Geology and Oil and Gas Possibilities of Upper Mississippian Rocks of Southwestern Virginia Southern West Virginia and Eastern Kentucky

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GEOLOGICAL SURVEY BULLETIN 1072-K

Prepared in cooperation with the Division of Geology of the Virginia Department of Conservation and Development

Geology and Oil and Gas Possibilities of Upper Mississippian Rocks of Southwestern Virginia Southern West Virginia and Eastern Kentucky

By RALPH H. WILPOLT *and* DOUGLAS W. MARDEN

CONTRIBUTIONS TO ECONOMIC GEOLOGY

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By Ralph H. Wilpolt and Douglas W. Marden

ABSTRACT

The stratigraphy of the gas-producing formations of Late Mississippian age in southwestern Virginia and adjacent parts of southern West Virginia and eastern Kentucky was studied by measuring in detail surface sections exposed along a generally northeast line from Cumberland Gap, in Virginia, to Bluefield, W. Va., and along a roughly parallel line 15 to 25 miles to the northwest from Pineville, Ky., to Blowing Rock Gap, in Kentucky. The surface studies were supplemented by examination of samples from wells drilled for oil and gas. The rocks studied range from the top of the Maccrady shale to the base of the Pottsville formation, and include, from oldest to youngest, the Greenbrier limestone, the Bluefield formation, the Hinton formation, the Princeton sandstone, and the Bluestone formation. The stratigraphic classification used differs somewhat from previous classifications of these rocks, as is shown by a correlation chart. The formations all thicken from northwest to southeast toward the Appalachian geosyncline. The Greenbrier limestone, chiefly limestone and dolomite with some calcareous mudstone, ranges from 250 to 848 feet in thickness; the Bluefield formation, principally calcareous shale with some limestone, siltstone, and sandstone, from 191 to about 1,950 feet; the Hinton formation, principally red shale and siltstone but with a sandstone and limestone member and locally thin coal beds, from 288 to 1,683 feet; the Princeton sandstone, from 0 to 240 feet; and the Bluestone formation of interbedded shale, mudstone, siltstone, sandstone, limestone, and thin coal beds, from 300 to 1,015 feet. This sequence of formations contains several gas-producing sands; possibilities for gas production are believed to be excellent in the part of the area in which rocks of the Pottsville formation are present at the surface. Further production should be obtained from the Greenbrier limestone, from beds in the Bluefield and Hinton formations (the several Maxton sands of drillers), and the Princeton sandstone (Ravencliff sand of drillers). Data on drilled wells which were started before December 1948 are included in the report.

INTRODUCTION

PURPOSE OF REPORT

Since the discovery in January 1948 of gas in commercial quantities in rocks of Mississippian age in Buchanan County, Va.,

additional wells have been completed successfully in Buchanan and Dickenson Counties. A study of the stratigraphy of the Upper Mississippian rocks of southwestern Virginia was undertaken as a cooperative project by the Division of Geology of the Virginia Department of Conservation and Development and the U.S. Geological Survey in order to gain more complete and accurate knowledge of the stratigraphy of these rocks for use as a guide in the search for oil and gas. The results of stratigraphic fieldwork during the latter half of 1948 and of studies of subsurface stratigraphy during the first half of 1949 are summarized herein. A preliminary report (Wilpolt and Marden, 1949) and a list including some of the wells studied for this report (Huddle and others, 1956) have been published; detailed well logs (Huddle and others, 1955) and measured sections (Wilpolt and Marden, 1955) have been released for public inspection.

LOCATION OF AREA

The greater part of the area described in this report is in the extreme southwestern part of Virginia and includes parts of Lee, Scott, Wise, Russell, Dickenson, Buchanan, and Tazewell Counties. In order to understand the stratigraphic problems involved, it was necessary to include the adjacent part of West Virginia and the outcrops of Upper Mississippian strata along Pine Mountain, Ky. (pl. 27). The area is well traversed by State and Federal highways and by railroads.

FIELD AND LABORATORY WORK

Surface sections were measured along the northwesternmost ridges of the folded Appalachians from Cumberland Gap, Virginia, to a few miles northeast of Bluefield, in West Virginia, and along the northwestern slope of Pine Mountain in Kentucky (pl. 27). The sections were measured in gaps along both flanks of the Powell anticline and within its rim. Wherever suitable road- or railroad-cuts were present, sections were also measured northeastward adjacent to the numerous northwestern border faults of the folded Appalachians. All well-exposed surface sections were measured. Subsurface information from wells drilled in the area between the lines of surface control is shown in plates 28 and 29. The location of the surface sections and wells are shown on plate 27; other data related to the sections and wells are presented in table 1, and detailed descriptions of sections 5, 7, 8, 13, and 15 are given on p. 622–651.

The surface sections were measured by using a tape and a Brunton compass, and thicknesses of all large covered intervals were determined with a plane table and a telescopic alidade. All drill cuttings available for study were examined through a binocular microscope.

SCOPE OF REPORT

This report discusses the character and oil and gas possibilities of the Upper Mississippian sedimentary rocks which lie between the top of the Maccrady shale and the base of the Pottsville formation of Pennsylvania age. These rocks consist, in ascending order, of the Greenbrier limestone, the Bluefield formation, the Hinton formation, the Princeton sandstone, and the Bluestone formation. A brief discussion of the sedimentary history is also included.

ACKNOWLEDGMENTS

The writers appreciate the cooperation of the officials and the geological staffs of several companies that furnished well samples, sample logs, and other data. These companies and individuals are: Bell-Knox Pipeline Co., Inc., M. D. Voorhees, drilling superintendent; Clinchfield Coal Co., A. R. Matthews, president, R. H. Hughes, chief engineer, E. D. Hilton, engineer; Columbian Carbon Co. and Columbian Fuels Corp., A. Y. Barney, geologist; Godfrey L. Cabot, Inc., Harvey Simmons, general superintendent, J. E. Walker; Peoples Natural Gas Co. (Hope Natural Gas Co.), Fenton H. Finn, system geologist, G. C. Borland, geologist; Pipe Line Construction and Drilling Co., Byron Finch; United Fuel Gas Co., W. B. Maxwell, chief geologist; United Producing Co., Inc., E. C. Stanton, chief geologist; Virginia Coal and Iron Co., W. Rodgers Moore, chief engineer.

Appreciation is expressed to Eloise Little Jacobsen, Mary Beth McFarlan, Philip T. Stafford, and William A. Heck for data based on numerous sample studies made by them.

PREVIOUS WORK

The stratigraphy of the Upper Mississippian rocks of southwestern Virginia has been discussed briefly in county coal reports of the Virginia Geological Survey by Eby (1923a, p. 56–62), Giles (1921, p. 9–10; 1925, p. 16–20), Harnsberger (1919, p. 10–14), Hinds (1918, p. 9, 10), and Wentworth (1922, p. 10). Cooper (1944, p. 154–187) mapped the Burkes Garden quadrangle in which the strata described in this report are well exposed. Butts (1933, p. 32–46; 1940, p. 355–407) includes discussions of the Upper Mississippian strata and Reger (1926, p. 291–491) studied in detail the Upper Mississippian rocks in southern West Virginia. A general discussion of the oil and gas possibilities of the part of southwestern Virginia included in this study is contained in reports by Eby (1923a, p. 578–583; 1923b, pl. 37), Giles (1927, p. 819–823), and McGill (1936).

GENERAL GEOLOGIC STRUCTURE

The principal structural feature of the area is the Cumberland overthrust block, which is the result of movement from southeast to northwest along the Pine Mountain fault. The Pine Mountain fault limits the block on the northwest, the Russell Fork fault on the northeast, and the St. Paul fault on the southeast (pl. 27). The general structure of that part of the block northwest of the Powell anticline is a syncline which is called the Middlesboro syncline. Rocks of Pennsylvanian age occupy a strip from 10 to 25 miles wide in the Cumberland overthrust block. The details and tectonics of the Cumberland overthrust block are discussed by Butts (1927a), Miller and Fuller (1947), and Miller and Brosgé (1950); they are also described in the county coal reports of southwestern Virginia published by the Virginia Geological Survey. Northeast of the area where the Russell Fork and St. Paul faults nearly join there are numerous thrust faults of the Appalachian type. Farther northeast are several major folds which follow the Appalachian trend, the Abbs Valley and the Dry Fork anticlines, and the Hurricane Ridge syncline. The southeast flank of the syncline is overturned toward the northwest. Southeast of the St. Paul fault is the Greendale syncline. The general structural features of the area are indicated on the index map (pl. 27).

In general the regional dip of the surface rocks (the coal measures of Pottsville age) north of the Russell Fork fault is toward the northwest in Buchanan County, Va., and McDowell and Wyoming Counties, W. Va., but the structure contours indicate that over a large part of these counties the underlying Mississippian strata rise northwestward in altitude (figs. 24, 25).

STRATIGRAPHY

The rocks between the Maccrady shale of Mississippian age and the Pottsville formation of Pennsylvanian age herein designated as Greenbrier limestone, Bluefield formation, Hinton formation, Princeton sandstone, and Bluestone formation, have been referred to by various workers in southwestern Virginia as the Newman limestone and the Pennington shale (fig. 26). The type locality of the Newman limestone is in Newman Ridge, Hancock County, Tenn. (Wilmarth, 1938, p. 1486). The lower solid-limestone part of the Newman limestone is equivalent to the Big Lime of the drillers in Virginia, West Virginia, and Kentucky; it is also equivalent to the Greenbrier series as used by Reger (1926, p. 445–491) in southern West Virginia. The name Pennington shale was first applied by Campbell (1893, p. 28, 37) to strata at Pennington Gap, in Virginia, between the Newman limestone and Pottsville formation. The Pennington

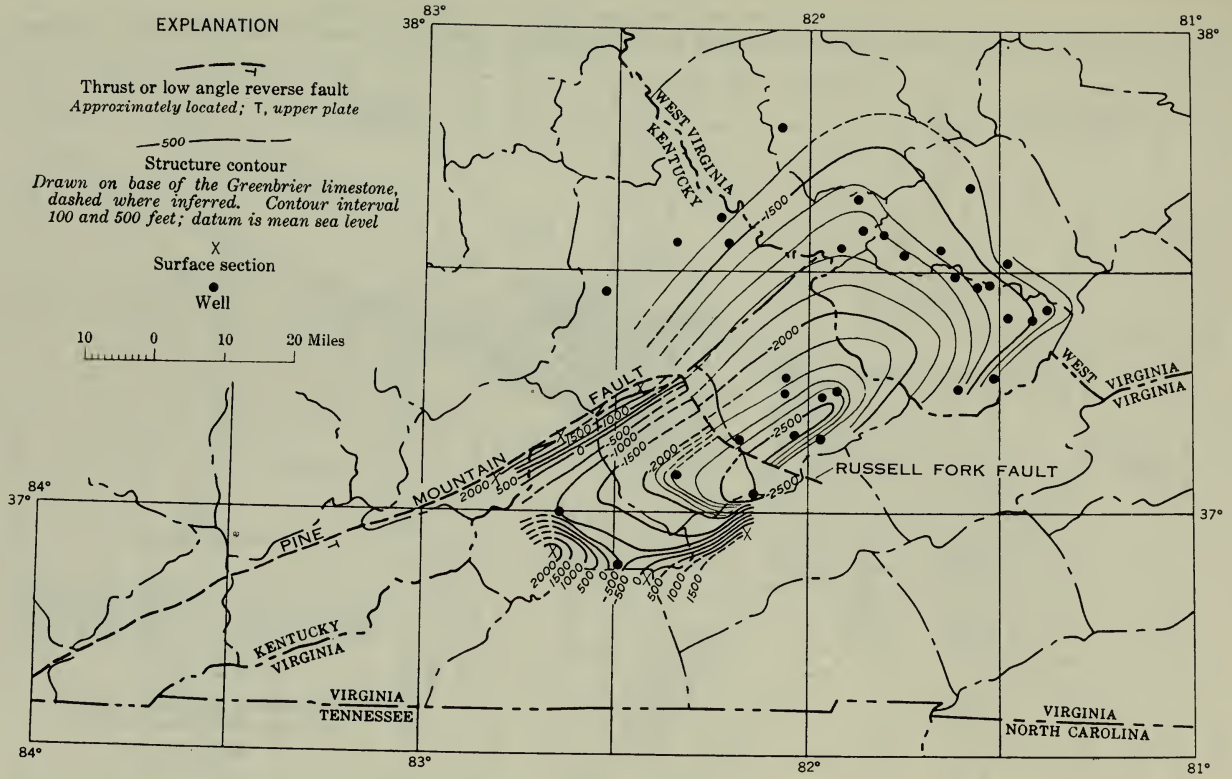

FIGURE 24.—Generalized structure map of southwestern Virginia, southern West Virginia, and eastern Kentucky. Contours drawn on base of Greenbrier limestone.

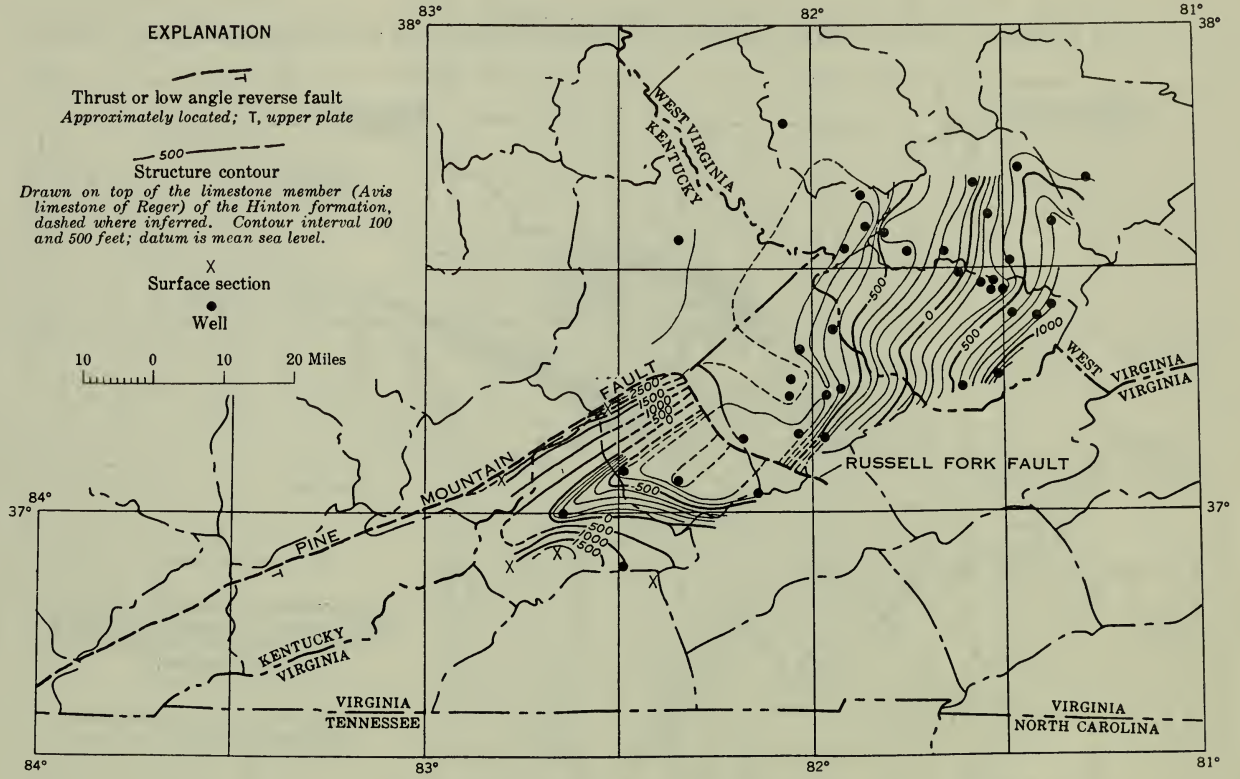

FIGURE 25.—Generalized structure map of southwestern Virginia, southern West Virginia, and eastern Kentucky drawn on top of the limestone member of Hinton formation (Avis limestone of Reger).

was raised to group status by Harris and Miller (1958); it includes the Hinton, Princeton, and Bluestone formations.

In southern West Virginia the lower limestone part (Big Lime) of the Newman limestone is equivalent to the Greenbrier series as used by Reger (1926, p. 445–491); the Mauch Chunk series as used by Reger (1926, p. 291–444) is equivalent to the Pennington formation and the upper part (Glen Dean) of the Newman limestone of southwestern Virginia according to Butts (1933, 1940). A correlation chart showing the classification of stratigraphic nomenclature used in this report and the nomenclature which has been in use for formations in southwestern Virginia, southern West Virginia, and eastern Kentucky is given in figure 26.

The stratigraphic information obtained from the study of the surface sections and well samples is presented in the lines of graphic sections (pls. 28, 29).

GREENBRIER LIMESTONE

Name.—As previously stated, the rocks called the Greenbrier limestone in this report have been referred to as the Greenbrier series by other writers. The name "Greenbrier series" has been used for a predominantly calcareous sequence of rocks in West Virginia (Reger, 1926, p. 445), but it is not clear by whom the term was first used. The name was derived from the Greenbrier River in southern West Virginia (Wilmarth, 1938, p. 867).

Distribution.—The Greenbrier limestone is easily traced from Cumberland Gap (sec. 1, pl. 28) northeastward along the northwest flank of the Powell anticline to Little Stone Gap (sec. 13, pl. 28), where the outcrop curves around the nose of the anticline. From Little Stone Gap to the St. Paul fault, the Greenbrier crops out along the southeast flank of the anticline and commonly forms a resistant escarpment within the rim of the Powell anticline. Northeastward to the Hurricane Ridge syncline the Greenbrier is discontinuous, for it has been faulted out in places along the St. Paul and other thrust faults. This limestone sequence is preserved in the Greendale syncline area and in the Hurricane Ridge syncline. The Greenbrier limestone also crops out along the northwest slope of Pine Mountain in Kentucky from southwest of Pineville northeastward to the "Breaks of the Sandy" in southern Pike County and in Virginia in northeastern Dickenson County. In the subsurface of the area studied it is present wherever rocks of Pennsylvanian age cover the surface.

Lithology.—The Greenbrier limestone consists of a thick sequence of dense and crystalline, highly fossiliferous, locally cherty limestone which generally ranges in color from gray to brownish gray to black. These beds are normally thick bedded but are relatively

thin bedded near the top of the formation. Mottled red and green beds of limestone, calcareous mudstone, and small amounts of gray shale are present. Crossbedded oolitic and clastic limestones are abundant. Some disconformities are present locally within this large mass of limestone. There is a dolomitic zone near the base in many of the surface sections and wells. This zone, from which gas is produced in several fields in southern West Virginia, was described by Martens and Hoskins (1948). The thickness of the Greenbrier ranges from 250 feet at Pineville (sec. 2, pl. 28) to 848 feet at Bishop-Stony Ridge, Virginia (sec. 46, pls. 28, 29).

Commercial accumulations of gas occur sporadically in the zones of crossbedded oolitic and clastic limestone in the Greenbrier limestone. Rittenhouse (1949) made a petrologic study of these zones in West Virginia and found that they were composed of quartz sand, lime sand, and oolites in varying proportions. He suggested that the clastic textures indicate that these zones in the Greenbrier were deposited in the same manner as quartz sands normally are and thus represent near-shore deposits, such as old beaches, bars, dunes, or river channels, which should have definite recognizable trends. Rittenhouse's studies of the relative percentages of quartz sand and oolites or lime sand indicate two or more sources of sediments to the north of northern West Virginia.

Members.—Two members of the Greenbrier limestone, the Hillsdale member and the Taggard red member, are differentiated in the graphic sections (pls. 28, 29) wherever they could be recognized. The main body of the Greenbrier limestone is undifferentiated in this report.

The Hillsdale member of the Greenbrier was named the Hillsdale limestone and given formational rank by Reger (1926, p. 476–480). The Hillsdale member consists of dark-gray, grayish-black to black cherty limestone. The chert is black, brown, red, and gray and is present in the form of irregular nodules, stringers, beds, and fossil replacements. Chert fossil specimens of lithostrotionoid corals are abundant. This member is identifiable in the surface exposures over most of the area studied but is absent to the northeast along Pine Mountain (pl. 28).

In this report the Taggard red member of the Greenbrier limestone includes the three lithologic units, a lower and an upper shale with an intervening limestone, to which Reger (1926, p. 476–480) applied the term Taggard. The Taggard red member consists of maroon-red and green dense limestone, calcareous mudstone which often breaks with a conchoidal fracture, and some oolitic and clastic beds. It ranges in thickness from 3 to 50 feet and is normally from 50 to 100 feet above the Hillsdale member of the Greenbrier. This member was

relatively easy to identify where exposed but very difficult where unexposed.

Age and correlation.—Butts (1933, p. 38–42) divided the limestone sequence herein referred to as the Greenbrier limestone into the limestone of Warsaw age, the St. Louis limestone, the Ste. Genevieve limestone, and the Gasper limestone in ascending order. These formations constitute the lower solid-limestone part of the Newman limestone (Butts, 1933, p. 40), the upper beds of the Newman being assigned by Butts to the Glen Dean limestone (Bluefield formation of this report).

The limestone of Warsaw age contains *Spirifer bifurcatus* Hall, *Polypora varsoviensis* Prout, and *Fenestralia sancti-ludovici* Prout, all considered by Butts (1933, p. 39) as fairly distinctive Warsaw fossils. A buff to gray, sometimes greenish-buff, locally dolomitic, thin- to medium-bedded sequence of impure limestone, which sometimes contains small amounts of white anhydrite and which ranges in thickness from a few feet to 60 feet, crops out at the base of the Greenbrier limestone. These beds probably represent Butts' limestone of Warsaw age, but they were not differentiated in the graphic sections (pls. 28, 29). Averitt (1941, p. 17–21) referred to these strata as the Little Valley limestone.

The Hillsdale member of the Greenbrier limestone (St. Louis limestone of Butts) is considered to be of St. Louis age because of the presence of the guide fossils *Lithostrotionella "canadensis"* (Castelnau) and *L. prolifera* (Hall) (Butts, 1940, p. 359).

Butts (1933, p. 40) subdivided the main body of the Greenbrier limestone which lies above the Hillsdale member into the Ste. Genevieve limestone and the overlying Gasper limestone. He considered that the Ste. Genevieve was well marked throughout Virginia by its guide fossil *Platycrinus huntsvillae* Troost [= *P. penicillus* Meek and Worthen]; he thus correlated this part of the Big Lime with the Ste. Genevieve of the Mississippi Valley section. He differentiated the Gasper limestone on the basis of species of *Talarocrinus*, *Pterotocrinus serratus* Weller, and *Pentremites godoni* (Defrance), which are characteristic of the Gasper in its type area in central Kentucky (Butts, 1933, p. 41). The reader is referred to Butts (1940) for relatively complete lists of the fossils found in his limestone of Warsaw age, St. Louis limestone, Ste. Genevieve limestone, and Gasper limestone; all these units are included in the Greenbrier limestone of this report.

The part of the Greenbrier limestone below the Gasper limestone of Butts is believed to be of the age of the Meramec group; the Gasper limestone of Butts is probably early Chester in age (Weller and others, 1948).

Stratigraphic relations.—The Greenbrier limestone rests disconformably on the Maccrady shale of Osage age (Butts, 1933, p. 354), which consists of red, green, and gray shale, siltstone, fine to very fine grained sandstone, and, in the subsurface, some anhydrite. No attempt was made to study the Maccrady in detail. The red clastics of the Maccrady are helpful in locating the base of the Greenbrier limestone in the subsurface. The Greenbrier is overlain apparently conformably by the Bluefield formation.

BLUEFIELD FORMATION

Name.—The Bluefield formation was named the Bluefield shale by Campbell (1896) from exposures at Bluefield, W. Va. In this report, the Bluefield is referred to as a formation because of the heterogeneous character of its rocks. Reger (1926, p. 304) classified the Bluefield as a group for the same reason.

Distribution.—Except where it has been eliminated by faulting, the Bluefield formation is easily traced along the two lines of surface control from Cumberland Gap to the vicinity of Bluefield, and along Pine Mountain (pl. 28). Owing to its nonresistant character, good surface exposures are rare. It is present in the subsurface of the entire area.

Lithology.—The Bluefield formation consists principally of calcareous shale, with some limestone, siltstone, and sandstone. It also contains a few thin impure lenticular coal beds in southern West Virginia (well 51, pl. 29). In a fresh exposure the shale beds are usually bluish gray and yellowish green, but upon weathering they become yellow, brown, and olve drab and lose their calcareous content by leaching. In the northeastern part of the area studied there are some red shale beds in the upper half of the formation.

The formation also contains several brownish-gray impure shaly limestone beds, some of which are oolitic and clastic. One of these beds, the Little Lime unit of the drillers, is present in many localities from 50 to 200 feet above the top of the Greenbrier limestone; it is particularly resistant to weathering on the surface, thus forming small hogbacks wherever the rocks are tilted. The softer shaly beds between the Little Lime and the top of the Greenbrier limestone (Big Lime) are called the Pencil Cave by drillers.

The sandstone beds in the Bluefield formation are mostly white to buff, thin bedded, ripple marked, shaly, locally calcareous, and impure. Lithologically they are similar to the sandstones of the Hinton and Bluestone formations. Two of these sandstone beds in the Bluefield, which cannot be correlated over great distances, have been called collectively the lower Maxton sands by subsurface workers and drillers; they have been differentiated in the graphic sections wher-

ever possible. Some of these sandstones probably change laterally to finer grained clastics such as siltstone and shale, thus making correlation difficult.

The Bluefield formation ranges in thickness from 191 feet on Pine Mountain near Whitesburg, Ky. (section 11, pl. 28), to about 1,950 feet 3 miles northeast of Bluefield (section 50, pls. 28, 29). The beds in the lower half of the Bluefield are in part similar in lithologic characteristics to the underlying Greenbrier limestone, but the rocks in the upper half are more similar to the overlying Hinton formation. Apparently the Bluefield represents a transitional zone between the Greenbrier limestone and the Hinton formation.

Age and correlation.—Butts (1940, p. 382), recognizing that in different areas the Bluefield shale, Glen Dean limestone, and Cove Creek limestone occupy about the same stratigraphic position, considered them to be different facies of the same unit. The Glen Dean limestone was named by Butts (1917, p. 97) from Glen Dean, Breckinridge County, Ky. The Cove Creek limestone was also named by Butts (1927b, p. 16) from Cove Creek in the Greendale syncline, Scott County, Va., 5 miles southwest of Mendota. The Glen Dean and Cove Creek formations of Butts are lumped with the Bluefield in this report (fig. 26). The Bluefield formation is probably of early Chester age.

The Bluefield formation is moderately fossiliferous with fenestellid bryozoans, *Pentremites*, and brachiopods being especially abundant. The guide fossils of the Glen Dean facies are *Pentremites godoni abbreviatus* Hambach [= *P. brevis* Ulrich], *P. elegans* Lyon [= *P. canalis* Ulrich], *P. pyramidatus* Ulrich, *Pterotocrinus spatulatus* Wetherby, and *Prismopora serrulata* Ulrich (Butts, 1933, p. 41). Lists of the fossils identified from the Bluefield formation and its correlatives are given by Butts (1940, p. 391, 392) and Cooper (1944, p. 171, 172).

Stratigraphic relations.—The lower contact of the Bluefield formation is usually clearly defined, but locally it may be slightly transitional. There may have been a hiatus at the upper contact with the Stony Gap sandstone member of the Hinton formation, for the Bluefield is often slightly channeled by this sandstone. In general, it is relatively easy to determine the lower and upper contact on the surface and in the subsurface.

PENNINGTON GROUP

The name Pennington was first applied by Campbell (1893) to the 1,025 feet of red and green shale with beds of sandstone which overlies the Newman limestone and underlies the Pottsville formation. Cooper (1944, p. 172–180) considered the Pennington the equivalent

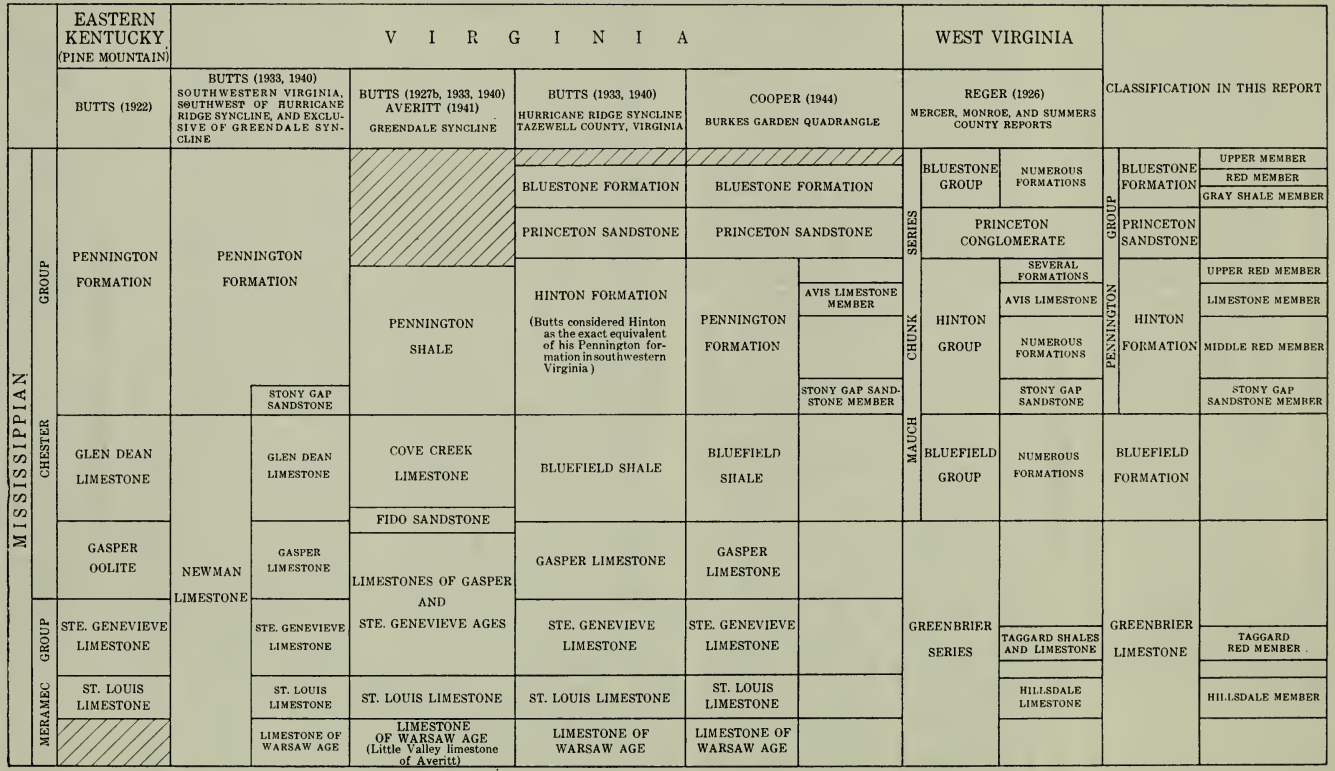

FIGURE 26.—Correlation chart.

of the Hinton formation. The Pennington has been raised to group status by Harris and Miller (1958) to include the Hinton formation, the Princeton sandstone, and the Bluestone formation, the same stratigraphic sequence as defined by Campbell.

HINTON FORMATION

Name.—Campbell (1896) named the Hinton formation from exposures in the New River gorge near Hinton, Summers County, W. Va. Reger (1926, p. 304) referred to the same sequence of strata as the Hinton group. The Hinton formation is identical with the Pennington formation as used by Cooper (1944) and with the lower half of the Pennington formation of southwestern Virginia as originally defined by Campbell in 1896 (fig. 26).

Distribution.—The Hinton formation was traced in surface exposures (pl. 28) from Pennington Gap (sec. 7) northeastward to Princeton, W. Va. (sec. 50), and from Hurricane Gap, in Kentucky (sec. 8), northeastward along Pine Mountain to Blowing Rock Gap (sec. 23). It is identifiable in the subsurface between these two lines of surface control, but the formation cannot be recognized with certainty to the west and southwest. Where it could not be recognized, it is included with the Bluestone formation in the geologic sections.

Lithology.—In general the Hinton formation is characterized by red shale and siltstone although much sandstone, limestone, and dolomite are also present; thin impure coal beds are present locally. The Hinton (pl. 28) ranges in thickness from 288 feet at Hurricane Gap (sec. 8) to 1,683 feet in the Burkes Garden quadrangle (sec. 49).

Members.—In this report the Hinton formation has been divided into four members, the Stony Gap sandstone member at the base, the middle red member, the limestone member (Avis limestone of Reger), and the upper red member at the top.

The Stony Gap sandstone was named by Reger (1926, p. 372) from Stony Gap, Mercer County, W. Va.; it consists chiefly of buff to white fine-grained subangular crossbedded sandstone with some intercalations of shale and siltstone and local beds of coal. It is resistant and caps ridges and hogbacks. It was possible to identify the Stony Gap sandstone member (pl. 28) from Pennington Gap (sec. 7) to Princeton (sec. 50) and from Pineville (sec. 2) northeastward on Pine Mountain to Osborn Gap (sec. 17). It is present in the subsurface of the entire area. From the Buffalo Mountain section (sec. 28) northeastward to the Burkes Garden quadrangle (sec. 49) the Stony Gap departs from its resistant character and becomes slabby, thin and wavy bedded, and nonresistant, and contains several beds of shale. In this northeastern area it is more

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difficult to recognize the Stony Gap in the subsurface. At Stony Ridge, a prominent topographic feature near Bluefield, it again is thicker bedded and resistant. The Stony Gap sandstone member corresponds to the middle Maxton sand of subsurface workers and drillers. It is an important gas-producing strata in northeastern Kentucky and southern West Virginia and also has gas-producing potentialities in southwestern Virginia.

The middle red member of the Hinton formation is composed chiefly of red silty shale interbedded with thin beds of sandstone, siltstone, impure limestone, and dolomite. It also contains several sandstone units which are similar in character to the Stony Gap sandstone member of the Hinton and which can be correlated over small areas in the subsurface. These sandstone units have been called collectively the upper Maxton sands by the drillers. The shale is locally calcareous. Because of the large amount of red sediments which make up the main body, the middle red member is one of the most distinctive stratigraphic units studied. It thickens gradually from southwest, west, and northwest toward northeastern Tazewell County, Va., and southwestern Mercer County, W. Va. (pls. 28, 29).

The limestone member (Avis limestone of Reger) of the Hinton formation consists of dark calcareous shale or gray to brownish-gray, highly fossiliferous, impure shaly limestone. The term Avis was first used for this unit by Reger (1926, p. 296, 347) for rocks near Avis and Hinton, Summers County, W. Va. The fossils consist of numerous bryozoans, dwarfed brachiopods and pelecypods, and crinoids. *Reticulariina spinosa* (Norwood and Pratten), *Composita subquadrata* (Hall), *Spirifer increbescens* Hall, *Stenopora* sp., *Archimedes* sp., and *Schuchertella ruginosa* (Hall and Clarke) have been identified from these beds (Cooper, 1944, p. 175).

The limestone member of the Hinton formation is often leached of its calcareous content on the surface and weathers to an olive-drab clay residuum. The limestone member is present throughout most of the area; however, it can be identified only with great difficulty in the subsurface of eastern Kentucky and of the area northwest of McDowell and Wyoming Counties, W. Va. It is composed of red, brown, and gray calcareous shale and limestone in wells 64, 65, and 66 (pl. 29). Locally, as in the Whitesburg section (sec. 11, pl. 28), the limestone member appears to have been reworked into the basal bed of the Princeton sandstone. The Princeton outcrop in this locality has a cellular texture caused by the leaching of fossils and fragments of limestone which were included in the sandstone. The limestone member of the Hinton was used as a stratigraphic datum to aline most of the surface sections and wells in the lines of graphic sections (pls. 28, 29).

The upper red member of the Hinton formation consists of red, greenish-gray, and gray shale which locally may be calcareous. It also contains several nonpersistent lenticular beds of sandstone and siltstone. This member is similar lithologically to the middle red member of the Hinton formation. The thickness ranges from a few inches to 485 feet, the maximum development being attained in the northeastern half of Tazewell County, Va., and in southwestern Mercer County, W. Va. (pl. 29). Rapid thinning takes place to the southwest, west, and northwest.

Age and correlation.—The Hinton formation is thought to be late Chester in age. Cooper (1944, p. 180) records *Sulcatopinna missouriensis* (Swallow) in shale a few feet above the limestone member of the Hinton in an exposure opposite the railroad station at Falls Mills, Va. This species is especially characteristic of the Menard and Clore limestones of southern Illinois and western Kentucky (Butts, 1940, p. 401).

Stratigraphic relations.—As mentioned previously, the basal contact of the Hinton formation (base of Stony Gap sandstone member) may represent a hiatus. The top contact may also represent a hiatus, because the upper red member of the Hinton formation is wedgelike and is absent over much of the area, although in any individual exposure the strata appear to represent an uninterrupted sequence of deposition.

PRINCETON SANDSTONE

Name.—The Princeton sandstone of this report was named the Princeton conglomerate by Campbell and Mendenhall (1896, p. 487, 489) from Princeton, Mercer County, W. Va.

Distribution.—On the southeastern belt of outcrop the Princeton sandstone is recognizable from Pennington Gap northeastward into southern West Virginia, but along Pine Mountain it is recognizable with certainty at only two localities at Hurricane Gap and Whitesburg (sec. 8 and 11, pl. 28). Apparently there is a change in lithologic character to siltstone and shale northwestward from the southeastern belt of outcrop (pl. 28).

Lithology.—The Princeton sandstone is composed chiefly of white quartzose crossbedded massive sandstone, normally made up of rounded medium grains; some fine- and coarse-grained and conglomeratic zones are present. The grains are cemented by calcium carbonate or silica, and the cementing agent changes both vertically and laterally in the sandstone. Some gray shale, gray to red shale, limestone, and coal are also included. On the surface the Princeton usually forms steep cliffs, cuestas, or hogbacks, depending on the dip of the beds. The sandstone ranges in thickness from a few inches to 240 feet.

Age and correlation.—According to Butts (1940, p. 402) the presence of a few fragments of fossil plants in the Princeton sandstone suggest that it is of Late Mississippian (Chester) age. The gas-producing Ravencliff sand of drillers in southern West Virginia and southwestern Virginia is considered in this report to be equivalent to the Princeton sandstone of the surface.

Stratigraphic relations.—In individual surface exposures the Princeton sandstone appears to be conformable with the underlying rocks; regionally, however, a hundred feet of underlying beds may have been eroded before the Princeton was deposited. The upper contact is apparently conformable.

BLUESTONE FORMATION

Name.—Campbell (1896, p. 3) named the Bluestone formation for exposures along the Bluestone River in Mercer County, W. Va. Reger (1926, p. 304) classified these rocks as the Bluestone group.

Distribution.—In most of the area the Bluestone formation can be differentiated; however, it was impossible to recognize this formation in Virginia and Kentucky southwest of a line connecting the Pennington Gap and the Hurricane Gap sections (line *D–D'*, pl. 27), in eastern Kentucky, and in West Virginia northwest of southeastern Mingo County.

Lithology.—The Bluestone formation consists of interbedded shale, mudstone, siltstone, sandstone, and limestone; it contains more thin impure coal beds than the other formations described. It ranges in thickness from 300 feet on Pine Mountain at Hurricane Gap (sec. 8, pl. 28) to 1,015 feet at Rock, W. Va. (sec. 52, pl. 29).

Members.—The Bluestone formation is divided, in ascending order, into the gray shale member, the red member, and the upper member.

The gray shale member of the Bluestone formation consists of gray and black shale which contains some beds of siltstone, sandstone, red shale, and limestone. The shale is very calcareous; locally it is carbonaceous. Sandstone, sometimes conglomeratic, makes up a large part of the member, especially in the upper half (pl. 28). The gray shale member can be identified over much of the area, but good surface exposures are uncommon because of the nonresistant character of the shale. It is not identifiable to the west in the subsurface.

The red member of the Bluestone formation is composed chiefly of locally calcareous red shale with some siltstone, small amounts of calcareous sandstone, and lenticular beds of limestone. It can be traced over much of the area but loses its identity to the west.

The upper member of the Bluestone formation consists principally of beds of white, gray, and greenish-gray sandstone which in many

places weather slightly greenish. The sandstone is usually medium and coarse grained and locally is conglomeratic. Individual layers are crossbedded and resistant and resemble very much the sandstone beds of the overlying Pottsville formation. Interbedded with the sandstone are gray, green, black, and red shale and siltstone. This member contains several coal beds which can be correlated over considerable distances.

Age and correlation.—According to Butts (1940, p. 405) the Bluestone formation may be equivalent to the Degonia sandstone and the Kincaid limestone of late Chester age in southern Illinois. The Princeton sandstone and the Bluestone formation have yielded only fragmentary collections of fossils, and these formations are at present classified as Mississippian in age.

Stratigraphic relations.—The Bluestone formation is apparently conformable with the underlying strata but, regionally, several hundred feet of beds in its upper part may have been truncated before the overlying basal sandstone of the Pottsville formation was deposited.

POTTSVILLE FORMATION

The basal beds of the Pottsville formation of Pennsylvanian age consist of thick ledges of white and gray, very quartzose crossbedded resistant medium- and coarse-grained sandstone which is conglomeratic in many places. Drillers call the basal sand in eastern Kentucky the third salt sand because of the presence of connate salt water. In general, the grains are more rounded and the sandstone is less impure than the sandstone beds of the Bluefield, Hinton, and Bluestone formations. The basal sandstone beds are, however, identical lithologically with the Princeton sandstone. Regional angularity with the underlying sediments probably exists at the base of the Pottsville, although the basal contact is that of a disconformity in any individual exposure. No attempt was made to study the Pottsville formation in detail. In the graphic sections (pls. 28, 29) the depth to the base of the Pottsville formation has been indicated at the contact with the underlying beds.

Only the lower few feet of the Pottsville formation is shown in the graphic sections (pls. 28, 29). The lower part of the beds referred to as the Pottsville formation in this report (but not shown completely on the graphic sections) is included in the Lee formation in the county coal reports of southwestern Virginia published by the Virginia Geological Survey and in the Pocahontas formation in the county coal reports of southern West Virginia published by the West Virginia Geological Survey.

SEDIMENTARY HISTORY

Several facies are recognizable in the Upper Mississippian rocks of the area studied. Fossiliferous marine limestone is represented by the Greenbrier limestone and red beds are present in all the formations. Sparse crossbedded sandstone is found in the Bluefield formation, in the Stony Gap sandstone member and other sandstone beds of the Hinton formation, in the Princeton sandstone, in the upper member of the Bluestone formation, and in the sandstone beds of the Pottsville formation. Thin gray and grayish-black noncalcareous carbonaceous shale occurs at several intervals in the Hinton formation; such a facies constitutes the main body of the gray shale member of the Bluestone formation, is also found in the upper member of the Bluestone formation, and is most abundant of all in the rocks of Pottsville age. Cooper (1948, p. 259–261) discussed in a general manner the limestone and the red beds of the Greenbrier limestone.

The thickness maps (figs. 27–30) indicate a more or less regular rate of thickening of all the formations from northwest to southeast. The thickness lines parallel the approximate trend of the Appalachian geosyncline in this latitude, although there are some local variations. The greatest deviation noted from the regularity of thickening is near Bluefield, W. Va., and in northeastern Tazewell County, Va., where all of the formations thicken in a relatively short distance. It is known that the Bluefield, Hinton, and Bluestone formations reach their greatest thickness in the Hurricane Ridge syncline (Reger, 1926, p. 292) just north of Bluefield. An eastern source is implied by this evidence and it is also suggested that this local thickening is related to a deltaic environment. The thickness maps also indicate, by the irregular distribution of the sediments, that considerable shifting back and forth took place during successive periods of deposition.

The results of the writers' studies of the Mississippian rocks are in accord with the general concept as presented by King (1950) that a source area for the sediments existed to the east of the Appalachian basin and geosyncline during the deposition of the Greenbrier, Bluefield, Hinton, Princeton, and Bluestone formations, as well as during earlier geologic periods. Rittenhouse (1949) found evidence that the Greenbrier limestone may represent marginal deposits in an ocean rather than in an epicontinental sea. He suggested the existence of a low-lying land mass to the northwest of the area of deposition of the Greenbrier in West Virginia. His work did not produce any data suggestive of the presence of a source area for the sediments to the southeast of the area of deposition of the Greenbrier

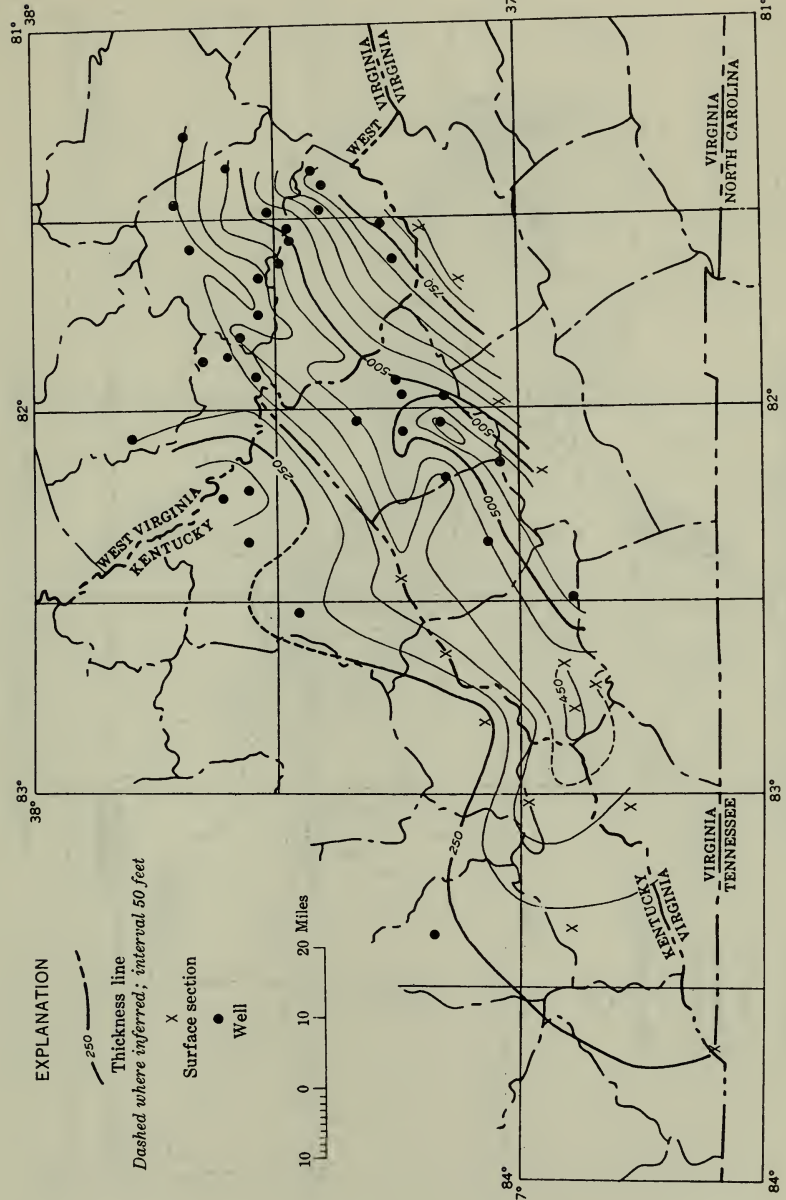

FIGURE 27.—Thickness map of the Greenbrier limestone.

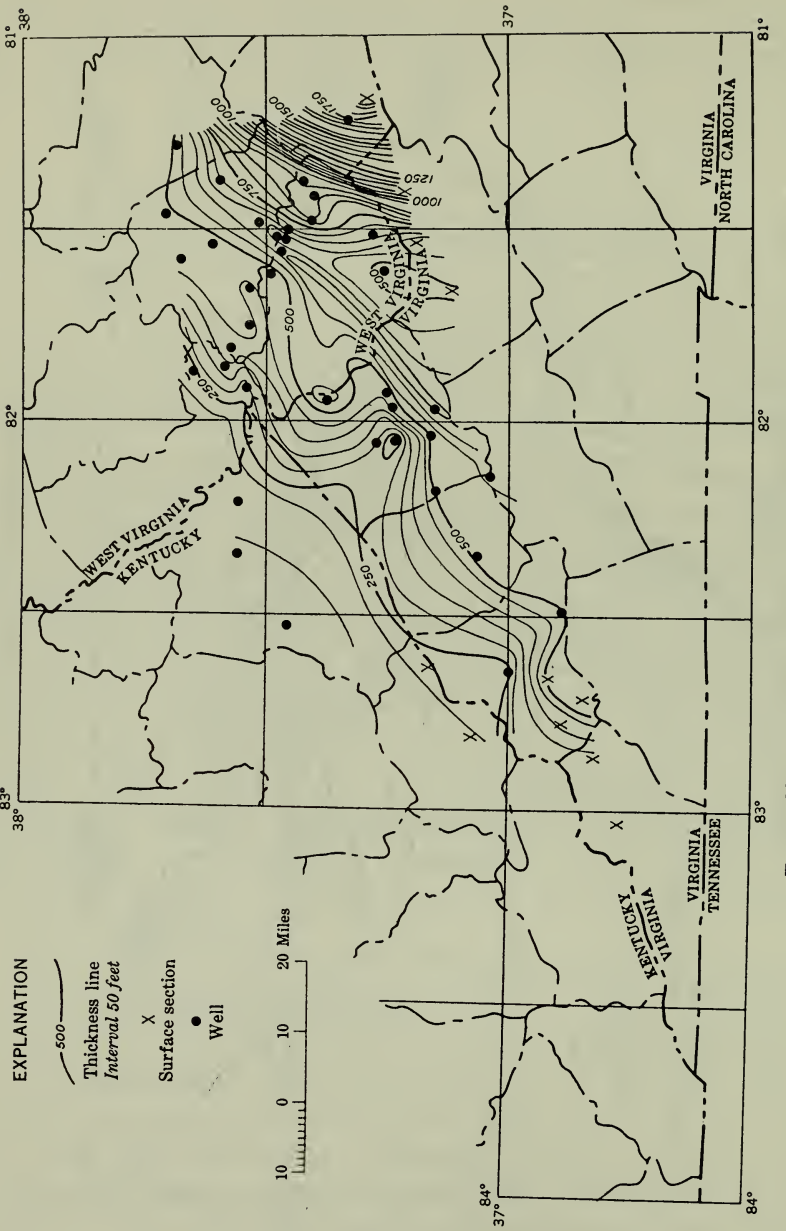

FIGURE 28.—Thickness map of the Bluefield formation.

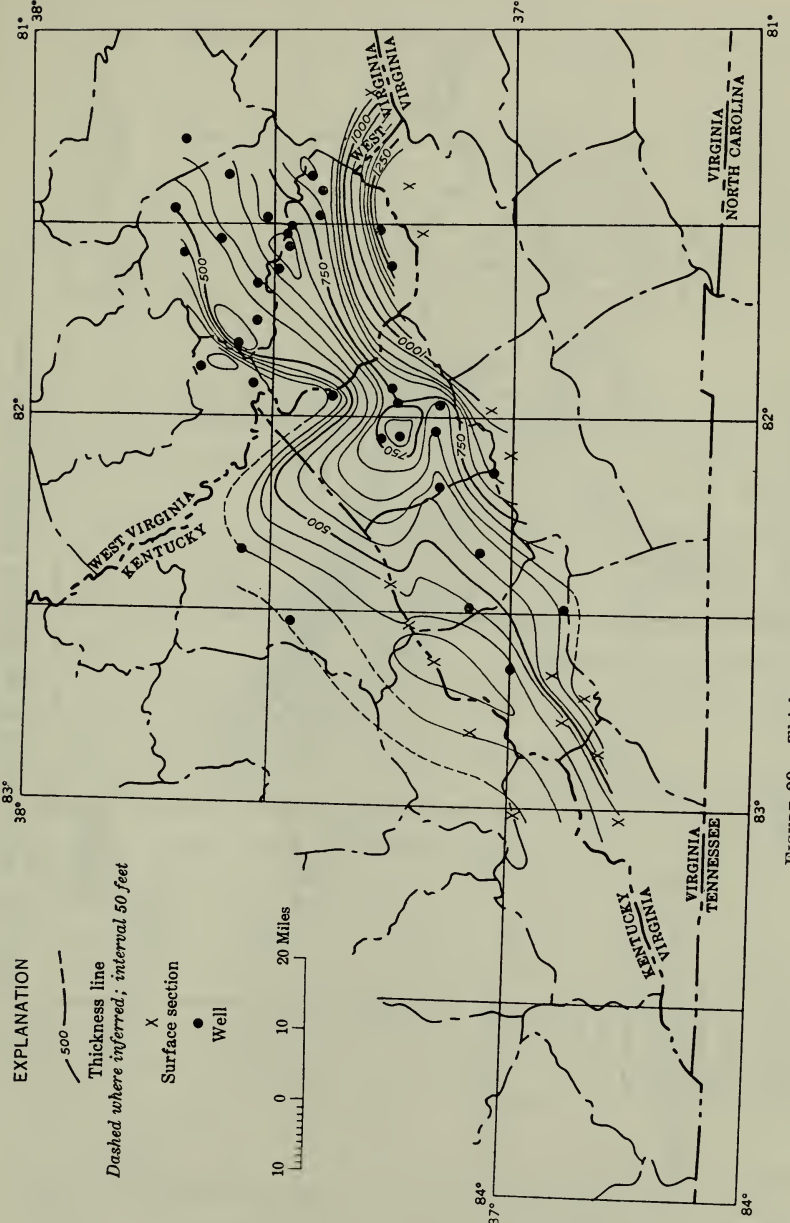

FIGURE 29.—Thickness map of the Hinton formation.

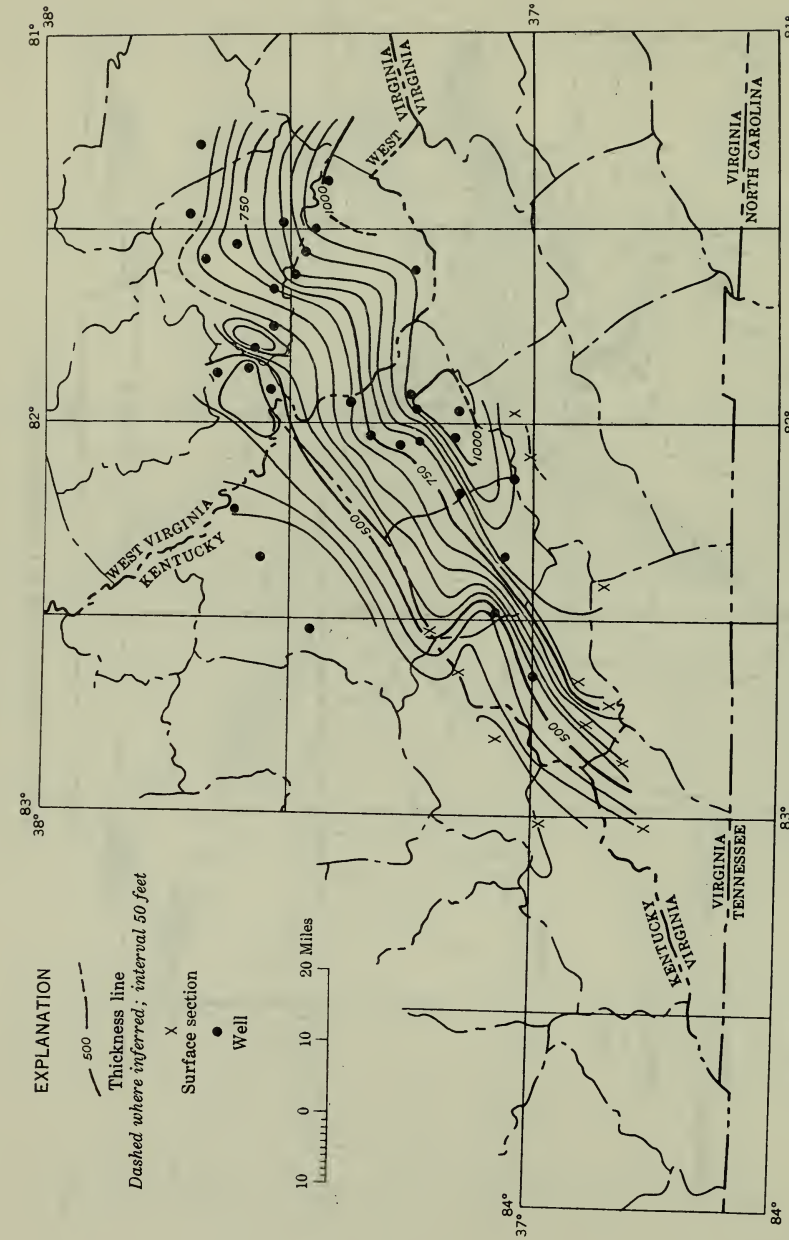

FIGURE 30.—Thickness map of the Princeton sandstone and Bluestone formation.

in West Virginia. Both the land mass suggested by Rittenhouse and a source area to the southeast may have existed.

Periods of uplift and quiescence in the source areas affected the type of rock material being formed and transported westward to the areas described in this report. The red color of the red bed facies is thought to be due to oxidation of the surface rocks and soils of the source area during periods of deep weathering prior to transportation to the sedimentary basins. It is possible that each of the principal stages of sandstone deposition resulted in a regressive-transgressive sandstone. Regression would have taken place in general from east to west, followed by transgression from west to east. The other facies described previously (p. 604) would also fall into this general pattern.

At the end of deposition of the Maccrady shale all the area studied was inundated by relatively shallow seas. Most of the area was on the northwestern edge of the Appalachian geosyncline as delimited at this stage in geologic time, the present Bluefield area and the Greendale syncline area being in the geosyncline. A line connecting these localities would probably represent approximately the trend of the geosyncline of that time. Because marine invertebrate life was prolific, the Greenbrier limestone is highly fossiliferous. Numerous small changes in depositional environment took place during Greenbrier time, and several types of limestone were deposited. The red muddy limestone zones, such as the Taggard red member of the Greenbrier limestone, represent geologic recurrences of the red bed facies of the underlying Maccrady shale.

Toward the end of Greenbrier time the limestones became thinner bedded and shaly. The general environment changed rapidly and the calcareous shales, shaly limestones, limestones, and sandstones of the Bluefield formation were deposited in apparent conformity on the Greenbrier limestone. Some limestones similar to those of the Greenbrier were deposited in the lower part of the Bluefield formation. Such limestones indicate recurrence of environmental conditions similar to those in which the Greenbrier limestone was deposited. The sandstones and small amounts of red shale presage the more extensive deposition of red beds later in Mississippian time. In general the rocks of the Bluefield formation are a mixture of all the facies recognized in the area.

The basal Stony Gap sandstone member of the Hinton formation is the first widespread sand deposit in the Mississippian rocks of the area studied. These sands formed a persistent blanket and covered a greater area than the later sandstone units. After the deposition of the sandstone, the middle red member of the Hinton formation was deposited during a relatively long period of quiescence. Many thin

lenticular beds of sandstone, siltstone, limestone, dolomite, and gray shale were also formed at this time owing to oscillations in sea level within the Appalachian basin and the source area. Several of the lenticular sandstones probably are due to short periods of disturbance in the source areas. The limestone member (Avis limestone of Reger) of the Hinton formation represents a marine inundation of most of the area. The "dwarfed" fauna, shaly character, and locally carbonaceous nature of the fossil replacements possibly indicate shallow restricted seas. The upper red member of the Hinton formation, which occurs locally between the limestone member and the Princeton sandstone, exhibits a recurrence of lithologies common in the middle red member of the Hinton formation. In the areas where the upper red member of the Hinton is not present, it was either not deposited or was removed prior to the deposition of the Princeton sandstone.

The Princeton sandstone resulted from the second strong uplift of the source areas during Late Mississippian time in this area. Its distribution was also blanketlike, but it does not cover as large an area as the Stony Gap sandstone member of the Hinton formation. During this time there were periods of quiescence during which finer grained clastic materials were deposited.

The gray shale member of the Bluestone formation apparently represents a period of quiescence during which the environment in the source areas was not conducive to the formation of red soils. Like the Princeton sandstone, this member of the Bluestone formation is similar to part of the Pottsville formation. The existence of the red member of the Bluestone formation indicates a recurrence of conditions that prevailed during deposition of the red facies of the Hinton formation. The upper member of the Bluestone formation is composed of sediments that reflect a third crustal disturbance. Locally the environmental conditions in the source areas were favorable for the formation of the red soils and thus there are scattered occurrences of the red shale facies comparable to those of the Hinton formation. Changing environmental conditions in the Appalachian basin during the deposition of the upper part of the Bluestone formation are indicated by the presence of several coal beds, some of which seem to be relatively persistent although others are definitely lenticular. Lagoonal and swampy environments existed during these coal-forming times.

The coarsely clastic and conglomeratic nature of the basal part of the Pottsville formation indicates the beginning of a period of intense uplift in the source areas. These sediments were transported and deposited much farther to the west and in larger volumes than any of the coarser clastic materials in the previously described rocks.

OIL AND GAS POSSIBILITIES

The presence of oil in commercial quantities in the Upper Mississippian rocks in the area studied does not appear likely. Oil has been found in West Virginia in dolomitic and clastic limestone zones of the Greenbrier limestone, and shows of oil were found in one of the Maxton sands of the drillers in wells drilled in Buchanan County, Va., by the United Producing Company, Inc., and by the United Fuels Co. Free oil has been observed in several surface exposures of the Greenbrier. The Greenbrier limestone may contain some oil in dolomitic and clastic zones in southwestern Virginia.

Rocks such as the Trenton limestone of Ordovician age, which are below those studied, seem more likely to contain oil. The Trenton limestone, which is productive in the Rose Hill oil field, Lee County, Va. (Miller and Fuller, 1947), should be present beneath the Cumberland overthrust block and also outside the block northeast of the Russell Fork fault. The Trenton may not be at as great a depth underneath the overthrust block as it is to the northeast. If the rocks beneath the Cumberland overthrust block are folded and truncated by the Pine Mountain fault, local petroliferous zones may occur directly beneath the fault zone.

The possibilities for developing new gas fields are very good in the parts of the counties of southwestern Virginia and eastern Kentucky in which the coal measures of Pennsylvanian age occur as the surface rocks. Gas has already been discovered in Dickenson and Buchanan Counties, Va. Of 12 wells which were completed by June 1949 in these counties, gas in commercial quantities was discovered in 8 (Miller and Brosgé, 1950). The total daily volume of gas production from these 8 wells was 41 million cubic feet. The production has all been from the Mississippian rocks described in this report, and the units from which gas has been produced have been indicated on the graphic sections wherever possible. The gas from several of the producing fields in Wyoming and McDowell Counties, W. Va., is also from these Mississippian rocks.

The gas in Dickenson and Buchanan Counties is found in several zones. The two most productive zones to date are in the Greenbrier limestone and the Princeton sandstone (Ravencliff sand of the drillers). One well, the Pipe Line and Construction Company's Curtis No. 1A, has produced a large quantity of gas from the Stony Gap sandstone member of the Hinton formation (middle Maxton sand of drillers). No samples from the producing zone of this well were available to the writers at the time of this study.

Not enough information is available to determine with certainty the geologic reasons for these accumulations of gas. The gas in the

nondolomitic parts of the Greenbrier limestone is present in oolitic and clastic limestone zones, where the porosity of the rock would naturally be higher than in the denser limestones. Rittenhouse (1949) has suggested that the clastic limestone beds, composed of lime sand, oolites, and quartz sand, were deposited in a near-shore environment in an alternately transgressing and regressing sea. Thus they would exhibit the form of beach, bar, dune, and channel deposits and, with the exception of the channel deposits, would be long relatively narrow sedimentary accumulations alined parallel to the ancient shoreline. The channel deposits would also be long and narrow but perpendicular to the shore and at greater depths than the other clastic deposits of the same age. The trend of the ancient shoreline in southern West Virginia, according to Rittenhouse (1949), was northeastward. Future studies may prove the existence of productive trends as suggested above.

The dolomitic zone near the base of the Greenbrier limestone, which produces gas and oil in West Virginia fields, consists of sandy dolomite, dolomitic sandy limestone, and dolomitic sandstone; it is relatively porous (Martens and Hoskins, 1948). No production is known to have come from this zone in southwestern Virginia.

The geologic controls for the accumulation of gas in the Maxton sands of drillers and in the Princeton sandstone are also undetermined. Some subsurface geology specialists have suggested the possibility that these sandstone units contain gas only in the sands which are cemented by calcium carbonate and not in those sands with siliceous cement. The changes in cementation apparently take place both vertically and horizontally within each sandstone. Differences in grain size have also been suggested as a possible control for the accumulation of gas; however, numerous wells penetrated very coarse grained and porous sandstones which were dry. Sand accumulation in the Princeton sandstone and Maxton sands of the drillers may be due to environments similar to those suggested above for the clastic deposits of the Greenbrier limestone. As new wells are drilled as much geologic information as possible should be accumulated from the well samples. Productive trends may be discovered which, when correlated with sample studies, will explain the accumulations of gas and oil and aid in the discovery of other fields.

The source of the gas in the Greenbrier limestone is believed to be the Greenbrier itself. The limestone is highly fossiliferous and, when broken on the outcrop, emits a very fetid odor. The writers believe the sources of the gas in the lower Maxton sand of drillers and in the Stony Gap sandstone member (middle Maxton sand of drillers) of the Hinton formation to be the fossiliferous and shaly Bluefield formation. The gas in the Princeton sandstone could have

come from several sources: the underlying fossiliferous limestone member of the Hinton formation (Avis limestone of Reger), another limestone present locally above the Princeton sandstone, or the gray shale member of the Bluestone formation which is present everywhere above the Princeton. F. R. Clarkson (personal communication) suggests as a possible source the gray shale member of the Bluestone formation. The writers believe that the limestone member of the Hinton formation is the source of the gas in the Princeton sandstone.

A favorable area to test gas possibilities of the Princeton sandstone in the Cumberland overthrust block would be on the northwestern flank of the Middlesboro syncline. In the subsurface the Princeton probably changes to finer grained rocks in most parts of this area. Thus, updip change to finer grain sizes and consequent trapping of gas are possible.

There are several potential gas-producing zones above and below the Greenbrier limestone. E. D. Hilton (written communication, July 14, 1949) reported gas at a depth of 1,728 feet in the No. 104 well of the Clinchfield Coal Corporation in Dickenson County, Va. The well gaged 94,000 cubic feet of gas per day. The type of rock in which the gas was found is not known to the writers, but it was probably sandstone. Beds of sandstone within the Price sandstone, which underlies the Maccrady shale, offer possibilities of gas production. Several producing sands in West Virginia, such as the Big Injun and Wier sands of drillers, are included in the Maccrady shale and Price sandstone. The Devonian and Mississippian black shales are also believed to be potential gas-producing zones, as most of the gas production in Pike County, Ky., comes from these beds (McFarlan, 1943, p. 360, pl. 18). The Pine Mountain fault block is thought to have slipped along these black shales which underlie a large part of the Cumberland overthrust block. The oil and gas possibilities along and beneath this fault zone have been discussed by Miller and Borsgé (1950), but little is known about the possibilities within the fault zone itself as it is not known to have been penetrated by drilling in the area included in the study.

It is the usual practice in the area to acidize the wells producing from limestone. The dolomitic zone near the base of the Greenbrier limestone in West Virginia gives better production after shooting than after acidizing. The producing sandstones are usually shot.

In summary, it is the opinion of the writers that the gas-producing possibilities of the Mississippian rocks are excellent in that part of the area studied in which beds of the Pottsville formation of Pennsylvanian age are present at the surface. Production should be obtained from the Greenbrier limestone, the several Maxton sands of

drillers, and the Princeton sandstone (Ravencliff sand of drillers). In the subsurface in Wise, Dickenson, and Buchanan Counties, Va., the depth to the top of the Princeton sandstone (Ravencliff sand) ranges from 2,000 to 3,000 feet; the depth to the top of the Stony Gap sandstone member (middle Maxton sand) of the Hinton formation from 2,200 to 3,700 feet; and the depth to the top of the Greenbrier limestone (Big Lime) from 3,000 to 4,500 feet. Gas or oil production from zones beneath the Greenbrier limestone and from rocks of Pennsylvanian age may be possible.

The writers believe that structural controls in the area have not played so important a part as stratigraphic traps in the accumulation of oil and gas, but structures may have localized accumulations where they are associated with stratigraphic traps.

TABLE 1.—*Data on wells and surface sections*

No. on map and sections	Name of section or well	Location	Source of information	Gas production (thousand cubic feet per day) and producing zone	Status	Surface elevation (feet)	Graphic sections (pls. 28, 29; fig. 24)
1	Cumberland Gap section.	Measured on northeast side gap along U.S. 58, Middlesboro quadrangle, Lee County, Va.	Wilpolt and Marden, 1955.				*A-A'*
2	Pineville section	Measured on northeast side of Cumberland River gap through Pine Mountain along RR tracks, Cumberland Gap quadrangle, Bell County, Ky.	Wilpolt and Marden, 1955.				*C-C'*
3	Rhama Jackson well No. 1.	Knox County, Ky	Samples from Bell-Knox Pipe Line Co., Inc.	385 initial, 1,038 after acidizing, from Greenbrier limestone at 1,544–1,570 feet.	Completed, Aug. 1948.		*C-C'*
4	Black Star Coal Co. well No. 1.	6,500± ft west of 83°20′ and 100± ft south of 37°10′, Hyden quadrangle, Leslie County, Ky.	Samples furnished by Kentucky Geol. Survey.	231 open flow from brown shale and "Corniferous" limestone.	Shut in, Aug. 1945.		*D-D'*
5	Harlan section	Measured 3.5± miles north of Harlan, Ky., on north slope of Pine Mountain along Ky. 257, Harlan quadrangle, Harlan County, Ky.	Page 622, this report				*C-C'*
6	Hagan section	Measured along old mountain road, 0.7 mile N. 20° W. of Hagans, Va., RR station, Jonesville quadrangle, Lee County, Va.	Wilpolt and Marden, 1955.				*A-A'*
7	Pennington Gap section.	Greenbrier limestone measured on northeast side of gap; overlying beds measured along RR on southwest side of gap, except for Princeton sandstone which was measured at water level on northeast side, Nolansburg quandrangle, Lee County, Va.	Page 626, this report				*A-A'* *D-D'*
8	Hurricane Gap section.	Measured on north slope Pine Mountain about 2 miles west and slightly north of Cumberland, Va., at Hurricane Gap, along State Route 463, Nolansburg quadrangle, Letcher County, Ky.	Page 631, this report				*C-C'* *D-D'*
9	Olinger section	0.25± mile northeast of Olinger, measured up hillside on north side of L. & N. RR, Big Stone Gap quadrangle, Lee County, Va.	U.S. Geol. Survey				*A-A'*
10	Big Stone Gap section.	Measured through quarry and along Southern Railway in gap of Powell River through Little Stone Mountain, 0.75± mile north of Big Stone Gap, Va.; upper 85 ft measured along L. & N. RR on southwest side of same gap, Big Stone Gap quadrangle, Wise County, Va.	Wilpolt and Marden, 1955.				*A-A'*

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TABLE 1.—*Data on wells and surface sections*—Continued

No. on map and sections	Name of section or well	Location	Source of information	Gas production (thousand cubic feet per day) and producing zone	Status	Surface elevation (feet)	Graphic sections (pls. 28, 29; fig. 24)
11	Whitesburg section	Measured 3 miles south of Whitesburg, Ky., on northwest slope of Pine Mountain along U.S. 119, Whitesburg quadrangle, Letcher County, Ky.	Wilpolt and Marden, 1955.				*C–C′*
12	East Stone Gap section.	Measured 2.5± miles southeast of East Stone Gap, Va., in partial gap in Powell Mountain cut by South Fork Powell River: the Greenbrier limestone was measured on southwest side of gap along road to top of mountain; the remainder of the section on northeast side of gap along old logging road, Wise quadrangle, Wise County, Va.	Wilpolt and Marden, 1955.				*A–A′*
13	Little Stone Gap section.	Measured along Va. 610 in Little Stone Gap, Wise quadrangle, Wise County, Va.	Page 637, this report				*A–A′* *B–B′* *E–E′*
14	Isaac Kaufman well No. 1.	6,400 ft east of 82°40′ and 400 ft north of 37° on Buck Knob anticline, Pound quadrangle, Wise County, Va.	Samples from Virginia Coal & Iron Co. (Huddle and others, 1955, 1956).	Dry and abandoned; strong show of gas at 3,600 ft (not gaged); show of oil at 2,450–2,470 ft.	Completed, May 1933.	2,230	*B–B′* *E–E′*
15 (A, B, C, D)	Pound Gap section	Measured on northwest slope of Pine Mountain along U.S. 23, Pound quadrangle, Letcher County, Ky.	Page 645, this report				*C–C′* *E–E′*
16	J. Morg Sword well No. 1 (GW–834).	3.2 miles south of 37°30′ and 1.7 miles west of 82°30′, 2 miles west-southwest of Pikeville, Pikeville quadrangle, Pike County, Ky.	Martens, 1945, p. 748–751.	536 from black shale between 2,376–3,067 ft after shot.	Completed, Oct. 1939.	664	*E–E′* *F–F′* *G–G′*
17	Osborn Gap section	Measured on northwest slope of Pine Mountain along old logging road through gap and 0.25 mile northeast of old logging road, Pound quadrangle, Pike County, Ky.	Wilpolt and Marden, 1955				*C–C′* *F–F′*
18	Clinchfield Coal Corp. diamond-drill hole S–1.	4,200± ft east of 82°30′ and 450± ft north of 37°05′ on Cranesnest River below mouth of Lick Fork, Clintwood quadrangle, Dickenson County, Va.	Eby, 1923a, p. 111–114		Prior to 1923	1,492	*B–B′* *F–F′*
19	Hagan well No. 1	200 ft east of 82°30′ and 9,500 ft south of 36°55′ on Corder Creek, Powell anticline, Coeburn quadrangle, Wise County, Va.	Samples from Virginia Coal & Iron Co. (Huddle and others, 1955, 1956)	Dry and abandoned; 110–250 from Princeton sandstone; shows of gas in Stony Gap sandstone member of Hinton formation and Greenbrier limestone; strong shows of gas in black shale.	Completed, Apr. 1940.	2,500±	*A–A′*

20	Miller Yard section	Measured along Clinchfield RR from southwesternmost switch of the RR yard to the base of the Pottsville formation, taking advantage of the excellent exposures in the turnaround Y, Coeburn quadrangle, Scott County, Va.	Wilpolt and Marden, 1955.				*A–A′* *F–F′*
21	Hamlin section	Measured 0.5± mile southwest of Hamlin, along Virginia State Route 64 and Clinchfield RR, Coeburn quadrangle, Russell County, Va.	Wilpolt and Marden, 1955.				*A–A′*
22	Clinchfield Coal Corp. well No. 101.	4,500± ft west of 82°20′ and 6,200± ft south of 37°05′, 0.25± mile south of Nora, Clintwood quadrangle, Dickenson County, Va.	Samples from Clinchfield Coal Corp. (Huddle and others, 1955, 1956).	1,632 from Greenbrier limestone, 3,839–3,877 ft, after acidizing.	Completed, Mar. 1949.	1,520	*B–B′* *F–F′*
23	Blowing Rock Gap section.	Measured on north slope of Pine Mountain in abandoned quarry, Clintwood quadrangle, Pike County, Ky.	Wilpolt and Marden, 1955.				*C–C′* *G–G′*
24	Jake Smith et al. well No. 1 (GW-832).	On Dicks Fork of Big Creek, 1 mile southeast of Grigger, 1.6 miles south of 37°35′ and 0.6 mile west of 82°20′, Williamson quadrangle, Pike County, Ky.	Martens, 1945, p. 740–748.	Dry and abandoned	Completed, Nov. 1939.	1,068	*I–I′*
25	Clinchfield Coal Corp. well No. 102.	On Fox Creek 1,600± ft up stream from Russell Fork, 5,000 ft west of 82°10′ and 4,500 ft south of 37°10′, Bucu quadrangle, Buchanan County, Va.	Samples from Clinchfield Coal Corp. (Huddle and others, 1955, 1956).	Dry and abandoned; gas show in middle Maxton sand of drillers.	Completed, Apr. 1950.	1,373	*B–B′* *G–G′*
26	Clinchfield Coal Corp. well No. 1 (272).	6,300± ft east of 82°10′ and 10,600± ft north of 37°, 1.5± miles north of Dump Creek School on Skeen Creek, Bucu quadrangle, Russell County, Va.	Sample log (Martens, 1945, p. 862–866).	Dry and abandoned; scattered shows of gas.	Completed, Mar. 1933.	2,050	*G–G′*
27	Sinkhole Valley section.	Measured on southwest side of Va. 600 and on northwest slope of Sinkhole Valley, 0.7± mile southeast of village of Dump Creek, Carterton quadrangle, Russell County, Va.	Wilpolt and Marden, 1955.				*A–A′*
28	Buffalo Mountain section.	Measured along Musick School tributary of Weaver Creek, 0.4± mile up from creek, Carterton quadrangle, Russell County, Va.	Wilpolt and Marden, 1955.				*A–A′* *G–G′* *H–H′*
29	Hart Creek section	0.5± mile up Hart Creek from junction with Weaver Creek, measured on northeast side of road, Bucu quadrangle, Russell County, Va.	U.S. Geol. Survey				*A–A′* *G–G′* *H–H′*
30	Lewis Creek section	Measured from 0.25 to 0.50 mile up Lewis Creek from the intersection of Stone Branch and Lewis Creek, Richlands quadrangle, Russell County, Va.	U.S. Geol. Survey				*A–A′*
31	Hugh McRae well No. 6431.	On Walker Branch of Garden Creek, 9,800 ft east of 82° and 4,350 ft south of 37°10′, Richlands quadrangle, Buchanan County, Va.	Samples from United Fuel Gas Co. (Huddle and others, 1955, 1956).	133 at 935–938 ft	Completed, J ly 1949.	1,799	*H–H′*
32	Yukon-Pocahontas well No. 2-1466.	On Breedan Branch of Right Fork Garden Creek, 13,800 ft east of 82°05′ and 200 ft south of 37°10′, Bucu quadrangle, Buchanan County, Va.	Sample log from United Producing Co. (Huddle and others, 1955, 1956).	Dry and abandoned; scattered shows of gas, show of oil at 1,086 ft.	Completed, July 1948.	1,751	*B–B′*

TABLE 1.—*Data on wells and surface sections*—Continued

No. on map and sections	Name of section or well	Location	Source of information	Gas production (thousand cubic feet per day) and producing zone	Status	Surface elevation (feet)	Graphic sections (pls. 28, 29; fig. 24)
33	Yukon-Pocahontas well No. 1-1454.	On Levisa Fork, 3,400± ft east of 82°05′ and 5,100± ft south of 37°15′, Bucu quadrangle, Buchanan County, Va.	Sample log from United Producing Co.	Dry and abandoned; scattered shows of gas.	Completed, Mar. 1948.	1,206	*H–H′*
34	A. L. Powers well No. 1.	On Booth Branch Slate Creek, 16,300 ft west of 82° and 27,400 ft south of 37°20′, 2.6± miles east of Grundy, Hurley quadrangle, Buchanan County, Va.	Samples from Pipe Line Drilling & Construction Co. (Huddle and others, 1955, 1956).	3,452 from Greenbrier limestone, probably near bottom of hole (see graphic sections).	Completed, Apr. 1949.	1,509	*H–H′*
35	F. H. Curtis well No. 1-A.	On Mill Creek 9,800 ft west of 82° and 29,400 ft south of 37°25′, Hurley quadrangle, Buchanan County, Va.	Samples from Pipe Line Drilling & Construction Co. (Huddle and others, 1955, 1956).	6,005 initial from Maxton sand of drillers, 3,397–3,431 ft.	Completed, June 1949.	1,987	*C–C′* *H–H′* *I–I′*
36	Columbian Fuels Corp. well GW-1245.	On Camp Branch of Middle Fork Blackberry Creek, 12,400± ft east of 82°15′ and 10,800± ft south of 37°35′, Matewan quadrangle, Pike County, Ky.	Sample log from Columbian Fuels Corp.	5,441 final open flow after acidizing, from Greenbrier limestone, 2,380–2,385 ft.	Shut in, June 1945.	939	*J–J′*
37	Columbian Fuels Corp. well GW-1203.	On Blackberry Fork Pond Creek, 9,800± ft north of 37°35′ and 5,200 ft east of 82°15′, Matewan quadrangle, Pike County, Ky.	Sample log from Columbian Fuels Corp.	Dry and abandoned; several shows.	Completed, Feb. 1943.	812.8	*J–J′*
38	Columbian Fuels Corp. well GW-954.	1.9 miles east-northeast of War Eagle, 15,600 ft north of 37°30′ and 300 ft east of 81°55′, Gilbert quadrangle, Mingo County, W. Va.	Samples from Columbian Carbon Co.	Dry and abandoned	Completed, Mar. 1948.	1,272	*C–C′*
39	National Shawmut Bank of Boston well No. 5810.	On Knox Creek 0.1 mile west of Whiteoak Fork, 15,000 ft north of 37°20′ and 9,800 ft west of 81°55′, Laeger quadrangle, Buchanan County, Va.	Samples from United Fuel Gas Co. (Huddle and others, 1955, 1956).	Dry and abandoned; scattered shows of gas.	Completed, Aug. 1949.	1,263	*C–C′* *J–J′*
40	R. J. Carlson well No. 1.	0.55 mile south of Dwight, Va., and 0.28 mile west of Dismal Creek, 29,400 ft south of 37°20′, 3,500 ft west of 81°55′, Laeger quadrangle, Buchanan County, Va.	Samples from Pipe Line Drilling & Construction Co. (Huddle and others, 1955, 1956).	400 from Greenbrier limestone, 4,040–4,044 ft.	Shut in, June 1949.	2,122	*B–B′* *J–J′*
41	Slocum Land Corp. well No. 1-1525.	2 miles west of Dwight, Va., 29,950 ft south of 37°20′ and 13,000 ft west of 81°55′, Laeger quadrangle, Buchanan County, Va.	Samples from United Producing Co. (Huddle and others, 1956).	348 from Princeton sandstone (Ravencliff sand of drillers).	Completed, Aug. 1948.	1,621	*I–I′*
42	W. M. Ritter well No. 1-V-1461.	2 miles west-southwest of Dwight, Va., 2,100 ft south of 37°15′ and 12,250 ft west of 81°55′, Richlands quadrangle, Buchanan County, Va.	Samples from United Producing Co. (Huddle and others, 1956).	17,196 from Princeton sandstone (Ravencliff sand of drillers), 2,295–2,301 ft.	Completed, Feb. 1948.	1,619	*B–B′* *I–I′*

43	W. M. Ritter well No. 3–V–1526.	2.4 miles southwest of Dwight, Va., 4,000 ft south of 37°15′ and 13,500 ft west of 81°55′, Richlands quadrangle, Buchanan County, Va.	Sample log from United Producing Co.	4,213 from Princeton sandstone (Ravencliff sand of drillers).	Shut in, July 1948.	2,279	*I–I′*
44	Yukon-Pocahontas well No. 3–1563.	2.8 miles southwest of Dwight, Va., on the north bank of Big Branch Creek, 6,500 ft south of 37°15′ and 14,000 ft west of 81°55′, Richlands quadrangle, Buchanan County, Va.	Samples from United Producing Co. (Huddle and others, 1955, 1956).	6,152 from Greenbrier limestone, 3,885–3,905 ft.	Completed, May 1949.	1,673	*I–I′*
45	Bandy section	Lower 1,016 ft measured 11,300 ft north of 37°05′ and 10,500 ft west of 81°40′; upper 665 ft measured 19,400 ft north of 37°05′ and 10,000 ft east of 81°40′, Pounding Mill quadrangle, Tazewell County, Va.	Wilpolt and Marden, 1955.				*A–A′*
46	Bishop-Stony Ridge section.	Measured along Va. 16; section starts 0.6 mile southeast Bishop, Pounding Mill quadrangle, Tazewell County, Va.	Wilpolt and Marden, 1955.				*A–A′, I–I′ J–J′, K–K″*
47	United Fuel Gas Co. well No. 6219.	0.7 mile south-southeast of Newhall, W. Va., on the west side of W. Va. 16, Welch quadrangle, McDowell County, W. Va.	Samples from United Fuel Gas Co.	Dry and abandoned	(?)	1,600±	*J–J′*
48	Pocohontas Land Corp. well No. 9249.	2.7 miles south-southeast of Filbert, 12,500 ft north of 37°15′ and 5,100 ft west of 81°30′, Welch quadrangle, McDowell County, W. Va.	Sample log from Peoples Natural Gas Co. (Hope Natural Gas Co.).	73 natural from Berea sand, 4,217–4,239 ft; final open flow from Berea sand and Greenbrier limestone, 67; scattered shows in Stony Gap sandstone member, Bluefield formation, and Greenbrier limestone.			*K–K′*
49	Burkes Garden quadrangle section.	Several partial sections combine into a composite section; measured at West Graham, Tiptop, Mud Fork, and Bailey, in Burkes Garden quadrangle, Tazewell County, Va.	Cooper, 1944, p. 169–187.				*A–A′*
50	Stony Gap section	Main part of section measured along old road between Bluefield and Princeton, starting at Stony Gap, about 3½ miles east-northeast of Bluefield; partial sections measured along U.S. 19, the new road from Bluefield to Princeton, Bluefield quadrangle, Mercer County, W. Va.	U.S. Geol. Survey				*A–A′ L–L′*
51	A. W. Hicks well No. 6478.	1,500 ft south of 37°20′, 7,600 ft east of 81°15′, on Red Oak Ridge in the Bluefield quadrangle, Mercer County, W. Va.	Samples from United Fuel Gas Co. (Huddle and others, 1956).	47; 26 at 3,180–3,187 ft after shooting.	Completed, Feb. 1951.	2,834	*L–L′*
52	Rock section	Section measured from 0.25± mile north of Rock, to about 1 mile up an old road a short distance east of Rock, Bluefield quadrangle, Mercer County, W. Va.	Samples from United Fuel Gas Co. (Huddle and others, 1956).				*L–L′*
53	Hope Natural Gas Co. well No. 9143.	On Bearwallow Creek 1.25 miles northeast Rolfe, 3,750 ft north of 37°25′ and 11,500 ft east of 81°25′, Bramwell quadrangle, McDowell County, W. Va.	Sample log from Peoples Natural Gas Co. (Hope Natural Gas Co.).	9 from Wier sand of drillers; scattered shows above base Greenbrier limestone.	Plugged	2,122	*L–L′*

TABLE 1.—*Data on wells and surface sections*—Continued

No. on map and sections	Name of section or well	Location	Source of information	Gas production (thousand cubic feet per day) and producing zone	Status	Surface elevation (feet)	Graphic sections (pls. 28, 29; fig. 24)
54	Hope Natural Gas Co. well No. 9161.	1 mile north Elkhorn, 5,950 ft south of 37°25′ and 1,850 ft east of 81°25′, Bramwell quadrangle, McDowell County, W. Va.	Sample log from Peoples Natural Gas Co. (Hope Natural Gas Co.).	49 from "crevass" below Berea sand, decreased to 33; scattered shows above.	(?)	2,073	*L–L′*
55	Hope Natural Gas Co. well No. 9232.	0.35 mile southwest of Landgraff, 3,400 ft south of 37°25′ and 7,000 ft east of 81°30′, Bramwell quadrangle, McDowell County, W. Va.	Sample log from Peoples Natural Gas Co. (Hope Natural Gas Co.).	381 from Wier sand of drillers (?), blew down to 207, final open flow 298 after shot; scattered shows.	Producing, Nov. 1948.	1,726	*K–K′* *L–L′*
56	Godfrey L. Cabot, Inc., well No. 1296–27	On Laurel Branch, 2.15 miles north of Kimball, 15,900 ft south of 37°30′ and 2,200 ft west of 81°30′, Welch quadrangle, McDowell County, W. Va.	Samples from Godfrey L. Cabot, Inc.	----------	Completed, June 1949.	1,815	*L–L′*
57	Godfrey L. Cabot, Inc., well No. 1293–25	3.1 miles north-northwest of Kimball, 11,500 ft south of 37°30′ and 8,500 ft west of 81°30′, Welch quadrangle, McDowell County, W. Va.	Samples from Godfrey L. Cabot, Inc.	Dry and abandoned----------	Completed----	7,785.4	*L–L′*
58	Godfrey L. Cabot, Inc., well No. 1279–23	3.65 miles north-northwest of Kimball, 8,800 ft south of 37°30′ and 10,300 ft west of 81°30′, Welch quadrangle, McDowell County, W. Va.	Sample log from Godfrey L. Cabot, Inc.	3,540 after shot, from Wier sand of drillers, 3,570–3,611 ft; 2,268 before shot.	Producing, Sept. 1948.	1,869	*L–L′*
59	Hope Natural Gas Co. well No. 9127.	On Jenny Branch 1.95 miles south of Fairview School, 6,000 ft north of 37°30′ and 3,335 ft east of 81°30′, Mullens quadrangle, Wyoming County, W. Va.	Sample log from Peoples Natural Gas Co. (Hope Natural Gas Co.).	300 from Greenbrier limestone, blew out completely; plugged and abandoned.	Completed, Sept. 1947.	1,827	*B–B′* *K–K′*
60	Hope Natural Gas Co. well No. 9216.	On Puncheoncamp Branch 3.1 miles north-northeast of Welch, 9,000 ft south of 37°30′ and 6,400 ft east of 81°35′, Welch quadrangle, McDowell County, W. Va.	Sample log from Peoples Natural Gas Co. (Hope Natural Gas Co.).	18 from Wier sand of drillers after shot (32 blew down at 5).	Completed, Sept. 1948.	1,678	*B–B′* *L–L′*
61	John Gilbert et al., Trustees, well No. 2.	On Davy Branch 2 miles east-northeast of Davy, 2,200 ft south of 37°30′ and 13,200 ft west of 81°35′, Welch quadrangle, McDowell County, W. Va.	Sample log (Martens, 1945, p. 413–418).	Dry and abandoned; scattered shows.	Completed, May 1943.	1,448	*L–L′*
62	John Gilbert, Trustee, well No. 3 (1076).	On Trace Fork 1.5 miles south of Ox, 17,450 ft south of 37°35′ and 22,700 ft west of 81°35′, Pineville quadrangle, Wyoming County, W. Va.	Sample log (Martens, 1945, p. 700–703).	440 from Berea sand----------	Completed, Aug. 1943.	1,451	*L–L′*
63	John Gilbert et al., Trustee, well No. 1 (1068).	On Little Huff Creek 0.1 mile east of Defeat Branch, 17,400 ft south of 37°35′ and 1,350 ft west of 81°45′, Gilbert quadrangle, Wyoming County, W. Va.	Sample log (Martens, 1945, p. 711–716).	Dry and abandoned; scattered shows, no test.	Completed, Apr. 1943.	1,158	*L–L′*

64	Godfrey L. Cabot, Inc., well No. 1107-1.	0.95 mile west of Hanover and Little Huff Creek, 3,900 ft south of 37°35′ and 18,750 ft west of 81°45′, Gilbert quadrangle, Wyoming County, W. Va.	Sample log from Godfrey L. Cabot, Inc.	60 from Greenbrier limestone, 3,700–3,717 ft; 15 from Berea sand, 3,402–3,409 ft; plugged back and producing from Greenbrier limestone.	Producing, Nov. 1947.	1,082	*L–L′*
65	Columbian Carbon Co. well GW–1063.	1.3 miles west of Justice on Neds Branch, 2,400 ft north of 37°35′ and 7,100 ft west of 81°50′, Gilbert quadrangle, Mingo County, W. Va.	Sample log from Columbian Carbon Co.	Dry and abandoned; show in Pottsville formation.	Completed, Aug. 1948.	972	*C–C′* *L–L′*
66	Columbian Carbon Co. well GW–1087.	0.9 mile north of Tamcliff on Canebrake Branch of Guyandot River, 5,700 ft south of 37°40′ and 12,100 ft west of 81°50′, Stafford District, Mingo County, W. Va.	Samples from Columbian Carbon Co.	403 from Greenbrier limestone after acidizing, 2 pays at 2,473–76 ft (189) and 2,489 ft (215), show at 2,400 ft in Greenbrier.	Producing, Dec. 1948.	858	*L–L′*
67	Columbian Carbon Co. well GW–1096.	2.9 miles southwest of Whitman Junction, 19,800 ft north of 37°45′ and 29 ft east of 82°05′, Holden quadrangle, Logan County, W. Va.	Samples from Columbian Carbon Co.	97 total production from Greenbrier limestone after acidizing: 2,064 ft (23.5), 2,170 ft (100.5), 2,184–91 ft (267); Pocono(?) sandstone, 2,347–57 ft (273); oil show in Greenbrier, 2,048–2,053 ft.	Producing, Nov. 1948.	911	*L–L′*
68	The Watts Land Co. well No. 1 (1047).	0.8 mile north of Jesse on Cabin Branch, 25,200 ft south of 37°45′ and 21,800 ft west of 81°30′, Pineville quadrangle, Wyoming County, W. Va.	Sample log (Martens, 1945, p. 717–723).	Dry and abandoned	Completed, June 1943.	1,548	*C–C′* *K–K′*
69	C. C. Sharp well No. 1 (1046).	On west side of Rockcastle Creek, 2.2 miles north of Pineville, 19,300 ft south of 37°40′ and 12,150 ft west of 81°30′, Pineville quadrangle, Wyoming County, W. Va.	Sample log (Martens, 1945, p. 703–707).	561 after acidizing; pays: Little Lime of drillers, 2,090–92 ft (424 initial); Greenbrier limestone, 2,252–54 ft (445 initial).	Completed, Sept. 1942.	1,426	*K–K′*
70	Gulf Smokeless Coal Co. well No. 1.	0.7 mile north of Mullens and 0.35 mile southeast of Nuriva, 26,900 ft south of 37°40′ and 11,500 ft west of 81°20′, Mullens quadrangle, Wyoming County, W. Va.	Sample log (Martens, 1945, p. 723–727).	60	Completed, Nov. 1940.	1,508	*B–B′*
71	Milams Fork Smokeless Coal Land Co. well No. 13.	1.2 miles southwest of McAlpin, on Mullens Branch, 24,825 ft south of 37°45′ and 10,000 ft west of 81°15′, Mullens quadrangle, Wyoming County, W. Va.	Sample log (Martens, 1945, p. 727–731).	10	Completed, Jan. 1942.	1,820	*B–B′*
72	Wyoming-Pocahontas Coal & Coke Co. well No. 14 (15).	On Laurel Fork 2.7 miles north of Tipple, 15,750 ft south of 37°45′ and 13,700 ft west of 81°25′, Mullens quadrangle, Wyoming County, W. Va.	Sample log (Martens, 1945, p. 732–734).	140 increased from 75, after acidizing with 2,000 gallons in two stages; from Greenbrier limestone, 2,390–95 ft (52), 2,675–80 ft (70); gas shows, 980–83 ft, 2,353–56 ft (10), 2,405–10 ft, 2,375–80 ft (10), and 2,490–94 ft (61).	Completed, Sept. 1942.	1,790	*C–C′*

MEASURED GEOLOGIC SECTIONS

SECTION 5 (HARLAN SECTION)

[Measured 3.5 miles north of Harlan, Ky., on north slope of Pine Mountain along State Route 257; Harlan quadrangle, Harlan County, Ky. See pl. 28]

	Feet
Pottsville formation:	
58. Sandstone, white, stained pink and yellowish brown, subrounded- to subangular-grained, highly crossbedded	Not measured
Bluestone and Bluefield sequence (462+ feet):	
57. Sandstone, grayish-white, thin shale partings, very thin and wavy-bedded, channeled in top	3.0
56. Sandstone, white; subangular medium-grained, thick-bedded and crossbedded; weathers greenish and to rounded surfaces; resistant; channels underlie unit	7.5
55. Sandstone, grayish-white, fine-grained, thin- and wavy-bedded; black shale partings throughout entire unit	29.0
54. Sandstone, grayish-white; weathers to green and light brown; subangular fine-grained; scattered black mineral in one bed; crossbedded, lenticular	4.0
53. Sandstone, grayish-white, very fine grained; very thin wavy-bedded with very thin black shale partings	4.0
52. Sandstone, grayish-white, subangular fine-grained, slightly quartzitic, thin-bedded; breaks angularly	4.5
51. Shale, grayish-black, becoming medium gray upward; weathers greenish gray; contains a few thin ribs of sandy shale; upper foot consists of extremely friable limonitic-stained sandstone which contains scattered impressions of marine fossils (brachiopods and crinoids)	8.5
50. Sandstone, buff and light-gray, subangular fine- and medium-grained, quartzitic; contains shale pebbles from 11.5 to 13.0 feet above base; thin- and medium-bedded, becoming thick bedded above	16.0
49. Sandstone, light-gray, very fine grained; thin wavy-bedded with gray shale partings; 19.5 to 22.0 feet above base contains a dark-gray subangular medium-grained ripple-marked sandstone that weathers yellowish brown	26.5
48. Sandstone, buff and pink, subangular medium-grained, locally fine-grained, slightly quartzitic, crossbedded, massive; consists of three beds separated by slabby shaly sandstone	20.0
47. Sandstone, light-gray, buff, and white; subangular very fine-grained, medium-grained locally; wavy-bedded with thin black shale partings	5.5
46. Siltstone and shale, olive-drab, locally red; contains macerated plant fragments. This is lowest exposure in road cut near top of Pine Mountain	21.0
45. Covered interval	98.0

Bluestone and Bluefield sequence—Continued	Feet
44. Siltstone, greenish-buff, sandy, thin-bedded with very thin shale partings	6.0
43. Sandstone, buff, weathers yellowish brown; subangular fine-grained; contains scattered black mineral; medium- and thick-bedded	20.0
42. Shale, green and dark-gray, slightly silty	8.0
41. Covered interval	73.0
40. Limestone, dark-gray, impure, shaly, fossiliferous	4.0
39. Covered interval	23.0
38. Sandstone, white (with greenish tint locally) and buff; subangular fine-grained; thin-bedded and flaggy	2.5
37. Shale, greenish-yellow to buff, sandy, silty, micaceous; contains macerated plant fragments; wavy-bedded	7.0
36. Shale, light-brown to dark-red, greenish-gray locally	5.5
35. Shale, dark- and some medium-gray; weathers black and orange brown; contains plant fragments locally; sandy, silty	36.5
34. Limestone, dark-gray; weathers buff to yellowish brown; sub- to fine-crystalline with scattered blebs of white calcite as much as 1½ inches in diameter; weathers ribby; very fossiliferous (cephalopods, brachiopods, and crinoids)	4.0
33. Shale, dark-gray, slightly silty locally; weathers greenish and yellowish brown	3.5
32. Limestone, brownish-gray, fine-crystalline, shaly in upper half, fossiliferous (brachiopods and crinoids); slight fetid odor	2.5
31. Shale, dark-gray; sandy in lower 10 feet; 1-foot bed of dark-gray, fossiliferous limestone present 6 feet below top of unit	19.0
30. Covered interval. The contact between Greenbrier limestone and Bluefield formation probably lies within this interval near base	190.0
Greenbrier limestone (291+ feet):	
29. Limestone and calcareous mudstone, light- to medium-gray with tannish tint; weathers ribby; fossiliferous (*Pentremites*, crinoids, and brachiopods), thin-bedded; fetid odor	20.0
28. Limestone with some calcareous mudstone, light- to medium-gray with tannish tint; weathers white and medium gray; fossiliferous, thick-bedded	5.0
27. Limestone and calcareous mudstone, light- to medium-gray with tannish tint, fossiliferous; mudstone weathers greenish yellow and ribby	13.5
26. Limestone, medium-gray and medium grayish-green, subcrystalline, locally coarse-crystalline, fossiliferous (corals and brachiopods), thick-bedded	12.5
25. Limestone or calcareous mudstone, light-gray with yellowish tint, fossiliferous; channeled in top by a grayish-green shale which locally overlies this unit	2.5

Greenbrier limestone—Continued	Feet
24. Limestone, light-gray, becoming dark gray upward; very oolitic, becoming less oolitic upward; slight fetid odor; cavernous	5.0
23. Limestone, dark-gray, coarse-crystalline; oolitic locally, with an oolitic bed from 13 to 15 feet above base; dense to subcrystalline in upper quarter; stylolitic, fossiliferous, massive, cavernous	20.0
22. Limestone, dark-gray; dense, becoming fine crystalline upward; fossiliferous; strong fetid odor; conspicuous bedding plane at top of unit	9.0
21. Mudstone, medium- to dark-gray; dense to subcrystalline with lenses of coarse-crystalline limestone; calcareous, fossiliferous; contains disseminated large green minerals which resemble malachite	6.5
20. Limestone, medium- and dark-gray, and calcareous mudstone, fossiliferous (brachiopods and crinoids), medium-bedded; fetid odor. The base of this unit is 8 feet above third L-shaped culvert uphill from quarry along highway	3.5
19. Limestone, medium-gray with tannish tint, sparsely oolitic; contains large calcite grains throughout; some calcareous mudstone in base; strong fetid odor	11.0
18. Limestone, medium-gray; fine-crystalline, becoming dense upward; sparsely oolitic in lower half, slightly fossiliferous, massive, cavernous; fetid odor; top bedding plane conspicuous	11.0
17. Limestone, medium-gray; dense to subcrystalline, becoming medium crystalline and oolitic upward; massive	3.0
16. Limestone, medium-gray, fine- to coarse-crystalline, oolitic; upper 0.5 to 1.0 foot consists of black carbonaceous calcareous mudstone with small rounded limestone pebbles throughout	2.5
15. Limestone, medium-gray with tannish tint, medium-crystalline to subcrystalline, oolitic, stylolitic, massive to thick-bedded; slight fetid odor in top. Top of unit is 9 feet above second L-shaped culvert uphill from quarry	13.0
Taggard red member (20.5 feet):	
14. Limestone or calcareous mudstone, medium- to dark-gray with strong reddish tint; weathers light green in top; dense to subcrystalline; conchoidal fracture	4.5
13. Limestone, green and red in base, medium-gray with reddish and greenish tints above; coarse-crystalline in base, becoming subcrystalline above; oolitic in base, fossiliferous locally, red-green shale partings, thin- to medium-bedded	9.0
12. Limestone and calcareous mudstone, mottled red and green, dense to coarse-crystalline, fossiliferous, thick-bedded; slight fetid odor	7.0

Greenbrier limestone—Continued	Feet
Base of Taggard red member.	
11. Limestone, light- to medium-gray with tannish tint, medium- to coarse-crystalline, oolitic throughout; weathers to rough ribbed surfaces owing to resistant crinoidal beds; massive, but thin-bedded locally; crossbedded, fossiliferous (*Spirifer*, corals, and crinoids)	20.5
10. Limestone, light- to medium-gray, dense to subcrystalline in base and upper two-thirds and coarse-crystalline and very oolitic from 2.0 to 3.5 feet above base, fossiliferous, massive, cavernous	10.5
9. Limestone, light-gray with slight buff tint, fine-crystalline, becoming medium-crystalline upward, oolitic throughout, fossiliferous (bryozoans, small brachiopods, and crinoids); channeled at top	5.0
8. Limestone, buff and light-gray, subcrystalline and dense, fossiliferous (crinoids), massive and thick-bedded, stylolitic near base, cavernous	5.0
7. Limestone, buff to light-gray with yellowish tint, very oolitic, massive, cavernous; yellowish-brown earthy porous irregular masses on surface of rock locally	26.5
6. Limestone, light-gray, buff, and medium-gray with reddish tint locally, oolitic locally, subcrystalline to fine-crystalline, massive but locally thin-bedded; yellowish-brown earthy porous masses on surfaces locally; fossiliferous (crinoids and brachiopods); top bedding plane stylolitic; fetid odor locally. This unit is present in lower end of quarry.	19.5
5. Limestone, medium-, dark-, and greenish-gray, dense to medium-crystalline; conchoidal fracture; thin- to medium-bedded; weathers ribby; slight fetid odor	12.0
Hillsdale member (33.5 feet):	
4. Limestone, greenish-yellow in base, becoming dark gray above, dense; conchoidal fracture; very cherty, the chert being yellowish brown, bluish black, and locally red and in the form of nodules and 2-inch thick beds; fossiliferous; fetid odor; weathers ribby owing to chert beds	20.5
3. Limestone, medium- to dark-gray with yellowish-brown tint, dense to subcrystalline; three layers of black and yellowish-brown platy chert at base; yellowish-brown chert nodules scattered throughout rock above, evidently having replaced corals and other fossils; very fossiliferous (corals, brachiopods, and crinoids)	9.0
2. Limestone, yellowish-brown, becoming dark gray above; weathers gray to yellowish brown and ribby; dense to subcrystalline; silty, cavernous in base. A spring flows out of this zone	4.0
Maccrady shale:	
1. Siltstone, shaly, and very fine grained sandstone, greenish-yellow, purple, and buff, slightly calcareous, very thin bedded	Not measured.

SECTION 7 (PENNINGTON GAP SECTION)

[Greenbrier limestone measured on northeast side of Pennington Gap; overlying beds measured along railroad on southwest side of gap, except for Princeton sandstone which was measured at water level on northeast side; Nolansburg quadrangle, Lee County, Va. See pl. 28]

	Feet
Pottsville formation:	
111. Sandstone, white, conglomeratic; contains rounded pebbles of quartz as much as three-eighths inch in diameter; very quartzose, massive, crossbedded. Base of unit exposed about 100 feet south of railroad tunnel	Not measured
Pennington group (810.5 feet):	
Bluestone formation (290 feet):	
110. Shale, greenish-gray	3.0
109. Sandstone or sandy siltstone, very fine grained, thin- and medium-bedded, fissile	12.0
108. Shale, greenish-gray; contains 1-foot thick impure coal bed 4.5 to 5.5 feet above base	8.5
107. Siltstone, medium-gray with slight greenish tinge, sandy, shaly, fissile, micaceous	10.0
106. Sandstone, green, very fine grained, very micaceous, silty; thin-bedded in base, thick-bedded upward	4.0
105. Shale, greenish-gray, weathers tannish	1.5
104. Sandstone, green, very fine grained, very micaceous, silty, thick-bedded	5.0
103. Covered interval	7.0
102. Sandstone, buff in base, light-green upward, extremely fine grained, slightly micaceous	23.0
101. Covered interval	216.0
Princeton sandstone (88 feet):	
100. Sandstone, greenish-buff, buff, and brownish-buff, subangular very fine to fine-grained; contains scattered black minerals; thin- to medium-bedded and crossbedded	14.5
99. Sandstone, yellowish-brown, buff, and white, subangular to angular very fine- to fine-grained, medium- to thick-bedded and crossbedded, very porous	9.0
98. Sandstone and interbedded shale, very thin bedded. The sandstone is greenish buff to greenish gray, becoming buff upward; it consists of subangular to subrounded medium to coarse grains	8.0
97. Shale, olive-drab and greenish-gray, laminated, micaceous; contains macerated plant fragments	2.0
96. Sandstone, white but weathers internally to buff and yellowish brown; subangular to subrounded medium- to coarse-grained; contains scattered black minerals; massive, and thick-bedded and crossbedded, resistant	54.5
Hinton formation (432.5 feet):	
Limestone member (Avis limestone of Reger) (67.5 feet):	
95. Covered interval	21.0
94. Shale, gray, calcareous, interbedded with thin limestone beds; fossiliferous (brachiopods); fetid odor	46.5

Pennington group—Continued
Hinton formation—Continued

	Feet
Middle red member (296 feet):	
93. Covered interval	16.0
92. Sandstone, greenish-gray and buff; weathers greenish with streaks of red locally; dirty, micaceous, poorly sorted; thin- and medium-bedded and crossbedded	49.0
91. Covered interval	2.0
90. Sandstone, tan and light-brown, subangular medium-grained, dirty, stained yellowish brown	22.5
89. Covered interval	58.0
88. Sandstone, buff- to yellowish-brown, fine- and medium-grained, slightly dirty, quartzitic, very slightly calcareous, thick-bedded in base, becoming medium bedded upward	13.0
87. Siltstone, light greenish-gray; weathers dark; shaly, sandy, very fissile; wavy- and medium-bedded and crossbedded	15.0
86. Sandstone, buff, fine-grained, quartzitic, medium- and thick-bedded and crossbedded, resistant	24.0
85. Sandstone, thin-bedded; otherwise similar to unit 88	19.0
84. Shale or shaly siltstone, black, thin wavy-bedded	5.5
83. Sandstone, buff to dark-brown, fine-grained, carbonaceous, thin-bedded and crossbedded; weathers reddish brown	2.5
82. Sandstone, buff to red, fine-grained, and black sandy shale	2.0
81. Sandstone, buff, fine-grained, thick-bedded	4.0
80. Sandstone, buff, fine-grained; contains scattered black minerals; weathers rusty to black; thick-bedded and crossbedded, becoming thin bedded upward	6.0
79. Shale, black, sandy; interbedded with light-gray fine-grained wavy-bedded sandstone	2.0
78. Sandstone, light-gray, fine-grained; contains scattered black minerals throughout; black shale parting 1 foot above base	3.5
77. Shale, black, sandy; interbedded with buff to medium-gray thin wavy-bedded sandstone	12.0
76. Sandstone, buff, fine-grained; contains scattered black minerals; interbedded with black sandy shale	4.0
75. Shale, black, white, and red; interbedded with buff to light-gray, mottled yellow and red, thin-bedded sandstone	21.0
74. Sandstone, buff, fine-grained, thin-bedded	3.0
73. Sandstone, light-gray; weathers to yellowish brown and red; fine-grained; contains scattered black minerals; interbedded with carbonaceous laminated shale which weathers locally to red	4.5
72. Sandstone, buff with yellowish tint, fine-grained, carbonaceous; contains scattered black and orange minerals; thin undulating bedding planes; crossbedded	4.0
71. Sandstone, light-gray; weathers brownish orange and red; fine-grained; contains scattered black minerals; thin-bedded and crossbedded; shaly	4.5

	Feet
Pennington group—Continued	
Hinton formation—Continued	
Stony Gap sandstone member (middle Maxton sand of drillers) (69 feet):	
70. Sandstone, dark-buff, thick-bedded and crossbedded	12.0
69. Sandstone, light brownish-buff; contains scattered black and orange minerals; fine-grained; thin wavy-bedded and crossbedded	9.0
68. Sandstone, light-gray; weathers yellowish brown; fine-grained, shaly, micaceous; contains scattered black minerals; very thin bedded	2.0
67. Sandstone, light-buff with some orange streaks, fine-grained; contains scattered black minerals; thick-bedded and crossbedded	46.0
Bluefield formation (359.5 feet):	
66. Sandstone, buff; weathers rusty, yellow, and orange; very fine grained; interbedded with buff shale	2.0
65. Shale, dark- and light-gray; contains carbonaceous plant remains	3.0
64. Shale, buff; weathers orange at base, becoming gray upward; sandy in base	2.5
63. Sandstone, medium-brown, fine-grained; contains scattered black minerals	1.0
62. Shale, light- and medium-gray with slight greenish tint; weathers brownish yellow; laminated	1.0
61. Shale, similar to unit 62 except interlaminated with gray to buff to brown shaly sandstone	2.0
60. Shale, dark-gray	1.5
59. Shale, buff; weathers reddish; finely laminated, sandy	2.0
58. Sandstone, buff, fine- and medium-grained, thin- and wavy-bedded	3.5
57. Sandstone, yellowish-buff, mottled with yellowish brown; weathers yellow or yellowish brown; fine- and medium-grained, thin wavy-bedded	26.0
56. Sandstone, buff to brown; weathers rusty red; fine-grained, thin wavy-bedded	2.0
55. Sandstone, medium-gray, buff, and yellowish-brown; weathers yellowish brown to red; shaly, fine-grained; contains scattered black minerals; thin wavy-bedded	1.0
54. Shale, medium-gray to slight greenish tint, laminated	5.0
53. Sandstone, medium-brown; weathers yellow to red; fine-grained; contains scattered black minerals	.5
52. Covered interval	155.0
51. Limestone, medium- to dark-gray with tannish tint, subcrystalline to fine-crystalline, fossiliferous (brachiopods), thin-bedded	9.5
50. Covered interval	4.0
49. Limestone, medium-gray with tannish tint, subcrystalline to fine-crystalline with scattered large crystals of calcite, oolitic locally, very oolitic in top, fossiliferous, thin- to medium-bedded	21.0

	Feet
Bluefield formation—Continued	
48. Limestone, tan with yellowish tint; weathers yellowish brown and ribby; subcrystalline to fine-crystalline with large white calcite crystals; fossiliferous (crinoids), thin-bedded	4.0
47. Mudstone, tan with greenish tint, calcareous; weathers to rounded surfaces	1.0
46. Covered interval	1.0
45. Mudstone, light brownish-yellow, calcareous; weathers to rounded surfaces; poorly exposed	1.0
44. Covered interval	49.5
43. Shale, dark-brown, calcareous, with several thin interbeds of medium-gray coarse-crystalline highly fossiliferous limestone	11.0
42. Covered interval	47.0
41. Limestone, dark-gray with tannish tint, subcrystalline to fine-crystalline, fossiliferous, thin-bedded	1.5
40. Covered interval	1.0
Greenbrier limestone (359 feet):	
39. Limestone, light- to medium-gray with slight tannish tint, fine-crystalline, oolitic locally, fossiliferous, thin-bedded	3.5
38. Covered interval	2.0
37. Limestone, similar to unit 39	15.0
36. Limestone, light- to medium-gray with tannish tint, subcrystalline to medium-crystalline, oolitic, fossiliferous, massive	12.5
35. Limestone or calcareous mudstone, light- to medium-gray with tannish tint, dense, fossiliferous, thin-bedded	14.0
34. Limestone, medium-gray with tannish tint, dense to subcrystalline with some large tan calcite crystals; conchoidal fracture, medium-bedded	1.0
33. Limestone, similar to unit 34	2.5
32. Limestone, light-gray with tannish tint, fine- to medium-crystalline, oolitic, fossiliferous; contains scattered black and orange minerals	18.5
31. Limestone, medium-gray with tannish tint, subcrystalline to fine-crystalline, oolitic, fossiliferous; contains scattered orange and black minerals; slight fetid odor, resistant	2.0
30. Limestone, tan and medium-gray, dense to subcrystalline, micaceous, thin-bedded	6.0
29. Limestone, medium-gray with strong tannish tint, dense to subcrystalline, oolitic locally, fossiliferous, thin-bedded	9.0
28. Limestone, medium- to dark-gray, subcrystalline to medium-crystalline; sparsely oolitic in base, very oolitic in top; fossiliferous (crinoids and brachiopods); thick-bedded, becoming thin bedded upward	16.5
27. Limestone, medium- to dark-gray with slight tannish tint, fine- to medium-crystalline, fossiliferous, massive; slight fetid odor	7.5

Greenbrier limestone—Continued	Feet
26. Limestone, medium- to dark-gray, brownish-red in lower half, subcrystalline to fine-crystalline; conchoidal fracture, fossiliferous (brachiopods), thin-bedded; slight fetid odor	5.0
25. Limestone, medium- to dark-gray with tannish and sometimes a tannish-red tint, dense, locally subcrystalline; black, brown, and reddish-brown thin calcareous-shale partings; laminated conchoidal fracture; slightly fossiliferous	24.0
24. Limestone, medium- to dark-gray with tannish tint, fine- to medium-crystalline, upper 5 feet oolitic; fossiliferous (crinoids and brachiopods), thin-bedded; fetid odor	17.5
23. Limestone or calcareous mudstone, medium-gray with tannish tint, mostly dense; conchoidal fracture, fossiliferous (crinoids), thin-bedded; slight fetid odor; cavernous at base	16.0
22. Limestone, light- to medium-gray, dense to fine-crystalline, fossiliferous, slightly oolitic; strong fetid odor; crude oil noted in fracture near top	8.5
21. Limestone, light-gray with tannish tint, becoming medium gray upward, subcrystalline to medium-crystalline, oolitic in some beds, medium-bedded; fetid odor	15.0
20. Limestone, light-gray with tannish tint, subcrystalline, stylolitic; bedding planes pitted and knobby; thick-bedded; fetid odor	5.0
19. Limestone, light-gray with tannish tint, dense to subcrystalline; contains scattered black minerals; stylolitic, numerous solution pits, fossiliferous, thin-bedded	3.5
18. Limestone, tan to light-gray, dense to subcrystalline; bedding planes knobby and pitted; sparsely fossiliferous, thin-bedded	18.5
17. Limestone, light to medium tannish-gray, dense to subcrystalline; contains scattered black minerals; nonresistant; slight fetid odor	6.0
16. Limestone, light to medium tannish-gray, dense to medium-crystalline, oolitic in top, fossiliferous (*Spirifer* and crinoids), thin-bedded; fetid odor	20.5
15. Limestone, light-gray with tannish tint; weathers light yellowish gray; dense to subcrystalline, thin-bedded	2.5
14. Limestone, light- to medium-gray with tannish tint, medium-crystalline, very oolitic, fossiliferous, massive	1.5
13. Limestone, medium-gray with tannish tint; weathers yellowish brown; dense to subcrystalline; conchoidal fracture, muddy; thick-bedded, becoming thin bedded upward	6.0
12. Limestone, light- to medium-gray with tannish tint; fine-crystalline, becoming medium crystalline upward; oolitic, fossiliferous (crinoids and bryozoans); conchoidal fracture, massive; slight fetid odor	12.0

	Feet
Greenbrier limestone—Continued	
11. Limestone, medium-gray with tannish tint, dense to subcrystalline, fossiliferous, thin-bedded; weathers to rounded surfaces; slight fetid odor	11.0
10. Covered interval	5.5
9. Limestone, light-gray, subcrystalline to fine-crystalline, very fossiliferous (*Spirifer*), thin-bedded and slabby	.5
8. Covered interval	5.5
7. Limestone, medium-gray with tannish tint, dense and medium-crystalline with scattered oolites near top; conchoidal fracture, fossiliferous (crinoids), thin- to medium-bedded; slight fetid odor	5.5
Taggard red member (4 feet):	
6. Limestone or calcareous mudstone, red and green, interbedded with medium gray; subcrystalline to fine-crystalline, laminated and thin-bedded	4.0
Base of Taggard red member.	
5. Limestone, light- to medium-gray with tannish tint, dense to subcrystalline; contains scattered black mineral; fossiliferous; conchoidal fracture, thin-bedded	3.0
4. Limestone, light- to medium-gray with slight yellowish-tan tint, fine- to medium-crystalline, oolitic, fossiliferous, thin-bedded; fetid odor	29.5
Hillsdale member (23 feet):	
3. Limestone, yellowish brownish-gray, becoming medium gray upward; contains scattered green (glauconite?) and black minerals and nodules of light-tan, red, medium-gray, and bluish-black chert; conchoidal fracture, fossiliferous, thin- to medium-bedded; fetid odor	23.0
Maccrady shale:	
2. Covered interval	1.0
1. Sandstone, red, becoming greenish yellow upward, shaly, micaceous; thin platy beds	Not measured

SECTION 8 (HURRICANE GAP SECTION)

[Measured on the north slope of Pine Mountain about 2 miles west and slightly north of Cumberland, Va., at Hurricane Gap along State Route 463, Nolansburg quadrangle, Letcher County, Ky. See pl. 28]

	Feet
Pottsville formation:	
82. Sandstone, white, conglomeratic, massive, crossbedded, resistant	Not measured
Pennington group (566.7 feet):	
Bluestone formation (228.2 feet):	
81. Sandstone, buff to yellowish-brown, subrounded medium-grained, thin-bedded and crossbedded	4.0
Coal, shaly	.2
79. Sandstone, light-buff; dark greenish gray near top; mottled buff and purplish-black stains in upper 1.5 feet; subangular fine-grained, micaceous; contains scattered black minerals, flaggy, thin-bedded and crossbedded	8.5

Pennington group—Continued

Bluestone formation—Continued

	Feet
78. Covered interval	20.0
77. Sandstone, light-gray, locally mottled yellowish brown, very fine grained; contains plant impressions locally; silty, friable, medium-bedded	8.0
76. Siltstone, light-gray, shaly; includes thin beds of fine-grained silty sandstone and greenish-buff mudstone which locally contains carbonaceous plant fragments. At 31.0 feet above base a 2-inch black carbonaceous coaly layer is present	33.5
75. Siltstone, shaly; yellowish-green and maroon-red mudstone from 8 to 10 feet above base. Poorly exposed	41.0
74. Siltstone, yellow with light-green tint, slightly sandy, friable, thin-bedded, shaly, micaceous	4.0
73. Mudstone, maroon-red in top and bottom, yellowish-green between; and friable siltstone	7.5
72. Siltstone, yellowish-green, buff and grayish-green locally, friable, micaceous, shaly, some muddy and sandy interbeds, 1-foot bed of red shale from 5 to 6 feet below top; channeled in top; nonresistant	41.0
71. Shale, red, mottled yellowish green locally, friable. Poorly exposed	13.0
70. Siltstone, yellowish-brown, green locally, sporadically sandy, black shale partings, thin- to medium-bedded, slightly resistant	9.0
69. Mudstone, yellowish-green to greenish-gray, red locally; thin sandstone beds locally	11.5
68. Siltstone, yellowish-green, sandy, micaceous, slightly fissile; contains macerated plant remains locally	9.0
67. Shale, red and yellowish-green, silty locally	7.0
66. Shale, red in base, alternating red and yellowish green above; some siltstone in base	11.0

Princeton sandstone (47 feet):

65. Sandstone, gray with greenish tint, greenish yellow upward, very fine grained, silty, micaceous; contains macerated plant fragments; thick-bedded, becoming thin- to medium-bedded upward	13.0
64. Sandstone, medium-gray with greenish and buff tints, subangular fine-grained; contains scattered black minerals; quartzitic, resistant, thick-bedded	2.0
63. Sandstone, medium-gray with greenish tint at base, changing upward to yellowish green, subangular fine-grained, dirty; contains scattered black and reddish-brown minerals; medium-bedded; channeled by overlying unit	20.0
62. Sandstone, gray with strong greenish-yellow tint, bluish-gray locally, subangular very fine grained, micaceous; thin- to medium- and wavy-bedded with black shale partings in thin-bedded part	12.0

	Feet
Pennington group—Continued	
Hinton formation (291.5 feet):	
Limestone member (Avis limestone of Reger) (45 feet):	
61. Shale, greenish-yellow, green, bluish-gray, and black, calcareous; contains scattered brachiopods locally. A 1-foot bed of black, very impure slightly fossiliferous limestone is present from 4.5 to 5 feet below top	45.0
Middle red member (100 feet):	
60. Shale; greenish-yellow, green, bluish-gray, and black siltstone locally	97.0
59. Covered interval	3.0
Stony Gap sandstone member (middle Maxton sand of drillers) (146.5 feet):	
58. Sandstone, buff in base, light yellowish green above, very fine and fine-grained; contains scattered black minerals; micaceous, thin- and wavy-bedded	20.0
57. Sandstone, light- to medium-gray, finely laminated, micaceous, flaggy, wavy-bedded with light-gray to black sandy shale partings	3.0
56. Sandstone, buff with some light-gray, subangular very fine to fine-grained, flaggy in base, thin- to medium-bedded upward, crossbedded, micaceous	19.0
55. Sandstone, light-gray, subangular fine-grained, micaceous, thick- to thin-bedded and crossbedded, occasional thin shale partings	20.0
54. Sandstone, gray, fine-grained, thin- and wavy-bedded with shale partings	2.5
53. Sandstone, buff to light-gray, subangular to subrounded fine-grained, thin- to medium-bedded and crossbedded, some black and light-gray shale partings	5.0
52. Sandstone, similar to unit 54	7.5
51. Sandstone, light-buff to mottled buff and grayish-brown, becoming light gray in top; subangular fine- to medium-grained; contains scattered black minerals; micaceous, thin-bedded and crossbedded; gray shale zones locally	18.0
50. Sandstone and sandy shale, buff and green, thin bluish-black shale partings (glauconite?), thin-bedded and crossbedded	6.5
49. Sandstone, shale, and sandy shale, light- and dark-gray, wavy- and thin-bedded; angular fine-grained. Sand is purer than in underlying units. Sandstone and shale pebbles in base	21.0
48. Sandstone, greenish-buff to greenish-gray, very fine grained, laminated, thin- to thick-bedded; crossbedded in middle; resistant; channeled in top	24.0
Bluefield formation (223.5 feet):	
47. Shale, light-gray, green, yellowish-brown, and locally reddish; weathers light grayish green and yellowish brown; sandy locally	7.5
46. Mudstone, green to greenish-yellow; weathers yellowish brown to black; micaceous, laminated	7.0

	Feet
Bluefield formation—Continued	
45. Sandstone, buff and greenish-gray, subangular very fine to fine-grained; greenish pebbles in base; contains scattered black minerals; micaceous, laminated, thin-bedded	2.0
44. Sandstone, buff to greenish-gray; contains macerated plant stems; fine-grained; contains sandy shaly zones	12.0
43. Sandstone, buff, micaceous, medium-grained, thick-bedded	3.0
42. Sandstone and sandy shale, buff to green, subangular very fine to medium-grained; glauconitic(?), thin- and wavy-bedded	13.0
41. Covered interval	24.0
40. Shale, gray, laminated	13.0
39. Covered interval	142.0
Greenbrier limestone (375 feet):	
38. Limestone, dark-gray; subcrystalline at base, medium-crystalline above; contains scattered black calcite crystals; fossiliferous (corals, *Dictyoclostus*, *Composita*, crinoids); a few smoky chert nodules in top; thin-bedded, slabby	10.0
37. Limestone, medium-gray, buff tint locally, fine-crystalline; scattered oolites; very fossiliferous (crinoids, brachiopods), massive; slight fetid odor	3.0
36. Limestone, light- to medium-gray with slight greenish tint; oolitic in lower half, subcrystalline above; very fossiliferous (bryozoans and crinoids), thin-bedded	3.0
35. Limestone, dark-gray and green in base, reddish-brown and yellowish-green above; dense and fine-crystalline, muddy, fossiliferous (brachiopods and bryozoans), shaly, thin-bedded	2.0
34. Limestone, dark-gray with greenish tint locally, subcrystalline; weathers light greenish gray and platy; nonresistant	4.5
33. Limestone, dark-gray with tannish tint; dense to subcrystalline and oolitic locally in basal 10 feet, medium-crystalline above, extremely oolitic in top 2 feet; very fossiliferous (crinoids, *Composita*, *Spirifer*); fetid odor; thin-bedded; weathers ribby. Upper half measured in small quarry	42.0
32. Limestone, medium-gray with tannish tint, dense to subcrystalline, crinoidal, fractured, fossiliferous; thin-bedded and stylolitic in base, massive above	5.0
31. Limestone, dark-gray, medium-gray upward; oolitic in base and extremely oolitic in top; contains scattered black minerals; upper bedding plane stylolitic; massive	13.0
30. Limestone and calcareous mudstone, green to yellowish-green, mottled locally with reddish purple; calcite veins throughout; subcrystalline, friable; very slight fetid odor	3.0

Greenbrier limestone—Continued	Feet
29. Limestone, medium- to dark-gray with tannish tint, subcrystalline and medium-crystalline; contains scattered black minerals and large calcite grains; oolitic, fossiliferous, medium-bedded and crossbedded	37.0
28. Limestone, medium to dark tannish-gray, locally muddy, dense to fine-crystalline, oolitic, thin- to medium-bedded, slight fetid odor; channeled slightly in top	2.5
27. Limestone, medium-gray with tannish tint, greenish-yellow laminae upward, fine- to coarse-crystalline, locally oolitic; thin-bedded, becoming massive upward; fetid odor locally	24.0
26. Limestone, dark-gray, fine-crystalline, oolitic; contains seams of black material (asphaltic?); calcareous mudstone in top; medium-bedded and crossbedded; weathers ribby; fetid odor	15.0
25. Limestone, medium- to dark-gray with tannish tint, subcrystalline to medium-crystalline, oolitic, fossiliferous; slight fetid odor, massive	8.0
24. Limestone, dark-gray, fine- to medium-crystalline, fossiliferous, thin-bedded; weathers ribby and yellowish brown	3.0
23. Limestone, medium- to dark-gray, greenish-purple from 10 to 11 feet above base; dense to subcrystalline in base, medium- to coarse-crystalline above; oolitic, fossiliferous; thin-bedded, becoming massive upward	22.0
22. Limestone, medium-gray, oolitic, medium-bedded; weathers yellowish brown; slight fetid odor	5.0
21. Limestone, medium-gray, strong tannish tint locally, dense to subcrystalline, oolitic locally, thin- to medium-bedded; conchoidal fracture, cavernous; slight fetid odor	22.0
20. Limestone or calcareous mudstone, greenish-gray and purple, subcrystalline to fine-crystalline, stylolitic in top, slight fetid odor	1.0
19. Limestone, medium-gray with tannish tint, dense, locally subcrystalline; very oolitic in base, slightly oolitic upward; medium-bedded in lower half, massive upward; cavernous	14.5
Taggard red member (18.5 feet):	
18. Limestone and calcareous mudstone, green and red, oolitic, dense in top, laminated; slight fetid odor	4.5
17. Limestone, medium-gray with slight tannish tint, fine- to medium-crystalline, oolitic; contains scattered dark-gray calcite grains; thin-bedded and crossbedded; slight fetid odor	4.0
16. Limestone, purplish-red and greenish-yellow, silty, thin-bedded; fetid odor	6.0
15. Limestone or calcareous mudstone, light-gray with yellowish tint, subcrystalline; conchoidal fracture	4.0

	Feet
Greenbrier limestone—Continued	
Base of Taggard red member.	
14. Limestone, medium-gray with tannish tint, locally greenish, fine- to medium-crystalline, oolitic, fossiliferous; conchoidal fracture, thin-bedded to massive	23.0
13. Limestone, medium-gray with tannish tint, locally greenish; disseminated red chert fragments and fossil replacements throughout; coarse-crystalline; includes some calcareous mudstone laminae; fossiliferous, medium-bedded, cavernous; slight fetid odor	5.5
12. Limestone, dark-gray with greenish-gray mudstone in base, coarse-crystalline; bed of brownish-red chert in middle; slight fetid odor	1.5
11. Limestone, medium-gray with tannish tint, locally greenish; subcrystalline to fine-crystalline in base, coarse-crystalline upward; medium-bedded; thin-bedded in top, with green shale partings; slight fetid odor	15.5
10. Limestone, light- to medium-gray with tannish tint; mostly very oolitic, but sparsely oolitic in top; fossiliferous (brachiopods, bryozoans), massive, cross-bedded	31.0
Hillsdale member (26.5 feet):	
9. Limestone, light-gray with yellowish-tannish tint, subcrystalline and fine-crystalline; contains bluish-white chert nodules and coral replacements; fossiliferous	10.0
8. Limestone, light-gray with slight tannish tint, subcrystalline to fine-crystalline; contains scattered calcite crystals, and numerous yellowish-brown chert nodules; conchoidal fracture, stylolitic in top	11.0
7. Dolomite, light-gray with yellowish tint, subcrystalline to fine-crystalline; conchoidal fracture; locally contains white and reddish-brown quartz nodules and stringers; medium-bedded	5.5
Base of Hillsdale member.	
6. Limestone, medium-gray with slight tannish and greenish tints, subcrystalline to fine-crystalline; contains scattered black minerals; conchoidal fracture, massive	5.0
5. Limestone, medium-gray to brownish-yellow; weathers yellow to yellowish brown; subcrystalline; contains scattered green minerals (glauconite?) and crystals of dark-gray calcite; stylolitic, fossiliferous; medium- to thick-bedded; channeled in top	9.0
Maccrady shale (106.5± feet):	
4. Mudstone, red and green	.5
3. Siltstone, variegated, sandy	4.0
2. Siltstone, red, mottled with grayish green, slabby	2.0
1. Sandstone and siltstone, dark-gray, red, and greenish-yellow, glauconitic, thin- to medium-bedded	±100.0

SECTION 13 (LITTLE STONE GAP SECTION)

[Measured along State Route 610, Little Stone Gap, Wise quadrangle, Wise County, Va. See pl. 28]

	Feet
Pottsville formation:	
134. Sandstone, white, very slightly conglomeratic, medium- and coarse-grained, crossbedded, very resistant	Not measured
Pennington group (1416.5 feet):	
Bluestone formation (692 feet):	
Upper member (279.5 feet):	
133. Covered interval. Abandoned prospect pit in lower part of interval in which a 24-inch coal bed is exposed	50.0
132. Sandstone, light-gray and greenish-gray, very fine and fine-grained, micaceous, dirty, light-gray sandy shale partings, thin-bedded, flaggy	19.0
131. Shale, light-green; weathers yellowish brown. Poorly exposed	5.0
130. Sandstone, olive-drab, fine-grained, dirty, micaceous, very thin bedded and crossbedded, flaggy	6.0
129. Shale, olive-drab and greenish-gray, sandy, silty. Poorly exposed	10.0
128. Sandstone, light-gray with slight greenish tint, fine-grained, very micaceous, slightly dirty; weathers yellowish brown with local reddish tints; massive, crossbedded, resistant	7.0
127. Shale, grayish-black, very fissile	5.0
126. Sandstone, white, very thin and wavy-bedded; interbedded with grayish-black beds and films of shale; entire unit weathers greenish and yellowish brown and contains black macerated plant fragments	5.5
125. Shale, dark-gray; contains thin coaly seams 1.5 feet above base; weathers bluish gray, mottled red, and yellowish brown; thin beds of micaceous sandstone in upper 3 feet	8.0
124. Sandstone, light-green, very fine grained, silty, micaceous, sandy shale partings, very thin bedded	14.0
123. Sandstone, buff, locally greenish-yellow; subangular medium- to coarse-grained; micaceous, thick-bedded, resistant. Exposed on highway opposite modern country home	18.0
122. Covered interval	57.0
121. Shale, olive-drab and greenish-gray, silty, sandy. Exposed in bottom of ditch	33.0
120. Sandstone, light-brown with greenish tint; angular and very fine grained; silty, dirty; thin- and wavy-bedded; grades upward into overlying unit	15.0
119. Shale, grayish-green. Poorly exposed in ditch	27.0
Red member (49 feet):	
118. Shale, maroon-red	5.0
117. Sandstone, olive-drab, very fine grained, micaceous locally, very thin and wavy-bedded	10.0

	Feet
Pennington group—Continued	
Bluestone formation—Continued	
Red member—Continued	
116. Covered interval	24.0
115. Shale, maroon-red	2.0
114. Siltstone, olive-drab, shaly, sandy	2.0
113. Shale, maroon-red	6.0
Gray shale member (363.5 feet):	
112. Sandstone, yellowish-brown, very fine grained, micaceous, silty. Exposed in ditch	8.0
111. Covered interval	144.5
110. Sandstone, buff, subangular medium-grained, medium-bedded, becoming thin bedded upward, porous; contains scattered black minerals; crossbedded, resistant	34.5
109. Covered interval	7.0
108. Sandstone, buff with greenish tint, subangular medium-grained, micaceous, medium- and thin-bedded. Exposed in old road below new highway	22.5
107. Covered interval	71.0
106. Shale, light-gray and grayish-black, interbedded	24.0
105. Covered interval	25.0
104. Shale, similar to unit 106	6.0
103. Covered interval	21.0
Princeton sandstone (144 feet):	
102. Sandstone, buff, subangular to medium-grained; contains scattered black minerals; slightly micaceous, porous, thick-bedded and crossbedded, resistant	33.5
101. Sandstone, white and buff; weathers reddish brown, yellowish brown, light gray, and pink; subangular fine-grained; very thin bedded, black shale partings throughout	32.0
100. Shale; probably was olive drab; weathers to light yellowish brown; fracture and bedding surfaces stained black. Exposed in ditch	5.5
99. Covered interval	15.0
98. Sandstone, buff and white; weathers pink locally; subangular medium-grained; contains scattered black minerals; porous, thick-bedded and crossbedded, very resistant	38.0
97. Sandstone and conglomerate white and buff, subangular medium- to coarse-grained; contain well-rounded quartz conglomerate from 6.5 to 9.0 feet above base; massive, crossbedded, conglomeratic throughout, very resistant	20.0
Hinton formation (580.5 feet):	
Limestone member (Avis limestone of Reger) (22+ feet):	
96. Shale, light greenish-yellow, silty; weathers light yellowish brown and yellow with yellowish-brown stains on bedding surfaces; fossiliferous (masses of fenestellid fronds with some brachiopods); is no longer calcareous due to leaching. The base of this member is apparently within the underlying covered interval	22.0

Pennington group—Continued

Hinton formation—Continued

	Feet
Middle red member (326.5– feet):	
95. Covered interval	47.5
94. Shale, olive-drab and greenish-yellow; weathers yellow and yellowish brown; silty, sandy. Exposed in ditch	30.0
93. Sandstone, buff, subangular medium- to coarse-grained, fine-grained locally, micaceous; contains plant fossils locally; soft shaly sandstone from 10.0 to 11.0 feet above base; medium-bedded, becoming thin bedded upward; crossbedded	31.0
92. Sandstone, black owing to abundance of black material (asphaltic?) in the interstices between grains; medium- to coarse-grained, soft and friable, massive, nonresistant	3.5
91. Sandstone, buff, angular fine- and medium-grained, very micaceous, medium-bedded and crossbedded	3.0
90. Shale, greenish-yellow with red and black films on bedding and fracture surfaces, silty, sandy, micaceous	3.5
89. Sandstone, buff, very fine to coarse-grained (poorly sorted); very micaceous, friable, porous; contains scattered black minerals; weathers brownish black. Poorly exposed	4.0
88. Sandstone, similar to unit 89. Poorly exposed in lower 7.5 feet	10.5
87. Sandstone, buff; weathers brown and black; contains limonitic concretions; subangular and subrounded medium- to coarse-grained	1.5
86. Covered interval	9.0
85. Sandstone, similar to unit 87; contains elongate shale pebbles	1.5
84. Covered interval	4.0
83. Sandstone, buff; fine-grained in base, subangular medium- to coarse-grained above; micaceous, porous; thin-bedded in base, medium-bedded above	19.5
82. Silty shale and shaly siltstone; olive-drab; weather greenish yellow with red, brown, and black films on fracture and bedding surfaces; silty fine-grained micaceous sandstone in top. Poorly exposed in ditch	42.0
81. Covered interval	116.0
Stony Gap sandstone member (middle Maxton sand of drillers) (232 feet):	
80. Sandstone, buff; subangular medium-grained; contains scattered black minerals; micaceous, porous, thin- and wavy-bedded. Exposed in road cut opposite small country store	15.0
79. Sandstone, buff; subangular medium-grained; contains abundant scattered black minerals; micaceous, very porous, medium-bedded, resistant	14.0
78. Covered interval	3.5
77. Sandstone, buff; stained yellowish brown, black, and green; subangular fine- to medium-grained; micaceous, porous, massive	7.0

Pennington group—Continued
Hinton formation—Continued
Stony Gap sandstone member—Continued

	Feet
76. Sandstone, buff; weathers pink; micaceous, slabby, thin- and wavy-bedded, nonresistant	2.5
75. Sandstone, buff, with slabby partings of fine-grained sandstone; contains scattered black minerals; micaceous; weathers greenish; porous	2.5
74. Sandstone, similar to unit 76	7.0
73. Sandstone, similar to unit 75	25.5
72. Sandstone, buff; weathers pink locally and greenish with black manganiferous stains; subangular medium-grained, locally fine- or coarse-grained; contains scattered black minerals; micaceous, porous, thick-bedded	11.5
71. Covered interval	6.0
70. Sandstone, buff with tannish tint; weathers green with black films on surface of rock; subangular medium-grained; slightly micaceous, porous, thick-bedded	3.5
69. Covered interval	27.0
68. Sandstone, white with pinkish tint; angular fine- to medium-grained; contains scattered black minerals; micaceous	2.0
67. Covered interval; probably underlain by green subangular fine- to medium-grained sandstone	4.0
66. Sandstone, buff becoming white upward; weathers green and yellowish brown with black stains; fine- and medium-grained, porous; thin-bedded, becoming medium bedded upward	7.5
65. Sandstone, buff, white locally, subangular medium-grained; contains scattered black minerals; micaceous, slightly quartzitic locally, thick-bedded and highly crossbedded, thin-bedded locally, ripple-marked, resistant	58.0
64. Sandstone, white, locally buff, subangular to subrounded medium-grained, locally coarse-grained, thin- and medium-bedded, crossbedded, somewhat slabby, ripple-marked, porous, quartzose, resistant. Lower beds of this unit exposed in bend of highway at crest of mountain	35.5
Bluefield formation (449 feet):	
63. Shale and siltstone, greenish-yellow and olive-drab; contain two beds of very fine grained greenish-yellow silty micaceous sandstone in base and from 4.5 to 5.5 feet above the base	12.0
62. Shale and shaly and sandy siltstone, light-yellow with greenish tint. Exposed in highest road cut in Little Stone Gap on the Powell Valley side	24.0
61. Covered interval	44.0
60. Shale; deeply weathered to light yellow and medium gray; probably was greenish gray originally; well-laminated	26.0

	Feet
Bluefield formation—Continued	
59. Covered interval	32.0
58. Siltstone, greenish-yellow, shaly, sandy; weathers yellowish on outcrop; red and black films on fracture and bedding surfaces and red zone from 17 to 18 feet above base; sandy in upper half	21.0
57. Covered interval	76.5
56. Shale and silty or shaly siltstone, yellowish-brown, fissile; numerous black films on bedding surfaces	21.0
55. Siltstone, greenish-yellow, very fossiliferous (abundant fenestellid bryozoa, brachiopods, crinoids)	31.0
54. Covered interval	23.0
53. Siltstone, greenish-yellow, shaly, black and red films on bedding surfaces; deeply weathered	45.0
52. Covered interval	80.5
51. Shale, olive-drab, silty, very fissile	11.0
50. Siltstone, olive-drab, shaly, highly calcareous. Poorly exposed	2.0
Greenbrier limestone (495 feet):	
49. Limestone, dark-gray; shaly partings, thin-bedded	4.0
48. Limestone, medium-gray, mottled with greenish gray; dense, scattered smoky and green calcite crystals; weathers white and knobby; medium-bedded; very slight fetid odor	9.5
47. Covered interval	11.0
46. Limestone, medium-gray; weathers grayish white; dense, thick-bedded; knobby surfaces, slight fetid odor	2.0
45. Covered interval; probably underlain by limestone	4.5
44. Limestone, grayish-black with greenish tint; weathers yellowish green; dense, very thin bedded; shaly partings, fetid odor	2.0
43. Limestone, grayish-black, muddy, shaly, dense, very fossiliferous (crinoids, brachiopods, *Pentremites*, corals); thin- and medium-bedded with shaly limestone or limy shale partings which weather to yellow; fetid odor	11.0
42. Limestone, medium-gray; very oolitic in base, becoming dense upward with scattered calcite crystals; very fossiliferous (*Pentremites*, corals, brachiopods), with red hematitic material locally replacing fossils; abundance of soft yellowish-brown irregular nodular earthy masses in upper 4 feet; medium-bedded, becoming thick bedded upward	11.5
41. Limestone, grayish-black, medium-gray upward; weathers distinctively yellow in top; dense with scattered bluish-gray and smoky calcite crystals; very fossiliferous (brachiopods, crinoids); medium-bedded; fetid odor. This is highest stratigraphic interval exposed in abandoned quarry on old road	6.0

Greenbrier limestone—Continued

		Feet
40.	Limestone, grayish-black, dense to subcrystalline, stylolitic(?), fossiliferous, thick-bedded, thin-bedded locally; fetid odor. Exposed in face of quarry	21.5
39.	Limestone, dark-gray to grayish-black, fine-crystalline; weathers yellow, green, and gray; thin- and medium-bedded with shaly and fissile limestone partings	21.5
38.	Limestone, dark-gray, becoming medium gray upward, fine-crystalline, highly oolitic in upper 5 feet, massive with some lamination visible in oolitic part, stylolitic, fossiliferous; slight fetid odor	20.0
37.	Limestone, dark-gray, medium-crystalline, small amounts of yellowish-green muddy limestone in top and bottom, slightly fossiliferous, massive; fetid odor; separated from overlying unit by thin greenish-gray calcareous shale partings	8.5
36.	Limestone, black; contains muddy limestone partings which weather greenish yellow; sub- to fine-crystalline, fossiliferous, thin-bedded; slight fetid odor	10.0
35.	Limestone, black, dense, thin-bedded with shaly limestone partings in base; weathers massive above; fossiliferous; slight fetid odor	10.0
34.	Limestone, grayish-black; weathers bluish gray and grayish black; dense, fossiliferous; shaly limestone partings in lower half; medium-bedded, becoming thick bedded upward	10.0
33.	Limestone, medium- to dark-gray with greenish-yellow partings, grayish-black upward, subcrystalline, thin- and medium-bedded, cavernous; fetid odor	25.5
32.	Limestone, dark-gray, suboolitic and fine- to medium-crystalline, fossiliferous; greenish-yellow, muddy limestone partings; weathers to rounded surfaces; fetid odor	9.5
31.	Limestone, light-gray with tannish tint; weathers yellow; two thin shaly partings; fossiliferous	2.0
30.	Limestone, dark-gray, medium-gray locally, slightly oolitic and subcrystalline with some very oolitic zones, fossiliferous, thick-bedded, crossbedded locally; breaks hackly; fetid odor	24.0
29.	Limestone, dark-gray, medium-gray locally, very oolitic, crossbedded	24.0
28.	Limestone, light-gray with slight greenish tint; weathers yellow, yellowish brown, and dirty gray; very silty and shaly; nonresistant; slight fetid odor	8.0
27.	Limestone, medium- to dark-gray, oolitic, fossiliferous, thick-bedded; fetid odor	4.5
26.	Limestone, medium-gray, subcrystalline with scattered oolites, very thin yellowish-weathering shaly limestone partings, slightly fossiliferous, thin-bedded; fetid odor	9.0
25.	Limestone, medium-gray, oolitic, thick-bedded, fossiliferous; slight fetid odor	11.0

	Feet
Greenbrier limestone—Continued	
24. Limestone, medium-gray, dense to subcrystalline; contains numerous shaly silty yellowish-weathering limestone partings; fetid odor	4.5
23. Limestone, medium-gray, dense and subcrystalline with scattered oolites, fossiliferous, thick-bedded, thin-bedded locally; slight fetid odor	18.0
22. Limestone, similar to unit 24	4.0
21. Limestone, light-gray; weathers dirty gray; dense, grading upward through slightly oolitic to highly oolitic in top; fossiliferous, stylolitic; thin irregular black seams (asphaltic?) filling fractures in upper half of unit; medium-bedded, thick-bedded upward; separated from overlying unit by 3-inch thick shaly silty limestone parting	17.5
20. Limestone, yellow and medium-gray; weathers distinctively yellowish; very silty, subcrystalline; conchoidal fractures; weathers spheroidally; contains brown sphalerite-like minerals locally	3.0
19. Limestone, medium-gray, very oolitic locally, dense, very fossiliferous; appears massive but probably is laminated; weathers to rounded surfaces; strong fetid odor	14.0
Taggard red member (35.5 feet):	
18. Limestone, yellowish-green in base, red above, becoming medium gray with slight greenish tint in top, silty, laminated; weathers finely ribby, owing to the laminae, and spheroidally	9.0
17. Limestone, similar to unit 19	16.5
16. Limestone, purplish-red, becoming light gray with slight greenish tint upward, muddy, silty, fossiliferous; conchoidal fracture; weathers spheroidally; thick-bedded; slight fetid odor	10.0
Base of Taggard red member.	
15. Limestone, light-gray, dense; scattered oolites toward top; fossiliferous, thick- and medium-bedded; fetid odor; channeled by overlying unit	15.0
14. Limestone, black, consists of oolites in a soft black matrix (asphaltic?); weathers dirty gray; massive. Units 10–14 were measured in quarry on Virginia Route 610; unit 14 is highest bed exposed in top of this quarry	5.5
13. Limestone, light-gray, very oolitic, crossbedded, fossiliferous; weathers massive; very strong fetid odor	22.0
12. Limestone, light-gray with tannish tint, subcrystalline to dense; one bed which weathers yellowish to grayish black contains scattered crystals of colorless calcite; silty; conchoidal fracture; upper contact stylolitic, dolomitic in lower half	5.0
11. Limestone, light-gray with tannish tint, fine-crystalline in one yellowish-weathering bed, very silty, dolomitic	3.0

Greenbrier limestone—Continued	Feet
10. Limestone, medium-gray; weathers dirty gray; very oolitic; contains soft, friable, porous yellowish-brown calcareous nodules and irregular masses; massive, crossbedded, cavernous; two prominent joints mineralized by calcite. This is lowest unit exposed in quarry in which units 10–14 were measured	19.0
Hillsdale member (46 feet):	
9. Limestone, greenish-gray and medium-gray, fine-crystalline, nodular and rubbly with shaly limestone partings, fossiliferous, dolomitic locally; many black chert nodules arranged in beds; fetid odor, thin-bedded. Exposed in road cut immediately under abandoned lime kiln	11.5
8. Limestone, dark-gray to grayish-black, very oolitic, fossiliferous; smoky-black and tan chert beds in lower half; thick-bedded, becoming thin bedded upward; channeled by overlying unit; very strong fetid odor	4.0
7. Limestone, greenish-gray and medium-crystalline in base; greenish-gray, rubbly nodular fine-crystalline with shaly partings above; weathers greenish and to a nodular ribby surface owing to the numerous thin black chert beds; fossiliferous; fetid odor; dolomitic locally	9.5
6. Limestone, grayish-black, dark-gray, and buff, dense to subcrystalline; conchoidal fracture, fossiliferous; very cherty, the chert being tan, yellowish brown, bluish gray, grayish, black, and white and in the form of nodules and beds; some of the chert probably represents replacements of corals; stylolitic, locally dolomitic in part, thick-bedded; slight fetid odor	21.0
Base of Hillsdale member.	
5. Limestone, tannish-brown; weathers yellowish brown; dense with scattered smoky calcite crystals; silty, slightly sandy, stylolitic, fossiliferous; 1.5-inch thick white secondary quartz seam present in basal contact; dolomitic in base; in two equal beds	2.5
Maccrady shale (4.5+ feet):	
4. Siltstone, dark-gray, very shaly; contains a few thin reddish streaks; channeled slightly by overlying unit	1.0
3. Sandstone, light grayish green, very fine grained, silty, thin-bedded	2.0
2. Shale, sandy siltstone, and fine-grained sandstone, green with some red	1.5
1. Sandstone, greenish-gray, very fine grained. This unit is top of a thick sequence of similar rock which contains red and green shale partings; beds range from 4 inches to 2 feet in thickness	Not measured

SECTION 15A–D (POUND GAP SECTION)

PART A

[Measured on northwest slope of Pine Mountain along U.S. 23 in the gap on top of mountain, Pound quadrangle, Letcher County, Ky. See pl. 28]

	Feet
Pottsville formation:	
12. Sandstone, white, conglomeratic	Not measured
Pennington group (252 feet):	
Bluestone formation (252 feet):	
11. Covered interval; some red and green shales and two thin coal beds exposed in road cut, where the beds are crumpled and in fault contact with the Pottsville formation	147.0
10. Sandstone, olive-drab to buff, micaceous, thin-bedded. This is highest stratigraphic unit measured along U.S. 23	2.5
9. Sandstone, siltstone, and shale, interbedded, olive-drab. The sandstone is dirty and thin bedded	20.5
8. Shale, black, with some fine-grained dark-gray sandstone in base, laminated. Base of this unit is the same as the base of unit 44 in geologic section 15D	12.0
7. Sandstone, light-green and white, micaceous, fine- and medium-grained; contains scattered black minerals; massive, resistant, faulted	17.0
6. Sandstone, light-gray and greenish-gray with fine shaly partings; angular and medium-grained; thin- and wavy-bedded and slabby; cut off on north by a fault with displacement of 2 to 3 feet	16.0
5. Shale, grayish-black, intimately interbedded with light-gray fine-grained sandstone, laminated, wavy-bedded	9.0
4. Shale, grayish-black, sandy, silty, crumpled; 6 inches of dark-gray fine-grained sandstone at top	5.0
3. Sandstone, white, subrounded medium-grained; contains black macerated plant remains; crossbedded; channels underlie unit	3.0
2. Shale, black, intimately interbedded with wavy-bedded light-gray fine-grained sandstone	19.0
1. Sandstone, greenish-gray, angular fine-grained, dirty, laminated, crossbedded. Exposed in drainage ditch at roadside	1.0

PART B

[Measured through quarry and along U.S. 23 on northwest slope of Pine Mountain, Letcher County, Ky. Between the top beds of geologic section 15B and the basal bed of geologic section 15A there is a thick covered interval which was not measured. A few small isolated outcrops are present in this covered interval. See pl. 28]

	Feet
Pennington group (175.5 feet):	
Hinton formation (175.5 feet):	
Middle red member (71 feet):	
49. Sandstone, light greenish-gray, angular fine-grained, dirty, medium-bedded, resistant. Crops out at turn in highway	3.0

Pennington group—Continued
Hinton formation—Continued
Middle red member—Continued

	Feet
48. Siltstone, yellowish-green, shaly, sandy. friable	12.0
47. Shale, yellowish-green	2.5
46. Shale, red	3.0
45. Shale, light grayish-green, very sandy	5.0
44. Sandstone, greenish-gray with some tan; angular fine-grained; medium-bedded in base, thin- and wavy-bedded above	6.0
43. Shale, olive-drab to greenish-gray, sandy; weathers mottled orange and reddish brown; nonresistant	17.5
42. Sandstone, buff in lower two-thirds, gray above, angular fine-grained, medium- to thin-bedded, crossbedded	9.0
41. Shale, grayish-black, interbedded with thin beds of fine-grained sandstone, nonresistant	13.0
Stony Gap sandstone member (middle Maxton sand of drillers) (104.5 feet):	
40. Sandstone, white; weathers yellowish brown to reddish brown locally; angular medium-grained, quartzitic, extremely resistant, pure, thick-bedded and crossbedded; weathers angular. This unit forms a steep cliff along the northwest slope of Pine Mountain	31.0
39. Sandstone, buff to yellowish-brown, fine-grained; shaly partings, thin-bedded; even bedding planes; channeled by unit 40	3.5
38. Sandstone, white; weathers light gray to dark gray, locally brownish yellow; fine-grained, shaly, thin- and wavy-bedded; contains plant fossils	2.5
37. Sandstone, white, gray, and yellowish-brown, and angular and medium coarse-grained, quartzitic, medium-bedded and crossbedded, ripple-marked locally, resistant; channels overlying shale	19.5
36. Shale, green	2.5
35. Sandstone, buff, angular medium-grained, thin- and wavy-bedded, sandy shale partings	12.5
34. Sandstone, buff in top and base, white in central part, angular medium-grained; contains scattered black minerals; thick-bedded and crossbedded, quartzitic, resistant	33.0
Bluefield formation (118.5+ feet):	
33. Shale, olive-drab; weathers grayish black with some variegated coloration; silty, sandy, channeled by sandstone above	7.0
32. Covered interval	5.5
31. Sandstone, buff with brownish stains; weathers yellowish brown; quartzitic; angular fine- to medium-grained, massive to medium-bedded and crossbedded	20.0
30. Covered interval	59.0
29. Sandstone, grayish-brown, very fine grained, dirty, flaggy, wavy-bedded; greenish-buff shale in base	1.5
28. Covered interval	19.5
27. Sandstone, light-gray, buff to brown, interbedded with sandy shale; subangular very fine grained, flaggy, thin- and wavy-bedded	6.0

	Feet
Bluefield formation—Continued	
26. Covered interval. The contact between the Greenbrier limestone and the Bluefield formation lies within this interval, probably midway	187.0
Greenbrier limestone (263+ feet) :	
25. Limestone, light-gray, dense, laminated, resistant	11.0
24. Limestone, light-gray; medium-crystalline and moderately oolitic except in upper 2 feet where it is dense; massive; thin bedded in top	11.0
23. Limestone, greenish-gray and light-gray, dense to subcrystalline, medium-bedded, laminated in part; slight fetid odor	4.5
22. Limestone, medium- to light-gray; coarse-crystalline in lower half, dense above; massive	13.0
21. Limestone, dark-gray, becoming medium gray upward; contains scattered dark crystals of calcite; crinoidal zone from 6.0 to 7.5 feet above base; well-laminated	9.5
20. Limestone, medium-gray, oolitic in base and top, silty with a conchoidal fracture in center, massive	16.5
19. Limestone, medium-gray, medium- and coarse-crystalline, oolitic in top; slightly fossiliferous; laminated but weathers massive; resistant. Three thin-bedded platy zones of smoky chert are present from 11 to 12 feet above base	18.0
18. Limestone, light- and medium-gray, silty locally, fine-crystalline with scattered oolites, very fine black seams and films (asphaltic?), reddish tint locally, thick-bedded	10.0
17. Limestone, medium-gray, oolitic, fossiliferous (corals and crinoids); contains scattered irregularly shaped earthy buff masses; massive	16.0
16. Limestone, medium-gray, oolitic, slightly fossiliferous, massive; slight fetid odor	23.0
15. Limestone, light-gray; upper few feet weathers distinctively yellowish; dense, stylolitic; conchoidal fracture; medium-bedded	5.5
14. Mudstone, calcareous, or muddy limestone, alternating purplish red and greenish gray, laminae as much as 1 inch thick, subcrystalline	5.0
13. Limestone, medium- and light-gray, medium-crystalline, oolitic, locally dense, thin-bedded; very slight fetid odor	15.5
12. Limestone or calcareous mudstone, red, locally lavender mottled with green, slightly laminated, dense; hackly and conchoidal fracture	5.0
11. Limestone, light-gray, oolitic; contains scattered coarse light-brown grains of calcite and some yellow-weathering muddy beds. The calcite grains locally are stained emerald green	14.0
10. Limestone, light-buff, greenish-gray in base, silty; weathers distinctively yellow; fine-crystalline; contains scattered fine seams of black material (asphaltic?); two beds	3.0

	Feet
Greenbrier limestone—Continued	
9. Limestone, light- and medium-gray, dense to subcrystalline, crossbedded (?); hackly fracture	17.0
8. Limestone, light-gray, finely crystalline, muddy; conchoidal fracture; stylolitic, massive; very slight fetid odor	4.0
Taggard red member (29 feet):	
7. Limestone, mottled gray and red in lower part, becoming light gray upward; fine-crystalline, fossiliferous; slight fetid odor	17.0
6. Limestone, red and green in base, red above; slightly silty, subcrystalline; conchoidal fracture; massive	12.0
Base of Taggard red member.	
5. Limestone, grayish-black; conchoidal fracture; fine-crystalline, silty, massive; very strong fetid odor	14.5
4. Limestone, greenish-gray, very shaly, friable; strong fetid odor	2.0
3. Limestone, buff, very silty and sandy, gritty, dense, thick-bedded	4.0
2. Limestone, tannish-gray to tan, dense with some crystals of calcite, slightly fossiliferous, silty, sandy, medium-bedded; slight fetid odor	12.5
Maccrady shale:	
1. Sandstone and shale	Not measured

PART C

[Measured immediately above the Kentucky portal of Pine Mountain tunnel (C. & O. Ry.), Pound Gap, Pine Mountain, Pound quadrangle, Letcher County, Ky. See pl. 28]

	Feet
Pennington group:	
Hinton formation (Stony Gap sandstone member).	
Bluefield formation (219 feet):	
12. Shale, light-green; weathers locally to yellowish brown; thin ribs of green sandy siltstone in middle and in top; red shale from 19.0 to 20.5 feet above base	23.5
11. Shale, dark-gray; weathers light gray; some ribs of light-gray fine-grained dirty sandstone	34.5
10. Shale, grayish-black and black; weathers dark gray and black; slightly silty, very fissile	44.0
9. Sandstone, medium- and dark-gray, subangular very fine grained, slabby, silty, shaly; grades upward to siltstone	14.0
8. Shale, various shades of gray, grayish-black, and black, carbonaceous, very fissile, folded and crumpled	21.0
7. Sandstone, purplish-brown; weathers distinctively green with some yellowish-brown mottling; angular fine-grained, porous, quartzitic, resistant, medium-bedded; breaks angularly	11.0
6. Sandstone, dark-gray with a purplish tint; weathers mottled yellow, orange, yellowish brown, reddish brown, and green; subangular very fine grained; silty shaly, glauconitic(?), thin-bedded	5.0

	Feet
Bluefield formation—Continued	
5. Shale, dark-gray and grayish-black, very fissile, sandy locally; contains scattered ribs of brown very fine grained silty sandstone	15.0
4. Siltstone, dark-gray, calcareous, porous, medium-bedded	4.0
3. Shale, similar to unit 5	19.0
2. Sandstone, gray in lower half, purple above; very fine grained, with shale partings; thin bedded in lower half, becoming thicker bedded above	12.0
1. Shale, black, silty, very fissile, carbonaceous; some green laminae	16.0
Greenbrier limestone.	

PART D

[Measured in the Pine Mountain tunnel (C. & O. Ry.), Pound Gap, Pound quadrangle, Letcher County, Ky., and Wise County, Va. See pl. 28]

	Feet
Pennington group (605 feet):	
Bluestone formation (238.5 feet):	
Note: The Bluestone formation is in fault contact with the Pottsville formation; thus, the upper beds of the Bluestone are absent in the tunnel.	
44. Shale, grayish-black and greenish-gray, very slightly calcareous, very micaceous and silty	8.5
43. Sandstone, light-gray, subangular fine- to medium-grained, slightly calcareous, micaceous; contains a few grains of pyrite; crossbedded	7.5
42. Shale, greenish-gray, calcareous; contains grayish-white micaceous fine-grained sandstone in base	12.5
41. Sandstone, grayish-white, micaceous, fine-grained, porous, moderately calcareous; contains scattered black minerals; crossbedded; seepage zone	9.0
40. Sandstone, grayish-white, fine- to medium-grained, calcareous, micaceous, hard, massive, crossbedded	12.0
39. Sandstone and shale, interbedded. The shale is grayish black and highly micaceous; the sandstone is white, fine and medium grained, subangular, and calcareous. This is probably an irregularly wavy bedded interval	10.0
38. Sandstone, grayish-white, subangular fine- to medium-grained, slightly calcareous, hard; contains scattered black minerals; slightly micaceous; seepage zone at base	4.5
37. Shale, grayish-black with very slight greenish tint, sandy, very slightly calcareous, silty	9.0
36. Shale, similar to unit 37; lumpy	14.0
35. Shale, similar to unit 37	17.0
34. Shale, similar to unit 37; very fissile	40.0
33. Shale, black, slightly calcareous; conchoidal fracture	28.0
32. Shale, grayish-black with slight greenish tint, slightly calcareous and highly calcareous locally; contains macerated black plant fragments; fossiliferous (brachiopods)	15.5

Pennington group—Continued

Bluestone formation—Continued

	Feet
31. Shale, dark-gray with greenish tint, slightly calcareous; contains plant fossils	14.5
30. Siltstone, greenish-gray, very sandy, gritty, slightly calcareous	10.5
29. Shale, green, locally red, moderately calcareous, muddy, shaly, lumpy	26.0

Hinton formation (366.5 feet):

Limestone member (Avis limestone of Reger) (39 feet):

28. Calcareous interval. The lower 4.5 feet consists of dark-gray shaly mudstone; 4.5 to 7.0 feet above base is medium-gray crystalline limestone; 7.0 to 22.0 feet above base is greenish-gray highly calcareous silty mudstone; upper 3.0 feet consists of red crinoidal muddy limestone	25.0
27. Shale, dark-gray, highly calcareous, silty; sandstone in base	7.5
26. Shale, extremely calcareous, or shaly limestone; dark-gray; abundant calcite crystals scattered throughout rock; silty	6.5

Middle red member (228.5 feet):

25. Shale, green, greenish-gray in top, highly calcareous, silty	11.5
24. Shale, red, muddy, lumpy, slightly calcareous	8.5
23. Shale, green, very calcareous, silty; very fine grained calcareous sandstone in top; entire unit micaceous	8.5
22. Siltstone and shale, greenish-gray, micaceous, slightly calcareous, hard	10.0
21. Shale, dark-gray, greenish-gray upward, moderately calcareous, silty	15.0
20. Shale, greenish-gray in lower two-fifths, red and greenish-gray above; silty, slightly calcareous, laminated	12.5
19. Shale, red with green zone from 13.5 to 14.5 feet above base, silty, slightly calcareous; conchoidal fracture	17.5
18. Shale, greenish-gray, silty, calcareous near top	5.0
17. Sandstone, greenish-gray, very fine grained; red shale in upper 9.0 feet	16.0
16. Sandstone, greenish-gray, calcareous, shaly, very fine grained, silty	7.0
15. Sandstone, similar to unit 16; more calcareous	6.0
14. Shale, dark-gray with slight reddish tint, silty, moderately calcareous	14.0
13. Shale, dark-gray and greenish-gray, red in middle, silty, slightly calcareous locally	17.5
12. Shale, greenish-gray, red locally, silty	12.5
11. Shale, dark-gray with slight greenish tint, micaceous, silty, very fissile	11.0
10. Sandstone; lower 6.0 feet light gray, fine grained, hard, micaceous, with scattered black minerals; remainder of unit gray, very fine grained slightly, calcareous, micaceous, thin and irregularly bedded with thin partings of grayish-black shale	15.0

Pennington group—Continued
Hinton formation—Continued
Middle red member—Continued

	Feet
9. Shale, dark-gray with slight greenish tint, micaceous; contains very thin beds of fine-grained sandstone; slightly calcareous; very fine grained micaceous sandstone at top	13.0
8. Sandstone, light-gray, becoming greenish gray in top; very fine grained; contains scattered black minerals; micaceous, calcareous upward, laminated	11.5
7. Siltsone, greenish-gray, sandy; light gray in the sandy parts; shaly, calcareous in part; channeled in top	7.0
6. Shale, dark-gray with a greenish tint, silty	9.5
Stony Gap sandstone member (middle Maxton sand of drillers) (99 feet):	
5. Sandstone, grayish-white, subangular fine- to medium-grained; contains scattered black minerals including pyrite; crossbedded; thin bedded in lower 10.0 feet, thicker bedded above; distinct break at top of unit. This is probably the resistant cliff-forming sandstone exposed on the surface (unit 40, section 15B)	34.5
4. Sandstone, grayish-white; fine-grained, locally medium-grained; contains scattered black minerals; slightly calcareous, crossbedded; thin bedded near top	15.0
3. Sandstone, grayish-white, subangular fine- and medium-grained, very calcareous; contains scattered grains of pyrite; thick-bedded and crossbedded	18.0
2. Sandstone, grayish-white, subangular to subrounded medium-grained, calcareous, porous; contains scattered grains of pyrite in base; thick-bedded and crossbedded, slightly micaceous	14.0
1. Sandstone, grayish-white, subangular fine- to medium-grained, micaceous; contains scattered black minerals; flaggy, thin-bedded and crossbedded; channeled at top	17.5
Bluefield formation (16 feet):	
Exposure southeast of concrete facing which lines first 800 feet of the Kentucky (northwest) end of tunnel	16.0

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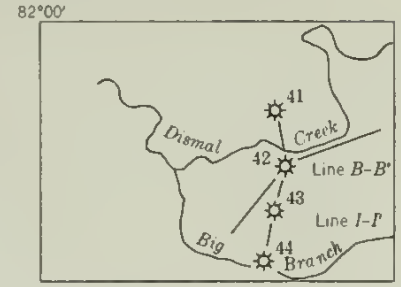

INSET A SHOWING LOCATIONS OF WELLS 41–44 ALONG LINES *B-B′* AND *I-I′*

0 1 2 Miles

EXPLANATION

Gas well

Dry hole with show of gas

Dry hole

Diamond-drill hole

Harlan

Surface section

Numbers refer to wells and sections shown in plates 28, 29, and table 1

Syncline

Overturned syncline

Approximately located

Thrust or low angle reverse fault
T, upper plate

A —— *A′*
Line of section

Antiline
Approximately located

502755 O - 59 (In pocket)

MAP OF SOUTHWESTERN VIRGINIA, SOUTHERN WEST VIRGINIA, AND EASTERN KENTUCKY SHOWING LOCATION OF SURFACE SECTIONS, WELLS LINES OF GRAPHIC SECTIONS, AND GENERAL STRUCTURAL FEATURES

Scale 1:1 000 000

10 0 10 20 30 Miles