Coalbed-Methane Production in the Appalachian Basin

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Conversion Factors

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Volume	
cubic foot (CF or ft^3)	0.02832	cubic meter (m^3)

Letter Symbols for Units of Measure

BCF	billion cubic feet ($ft^3 \times 10^9$)
MCF	thousand cubic feet ($ft^3 \times 10^3$)
MCF/day	thousand cubic feet per day
MMCF	million cubic feet ($ft^3 \times 10^6$)
TCF	trillion cubic feet ($ft^3 \times 10^{12}$)

Definitions

thousands	$= 10^3$
millions	$= 10^6$
billions	$= 10^9$
trillions	$= 10^{12}$

Coalbed-Methane Production in the Appalachian Basin

By Robert C. Milici[1] and Désirée E. Polyak[1]

Abstract

Coalbed methane (CBM) occurs in coal beds of Mississippian and Pennsylvanian (Carboniferous) age in the northern, central, and southern Appalachian basin coal regions, which extend almost continuously from Pennsylvania southward to Alabama. Most commercial CBM production in the Appalachian basin is from three structural subbasins: (1) the Dunkard basin in Pennsylvania, Ohio, and northern West Virginia; (2) the Pocahontas basin in southern West Virginia, eastern Kentucky, and southwestern Virginia; and (3) part of the Black Warrior basin in Alabama. The cumulative CBM production in the Dunkard basin through 2005 was 17 billion cubic feet (BCF), the production in the Pocahontas basin through 2006 was 754 BCF, and the production in the part of the Black Warrior basin in Alabama through 2007 was 2.008 TCF.

CBM development may be regarded as mature in Alabama, where annual production from 1998 through 2007 was relatively constant and ranged from 112 to 121 BCF. An opportunity still exists for additional growth in the Pocahontas basin. In 2005, annual CBM production in the Pocahontas basin in Virginia and West Virginia was 85 BCF. In addition, opportunities are emerging for producing the large, diffuse CBM resources in the Dunkard basin as additional wells are drilled and technology improves.

Introduction

Coalbed methane (CBM) occurs in coal beds of Mississippian and Pennsylvanian (Carboniferous) age in the northern, central, and southern Appalachian basin coal regions, which extend almost continuously from Pennsylvania southward to Alabama (fig. 1; figures follow References Cited). These three coal regions occur within the southern and central parts of the Appalachian structural basin (Milici, this volume, chap. G.1). The three Appalachian basin coal regions were defined by the U.S. Geological Survey (USGS) in the 2000 resource assessment of selected coal beds and zones (Northern and Central Appalachian Basin Coal Regions Assessment Team, 2001).

Most commercial CBM production in the Appalachian basin is from three structural subbasins: (1) the Dunkard basin in Pennsylvania, Ohio, and northern West Virginia; (2) the Pocahontas basin in southern West Virginia, eastern Kentucky, and southwestern Virginia; and (3) the part of the Black Warrior basin underlain by coal measures in Alabama (Lyons, 1998; Milici, 2004, which was superseded by Milici, this volume, chap. G.1). Each subbasin is within one of the three Appalachian basin coal regions.

In the northern, central, and southern Appalachian basin coal regions, CBM is produced from bituminous coal beds of Pennsylvanian age. CBM production takes place for several reasons: (1) to improve the safety of mines by removing methane in advance of underground coal mining, (2) to obtain commercial amounts of methane from fractured rock wastes (gob) and the breakdown of roof rock left after underground coal mining, and (3) to obtain commercial amounts of methane from coal beds that have not been mined and that serve both as source rocks and as reservoirs for the methane resources.

CBM development may be regarded as mature in Alabama, where annual production from 1998 through 2007 was relatively constant and ranged from 112 to 121 billion cubic feet (BCF) (Alabama State Oil and Gas Board, 2008). An opportunity still exists for additional growth in the Pocahontas basin, where Virginia's annual CBM production exceeded 81 BCF in 2006 (Virginia Division of Gas and Oil, 2007). In addition, opportunities are emerging for producing the large, diffuse CBM resources in the Dunkard basin as additional wells are drilled and technology improves.

CBM reservoirs commonly occur within their own source rocks (coal) where methane is generated by biogenic or thermal maturation processes that affect the coal macerals. The methane is adsorbed onto the surfaces of pores and fractures of various sizes within the coal bed, and from there, it may escape into the atmosphere at natural exposures or migrate into production drill holes or mines that have penetrated the formation. The gas produced from coal beds is almost entirely methane, although it commonly contains small amounts of other hydrocarbons, hydrogen, carbon monoxide, carbon dioxide, and nitrogen. Gas obtained from underground mines may contain a considerable amount of gas other than methane.

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Almost all wells drilled into methane-bearing coal-bed reservoirs produce some gas regardless of the structural position of the coal bed at any given location. The gas, however, exhibits little tendency to segregate from formation waters, and the associated water commonly serves as an effective seal. Where present, formation waters are removed by pumping as a CBM field is developed. Removal of the water reduces the pressure within the reservoir and allows the methane to escape from the coal and into the wellbore. In general, CBM fields that were originally defined by separate discoveries appear to grow together or merge as development progresses, and boundaries between fields become obscure as more wells reveal the existence of large, tabular, continuous accumulations that may persist laterally beneath several counties.

This report supersedes USGS Open-File Report 02–105 (Milici, 2002). The second author of this report (Polyak) helped to revise the 2002 report and to add CBM production information for the Appalachian basin up to 2006.

CBM Assessment in 1996

In assessing CBM resources, Rice and Finn (1996) identified three regional plays in the northern and central parts of the Appalachian Plateaus: the Northern Appalachian Basin Syncline Play, the Northern Appalachian Basin Anticline Play, and the Central Appalachian Basin–Central Basin Play. The Northern Appalachian Basin Anticline Play was defined as occurring structurally above the water table, and the Northern Appalachian Basin Syncline Play was defined as occurring below the water table in folded rocks (Patchen and others, 1991). Rice and Finn (1996) reported at the mean 10.4 trillion cubic feet (TCF) as technically recoverable gas for the syncline play, 1.07 TCF for the anticline play, and 3.07 TCF for the Central Basin Play. In addition, they assessed at the mean 2.30 TCF of technically recoverable, undiscovered CBM resources from the Black Warrior basin in the southern part of the Appalachian basin and 0.295 TCF from the Cahaba coal field, which lies within the Cahaba syncline adjacent to the Black Warrior basin within the folded and faulted southern Appalachian Valley and Ridge province.

Rice and Finn (1996) estimated 5 TCF as the in-place gas resources of the Central Appalachian Basin–Central Basin Play in southern West Virginia and southwestern Virginia. Subsequently, Nolde and Spears (1998) revised the in-place estimate upward to 6.7 TCF for the Virginia part of the play.

Subsequent drilling and multiple completions (perforation and fracturing of the coal bed) within stacked coal-bed reservoirs, however, indicate that there is not a strict relation between the location of CBM fields and pools and geologic structure in Pennsylvania; thus, the definition of assessment unit locations on anticlines or synclines (Rice and Finn, 1996) is not valid everywhere (Bruner and others, 1995, reprinted 1998). Other assessment units have been defined.

CBM Assessment in 2002

Assessment teams for the U.S. Geological Survey's 2002 National Oil and Gas Assessment (NOGA; Hatch and others, 2003; Milici and others, 2003; Milici and Hatch, 2004) used the total petroleum system (TPS) concept (Magoon, 1988); within each TPS, assessment units of relatively similar geological areas were selected instead of plays. Furthermore, the 2002 NOGA teams used a 30-year timeframe for the assessment instead of the unrestricted timeframe of Rice and Finn (1996), and they had more exploration and production data than Rice and Finn, who had to use an analog method (Milici, this volume, chap. G.1). The 2002 assessment teams estimated the fractile and mean amounts of undiscovered, technically recoverable CBM resources in three Appalachian regions that were already productive.

The principal area of the Dunkard basin that was assessed quantitatively by the USGS in the 2002 assessment is that designated as the Carboniferous Coal-bed Gas Minimum Petroleum System (MPS) in western Pennsylvania and adjacent West Virginia (Milici, this volume, chap. G.1; see fig. 2 of this report). That minimum petroleum system is in the northeastern part of the East Dunkard (Folded) Assessment Unit (AU). That area was considered the most likely to be developed within the 30-year timeframe of the USGS assessment. The USGS estimated a mean of about 4.8 TCF of technically recoverable methane for the East Dunkard (Folded) AU (Milici and others, 2003).

The area of the Pocahontas basin that is considered most likely to be developed during the next 30 years is the area of the minimum petroleum system within the Pocahontas Basin AU, which includes the producing area in Virginia and West Virginia. In 2002, the USGS assessed this area (at the statistical mean) as containing about 3.58 TCF of technically recoverable undiscovered methane (Milici and others, 2003).

In 2002, the USGS estimated a mean of about 7 TCF of technically recoverable methane for the Black Warrior Basin AU, which is primarily in the Alabama part of the Black Warrior basin (Hatch and others, 2003). About 15.5 TCF of technically recoverable undiscovered methane were assessed at the statistical mean in the Appalachian Basin Province and the Black Warrior Basin Province combined (Milici and Hatch, 2004).

Dunkard Basin

Pennsylvania

The Dunkard basin includes parts of Pennsylvania, Ohio, and northern West Virginia. Figure 2 shows the location of some CBM fields in the Carboniferous Coal-bed Gas MPS in the Dunkard basin in southwestern Pennsylvania and adjacent

West Virginia. Figure 3 shows generalized stratigraphic nomenclature for Pennsylvanian units in the Dunkard basin. The units include many coal beds.

As of 2005, 214 wells were producing CBM from bituminous coals in southwestern Pennsylvania (table 1; tables follow figures at the end of the report). They included 116 wells from the Campbells Mill pool in the Blairsville field (Indiana County), 7 wells in Cambria County, 25 wells in Westmoreland County, 3 wells from the Lagonda field in Washington County, 18 wells in Fayette County, and about 45 wells drilled into Pittsburgh gob in the underground mines in the southwestern corner of Greene County (Pennsylvania Bureau of Topographic and Geologic Survey, 2006). Figure 4 shows cumulative CBM production for these counties.

The Blairsville field (fig. 2) is the most significant commercial CBM field in Pennsylvania. In this field, CBM is produced from several coal beds commonly completed over a vertical interval of 250 feet (ft) in wells that include the Bakerstown, Brush Creek, Upper and Lower Freeport, Upper, Middle, and Lower Kittanning, Clarion, and Brookville coal beds or coal zones. Markowski (1998) pointed out that the Allegheny Group, which contains the Brookville, Clarion, Lower, Middle, and Upper Kittanning, and Lower and Upper Freeport coal beds or coal zones (fig. 3), is the stratigraphic interval that is most likely to yield commercial quantities of gas in Pennsylvania, as well as in northern West Virginia and Ohio.

Because the amount of CBM contained within a coal bed commonly increases with the depth of the coal bed beneath the surface and because commercial quantities of CBM generally occur below 500 ft of overburden, the area of the Dunkard basin where Allegheny Group coal beds may have sufficient cover to produce commercial quantities of gas occurs generally where the Allegheny is overlain by the Conemaugh Group (figs. 3 and 4). The Dunkard basin is defined generally by the cropline of the base of the Conemaugh Group (which is the top of the Allegheny Group).

Northern West Virginia and Ohio

In Wetzel County, W. Va. (fig. 5), methane has been produced from both the Pittsburgh coal bed and, to a lesser extent, the Sewickley coal bed. CBM was first produced from the Pittsburgh coal bed in 1931, when four wells were drilled on the Littleton anticline (fig. 5) (Patchen and others, 1991). Three were completed successfully as gas wells, and no water was reported. Subsequently, the Big Run field was discovered in 1932 when a well that was first completed in 1905 in a deeper Paleozoic stratigraphic unit was re-completed at a depth of about 1,000 ft in 9 ft of Pittsburgh coal. It produced more than 212 million cubic feet (MMCF) of gas from 1932 until it was abandoned in 1968 when water problems developed. Between 1949 and 1965, 35 more wells were drilled in the field; they had initial production rates that ranged from 8 to 60 thousand cubic feet per day (MCF/day). Active development of the field ceased in 1967.

In 2004, CBM was produced from about 50 wells in Monongalia County in northern West Virginia (fig. 4) that were drilled into the gob of an underground mine in the Pittsburgh coal bed. Production from this field commenced in 1990 and declined from more than 223 MMCF from 7 wells in 1993 to about 62.5 MMCF in 1999 (West Virginia Geological and Economic Survey, 2006) (fig. 6). In 2000, production increased again to 174.2 MMCF, and in 2002, it reached a maximum of 307.8 MMCF. After 2002, production from this field declined to 180.1 MMCF in 2004.

Figure 7 shows the cumulative CBM production in the part of the Dunkard basin in Pennsylvania and northern West Virginia. Annual production was still generally increasing from 1999 through 2005.

In Ohio, Wolfe (1997) reported a flow of 300 to 500 MCF/day of gas having a methane content of 91 percent from Vent No. 5 (originally a gob drainage well) at the Nelms-Cadiz Portal underground mine complex in Harrison County. In 1996, the well produced 47.5 MMCF in 61 days; in 1997, it produced 47.5 MMCF; and in 1998, it produced 56.5 MMCF in 6 months on line (Steve O’Pritza, Ohio Division of Oil and Gas, oral commun., June 2000). The mine is reported to be in the No. 6A (Lower Freeport) coal bed. Gas from this vent was used at the mine to run several internal combustion engines. Since 1996, 16 wells have been permitted for CBM exploration in Harrison County, Ohio. As of June 2000, the status of these 16 wells was that 4 were producing, 2 more were completed and were not yet producing, 1 had an active application, and the rest were not drilled (Steve O’Pritza, oral commun., June 2000).

Pocahontas Basin

The Pocahontas basin includes the coal fields of southwestern Virginia and southern West Virginia (fig. 8). CBM production from the Pennsylvanian-age coal began commercially in southwestern Virginia in 1988 (Nolde and Spears, 1998) and in southern West Virginia in 1989 (West Virginia Geological and Economic Survey, 2006). Much earlier, gas was vented into the atmosphere from vertical ventilation holes drilled to degas the coal beds in advance of underground mining or from wells draining underground mine gob. As development within the Pocahontas basin matured, CBM fields were developed when multiple unmined coal beds were drilled, stimulated, and completed. In 2000, 84 wells produced 4 BCF of CBM in southern West Virginia; in 2004, production in the area rose to 10 BCF (fig. 9) (West Virginia Geological and Economic Survey, 2006). In 2004, 2,557 wells produced 66.7 BCF of CBM in Virginia (fig. 10). Figure 11 shows that the cumulative CBM production in the part of the Pocahontas basin in Virginia and southern West Virginia was 673 BCF through 2005.

Typically, from 6 to 10 coal beds (fig. 12) having a total coal thickness of about 10 to 30 ft are selected and completed in each well, and the gas produced is commingled and produced from the wellbore. The coal beds of the Pocahontas Formation are, in general, among the more productive of the Pennsylvanian sequence within the Pocahontas basin. The Pocahontas Formation and its contained coal beds are truncated by a regional unconformity that cuts downward stratigraphically to the northwest, from Virginia into Kentucky, to where only younger formations and coal beds are preserved (Englund and Thomas, 1990).

In recent years, several wells have been completed for CBM in Bell and Clay Counties, Ky. (table 1, fig. 8). The wells produced for a short time from coal beds in the Pennsylvanian Breathitt Formation, probably from Lower Elkhorn coals (Brandon Nuttall, Kentucky Geological Survey, written commun., July 2001). The CBM potential of deeper coal beds in eastern Kentucky is relatively untested.

Black Warrior Basin

CBM production from the Black Warrior basin, in the southern part of the Black Warrior coal field of Alabama (fig. 13), ranked third in the United States in 2006; the most productive basins were the San Juan basin of New Mexico and Colorado and the Powder River basin in Wyoming (U.S. Energy Information Administration, 2007). Like the CBM-producing coal beds in the remainder of the Appalachian basin, those of the Black Warrior coal field in the southern Appalachian basin coal region are of Pennsylvanian age; methane is produced from Early Pennsylvanian coal beds of the Pottsville Formation (fig. 14).

Alabama's CBM production began in 1980, when the first permit for a CBM well was issued by the State. By 2005, a total of 22 coal-bed-degasification fields had been established (Alabama State Oil and Gas Board, 2006); 20 were in the Black Warrior basin, and 2 were in the nearby Cahaba basin (fig. 13). Of the 6,007 wells drilled for CBM by 2004 in Alabama, 3,474 wells remained in production in 2004 (Alabama State Oil and Gas Board, 2004). Wells commonly are completed in the Black Creek (7 ft cumulative coal thickness (CCT)), Mary Lee (12 ft CCT), and Pratt coal zones (6 ft CCT). In Alabama, annual CBM production for 1993 to 2007 exceeded 100 BCF (fig. 15, table 2), cumulative production through 2007 exceeded 2 TCF, and reserves may exceed 3 TCF (Alabama State Oil and Gas Board, 2008).

The northern part of the coal field in Alabama is underlain by a generally thinner coal-bearing stratigraphic section than that in the Black Warrior basin to the south, less coal is mined, and the methane resources of the region have not yet been exploited (Pashin and Hinkle, 1997). The Cahaba basin, which produces much less methane than the Black Warrior basin, lies in an elongated, northeast-oriented synclinal trend (figs. 1 and 13) within the folded and faulted Appalachian Mountains, about 6 miles southeast of the Black Warrior basin (Pashin and others, 1995). Methane production in the Cahaba basin is from coal beds of the Pottsville Formation of Early Pennsylvanian age.

Conclusions

In Alabama, in the southern part of the Appalachian basin, coalbed-methane development may be regarded as mature; the annual production in Alabama from 1998 through 2007 was relatively constant and ranged from 112 to 121 BCF. Through 2007, cumulative CBM production was more than 2 TCF.

An opportunity still exists for additional growth in the Pocahontas basin. In 2005, annual CBM production in the Pocahontas basin in Virginia and West Virginia was 85 BCF. The CBM potential of deeper coal beds in eastern Kentucky is relatively untested.

The Dunkard basin is not fully explored. Large, diffuse CBM resources of the northern Appalachian coal region in northern West Virginia, Ohio, and Pennsylvania may be better exploited in the future as our geologic understanding of the occurrence of CBM increases and as exploration strategies and drilling and completion technologies improve.

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Figures 1–15 and Tables 1 and 2

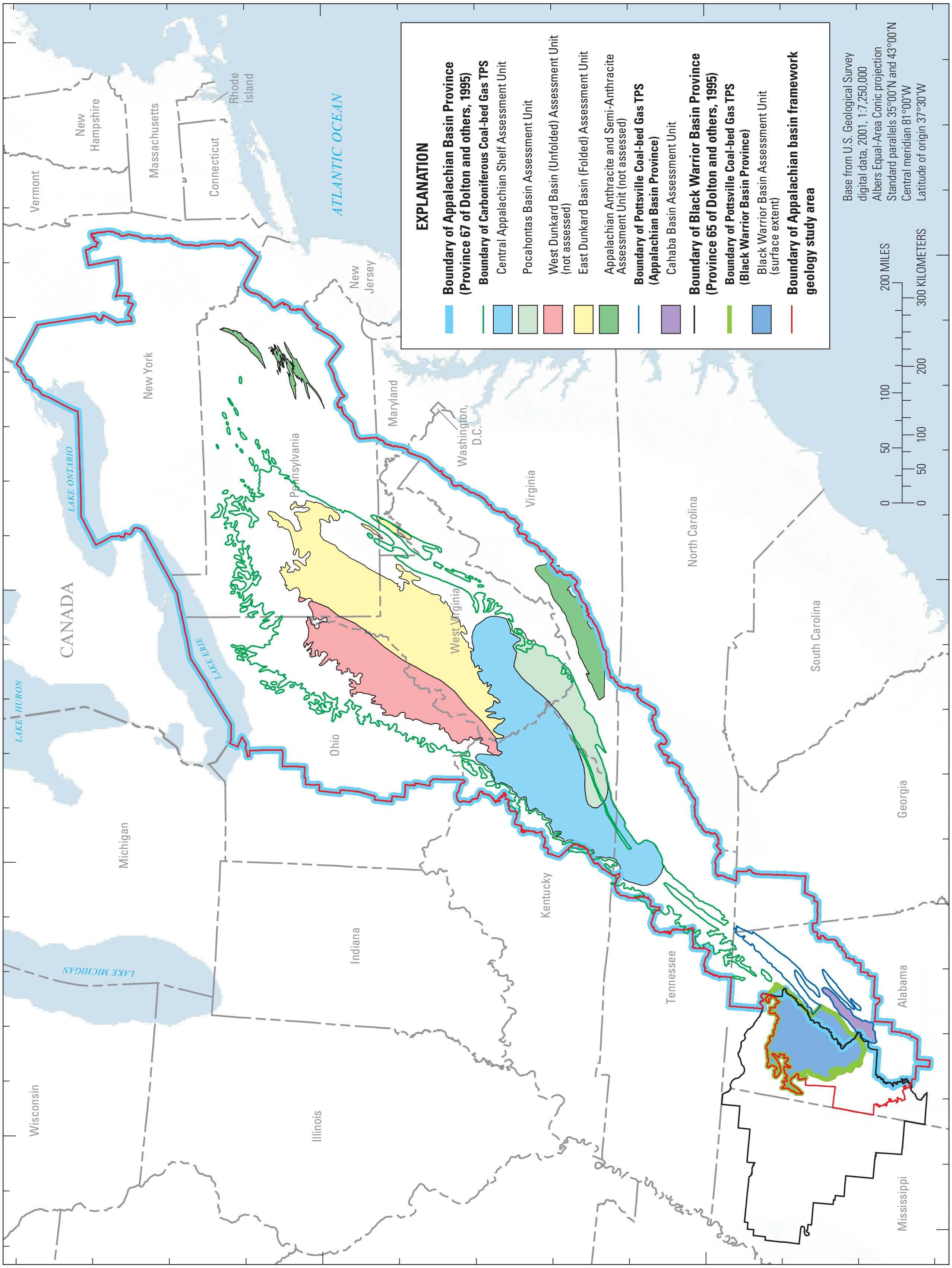

EXPLANATION
Boundary of Appalachian Basin Province (Province 67 of Dolton and others, 1995)
Boundary of Carboniferous Coal-bed Gas TPS
Central Appalachian Shelf Assessment Unit
Pocahontas Basin Assessment Unit
West Dunkard Basin (Unfolded) Assessment Unit (not assessed)
East Dunkard Basin (Folded) Assessment Unit
Appalachian Anthracite and Semi-Anthracite Assessment Unit (not assessed)
Boundary of Pottsville Coal-bed Gas TPS (Appalachian Basin Province)
Cahaba Basin Assessment Unit
Boundary of Black Warrior Basin Province (Province 65 of Dolton and others, 1995)
Boundary of Pottsville Coal-bed Gas TPS (Black Warrior Basin Province)
Black Warrior Basin Assessment Unit (surface extent)
Boundary of Appalachian basin framework geology study area
Base from U.S. Geological Survey digital data, 2001, 1:7,250,000
Albers Equal-Area Conic projection
Standard parallels 35°00'N and 43°00'N
Central meridian 81°00'W
Latitude of origin 37°30'W
0 50 100 200 MILES
0 50 100 200 300 KILOMETERS
70°
75°
80°
85°
90°
40°
35°
CANADA
ATLANTIC OCEAN
LAKE ONTARIO
LAKE ERIE
LAKE HURON
LAKE MICHIGAN
Vermont
New Hampshire
Massachusetts
Rhode Island
Connecticut
New York
New Jersey
Pennsylvania
Maryland
Washington, D.C.
Virginia
West Virginia
Ohio
Michigan
Indiana
Kentucky
North Carolina
South Carolina
Tennessee
Georgia
Alabama
Mississippi
Illinois
Wisconsin

Figure 1 (facing page). Map of the central and southern parts of the Appalachian structural basin showing oil and gas provinces and assessment units used by the U.S. Geological Survey (USGS) during the 2002 National Oil and Gas Assessment (Milici and others, 2003; Milici and Hatch, 2004). Figure from Milici (this volume, chap. G.1, fig. 1*A*). The focus in this report is on coalbed-methane (CBM) production from the major CBM-producing areas in the Appalachians, which are in the Dunkard basin, the Pocahontas basin, and a part of the Black Warrior basin in Alabama; the locations of these basins are generally shown on the map by the assessment units named for them.

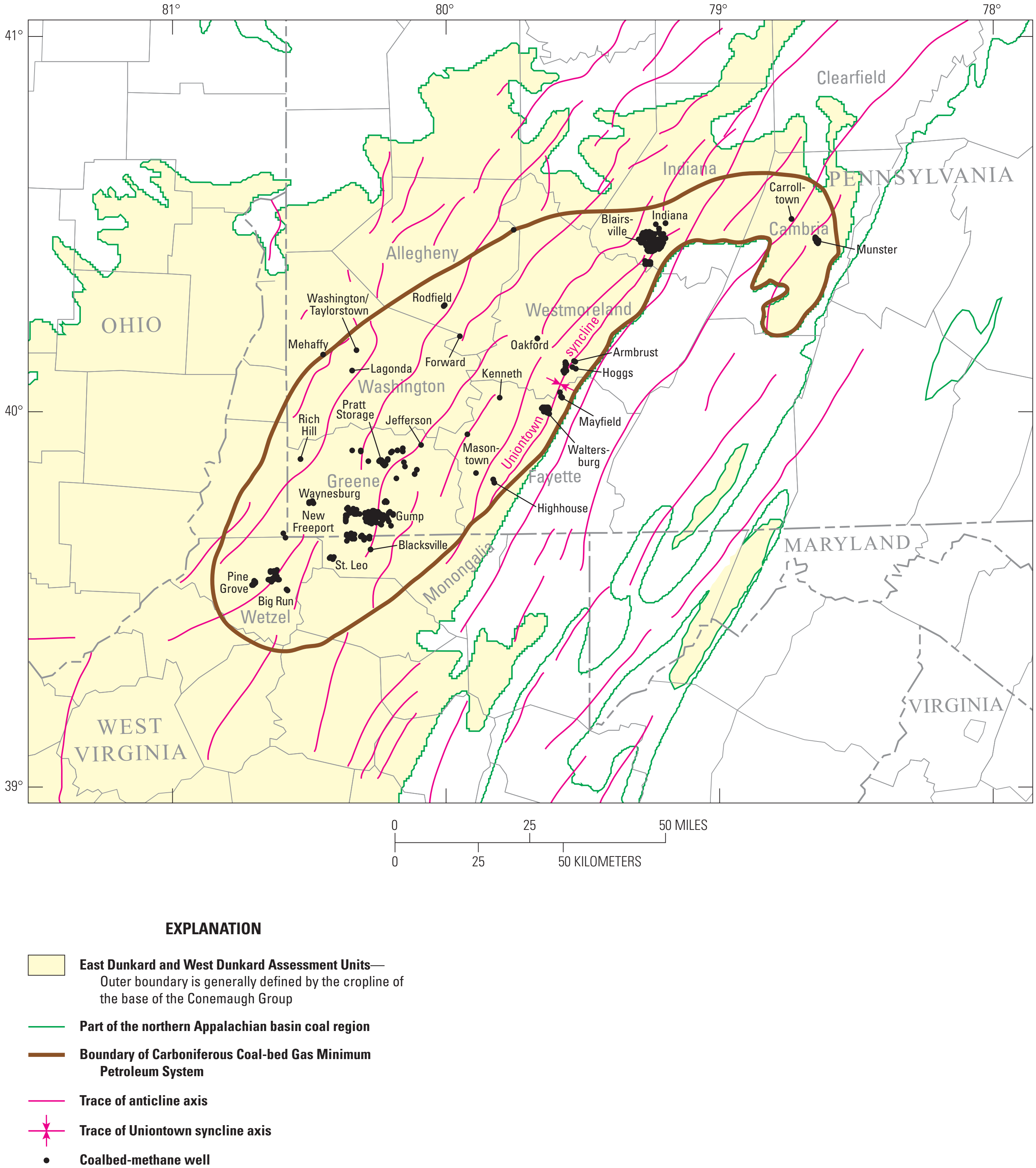


Figure 2. Map showing major coalbed-methane (CBM) fields (names in small black type) and CBM wells of the Dunkard basin. From Milici (this volume, chap. G.1, fig. 12). Locations of CBM wells from Markowski (2000) and Avary (2004). Selected counties are labeled. The Dunkard basin is shown in figure 1; only its northeastern part has CBM fields.

System	Group	Coal bed or zone
Permian	Dunkard	Waynesburg
Pennsylvanian	Monongahela	Sewickley Redstone Pittsburgh
	Conemaugh	Bakerstown Brush Creek Mahoning
	Allegheny	Upper Freeport Lower Freeport Upper Kittanning Middle Kittanning Lower Kittanning Clarion Brookville
	Pottsville	Mercer Quakerstown Sharon

Figure 3. Chart showing major coal beds of the Dunkard basin. Figure from Milici (this volume, chap. G.1, fig. 4).

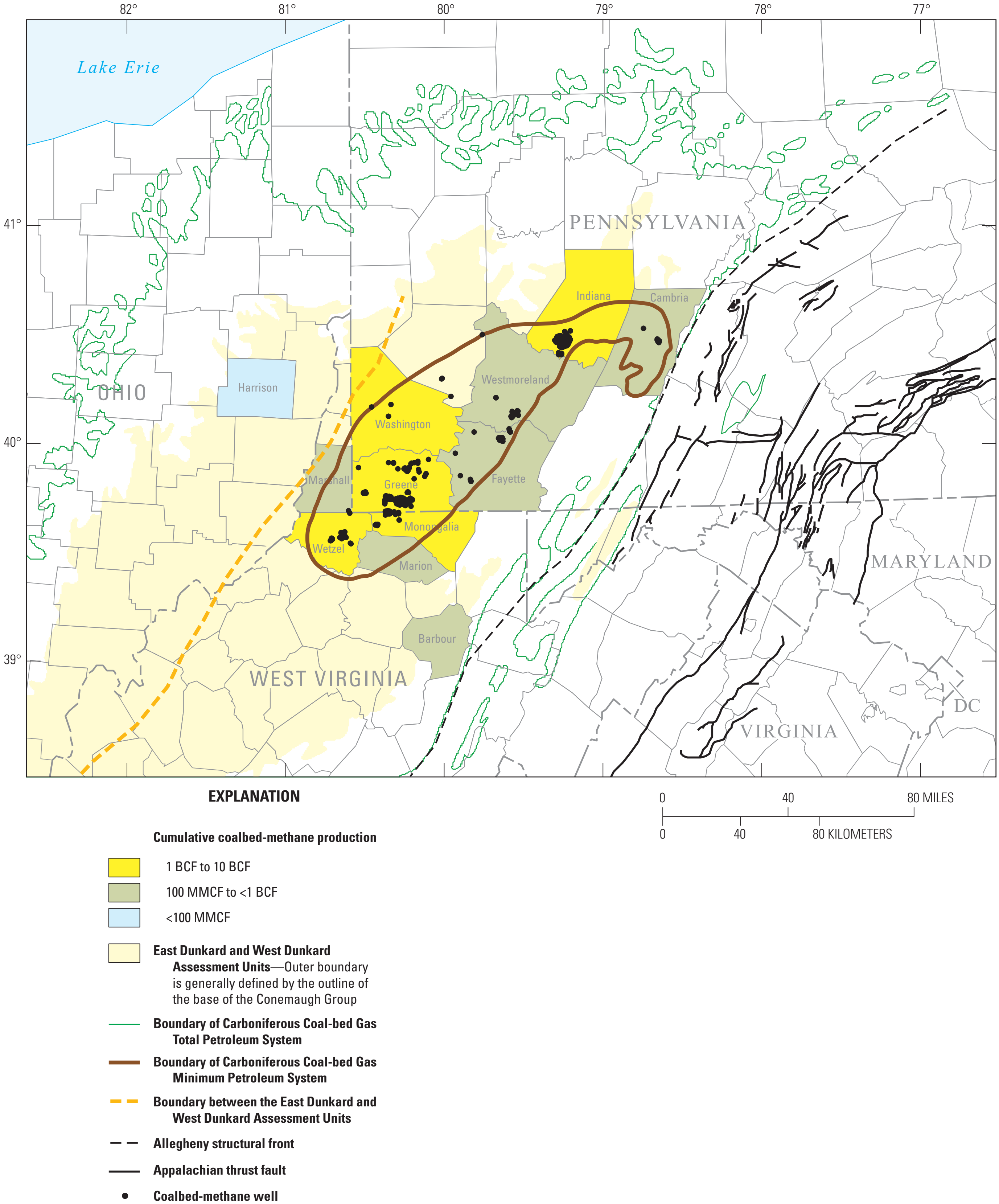


Figure 4. Map showing cumulative production of coalbed methane (CBM) for selected counties in the Dunkard basin by 2005. CBM production data from sources identified in table 1. Figure from Milici (this volume, chap. G.1, fig. 14). BCF, billion cubic feet; MMCF, million cubic feet.

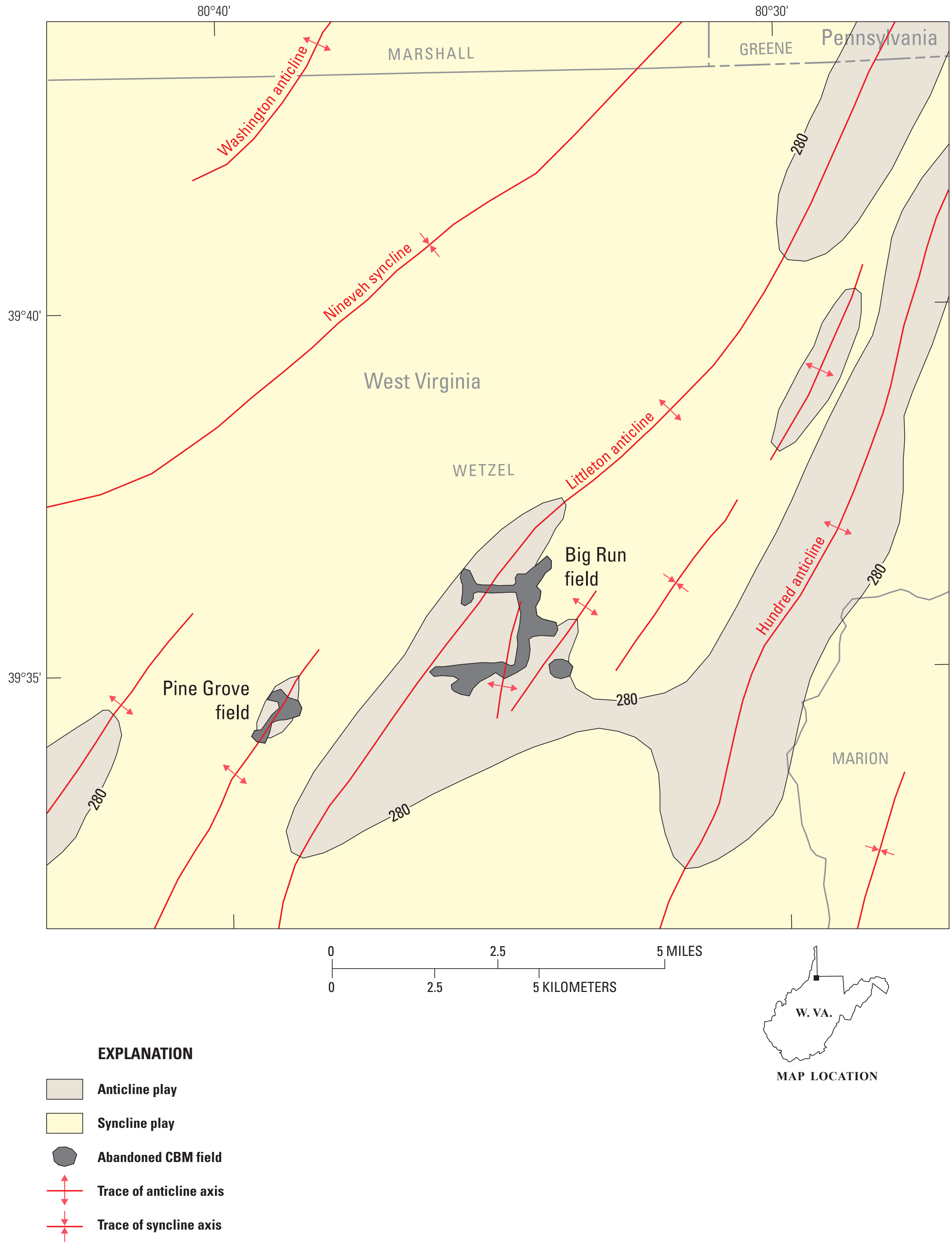


Figure 5. Map showing location of abandoned anticlinal coalbed-methane (CBM) fields in northern West Virginia (adapted from Patchen and others, 1991). Contours are elevations above sea level, in feet.

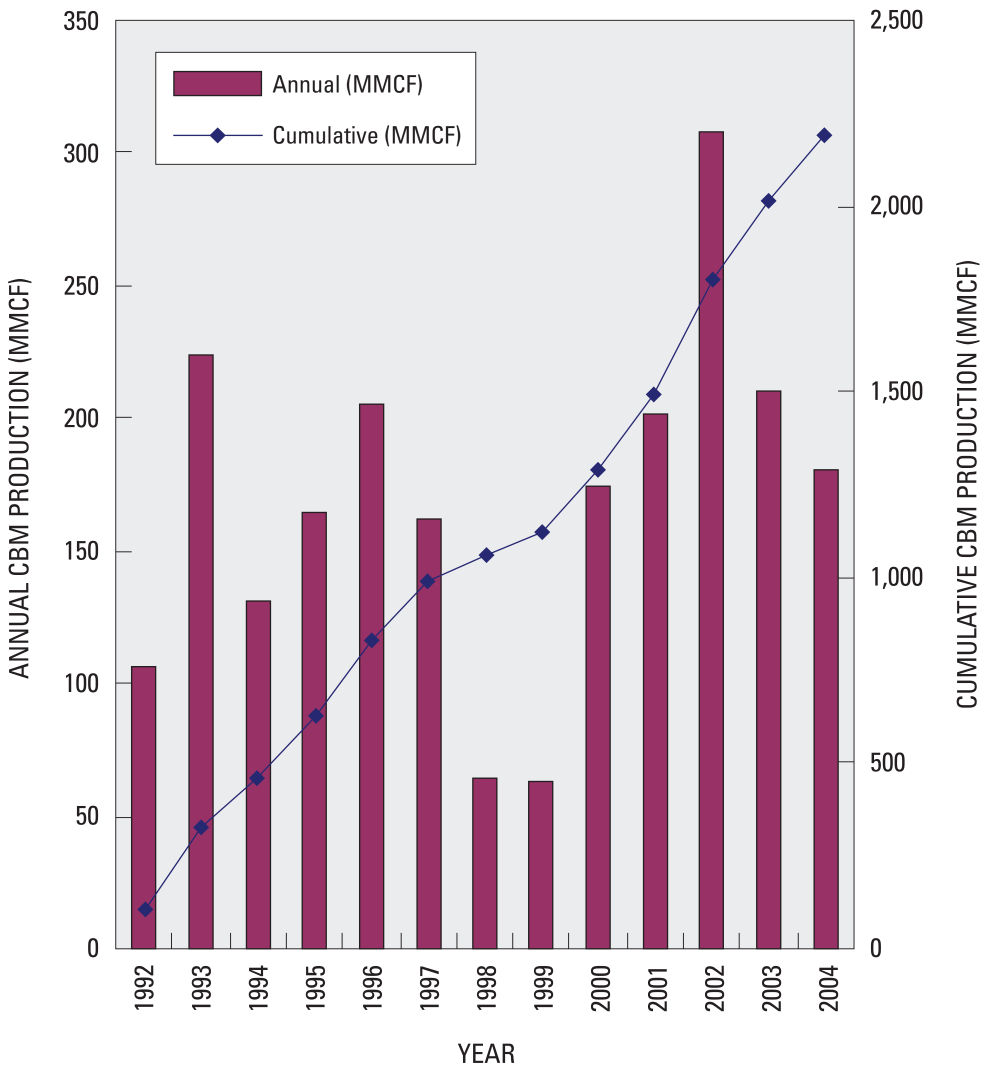


Figure 6. Graph showing coalbed-methane (CBM) annual and cumulative production from 1992 through 2004 in Monongalia County, W. Va., from about 50 wells drilled into the gob of underground mines in the Pittsburgh coal bed. Data from West Virginia Geological and Economic Survey (2006). MMCF, million cubic feet.

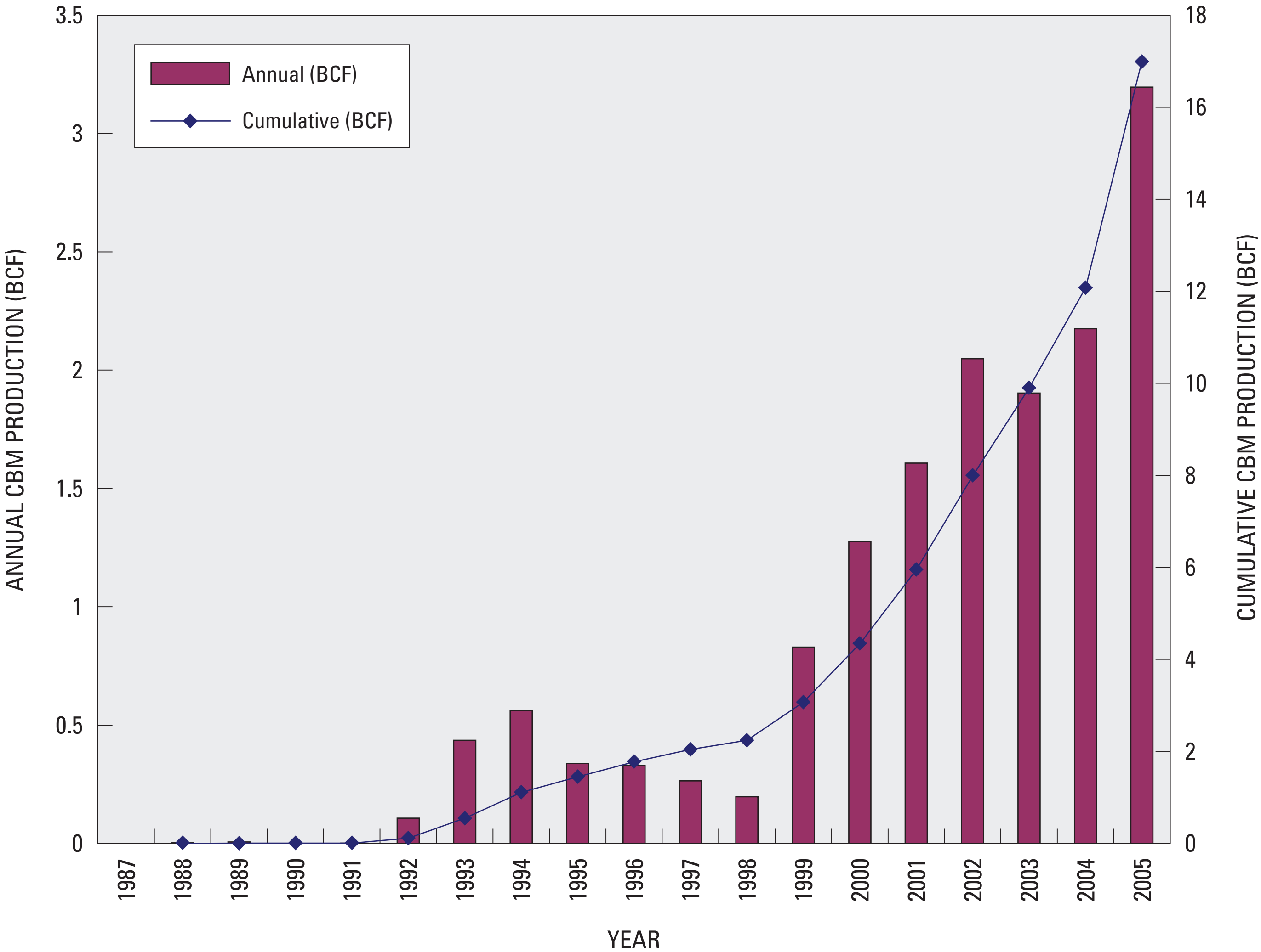


Figure 7. Graph showing coalbed-methane (CBM) annual and cumulative production from 1987 through 2005 in the Dunkard basin in Pennsylvania and northern West Virginia. Data from Pennsylvania Bureau of Topographic and Geologic Survey (2007) and West Virginia Geological and Economic Survey (2006). BCF, billion cubic feet.

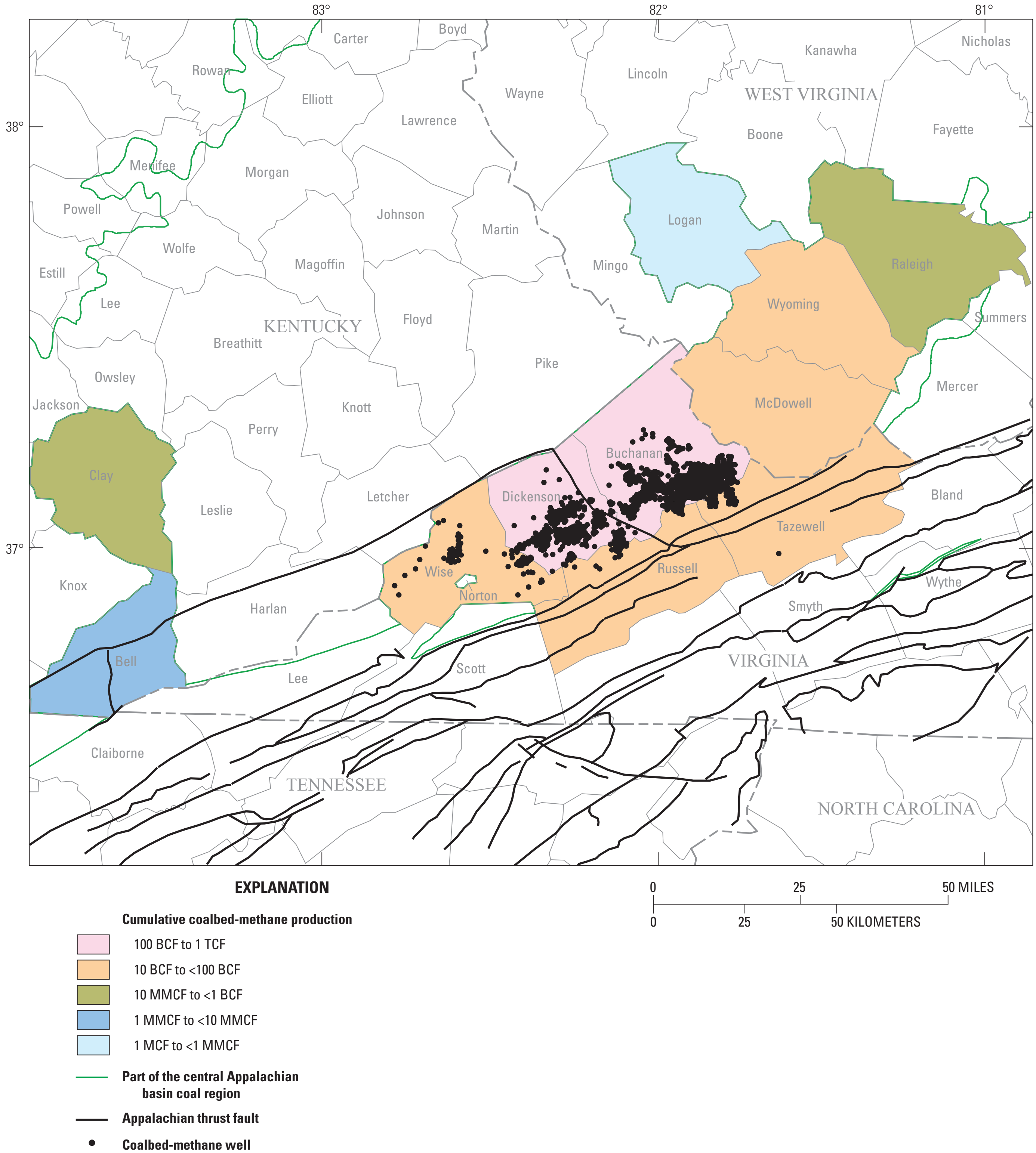


Figure 8. Map showing cumulative production of coalbed methane (CBM) for selected counties in the Pocahontas basin. CBM production data from sources identified in table 1. BCF, billion cubic feet; MCF, thousand cubic feet; MMCF, million cubic feet; TCF, trillion cubic feet.

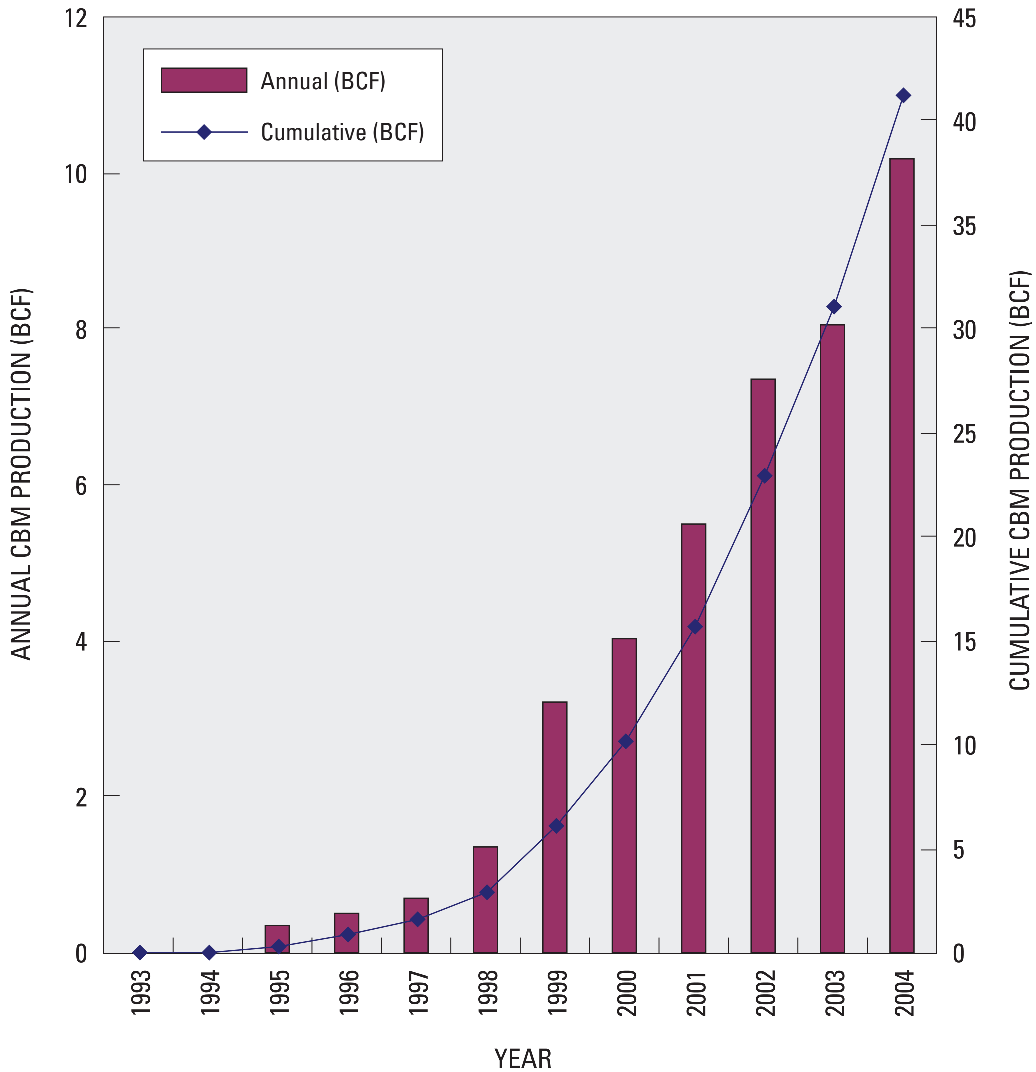


Figure 9. Graph showing coalbed-methane (CBM) annual and cumulative production from 1993 through 2004 from the Bradshaw, Slab Fork, and Welch fields in McDowell, Wyoming, and Raleigh Counties, W. Va. Production was from about 100 wells in the Beckley and Pocahontas coal beds. Data from West Virginia Geological and Economic Survey (2006). BCF, billion cubic feet.

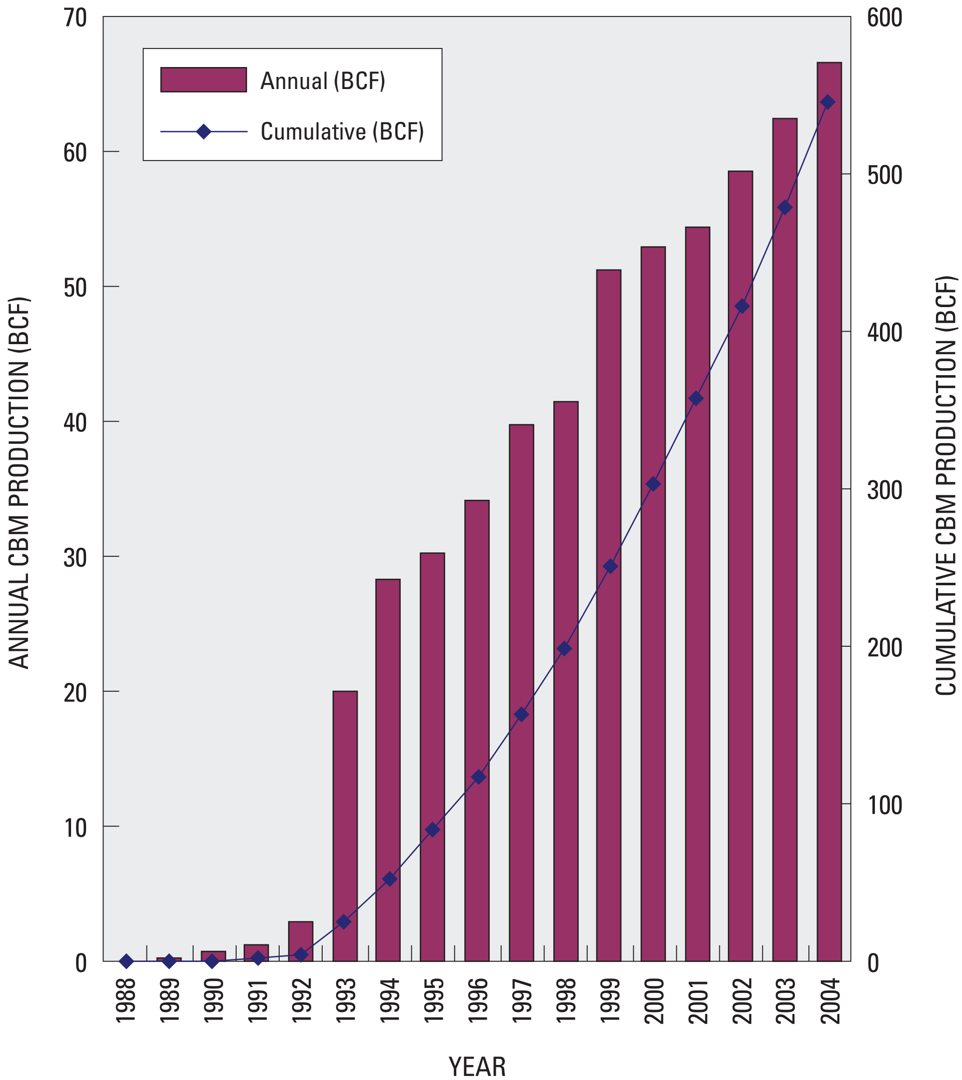


Figure 10. Graph showing coalbed-methane (CBM) annual and cumulative production from 1988 through 2004 in Virginia. Production in 2004 was from about 2,557 wells. Data from Nolde and Spears (1998), Sweet and Nolde (1999), and Virginia Center for Coal and Energy Research (2006). BCF, billion cubic feet.

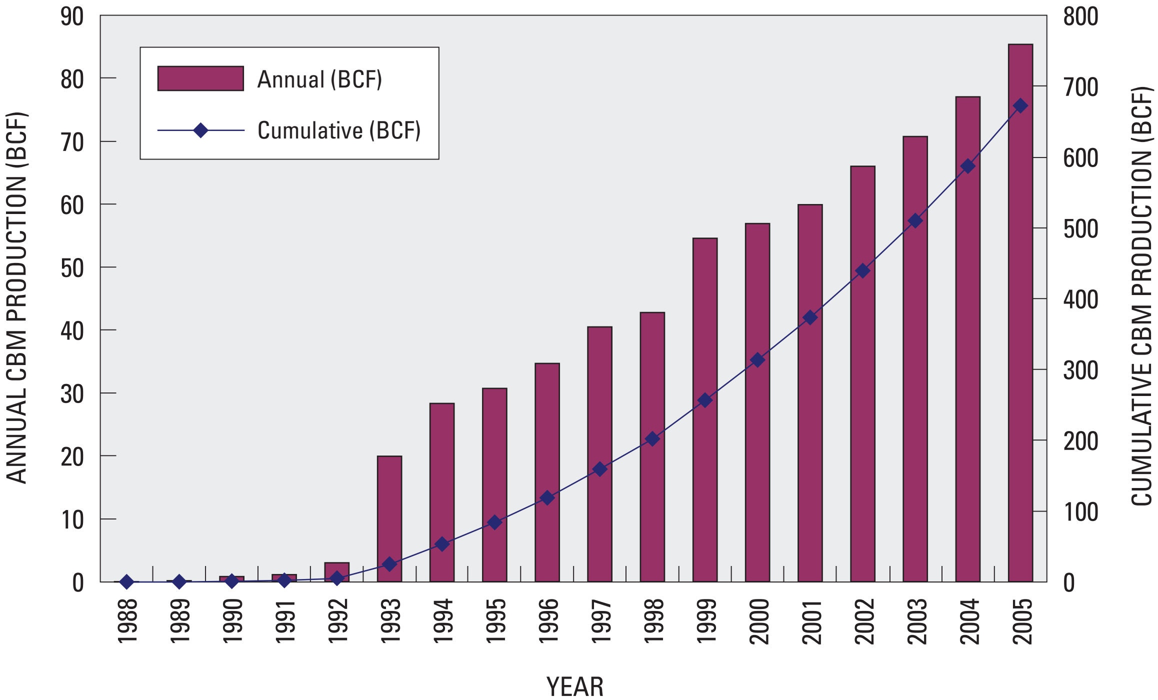


Figure 11. Graph showing coalbed-methane (CBM) annual and cumulative production from 1988 through 2005 in the Pocahontas basin in Virginia and southern West Virginia. Data from West Virginia Geological and Economic Survey (2006) and Virginia Division of Gas and Oil (2007). BCF, billion cubic feet.

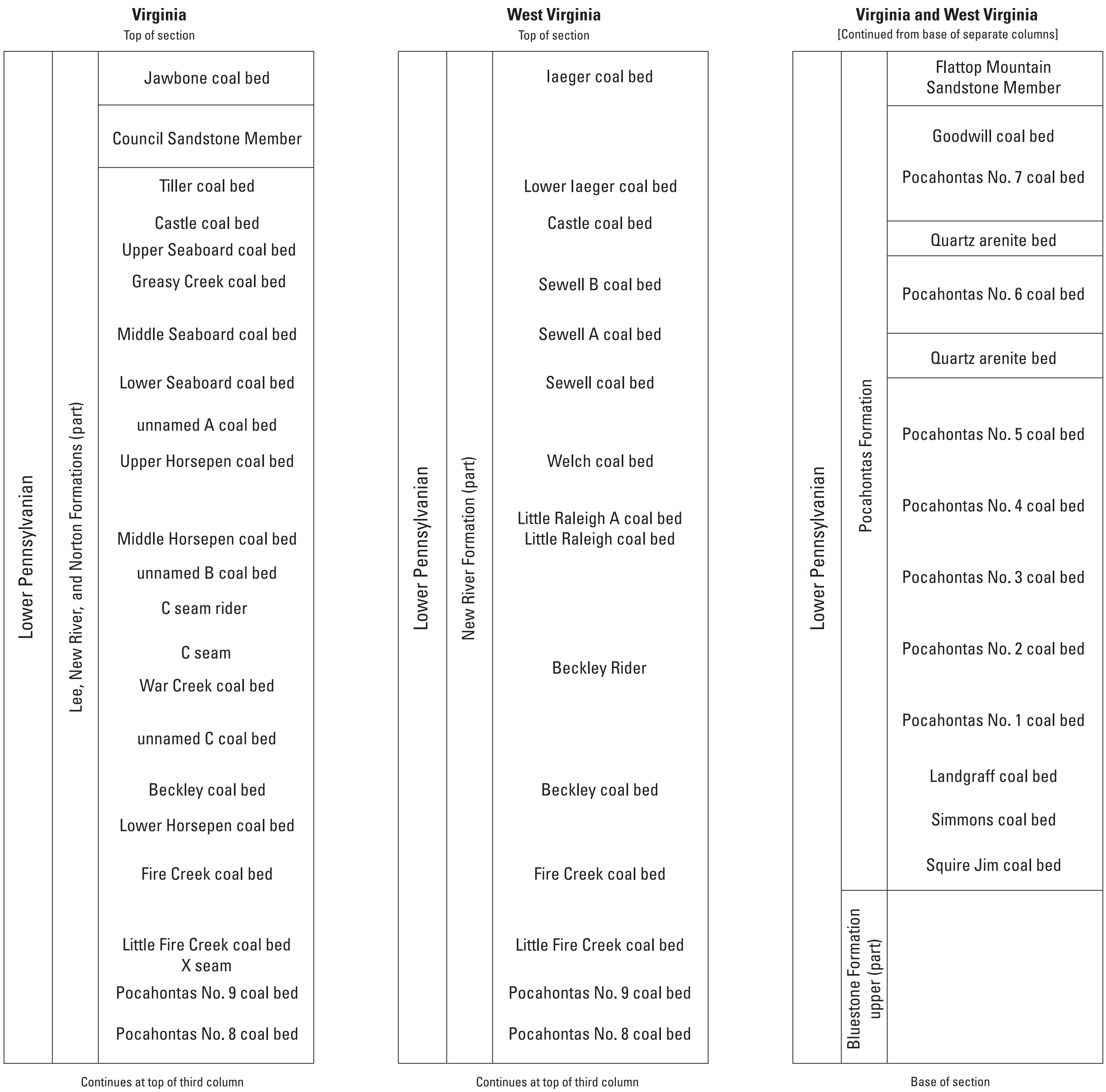
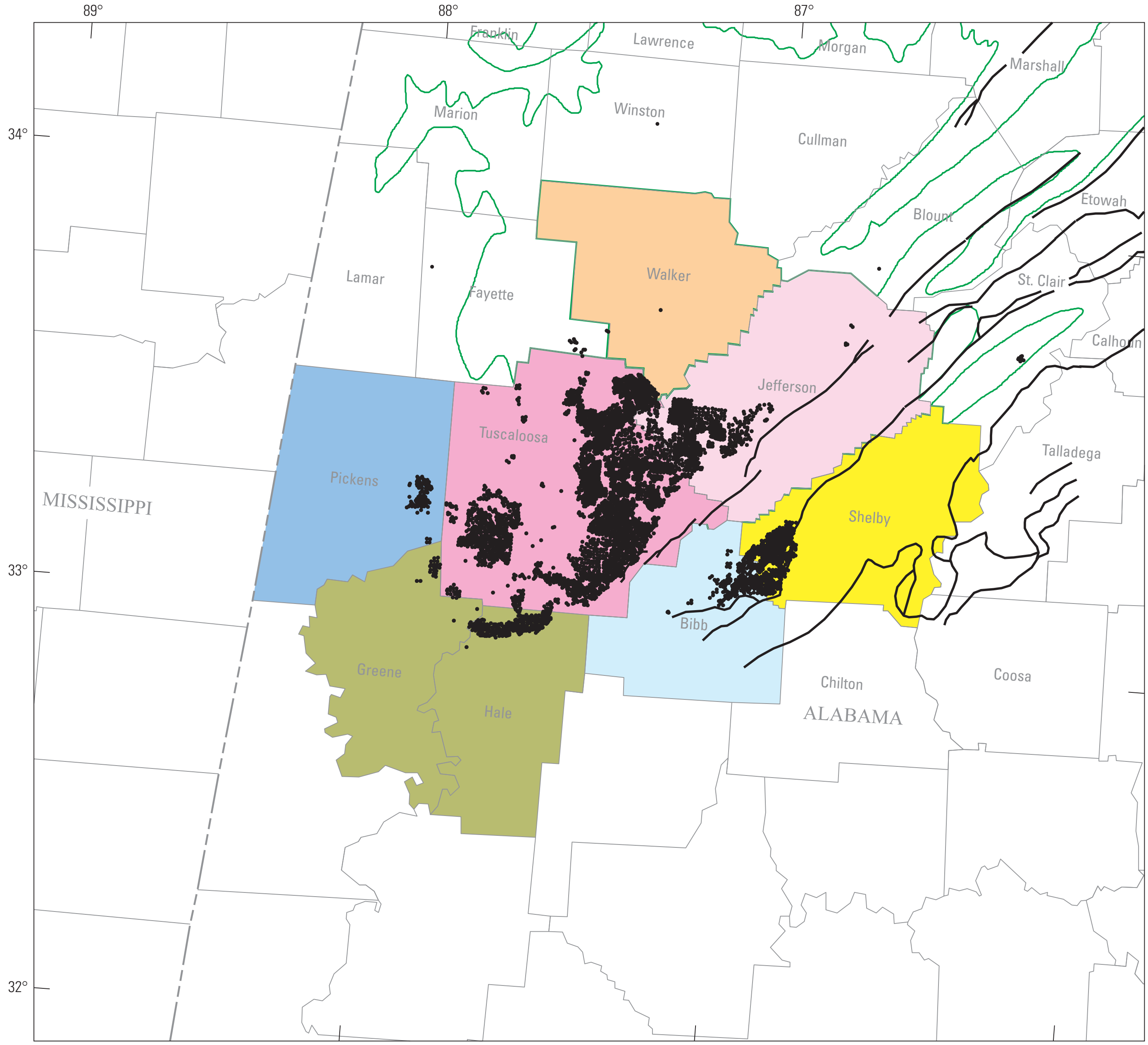


Figure 12. Chart showing stratigraphic nomenclature for Lower Pennsylvanian formations, sandstones, and coal beds in coalbed-methane (CBM) fields in the Pocahontas basin in southwestern Virginia and adjacent West Virginia. The selected coal beds listed include those in which wells have been completed for CBM. Data from Arkle and others (1979), Englund (1979), Nolde (1994a,b), and Milici, Freeman, and Bragg (2001). Figure from Milici (this volume, chap. G.1, fig. 18).



EXPLANATION

Cumulative coalbed-methane production

- >1 TCF
- 100 BCF to 1 TCF
- 10 BCF to <100 BCF
- 1 BCF to <10 BCF
- 10 MMCF to <1 BCF
- 1 MMCF to <10 MMCF
- <1 MMCF

Part of the southern Appalachian basin coal region

Appalachian thrust fault

Coalbed-methane well

0 25 50 MILES

0 25 50 KILOMETERS

Figure 13. Map showing cumulative production of coalbed methane (CBM) for selected counties in the Black Warrior, Cahaba, and Coosa basins of Alabama by 2003. CBM production data from sources identified in table 1. Well locations from Jack Pashin (Geological Survey of Alabama, written commun., 2003).

System	Series	Formation	Coal groups	Coal zones
Pennsylvanian	Lower	Pottsville Formation	Brookwood	
			Utley	
			Gwin Cobb	Gwin Thompson Mill Cobb Thomas
			Pratt	Pratt Corona Nickel Plate
			Curry	Curry
			Gillespy	Gillespy
			Mary Lee	New Castle Mary Lee Blue Creek Jagger
			Upper Black Creek	Lick Creek
			Lower Black Creek	Jefferson Black Creek

Figure 14. Chart showing stratigraphic nomenclature for Lower Pennsylvanian units in the Black Warrior basin, Alabama. From Pashin and Hinkle (1997).

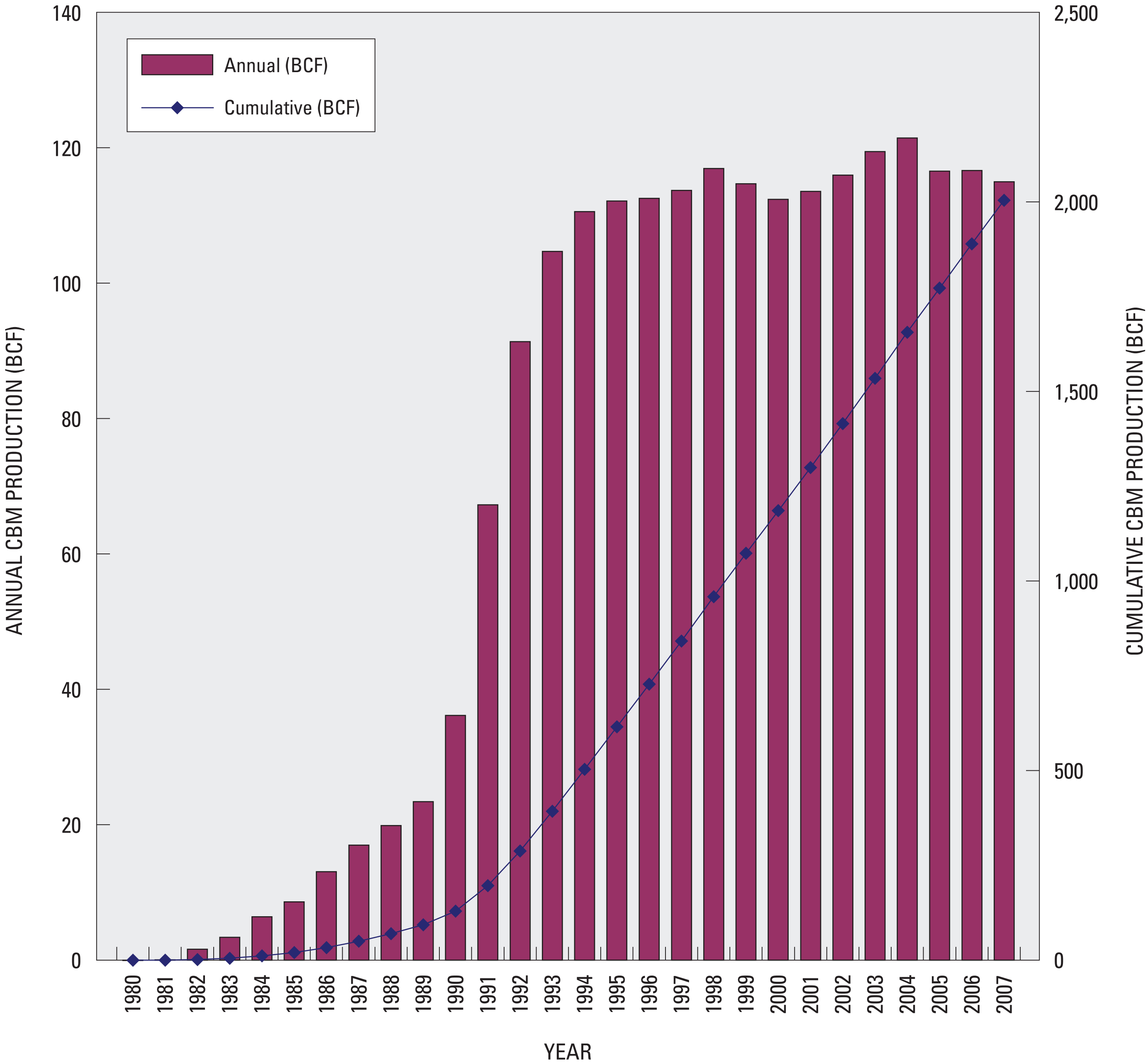


Figure 15. Graph showing coalbed-methane (CBM) annual and cumulative production from 1980 through 2007 in the Black Warrior and Cahaba basins in Alabama. Data from Alabama State Oil and Gas Board (2008). BCF, billion cubic feet.

Table 1. Cumulative production of coalbed methane (CBM) from the Appalachian basin, by county.

[Sources of data: Alabama State Oil and Gas Board (2004), Kentucky Division of Oil and Gas Conservation (2004), Pennsylvania Bureau of Topographic and Geologic Survey (2006), Virginia Center for Coal and Energy Research (2004), Virginia Division of Gas and Oil (2007), and West Virginia Geological and Economic Survey (2006). Terms used: MCF, thousand cubic feet; ND, no data]

Basin	State and county	Year of first production	Cumulative production date	Number of producing wells as of cumulative production date	CBM cumulative production (MCF)
Black Warrior	Alabama:				
	Bibb[1]	1990	10/31/2003	0	583
	Greene	1992	10/31/2003	0	99,565
	Hale	1990	10/31/2003	0	111,543
	Jefferson	1980	10/31/2003	655	184,658,319
	Pickens	1990	10/31/2003	0	1,873
	Shelby	1990	10/31/2003	0	3,969,067
	Tuscaloosa	1981	10/31/2003	3,096	1,310,241,313
	Walker	1989	10/31/2003	102	18,937,713
	Subtotal Black Warrior basin			3,853	1,518,019,393
Pocahontas	Virginia:				
	Buchanan	1992	2006	1,927	509,961,998
	Dickenson	1988	2006	993	120,524,623
	Russell	1990	2006	368	35,177,817
	Tazewell	1990	2006	282	19,363,221
	Wise	1990	2006	107	10,974,626
	Subtotal			3,677	696,002,285
	West Virginia:				
	Logan	2002	2005	1	418
	McDowell	1995	2005	207	18,019,064
	Raleigh	1992	2005	9	563,607
	Wyoming	1994	2005	95	39,406,547
	Subtotal			312	57,989,636
	Kentucky:				
	Bell	1998	2002	3	7,674
	Clay	1998	2002	5	56,478
	Leslie	2000	2002	1	ND
	Letcher	1997	2002	1	ND
	Subtotal			10	64,152
	Subtotal Pocahontas basin			3,999	754,056,073
Dunkard	Pennsylvania:				
	Cambria	1997	2005	7	197,472
	Fayette	1999	2005	18	494,959
	Greene	1988	2005	45	2,198,704
	Indiana	1993	2005	116	6,597,910
	Washington	1993	2005	3	1,472,837
	Westmoreland	2002	2005	25	322,478
	Subtotal			214	11,284,360
	West Virginia:				
	Barbour	2004	2005	2	146,386
	Marion	2002	2005	14	589,601
	Marshall	ND	2005	4	407,711
	Monongalia	1992	2005	54	2,716,830
	Wetzel[2]	1931	2005	1	2,213,095
	Subtotal			75	6,073,623
	Subtotal Dunkard basin[3]			289	17,357,983
Appalachian basin total[3]				8,141	2,289,433,449

[1]Most production in Bibb County, Ala., was from the Cahaba basin (fig. 1), and so the 583 MCF are not included in the totals for the Black Warrior basin and Appalachian basin.

[2]Includes production data for the Big Run field from Patchen and others (1991).

[3]Small amounts of gas produced in Harrison County, Ohio, are not included.

Table 2. Coalbed-methane (CBM) annual and cumulative production from 1980 through 2007 in the Black Warrior and Cahaba basins in Alabama.

[Data from Alabama State Oil and Gas Board (2008). MCF, thousand cubic feet]

Year	CBM production (MCF)	
	Annual	Cumulative
1980	4,613	4,613
1981	48,526	53,139
1982	1,623,575	1,676,714
1983	3,405,791	5,082,505
1984	6,428,950	11,511,455
1985	8,650,891	20,162,346
1986	13,065,686	33,228,032
1987	17,017,556	50,245,588
1988	19,867,671	70,113,259
1989	23,403,661	93,516,920
1990	36,479,405	129,996,325
1991	67,912,166	197,908,491
1992	91,923,808	289,832,299
1993	105,103,320	394,935,619
1994	111,100,817	506,036,436
1995	112,490,177	618,526,613
1996	112,955,584	731,482,197
1997	113,915,873	845,398,070
1998	116,946,209	962,344,279
1999	114,657,648	1,077,001,927
2000	112,393,459	1,189,395,386
2001	113,527,128	1,302,922,514
2002	115,948,503	1,418,871,017
2003	119,403,160	1,538,274,177
2004	121,443,917	1,659,718,094
2005	116,531,583	1,776,249,677
2006	116,623,703	1,892,873,380
2007	114,980,535	2,007,853,915