medium-gray, very finely micaceous	305–307
Sandstone, medium-light-gray, fine- to medium-grained, limy to very limy; white vein-calcite crystals; dark grains	307–320
Siltstone, medium-gray, coarse-grained, hard, finely micaceous, slightly limy	320–340
Sandstone, medium-light-gray, fine- to medium-grained, micaceous, slightly limy to very limy, silty; abundant white vein calcite	340–350
Claystone, medium-gray, silty, finely micaceous, slightly limy	350–357

[1] Color terms used are those of the "Rock-Color Chart" (Goddard and others, 1948). The "red" beds typical of the Catskill Formation are grayish-brown to brownish-gray.

Susquehanna Group—Continued

Catskill Formation—Continued

Zone C—Continued

	Depth (feet)
Sandstone, medium-gray, very fine grained, silty, limy; white vein-calcite crystals	357–380
Siltstone, medium-gray, coarse-grained, finely micaceous, slightly limy; white vein-calcite crystals	380–400
Sandstone, medium-light-gray to light-bluish-gray, very fine to fine-grained, silty, slightly limy	400–408
Shale, medium-gray	408–420
Sandstone, medium-light-gray, fine-grained, finely micaceous, silty, limy; grades into overlying shale; grain size increases downward to fine to medium; lower part is more limy and has white vein-calcite crystals	420–462
Shale, greenish-gray	462–465
Shale, grayish-brown, silty, slightly limy	465–472
Sandstone, light-gray to light-bluish-gray, very fine grained, finely micaceous	472–495
Shale, grayish-brown, silty	495–504
Sandstone, medium-light-gray, very fine grained, finely micaceous, slightly limy; interbedded with medium-gray coarse-grained siltstone	504–518
Sandstone, light-gray, fine-grained, finely micaceous, slightly limy	518–525
Sandstone, light-gray, very fine grained; interbedded with medium-light-gray finely micaceous siltstone	525–545
Shale, grayish-brown to medium-light-gray	545–560
Sandstone, light-bluish-gray, fine- to medium-grained, micaceous, slightly limy, silty, locally pyritic; grain size increases downward; sand-sized fragments of dark rock	560–599
Siltstone, medium-gray, finely micaceous	599–601
Sandstone, medium-light-gray, fine-grained, micaceous, slightly limy, silty; dark rock grains	601–622
Siltstone, medium-gray, limy	622–627
Sandstone, light-gray, very fine to fine-grained, micaceous, silty, slightly limy; grain size increases downward	627–655
Siltstone, medium-gray	655–660
Sandstone, medium-light-gray, fine- to medium-grained micaceous; dark rock grains	660–680
Sandstone (as above), limy	680–685
Shale, medium-gray, very finely micaceous	685–690
Sandstone, light-gray, fine-grained, slightly limy, slightly micaceous	690–700
Sandstone, medium-light-gray, fine-grained, micaceous, slight limy, silty; silty zone at top 2 ft thick contains pyritized and coalified plant fragments; medium-gray shale layers	700–725
Siltstone and shale, medium-gray, finely micaceous; contains small "nodules" and lenses of light-brownish-gray silty siderite; trace of pyrite	725-770

Susquehanna Group—Continued

Catskill Formation—Continued

Zone C—Continued

	Depth (feet)
Siltstone, medium-gray, very limy; finely sandy in upper half; siderite; white vein calcite	770–795
Siltstone and shale, grayish-brown, slightly limy; white vein calcite; trace of pyrite; grayish-brown siderite	795–827
Sandstone, medium-light-gray, fine-grained, slightly micaceous, limy, silty	827–845
Sandstone, medium-light-gray, fine-grained, micaceous, very limy; coal; pyrite; abundant white vein calcite	845–856
Siltstone, medium-gray, finely micaceous; silty very fine grained sandstone beds	856–870
Sandstone, light-gray, fine-grained, slightly micaceous, slightly limy; dark rock grains; some medium quartz grains in lower part	870–900
Sandstone, medium-light-gray, very fine to fine-grained, finely micaceous, slightly limy, silty	900–923
Shale, medium-gray	923–935
Shale, medium-gray and brownish-gray	935–948
Shale, grayish-brown, silty	948–955
Shale and siltstone, medium-light-gray	955–975
Sandstone, medium-light-gray, fine-grained, micaceous, slightly limy	975–981
Shale, medium-gray	981–985
Sandstone, medium-light-gray, fine- to medium-grained, micaceous slightly limy dark rock grains	985–1,000
Shale, medium-gray; silty in part	1,000–1,015
Sandstone, medium-light-gray, fine grained, finely micaceous, very slightly limy	1,015–1,045
Shale, medium-gray, finely micaceous; silty in part; trace of pyrite	1,045–1,080
Sandstone, medium-light-gray, fine-grained, silty, very slightly limy	1,080–1,095
Shale, medium-gray	1,095–1,117
Sandstone, medium-light-gray, fine-grained, micaceous, silty	1,117–1,142
Shale, medium-gray	1,142–1,147
Sandstone, medium-light-gray, very fine to fine-grained, silty	1,147–1,160
Shale, medium-gray; silty in part	1,160–1,181
Sandstone, medium-light-gray, fine-grained, micaceous, limy	1,181–1,195
Sandstone, medium-gray, very fine grained, slightly limy, silty; medium-gray shale beds	1,195–1,205
Sandstone, medium-light-gray, fine-grained, micaceous, slightly limy, silty; coal; pyrite; dark rock grains; medium-gray shale beds	1,205–1,305
Sandstone, medium-light-gray, fine- to medium-grained, slightly limy; dark rock grains	1,305–1,317

	Depth (feet)
Susquehanna Group—Continued	
Catskill Formation—Continued	
Zone C—Continued	
Shale, medium-gray; slightly limy in part	1,317–1,327
Sandstone, medium-light-gray, fine-grained, slightly limy, silty; micaceous in part	1,327–1,354
Shale, medium-gray	1,354–1,357
Sandstone, medium-light-gray, very fine to fine-grained, slightly limy; trace of mica	1,357–1,393
Shale, medium-light-gray, very slightly limy; silty in part	1,393–1,415
Sandstone, medium-light-gray, very fine to fine-grained, silty; very limy in lower part	1,415–1,450
Shale, medium-gray	1,450–1,460
Sandstone, medium-light-gray, very fine grained, slightly limy; very silty	1,460–1,473
Shale, medium-gray, slightly micaceous; silty in part	1,473–1,522
Sandstone, medium-light-gray, very fine grained, very slightly limy, silty; medium-gray shale partings; trace of pyrite; coaly partings	1,522–1,553
Shale, medium-gray; silty in part; locally limy	1,553–1,589
Sandstone, medium-light-gray, very fine grained, silty, very slightly limy	1,589–1,612
Zone B:	
Sandstone, medium-light-gray, very fine to medium-grained, limy, silty; trace of coarse grains in upper part	1,612–1,620
Shale, medium-gray; mostly clay	1,620–1,628
Sandstone, medium-light-gray, very fine to fine-grained, silty; siliceous in part; grain size increases downward, some medium grains in lower part; trace of coal	1,628–1,643
Shale, medium-light-gray, fissile, and medium-light-gray siltstone	1,643–1,662
Sandstone, medium-light-gray, very fine grained, very slightly limy, silty	1,662–1,672
Shale, medium-light-gray, fissile, and medium-light-gray siltstone	1,672–1,733
Sandstone, medium-light-gray, very fine grained, very slightly micaceous, silty, slightly limy; pyrite	1,733–1,742
Shale, medium-gray, fissile	1,742–1,744
Sandstone, medium-light-gray, silty, fine-grained; interbedded with siltstone and shale	1,744–1,760
Sandstone, medium-light-gray, fine-grained to very coarse grained, slightly limy, poorly sorted; quartz granules; partings of medium-gray shale	1,760–1,768
Shale, medium-gray; silty in part	1,768–1,780
Sandstone, medium-light-gray to medium-gray, very fine to fine-grained, finely micaceous, slightly limy, silty; crinoids	1,780–1,810
Shale, medium-gray, fissile; trace of pyrite	1,810–1,820

Susquehanna Group—Continued
Catskill Formation—Continued
Zone B—Continued

	Depth (feet)
Sandstone, medium-light-gray, very fine grained, finely micaceous, slightly limy to limy; interbedded with medium-gray shale and coarse-grained siltstone; grades downward to finer grained rock; mostly siltstone and shale in lower half; crinoids at 1,835–1,845 ft and 1,862–1,869 ft	1,820–1,870
Sandstone, medium-light-gray, very fine grained, finely micaceous, silty	1,870–1,878
Siltstone, medium-gray, very finely micaceous	1,878–1,890
Sandstone, medium-light-gray, very fine grained, limy, finely micaceous; interbedded with nearly 50 percent medium-gray shale and siltstone	1,890–1,915
Shale, medium-gray; silty in part	1,915–1,938
Sandstone, medium-light-gray, very fine grained, slightly limy, silty; crinoids	1,938–1,948
Shale, medium-gray, slightly micaceous, fissile, silty; interbedded with medium-gray to medium-light-gray slightly limy coarse-grained siltstone	1,948–2,000
Sandstone, medium-light-gray, very fine to fine-grained, slightly limy, silty	2,000–2,008
Shale, medium-gray; silty in part	2,008–2,018
Sandstone, medium-light-gray, very fine to fine-grained, finely micaceous, slightly limy	2,018–2,037
Shale, medium-gray	2,037–2,045
Sandstone, light-gray, fine-grained, slightly micaceous, limy, relatively clean; angular grains; drilling frees individual sand grains	2,045–2,055
Sandstone, medium-gray, very fine grained, slightly limy, silty	2,055–2,068
Shale, medium-gray, finely micaceous; medium-gray finely sandy coarse-grained siltstone beds	2,068–2,097
Sandstone, light-gray, fine- to medium-grained, finely micaceous, limy; grain size decreases downward	2,097–2,112
Shale, medium-gray, finely micaceous, slightly limy; silty in part; pelecypods at 2,120–2,130 ft	2,112–2,165
Sandstone, medium-light-gray, fine-grained to very coarse grained, very silty, limy, poorly sorted; quartz granules	2,165–2,172
Shale, medium-gray	2,172–2,180
Sandstone, medium-light-gray, very fine grained, silty, slightly limy	2,180–2,190
Shale, medium-gray; silty in part	2,190–2,200
Sandstone, medium-light-gray, fine-grained, slightly limy, well-sorted; dark rock grains	2,200–2,209
Shale, medium-gray; silty in part	2,209–2,238
Siltstone, medium-light-gray, micaceous, very finely sandy	2,238–2,245
Shale, medium-gray; silty in part	2,245, 2,255
Sandstone, medium-gray, very fine to very coarse grained, very silty, poorly sorted	2,255–2,265

Susquehanna Group—Continued

Catskill Formation—Continued

Zone A:	*Depth (feet)*
Shale, medium-gray; silty in part; very fine grained sandstone at 2,280–2,282 ft	2, 265–2, 295
Sandstone, medium-light-gray, very fine to fine-grained, very slightly limy, silty	2, 295–2, 304
Siltstone, medium-gray, finely micaceous	2, 304–2, 315
Sandstone, medium-gray, very fine to fine-grained, limy, silty	2, 315–2, 330
Shale, medium-gray	2, 330–2, 345
Sandstone, medium-gray, very fine grained, very silty	2, 345–2, 355
Shale, medium-gray	2, 355–2, 385
Siltstone, medium-gray, very finely sandy, slightly limy	2, 385–2, 396
Shale, medium-gray	2, 396–2, 432
Siltstone, medium-light-gray, very finely sandy	2, 432–2, 445
Shale, medium-gray	2, 445–2, 458
Siltstone, medium-gray, finely sandy; medium-gray shale beds	2, 458–2, 480
Shale, medium-gray; silty in part	2, 480–2, 530
Sandstone, medium-light-gray, very fine to fine-grained, slightly limy, silty; pyrite	2, 530–2, 550
Shale, medium-gray; interbedded with coarse-grained siltstone and very fine grained sandstone	2, 550–2, 580
Shale, medium-gray; silty in part	2, 580–2, 597
Siltstone, medium-light-gray, coarse-grained; slightly limy medium-gray shale beds	2, 597–2, 640
Shale, medium-gray, silty	2, 640–2, 650
Siltstone, medium-gray, finely micaceous, slightly limy	2, 650–2, 660
Sandstone, medium-light-gray, very fine to fine-grained, very finely micaceous, silty, slightly limy	2, 660–2, 670
Siltstone, medium-light-gray, finely micaceous, slightly limy	2, 670–2, 695
Shale, medium-gray; silty in part	2, 695–2, 733
Siltstone, medium-gray, slightly limy, and medium-gray shale	2, 733–2, 770
Shale, medium-gray, silty; siltstone in part	2, 770–2, 840
Siltstone, medium-light-gray, coarse-grained, very limy; crinoids and brachiopods	2, 840–2, 845
Siltstone, medium-gray to medium-light-gray, very finely micaceous, slightly limy; medium-gray shale beds	2, 845–2, 910
Shale and siltstone, medium-gray to medium-dark-gray; siltstone is finely micaceous, coarse grained, limy; white vein calcite locally	2, 910–3, 010
Sandstone, medium-light-gray, very fine grained, very limy, silty	3, 010–3, 020
Siltstone and shale, medium-gray; very limy in part; crinoids and a few brachiopods, especially at 3,020–3,030 and 3,065–3,075 ft	3, 020–3, 075
Shale, medium-gray	3, 075–3, 095

	Depth (feet)
Susquehanna Group—Continued	
Catskill Formation—Continued	
Zone A—Continued	
Siltstone and shale, medium-gray; very limy and finely micaceous in more silty part; crinoids and brachiopods in upper part; trace of pyrite at 3,178–3,186 ft	3,095–3,195
Siltstone, medium-light-gray, limy, finely micaceous; trace of very fine sand; medium-gray shale beds; crinoids and brachipods	3,195–3,222
Shale, medium-dark-gray; interbedded with medium-gray to medium-light-gray finely micaceous very limy siltstone; abundant crinoids and gastropods	3,222–3,240
Sandstone, medium-light-gray, very fine grained, finely micaceous, limy, silty; trace of fossils	3,240–3,250
Shale, medium-dark-gray	3,250–3,260
Siltstone, medium-light-gray, finely micaceous, limy	3,260–3,270
Shale, medium-dark-gray	3,270–3,283
Siltstone, medium-light-gray, finely sandy; interbedded with medium-gray shale; crinoidal in part	3,283–3,300
Shale, medium-dark-gray; interbedded with medium-gray finely micaceous slightly limy siltstone	3,300–3,324
Siltstone, medium-dark-gray, finely micaceous, slightly limy; trace of well-rounded medium quartz sand	3,324–3,330
Shale, medium-gray	3,330–3,340
Trimmers Rock Formation (1,907 ft):	
Upper zone:	
Sandstone, medium-light-gray, limy, silty, very fine to fine-grained; trace of medium to coarse grains	3,340–3,345
Sandstone (as above); many clear quartz granules in some beds; medium-gray shale and siltstone beds	3,345–3,370
Sandstone, medium-light-gray, fine-grained, slightly limy, micaceous; abundant coarse grains and granules of quartz in fine-grained matrix	3,370–3,375
Shale, medium-gray to medium-dark-gray; interbedded with slightly limy siltstone	3,375–3,390
Sandstone, medium-light-gray, fine-grained, finely micaceous, limy; abundant coarse grains and granules of quartz in fine-grained matrix	3,390–3,405
Sandstone, medium-light-gray, very fine grained; interbedded with medium-gray silty shale	3,405–3,415
Sandstone, medium-light-gray, very fine to fine-grained, finely micaceous, slightly limy, silty; some medium to coarse grains	3,415–3,423
Siltstone, medium-light-gray, finely micaceous, slightly limy, very finely sandy	3,423–3,433
Sandstone, medium-light-gray, fine- to coarse-grained, finely micaceous, slightly limy, silty; smaller grains are angular, larger grains subrounded; drills free in part	3,433–3,445
Sandstone, medium-light-gray, fine-grained, finely micaceous, slightly limy, silty; trace of medium grains; drills free	3,445–3,460

Susquehanna Group—Continued
Trimmers Rock Formation—Continued
Upper zone—Continued

	Depth (feet)
Siltstone, medium-gray, finely micaceous, slightly limy, silty, sandy; white vein calcite; quartz crystals; medium sand	3,460–3,465
Sandstone, medium-light-gray, very fine to medium-grained, finely micaceous, limy, silty; some coarse to very coarse sand; white crystals of vein calcite with quartz crystals attached; dark rock grains	3,465–3,500
Sandstone (as above), and medium-gray shale	3,500–3,518
Sandstone, medium-light-gray, fine-grained, micaceous, slightly limy, silty	3,518–3,530
Sandstone, light-gray, medium- to coarse-grained, limy; milky and clear quartz grains and granules; small quartz crystals and very fine to fine grains of dark rock in an otherwise clean quartz sand containing white calcite and quartz cement	3,530–3,562
Siltstone, medium-light-gray, limy, very finely micaceous, finely sandy	3,562–3,580
Sandstone, medium-gray, very fine to fine-grained, finely micaceous, slightly limy, silty	3,580–3,590
Shale, medium- to light-gray, slightly limy	3,590–3,598
Sandstone, light-gray, very fine to fine-grained, limy, clean; some subrounded medium grains; quartzite in part	3,598–3,608
Shale, medium-light-gray to greenish-gray, slightly limy; silty in lower part	3,608–3,625
Sandstone, light-gray, fine- to medium-grained, slightly limy, clean; many well-rounded grains	3,625–3,630
Shale, medium-light-gray, slightly limy, very finely micaceous	3,630–3,642
Sandstone, medium-gray, very fine grained, finely micaceous, very silty, slightly limy	3,642–3,654
Shale, medium-light-gray, slightly limy; slightly silty in part	3,654–3,665
Sandstone, medium-light-gray, very fine grained, micaceous, slightly limy, very silty; grades downward to light-gray slightly limy fine-grained sandstone	3,665–3,684
Shale, medium-light-gray, slightly limy; silty in part	3,684–3,691
Sandstone, medium-light-gray, fine-grained, slightly limy, silty; scattered coarse grains and granules of quartz	3,691–3,700
Sandstone, light-gray, medium- to coarse-grained, limy; many quartz granules; subrounded quartz grains; fine-grained dark rock fragments; medium-gray silty fine-grained matrix at 3,710–3,715 ft; light-gray quartzitic very coarse grained sandstone at 3,715–3,725 ft	3,700–3,725
Shale, medium-gray	3,725–3,732
Sandstone, medium-light-gray, very fine to fine-grained, very silty, slightly limy; less silty and slightly coarser in lower half	3,732–3,776

Susquehanna Group—Continued

Trimmers Rock Formation—Continued

Upper zone—Continued

	Depth (feet)
Shale, medium-light-gray, slightly limy; interbedded with finely micaceous siltstone	3,776–3,797
Sandstone, medium-gray, very fine to fine-grained, limy, silty	3,797–3,804
Shale, medium-gray, and medium-light-gray finely micaceous slightly limy very finely sandy siltstone; coarse-grained sandstone containing quartz granules at 3,815–3,816 ft	3,804–3,847
Sandstone, medium-light-gray, very fine grained, slightly micaceous, limy, silty; pyritized plants	3,847–3,865
Shale, medium-gray	3,865–3,868
Sandstone, medium-light-gray, very fine grained, micaceous, limy; trace pyrite	3,868–3,888
Sandstone, medium-light-gray, fine-grained, silty, slightly limy; very coarse grains and granules in some beds	3,888–3,912
Shale, medium-light-gray	3,912–3,920
Sandstone, light-gray, fine- to medium-grained, limy, poorly sorted; very coarse grains in upper part	3,920–3,932
Shale, medium-light-gray, finely micaceous, and medium-light-gray slightly limy siltstone	3,932–3,940
Siltstone, light-greenish-gray, limy, finely sandy; trace of medium to coarse quartz grains	3,940–3,950
Shale, medium-light-gray	3,950–3,960
Sandstone, light-gray, fine-grained, slightly silty; medium and coarse grained in lower half	3,960–3,975
Sandstone, medium-light-gray, fine-grained, micaceous, limy, silty	3,975–3,980
Siltstone, medium-light-gray, very finely micaceous, slightly limy; trace of very fine grained sandstone at 3,989–3,991 ft	3,980–3,995
Sandstone, medium-light-gray, fine-grained to very coarse grained, limy, silty, poorly sorted; clear and milky quartz granules	3,995–4,000

Middle zone:

Shale, medium-light-gray, slightly limy, and medium-light-gray, slightly limy siltstone	4,000–4,070
Siltstone, medium-light-gray, slightly limy; very finely sandy in part; crinoids at 4,080 ft	4,070–4,100
Sandstone, light-gray, very fine grained, micaceous, slightly limy, silty	4,100–4,110
Shale, medium-gray, micaceous, slightly limy; silty in part	4,110–4,120
Siltstone, medium-light-gray, micaceous, slightly limy; medium-gray shale beds	4,120–4,150
Sandstone, medium-gray, very fine grained, micaceous, slightly limy, very silty	4,150–4,158

	Depth (feet)
Susquehanna Group—Continued	
Trimmers Rock Formation—Continued	
Middle zone—Continued	
Siltstone, medium-light-gray, micaceous, slightly limy to limy; 40 percent medium-gray shale; pyritized plants at 4,305 ft	4, 158–4, 335
Sandstone, light-gray, very fine grained, finely micaceous	4, 335–4, 350
Lower zone:	
Siltstone, medium-gray, micaceous, limy; brachiopods and pyritized plants in upper part	4, 350–4, 365
Shale, medium-gray, finely micaceous; silty in part	4, 365–4, 373
Siltstone, medium-light-gray, micaceous, slightly limy; medium gray below 4,385 ft	4, 373–4, 445
Siltstone, medium-light-gray to medium-gray, finely micaceous, slightly limy; medium-gray shale beds	4, 445–4, 540
Siltstone, medium-light-gray, coarse-grained, finely micaceous, slightly limy	4, 540–4, 555
Siltstone, medium-gray, finely micaceous, slightly limy; 40 percent medium-gray shale	4, 555–4, 730
Shale, medium-gray, finely micaceous, slightly limy, silty	4, 730–4, 820
Siltstone, medium-gray to medium-light-gray, finely micaceous, slightly limy; 40 percent medium-gray shale	4, 820–4, 840
Shale, medium-gray, finely micaceous; silty in part	4, 840–4, 925
Siltstone, medium-gray to medium-light-gray, slightly micaceous, slightly limy to limy; nearly 50 percent medium-gray shale	4, 925–5, 005
Shale, medium-gray to medium-dark-gray; silty in part; trace of pyrite	5, 005–5, 105
Shale, medium-gray to medium-dark-gray, slightly limy to limy; silty in part; white vein calcite	5, 105–5, 185
Siltstone, medium-gray, finely micaceous, slightly limy to limy; vein calcite and fossil fragments; 10 percent medium-gray shale; trace of pyrite; crinoids in upper part. Base of Tully Limestone reported at 5,235 ft	5, 185–5, 235
Siltstone, medium-dark-gray, micaceous, limy	5, 235–5, 247
Hamilton Group:	
Mahantango Formation (1,373 ft):	
Shale, medium-dark-gray, slightly limy to limy; silty in part; trace of white vein calcite and pyrite; brachiopods at 5,340 ft	5, 247–5, 390
Shale, medium-gray to medium-dark-gray, limy; crinoids and brachiopods	5, 390–5, 455
Shale, medium-gray to medium-dark-gray, subfissile, slightly limy to limy; trace of pyrite; brachiopods at 5,475 and 5,580 ft; crinoids at 5,515, 5,535, and 5,560 ft	5, 455–5, 640
Shale, medium-dark-gray, very limy, very fossiliferous; crinoids and brachiopods. Limestone beds may be present in more fossiliferous part	5, 640–5, 675

	Depth (feet)
Hamilton Group—Continued	
Mahantang Formation—Continued	
Shale, medium-dark-gray, very limy; abundant crinoids	5, 675–5, 695
Shale, medium-dark-gray, finely micaceous, slightly silty, slightly limy to limy; trace of crinoids at 5,720 ft	5, 695–5, 735
Siltstone, medium-dark-gray, finely micaceous, limy; crinoids, white vein calcite and clear quartz crystals at 5,745–5,760 ft; brachiopods at 5,775 ft	5, 735–5, 790
Shale, medium-dark-gray, finely micaceous, slightly limy to limy; silty in part; pyrite; brachiopods at 5,830 ft	5, 790–5, 905
Shale, medium-dark-gray to dark-gray, finely micaceous, slightly limy to limy, silty; white vein calcite; pyrite; crinoids, in part pyritized, at 5,910 and 5,950 ft	5, 905–6, 000
Shale, medium-dark-gray, finely micaceous, very slightly limy to nonlimy, silty	6, 000–6, 165
Shale, medium-gray, finely micaceous, slightly limy to limy, silty; trace of pyrite	6, 165–6, 215
Shale, medium-gray to medium-dark-gray, slightly micaceous, very limy, very fossiliferous; brachiopods and crinoids	6, 215–6, 220
Shale, medium-dark-gray, finely micaceous, limy; very silty in part; trace of pyritic white vein calcite	6, 220–6, 235
Shale, medium-dark-gray, finely micaceous, slightly limy; trace of white vein calcite	6, 235–6, 300
Shale, medium-dark-gray, finely micaceous, slightly limy; subfissile in part; trace of pyrite and white vein calcite; unidentified fossil fragments—brachiopods(?)—in upper part	6, 300–6, 400
Shale, medium-dark-gray, finely micaceous, slightly limy; pyrite; unidentified markings in upper part—may be small calcite-filled worm tubes	6, 400–6, 425
Shale, dark-gray, finely micaceous, limy, silty; trace of white vein calcite	6, 425–6, 575
Shale, dark-gray, very finely micaceous	6, 575–6, 590
Shale, dark-gray, very finely micaceous, slightly limy, slightly silty, subfissile; thin white calcite veins	6, 590–6, 620
Marcellus Shale (790 ft):	
Shale, dark-gray to grayish-black, finely micaceous, slightly silty, slightly limy, subfissile; trace of white vein calcite; unit becomes less silty, less limy, and more fissile downward; a few thin-shelled pelecypods? at 6,635 ft	6, 620–6, 765
Shale, dark-gray to grayish-black, subfissile; white vein calcite and pyrite locally; faint impressions of thin-shelled pelecypods? at 6,860 ft	6, 765–6, 885
Shale, grayish-black, subfissile; finely crystalline pyrite; crinoids at 6,965 ft	6, 885–6, 985
Shale, dark-gray, silty, very pyritic	6, 985–7, 000
Shale, dark-gray to grayish-black, very finely micaceous; pyrite; pyritic calcite veins about 1 mm wide; tiny gastropod at 7,030 ft	7, 000–7, 106
Shale, grayish-black, very finely micaceous; tends to be softer and more sooty downward; white vein calcite	7, 106–7, 220

	Depth (feet)
Hamilton Group—Continued	
Marcellus Shale—Continued	
Shale, grayish-black, very finely micaceous, slightly limy; pyrite	7,220–7,255
Shale, grayish-black very finely micaceous, very limy; pyrite	7,255–7,272
Shale, medium-dark-gray, very finely micaceous, very limy; pyrite; very silty limestone beds at 7,323–7,327 ft	7,272–7,334
Shale, dark-gray to grayish-black, very finely micaceous, limy to very limy, subfissile; pyrite	7,334–7,410
Onondaga Limestone (315 ft):	
Limestone, medium-gray, very clayey, fine-grained (hardly separable from the associated very limy shale); pyrite; a few gastropods	7,410–7,424
Shale, grayish-black, finely micaceous, very limy	7,424–7,435
Limestone, medium-gray, very clayey, micaceous, fine-grained; insoluble residue of clay and very finely crystalline pyrite; trace of grayish-black chert	7,435–7,445
Shale, grayish-black, finely micaceous, very limy; pyrite	7,445–7,450
Limestone, medium-gray, clayey, silty, finely micaceous, fine-grained; trace of dark-gray limy chert; insoluble residue of coarse silt to clay; pyrite	7,450–7,460
Limestone, medium- to dark-gray, finely micaceous, silty, clayey, fine grained; 20 percent dark-gray slightly limy silty chert; insoluble residue of soft dark-gray silt and clay aggregate and chert; pyrite; light-gray nonlimy soft fine-grained homogeneous bentonite bed at 7,464 ft	7,460–7,475
No sample—gamma-ray and neutron curves suggest limestone similar to that above and below	7,475–7,490
Limestone, medium-dark-gray, slightly clayey, fine-grained; 10 percent dark-gray to brownish-gray silty chert; insoluble residue from much of the limestone is trace of clay; from a few beds, residue is silt; white vein calcite and clear quartz crystals; several layers of light-gray bentonite, some of which contain light-brown mica, at 7,512–7,517 and 7,521–7,525 ft	7,490–7,525
Limestone, medium-gray to medium-dark-gray, silty, fine-grained; 5 percent medium-gray slightly limy chert in some beds; insoluble residue of partly aggregated coarse silt	7,525–7,570
Limestone, medium-dark-gray, silty, fine-grained; relatively heavy insoluble residue of partly disaggregated coarse silt; limestone becomes slightly darker and more silty downward	7,570–7,620
Limestone, medium-dark-gray, silty, fine-grained; insoluble residue of silt aggregate	7,620–7,660
Limestone, medium-dark-gray, very silty, fine-grained; finely crystalline pyrite; insoluble residue of dark-gray silt aggregate; unit becomes more silty downward; very limy shale in part in lower 10 ft	7,660–7,692
Limestone, medium-gray, silty, fine-grained; insoluble residue of medium-light-gray silt aggregate; grades into the underlying strata	7,692–7,725

	Depth (feet)
Esopus Shale (467 ft):	
Shale, medium-dark-gray to dark-gray, very limy (may be nearly 50 percent calcite); slightly siliceous in lower part; insoluble residue of medium-light-gray silt aggregate; pyrite; brachiopods in lower part	7,725–7,760
Shale, medium-dark-gray, very limy; insoluble residue of medium-light-gray silt aggregate; pyrite; becomes less limy downward; grades into underlying unit	7,760–7,830
Shale, medium-dark-gray, limy; insoluble residue of medium-light-gray to dark-gray silt aggregate; pyrite; brachiopods at 7,840 and 7,880 ft	7,830–7,910
Shale, medium-dark-gray, slightly limy, pyrite; brachiopods at 7,935 and 8,030 ft	7,910–8,050
Shale, medium-dark-gray	8,050–8,155
Shale, dark-gray, finely micaceous, slightly limy	8,155–8,192
Oriskany Group:	
Shriver Chert (128 ft):	
Limestone, finely mottled light- and medium-gray, siliceous, cherty, fine-grained to finely crystalline; 30 percent light-brownish-gray translucent chert; insoluble residue of a coarse-grained siliceous silt—nearly chert in part and dark-gray silt aggregate in part	8,192–8,205
Limestone, medium-brownish-gray, silty, very cherty, fine-grained; nearly 50 percent brownish-gray conchoidal-fracturing limy subtranslucent chert—under water, rock shows small "cloudy" limy inclusions	8,205–8,210
Limestone, medium-gray to brownish-gray, silty, siliceous, fine-grained; insoluble residue of siliceous silt aggregate resembling chert; brachiopods	8,210–8,220
Chert, brownish-gray to dark-gray, silty, very limy, compact to fine-grained; subconchoidal fracture; medium-gray mottled siliceous limestone beds; insoluble residue of hard siliceous silt aggregate grades to dense chert	8,220–8,230
Chert (similar to unit above); grades downward to darker, more silty and shaly rocks	8,230–8,240
Limestone, dark-gray, very silty, very siliceous, fine-grained; dark-gray very limy shale beds at 8,255–8,260 and 8,275–8,285 ft; insoluble residue of dark-gray silt aggregate that is nearly chert in part; grades downward to very limy shale of underlying unit; brachiopods	8,240–8,320
Helderberg Group:	
Port Ewen Limestone equivalent (179 ft):	
Shale, grayish-black, finely micaceous, very limy; trace of pyrite at 8,420 ft; gastropods at 8,426 ft	8,320–8,430
Siltstone, medium-gray, very limy, hard	8,430–8,440
Shale, grayish-black, finely micaceous, limy	8,440–8,475
Siltstone, dark-gray, finely micaceous, limy; grades to silty shale; finely crystalline pyrite	8,475–8,499
Becraft Limestone (18 ft):	
Limestone, medium- to dark-gray, finely micaceous, very silty, fine-grained; interbedded with dark-gray very limy shale in lower part; pyrite; very fossiliferous—crinoids, brachiopods, bryozoans?, ostracodes	8,499–8,517

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Helderberg Group—Continued	*Depth (feet)*
New Scotland Limestone equivalent (66 ft):	
Shale, dark-gray, finely micaceous, very limy; silty in part; trace of thinly bedded very silty limestone in lower part; trace of pyrite; ostracodes	8, 517–8, 583
Kalkberg Limestone (35 ft):	
Limestone, medium-gray to medium-light-gray, very silty, fine-grained; 5 percent medium-gray to light-brownish-gray dense chert; insoluble residue of medium-light-gray siliceous silt aggregate; pyrite; ostracodes and brachiopods	8, 583–8, 618
Total depth	8, 618

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