VIRGINIA DIVISION OF MINERAL RESOURCES
PUBLICATION 144

GEOLOGY, NATURAL GAS, OIL, AND OTHER MINERAL RESOURCES OF WISE COUNTY, VIRGINIA

Jack E. Nolde

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF MINES, MINERALS AND ENERGY
DIVISION OF MINERAL RESOURCES
Stanley S. Johnson, State Geologist

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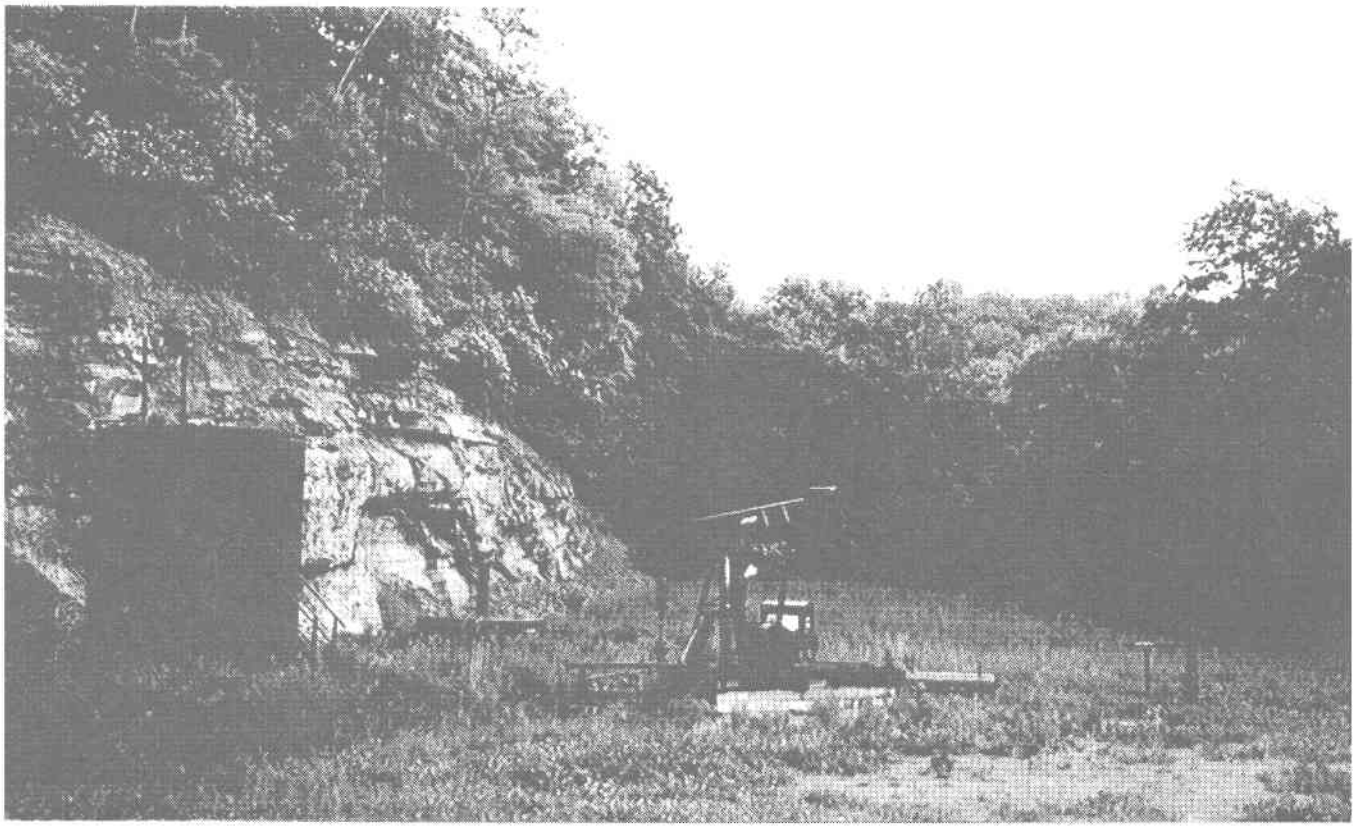

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FRONT COVER: Pumping unit in operation at Equitable Resources Energy Company, William Robinette VCP-3095 (coalbed methane) well in the Roaring Fork gas field, Norton quadrangle. Unit is used to draw water off coalbed to increase gas production. Water is stored in tank to the left. Well on right is VP-133734. This conventional well is producing from the Chattanooga Shale, Berea Sandstone, Price Formation, and Greenbrier Limestone. (Photograph by Bob Wilson, Virginia Division of Gas and Oil.)

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GEOLOGY, NATURAL GAS, OIL, AND OTHER MINERAL RESOURCES OF WISE COUNTY, VIRGINIA

Jack E. Nolde

INTRODUCTION

Wise County in southwestern Virginia contains 407.5 square miles (260,800 acres) (Figures 1 and 2). The county is bordered by Lee County on the southwest, by Scott County on the south, by Russell County on the southeast and east, by Dickenson County on the northeast, and by Letcher and Pike Counties, Kentucky on the northwest. About 85 percent (about 221,984 acres) of Wise County lies within the Appalachian Plateaus province. The rest (about 38,816 acres) is in the Valley and Ridge province, which includes Powell Valley and a small limestone and dolostone area southwest and northeast of the Town of St. Paul.

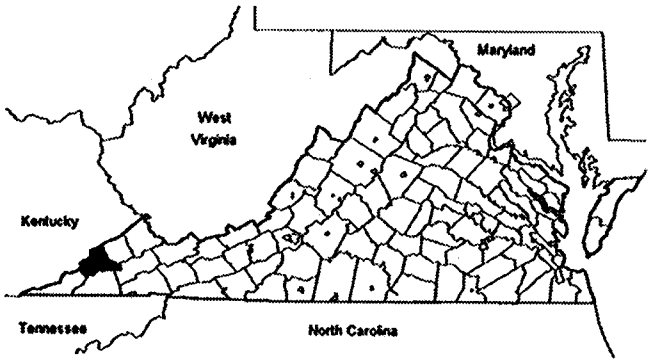

Figure 1. Index map showing location of Wise County, Virginia.

Rocks penetrated by wells range in age from Middle Pennsylvanian to Late Ordovician, and include at least 11,600 feet of sandstone, siltstone, shale, limestone, and dolostone. Late Ordovician strata, principally dolostone and limestone, are at least 1,700 feet thick; Silurian strata consist of sandstone, shale, and dolostone and are about 800 feet thick; Devonian strata consist of shale and sandstone and are about 1,200 feet thick; Mississippian strata consist of limestone, shale, and sandstone and are 2,700 feet thick; Pennsylvanian strata consisting of sandstone, siltstone, and coal are as much as 5,200 feet thick.

Two major structural features are present in Wise County: the Powell Valley anticline along the southern border of the county and the Middlesboro syncline in the northwestern part of the county. Many smaller structures, including small folds and faults, are superimposed on these major features.

Three-Hundred and eighty wells were drilled in Wise County through September 30, 1996 (Table 1) since drilling began in the middle 1890s. The locations of 380 wells drilled for natural gas, oil, and coalbed methane is shown on Plate 1 and are listed in Appendix C. There are nine major gas producing fields in Wise County (Figure 4): Bear Creek, Black Creek, Flat Gap, Flatwoods, Glamorgan, High Knob, Meade Creek, Nora, and Roaring Fork. Six minor gas productive areas, containing one well, are present. These six areas have not been assigned a name. As of June 30, 1996, based on current Statewide spacing for conventional gas wells (2,640 feet), approximately 35 percent of the total area of Wise County has been drilled.

Natural gas is found in rocks of Devonian, Mississippian, and Pennsylvanian age and has been produced from Wise County since 1953. Natural gas production is primarily from the Devonian-Mississippian Chattanooga Shale reservoir including the Berea Sandstone. Secondary reservoirs are the Price Formation and Greenbrier Limestone. Total natural gas production for 1995 from the county was 7,489,676 Mcf from 338 wells owned by two producing companies, Equitable Resources Energy Company and AMVEST Oil and Gas, Inc. Gas production has increased within the past ten years because of price increases, resulting in new pipeline outlets. Cumulative natural gas production for the county amounted to 70,471,873 Mcf for 1953 to 1995 (Appendix A). The cumulative dollar value of natural gas produced is $155,795,156. Gas production from conventional reservoirs amounted to 7,230,740 Mcf during 1995. This is about 18.5 percent below the previous year. Cumulative conventional gas production is 70,071,819 Mf for 1953 to 1995. The value of conventional gas produced during 1995 is $12,653,795. Cumulative dollar value of conventional gas produced for 1953 to 1995 is $155,043,318.

Oil has been produced since 1983 from the Mississippian age Greenbrier Limestone. Production for 1995 was 6,111.57 barrels from forty-two wells. Cumulative oil production from 1983 to 1995 was 41,158.67 barrels. Cumulative dollar value of oil produced is $594,303.

Coalbed methane exploration and development began in late 1990. The coalbed methane is produced from coalbeds and associated strata in the Pennsylvanian age Pocahontas, Lee, and Norton Formations. Production from coalbeds and associated strata accounted for 258,936 Mcf of the total natural gas production. Cumulative coalbed methane produced for 1991 to 1995 amounts to 400,054 Mcf. The value of coalbed methane produced during 1995 is $453,138. Cumulative dollar value of coalbed methane produced is $751,838.

Total depth of producing conventional gas wells range from 3,635 to 8,357 feet, but average about 5,540 feet. Total depth of producing coalbed methane wells range from 2,406 to 2,831 feet with an average of 2,630 feet.

At the end of 1995 proven natural gas reserves for Wise County was nearly 276-billion cubic feet. Based on cumula-

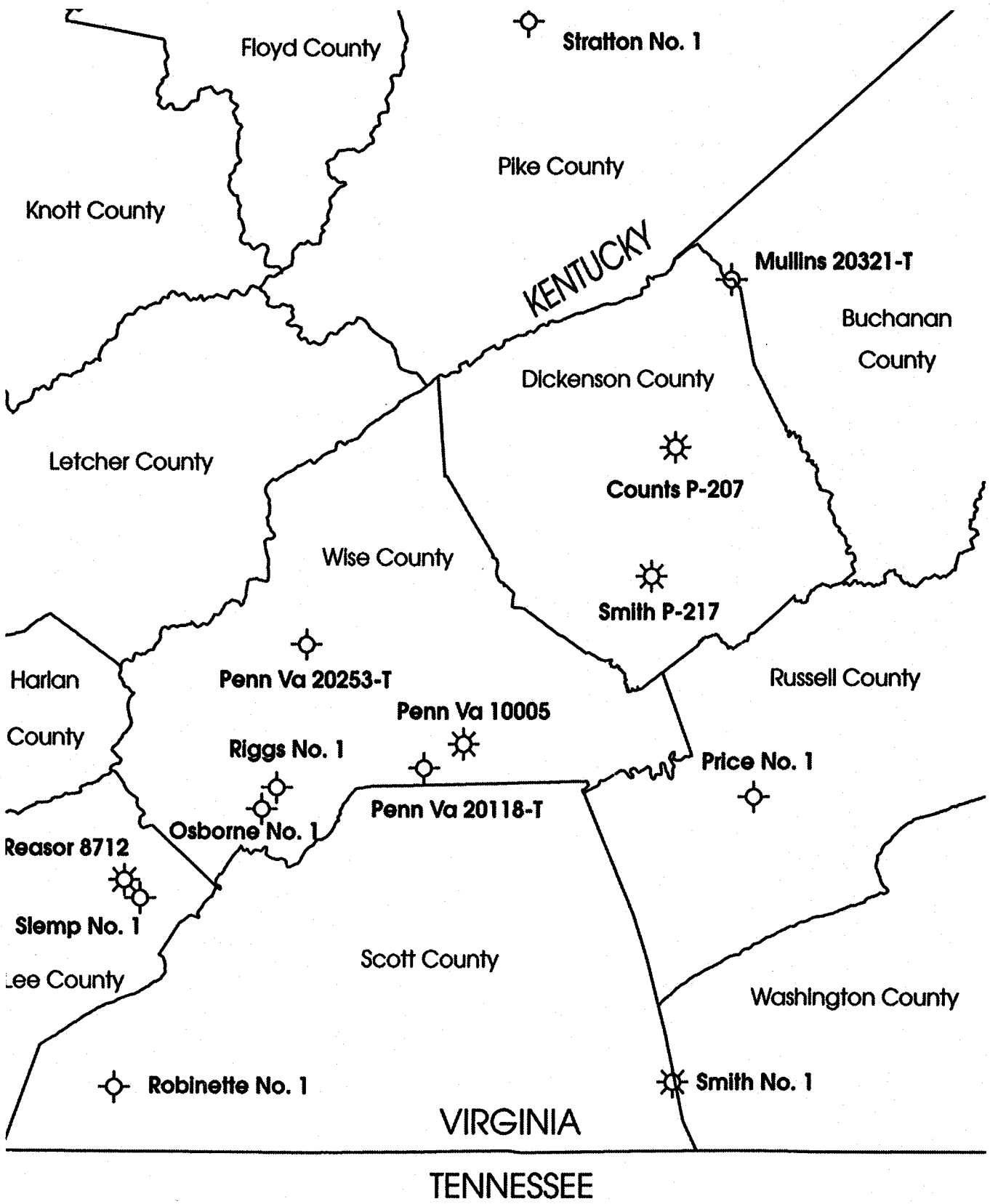

Figure 2. Location of wells penetrating Ordovician age and older rocks in the vicinity of Wise County.

Table 1. Number of wells drilled for natural gas in Wise County, 1890-1995. Data compiled from the Division of Mineral Resources Wellsum database.

Year	Gas Well	Gas/oil	Gas-PA	Dry Hole	Coalbed	Total
1890	0	0	0	1	0	1
1933	0	0	0	1	0	1
1940	0	0	0	1	0	1
1941	0	0	0	1	0	1
1942	0	0	0	1	0	1
1950	0	0	0	1	0	1
1951	0	0	0	1	0	1
1952	0	0	0	0	0	0
1953	2	0	0	0	0	2
1954	1	1	0	0	0	2
1955	4	0	2	0	0	6
1956	4	0	0	0	0	4
1957	1	0	1	0	0	2
1958	2	0	0	0	0	2
1959	1	0	0	0	0	1
1960	1	0	0	0	0	1
1961	1	0	0	0	0	1
1962	0	0	0	0	0	0
1963	0	0	0	0	0	0
1964	0	0	0	0	0	0
1965	0	0	0	0	0	0
1966	0	0	0	0	0	0
1970	0	0	0	1	0	1
1971	0	0	0	0	0	0
1972	0	0	0	0	0	0
1973	0	0	0	0	0	0
1974	0	0	0	1	0	1
1975	2	0	0	4	0	6
1976	0	0	0	1	0	1
1977	0	0	0	0	0	0
1978	1	0	0	0	0	1
1979	4	0	0	0	0	4
1980	3	0	0	0	0	3
1981	1	0	0	0	0	1
1982	6	3	0	1	0	10
1983	4	3	0	0	0	7
1984	34	12	2	0	0	48
1985	35	8	1	0	0	44
1986	41	6	0	0	0	47
1987	12	0	0	0	0	12
1988	7	0	0	0	0	7
1989	12	1	0	1	0	14
1990	9	0	0	0	2	11
1991	0	0	0	0	0	0
1992	20	6	0	0	2	28
1993	37	6	0	0	6	49
1994	29	1	2	0	12	44
1995	8	0	0	0	2	10
Total	**282**	**47**	**8**	**16**	**24**	**377**

tive production, potential producible acreage, and potential undiscovered producible reserves, there are more than 896-billion cubic feet of estimated potential producible reserves.

Other mineral resources in Wise County are coal, limestone, clay and shale, sandstone, iron, and manganese. Coal, limestone, and sandstone were the only other resources mined in Wise County during 1995.

This publication was compiled mainly from the Department of Mines, Minerals and Energy, Division of Mineral Resources and Division of Gas and Oil databases and files. The Division of Mineral Resources maintains a current computer database on oil and gas drilling activity, geology, and annual production of oil and gas in the Commonwealth. Files for individual wells usually include a copy of the permit, completion and plugging data, logs run, and production records. This information may be obtained from the Division of Gas and Oil or the Division of Mineral Resources. Drill cuttings are available for examination for some wells (Nolde, 1996). Except confidential information, usually 90 days, these files are available for public inspection. Permitting and other regulatory aspects of oil and gas drilling activities should be addressed to the Division of Gas and Oil in Abingdon, Virginia.

STRATIGRAPHY

The stratigraphic names, rankings, and age assignments used in this report follow usage on the **Correlation of Stratigraphic Units in North America (COSUNA)-Southern Appalachian Region Correlation Chart** by Patchen and others (1985). The subsurface rocks of the Appalachian Plateaus province in Virginia are well known from studies of deep wells drilled for natural gas. These rocks range in age from Precambrian basement to Late Ordovician Eggleston Formation. The surface rocks of the Appalachian Plateaus and Valley and Ridge provinces are also well known from surface geologic mapping and by the study of deep wells drilled for natural gas. The surface rocks range in age from the Late Ordovician Eggleston to the Middle Pennsylvanian Harlan Formation. Stratigraphic descriptions are based on Miller (1965), Evans and Troensegaard (1991), Henika (1988), Nolde (1994a), Nolde and Diffenbach (1988), Nolde and others (1986, 1988a, 1988b), and Whitlock and others (1988). Thicknesses of stratigraphic units were determined from geophysical logs and represent the well penetration thickness and not necessarily the true thickness.

The deepest well drilled in the county as of September 30, 1996 is the Columbia Natural Resources No. 20118-T (Figure 2, Plate I, Appendix B). This well drilled in the southern part of the Wise quadrangle, reached a depth of 8,357 feet. The formation at the bottom of this hole is probably the Martin Creek Limestone of Late Ordovician age. Rocks older than the Martin Creek Limestone have been penetrated in Russell County in the Gulf Oil Corporation, W. R. Price No. 1 well (Figure 2), a basement test, and in Dickenson County in the Columbia Gas Transmission Corporation, Bruce Mullins Heirs No. 20321-T (Figure 2), which penetrated the Kingsport-Mascot (Beekmantown or Knox) part of the section. The Price well, total depth of 17,003 feet, is in the northwest corner of the Hansonville quadrangle, Russell County about four miles southeast of the Wise County line. The Mullins No. 20231-T well, total depth of 9,361 feet, is in the Elkhorn City quadrangle, Dickenson County, about twenty-six miles north of St. Paul. Four other wells have penetrated rocks of Ordovician age in Wise County (Figure 2): the Castle and Jenkins, W. B. Osborne No. 1 in the East Stone Gap quadrangle; the Columbia Natural Resources, Penn Virginia Resources No. 20253-T in the Norton quadrangle; the Trans State Oil, Ltd., Bruce Riggs No. 1 well in the Norton quadrangle, and the Equitable Resources Exploration, Penn Virginia Resources No. 10005 well in the Wise quadrangle. Depths from the surface to the top of a unit and thickness of the unit in the 20253-T well, the 10005 well, and the 20118-T well are listed in Table 2.

PRECAMBRIAN BASEMENT

Gulf Oil Corporation encountered Precambrian crystalline rocks in the Price No. 1 well, Russell County at a depth of 16,646 feet. They drilled 375 feet into basement. Sample examination, chemical analysis, and X-ray analysis of the basement rocks in the Price well suggest a granulite lithology. These rocks had been subsequently remetamorphosed to lower greenschist facies during Grenville or post-Grenville time.

CAMBRIAN SYSTEM

Six stratigraphic units comprise the Cambrian System in Wise County: unnamed basal clastic and carbonate unit; Rome, Honaker, Nolichucky, and Maynardville Formations; and Copper Ridge Dolomite. The following descriptions of the stratigraphic units are based on sample studies and analysis of geophysical logs. Two wells were used, the Gulf Oil Corporation, W. R. Price No. 1 well in Russell County and the Signal Oil & Gas Company, Henry Stratton No. 1 well (Figure 2) in Pike County, Kentucky. The Cambrian stratigraphic section generally thins to the southeast from 3,171 feet in the Stratton well to 2,994 feet in the Price well.

Basal Clastic and Carbonate Unit

The basal clastic and carbonate unit of Early Cambrian age is divided into four distinct lithologic units. These are dolomitic sandstone, limestone and dolostone, dolostone, and dolomitic limestone. The dolomitic sandstone (Chilhowee Group) also known as the "basal sand" to drillers, consists predominantly of light-gray to white, fine- to very coarse-grained, poorly-cemented, slightly dolomitic sandstone. The sandstone is interbedded with gray, argillaceous, dolomitic siltstone, and light-gray, aphanic, argillaceous, silty, sandy dolostone. The dolomitic sandstone unit thin northwestwards from 156 feet in the Price well to about 75 feet along the Pike County, Kentucky and Wise County, Virginia boundary.

The limestone and dolostone unit, about 104 feet thick,

Table 2. Deep stratigraphic tests in Wise County.

	Columbia Gas Transmission Corp. Well No. 20253-T		Wise Oil & Gas Exploration Well No. 10005		Columbia Gas Transmission Corp. Well No. 20118-T	
File Number	WS-030		WS-047		WS-023	
Quadrangle	Norton		Wise		Wise	
Surface Elevation	2,548		2,539		3,450	
Total Depth	6,901		5,966		8,020	
	Depth	Thickness	Depth	Thickness	Depth	Thickness
Pennsylvanian	0	3,118	0	630	0	645
Lee Fm	0	3,118	0	630	0	645
Mississippian	3,118	2,022	630	2,022	645	2,680
Bluestone Fm	3,118	297	630	297	645	305
Hinton Fm	3,415	395	996	395	950	745
Bluefield Fm	3,810	395	1,800	395	1,695	465
Greenbrier Ls	4,205	393	2,312	393	2,160	536
Maccrady Sh	4,598	22	2,862	22	2,696	34
Price Fm	4,620	195	2,892	195	2,730	240
Chattanooga Sh	4,815	325	3,148	325	2,970	355
Devonian	5,140	825	3,530	825	3,325	1,095
Chattanooga Sh	5,140	720	3,530	720	3,325	997
Wildcat Valley Ss	5,860	105	4,274	105	4,322	98
Silurian	5,965	857	4,375	857	4,420	830
Hancock Fm	5,965	315	4,375	315	4,420	310
Rose Hill Fm	6,280	340	5,250	340	4,730	270
Clinch Ss	6,620	202	5,535	202	5,000	250
Ordovician	6,822	79+	5,840	126+	5,250	2770+
Sequatchie Fm	6,822	79+	5,840	126+	5,250	655
Reedsville Sh					5,905	195
Trenton Ls					6,100	665
Eggleston Ls					6,765	203
Hardy Creek Ls					6,968	142
Ben Hur Ls					7,110	180
Woodway Ls					7,290	355
Hurricane Bridge Ls					7,645	285
Martin Creek Ls					7,930	90+
Total Depth	**6,901**		**5,966**		**8,020**	

consists of limestone that is typically medium- to dark-gray and fine-grained. Dolostone in the unit is brownish-gray, fine- to medium-crystalline and saccharoidal with some coarse crystals. The dolostone unit, about 38 feet thick, consists of medium- to dark-gray shale with brownish-gray, aphanic dolostone. The dolomitic limestone unit, about 106 feet thick, consists mainly of light- to medium-gray and brownish-gray, medium- to coarsely-crystalline dolomitic limestone. The basal clastic and carbonate unit thins from about 404 feet to about 323 feet northwestwards along the state boundary between Pike County, Kentucky and Wise County, Virginia.

Rome Formation

The Rome Formation of Early to Middle Cambrian age consists predominantly of grayish-red to pale red, micaceous shale and siltstone. Minor amounts of grayish-green shale, light-gray, aphanic, thin-bedded dolostone, and pale red, sandy siltstones are also common. The upper 70 to 110 feet of the Rome Formation consists of grayish-green shale. These shales appear to correlate to the Pumpkin Valley Shale, Middle Cambrian-age, as described by Rogers and Kent (1948) at Lee Valley, Hawkins County, Tennessee. Below the Pumpkin Valley Shale is a 250-foot-thick dolostone that is grayish-brown to dark-gray and aphanic. Another dolostone with similar characteristics is about 955 feet below the top of the Rome and is 70 feet thick. The formation thickens to the northwest from 1,305 feet in the Price well to about 1,495 feet along the Pike County, Kentucky and Wise County, Virginia boundary.

Honaker Formation

The Honaker Formation of Middle Cambrian age is divided into three distinct lithologic units: lower, middle, and upper. The lower unit, about 226 feet thick, consists of medium-dark-gray to medium-gray, aphanic limestone. Limestones are generally thin bedded with uniform partings. The middle unit, about 350 feet thick, consists of dark-gray to grayish-black, fine- to medium-crystalline dolostone. The upper unit, about 250 feet thick, consists mainly of light-gray and brownish-gray, finely-crystalline limestone. The Honaker Formation thickens northwestwards from 826 feet in the Price well to about 870 feet along the Pike County, Kentucky and Wise County, Virginia boundary.

Nolichucky Formation

The Nolichucky Formation of Middle Cambrian age is composed of olive-green calcareous shale with interbedded limestone units that become more numerous toward the top of the formation. The formation can be divided into three distinct lithologic units: lower shale, middle limestone, and upper shale. The lower and upper shale units are lithologically similar. They are grayish-olive to olive-green in color, but the lower unit is very silty and calcareous, whereas the upper unit is less silty and more calcareous. The middle limestone member has a micritic texture, but it contains thin beds of fine- to coarsely-crystalline, oolitic, and pelletal limestone. The oolitic beds are restricted to fine-grained limestone and the pelletal beds are associated with the medium- to coarsely-crystalline limestone. The Nolichucky thickens to the northwest from 460 feet in the Price well to about 520 feet along the Pike County, Kentucky and Wise County, Virginia boundary.

Maynardville Formation

The Maynardville Formation (Late Cambrian age) consists of two members, the Low Hollow limestone and the Chances Branch dolomite. The Low Hollow member, which makes up approximately the lower half, is typically a light- to dark-gray, fine-grained limestone with clay or silt partings. Partings in the Low Hollow are thicker and more irregular than those of the Honaker. The Chances Branch member is generally in sharp contact with the Low Hollow member. The lower part of the Chances Branch is a medium-gray, fine-grained dolostone, with some black chert. The upper portion of the member contains light- to dark-gray, fine- to medium-grained, thinly-laminated dolostone. Black chert and some dark gray, saccharoidal, vuggy dolostone are also present. The Maynardville Formation generally thickens to the southeast. The thickness ranges from 120 feet in the Stratton well to 260 feet in the Price well.

Copper Ridge Dolomite

The Copper Ridge Dolomite (average thickness of 520 feet) of Late Cambrian age, is divided into two informal members: lower and upper. The lower member is composed of dark-gray to dark-brown, medium- to coarsely-crystalline, thick-bedded dolostone, some of which has a petroliferous-odor. Thin beds of white chert occur in the member. The upper member is a white to light-gray, aphanic- to coarsely-crystalline dolostone; bedding is medium to thick. Dark-gray dolostone is also present locally in the upper member as are thin beds and lenses of white chert. Some black chert and some dark gray, saccharoidal and vuggy dolostone, similar to that found in the Maynardville Formation, are also present.

ORDOVICIAN SYSTEM

The Ordovician System contains a dolostone interval, a lower limestone and shale interval, and an upper shale and limestone interval. Three formations comprise the dolostone interval and they are all Early Ordovician age. These are from oldest to youngest: Chepultepec, Kingsport, and Mascot. The dolostone interval averages 1,000 feet in thickness. Eight formations characterize the limestone and shale interval. These formations range in age from Middle to Late Ordovician. They are from oldest to youngest, Dot, Poteet, Rob Camp, Martin Creek, Hurricane Bridge, Woodway, Ben Hur, and Hardy Creek Limestones. The interval between the base of the

Woodway Limestone and the top of the Hardy Creek Limestone, known as the "Black River" by drillers, averages 485 feet in thickness. The limestone and shale interval ranges from 1,176 feet in the Price well to 1,194 feet in the Mullins well. The shale and limestone interval of Late Ordovician age includes four formations, the Eggleston and Trenton Limestones, the Reedsville Shale, and the Sequatchie Formation. The interval ranges in thickness from 1,640 feet in the Price well to 1,506 feet in the Mullins well.

The following summarized description of the Early, Middle, and Late Ordovician rocks are based on sample descriptions and analysis of geophysical logs. Three wells were used: the Gulf Oil Corporation, W. R. Price No. 1; Columbia Gas Transmission, Bruce Mullins No. 20321-T well; and Penn Virginia Corporation well No. 20118-T (Figure 2).

Chepultepec Dolomite

The Chepultepec Dolomite of Early Ordovician age ranges from 535 to 569 feet in thickness and can be divided into two informal members, a lower sandy dolostone and an upper argillaceous dolostone. The sandy dolostone member includes sandy, light-brown, medium- to coarsely-crystalline, saccharoidal dolostone; light-gray to light-brown, fine- to medium-crystalline dolostone; and white, medium-grained sandstone.

The argillaceous dolostone member is largely light-gray to grayish-brown argillaceous dolostone with a few pinkish-gray dolostone beds. Small amounts of light-gray to white oolitic chert nodules and beds are present.

Kingsport Dolomite

The Kingsport Dolomite of Early Ordovician age has an average thickness of 245 feet and is a light-gray and yellowish-gray, medium- to coarsely-crystalline, saccharoidal dolostone containing very little chert. Near the base of the Kingsport some beds contain quartz grains, or flat nodules of light-gray, non-oolitic chert, or small vugs filled or lined with calcite, dolomite, or quartz. Interbedded, white, finely-crystalline dolostone, is present at the top of the formation.

Mascot Dolomite

The Mascot Dolomite of Early Ordovician age averages 200 feet in thickness, is composed of fine-grained, light-gray to white dolostone with pink dolomite blebs. Chert nodules are scattered throughout the unit with local beds of coarsely-crystalline dolostone. Beds of green shale ranging from fractions of an inch to several inches in thickness separate most of the dolostone beds and are helpful in identifying the Mascot Dolomite in well cuttings. There are a few three to four feet thick beds of conchoidally-fracturing limestone, present throughout the formation. The Mascot Dolomite generally thickens toward the southeast. The thickness ranges from 191 feet in the Mullins wells to 235 feet in the Price well.

Dot Limestone

The Dot Limestone (known as the "Wells Creek" by drillers) of Middle Ordovician age ranges in thickness from 110 to 135 feet and is divided into two members: lower and upper. Light-gray, argillaceous dolostone comprises the lower member. The basal beds of the Dot are slightly to very conglomeratic with chert and dolostone pebbles. The upper member is predominantly limestone, but in the lower part it contains interbedded dolostone. The limestone is pale brown to gray and aphanic. The Dot in the Mullins 20321-T well is dolomitic limestone and consists of an argillaceous dolostone in the lower part and light-gray limestone in the upper part.

Poteet Limestone

The Poteet Limestone of Late Ordovician age has an average thickness of 80 feet and is a light-brown to light-gray, aphanic- to finely-crystalline limestone. Dark-gray, fine-grained limestone occurs at the base and is overlain by fine-crystalline limestone with abundant dark-brown chert nodules and lenses. The upper part of the Poteet contains beds of aphanic limestone with calcite "birdseye."

Rob Camp Limestone

The Rob Camp Limestone of Late Ordovician age ranges from 75 to 100 feet in thickness and is a light-olive-gray, aphanic limestone with calcite "birdseyes." Generally the Rob Camp contains no chert.

Martin Creek Limestone

The Martin Creek Limestone of Late Ordovician age averages 75 feet in thickness and is dark-olive-gray to light-olive-gray, finely-crystalline limestone with beds of dark-olive-gray, medium-crystalline limestone with abundant fossil fragments at the base. Abundant dark-brown to gray chert nodules are present in some beds.

Hurricane Bridge Limestone

The Hurricane Bridge Limestone of Late Ordovician age is 300 feet thick and is composed of light-gray, finely-crystalline to aphanic limestone. Beds of dark gray chert are present throughout the formation.

Woodway Limestone

The Woodway Limestone of Late Ordovician age is 285 feet in thickness and consists of light-olive-gray to light-brownish-gray limestone. Beds of argillaceous limestone and beds of chert nodules occur near the base and top of the formation.

Ben Hur Limestone

The Ben Hur Limestone of Late Ordovician age is 125 feet in thickness and consists of light-brown and light-gray, fine-grained and finely-crystalline, argillaceous limestone with beds of coarsely-crystalline limestone.

Hardy Creek Limestone

The Hardy Creek Limestone of Late Ordovician age is 75 feet thick and consists of light- to medium-brown and gray, fine- grained, argillaceous limestone containing coarsely-crystalline limestone beds.

Eggleston Limestone

The Eggleston Limestone of Late Ordovician age ranges in thickness from 140 to 170 feet and is divided into three informal members: lower, middle, and upper. The lower member, 51 feet thick in the Mullins well, is composed entirely of greenish-gray, calcareous mudstone with abundant small masses (birdseye) of white calcite. This member is poorly bedded with crumpling and flowage in the mudstone.

The middle member is 155 feet thick and contains a gray and brown platy limestone that is either aphanic or fine- to coarsely-crystalline. The beds range from 1 inch to 12 inches in thickness. Only the crystalline beds contain described fossils.

The upper member is 60 feet thick and contains zones of platy limestone. Two distinct beds of K-bentonite from less than one-inch up to several feet thick, are present in the upper member. The two K-bentonites are about 12 and 56 feet below the top of the Eggleston. Haynes (1992) reported that the lower K-bentonite correlates with the "Deicke" and the upper is the "Millbrig."

Trenton Limestone

The Trenton Limestone of Late Ordovician age has an average thickness of 625 feet and can be divided into three informal members: lower, middle, and upper. The lower member of the Trenton, approximately 200 feet thick, is composed of gray or mottled-gray and white, coarsely-crystalline, fossiliferous limestone that contains mostly brachiopods, bryozoans, and gastropods. Partings of dark-gray shale separate limestone beds. The middle member of the Trenton, about 275 feet thick, is a gray, fine- to medium-crystalline, even-bedded, siliceous limestone. The upper member, 75 feet thick, is a brown- to brownish-gray, coarsely-crystalline, coquinoid limestone. Three K-bentonite beds typically occur within the Trenton. They are approximately at 75, 215, and 495 feet below the top of the formation.

Reedsville Shale

The Reedsville Shale of Late Ordovician age has an average thickness of 540 feet and consists of alternating beds of greenish-gray, soft shale and two types of Trenton-like limestone. One limestone is a light-gray to brownish-gray, siliceous coquinite and the other type is finely crystalline and medium gray in color. The individual thicknesses and horizontal and vertical positions of these shale and limestone beds vary between localities in Wise County.

Sequatchie Formation

The Sequatchie Formation of Late Ordovician age is 260 feet thick in the Penn Virginia No. 20118 well and is a grayish-red to green, calcareous, laminated mudstone and muddy siltstone. In the lower part of the formation, the mudstones and muddy siltstones are dominantly green and the nodular-bedded, argillaceous limestone is grayish-green in color. Mudstones and muddy siltstones are grayish-red in the upper part of the formation.

SILURIAN SYSTEM

Clinch Sandstone

The Clinch Sandstone of Early Silurian age ranges from 200 to 290 feet in thickness and can be divided into two members, the Hagan Shale (lower unit) and the Poor Valley Ridge Sandstone (upper unit) (Miller and Fuller, 1954). A 15-inch sandstone bed marks the base of the Hagan Shale resting disconformably on the Sequatchie Formation. Greenish-gray shale overlies the sandstone bed and contains many platy beds one to three inches thick, composed of silty or sandy limestone. The Hagan Shale Member ranges from 60 to 130 feet in thickness. The upper two-thirds of the Clinch is chiefly sandstone, the Poor Valley Ridge member. The contact between the Hagan Shale and the Poor Valley Ridge is at the base of the lowest thick-bedded, grayish-red to light-gray, fine- to medium-grained sandstone. This sandstone lithology comprises the rest of the overlying Poor Valley Ridge member.

Rose Hill Formation

The name Rose Hill replaces "Clinton" of older usage. It is Early Silurian age and is 300 to 400 feet thick. The Rose Hill is mainly greenish-gray shale, but contains thin- to medium-beds of grayish-red, fine-grained sandstone and hematitic sandstone beds up to 2 feet thick. Shale in the lower part of the Rose Hill contains abundant fossils, especially brachiopods and ostracodes.

Hancock Formation

In Wise County, the Hancock Formation of Late Silurian age, is about 200 feet thick and consists of medium- to dark-gray, finely-crystalline limestone and brownish-gray dolostone. At the base of the Hancock are a few feet of medium- to coarse-grained sandstone or calcareous sandstone that contains some small pebbles of quartz.

DEVONIAN SYSTEM

Wildcat Valley Sandstone

The Wildcat Valley Sandstone ("Corniferous" of drillers) of Early to Middle Devonian age, has a thickness of 95 feet and consists of sandstone, limestone, and shale. The sandstone is dark yellowish-orange, medium- to coarse-grained, porous, friable, and quartzose, contains chert, and bryozoan and coral fragments. The limestone is gray to pinkish-gray and brown, medium- to coarsely-crystalline with disseminated quartz sand grains and lenticular quartz sandstone beds. Light-gray to light-olive-gray chert with abundant bryozoan and coral fragments is abundant. The shale is light olive gray and finely laminated. The Wildcat Valley Sandstone lies disconformably on the Hancock Formation.

DEVONIAN AND MISSISSIPPIAN SYSTEMS

Chattanooga Shale

The Chattanooga Shale (Late Devonian- to Early Mississippian-age) is divided into three members. From oldest to youngest, they are the lower black shale, the middle gray siltstone, and the Big Stone Gap Shale.

The lower black shale member is from 350 to 400 feet thick. The member is a medium-gray, grayish-black to black, very fine-grained, thin-bedded to laminated shale. Shale is typically hard, brittle, and contains paper- to platy-partings. The lower black shale member lies disconformably on the Wildcat Valley Sandstone.

The middle gray siltstone member averages 620 feet in thickness and is a medium-gray, grayish-black to gray, fine- to very fine-grained, thin-bedded to laminated siltstone with sandstone and shale interbeds. Layers of olive-gray, dark-gray, and grayish-black, fissile to platy, thin-bedded shale are common. In Wise County, the middle gray siltstone member overlies the lower black shale member with apparent conformity and is conformably overlain by the Big Stone Gap Member.

The Big Stone Gap Member is 400 to 450 feet thick and is a grayish-black to black, silty, pyritic shale. It is typically hard, brittle, papery to platy, thin- to medium-laminated shale. In Wise County, the Big Stone Gap Member conformably overlies the middle gray siltstone member. The lower contact is difficult to pick because the middle gray siltstone member and the overlying Big Stone Gap Member (below the Berea Sandstone bed) laterally-grade into the more homogeneous greenish to brownish-gray shale and siltstone. The Berea Sandstone bed of the Big Stone Gap Member is the most significant bed within the Chattanooga Shale, and is present in all wells that penetrate the shale. The Berea ranges from 19 to 150 feet and averages 89 feet thick. It consists of light-gray siltstone and light- to medium-gray, very fine-grained sandstone.

MISSISSIPPIAN SYSTEM

Price Formation

The Price Formation ("Weir" of drillers) of Early Mississippian age, has a thickness range of 200 to 300 feet and generally consists of two units, a lower interbedded siltstone-shale-sandstone unit and an upper sandstone unit. In the lower unit, the siltstone is medium-gray, thinly laminated, hard, hackly, and fissile, with platy partings, and contains as much as 5 percent detrital mica. The upper 20 feet of the lower unit is very fine-grained, thin- to medium-bedded, light-gray sandstone. The upper unit of the Price Formation is a very fine-grained, medium-gray sandstone that is medium bedded, cross laminated, and slightly micaceous. It is interbedded with hard, hackly, thinly-laminated, medium-gray siltstone. The contact of the Price with the underlying Big Stone Gap Member of the Chattanooga Shale is gradational.

Maccrady Shale

The Maccrady Shale ("Red Injun" or "Injun" of drillers) of Late Mississippian age ranges in thickness from less than one foot to as much as 100 feet. The Maccrady consists of grayish-red to greenish-gray shale and siltstone with interbedded thin- to medium-bedded, dark-gray to greenish-gray, very fine-grained sandstone. Shales are thinly laminated, hard, and brittle with platy partings whereas the siltstone is very thin-bedded, hard, and hackly with flaggy partings. The Maccrady seems conformable with the underlying Price Formation.

Greenbrier Limestone

The Greenbrier Limestone ("Big Lime" of drillers) of Late Mississippian age averages 490 feet in thickness. The Greenbrier consists of a thick sequence of dense, crystalline, dark-gray, brownish-gray to very light-gray, micritic to sparry, highly fossiliferous, oolitic, locally cherty limestone. The limestone contains interbeds of shale, siltstone, and argillaceous limestone. The lower 40 feet contain black, gray, and pale-red chert nodules. A pale-brown dolostone occurs near the top of the chert-bearing zone. The limestone lies disconformably on the Maccrady Formation or when the Maccrady is absent on the underlying Price Formation. The Greenbrier generally thickens from 350 feet along the Letcher County, Kentucky and Wise County, Virginia boundary to 605 feet toward the southeast along the Russell-Wise County line.

Bluefield Formation

The Bluefield Formation of Late Mississippian age has an average thickness of 350 feet and consists mainly of calcareous shale, siltstone, limestone, and minor sandstone. The calcareous shales and siltstones are generally gray, grayish red, moderate red, greenish gray, and pale green. Limestones, which are dominant in the lower part of the formation, are

gray, silty, fossiliferous, and fine to medium grained. The sandstones are light to medium gray, very fine to fine grained, calcareous, and discontinuous. Three formally named members of the Bluefield Formation occur in Wise County, from oldest to youngest: the Lillydale Shale, the Glenray Limestone, and the Indian Mills Sandstone.

The Lillydale Shale Member ("Pencil Cave shale" of drillers), is between 80 and 130 feet thick and is a dark- to greenish-gray, micaceous shale, which is black and carbonaceous at the base. The shale contains many lenses of siderite and a few sandstone beds.

The Glenray Limestone ("Little Lime" of drillers) ranges in thickness between 10 and 80 feet, lies 50 to 150 feet above the base of the Bluefield and directly above the Lillydale Shale. The limestone is medium light gray, aphanic, silty, dolomitic, and micritic; it also contains black chert nodules. The member is thin to thick bedded and is interbedded with light-greenish-gray shale and siltstone.

Strata between the Glenray Limestone and the Indian Mills Sandstone averages 150 feet in thickness. The strata consist of fossiliferous, light-greenish-gray shale and limestone and grayish-red to greenish-gray, fine-grained sandstone.

The Indian Mills Sandstone Member ("Lower Maxton" of drillers, also may be spelled "Maxon" by drillers) ranges from 5 to 80 feet in thickness and is light-gray to light-greenish-gray, very fine- to fine-grained, quartzose to feldspathic sandstone.

The lower contact of the Bluefield Formation with the Greenbrier Limestone is gradational. The Bluefield attains a maximum thickness of 470 to 475 feet in the southeastern part of the area and thins to the northwest and west to about 230 feet along the state boundary between Wise County, Virginia and Letcher County, Kentucky.

Hinton Formation

The Hinton Formation of Late Mississippian age averages 650 feet in thickness and is composed of interbedded gray, grayish-red, and greenish-gray shale and siltstone with minor amounts of calcareous siltstone and limestone. The formation is divided into six distinct lithologic members: the Stony Gap Sandstone at the base, the middle red, the Little Stone Gap, the middle shale, the Tallery Sandstone, and the Pratter Shale at the top.

The Stony Gap Sandstone Member ("Middle Maxton" or "Middle Maxon" of drillers), ranges in thickness from less than one foot to 180 feet, and consists chiefly of light-gray to white, fine-grained sandstone with interbedded medium-gray siltstone and shale. There are some local beds of coal. In central and northwestern Wise County the Stony Gap Sandstone grades laterally into siltstone.

The middle red member (Wilpolt and Marden, 1959) attains a maximum thickness of about 650 feet in southeastern Wise County and thins northwestward to about 300 feet along the Letcher County, Kentucky and Wise County, Virginia boundary. It is chiefly grayish-red shale interbedded with limestone and sandstone with olive-gray, grayish-red to medium-gray shale and siltstone.

The Little Stone Gap Member, named by Miller (1964) (the Avis Limestone of Reger, 1926), averages about 30 feet thick and is a medium-gray, abundantly fossiliferous, argillaceous, highly calcareous shale, mudstone, and micritic limestone.

The middle shale member of Englund (1968) averages 20 feet in thickness and consists of medium-gray and greenish-gray shale, with a few thin grayish-red beds that are calcareous. This member also contains interbeds of very fine- to fine-grained, light-gray to grayish-red sandstone and medium-gray argillaceous limestone. The shale ranges from 40 feet in the southeast, thinning to the northwest to zero feet, where eroded during or before deposition of the overlying Tallery Sandstone.

The Tallery Sandstone Member of Reger (1926) ("Ravencliff" of drillers) ranges in thickness from about 30 feet to as much as 160 feet and is a very light-gray and light-greenish-gray, fine- to medium-grained, feldspathic sandstone containing rounded quartz pebble conglomerates. In southwestern Virginia the Tallery is commonly confused with the younger Princeton Sandstone (Campbell and Mendenhall, 1896).

The Pratter Shale Member of Englund (1968) averages 40 feet in thickness and is normally the top bed of the Hinton Formation throughout the study area. It consists of grayish-red shale with thin beds of siltstone, limestone, and very fine-grained sandstone.

The lower contact of the Hinton Formation may be a disconformity. In central and northwestern Wise County the basal Stony Gap Sandstone is absent, so the lower contact is gradational. The Hinton ranges from 470 feet near the state boundary between Wise County, Virginia and Letcher County, Kentucky to as much as 820 feet near the Russell-Wise County line.

Bluestone Formation

The Bluestone Formation of Late Mississippian age consists mainly of shale, siltstone, and sandstone. The shale is grayish-red to greenish-gray and locally medium- to dark-gray, calcareous in part, locally carbonaceous, and may contain fossil fragments. Siltstone is pale red to pale green, mottled, and calcareous. Sandstone beds are thin to discontinuous, dark yellowish-brown to gray, very fine to fine grained, and micaceous. The formation has been divided into several members (Reger, 1926; Cooper, 1944; Wilpolt and Marden, 1959; Englund, 1968). In Wise County the Bluestone contains three distinct members: Pride Shale, middle sandstone, and upper shale.

The basal Pride Shale Member ranges from 60 feet in the northwestern part of the county to about 300 feet in the southeast and consists of grayish-black shale that contains beds of siltstone, sandstone, and limestone. The member can be traced throughout the subsurface in the study area.

The middle sandstone member ranges between zero and 180 feet in thickness and thins from southeast to northwest. It consists of greenish-gray, very fine- to coarse-grained argillaceous sandstone; that interfingers with lenses of conglomerate containing pebbles of limestone and quartz. This member

appears to correlate in part with the Glady Fork Sandstone Member of Reger (1926).

The upper shale member ranges from zero to 320 feet in thickness and thins from southeast to northwest and consists of greenish-gray to grayish-red or medium-gray siltstone and calcareous shale. Sandstone in the unit is medium to dark gray, fine to medium grained, and locally conglomeratic.

The lower contact of the Bluestone Formation may be a disconformity because the upper beds of the Hinton Formation and the overlying Princeton Sandstone are wedge-like and are absent in the area. Although the lower boundary of the Bluestone is well defined and sometimes abrupt, in any local stratigraphic section the strata appear to represent an uninterrupted depositional sequence. The Bluestone ranges in thickness from 210 feet near the Wise County, Virginia-Letcher County, Kentucky boundary to as much as 530 feet near the Wise and Russell County line.

PENNSYLVANIAN SYSTEM

Pocahontas Formation

The Pocahontas Formation of Early Pennsylvanian age consists of medium- to dark-gray, very fine-grained sandstone, medium- to dark-gray siltstone, and coal beds. Coal beds present in the area are the Squire Jim and the Pocahontas numbers 1 through 7. The Pocahontas Formation attains a maximum thickness of about 750 feet near the Wise and Russell County line. From the county line the formation thins in a northwestward direction. Near Russell Creek, Pocahontas equivalent strata above the lower quartzarenite bed of the Lee Formation are about 130 feet thick, but thin to less than 1 foot near the Town of Banner to the northwest. At Banner, the top of the Pocahontas is shifted to the base of the lower quartzarenite bed, where the remaining part of the Pocahontas, below the lower quartzarenite bed, is about 320 feet thick. At Banner, a coal equivalent to the Pocahontas No. 3 lies 15 feet below the lower quartzarenite bed (Nolde, 1994a). Northwest of Banner the Pocahontas thins to less than 1 foot near the Town of Wise. A schematic diagram of the relationships of the rock stratigraphic units is shown in Figure 3.

Lee Formation

The Lee Formation of Early Pennsylvanian age ranges between 1,450 and 900 feet in thickness and contains three massive sandstone units separated by siltstones and thin coal beds. The sandstone units are quartzose, very hard, light gray to white, and fine to medium grained with basal conglomerates. The Lee is composed of three members: the Middlesboro, the Hensley, and the Bee Rock Sandstone. The lower two sandstones and a shale zone make up the Middlesboro Member. A series of higher siltstones and coal beds comprise the Hensley Member, and the upper quartzose sandstone unit, the Bee Rock Sandstone Member. Coal beds present in the Lee Formation are the Pocahontas No. 8, Little Fire Creek, Lower Horsepen, Beckley, War Creek, C, Middle and Upper Horsepen, and Lower Seaboard. To the southeast and east the lower quartzose sandstone unit of the Middlesboro Member intertongues with the Pocahontas Formation. The Bee Rock Sandstone Member is present west and northwest of the Town of Wise. East and southeast of the Town of Wise the Bee Rock Sandstone Member grades laterally into the McClure Sandstone Member of the Norton Formation. The Lee averages 1,450 feet thick where the Bee Rock Sandstone is present and 900 feet where the Bee Rock is absent, generally thinning from west to east. A schematic diagram of the relationships of the rock stratigraphic units is shown in Figure 3.

Lower Norton Formation

The lower unit of the Norton Formation, which averages 500 feet in thickness, consists of strata between the top of the Middlesboro Member of the Lee Formation and the base of the Kennedy coal bed (Nolde, 1994a). The lower unit and its lateral equivalents, the Bee Rock Sandstone and Hensley Members of the Lee Formation, are present throughout the subsurface. The lower unit contains much less sandstone and more shale and siltstone than the Lee Formation and the sandstones are more argillaceous and micaceous. Coal beds or coal zones within the lower unit are: Upper Seaboard, Upper Seaboard "A", Tiller, Jawbone, Raven, and Aily.

Upper Norton Formation and Gladeville Sandstone

The upper unit of the Norton Formation consists of strata from the base of the Kennedy coal bed to the base of the Gladeville Sandstone. When the Gladeville is absent, the top of the Norton is placed at the base of the Dorchester coal bed. Shale and siltstone dominate the upper unit with local development of thick sandstone bodies. Three marine shale sequences are present in the upper unit. They are above the Lower Banner coal, Splash Dam coal, and Hagy coal. Coal beds within the upper unit are Kennedy, Lower Banner, Upper Banner, Splash Dam, Hagy, and Norton. The unit ranges from 700 and 950 feet in thickness.

The Gladeville, which separates the Norton and Wise Formations, is largely a quartzose to feldspathic and micaceous, light-gray to white, fine- to medium-grained sandstone that ranges from less than one foot to as much as 50 feet in thickness.

Wise and Harlan Formations

The Wise Formation is composed of strata from the top of the Gladeville Sandstone or base of the Dorchester coal bed, when the Gladeville is absent, to the top of the High Splint coal bed or the base of the Harlan Formation, when the High Splint coal bed is absent. Characteristically, siltstone and sandstone dominate the Wise. Limestone and calcareous shales occur within the siltstone units. The shale beds are dark gray to grayish-black and contain fossil plants and marine invertebrate fossils. Two widespread shale beds are the Kendrick

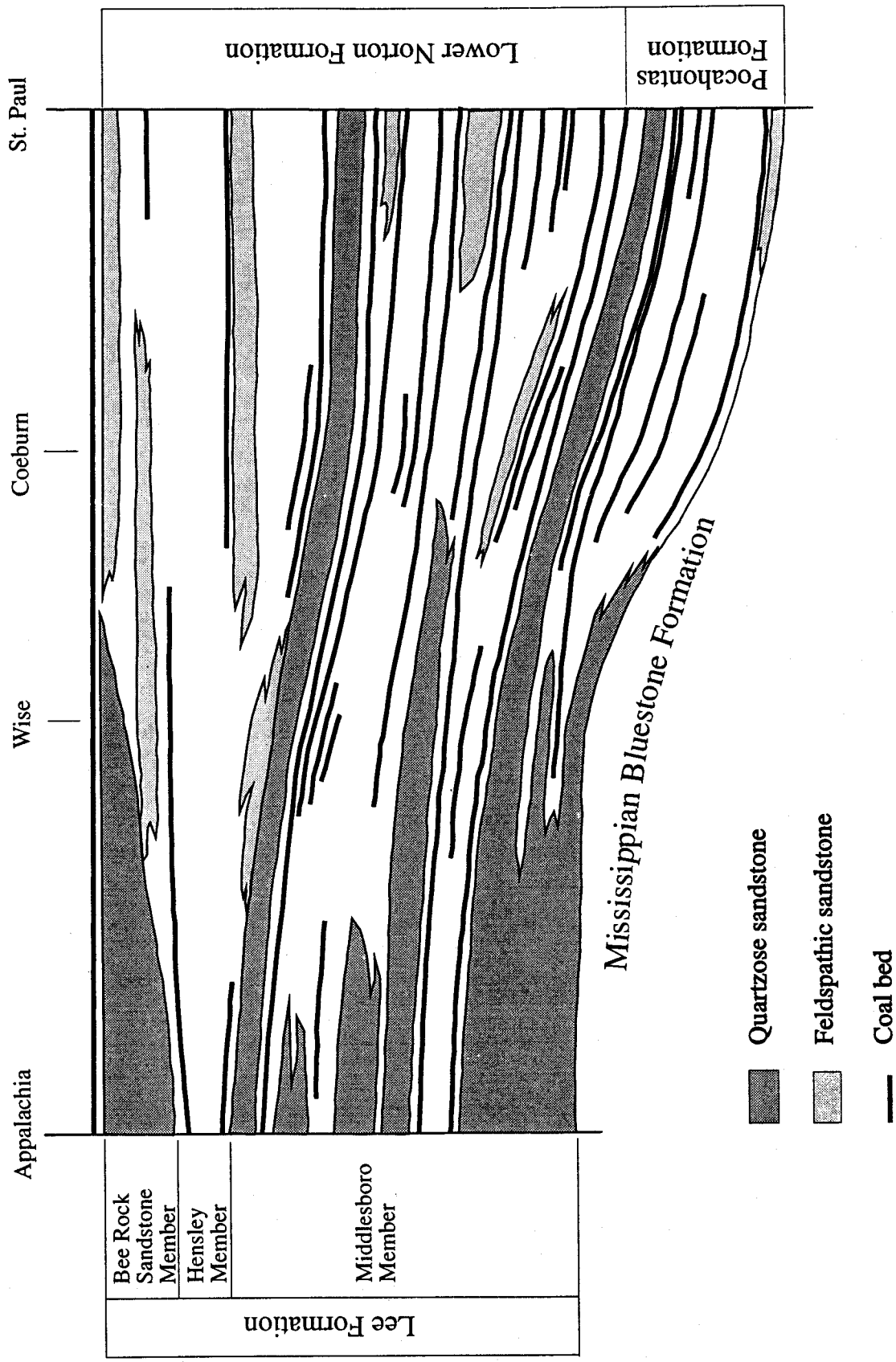

Figure 3. Schematic correlation diagram showing stratigraphic relationships, lithology, and distribution of the Pocahontas, Lee, and lower Norton Formations.

and Betsie. The most widespread limestone bed is associated with the Magoffin Member. The more important coal beds are in ascending order: Dorchester, Clintwood, Imboden, Taggart, Low Splint, Phillips, Pardee, and High Splint. The thickness of the formation ranges from less than 1 foot in the eastern part of the county to as much as 2,268 feet on Black Mountain along the Letcher County, Kentucky and Wise County, Virginia line.

The Harlan Formation extends upward from a basal cliff-forming sandstone to the top of Black Mountain. The formation consists predominantly of light- to medium-gray, fine- to medium-grained sandstone with interbedded medium-gray shale and siltstone. The Harlan Formation contains the No. 13 coal bed. The maximum preserved thickness is 600 feet.

STRUCTURE

The surface of the Precambrian basement rocks, deformed and metamorphosed during the Grenville orogeny about 940 million years ago, slopes to the southeast at 69 feet per mile. Similarly the sedimentary cover rocks, for example the top of the Berea Sandstone bed, of Early Mississippian age, slopes to the southeast at 63 feet per mile.

The Pine Mountain fault and structures above this fault formed during the Alleghanian orogeny. The overriding block of this fault namely the Pine Mountain fault block contains broad synclines and anticlines that trend northeast-southwest and are broken by northwest-southeast trending normal faults (Henika, 1994). Major structural features (Plate 1) are the Pine Mountain fault, Powell Valley anticline, the Middlesboro syncline, the Dorchester syncline, the Buck Knob anticline, the Gladeville anticline, the Glamorgan fault, the Coeburn fault, the Kent Junction fault, and the St. Paul fault.

The Pine Mountain fault crops out about 3000 feet northwest of the Virginia-Kentucky state line and trends roughly parallel to the State line. About 3.5 miles southeast of the outcrop (near the axis of the Middlesboro syncline) the fault lies about 3000 feet below sea level. Throughout the remainder of Wise County the fault plane slopes to the southeast to where it lies about 5100 feet below sea level near Town of St. Paul at the Wise and Russell County line.

The Powell Valley anticline, in the southern part of the county, is an elongate, fault-bend fold that plunges to the east.

The Middlesboro syncline is oriented in a northeast-southwest direction through northwestern Wise County generally parallel to the Pound River. The syncline reflects the location and geometry of a subsurface structural ramp on the Pine Mountain fault that rotated the overlying rocks during thrusting (Henika, 1994). Beds on the northwest limb of the syncline have dips up to 16 degrees toward the southeast whereas beds on the southeast limb have much gentler dips of generally 5 degrees to the northwest.

The Glamorgan fault can be traced northward from Ramsey to the Virginia-Kentucky state boundary near Pound Gap. The fault plane is linear, steep to vertical with local variations, and an upthrown side to the east.

The Coeburn fault trend is north-south and the rocks in Caney Ridge and Coeburn quadrangles are upthrown to the west and are parallel to the Glamorgan fault, six miles to the west. Movement along the fault is believed to be mainly vertical with a thrust to the east component. The fault probably formed as the result of differential horizontal stress within the Pine Mountain fault block. The fault consists of a 400-foot wide zone of disruption. Vertical displacement along the fault ranges between 20 and 140 feet. Horizontal displacement along the fault is probably less than 2,000 feet.

The Kent Junction fault is a minor northwest-dipping normal fault, which trends roughly northeast-southwest. Vertical displacement along the fault is about 150 feet.

The St. Paul fault brings Middle Cambrian limestone and dolostone of the Honaker Formation into fault contact with Early Pennsylvanian siltstone and sandstone of the Pocahontas and Lee Formations. The fault lies 5660 feet below sea level in the Gulf Price No. 1 well about four miles southeast of St. Paul. Geophysical data along with surface geology indicate that the St. Paul fault merges with the Pine Mountain fault. Movement along the St. Paul fault was from southeast to northwest. Near the fault contact the Pennsylvanian units have been overturned. The southeast limb has been detached and thrust northwestward along a subsidiary fault.

NATURAL GAS, OIL, AND COALBED METHANE

Exploration for oil and natural gas in Wise County began with the drilling of the G.W. Gish well, in the Nettle patch area, in the middle 1890s to a total depth of 2,153 feet. The Gish well (Plate 1, 60A 9-0-1), about 2 miles southeast of the Town of Norton, had a show of gas at 626 feet within the upper part of the Bluefield Formation. The driller reported a "white lime" at 1,000 feet below the surface. This "white lime" correlates with the Greenbrier Limestone.

Six wells (Table 1) were drilled from about 1900 to 1952 in Wise County. These wells had shows of gas, but were completed as dry holes. In 1953 two-commercial gas wells were drilled and completed in the county. The first well was completed in July 1953 along Phillips Creek in the Flat Gap area in the western part of the county. Later a second well was completed in August 1953 in the Nora gas field in the Caney Ridge area. A slight increase in drilling activity from 1954 to 1983 resulted in the drilling and completion 36 gas wells and seven oil wells. A rapid increase in drilling activity between 1984 and 1986 resulted in 139 wells being drilled of which 110 resulted in a gas well, 26 were oil wells, and three wells were plugged and abandoned. A decrease in drilling activity between 1987 and 1991 resulted in drilling and completion of 40 gas wells, one oil well, two coalbed methane wells, and one dry hole. An increase in drilling activity during 1992 and 1994 resulted in 86 gas wells, 13 oil wells, and twelve coalbed methane wells. Also during this time two wells were plugged and abandoned. During 1995, eight gas wells and two coalbed methane wells were drilled. As of June 30, 1996, 377 wells had been drilled in this county in the search for natural gas. Three-hundred and fifty-two were drilled for conventional gas and 25 were drilled for coalbed methane. Twenty-four of the coalbed methane wells are producing gas, one was drilled as a corehole and is plugged and

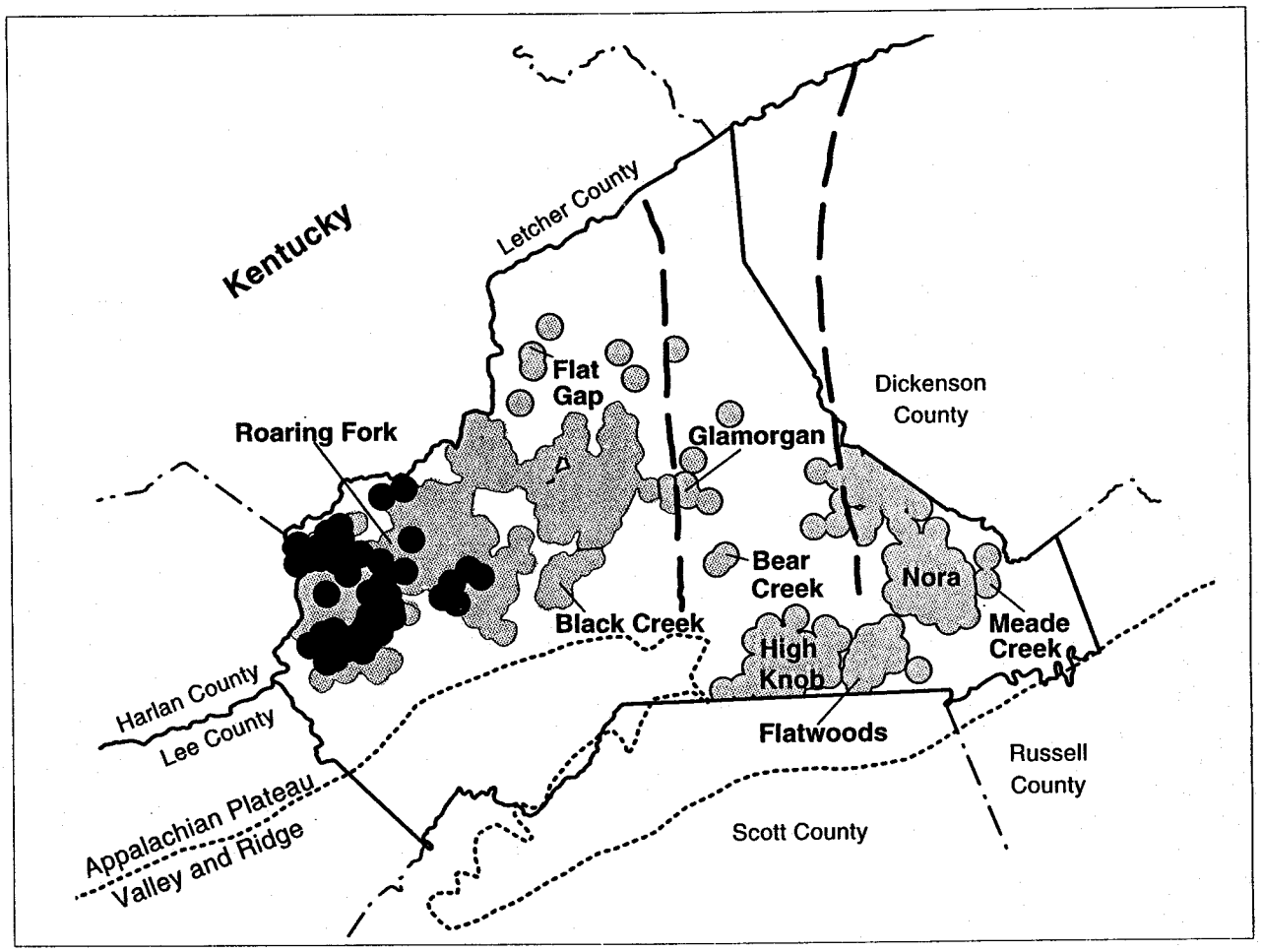

Figure 4. Location of Wise County gas fields.

abandoned. Of the 377 wells drilled, 306 are producing gas, 47 are producing gas and oil, eight are plugged and abandoned, and 16 are dry holes. This is a 93.6 percent success rate. Three-hundred and sixty-six of the 377 wells are in nine gas fields (Figure 4). The nine gas fields (Table 3): Bear Creek (2), Black Creek (10), Flat Gap (2), Flatwoods (17), Glamorgan (6), High Knob (33), Meade Creek (3), Nora (56), and Roaring Fork (235). The remaining eleven wells are not assigned to a field. The Coalbed methane wells are in Nora field (eight wells), Meade Creek field (one well), and Roaring Fork field (fifteen wells).

Between the middle 1890s and 1996 there have been 15 natural gas operators in Wise County (Table 4). Four operators drilled wells in the county before commercial amounts of gas were discovered. These operators were an unknown in 1890s, Benedum Trees in 1933, Southwest Oil & Gas in 1940, and New York Mining and Manufacturing in 1951. These operators were unsuccessful in discovering natural gas. Then in 1953 Clinchfield Coal Company drilled and completed the first two commercial gas wells in the county. Clinchfield produced gas from these two wells until they were shut-in in 1959. In 1967, Penn Virginia Resources purchased the two wells from Clinchfield Coal Company. In 1968 Trans State Oil and Gas drilled a well in Powell Valley near Butcher Gap. They encountered oil in the Clinch Sandstone from a depth of 970 to 985 feet. The well was abandoned because of hole problems. During 1972 Columbia Gas Transmission completed a lease with the Penn Virginia Corporation and in 1974 Columbia began drilling on these leases. During 1979 Philadelphia Oil Company expressed its intent to drill one well in Wise County for extension of the Nora field. In 1979 they drilled and completed five wells. Wise Oil and Gas began a drilling program in 1981 near Black Creek in the Norton area. They drilled 10 wells. Also in 1981 American Natural Resources (ANR) began a drilling program. They began drilling in the Roaring Fork area during 1983. ANR produced the first oil. In 1985 ANR purchased the two Penn Virginia wells. In 1987 Philadelphia Oil Company was purchased by Equitable Resources Exploration, Inc. AMVEST Oil and Gas, Inc. began drilling in 1988. In 1992 Equitable Resources Exploration purchased ANR Production wells. Then in 1996 Equitable changed their name to Equitable Resources Energy Company. Currently Equitable Resources Energy Company and AMVEST Oil & Gas, Inc. are the only natural gas producers in the county.

Table 5 presents information on the number of completions per producing formation by field. The Chattanooga Shale including the Berea sandstone is the dominant zone (44 per-

Table 3. Summary of wells drilled by field and result, 1890-1995.

Field	Gas Well	Oil Well	Gas Well-PA	Dry Hole	Coalbed Methane	Total
Bear Creek	2					2
Black Creek	9			1		10
Flat Gap	1		1			2
Flatwoods	15		1	1		17
Glamorgan	6					6
High knob	30			3		33
Meade Creek	2				1	3
Nora	49		1		8	58
Roaring Fork	164	47	4	5	15	235
Non-associated	4		1	6		11
Total	**282**	**47**	**8**	**16**	**24**	**377**

Table 4. Summary of wells drilled by Operator and result.

Operator	Began Drilling Activity	Gas	Oil Well	Coalbed Methane	Gas-PA	Dry Hole	Total drilled
Amvest Oil & Gas, Inc.	1988	6	0	0	0	0	6
ANR Production Co.	1984	133	29	0	2	1	165
Benedum Trees	1933	0	0	0	0	1	1
Castle & Jenkins	1950	0	0	0	0	1	1
Clinchfield Coal Co.	1953	17	1	0	3	0	21
Coastal Oil & Gas Corp.	1990	2	0	0	0	0	2
Columbia Gas Transmission	1974	4	0	0	0	6	10
Equitable Resources Expl.	1987	99	13	24	2	0	138
New York Mining & Manufacture	1951	0	0	0	0	1	1
Penn Va Resources	1989	0	0	0	1	0	1
Philadelphia Oil Co.	1979	16	0	0	0	0	16
Southwest Oil & Gas	1940	0	0	0	0	3	3
Trans State Oil & Gas	1970	0	0	0	0	1	1
Unknown	1895	0	0	0	0	1	1
Wise Oil & Gas	1982	5	4	0	0	1	10
Total		**282**	**47**	**24**	**8**	**16**	**377**

Table 5. Number of completed intervals by field.

Producing Zone	Bear Creek	Black Creek	Flat Gap	Flatwoods	Glamorgan	High Knob	Meade Creek	Nora	Roaring Fork	Number of Completions
Lee							1	7	15	23
Pocahontas							1	9		10
Ravencliff								4	1	5
Stony Gap Ss								2		2
Bluefield						1				1
Greenbrier Ls	1	4	1	7	3	12	1	19	97	145
Price		5	1		4			1	180	191
Chattanooga Sh	1	9	1	12	6	23		10	193	155
Berea Ss		8	1	15		23	2	43	136	228
Wildcat Valley Ss								1		1
Number of completion zones per field	2	26	4	34	13	59	5	96	622	861
Number of Wells in Gas Field	2	9	1	15	6	30	3	57	226	349

cent) completed for natural gas production.

Accumulation of natural gas in this area is related to permeability and porosity rather than structure. Even in the thick sandstones, only thin zones may be sufficiently permeable for gas accumulation. Permeable beds in these thin zones, form the reservoirs. Dry holes may be present, even in areas shown to be productive, because of lack of permeability and porosity.

DESCRIPTION OF INDIVIDUAL GAS FIELDS

BEAR CREEK FIELD

The Bear Creek field (Figure 4), discovered on January 3, 1956, comprises roughly 792 acres and contains two wells. The combined total depth of the wells is 10,519 feet; the average depth is about 5,260 feet. The Clinchfield Coal Company in partnership with Wise Development Company drilled the first well No. 171 and encountered gas in the Greenbrier Limestone at a depth of 4,365 to 4,558 feet. Initial open flow gauged 33 Mcf per day. After acidizing the Greenbrier Limestone from 4,263 to 4,584 feet with 4,000 gallons of acid, final open flow was 1,180 Mcf per day. Rock pressure after stabilizing flow for 72 hours was gauged at 1,010 pounds per square inch.

The second well, the Clinchfield Coal Company, Wise Development well No. 187, completed on July 10, 1957 was drilled to a depth of 5,935 feet. Gas shows were reported in the Greenbrier Limestone (4,735 feet) and the Chattanooga Shale (5,541 and 5,875 feet). They explosively fractured the Chattanooga Shale with 8,734 pounds of gelatine in the interval 4,999 to 5,914 feet. Final open flow after the first hour was 310 Mcf. Rock pressures after 48 hours was 410 pounds per square inch. As of January 1, 1958, both wells were shut in.

BLACK CREEK FIELD

The Black Creek field (Figure 4, Table 3) comprises roughly 2,486 acres and contains 10 wells. The combined total depth of the wells is 59,096 feet; the average depth is about 5,909 feet. The field was discovered on June 8, 1983 when the Wise Oil and Gas Exploration, Inc., and Greater Wise, Inc. drilled well No. 10013 and encountered gas in the Greenbrier Limestone, Price Formation, and Chattanooga Shale. Initial open flow was 193 Mcf per day from the Greenbrier Limestone, 168 Mcf per day from the Price Formation, and 75 Mcf per day from the Chattanooga Shale. Both the Price Formation (4,268-4,354 feet) and the Chattanooga Shale (5,135-5,278) was hydraulically fractured. The Greenbrier Limestone was acidized from 3,987 to 4,152 feet. New York Mining and Manufacturing Company drilled one dry hole within the field boundary. This well was the Graham No. 1, which was completed on December 8, 1951. They drilled the well to a depth of 6,070 feet and penetrated shales in the Silurian Rose Hill Formation for about 80 feet. Gas shows were reported in the Graham well in the Price Formation and Berea Sandstone. Subsequently, eight additional wells have been drilled and completed as producers. Nine wells (Table 5) in the field produce gas from the Chattanooga Shale, Berea Sandstone, Price Formation, and Greenbrier Limestone. Average final flows from these reservoirs are 478 Mcf per day from the Chattanooga Shale, 293 Mcf per day from the Price Formation, and 2,455 Mcf per day from the Greenbrier Limestone.

FLAT GAP FIELD

The Flat Gap field (Figure 4) comprises roughly 833 acres and contains two wells. Equitable Resources Exploration discovered the field on August 22, 1994, when they drilled the Ernest Bolling V-3140 well and encountered gas in the Greenbrier Limestone and Chattanooga Shale. Total depth of the V-3140 well is 5,060 feet. The Greenbrier was acidized from 3,570-3,587 feet. The Price Formation was hydraulically fractured from 3,670 to 3,840 feet. Also the Berea Sandstone (from 4,041-4,110 feet) and the Chattanooga Shale from 4,110 to 4,502 feet and 4,752 to 4,858 feet were hydraulically fractured. Commingling of gas from the Chattanooga Shale was 169 Mcf; the Price Formation and Greenbrier Limestone yielded 1,075 Mcf. Equitable attempted to drill another well, the Red River Coal Company V-3199, in the field in December of 1994. The well site was abandoned because of hole trouble.

FLATWOODS FIELD

The Flatwoods field (Figure 4, Table 3) comprises roughly 3,971 acres and contains 17 wells. The combined total depth of the wells is 77,100 feet; the average depth is about 4,819 feet. Philadelphia Oil Company and Banner Coal Company discovered the field on May 16, 1987, when they drilled well P-366 and encountered gas in the Berea Sandstone. Hydraulic fracturing of both the Berea Sandstone and Cleveland Shale interval (4,344-4,774 feet) yielded a final flow of 1,060 Mcf after stabilizing flow for six hours. One dry hole, the Columbia Gas Transmission Corporation's Penn Virginia Resources well No. 20225, is near the field limits. Subsequently, 14 additional wells have been completed as producers from commingled reservoirs. Average final flow for commingled gas from that part of the Chattanooga Shale that lies below the Berea Sandstone is 399 Mcf per day; from the Chattanooga Shale including the Berea Sandstone, 848 Mcf per day; and from the Chattanooga Shale and Greenbrier Limestone, 1,179 Mcf per day. One well completed in the Berea Sandstone yields 220 Mcf per day. A gas well was drilled as a corehole to test for the presence of coal beds. Coalbeds were present, but were too thin to produce. The well was plugged and abandoned in August 1994.

GLAMORGAN FIELD

The Glamorgan field comprises roughly 2,285 acres and contains six wells. The combined total depth of the wells is 35,946 feet; the average depth is about 5,991 feet. AMVEST Oil and Gas, Inc. and Glamorgan Coal Company discovered the field on August 31, 1988, when they drilled the No. G-3

well and encountered gas in the Chattanooga Shale from 5,188 to 5,284 feet and from 5,766 to 5,854 feet. Hydraulic fracturing of the Chattanooga Shale from the interval 5,188 to 5,284 feet and at 5,766 feet produced a final open commingled flow of 358 Mcf per day after stabilizing flow for four hours. Average final open flow for two wells producing commingled gases from the Chattanooga Shale and Berea Sandstone is 325 Mcf per day. Four wells produce 489 Mcf per day by commingling of gas from the Chattanooga Shale, Price Formation, and Greenbrier Limestone.

HIGH KNOB FIELD

The High Knob field (Figure 4), roughly a 7,638-acre area containing 33 wells, was discovered on February 13, 1975, when Columbia Gas Transmission Corporation, Penn Virginia Resources drilled the No. 20120-T well and encountered gas in the Berea Sandstone from 3,318 to 3,385 feet. After hydraulic fracturing, final open flow from the Berea was 614 Mcf after flow had been stabilized for six hours. The combined total depth of the 33 wells is 148,609 feet; the average depth is about 4503 feet. Of the 33 wells in the field, 30 are producing gas and three are dry holes. The three dry holes were drilled between 1940 and 1942 and before the discovery of the High Knob field.

MEADE CREEK FIELD

The Meade Creek field, which comprises roughly 1,091 acres and contains three wells, was discovered on September 1, 1987. The combined total depth of the conventional gas wells is 12,556 feet; the average depth is 6,278 feet. A coalbed methane well was drilled to a total depth of 2,530 feet. ANR Production Company drilled the discovery well. This well, ANR No. 75, encountered gas in the Greenbrier Limestone from 4,818 to 4,834 feet and in the Berea Sandstone from 5,472 to 5,572 feet. After hydraulically fracturing the Berea, final open flow was 133 Mcf per day after flow had stabilized for three hours. After acidizing and stabilization of flow for three hours, the Greenbrier Limestone yields 1,163 Mcf per day.

A second well, the ANR Production Company No. 13 completed on October 9, 1990, was drilled to a depth of 6,896 feet. The driller reported a gas show in the Berea Sandstone (5,581 to 5,692 feet). The Berea was hydraulically fractured in the 5,618 to 5,667-interval. Final open flow after allowing the flow to stabilize for three hours was 169 Mcf per day. Rock pressure after 48 hours was 615 pounds per square inch.

The third well completed in the field was a coalbed methane well. Equitable Resources Exploration drilled the No. VC-2929 well, which was completed on July 21, 1993. Coal beds and associated rocks were hydraulically fractured in the Pennsylvanian-age Pocahontas (1,908-2,435 feet), including the Pocahontas coalbeds 7, 6, 5, 4, 3, and 1, and Lee Formations (1,197-1,845 feet), including the Greasy Creek, Lower Seaboard, Middle and Upper Horsepen, "C", War Creek, Lower Horsepen,and Little Fire Creek coalbeds. The average thickness of these coalbeds are 2.6 feet. Commingling of gas from these formations was gauged at 53 Mcf after six hours. Rock pressure after 48 hours was 305 pounds per square inch.

NORA FIELD

The Nora field is the largest gas field in the Commonwealth and comprises more than 178 square miles (113,920 acres) in Dickenson and Wise Counties. It contains 638 wells. The field was discovered in Dickenson County on April 12, 1949, when the Clinchfield Coal Company, drilled the H. P. Phillips No. 101 well. The well penetrated a producing zone in the Greenbrier Limestone from a depth of 3,849 to 3,877 feet. Initial flow of gas was 426 Mcf per day. They acidized the Greenbrier from 3,801 to 3,894 feet with 1,000 gallons of acid. Final flow after acidization was 1,632 Mcf per day. The well also had a gas show in the Lee Formation at a depth from 1,028 to 1,032 feet. With subsequent development of the Nora field, gas was discovered in the Wise County portion on September 2, 1953 with the drilling and completion of the Clinchfield Coal Company, Dunn Coal Land No. 148. The well's total depth was 5,738 feet after bottoming in 2 feet of the Early Devonian-age Wildcat Valley Sandstone. Final open flow of gas from the Chattanooga Shale was 440 Mcf per day.

Of the 178 square miles in the field, approximately 25 square miles (15,857 acres) are in Wise County. The field lies mostly east and along the Coeburn fault and north of the Guest River. Fifty-six wells are in the Wise County portion of the field. Of the 50 conventional wells, 49 are producing gas, and one is plugged and abandoned. The combined total depth of the conventional gas wells is 284,118 feet; the average is about 5,682 feet. The field (Table 5) produces from the Chattanooga Shale, Berea Sandstone, Price Formation, Greenbrier Limestone, Hinton Formation, and the Pennsylvanian coalbeds and associated rocks.

Coalbed methane exploration and development began in Wise County in late 1990. Two wells were drilled and completed in the Coeburn area. The first coalbed methane well completed in Wise County was the Equitable Resources Exploration, Martha J. Blackwell PC-389 on August 14, 1990. Coal beds and associated rocks were hydraulically fractured in the Pennsylvanian-age Pocahontas (2,330-2,734 feet) and Lee Formations (2,004-2,330 feet). Commingling of gas from these intervals was gauged at 60 Mcf per day. The second well, Equitable Resources Exploration, James H. Dunn P-437C, completed on October 23, 1990, was drilled to a total depth of 2678 feet.

One coalbed methane well was completed in 1992; one well in 1993; and four wells in 1994. All eight coalbed methane wells are producing gas. The combined total depth drilled for coalbed methane is 21,960 feet; the average is about 2,745 feet. Coalbeds and associated rocks were hydraulically fractured, in the Pennsylvanian-age Pocahontas (2,341-2,425 feet) Formation, including the Pocahontas No. 6 coalbed and Lee (2,070-2,341 feet) Formation, including the War Creek, Beckley, Lower Horsepen, Little Fire Creek, and Pocahontas No. 8 coalbeds. The average thickness of these coalbeds is 2.8 feet. Gas production from this well began in March 1991

with a production of 284 Mcf for one day. The well produced for six months during 1991 at a rate of 56.9 Mcf per day. Cumulative gas production from this well during 1991 amounted to 8,535 Mcf. Cumulative water production from this well was 350.5 barrels, averaging 29.2 barrels per month during 1991.

ROARING FORK FIELD

The Roaring Fork field (Figure 4, Table 3), which covers roughly 45,990 acres and contains 235 wells, was discovered on January 4, 1954, when Clinchfield Coal Company, Virginia Coal and Iron Company drilled well No.155. They encountered gas in the Greenbrier Limestone (3,980 to 4,000-foot interval), with an initial flow of gas at 95 Mcf per day. After acidizing the limestone the final open flow was 2,100 Mcf per day. This was after the first hour of flow with a measured initial rock pressure of 920 pounds per square inch; however, after 72 hours, rock pressure had risen to 980 pounds per square inch. Of the 220 conventional gas wells completed, 164 are producing gas, 47 are producing gas and oil, four are plugged and abandoned, and five are dry holes. Natural gas (Table 5) is produced from the Chattanooga Shale, Berea Sandstone, Price Formation, and Greenbrier Limestone. Oil is produced from the Greenbrier Limestone.

Coalbed methane exploration and development began in the Roaring Fork field in late 1992 with the drilling and completion of one well, about 1.3 miles north of Pinnacle Gap in the Flat Gap Quadrangle. This well is Equitable Resources Exploration, Lucinda Horn VCP-2627 completed on December 22, 1992. Coal beds and associated rocks were hydraulically fractured in the Pennsylvanian-age Lee Formation (1,248-2,272 feet). Commingled gas from these formations was gauged at 17 Mcf per day. Three coalbed methane wells were completed in 1993; seven wells during 1994; and four wells during 1995.

SOURCE AND MIGRATION OF GAS

Most of the organic material in the Devonian shales is marine in origin (Maynard, 1981) and is therefore prone to generate oil or gas. The black, organic shale and greenish-gray, silty shales that compose the middle gray siltstone and lower black shale members of the Chattanooga Shale are referred collectively as the "Devonian shales." Any hydrocarbon production from these shales is almost exclusively gas, and is not from porous-permeable reservoirs such as sandstones and carbonates (in which gas is stored in discrete pore spaces and migrates to the well through permeable rock). Schettler and Parmely (1986) have shown that within the Devonian shale sequence, the black shales have sufficient kerogen content in some areas to serve as a source rock for gas. Their data show that, as part of the total gas-transport system within Devonian shales, gas migrates from the black shales at the molecular level into the less-organic siltstone reservoirs.

Cole and others (1987) identified four major source rocks in Ohio: the Sunbury Shale, the Ohio and Olentangy Shales, and the Point Pleasant Formation. The Point Pleasant is correlative in part to the Reedsville Shale. Organic-rich shale in the Sunbury and Ohio Shale, which is equivalent to the Big Stone Gap and middle gray siltstone members of the Chattanooga Shale have been traced into Wise County from Ohio and West Virginia. The source rock associated with the lower black shale member of the Chattanooga Shale, is the Olentangy Shale. Oil has not been produced from the Devonian shales in Wise County. This is probably due to the extremely low permeability of the source rocks, which does not allow migration to reservoir-quality rock. Therefore, any oil that may be generated in the Devonian shales will be converted to gas with an increase in thermal maturity. Gas and oil are produced from both primary and secondary porosity in Mississippian rocks. The Greenbrier Limestone is probably the source of the gas and oil in Greenbrier reservoirs. The dark shale of the Bluefield Formation is suspected of being the source of gas in the Stony Gap Sandstone, and the Little Stone Gap Limestone the source of Ravencliff gas. Because the organic material associated with the Pennsylvanian-age rocks is terrestrial in origin, they are more prone to generating gas.

Depth, durations of burial, and geothermal gradient are the most important factors that control thermal maturation of organic matter. In recent years, attention has been directed toward the use of conodont color alteration as an index of organic thermal maturity (Epstein, 1975; Epstein and others, 1974). Epstein and others (1977) and Harris and others (1978) have compiled maps showing Conodont Alteration Index (CAI) isograds. These maps show values of CAI for limestones of Ordovician through Pennsylvanian intervals in parts of the Appalachian basin. A CAI value of 1.5 correlates with a vitrinite reflectance range of 0.7 to 0.85 and a fixed carbon range of 60 to 65 percent. In Wise County CAI mapping reveals that CAI in Ordovician limestone and in Devonian and Mississippian shales range between 1.5 and 2.5; CAI isograds follow the pattern of folding.

Maturation of hydrocarbons and the timing of oil and gas generation are believed to depend upon the time-temperature history of a sediment. Based on the burial history and the geothermal gradient, one can estimate the timing of hydrocarbon generation (Waples, 1980). This is done by determining the time-temperature index of maturity, the TTI (Lopatin, 1971; Waples, 1980). TTI values of one to 15 signify a zone of wet gas generation, values of 15 to 160 a zone of oil generation, and 1,500 is the upper limit for occurrence of wet gas.

A simplified burial history model for the Paleozoic rocks in Wise County was constructed (Figure 5). Basic assumptions were, 1) a constant surface temperature of 50° F(10° C) and 2) a geothermal gradient of 1.9° F/100 ft (35° C/km) for the lower Paleozoic rocks and 2.5° F/100 ft (45° C/km) for upper Paleozoic rocks. During the Late Paleozoic and Early Mesozoic the crust was being extended and faulted. Therefore, a higher geothermal gradient for the upper Paleozoic rocks is assumed.

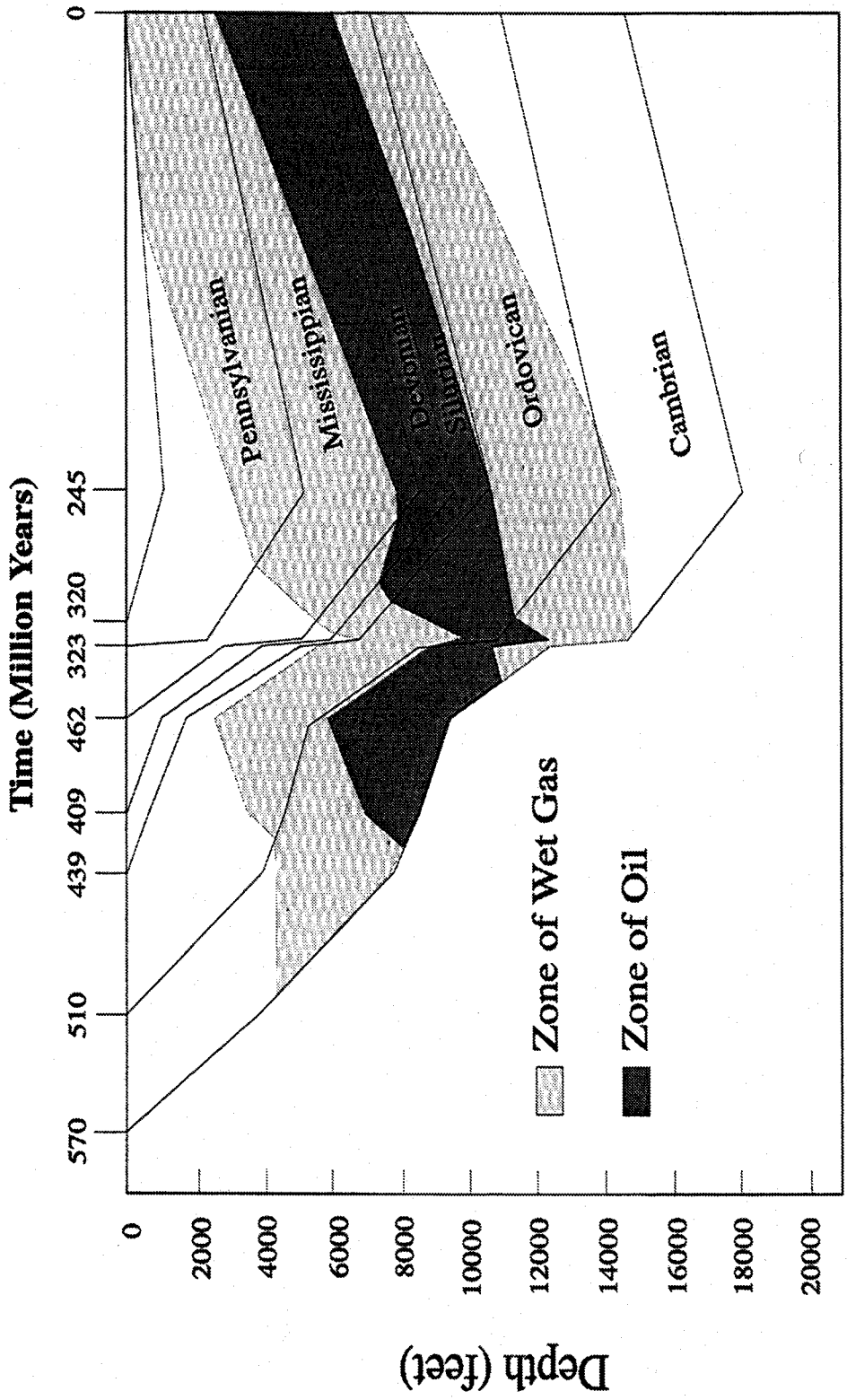

Figure 5. Time-temperature model for the Paleozoic rocks in Wise County.

Because of burial and subsidence, the Cambrian System rocks entered the "oil window" during the Early Silurian time (about 435 million years ago) and exited the window during Early Pennsylvanian time (about 320 million years ago). Continued burial caused the Ordovician rocks to enter the oil window at the beginning of the Late Silurian (about 418 million years ago) time. Further burial moved the Late Ordovician Trenton Limestone (which produces oil in Lee County) into the oil window about 320 million years ago during Early Pennsylvanian. The Trenton remained in the window until 290 million years ago (at the beginning of Permian time). The Chattanooga Shale of Devonian- and Mississippian-age would have started generating oil in Late Triassic time. The Late Mississippian Greenbrier Limestone entered the oil window about 276 million years ago (Early Permian time). The Greenbrier Limestone is still in the "oil window"; this explains the oil production. Pennsylvanian rocks entered the oil window at the beginning of Triassic time. Based on the previous discussion of time-temperature relationships it appears that the primary source rocks in Wise County are the black shales associated with the Big Stone Gap Member, middle gray siltstone member, and the lower black shale member.

COMPLETION TECHNIQUES

Devonian shale gas wells fall into three categories of completion types: (1) open-hole, natural flow, (2) open-hole, stimulated flow, and (3) cased-hole, perforated casing and stimulated flow. "Natural" open-hole completions are wells in which no casing was run and gas flow volumes were sufficient to preclude stimulation. Devonian shale gas production is dependent on fracture permeability. In the second category, well completion involves stimulating thick intervals of the shale, generally concentrating on the organic-rich shale zones. Stimulated open-hole wells have been treated with explosives to increase production rates by localized shattering of the reservoir rock over long intervals. More than 1,000 feet of section has been treated in stages in individual wells, with a variety of techniques used to pick perforation depths within the overall interval. In these cases, knowing exactly where the production originates is impossible. The third category comprises most wells that have had casing run for completion and were perforated in selected intervals. Individual shaped charge could be placed at any point within the well, and then the well could be fractured hydraulically. The operators have concentrated on coarser-grained intervals in the eastern edge of the area, as siltstone zones are more prominent. Still, "siltstone-type" completions (thinner intervals) have been used in the area to the west, and "shale-type" completions (thicker intervals) have been tried in the eastern part of the area. In the past couple of years, operators have increasingly used a variety of logging techniques to detect the location of productive fractures in their wells, and have then concentrated their stimulation on these zones, despite lithology or formation.

Early in the history of gas production from Devonian shales, explosives were detonated in an open hole to induce fractures in the shale and increase production. In recent years, researchers have found better ways to complete wells in Devonian shale. A variety of materials and methods have been used to create fractures and stimulate production, including the use of foam (nitrogen and water), liquid carbon dioxide, gelled liquids, massive hydraulic fracturing, and improved explosive fracturing. According to Lancaster and others (1987), massive hydraulic fracturing that reduces liquid volumes and maximizes proppant concentration is the most effective way to stimulate Devonian shale wells. They think that modern foam technology can achieve these goals at competitive costs.

Explosive stimulation of production in open-hole wells, was used from the late 1800s to the late 1960s, but is not practiced now. Very few Devonian shale wells have been completed as open-holes in Wise County since the late 1960s. Hydraulic fracturing of cased and perforated wells has a become common practice since the middle 1960s and now is used almost exclusively in this county. Berea Sandstone, Price Formation, Stony Gap Sandstone, and Ravencliff gas wells have casing run for completion and are perforated at those intervals. These intervals are foam fractured, using nitrogen and water with a sand proppant. The productive interval in the Greenbrier Limestone is acidized.

CHARACTERISTICS OF OIL AND NATURAL GAS

The late D. M. Young collected a sample of oil from the Clinchfield Coal Co., Virginia Coal and Iron Co. well No. 217 (Plate 1, 61A 1-07). The well is in the Roaring Fork gas field, about one-half mile northeast of Stonega, in the Appalachia quadrangle. The sample was taken at a depth of 4,200 feet in the Greenbrier Limestone. The U.S. Bureau of Mines used the Hempel method to determine the physical characteristics of the oil sample. The method involves breaking down the oil, using 15 distillation fractions, including specific gravity, viscosity, sulfur content, which depend on the relative amounts of various organic compounds in the fraction. Results for this sample are as follows: API gravity of the oil 39.6 degrees and sulfur content of 0.46 percent. Because of this relationship, certain compositional aspects of the oil can be deduced. The correlation index (Smith, 1940) of the distillation fractions for this sample ranges between 15 and 31 and the sample of oil falls within the paraffinic range. Therefore this oil is medium API gravity, low sulfur, wax-bearing, paraffin base crude.

Moore (1982) reported the results of a U.S. Bureau of Mines gas analysis for a sample from the Greenbrier Limestone. The sample was from the Clinchfield Coal Company, Virginia Coal and Iron Company well No. 185 (Roaring Fork gas field, Plate 1, 61A 1-06). The sample contained methane 84.1 percent, ethane 8.5 percent, propane 3.5 percent, other organic gases 1.6 percent and nitrogen 1.8 percent, specific gravity 0.665, and heating value 1,154 BTUs per cubic-foot. The analysis of a gas sample from the Chattanooga Shale (Moore, 1982) just below the Berea Sandstone (Clinchfield

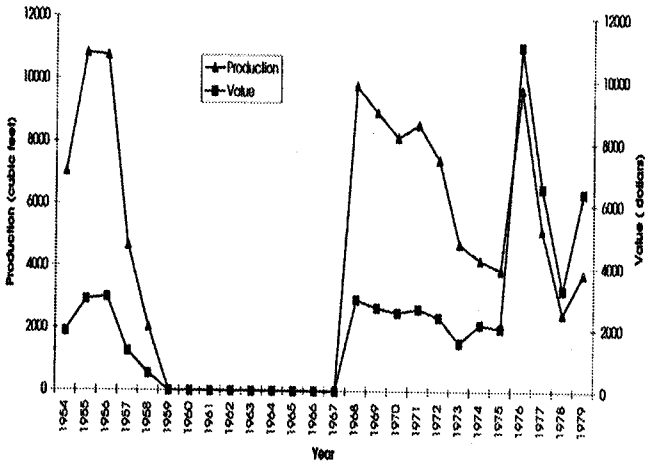

Figure 6. Production and value of natural gas, 1953-1979.

Coal Company, Virginia Coal and Iron Company well No. 160, Plate 1, 61A 1-02), (Roaring Fork gas field) is: methane 85.7 percent, ethane 8.4 percent, propane 2.6 percent, other organic gases 1.6 percent, and nitrogen content 1.5 percent, specific gravity 0.655, and heating value of 1,148 BTUs per cubic-foot. Hamak and Sigler (1989) presented the following analysis of gas from the Berea Sandstone in the Nora gas field (Philadelphia Oil Company, Banner Coal Company well No. P-348, Plate 1, 59B 5-01, depth of 5,077 feet): methane 97.3 percent, ethane 1.8 percent, propane 0.2 percent, other organic gases 0.1 percent, and nitrogen 0.5 percent, specific gravity 0.569, and heating value 1,025 BTUs per cubic-foot.

PRODUCTION AND ESTIMATED RESERVES

Natural gas production began in 1954 (Figure 6) by the Clinchfield Coal Company. Clinchfield produced 7,035 Mcf from two wells completed in the Roaring Fork area. Production increased during 1955 to 10,837 Mcf and 10,765 Mcf in 1956. From 1956 to 1959 production declined to 0 Mcf. No production was recorded from 1959 to 1967. In 1967 Clinchfield Coal Company sold the two wells to the Penn Virginia Corporation. Penn Virginia used the gas from these wells at their Wentz coal preparation plant. The combined production from these wells was 9,806 Mcf during 1968. A steady decline in production from 1968 to 1975 was caused by a lack of demand for the gas. Demand increased during 1976. Production decreased to 2,508 Mcf in 1978 and rose slightly to 3,798 Mcf during 1979 for these two wells. In 1979 the Philadelphia Oil Company drilled four development wells for the extension of the Nora gas field into Coeburn area. During 1980 the two Penn Virginia wells produced 3,288 Mcf and with completion of the four Philadelphia Oil Company wells added an additional 196,376 Mcf for a total of 199,664 Mcf(Figure 7, Appendix A). By 1984 Penn Virginia produced 773 Mcf from one well, while Philadelphia Oil Company produced 364,122 Mcf from nine wells. In 1984 ANR Production Company began drilling in the Roaring Fork area. By the end of 1984 ANR Production Company had 63 producing wells yielding 242,338 Mcf, an additional 44 wells were completed during 1985. Total production of natural gas for 1985 amounted to 607,233 Mcf. The completion of the 63 ANR wells produced a significant rise in production during 1985. Production increased to 6,536,516 Mcf, a 1,076 percent increase over the 1984 production. Overall production declined to 3,274,386 Mcf by 1990. From 1990 to 1994 gas production increased from 3,274,386 Mcf to 8,994,561 Mcf. Total natural gas production fell in 1995 to 7,489,676 Mcf.

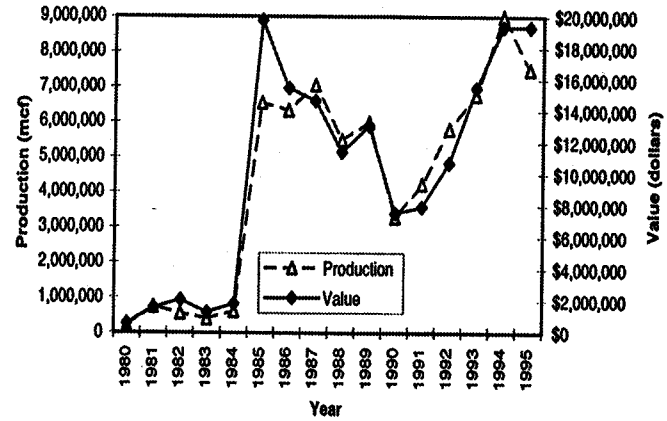

Figure 7. Production and value of natural gas, 1980-1995.

Two coalbed methane wells were drilled and completed in 1990. Production of coalbed methane began in Wise County in 1991. One well was on line during 1991 and yielded 8,535 Mcf of gas. By 1993 the two wells produced 3,832 Mcf gas. In 1994 16 wells were producing coalbed methane. By the end of 1995 20 wells was producing coalbed methane. Production of methane from these wells was 258,936 Mcf. Cumulative production by the end of 1995 from coalbed methane wells amounted to 400,054 Mcf in the county.

As of December 31, 1995, no gas production has been reported for the Bear Creek, Flat Gap, and the six minor productive areas. Since coming on line in 1991 the Flatwoods field (Appendix B) has produced a cumulative production of 1,491,345 Mcf of gas. Cumulative gas production from the Meade Creek field is 174,488 Mcf and the Black Creek field is 528,533 Mcf. Cumulative gas production from the Glamorgan field is 158,590 Mcf. The High Knob field has a cumulative gas production of 3,225,697 Mcf, while the Nora field is 10,304,249 Mcf. The Roaring Fork field has the largest cumulative gas production of 55,116,488 Mcf.

The first reported oil production in Wise County was from the Roaring Fork gas field for 1983. One well-yielded 60 barrels of oil worth $1935.00. The production and value steadily increased through 1989 with a production of 3,132.76 barrels worth $56,922.25 from 21 wells. Production and value decreased through 1991 to 1,743.71 barrels worth $33,653.60 from 11 wells. Since 1991 oil production has increased and in 1994 32 wells produced 10,120.06 barrels worth $150,788.89. This was an average of 316.25 barrels worth $4712.15 per well. Production of oil fell in 1995 to 6,111.57

barrels. Appendix A and Figure 8 show annual oil production and value for the period 1983 to 1995.

Because reserve estimates are continually fluctuating, year-end reserve estimates furnish a practical guide for general trends in reserve levels (Table 6). Evaluating levels of reserves aids in determining the capability of the natural gas industry to achieve production requirements. Because their requirements are, uncertain, historical reserve levels may be evaluated by comparing annual reserves and production information.

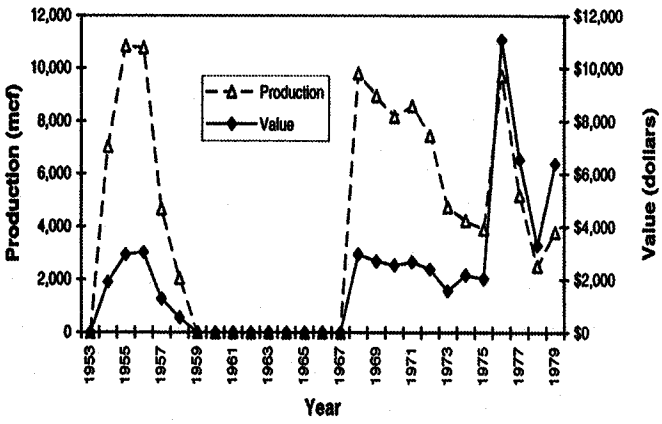

Figure 8. Production and value of oil, 1982-1995.

A useful indicator to evaluate changes in estimated reserves is the ratio of reserves to production (a reserve index). For an individual county, a reserve index provides a simple measure of the supply of reserves relative to the flow rate of natural gas. The index gauges how long the current level of proved reserves would last assuming all wells continued producing at the same annual rate. Production cannot be continued at a constant level to the point of depletion. Also, new drilling adds reserves each year. Therefore, the reserve index is an excellent measure for trend analysis, and does not signify how long the present supply of natural gas will last.

Since 1968, the reserve index ranged from a low of 5.0 in 1974 to a high of 40.2 in 1983. Between 1968 and 1974 reserves were considerably depleted, and the reserve index fell to 5.0 in 1974. The small increase in drilling activity from 1974 to 1983 provided for a steady growth in natural gas reserves ending in a reserve index of 40.2 in 1983. The rapid increase in drilling activity during 1984 to 1986 added an additional 87.7 Bcf of gas reserves, bringing it to 103.5 Bcf for 1986. The decrease in drilling activity during 1987 to 1991 saw a decrease in gas reserves caused by a higher rate of production. The higher reserve index for 1992, 1993, and 1994 was caused in part by the purchase of ANR production Company by Equitable Resources Energy Company in 1992. Equitable's rapid development of the conventional gas reservoirs along with coalbed methane provided for the higher production and reserves in Wise County.

In 1995 Wise County produced 7,489,676,000 cubic feet of gas from 338 wells, which is an average of 22,158,805 cubic feet per well. Three hundred and eighteen conventional gas wells produced 7,230,740,000 cubic feet, with an average of 22,738,176 cubic feet per well. Conventional gas wells are producing from the Chattanooga Shale, including the Berea Sandstone, the Price Formation, and the Greenbrier Limestone. The twenty coalbed methane wells yielded 258,936,000 cubic feet of gas, with an average of 12,946,800 cubic feet per well. Coalbed methane wells are producing from the Pocahontas, Lee, and Norton Formations.

Proven reserves are those quantities of natural gas that geological and engineering data show with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. Petroleum engineering and geological judgment are required in estimating reserves. Therefore, the results are not precise measurements. As of December 31, 1995, proven reserves in Virginia (Table 6) were 1,838 billion cubic feet of dry natural gas (Energy Information Administration, 1996).

At the end of 1995 proven reserves for Wise County amounted to 276 billion cubic feet based on production data. The total area of Wise County is 260,800 acres. The potential producible acreage is 221,984 acres and with 57,312 acres now producing gas, and 164,672 acres remain undeveloped. With a success rate of 93 percent, drilling this acreage could result in 153,145 future producible acres. Two hundred and fifty-three acres per well provide a potential additional 605 productive wells. Cumulative production during 1953 to 1995 is 70,471,783 Mcf. In 1995, 338 producing wells reported yielded an estimate of 1,025,064 Mcf average ultimate recovery per completed well. Multiplying future wells by ultimate recovery yield 620,163,000 Mcf potential undiscovered producible reserves. Adding this value and the proven reserves equals 896.2 billion cubic feet of estimated potential producible reserves as of December 1995.

OTHER MINERAL RESOURCES

Other mineral resources in Wise County include coal, clay and shale, sandstone, sand and gravel, limestone, iron, and manganese. Wise County ranked second in Virginia in total value of mineral production in 1995. Total value of mineral production, including natural gas, oil, and coalbed methane was $326,364,776. Non-fuel mineral products (limestone and sandstone) yielded more than $3,338,205 in 1995.

COAL

Coal is the most valuable resource in Wise County and has been mined since 1892. Commercial coal production has grown from 2,000 short tons in 1892 to an all-time peak of 14,103,135 short tons in 1985. During 1995 12,909,524 short tons of coal was produced (Table 7). This represents about 34.4 percent of coal production in the State. Wise County is second only to Buchanan County (15,704,324 short tons) in overall coal production (Nolde, 1994b). Cumulative coal production for 1892 to 1995 is about 593,717,904 short tons. Coal is present in the Norton, Wise, and Harlan Formations. There are at least 20 minable coal beds in the County. The top five coal beds mined

Table 6. Reserve statistics for Wise County, 1968-1994.

Year	Proved Reserves (Bcf)*	State Production (Bcf)	Wise County Production (Bcf)	Wise County Reserves (Bcf)	Reserve Index (Years)
1968	34	3.39	0.10	1.0	10.0
1969	31	2.85	0.09	0.9	10.0
1970	32	2.87	0.08	0.9	11.3
1971	31	2.63	0.09	1.1	12.2
1972	36	2.80	0.07	0.9	12.8
1973	37	5.13	0.05	0.4	8.0
1974	45	7.10	0.04	0.2	5.0
1975	48	6.72	0.04	0.3	7.5
1976	56	6.94	0.10	0.8	8.0
1977	92	8.22	0.05	0.6	12.0
1978	95	8.49	0.03	0.3	10.0
1979	111	8.54	0.04	0.5	12.5
1980	119	7.81	0.20	3.0	15.0
1981	118	8.90	0.74	9.8	13.2
1982	122	6.88	0.56	9.9	17.7
1983	175	4.35	0.39	15.7	40.2
1984	216	8.93	0.61	14.7	24.1
1985	235	15.04	6.54	102.2	15.6
1986	253	15.43	6.31	103.5	16.4
1987	248	19.52	7.05	89.6	12.7
1988	230	18.69	5.48	67.4	12.3
1989	217	18.12	5.97	71.5	12.1
1990	138	15.57	3.27	28.9	8.8
1991	225	16.02	4.19	58.8	14.0
1992	904	31.38	5.79	166.8	28.8
1993	1,322	37.04	6.75	240.9	35.7
1994	1,833	50.26	8.99	327.8	36.5
1995	1,838	49.87	7.49	276.0	36.8

*Source: 1968-1976, American Petroleum Institute, 1995; !977-1995 Energy Information Administration, 1996.

during 1995 were: Wilson (1,638,610 short tons), Dorchester (1,352,568 short tons), Upper Banner (1,212,614 short tons), Imboden (1,195,896 short tons), and Kelly (1,002,879 short tons). Available proximate and ultimate analyses, physical properties, and chemical analyses of coal beds are listed in a publication by Wilkes and others (1992).

CLAY AND SHALE

Clay and shale deposits suitable for manufacture of various clay products are available in the county. These resources have not been developed commercially, and only minor exploratory tests have been made. The result of analyses of 14 samples of clay, shale, and related material from Wise County have been described by Johnson and others (1966). These samples are from the Rose Hill Formation, Big Stone Gap Member of the Chattanooga Shale, Lee Formation, Norton Formation, Wise Formation, and coal-mine refuse (Wise Formation). The samples have potential use in the manufacture of common brick, tile, and sintered lightweight aggregate. Shale was quarried near the south end of the Norton reservoir from the Bluestone Formation. The shale was used as raw material for lightweight aggregate (Nolde and others, 1986). Bricks were manufactured at Norton and clay dummies for use in stemming coal-mine drill holes were made from clay near Pound.

LIMESTONE AND DOLOSTONE

The Greenbrier Limestone is actively quarried at Rim Rock Quarries 0.4 miles southeast of Little Stone Gap. Vulcan Materials Company is quarrying the limestone for use as road stone, railroad ballast, and riprap. Vulcan Materials quarried 513,545 short tons of limestone during 1995 (Table 7). Southwest Quarries, Inc. abandoned a quarry near Big Stone Gap. They produced road aggregate, concrete aggregate, and building stone from the Greenbrier Limestone. Limestone and dolostone were quarried from the Hancock Formation by Rim Rock Quarries near East Stone Gap. The stone quarried was used as crushed stone. For a broad treatment of the limestone resources of Wise County, the reader is referred to a paper by Lovett (1994).

SANDSTONE, SAND AND GRAVEL

Sandstone suitable for building can be obtained in many parts of the county. Andover Enterprises, Inc. quarries sandstone for local roadstone use. They quarried 65,000 short tons during 1995 (Table 7). The Westmoreland Coal Company, Bullitt Quarry, was inactive during 1995. Between 1990 and 1995, Westmoreland quarried 20,079 short tons of sandstone. Sandstone was quarried near Pound and crushed to sand by the Adams Sand Corporation and marketed for building and other purposes. An abandoned sandstone quarry is near Kent Junction. The sandstone is just below the Clintwood coal bed (Nolde and others, 1986). Other sandstones of the Wise Formation are used locally as a base for coal-mine haul roads, railroad ballast and fill. Lee Formation sandstones, though of good quality, have not been excavated because they occur in the upper slopes of Little Stone Mountain and have steep dips. Sand and gravel from weathered quartzose sandstones of the Middlesboro Member of the Lee Formation were excavated near the north end of the Norton reservoir. The Tallery Sandstone of the Hinton Formation was quarried for roadstone near Benges Gap. Lovett (1994) discussed the location of sandstone quarries and the potential uses of the sandstone quarried.

IRON AND MANGANESE

Hematite iron ore was mined near Big Stone Gap, Irondale, and Oreton from about 1892 until 1920. Until 1902 the ore was shipped to Rockwood, Tennessee for reduction. Then, in 1902, a blast furnace was completed near East Stone Gap by the Union Iron and Steel Company. The increase in the price of coke and general operating expenses in 1920, exceeded the value of the pig iron, shutting down the mining and processing of the iron ore (Eby, 1923). The beds of Hematite are associated with the Rose Hill Formation (Miller, 1965) and are of two types, fossiliferous and oolitic.

Manganese minerals occur near roundstone in Powell Valley and are associated with the Wildcat Valley Sandstone. At many places the unconformity between the Wildcat Valley Sandstone and the Chattanooga Shale is marked by a layer of limonite. Manganese oxide is associated with the limonite, occurring mostly as chert breccia cemented by psilomelane. Small fragments of pure ore are also scattered throughout the breccia and float. The ore has not been mined and the quantity of ore is small.

Table 7. Production of other mineral resources in Wise County, 1990-1995, in short tons.

YEAR	COAL	LIMESTONE	SANDSTONE	TOTAL
1990	11,944,025	124,324	25,000	12,093,349
1991	11,986,626	744,250	12,279	12,743,155
1992	11,255,909	493,049	7,800	11,756,758
1993	12,941,463	578,957	0	13,520,420
1994	13,250,135	578,645	0	13,828,780
1995	12,909,524	513,545	65,000	13,488,069
TOTAL	74,287,682	3,032,770	110,079	77,430,069

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APPENDICES

Appendix A. Summary of natural gas (including coalbed methane) and oil production and value, 1953-1995.

Year	Annual Gas Production (Mcf)	Value (dollars)	Cumulative Gas Production (Mcf)	Annual Oil Production (Barrels)	Value (dollars)	Cumulative Oil Production (Barrels)
1953	Discovery		0			
1954	7,035	$1,899	7,035			
1955	10,837	$2,926	17,872			
1956	10,765	$3,014	28,637			
1957	4,670	$1,261	33,307			
1958	2,040	$551	35,347			
1959	0	$0	0			
1960	0	$0	0			
1961	0	$0	0			
1962	0	$0	0			
1963	0	$0	0			
1964	0	$0	0			
1965	0	$0	0			
1966	0	$0	0			
1967	0	$0	0			
1968	9,806	$2,942	45,153			
1969	8,962	$2,689	54,115			
1970	8,167	$2,532	62,282			
1971	8,580	$2,660	70,862			
1972	7,459	$2,387	78,321			
1973	4,750	$1,568	83,071			
1974	4,230	$2,157	87,301			
1975	3,913	$2,035	91,214			
1976	9,712	$11,072	100,926			
1977	5,192	$6,542	106,118			
1978	2,508	$3,285	108,626			
1979	3,798	$6,381	112,424			
1980	199,664	$569,042	312,088			
1981	740,387	$1,591,832	1,052,475			
1982	554,801	$2,047,216	1,607,276	0	$0	0
1983	390,084	$1,287,277	1,997,360	60	$1,935	60
1984	607,233	$1,821,699	2,604,593	416	$11,348	476
1985	6,536,516	$19,740,278	9,141,109	1,261	$31,210	1,737
1986	6,313,461	$15,467,979	15,454,570	1,486	$22,290	3,223
1987	7,045,696	$14,655,048	22,500,266	2,265	$35,674	5,488
1988	5,481,103	$11,400,694	27,981,369	2,435	$33,968	7,923
1989	5,972,375	$13,079,501	33,953,744	3,132	$56,908	11,055
1990	3,274,386	$7,531,088	37,228,130	2,659	$58,498	13,714
1991	4,217,651	$7,929,184	41,445,781	1,743	$33,640	15,457
1992	5,790,160	$10,711,796	47,235,941	3,667	$64,026	19,124
1993	6,751,695	$15,461,382	53,987,636	5,800	$94,018	24,924
1994	8,994,561	$19,338,306	62,982,197	10,120	$150,788	35,044
1995	7,489,676	$13,106,933	70,471,783	6,112	$150,788	41,156

Appendix B. Natural gas production by field for Wise County.

Year	Bear Creek	Black Creek	Flat Gap	Flatwoods	Glamorgan	High Knob	Meade Creek	Nora	Roaring Fork	Wise Total
1954									7,036	7,036
1955									10,837	10,837
1956	discovery								10,765	10,765
1957	0								4,670	4,670
1958	0								2,040	2,040
1959	0								0	0
1960	0								0	0
1961	0								0	0
1962	0								0	0
1963	0								0	0
1964	0								0	0
1965	0								0	0
1966	0								0	0
1967	0								0	0
1968	0								9,806	9,806
1969	0								8,962	8,962
1970	0								8,167	8,167
1971	0								8,580	8,580
1972	0								7,459	7,459
1973	0								4,750	4,750
1974	0								4,230	4,230
1975	0					disovery			3,913	3,913
1976	0					0			9,712	9,712
1977	0					0			5,192	5,192
1978	0					0			2,508	2,508
1979	0					0			3,798	3,798
1980	0					0		196,376	3,288	199,664
1981	0					0		738,211	2,176	740,387
1982	0					0		553,307	1,494	554,801
1983	0	discovery				0		389,589	495	390,084
1984	0	0				0		364,122	243,111	607,233
1985	0	0				0		360,174	6,176,342	6,536,516
1986	0	0				0		328,398	5,985,063	6,313,461
1987	0	0		discovery		0	discovery	322,725	6,722,971	7,045,696
1988	0	0		0	discovery	0	0	511,257	4,969,846	5,481,103
1989	0	0		0	0	0	0	567,911	5,404,464	5,972,375
1990	0	0		0	34,518	0	0	846,467	2,393,401	3,274,386
1991	0	0		17,396	26,682	0	0	618,466	3,555,108	4,217,651
1992	0	154,511		297,487	27,524	514,868	57,063	805,598	3,956,640	5,790,160
1993	0	136,720		448,660	50,333	695,147	15,162	587,194	4,794,931	6,751,695
1994	0	135,324	discovery	408,741	19,533	771,818	55,892	1,494,553	6,196,741	8,994,561
1995	0	101,978	0	319,062	0	819,500	46,371	1,619,901	4,597,993	7,489,676
Total	0	528,533	0	1,491,345	158,590	2,801,333	174,488	10,304,249	55,116,488	70,471,873

Appendix C. Summary of wells drilled for natural gas in Wise County, 1890-1995.

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date (feet)	Surface Elevation	Total Depth (feet)	Producing Formation
Appalachia (61A)									
WS-003	1-01	Equitable Resours. Explor.	Penn Va. Resources	155	Gas/Oil Well	1/4/54	2002	4010	Greenbrier Ls
WS-004	1-02	Equitable Resours. Explor.	Penn Va. Resources	160	Gas Well	8/26/54	2038	5182	Chattanooga Sh, Greenbrier Ls
WS-006	1-03	Equitable Resours. Explor.	Penn Va. Resources	166	Gas Well	12/12/54	1951	4007	Greenbrier Ls
WS-009	1-04	Equitable Resours. Explor.	Penn Va. Resources	170	Gas Well	9/30/55	2193	5400	Chattanooga Sh
WS-011	1-05	Penn Va. Resours. Corp.	Penn Va. Resources	177	Gas Well-PA	12/5/55	2261	4312	
WS-013	1-06	Equitable Resours. Explor.	Penn Va. Resources	185	Gas Well	6/22/56	1940	3955	Greenbrier Ls
WS-021	1-07	Equitable Resours. Explor.	Penn Va. Resources	217	Gas Well	3/31/61	2150	5367	Chattanooga Sh
WS-055	1-08	Equitable Resours. Explor.	Penn Va. Resources	10011	Gas Well	2/2/83	2312	5508	Chattanooga Sh, Price
WS-074	1-09	Equitable Resours. Explor.	Penn Va. Resources	10058	Gas Well	4/20/84	2391	5677	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-070	1-10	Equitable Resours. Explor.	Penn Va. Resources	10025	Gas Well	4/26/84	2384	5680	Chattanooga Sh, Price, Greenbrier Ls
WS-084	1-11	Equitable Resours. Explor.	Penn Va. Resources	10028	Gas Well	5/23/84	2330	5550	Chattanooga Sh, Price
WS-077	1-12	Equitable Resours. Explor.	Penn Va. Resources	10061	Gas Well	6/13/84	2347	5675	Price
WS-083	1-13	Equitable Resours. Explor.	Penn Va. Resources	10045	Gas Well	6/17/84	2377	5590	Price, Greenbrier Ls
WS-075	1-14	Equitable Resours. Explor.	Penn Va. Resources	10059	Gas Well	6/24/84	2362	5630	Chattanooga Sh, Price, Greenbrier Ls
WS-076	1-15	Equitable Resours. Explor.	Penn Va. Resources	10060	Gas Well	6/25/84	2388	5752	Chattanooga Sh, Price
WS-085	1-16	Equitable Resours. Explor.	Penn Va. Resources	10043	Gas Well	8/15/84	2175	5360	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-099	1-17	Equitable Resours. Explor.	Penn Va. Resources	10044	Gas Well	9/26/84	2807	6061	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-111	1-18	Equitable Resours. Explor.	Penn Va. Resources	10024	Gas Well	11/7/84	3118	6322	Chattanooga Sh, Berea Ss, Price
WS-151	1-19	Equitable Resours. Explor.	Penn Va. Resources	10046	Gas Well	7/27/85	2425	5775	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-177	1-20	Equitable Resours. Explor.	Penn Va. Resources	177-A	Gas Well	11/20/85	2290	5517	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-191	1-21	Equitable Resours. Explor.	Penn Va. Resources	10203	Gas Well	4/26/86	1964	5253	Chattanooga Sh, Berea Ss, Price
WS-190	1-22	Equitable Resours. Explor.	Penn Va. Resources	10023-R	Gas Well	5/2/86	2227	5475	Chattanooga Sh, Berea Ss, Price
WS-182	1-23	Equitable Resours. Explor.	Penn Va. Resources	10201	Gas Well	5/9/86	2317	5985	Chattanooga Sh, Berea Ss, Price
WS-196	1-24	Equitable Resours. Explor.	Penn Va. Resources	10168	Gas Well	5/18/86	3427	6701	Chattanooga Sh, Berea Ss, Price
WS-195	1-25	Equitable Resours. Explor.	Penn Va. Resources	10169	Gas Well	5/29/86	2917	6194	Chattanooga Sh, Berea Ss, Price
WS-202	1-26	Equitable Resours. Explor.	Penn Va. Resources	10268	Gas Well	7/5/86	2514	5760	Chattanooga Sh, Berea Ss, Price
WS-206	1-27	Equitable Resours. Explor.	Penn Va. Resources	10170	Gas/Oil Well	8/7/86	2775	5945	Chattanooga Sh, Price
WS-210	1-28	Equitable Resours. Explor.	Penn Va. Resources	10171	Gas Well	8/8/86	2726	5992	Chattanooga Sh, Berea Ss, Price
WS-211	1-29	Equitable Resours. Explor.	Penn Va. Resources	10270	Gas Well	8/8/86	3348	6511	Chattanooga Sh, Berea Ss, Price
WS-212	1-30	Equitable Resours. Explor.	Penn Va. Resources	10272	Gas Well	9/13/86	2556	5751	Chattanooga Sh, Berea Ss, Price
WS-217	1-31	Equitable Resours. Explor.	Penn Va. Resources	10277	Gas Well	9/28/86	2464	5712	Chattanooga Sh, Berea Ss, Price
WS-280	1-32	Equitable Resours. Explor.	Penn Va. Resources	10274	Dry Hole	8/12/89	2973	6151	
WS-416	1-33	Equitable Resours. Explor.	Penn Va. Resources	VCP-3098	Gas Well	12/20/93	2333	2644	Lee, Norton
WS-413	1-34	Equitable Resours. Explor.	Hagan and Olinger	VCP-3099	Gas Well	3/15/94	2388	2741	Lee, Norton, Wise
WS-087	2-01	Equitable Resours. Explor.	Penn Va. Resources	10056	Gas Well	4/28/84	2254	5543	Chattanooga Sh
WS-102	2-02	Equitable Resours. Explor.	Penn Va. Resources	10055	Gas Well	9/4/84	2723	5965	Chattanooga Sh, Berea Ss, Greenbrier Ls

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date (feet)	Surface Elevation	Total Depth (feet)	Producing Formation
WS-064	2-03	Equitable Resours. Explor.	Penn Va. Resources	10034	Gas Well	12/13/84	2916	6124	Chattanooga Sh, Price, Greenbrier Ls
WS-143	2-04	Equitable Resours. Explor.	Penn Va. Resources	10101	Gas Well	6/18/85	2063	5320	Chattanooga Sh, Berea Ss, Price
WS-156	2-05	Equitable Resours. Explor.	Penn Va. Resources	10041	Gas/Oil Well	8/31/85	2185	5430	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-175	2-06	Equitable Resours. Explor.	Penn Va. Resources	10159	Gas Well	11/17/85	2456	5727	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-176	2-07	Equitable Resours. Explor.	Penn Va. Resources	10162	Gas Well	12/6/85	2793	6046	Chattanooga Sh, Berea Ss, Price
WS-188	2-08	Equitable Resours. Explor.	Penn Va. Resources	10300	Gas Well	5/8/86	2118	5425	Chattanooga Sh, Berea Ss
WS-199	2-09	Equitable Resours. Explor.	Penn Va. Resources	10301	Gas/Oil Well	6/15/86	2895	6200	Chattanooga Sh, Berea Ss, Price
WS-229	2-10	Equitable Resours. Explor.	Penn Va. Resources	10323	Gas/Oil Well	12/14/86	3284	6494	Chattanooga Sh, Price
WS-095	3-01	Equitable Resours. Explor.	Penn Va. Resources	10078	Gas/Oil Well	9/22/84	2812	6089	Chattanooga Sh, Berea Ss, Price
WS-144	3-02	Equitable Resours. Explor.	Penn Va. Resources	10102	Gas Well	7/5/85	2014	5296	Chattanooga Sh, Berea Ss, Price
WS-172	3-03	Equitable Resours. Explor.	Penn Va. Resources	10155	Gas/Oil Well	11/8/85	2916	6244	Chattanooga Sh, Berea Ss, Price
WS-193	3-04	Equitable Resours. Explor.	Penn Va. Resources	10156	Gas/Oil Well	7/1/86	2589	5920	Chattanooga Sh, Berea Ss, Price
WS-343	3-05	Equitable Resours. Explor.	Kemmerer	V-2448	Gas/Oil Well	4/2/93	2890	5836	Chattanooga Sh, Price, Greenbrier Ls
WS-351	3-06	Equitable Resours. Explor.	Hagan	V-2449	Gas Well	9/3/93	2427	5350	Chattanooga Sh, Price
WS-373	3-07	Equitable Resours. Explor.	Penn Va. Resources	V-2693	Gas/Oil Well	5/24/94	2852	5792	Chattanooga Sh, Price
WS-024	4-01	Columbia Natural Resours.	Penn Va. Resources	20053-T	Dry Hole	7/11/75	2995	7081	
WS-065	4-02	Equitable Resours. Explor.	Penn Va. Resources	10033	Gas Well	12/8/83	2168	5485	Chattanooga Sh, Price, Greenbrier Ls
WS-093	4-03	Equitable Resours. Explor.	Penn Va. Resources	10074	Gas Well	9/8/84	3005	6290	Chattanooga Sh, Berea Ss, Price
WS-094	4-04	Equitable Resours. Explor.	Penn Va. Resources	10075	Gas Well	9/23/84	3128	6595	Chattanooga Sh, Berea Ss, Price
WS-097	4-05	Equitable Resours. Explor.	Penn Va. Resources	10076	Gas Well	9/28/84	3238	6562	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-107	4-06	Equitable Resours. Explor.	Penn Va. Resources	10077	Gas Well	9/30/84	3494	6810	Chattanooga Sh, Berea Ss, Price
WS-127	4-07	Equitable Resours. Explor.	Penn Va. Resources	10098	Gas Well	6/28/85	3012	6342	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-158	4-08	Equitable Resours. Explor.	Penn Va. Resources	10094	Gas Well	10/3/85	3191	6556	Chattanooga Sh, Berea Ss, Price
WS-205	4-09	Equitable Resours. Explor.	Penn Va. Resources	10151	Gas Well	7/5/86	2541	6009	Chattanooga Sh, Berea Ss, Price
WS-215	4-10	Equitable Resours. Explor.	Penn Va. Resources	10251	Gas Well	8/24/86	2529	5906	Chattanooga Sh, Berea Ss, Price
WS-228	4-11	Equitable Resours. Explor.	Penn Va. Resources	10154	Gas/Oil Well	12/24/86	3760	7108	Chattanooga Sh, Price
WS-256	4-12	Equitable Resours. Explor.	Penn Va. Resources	10153	Gas Well	10/8/89	3727	6964	Chattanooga Sh, Berea Ss, Price
WS-325	4-13	Equitable Resours. Explor.	Penn Va. Resources	V-2432	Gas Well	7/10/92	2230	5581	Chattanooga Sh, Price
WS-326	4-14	Equitable Resours. Explor.	Penn Va. Resources	VAP-2434	Gas Well	8/31/92	2456	5816	Chattanooga Sh, Berea Ss, Price
WS-329	4-15	Equitable Resours. Explor.	Penn Va. Resources	VAP-2438	Gas Well	11/2/92	2198	5557	Chattanooga Sh, Berea Ss, Price
WS-336	4-16	Equitable Resours. Explor.	Wells, Solomon	VAP-2436	Gas Well	1/27/93	2953	5860	Chattanooga Sh, Price
WS-338	4-17	Equitable Resours. Explor.	Kemmerer	V-2509	Gas Well	3/19/93	2320	5365	Chattanooga Sh, Price
WS-399	4-18	Equitable Resours. Explor.	Olinger	V-2851	Gas Well	10/15/93	2929	6010	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-403	4-19	Equitable Resours. Explor.	Olinger	V-2852	Gas Well	12/6/93	2661	5664	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date (feet)	Surface Elevation	Total Depth (feet)	Producing Formation
WS-402	4-20	Equitable Resours. Explor.	Olinger	V-2850	Gas Well	2/3/94	2642	5688	Chattanooga Sh, Price, Greenbrier Ls
WS-008	5-01	Equitable Resours. Explor.	Penn Va. Resources	167	Gas Well	4/25/55	1885	5143	Chattanooga Sh
WS-053	5-02	Equitable Resours. Explor.	Penn Va. Resources	10009	Gas/Oil Well	7/21/82	2141	5579	Chattanooga Sh, Price
WS-062	5-03	Equitable Resours. Explor.	Penn Va. Resources	10017	Gas/Oil Well	11/3/83	1735	5115	Chattanooga Sh, Price, Greenbrier Ls
WS-069	5-04	Equitable Resours. Explor.	Penn Va. Resources	10022	Gas Well	4/2/84	1774	5216	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-068	5-05	Equitable Resours. Explor.	Penn Va. Resources	10020	Gas/Oil Well	4/20/84	2206	5700	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-071	5-06	Equitable Resours. Explor.	Penn Va. Resources	10021	Gas Well	4/23/84	2218	5648	Chattanooga Sh, Berea Ss, Price
WS-090	5-07	Equitable Resours. Explor.	Penn Va. Resources	10054	Gas Well	8/11/84	2280	5530	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-098	5-08	Equitable Resours. Explor.	Penn Va. Resources	10039	Gas Well	9/5/84	2340	5715	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-116	5-09	Equitable Resours. Explor.	Penn Va. Resources	10086	Gas Well	9/11/84	1895	5373	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-101	5-10	Equitable Resours. Explor.	Penn Va. Resources	10051	Gas/Oil Well	9/12/84	2135	5480	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-115	5-11	Equitable Resours. Explor.	Penn Va. Resources	10085	Gas Well	9/16/84	1733	5185	Chattanooga Sh, Berea Ss, Price, Greenrbier Ls
WS-105	5-12	Equitable Resours. Explor.	Penn Va. Resources	10072	Gas Well	9/25/84	2225	5525	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-100	5-13	Equitable Resours. Explor.	Penn Va. Resources	10048	Gas Well	10/1/84	2178	5648	Chattanooga Sh, Berea Ss, Price Fm
WS-117	5-14	Equitable Resours. Explor.	Penn Va. Resources	10040	Gas Well	11/26/84	2280	5675	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-124	5-15	Equitable Resours. Explor.	Penn Va. Resources	10038	Gas Well	4/25/85	2222	5485	Chattanooga Sh, Berea Ss, Price
WS-113	5-16	Equitable Resours. Explor.	Penn Va. Resources	10049	Gas/Oil Well	4/26/85	2237	5618	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-123	5-17	Equitable Resours. Explor.	Penn Va. Resources	10037	Gas Well	6/11/85	2249	5553	Chattanooga Sh, Berea Ss, Price
WS-136	5-18	Equitable Resours. Explor.	Penn Va. Resources	10097	Gas Well	7/12/85	2220	5576	Chattanooga Sh, Berea Ss, Price
WS-152	5-19	Equitable Resours. Explor.	Penn Va. Resources	10099	Gas Well	8/13/85	2404	5746	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-122	5-20	Equitable Resours. Explor.	Penn Va. Resources	10026	Gas/Oil Well	8/26/85	2155	5637	Chattanooga Sh, Berea Ss, Price
WS-159	5-21	Equitable Resours. Explor.	Penn Va. Resources	10095	Gas Well	9/9/85	2220	5591	Chattanooga Sh, Berea Ss, Price
WS-142	5-22	Equitable Resours. Explor.	Penn Va. Resources	10042	Gas Well	5/7/86	2182	5456	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-337	5-23	Equitable Resours. Explor.	Olinger	V-2447	Gas/Oil Well	4/1/93	2184	5213	Chattanooga Sh, Price, Greenbrier Ls
WS-374	5-24	Equitable Resours. Explor.	Mullins & Creech	V-2676	Gas Well	7/24/93	2177	5139	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-414	5-25	Equitable Resours. Explor.	Elkins, James	VCP-3101	Gas Well	10/21/94	2225	2703	Lee
WS-015	6-01	Equitable Resours. Explor.	Penn Va. Resources	195	Gas Well	12/26/56	1904	5192	Price, Greenbrier Ls
WS-017	6-02	Equitable Resours. Explor.	Penn Va. Resources	206	Gas Well	5/23/58	2025	5356	Greenbrier Ls
WS-025	6-03	Columbia Natural Resours.	Penn Va. Resources	20054-T	Dry Hole	1/22/75	1942	5390	
WS-350	6-03	Equitable Resours. Explor.	Penn Va. Resources	V-2815	Gas/Oil Well	3/8/93	1942	4652	Price, Greenbrier Ls
WS-054	6-04	Equitable Resours. Explor.	Penn Va. Resources	10012	Gas/Oil Well	1/5/83	2062	5526	Chattanooga Sh, Price, Greenbrier Ls
WS-072	6-05	Equitable Resours. Explor.	Penn Va. Resources	10030	Gas Well-PA	3/29/84	2423	1837	
WS-119	6-06	Equitable Resours. Explor.	Penn Va. Resources	10030-A	Gas Well	5/17/84	2421	5766	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-080	6-07	Equitable Resours. Explor.	Penn Va. Resources	10027	Gas Well	6/28/84	2438	5825	Chattanooga Sh, Berea Ss, Greenbrier Ls

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date (feet)	Surface Elevation	Total Depth (feet)	Producing Formation
WS-081	6-08	Equitable Resours. Explor.	Penn Va. Resources	10029	Gas/Oil Well	7/12/84	2437	5875	Chattanooga Sh, Price
WS-086	6-09	Equitable Resours. Explor.	Penn Va. Resources	10053	Gas Well	7/23/84	2431	5778	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-096	6-10	Equitable Resours. Explor.	Penn Va. Resources	10052	Gas/Oil Well	11/25/84	1856	5174	Greenbrier Ls
WS-120	6-11	Equitable Resours. Explor.	Penn Va. Resources	10087	Gas Well	6/30/85	2131	5483	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-118	6-12	Equitable Resours. Explor.	Penn Va. Resources	10088	Gas Well	7/30/85	2263	5627	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-171	6-13	Equitable Resours. Explor.	Penn Va. Resources	10172	Gas Well	10/11/85	2429	5753	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-046	8-01	Equitable Resours. Explor.	Penn Va. Resources	10004	Gas/Oil Well	1/28/82	1853	5338	Price
WS-112	8-02	Equitable Resours. Explor.	Penn Va. Resources	10047	Gas Well	9/6/85	1935	5469	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-184	8-03	Equitable Resours. Explor.	Penn Va. Resources	10194	Gas Well	6/23/86	2038	5685	Chattanooga Sh, Price, Greenbrier Ls
WS-187	8-04	Equitable Resours. Explor.	Penn Va. Resources	10193	Gas Well	6/25/86	2155	5803	Chattanooga Sh, Berea Ss, Price, Greenbrier ls
WS-279	8-05	Equitable Resours. Explor.	Penn Va. Resources	10019	Gas/Oil Well	6/30/89	2218	5685	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-327	8-06	Equitable Resours. Explor.	Penn Va. Resources	VAP-2437	Gas/Oil Well	10/14/92	2217	5731	Chattanooga Sh, Berea Ss, Price
WS-316	8-07	Equitable Resours. Explor.	Town of Appalachia	VAP-2430	Gas/Oil Well	10/26/92	1769	5235	Chattanooga Sh, Berea Ss, Price
WS-335	8-08	Equitable Resours. Explor.	Nickels, W.H.	VAP-2445	Gas Well	11/12/92	2013	5461	Chattanooga Sh, Price
WS-371	8-09	Equitable Resours. Explor.	Olinger	V-2671	Gas Well	7/22/93	2237	5459	Chattanooga Sh, Berea Ss
WS-396	8-10	Equitable Resours. Explor.	Olinger	V-2697	Gas Well	8/23/93	2230	5350	Chattanooga Sh, Berea Ss, Price
WS-067	9-01	Equitable Resours. Explor.	Penn Va. Resources	10036	Gas Well	12/31/83	1912	5395	Chattanooga Sh, Price, Greenbrier Ls
WS-066	9-02	Equitable Resours. Explor.	Penn Va. Resources	10035	Gas Well	1/17/84	2274	5684	Chattanooga Sh, Price, Greenbrier Ls
WS-328	9-03	Equitable Resours. Explor.	Penn Va. Resources	VAP-2442	Gas/Oil Well	9/25/92	2237	5250	Chattanooga Sh, Price
WS-330	9-04	Equitable Resours. Explor.	Olinger	VP-2440	Gas Well	3/12/93	2366	5379	Chattanooga Sh, Price
Caney Ridge (89C)									
WS-037	8-01	Equitable Resours. Explor.	The Pittston Co.	P-093	Gas Well	10/1/79	2141	6088	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-410	8-02	Equitable Resours. Explor.	Odle, J.A.	PC-019	Gas Well	5/24/94	2129	2330	
WS-002	9-01	Pine Mtn. Oil & Gas Co.	Dunn Coal Land Co.	148	Gas Well	9/2/53	1874	5738	Chattanooga Sh, Berea Ss
WS-035	9-02	Equitable Resours. Explor.	Odle, J.A.	P-091	Gas Well	12/19/79	2068	5018	Berea Ss, Greenbrier Ls
WS-036	9-03	Equitable Resours. Explor.	Odle, J.A.	P-092	Gas Well	12/19/79	2108	5123	Berea Ss, Greenbrier Ls, Stony Gap Ss
WS-179	9-04	Equitable Resours. Explor.	Dunn, James H.	P-204	Gas Well	5/5/86	2539	6819	Chattanooga Sh, Berea Ss
WS-237	9-05	Equitable Resours. Explor.	Dunn, James H.	P-437C	Gas Well	10/23/90	2518	2678	Pocahontas, Lee
WS-442	9-06	Equitable Resours. Explor.	Dunn, James H.	VC-3035	Gas Well	11/10/94	2675	2830	Pocahontas, Lee
Coeburn (59B)									
WS-242	1-01	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	ANR-075	Gas Well	9/1/87	2289	5660	Berea Ss, Greenbrier Ls
WS-283	1-02	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	W6 #4	Gas Well	10/25/89	2711	6130	Chattanooga Sh, Berea Ss, Ravencliff
WS-418	1-03	Equitable Resours. Explor.	Ringley, Billy Ray	V-2714	Gas Well	6/3/94	2777	6121	Berea Ss
WS-406	1-04	Equitable Resours. Explor.	Robinette, Harry	V-2375	Gas Well	6/28/94	2730	6102	Berea Ss, Greenbrier Ls
WS-018	2-01	Pine Mtn. Oil & Gas Co.	Va. Iron, Coal & Coke Co.	207	Gas Well	3/12/58	2099	6288	Wildcat Valley Ss, Chattanooga Sh

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date	Surface Elevation (feet)	Total Depth (feet)	Producing Formation
WS-038	2-02	Equitable Resours. Explor.	Odle, J.A.	P-094	Gas Well	12/19/79	2154	5160	Berea Ss, Greenbrier Ls, Ravencliff
WS-039	2-03	Equitable Resours. Explor.	Henry, M.E. and W.R.	P-102	Gas Well	9/10/80	2415	5475	Berea Ss, Greenbrier Ls
WS-041	2-04	Equitable Resours. Explor.	Odle, J.A	.P-104	Gas Well	9/29/80	2184	5337	Berea Ss, Greenbrier Ls
WS-040	2-05	Equitable Resours. Explor.	Hensley, Samuel	P-103	Gas Well	11/6/80	2211	5325	Berea Ss, Greenbrier Ls, Stony Gap Ss
WS-050	2-06	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	ANP-1	Gas Well	3/18/82	2246	6559	Chattanooga Sh, Berea Ss
WS-282	2-07	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	V6 #2	Gas Well	10/2/89	2662	6844	Chattanooga Sh, Berea Ss
WS-241	2-08	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	V-2372	Gas Well	3/19/93	2681	6005	Berea Ss, Price
WS-386	2-09	Equitable Resours. Explor.	Gibson, George	VC-2927	Gas Well	7/30/93	2583	2801	Pocahontas, Lee
WS-401	2-10	Equitable Resours. Explor.	McReynolds, David	V-2703	Gas Well	10/8/93	2622	5953	Berea Ss
WS-407	2-11	Equitable Resours. Explor.	Robinette, S.B	VC-2990	Gas Well	6/29/94	2655	2854	Pocahontas, Lee
WS-385	2-12	Equitable Resours. Explor.	Horn, Samuel	VC-2926	Gas Well-PA	9/26/94	2602	2915	
WS-467	2-13	Equitable Resours. Explor.	Kilgore, Anne	V-3187	Gas Well	1/24/96	2475	5760	Berea Ss, Greenbrier Ls
WS-474	2-14	Equitable Resours. Explor.	Odle, J.A.	VAD-2374	Gas Well	1/29/96	2236	5430	Berea Ss, Greenbrier Ls, Ravencliff
WS-478	2-15	Equitable Resourc. Explor.	Horn, Samuel	VC-3553	Gas Well	4/29/96	2706	2755	Pocahontas, Lee
WS-016	3-01	Clinchfield Coal Co.	Va. Iron, Coal & Coke Co.	198	Gas Well-PA	7/20/57	2069	6109	
WS-042	3-02	Equitable Resours. Explor.	Dunn, James H.	P-105	Gas Well	1/10/81	2341	5356	Berea Ss, Greenbrier Ls
WS-051	3-03	Equitable Resours. Explor.	VICC Land Co.	ANP-16	Gas Well	6/7/82	2741	6840	Chattanooga Sh, Berea Ss
WS-049	3-04	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	ANP-3	Gas Well	7/2/82	2168	6197	Unknown
WS-180	3-05	Equitable Resours. Explor.	Fuller, N.R.	P-203	Gas Well	2/2/86	2185	5223	Berea Ss
WS-192	3-06	Equitable Resours. Explor.	Blackwell, Martha J.	P-225	Gas Well	4/11/86	2056	5049	Berea Ss
WS-194	3-07	Equitable Resours. Explor.	Dunn Tract	P-226	Gas Well	4/11/86	2522	5529	Berea Ss, Greenbrier Ls
WS-225	3-08	Equitable Resours. Explor.	Blackwell, Martha J.	P-389C	Gas Well	8/14/90	2651	2831	Pocahontas, Lee
WS-333	3-09	Equitable Resours. Explor.	Dunn, James	VAC-2024	Gas Well	9/1/92	2584	2721	Pocahontas
WS-248	4-01	Equitable Resours. Explor.	Penn Va. Resources	10909	Gas Well	5/14/90	2439	5388	Chattanooga Sh, Berea Ss
WS-224	5-01	Equitable Resours. Explor.	Banner Coal Co.	P-348	Gas Well	1/27/87	2149	5153	Berea Ss
WS-232	5-02	Equitable Resours. Explor.	Banner Coal Co.	P-366	Gas Well	5/16/87	1937	4614	Chattanooga Sh, Berea Ss
WS-251	5-03	Equitable Resours. Explor.	Banner Coal Co.	P-347	Gas Well	12/2/87	2111	5257	Berea Ss, Greenbrier Ls
WS-263	5-04	Equitable Resours. Explor.	Fleming Kinship	P-349	Gas Well	8/10/88	2364	5371	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-267	5-05	Equitable Resours. Explor.	Fleming Kinship	P-343	Gas Well	9/23/88	2509	5581	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-284	5-06	Equitable Resours. Explor.	Marham, John	P-344	Gas Well	11/16/89	2294	5414	Berea Ss
WS-270	5-07	Equitable Resours. Explor.	Fleming Kinship	P-342	Gas Well	3/7/90	2162	5323	Berea Ss, Greenbrier Ls
WS-322	5-08	Equitable Resours. Explor.	Addington, Inc.	P-341	Gas Well	1/22/93	2203	5453	Berea Ss, Greenbrier Ls
WS-382	5-09	Equitable Resours. Explor.	Robinette, S.B.	V-2376	Gas Well	7/15/93	2233	5559	Berea Ss, Greenbrier Ls
WS-392	5-10	Equitable Resours. Explor.	Rose, Kenneth	V-1835	Gas Well	8/26/93	2471	5538	Berea Ss, Greenbrier Ls
WS-398	5-11	Equitable Resours. Explor.	Kennedy, Rohona	V-2704	Gas Well	11/9/93	2332	5609	Berea Ss
WS-462	5-12	Equitable Resours. Explor.	Hutchinson, J.W.	V-3121	Gas Well	6/22/95	2310	5507	Berea Ss
WS-255	6-01	Equitable Resours. Explor.	Banner Coal Co.	P-345	Gas Well	11/18/87	2143	5310	Berea Ss, Ravencliff
WS-236	6-02	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	ANR-135	Gas Well	7/1/88	2163	5898	Berea Ss, Greenbrier Ls, Ravencliff
WS-286	6-03	Equitable Resours. Explor.	Fleming Kinship	P-346	Gas Well	11/24/89	2314	5466	Berea Ss
WS-295	6-04	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	W7 #13	Gas Well	10/9/90	2491	6896	Berea Ss
WS-291	6-05	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	W7 #2	Gas Well	10/1/90	2035	6057	Berea Ss
WS-380	6-06	Equitable Resours. Explor.	Meade, Joseph	VC-2929	Gas Well	7/21/93	2508	2530	Pocahontas, Lee
WS-381	6-07	Equitable Resours. Explor.	Williiams, G.B.	V-2379	Gas Well	7/27/93	2345	5583	Berea Ss, Greenbrier Ls

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date	Surface Elevation (feet)	Total Depth (feet)	Producing Formation
WS-422	6-08	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	V-2373	Gas Well	4/20/94	2028	5285	Berea Ss
WS-409	6-09	Equitable Resours. Explor.	Wilburn, A.R.	V-2707	Gas Well	6/9/94	2286	5504	Berea Ss
WS-425	6-10	Equitable Resours. Explor.	Sulfridge, L.L.	V-2922	Gas Well	7/12/94	2311	5534	Berea Ss
WS-408	6-11	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	V-2706	Gas Well	7/21/94	2388	5691	Berea Ss
WS-428	6-12	Equitable Resours. Explor.	Brothers, H., and Dickenson, C.G.	V-2716	Gas Well	9/15/94	1813	5116	Berea Ss, Bluestone
WS-424	6-13	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	V-2717	Gas Well	11/21/94	2146	5450	Berea Ss
WS-432	6-14	Equitable Resours. Explor.	Lawson, Henry	V-2378	Gas Well	12/21/94	2361	5628	Berea Ss
WS-440	6-15	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	V-2715	Gas Well	6/28/95	2828	6253	Berea Ss
WS-304	8-01	Equitable Resours. Explor.	Jefferson National Forest	V-2348	Gas Well	5/18/92	2393	4842	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-319	8-02	Equitable Resours. Explor.	U. S. Forest Service	VAP-2338	Gas Well	7/17/92	2341	4705	Chattanooga Sh, Berea Ss
WS-312	8-03	Equitable Resours. Explor.	Jefferson National Forest	VAP-2337	Gas Well	9/8/92	2325	4787	Chattanooga Sh, Berea Ss
WS-311	8-04	Equitable Resours. Explor.	U. S. Forest Service	VAP-2349	Gas Well	9/22/92	2256	4655	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-313	8-05	Equitable Resours. Explor.	Jefferson National Forest	VAP-2287	Gas Well	10/2/92	2239	4797	Chattanooga Sh, Berea Ss
WS-323	8-06	Equitable Resours. Explor.	Hillman Estate, B.F.	V-2267	Gas Well	12/4/92	2103	5038	Berea Ss
WS-439	8-07	Equitable Resours. Explor.	Penn Va. Resources	VSP-3243	Gas Well-PA	8/26/94	2342		
WS004A	9-01	Southwest Oil & Gas Co.	Hagan	1	Dry Hole	4/27/40	2500	3751	
WS006A	9-02	Southwest Oil & Gas Co.	Hagan	3	Dry Hole	3/8/42	2600	5348	
WS-033	9-03	Columbia Natural Resours.	Penn Va. Resources	20255	Dry Hole	4/9/76	2513	4600	
WS-048	9-04	Equitable Resours. Explor.	Penn Va. Resources	10006	Gas Well	5/19/82	2567	5458	Berea Ss
WS-281	9-05	Equitable Resours. Explor.	Penn Va. Resources	10913	Gas Well	8/21/89	2516	5592	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-245	9-06	Equitable Resours. Explor.	Penn Va. Resources	10933	Gas Well	8/22/89	2844	5184	Chattanooga Sh, Berea Ss, Greenbrier Ls, Bluefield
WS-266	9-07	Equitable Resours. Explor.	Penn Va. Resources	10927	Gas Well	5/18/90	2689	5382	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-250	9-08	Equitable Resours. Explor.	Penn Va. Resources	10959	Gas Well	7/2/90	2597	5424	Chattanooga Sh, Berea Ss
WS-306	9-09	Equitable Resours. Explor.	Yeary, James Earl	V-2332	Gas Well	2/24/92	2548	4562	Chattanooga Sh, Berea Ss
WS-317	9-10	Equitable Resours. Explor.	U. S. Forest Service	VP-2288	Gas Well	3/30/92	2306	4633	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-278	9-11	Equitable Resours. Explor.	Jefferson National Forest	VP 2326	Gas Well	4/9/92	2937	4493	Chattanooga Sh, Berea Ss
WS-315	9-12	Equitable Resours. Explor.	U. S. Forest Service	V-2350	Gas Well	4/27/92	2428	4733	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-310	9-13	Equitable Resours. Explor.	Jefferson National Forest	VP-2351	Gas Well	11/24/92	2553	4866	Chattanooga Sh, Berea Ss
WS-303	9-14	Equitable Resours. Explor.	Jefferson National Forest	V-2347	Gas Well	11/16/92	2443	4571	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-309	9-15	Equitable Resours. Explor.	U. S. Forest Service	VP-2357	Gas Well	5/19/93	2510	4681	Berea Ss, Greenbrier Ls
WS-368	9-16	Equitable Resours. Explor.	Hopkins, Ellis Kent	V-2692	Gas Well	5/26/93	2835	4453	Berea Ss, Greenbrier Ls
WS-298	9-17	Equitable Resours. Explor.	Jefferson National Forest	V-2344	Gas Well	5/6/94	2763	4904	Chattanooga Sh, Berea Ss
WS-379	9-18	Equitable Resours. Explor.	Reeves, Shirley	V-2690	Gas Well	10/1/94	2789	5064	Chattanooga Sh, Berea Ss, Ravencliff
East Stone Gap (60C)									
WS007A	3-01	Castle & Jenkins	Osborne, W.B.	1	Dry Hole	2/1/50	1560	4861	

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date	Surface Elevation (feet)	Total Depth (feet)	Producing Formation
Flat Gap (90C)									
WS-043	2-01	Wise Oil & Gas Explor. Co.	Penn Va. Resources	10001	Dry Hole	6/2/82	1698	4999	
WS-296	2-02	Equitable Resours. Explor.	Penn Va. Resources	P3 #1	Gas Well	7/12/90	1668	5288	Chattanooga Sh, Berea Ss
WS-001	5-01	Equitable Resours. Explor.	Va. Iron & Coal Co.	143	Gas Well	7/10/53	2225	5349	Chattanooga Sh
WS-426	5-02	Equitable Resours. Explor.	Bolling, Ernest	V-3140	Gas Well	8/22/94	2007	5060	Greenbrier Ls
WS-459	5-03	Equitable Resours. Explor.	Red River Coal Co.	V-3199	Gas Well-PA	12/13/94	1939	109	
WS003A	7-01	Benedum Trees Co.	Kaufman, Issac	1	Dry Hole	5/27/33	2230	3650	
WS-019	7-02	Equitable Resours. Explor.	Va. Iron & Coal Co.	144	Gas Well	3/21/59	2323	4006	Greenbrier Ls
WS-020	7-03	Equitable Resours. Explor.	Va. Iron & Coal Co.	216	Gas Well	5/15/60	2372	4056	Greenbrier Ls
WS-026	7-04	Equitable Resours. Explor.	Penn Va. Resources	20055-T	Gas Well	4/22/75	2280	5595	Chattanooga Sh
WS-231	7-05	Equitable Resours. Explor.	Penn Va. Resources	10216	Gas Well	9/13/87	2476	5981	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-226	7-06	Equitable Resours. Explor.	Penn Va. Resources	10014	Gas Well	11/5/87	2458	6130	Chattanooga Sh, Berea Ss, Price
WS-287	7-07	Equitable Resours. Explor.	Greater Wise, Inc.	Q5 #6	Gas Well	6/24/90	2299	5718	Chattanooga Sh, Berea Ss, Price
WS-344	7-08	Equitable Resours. Explor.	Horn, Lucinda	VAC-2627	Gas Well	12/22/92	2632	2570	Lee
WS-339	7-09	Equitable Resours. Explor.	Pridemore & Venable	VP-2535	Gas Well	3/29/93	2232	5105	Chattanooga Sh, Price
WS-353	7-10	Equitable Resours. Explor.	Davidson, W.R. and D.	VP-2532	Gas Well	4/21/93	2464	5208	Chattanooga Sh, Price, Greenbrier Ls
WS-357	7-11	Equitable Resours. Explor.	Triplett, Bertha Mae	V-2533	Gas Well	4/21/93	2253	4997	Chattanooga Sh, Price
WS-365	7-12	Equitable Resours. Explor.	Addington, Joseph	VC-2838	Gas Well	4/26/93	2482	2406	Lee
WS-342	7-13	Equitable Resours. Explor.	Addington, Joseph	V-2543	Gas Well	6/9/93	2411	5351	Chattanooga Sh, Price, Greenbrier Ls
WS-384	7-14	Equitable Resours. Explor.	Clark, Audrey	V-2536	Gas Well	8/5/93	2311	5060	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-387	7-15	Equitable Resours. Explor.	Kilgore, Frank	V-2767	Gas Well	9/16/93	2513	5699	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-405	7-16	Equitable Resours. Explor.	Roberts, H.D.	V-2665	Gas Well	11/30/93	2680	5579	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-354	7-17	Equitable Resours. Explor.	Chisnhall, James	V-2538	Gas Well	2/7/94	2534	5579	Chattanooga Sh, Price, Greenbrier Ls
WS-421	7-18	Equitable Resours. Explor.	Horn, Lucinda	V-3106	Gas Well	6/27/94	2360	5290	Chattanooga Sh, Price, Greenbrier Ls
WS-434	7-19	Equitable Resours. Explor.	Wampler, I.F. and Penn Va. Resources	VCP-3137	Gas Well	9/6/94	2457	2182	Lee
WS-435	7-20	Equitable Resours. Explor.	Pine Mtn. Oil & Gas	VC-3181	Gas Well	9/13/94	2511	2443	Lee
WS-449	7-21	Equitable Resours. Explor.	Penn Va. Resources	VC-3222	Gas Well	11/21/94	2512	2553	Lee
WS-448	7-22	Equitable Resours. Explor.	Va. Iron, Coal & Coke Co.	VC-3293	Gas Well	4/3/95	2251	1895	Lee, Norton
WS-463	7-23	Equitable Resours. Explor.	Penn Va. Resources	VC-3221	Gas Well	4/4/95	2680	1780	Lee, Norton
WS-430	7-24	Equitable Resours. Explor.	Penn Va. Resources	V-2768	Gas Well	7/17/95	2663	5445	Chattanooga Sh, Price, Greenbrier Ls
WS-468	7-25	Equitable Resourc. Explor.	Addington, Joseph	V-2764	Gas Well	12/12/95	2839	5225	Chattanooga Sh, Price Fm, Greenbrier Ls
WS-471	7-26	Equitable Resours. Explor.	Roberts, Robert	V-2537	Gas Well	12/19/95	2409	5200	
WS-034	8-01	Equitable Resours. Explor.	Penn Va. Resources	20338-T	Gas Well	5/8/78	2396	5740	Chattanooga Sh
WS-134	8-02	Equitable Resours. Explor.	Penn Va. Resources	10084	Gas Well	8/1/85	3035	6448	Chattanooga Sh, Berea Ss, Price
WS-131	8-03	Equitable Resours. Explor.	Penn Va. Resources	10110	Gas Well	10/10/85	2643	5990	Chattanooga Sh, Berea Ss, Price
WS-163	8-04	Equitable Resours. Explor.	Penn Va. Resources	10130	Gas Well	5/11/86	2669	6070	Chattanooga Sh, Berea Ss, Price
WS-201	8-05	Equitable Resours. Explor.	Penn Va. Resources	10113	Gas Well	9/8/86	2260	5600	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-173	8-06	Equitable Resours. Explor.	Penn Va. Resources	10114	Gas Well	12/8/86	2296	6085	Chattanooga Sh, Berea Ss

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date	Surface Elevation (feet)	Total Depth (feet)	Producing Formation
WS-334	8-07	Equitable Resours. Explor.	Roberts, W.H.	V-2420	Gas Well	1/13/93	2712	6117	Chattanooga Sh, Greenbrier Ls
WS-012	9-01	Equitable Resours. Explor.	Va. Iron & Coal Co.	180	Gas Well	7/6/56	2387	5624	Chattanooga Sh, Berea Ss
WS-088	9-02	Equitable Resours. Explor.	Penn Va. Resources	10063	Gas Well	7/1/84	2321	5615	Chattanooga Sh, Price
WS-104	9-03	Equitable Resours. Explor.	Penn Va. Resources	10067	Gas Well	9/11/84	2393	5550	Price
WS-091	9-04	Equitable Resours. Explor.	Penn Va. Resources	10065	Gas Well	9/17/84	2295	5566	Chattanooga Sh, Berea Ss, Price
WS-089	9-05	Equitable Resours. Explor.	Penn Va. Resources	10079	Gas Well	9/20/84	2206	5425	Chattanooga Sh, Berea Ss
WS-103	9-06	Equitable Resours. Explor.	Penn Va. Resources	10066	Gas Well	9/26/84	2279	5500	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-108	9-07	Equitable Resours. Explor.	Penn Va. Resources	10064	Gas Well	10/17/84	2774	6010	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-114	9-08	Equitable Resours. Explor.	Penn Va. Resources	10080	Gas Well-PA	12/31/85	2983	1575	
WS-129	9-09	Equitable Resours. Explor.	Penn Va. Resources	10108	Gas Well	5/21/85	2779	6061	Chattanooga Sh, Berea Ss, Price
WS-132	9-10	Equitable Resours. Explor.	Penn Va. Resources	10083	Gas Well	6/11/85	2827	6133	Chattanooga Sh, Berea Ss, Price
WS-133	9-11	Equitable Resours. Explor.	Penn Va. Resources	10082	Gas Well	6/11/85	2228	5505	Chattanooga Sh, Berea Ss, Price, Greenbrier ls
WS-174	9-12	Equitable Resours. Explor.	Penn Va. Resources	180-A	Gas Well	3/25/86	2532	5814	Chattanooga Sh, Berea Ss, Price
WS-207	9-13	Equitable Resours. Explor.	Penn Va. Resources	10366	Gas Well	8/7/86	3016	6205	Chattanooga Sh, Price
WS-214	9-14	Equitable Resours. Explor.	Penn Va. Resources	10382	Gas Well	9/13/86	2835	6080	Chattanooga Sh, Berea Ss, Price
WS-213	9-15	Equitable Resours. Explor.	Penn Va. Resources	10379	Gas Well	9/24/86	2837	6023	Chattanooga Sh, Berea Ss, Price
WS-149	9-16	Equitable Resours. Explor.	Penn Va. Resources	10080-A	Gas Well	10/15/86	2983	6207	Chattanooga Sh, Berea Ss, Price
WS-223	9-17	Equitable Resours. Explor.	Penn Va. Resources	10369	Gas Well	12/3/86	2964	6150	Chattanooga Sh, Berea Ss, Price
WS-222	9-18	Equitable Resours. Explor.	Penn Va. Resources	10368	Gas Well	11/7/87	2962	6085	Chattanooga Sh, Berea Ss, Price
WS-415	9-19	Equitable Resours. Explor.	Penn Va. Resources	VCP-3097	Gas Well	11/1/94	2293	2723	Lee
Norton (60B)									
WS-061	1-01	Equitable Resours. Explor.	Penn Va. Resources	10013	Gas Well	6/8/83	2453	6548	Chattanooga Sh, Price, Greenbrier Ls
WS-234	1-02	Equitable Resours. Explor.	Penn Va. Resources	10135	Gas Well	11/23/87	2440	5898	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-324	1-03	Equitable Resours. Explor.	Greater Wise, Inc.	V-2468	Gas Well	10/15/92	2428	5863	Chattanooga Sh, Berea Ss, Price, Greenbier Ls, Ravencliff
WS-341	1-04	Equitable Resours. Explor.	Gardner, W.H.	VAC-2628	Gas Well	1/19/93	2331	2500	Lee
WS-360	1-05	Equitable Resours. Explor.	Bailey, Irene et al.	V-2531	Gas Well	3/10/93	2497	5306	Chattanooga Sh, Price
WS-349	1-06	Equitable Resours. Explor.	Greater Wise	V-2431	Gas Well	3/19/93	2638	5409	Chattanooga Sh, Price, Greenbrier Ls
WS-340	1-07	Equitable Resours. Explor.	Hunsucker, Jeff	VP-2530	Gas Well	4/13/93	2443	5400	Chattanooga Sh, Price
WS-331	1-08	Equitable Resours. Explor.	Greater Wise, Inc.	VP-2529	Gas Well	4/14/93	2435	5200	Chattanooga Sh, Price
WS-375	1-09	Equitable Resours. Explor.	Devins, William R.	V-2525	Gas Well	6/21/93	2338	5179	Chattanooga Sh, Price, Greenbrier Ls
WS-369	1-10	Equitable Resours. Explor.	Gardner, Frank P.	V-2527	Gas Well	7/15/93	2477	5382	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-397	1-11	Equitable Resours. Explor.	Hunsucker, Jeff	VC-3006	Gas Well	8/6/93	2440	2165	Lee
WS-417	1-12	Equitable Resours. Explor.	Gardner, William H.	V-2745	Gas Well	6/10/94	2354	5553	Chattanooga Sh, Price, Greenbrier Ls
WS-423	1-13	Equitable Resours. Explor.	Hill, James M.	V-2749	Gas Well	7/5/94	2617	5836	Chattanooga Sh, Price

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date (feet)	Surface Elevation	Total Depth (feet)	Producing Formation
WS-461	1-14	Equitable Resours. Explor.	Greater Wise, Inc.	V-2753	Gas Well	7/13/94	2461	5420	Chattanooga Sh, Price, Greenbrier Ls
WS-433	1-15	Equitable Resours. Explor.	Robinette, William and Penn Va. Resources	VCP-3095	Gas Well	8/18/94	2605	2221	Lee
WS-429	1-16	Equitable Resours. Explor.	Greater Wise, Inc.	V-2751	Gas Well	8/26/94	2226	5504	Chattanooga Sh, Price, Greenbrier Ls
WS-427	1-17	Equitable Resours. Explor.	Gardner, William H.	V-2659	Gas Well	9/22/94	2385	5658	Chattanooga Sh, Price, Greenbrier Ls
WS-460	1-18	Equitable Resours. Explor.	Greater Wise, Inc.	VC-3294	Gas Well	1/6/95	2441	1500	Lee, Norton
WS-030	2-01	Columbia Natural Resours.	Penn Va. Resources	20253-T	Dry Hole	11/17/75	2548	6900	
WS-150	2-02	Equitable Resours. Explor.	Penn Va. Resources	10092	Gas Well	8/6/85	2151	5554	Chattanooga Sh, Berea Ss, Price
WS-155	2-03	Equitable Resours. Explor.	Penn Va. Resources	10131	Gas Well	12/7/86	2587	5996	Chattanooga Sh, Berea Ss, Price
WS-332	2-04	Equitable Resours. Explor.	Robinette, William	VP-2528	Gas Well	2/19/93	2545	5319	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-366	2-05	Equitable Resours. Explor.	Renfro	V-2655	Gas Well	6/28/93	2623	5614	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-376	2-06	Equitable Resours. Explor.	Greater Wise, Inc.	V-2656	Gas Well	7/7/93	2374	5320	Chattanooga Sh, Price, Greenbrier Ls
WS-394	2-07	Equitable Resours. Explor.	Greater Wise, Inc. and V.C. & I.	V-2757	Gas Well	9/14/93	2505	5510	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-400	2-08	Equitable Resours. Explor.	Robinette, William	V-2756	Gas Well	12/16/93	2371	5383	Chattanooga Sh, Berea Ss, Price,
WS-436	2-09	Equitable Resours. Explor.	Greater Wise, Inc. and V.C. & I.	V-2758	Gas Well	8/15/94	2688	5736	Chattanooga Sh, Price, Greenbrier Ls
WS-437	2-10	Equitable Resours. Explor.	Greater Wise, Inc.	V-2759	Gas Well	11/3/94	2541	5590	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-447	2-11	Equitable Resours. Explor.	Penn Va. Resources	VCP-3231	Gas Well	12/2/94	2375	2445	Lee
WS-475	2-12	Equitable Resourc. Explor.	Greater Wise, Inc.	V-2760	Gas Well	4/22/96	2204	5145	Chattanooga Sh., Price Fm, Greenbrier Ls
WS-044	3-01	Equitable Resours. Explor.	Penn Va. Resources	10002	Gas Well	3/2/82	2297	5543	Chattanooga Sh, Price, Greenbrier Ls
WS-058	3-02	Equitable Resours. Explor.	Penn Va. Resources	10015	Gas Well	2/28/83	1965	5342	Chattanooga Sh, Price
WS-078	3-03	Equitable Resours. Explor.	Penn Va. Resources	10062	Gas Well	5/13/84	1967	5365	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-147	3-04	Equitable Resours. Explor.	Penn Va. Resources	10057	Gas Well	6/9/85	2265	5580	Chattanooga Sh, Berea Ss, Price
WS-130	3-05	Equitable Resours. Explor.	Penn Va. Resources	10016	Gas Well	6/11/85	2368	5715	Chattanooga Sh, Berea Ss, Price
WS-140	3-06	Equitable Resours. Explor.	Penn Va. Resources	10091	Gas Well	7/21/85	2122	5580	Chattanooga Sh, Berea Ss, Price
WS-141	3-07	Equitable Resours. Explor.	Penn Va. Resources	10073	Gas Well	8/30/85	2339	5625	Chattanooga Sh, Berea Ss, Price
WS-181	3-08	Equitable Resours. Explor.	Penn Va. Resources	10200	Gas Well	4/5/86	2320	5596	Chattanooga Sh, Berea Ss, Price
WS-185	3-09	Equitable Resours. Explor.	Penn Va. Resources	10204	Gas Well	4/11/86	2362	5705	Chattanooga Sh, Berea Ss, Price
WS-186	3-10	Equitable Resours. Explor.	Penn Va. Resources	10205	Gas Well	7/12/86	2239	5580	Chattanooga Sh, Berea Ss
WS-183	3-11	Equitable Resours. Explor.	Penn Va. Resources	10202	Gas Well	10/28/86	1918	5240	Chattanooga Sh, Berea Ss, Price
WS-045	4-01	Equitable Resours. Explor.	Penn Va. Resources	10003	Gas/Oil Well	4/12/82	1989	5560	Chattanooga Sh, Price
WS-073	4-02	Equitable Resours. Explor.	Penn Va. Resources	10031	Gas Well-PA	3/7/84	2092	3480	
WS-092	4-03	Equitable Resours. Explor.	Penn Va. Resources	10031-A	Gas/Oil Well	5/3/84	2089	5520	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-079	4-04	Equitable Resours. Explor.	Penn Va. Resources	10071	Gas Well	5/16/84	2091	5510	Chattanooga Sh, Berea Ss, Price
WS-027	4-05	Equitable Resours. Explor.	Penn Va. Resources	20056-T	Gas Well	8/14/84	1866	4680	Chattanooga Sh, Price, Greenbrier Ls

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date	Surface Elevation (feet)	Total Depth (feet)	Producing Formation
WS-137	4-06	Equitable Resours. Explor.	Penn Va. Resources	10115	Gas Well	7/14/85	2134	5609	Chattanooga Sh, Berea Ss, Price
WS-135	4-07	Equitable Resours. Explor.	Penn Va. Resources	10089	Gas Well	7/21/85	2112	5587	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-139	4-08	Equitable Resours. Explor.	Penn Va. Resources	10104	Gas Well	8/23/85	1815	5314	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-160	4-09	Equitable Resours. Explor.	Penn Va. Resources	10106	Gas Well	10/6/85	1896	5470	Chattanooga Sh, Berea Ss, Price
WS-170	4-10	Equitable Resours. Explor.	Penn Va. Resources	10182	Gas Well	10/7/85	2154	5630	Chattanooga Sh, Berea Ss, Price
WS-138	4-11	Equitable Resours. Explor.	Penn Va. Resources	10105	Gas Well	10/9/85	2284	5783	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-167	4-12	Equitable Resours. Explor.	Penn Va. Resources	10184	Gas Well	10/23/85	2066	5506	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-165	4-13	Equitable Resours. Explor.	Penn Va. Resources	10186	Gas Well	11/13/85	2073	5530	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-168	4-14	Equitable Resours. Explor.	Penn Va. Resources	10183	Gas Well	11/27/85	2036	5491	Chattanooga Sh, Berea Ss, Price
WS-166	4-15	Equitable Resours. Explor.	Penn Va. Resources	10185	Gas/Oil Well	11/28/85	2087	5551	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-082	4-16	Equitable Resours. Explor.	Penn Va. Resources	10032	Gas Well	6/12/86	2162	5625	Chattanooga Sh, Price, Greenbrier Ls
WS-204	4-17	Equitable Resours. Explor.	Penn Va. Resources	10180	Gas Well	6/16/86	1763	5390	Chattanooga Sh, Berea Ss, Price
WS-169	4-18	Equitable Resours. Explor.	Penn Va. Resources	10181	Gas Well	10/3/86	2228	5760	Chattanooga Sh, Berea Ss, Price
WS-209	4-19	Equitable Resours. Explor.	Penn Va. Resources	10280	Gas Well	10/30/86	2145	5660	Chattanooga Sh, Berea Ss, Price
WS001A	5-01	New York Mining & Mfg.	Graham. R.S.	1	Dry Hole	11/17/51	2137	6057	
WS-121	5-02	Equitable Resours. Explor.	Penn Va. Resources	10081	Gas Well	11/7/84	2180	5787	Chattanooga Sh, Berea Ss, Price
WS-148	5-03	Equitable Resours. Explor.	Penn Va. Resources	10093	Gas Well	11/29/85	2383	5862	Chattanooga Sh, Berea Ss, Price
WS-218	5-04	Equitable Resours. Explor.	Greater Wise, Inc.	10126	Gas Well	11/15/86	2357	5918	Chattanooga Sh, Berea Ss
WS-219	5-05	Equitable Resours. Explor.	Greater Wise, Inc.	10128	Gas Well	11/19/86	2140	5721	Chattanooga Sh, Berea Ss
WS-220	5-06	ANR Production Co.	Greater Wise, Inc.	10123	Gas Well	12/5/86	2187	5782	Chattanooga Sh, Berea Ss
WS-230	5-07	Equitable Resours. Explor.	Greater Wise, Inc.	10125	Gas Well	9/21/87	2191	5725	Chattanooga Sh, Berea Ss, Price
WS-221	5-08	Equitable Resours. Explor.	Penn Va. Resources	10124	Gas Well	10/21/87	2215	5801	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-254	5-09	Equitable Resours. Explor.	Greater Wise, Inc.	10129	Gas Well	11/11/87	2335	5895	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-247	6-01	Equitable Resours. Explor.	Greater Wise, Inc	10122	Gas Well	11/24/87	2304	5825	Chattanooga Sh, Berea Ss, Price, Greenbrier Ls
WS-022	9-01	Tri-State Oil Ltd.	Riggs, Bruce	1	Dry Hole	12/31/70	1620	2140	
Pound (90D)									
WS-007	4-01	Clinchfield Coal Co.	Chase, J.T.	163	Gas Well-PA	3/25/55	1942	5241	
WS-005	4-02	Pine Mtn. Oil & Gas Co.	Chase, J.T.	162	Gas Well	4/20/55	1735	5744	Wildcat Valley Ss
WS-268	8-01	AMVEST Oil & Gas, Inc.	Glamorgan Coal Co.	3	Gas Well	8/31/88	2614	6175	Chattanooga Sh
WS-454	8-02	Equitable Resours. Explor.	Mullins, J.D.	V-3198	Gas Well	12/27/94	2100	5650	Chattanooga Sh
WS-269	9-01	AMVEST Oil & Gas, Inc.	Glamorgan Coal Co.	2	Gas Well	9/10/88	2409	5365	Chattanooga Sh, Price, Greenbrier Ls
WS-273	9-02	AMVEST Oil & Gas, Inc.	Glamorgan Coal Co.	1	Gas Well	11/1/88	2557	6141	Chattanooga Sh, Price, Greenbrier Ls

File Number	Map Number	Operator	Landowner	Well Number	Status	Completion Date	Surface Elevation (feet)	Total Depth (feet)	Producing Formation
Wise (60A)									
WS-010	2-01	Clinchfield Coal Co.	Wise Development Co.	171	Gas Well	1/3/56	2284	4584	Greenbrier Ls
WS-274	2-02	AMVEST Oil & Gas, Inc.	Glamorgan Coal Co.	5	Gas Well	2/15/89	2505	6243	Chattanooga Sh, Price, Greenbrier Ls
WS-276	3-01	AMVEST Oil & Gas, Inc.	Glamorgan Coal Co.	6	Gas Well	2/15/89	2282	5887	Chattanooga Sh, Price
WS-275	3-02	AMVEST Oil & Gas, Inc.	Glamorgan Coal Co.	7	Gas Well	2/15/89	2425	6135	Chattanooga Sh
WS-239	3-03	Equitable Resours. Explor.	The Hagan Estate	10103	Gas Well	5/6/90	2330	5900	Chattanooga Sh, Berea Ss, Price
WS-014	5-01	Clinchfield Coal Co.	Wise Development Co.	187	Gas Well	7/10/57	2198	5914	Chattanooga Sh
WS-358	6-01	Equitable Resours. Explor.	Peters, Verna J.	VP-2366	Gas Well	4/19/93	2222	4518	Berea Ss, Greenbrier Ls
WS-431	6-02	Equitable Resours. Explor.	The Hagan Estate	V-2367	Gas Well	10/17/94	2672	4801	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS005A	7-01	Southwest Oil & Gas Co.	The Hagan Estate	2	Dry Hole	2/3/41	2515	1407	
WS-028	7-02	Equitable Resours. Explor.	Penn Va. Resources	20120-T	Gas Well	2/13/75	2776	4342	Berea Ss
WS-047	7-03	Equitable Resours. Explor.	Penn Va. Resources	10005	Gas Well	3/19/82	2540	5965	Chattanooga Sh, Berea Ss
WS-265	7-04	Equitable Resours. Explor.	Cline, Hugh and McAfee, Carl	10967	Gas Well	11/23/88	3007	5040	Chattanooga Sh, Berea Ss
WS-262	7-05	Equitable Resours. Explor.	Penn Va. Resources	10925	Gas Well	5/26/89	2631	4505	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-288	7-06	Equitable Resours. Explor.	The Hagan Estate	T8 #6	Gas Well	11/27/89	2959	4290	Chattanooga Sh, Berea Ss
WS-258	7-07	Equitable Resours. Explor.	Adkins, Arthur and Uva	VP-2340	Gas Well	4/16/92	2836	3818	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-249	7-08	Equitable Resours. Explor.	Jefferson National Forest	V-2342	Gas Well	7/16/92	3043	4450	Chattanooga Sh, Berea Ss
WS-261	7-09	Equitable Resour. Explor.	Penn Va. Resources	VAP-2339	Gas Well	7/18/92	2779	3658	Chattanooga Sh., Berea Ss, Greenbrier Ls
WS-305	7-10	Equitable Resours. Explor.	Peters, Verna J.	VAP 2289	Gas Well	8/20/92	2209	3657	Chattanooga Sh, Berea Ss
WS-293	7-11	Equitable Resours. Explor.	Jefferson National Forest	V-2323	Gas Well	11/19/92	2736	4203	Chattanooga Sh, Greenbrier Ls
WS-272	7-12	Equitable Resours. Explor.	Penn Va. Resources	VAP-2324	Gas Well	11/20/92	2859	3635	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-352	7-13	Equitable Resours. Explor.	Nixon, Timothy B.	V-2363	Gas Well	8/30/93	2742	4578	Chattanooga Sh, Berea Ss
WS-246	7-14	Equitable Resours. Explor.	Jefferson National Forest	V-2341	Gas Well	9/30/93	3062	4500	Chattanooga Sh
WS-260	7-15	Equitable Resours. Explor.	Salyers, Steve	V-2343	Gas Well	4/30/94	2682	4470	Chattanooga Sh, Berea Ss
WS-438	7-16	Equitable Resours. Explor.	Fannon, Faye	V-2364	Gas Well	10/7/94	2725	4828	Chattanooga Sh, Berea Ss
WS-441	7-17	Equitable Resours. Explor.	Turkey Gap Coal Co.	V-2727	Gas Well	11/25/94	3091	4794	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-445	7-18	Equitable Resours. Explor.	Hamilton, Everett	V-2325	Gas Well	11/8/94	2936	4680	Chattanooga Sh, Berea Ss
WS-469	7-19	Equitable Resours. Explor.	Penn Va. Resources	V-2688	Gas Well	12/11/95	3133	4283	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-023	8-01	Columbia Natural Resours.	Penn Va. Resources	20118-T	Dry Hole	9/18/74	3449	8357	
WS-178	8-02	Equitable Resours. Explor.	The Hagan Estate	10900	Gas Well	12/2/85	3262	4397	Chattanooga Sh, Berea Ss, Greenbrier Ls
WS-420	8-03	Equitable Resours. Explor.	Jefferson National Forest	V-2685	Gas Well	6/9/94	3118	4365	Chattanooga Sh
WS002A	9-01	Unkown	Gish, G.W.	1	Dry Hole	1/2/0	2650	2153	
WS-031	9-02	Columbia Natural Resours.	Hagan, P. et ux	20117-T	Dry Hole	10/1/75	3487	3946	

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF MINES, MINERALS AND ENERGY
DIVISION OF MINERAL RESOURCES

PUBLICATION 144
GEOLOGY, NATURAL GAS, OIL, AND
OTHER MINERAL RESOURCES OF
WISE COUNTY, VIRGINIA

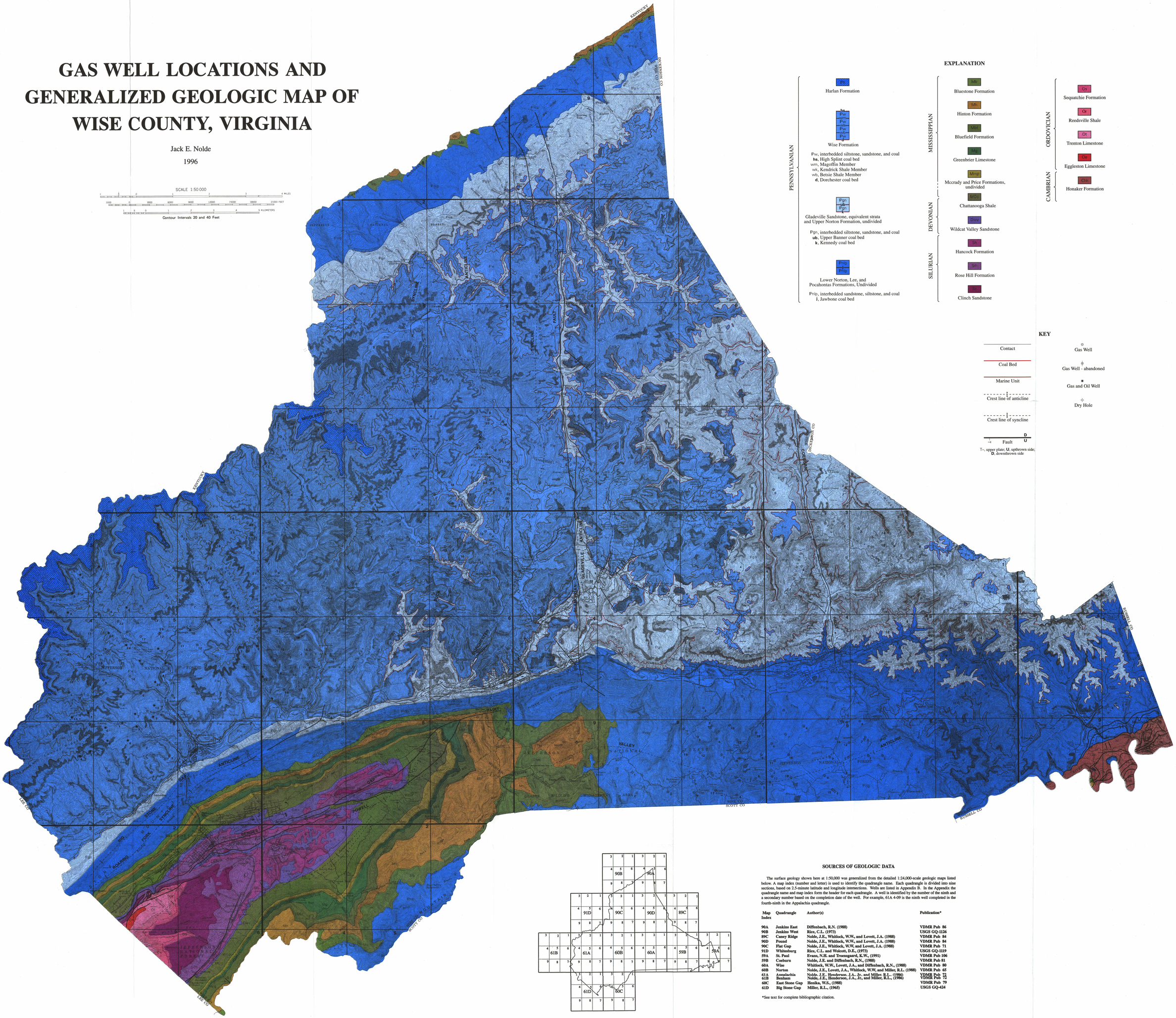
GAS WELL LOCATIONS AND GENERALIZED GEOLOGIC MAP OF WISE COUNTY, VIRGINIA

Jack E. Nolde

1996

SCALE 1:50 000

Contour Intervals 20 and 40 Feet



EXPLANATION

PENNSYLVANIAN

- Pcr — Harlan Formation
- hs, Pw, wm, Pw, wk, Pw, wb, Pw, d — Wise Formation
  - Pw, interbedded siltstone, sandstone, and coal
  - **hs**, High Splint coal bed
  - wm, Magoffin Member
  - wk, Kendrick Shale Member
  - wb, Betsie Shale Member
  - **d**, Dorchester coal bed
- Pgn, ub, Pgn, k — Gladeville Sandstone, equivalent strata and Upper Norton Formation, undivided
  - Pgn, interbedded siltstone, sandstone, and coal
  - **ub**, Upper Banner coal bed
  - **k**, Kennedy coal bed
- Pnc, Pnp — Lower Norton, Lee, and Pocahontas Formations, Undivided
  - Pnp, interbedded sandstone, siltstone, and coal
  - **i**, Jawbone coal bed

MISSISSIPPIAN

- Mbl — Bluestone Formation
- Mhi — Hinton Formation
- Mbf — Bluefield Formation
- Mgb — Greenbrier Limestone
- Mmp — Mccrady and Price Formations, undivided

DEVONIAN

- Dch — Chattanooga Shale
- Dwv — Wildcat Valley Sandstone

SILURIAN

- Sh — Hancock Formation
- Srh — Rose Hill Formation
- Sc — Clinch Sandstone

ORDOVICIAN

- Os — Sequatchie Formation
- Or — Reedsville Shale
- Ot — Trenton Limestone
- Oe — Eggleston Limestone

CAMBRIAN

- Ch — Honaker Formation

KEY

- Contact
- Coal Bed
- Marine Unit
- Crest line of anticline
- Crest line of syncline
- Fault (D / U) — T–, upper plate; **U**, upthrown side; **D**, downthrown side
- Gas Well
- Gas Well - abandoned
- Gas and Oil Well
- Dry Hole

SOURCES OF GEOLOGIC DATA

The surface geology shown here at 1:50,000 was generalized from the detailed 1:24,000-scale geologic maps listed below. A map index (number and letter) is used to identify the quadrangle name. Each quadrangle is divided into nine sections, based on 2.5-minute latitude and longitude intersections. Wells are listed in Appendix B. In the Appendix the quadrangle name and map index form the header for each quadrangle. A well is identified by the number of the ninth and a secondary number based on the completion date of the well. For example, 61A 4-09 is the ninth well completed in the fourth-ninth in the Appalachia quadrangle.

Map Index	Quadrangle	Author(s)	Publication*
90A	Jenkins East	Diffenbach, R.N. (1988)	VDMR Pub 86
90B	Jenkins West	Rice, C.L. (1973)	USGS GQ-1126
89C	Caney Ridge	Nolde, J.E., Whitlock, W.W., and Lovett, J.A. (1988)	VDMR Pub 84
90D	Pound	Nolde, J.E., Whitlock, W.W., and Lovett, J.A. (1988)	VDMR Pub 84
90C	Flat Gap	Nolde, J.E., Whitlock, W.W., and Lovett, J.A. (1988)	VDMR Pub 71
91D	Whitesburg	Rice, C.L. and Wolcott, D.E., (1973)	USGS GQ-1119
59A	St. Paul	Evans, N.H. and Troensgaard, K.W., (1991)	VDMR Pub 106
59B	Coeburn	Nolde, J.E. and Diffenbach, R.N., (1988)	VDMR Pub 81
60A	Wise	Whitlock, W.W., Lovett, J.A., and Diffenbach, R.N., (1988)	VDMR Pub 80
60B	Norton	Nolde, J.E., Lovett, J.A., Whitlock, W.W, and Miller, R.L. (1988)	VDMR Pub 65
61A	Annalachia	Nolde. J.E., Henderson. J.A., Jr., and Miller, R.L., (1986)	VDMR Pub 72
61B	Benham	Nolde, J.E., Henderson, J.A., Jr., and Miller, R.L., (1986)	VDMR Pub 72
60C	East Stone Gap	Henika, W.S., (1988)	VDMR Pub 79
61D	Big Stone Gap	Miller, R.L., (1965)	USGS GQ-424

*See text for complete bibliographic citation.

Base map prepared in the mid-1970s by the Division of Mineral Resources from reductions of 1:24,000-scale topographic maps.

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