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Chapter H

A Digital Resource Model of the Lower Pennsylvanian Pocahontas No. 3 Coal Bed, Pottsville Group, Central Appalachian Basin Coal Region

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Virginia Division of Mineral Resources
West Virginia Geological and Economic Survey

2000 RESOURCE ASSESSMENT OF SELECTED COAL BEDS AND ZONES IN THE NORTHERN AND CENTRAL APPALACHIAN BASIN COAL REGIONS

By Northern and Central Appalachian Basin Coal Regions Assessment Team

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ABSTRACT

The assessment of the Pocahontas No. 3 coal bed is part of the U.S. Geological Survey's National Coal Resource Assessment project. The Pocahontas No. 3 coal bed is one of the six coal beds assessed in the Appalachian Basin coal region. The resource model indicates that, of the original 7.2 billion short tons of Pocahontas No. 3 coal, 5.1 billion short tons remain. Most of these resources, however, are in the inferred or hypothetical categories. Remaining resources are generally thinner, deeper, and more costly to mine than the coal that has already been mined, and current production rates may not be sustainable throughout the 21st century.

INTRODUCTION

The Pocahontas No. 3 coal bed is within the Lower Pennsylvania Pocahontas Formation of the Pottsville Group. Where greater than 1.17 ft (14 in) in thickness, it underlies all or parts of Wyoming, McDowell, Raleigh, Summers, Mercer, Greenbrier, and Fayette Counties in West Virginia, and parts of Wise, Dickenson, Buchanan, Scott, Russell, and Tazewell Counties in adjacent Virginia, an area within the central part of the Appalachian Plateaus (figs. 1, 2). The eastern limit of the coal bed is along the Allegheny structural front. The western minable limit of the coal bed is in the subsurface and was selected where the thickness of the coal bed is less than 1.17 ft (Wood and others, 1983). The Pocahontas No. 3 coal bed is, in general, a high-rank, low-volatile bituminous (fig. 3), low-ash, low-sulfur coal that was once considered a standard for metallurgical coal (McColloch, 1995). Coal was first produced from the Pocahontas No. 3 coal bed in southwestern Virginia and southern West Virginia in 1882 and 1883, respectively (Rehbein and others, 1981; Hibbard, 1990). The resource model prepared for this assessment indicates that, of the original 7.2 billion short tons of Pocahontas No. 3 coal, 5.1 billion short tons remain (table 1); however, most of these resources, however, are in the inferred or hypothetical categories. The remaining resources are generally thinner, deeper, and more costly to mine than the coal that has already been mined.

The Pocahontas basin of southern West Virginia and southwestern Virginia is generally defined by the extent of the Lower Pennsylvanian Pocahontas Formation in the Pottsville Group within the central Appalachian Plateaus (Englund, Windolph, and Thomas, 1986). The Pocahontas basin was filled with as much as 4,000 ft of coal-bearing siliciclastic strata of the Pottsville Group (Lower Pennsylvanian Pocahontas and New River Formations and Middle Pennsylvanian Kanawha Formation) in southern West Virginia, and their lateral equivalents in Virginia (Hennen, 1915, 1919; Krebs, 1916; Reger, 1926; Price, 1939; Englund, 1979; Nolde, 1994a,b).

The Pocahontas Formation contains 13 named coal beds in southern West Virginia, and at least 8 named coal beds in Virginia, including the Pocahontas No. 1 to No. 7 coal beds

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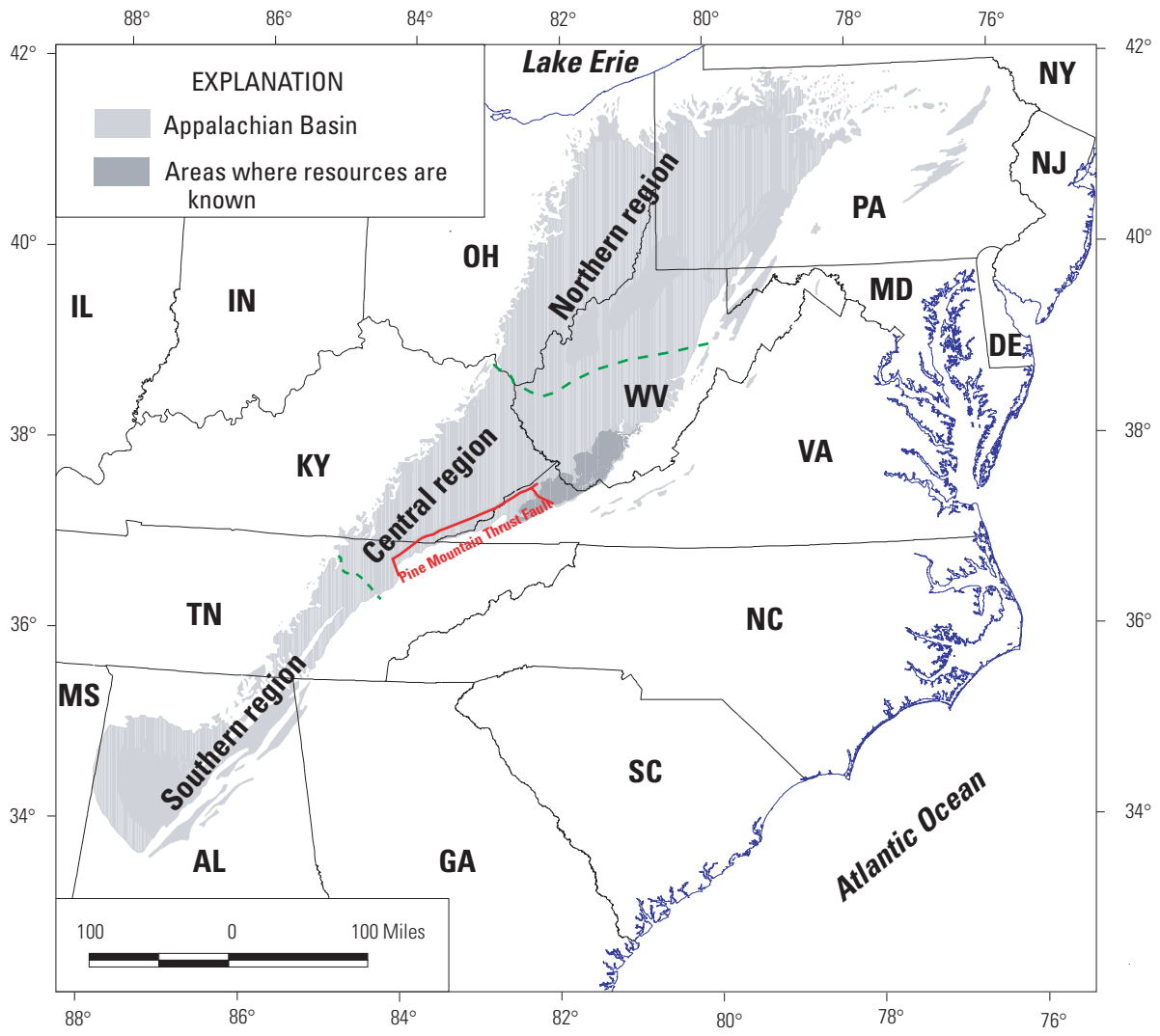

Figure 1. Map showing the location of the northern, central, and southern coal regions in the Appalachian Basin. The Pocahontas No. 3 coal bed occurs in the central coal region.

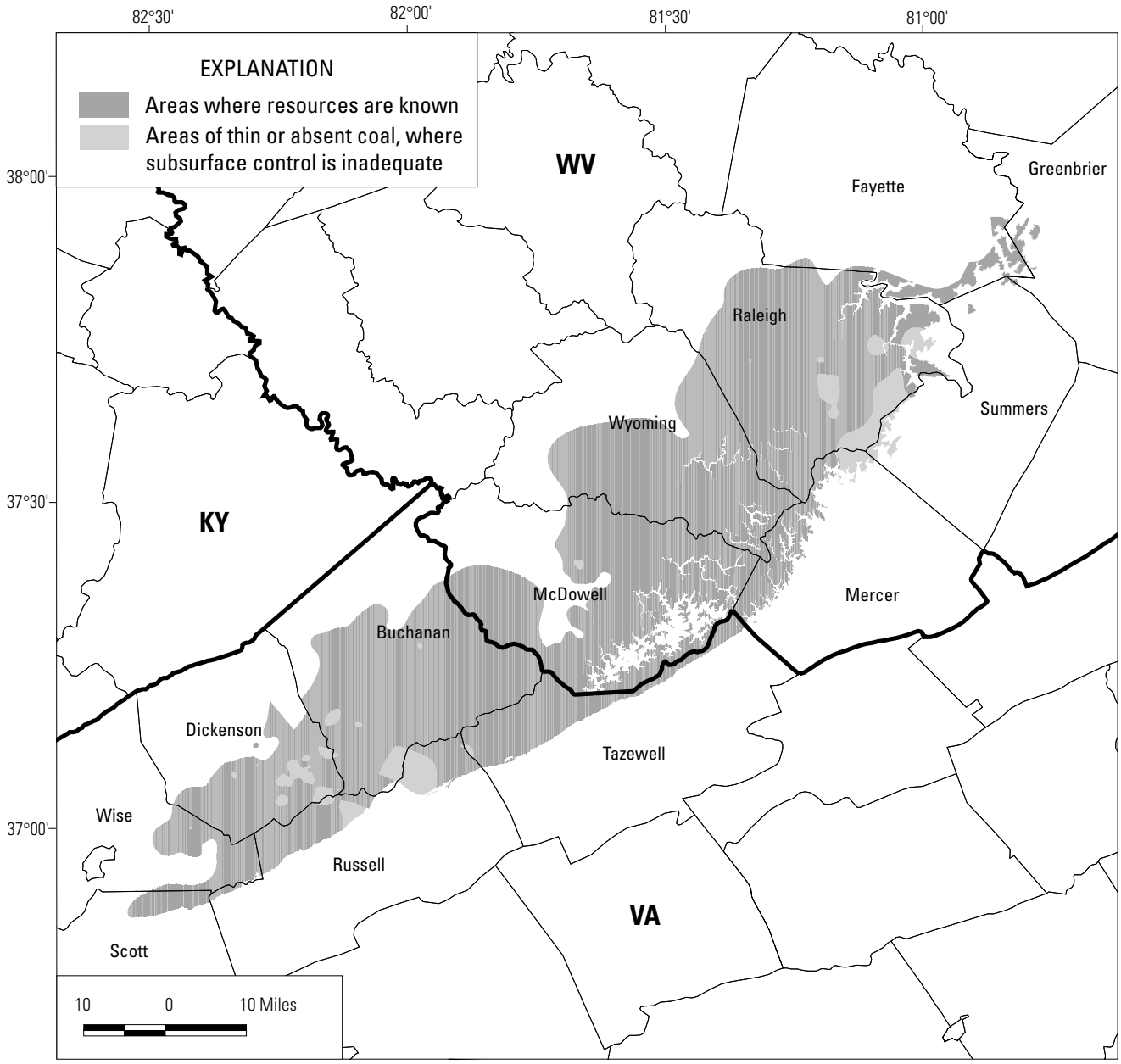

Figure 2. Map showing areal extent of the Pocahontas No. 3 coal bed, which extends through 12 counties in Virginia and West Virginia.

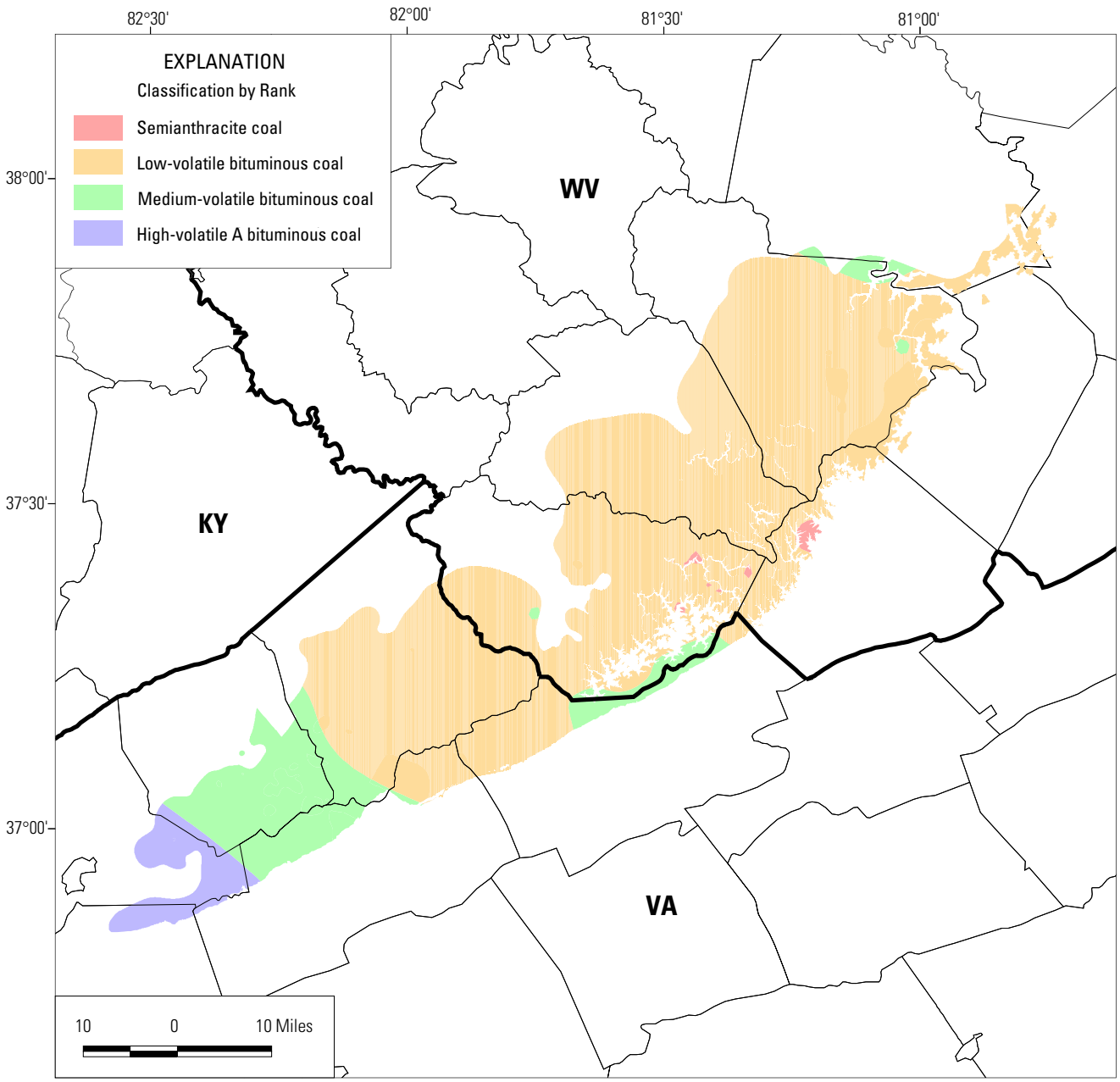

Figure 3. Map showing apparent rank of the Pocahontas No. 3 coal bed based on 125 analyses. The coal tends to increase in rank from high-volatile A bituminous in the southwest to low-volatile bituminous in the northeast with small bulls-eye-shaped pods of semianthracite observed along the eastern front in McDowell and Mercer Counties, W. Va. Methodology for rank determinations is based on the percentage of fixed carbon in the sample. When dry, mineral-matter-free (dmmf) fixed carbon is >69 weight percent, rank is determined on dmmf fixed carbon; when dmmf fixed carbon is <69 weight percent, rank is determined from moist, mineral-matter-free gross calorific values (American Society for Testing and Materials, 1996). See figure 2 for county names.

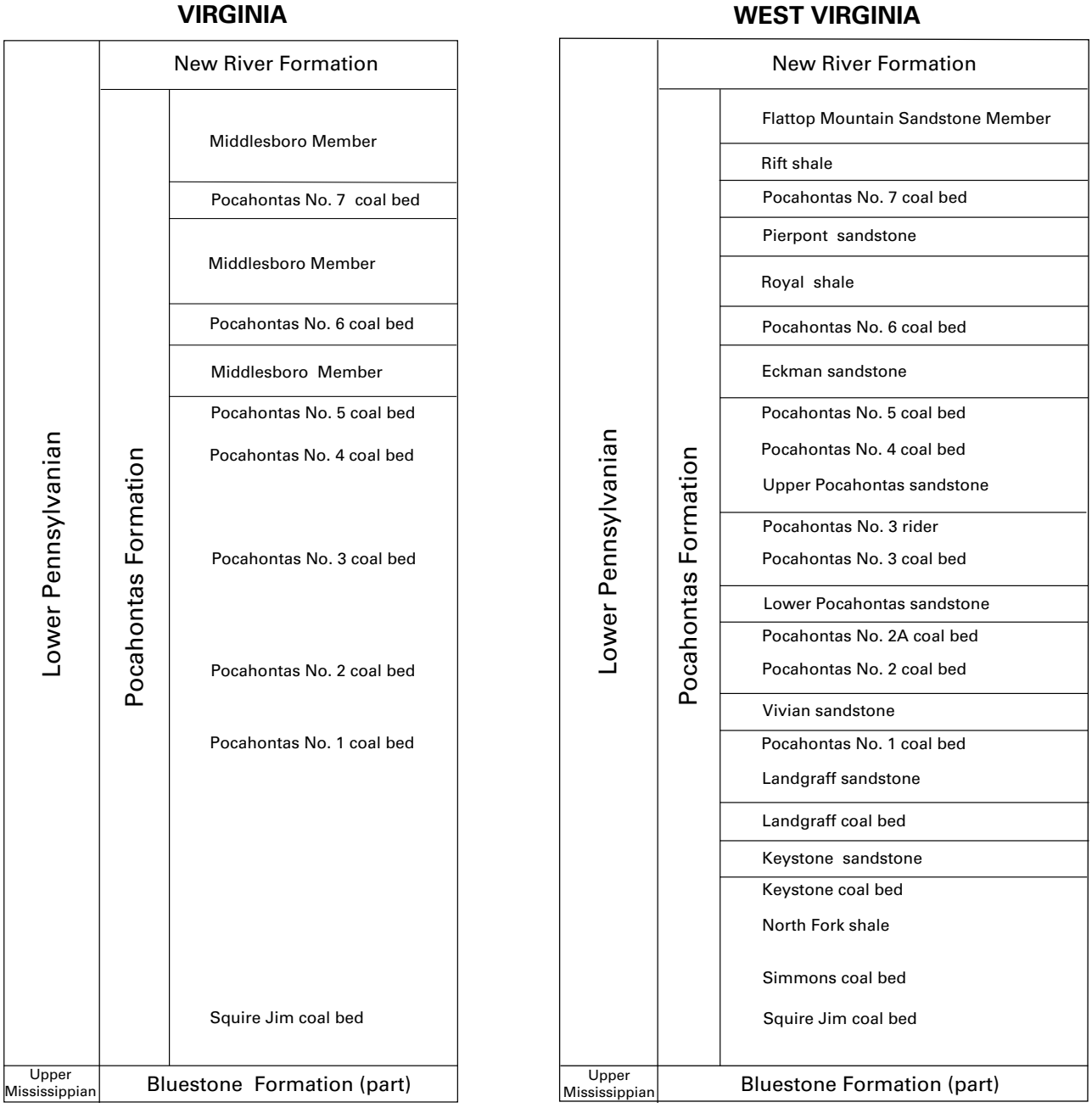

Figure 4. Chart showing stratigraphic nomenclature of the Lower Pennsylvanian Pocahontas Formation in southern West Virginia (Hennen, 1915, 1919; Krebs, 1916; Reger, 1926; Price, 1939) and southwestern Virginia (Englund, 1979; Nolde, 1994a,b).

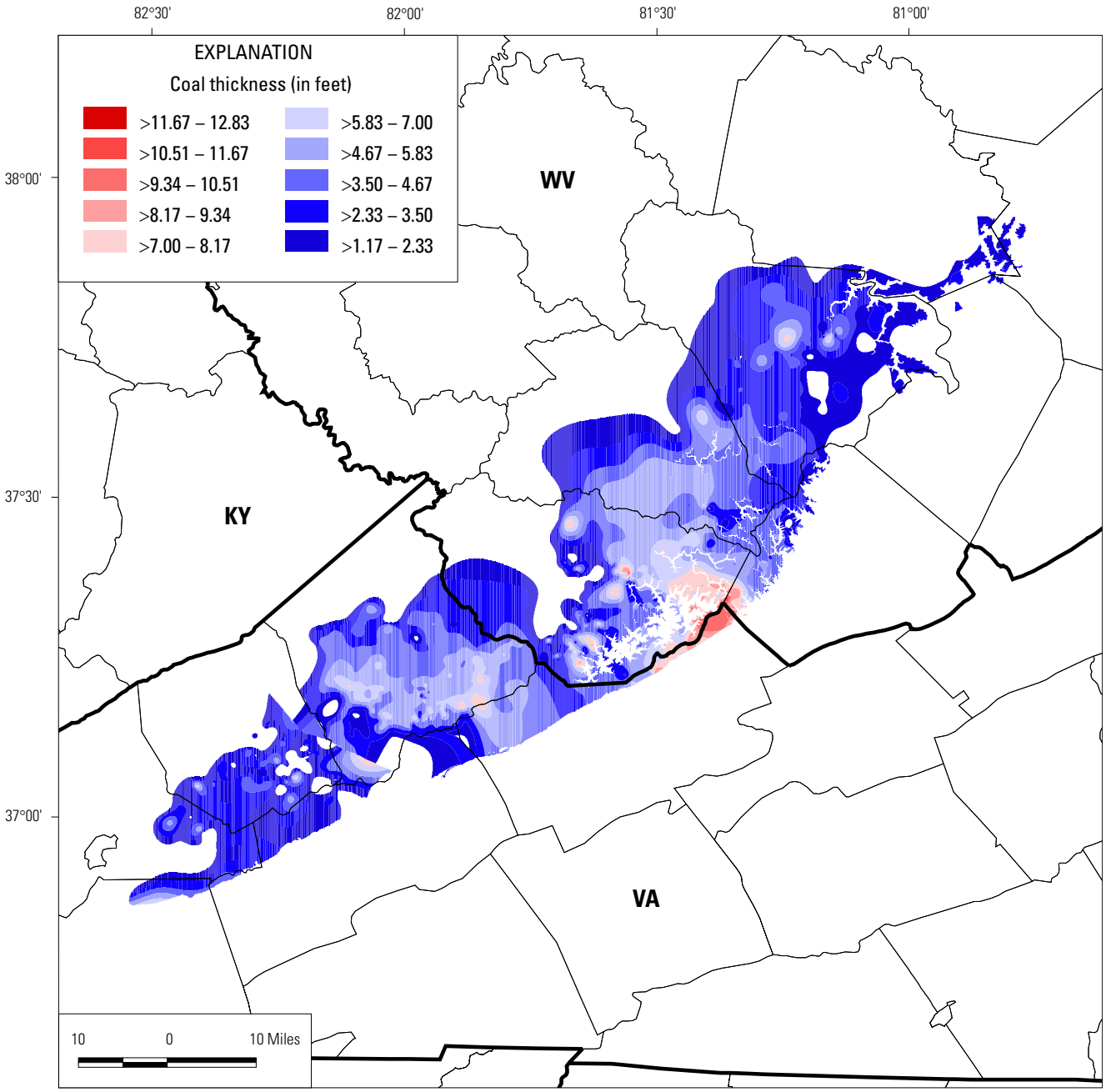

Figure 5. Map showing thickness contours, or isopach lines, of the Pocahontas No. 3 coal bed. The thickness isopachs, presented in 1.17-ft (14-in) intervals, were generated from 964 publicly available stratigraphic records. See figure 2 for county names.

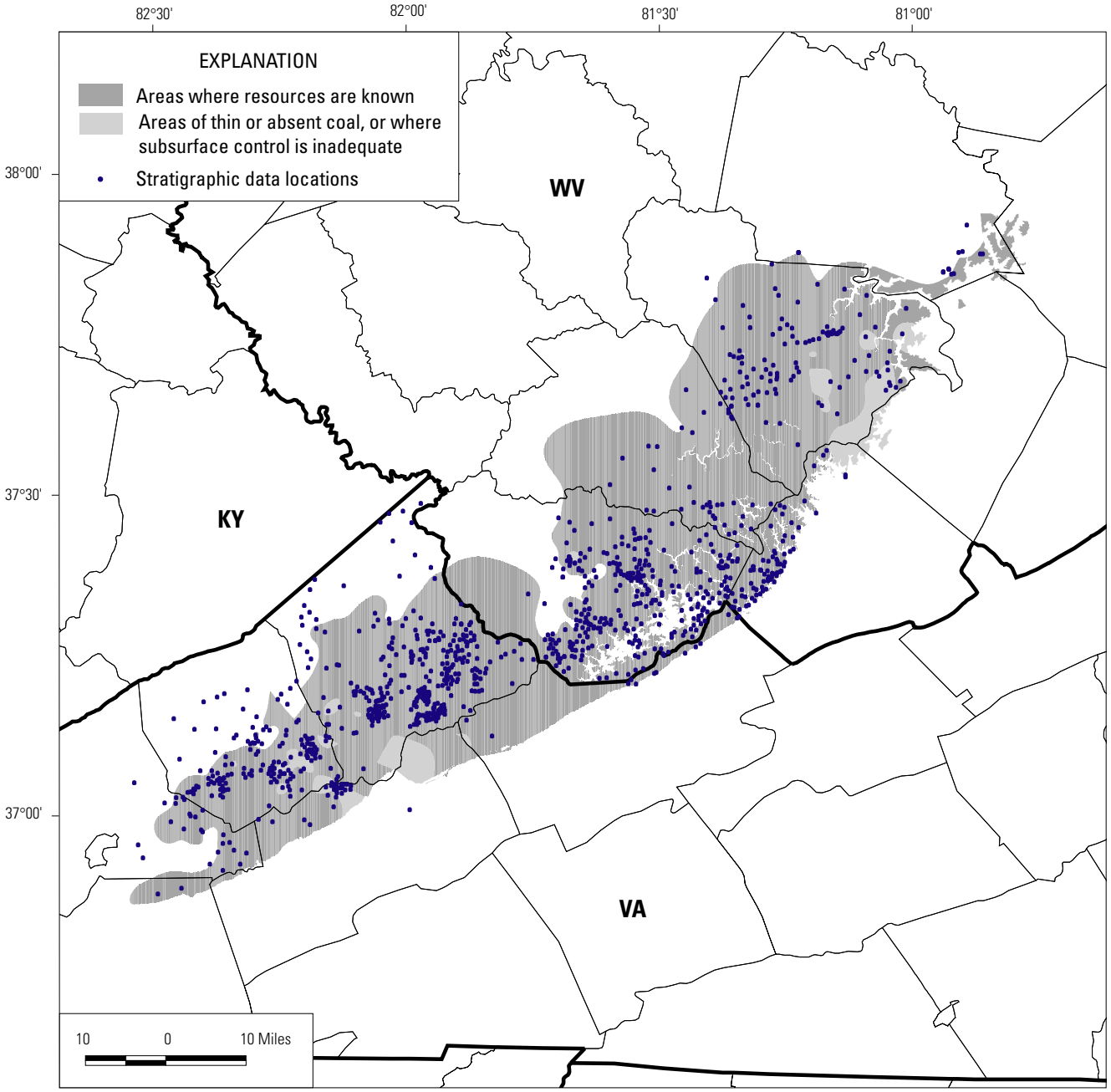

Figure 6. Map showing point locations of stratigraphic records that are publicly available and were used to model the coal resources of the Pocahontas No. 3 coal bed. Point identifier or record name, latitude, longitude, coal elevation, and coal thickness for all records can be downloaded from Appendix 1 in ASCII format. See figure 2 for county names.

Table 1. Original and remaining resources by State and county for the Pocahontas No. 3 coal bed, rounded to millions of short tons.

State/County	Original	Remaining	State/County	Original	Remaining
VIRGINIA			**WEST VIRGINIA**		
Buchanan	1,600	1,300	Fayette	65	65
Dickenson	380	380	Greenbrier	9.6	9.6
Russell	180	180	McDowell	1,700	770
Scott	76	76	Mercer	250	26
Tazewell	540	380	Raleigh	1,200	1,000
Wise	150	150	Summers	6.6	6.6
			Wyoming	1,100	740
Virginia Total	2,900	2,500			
			West Virginia Total	4,300	2,600
			Grand Total	7,200	5,100

(fig. 4). Of these, the Pocahontas No. 3 is the most persistent and thickest coal bed in the basin and contains the greatest amount of high-quality coking coal. Figure 5 shows the thickness of the Pocahontas No. 3 coal bed.

This report is a cooperative effort among the West Virginia Geological and Economic Survey (WVGES), the Virginia Division of Mineral Resources (VDMR), and the U.S. Geological Survey (USGS). In general, stratigraphic, structural, and coal-bed thickness data were obtained from the State geological surveys and from the USGS's National Coal Resources Data System (NCRDS). Locations of structural and coal-thickness data points are shown in figure 6.

ACKNOWLEDGMENTS

The writers are indebted to Susan J. Tewalt and Peter D. Warwick for assistance with software; to Ryan Denning (VDMR) for helping with the Virginia stratigraphic database; to David T. Butler for producing graphic files and for helping prepare the geochemical maps; to David Glick (The Pennsylvania State University) and William Grady (WVGES) for additional geochemical data; and to Susan J. Tewalt, C. Blaine Cecil, B. Mitchell Blake, Jr. (WVGES), Kenneth J. Englund (USGS, retired), Jack E. Nolde (VDMR), David B. Spears (VDMR), and Roy S. Sites (VDMR) for reviewing this manuscript and assessment maps during the course of this project.

GEOLOGY

INTRODUCTION

The Pocahontas basin is within the western margin of the folded and faulted Appalachians. The basin was deformed during the Alleghanian (post-Permian) orogenic phase of Appalachian mountain building. In Virginia, the Pocahontas No. 3 coal bed is adjacent to and on the Pine Mountain block (fig. 1) and arches over the nose of the Powell Valley anticline (fig. 7). The Pine Mountain block is a superficial structure that overlies a décollement in the Devonian and Silurian strata below (see Harris and Milici, 1977, for a summary). In nearby West Virginia, the coal bed is folded into several low-amplitude, but conspicuous, anticlines and synclines. The largest of these folds, the Dry Fork anticline (fig. 7), brings the coal bed to the surface in the southeastern part of the Pocahontas basin. All of these surficial structures are related to the latest Paleozoic deformation of the mountain chain, which in many places resulted in tangential shortening of the uppermost strata above a décollement in the shale or salt formations (Rodgers, 1949; Young, 1957; Milici, 1980).

The stratigraphy of the Pocahontas basin and surrounding area has been described in detail in several WVGES county reports (Hennen, 1915, 1919; Krebs, 1916; Reger,

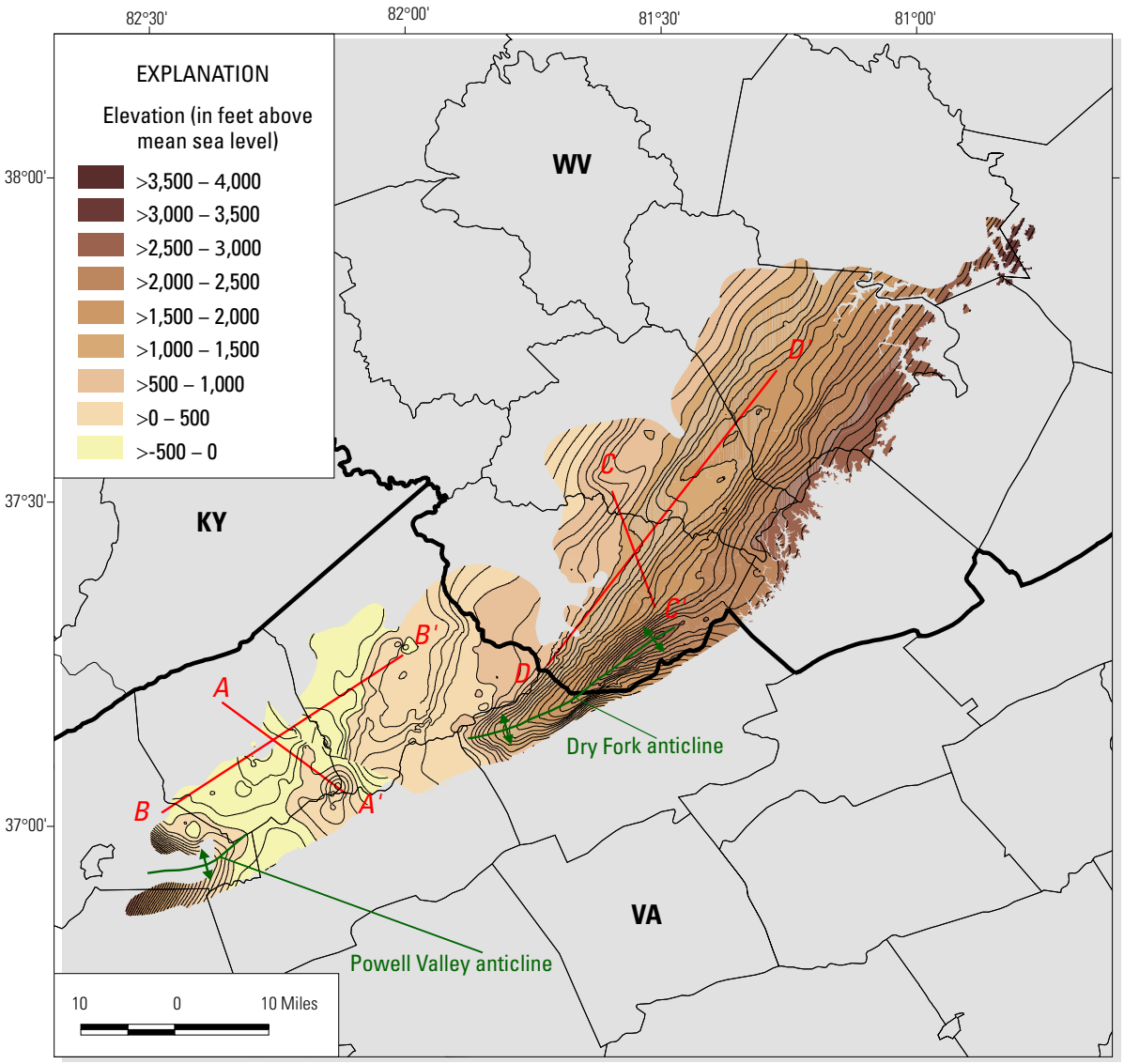

Figure 7. Structure-contour map of the Pocahontas No. 3 coal bed. The contours are presented on the top of the coal bed at 100-ft intervals, color coded to 500-ft intervals for visual acuity. Approximately 716 publicly available elevations were used to generate the map. The Dry Fork and Powell Valley anticlines, and cross sections *A-A´*, *B-B´*, *C-C´*, and *D-D´* (figs. 10–13) are shown. See figure 2 for county names.

1926; Price, 1939), Virginia Geological Survey county reports (Hinds, 1918; Harnsberger, 1919; Giles, 1921; Wentworth, 1922; and Eby, 1923), USGS Open-File Reports (Englund, 1972a,b,c,d), and summarized by Miller (1974), Arkle and others (1979), Englund (1979), and Nolde (1994a). In general, Englund, Gillespie, and others (1986) and Englund, Windolph, and others (1986) determined that the Pocahontas Formation was deposited as a series of northwestward-prograding delta lobes that were fringed seaward (westward) by quartz arenite bars or barriers. Cecil and others (1985) suggested that the thickness variations and low impurity content in the Pocahontas No. 3 coal bed indicate that it may have formed from ombrogenous, domed peat deposits along coastal lowlands.

STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS

The Pocahontas Formation consists mostly of sandstone with lesser amounts of siltstone, shale, and coal (figs. 8, 9). In Virginia, the Pocahontas Formation is in a complex facies configuration (fig. 9), both laterally and vertically, with the Lee and New River Formations. To the south and west, the Pocahontas Formation extends stratigraphically from the top of the Bluestone Formation (Mississippian) to the base of the Lee Formation or, where present, to the base of the Pocahontas No. 8 coal bed of the New River Formation (Englund, 1979; Nolde, 1994b; fig. 4). In West Virginia, the

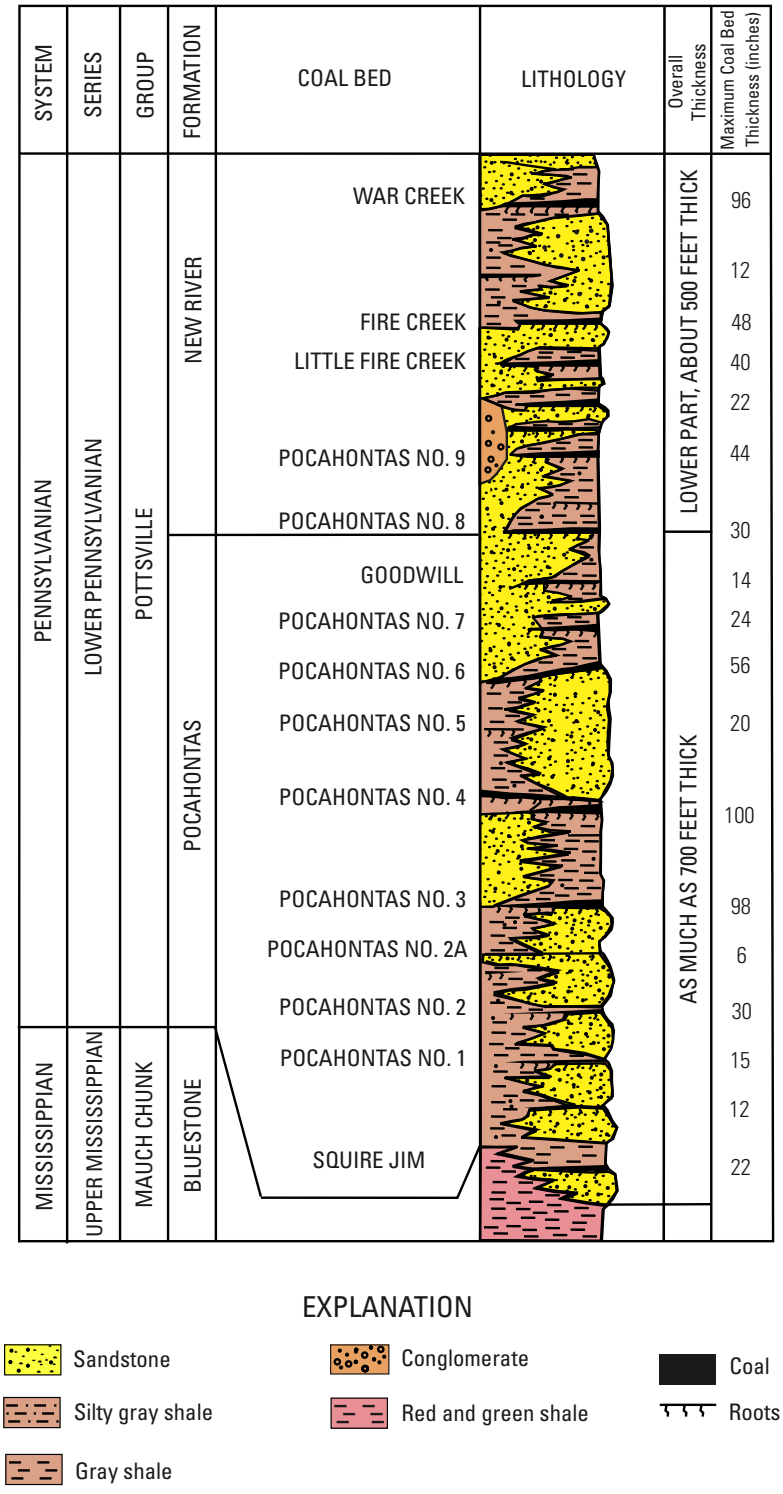

Figure 8. Generalized stratigraphic column of the uppermost Bluestone Formation, Pocahontas Formation, and the lower part of the New River Formation, McDowell County, W. Va. (adapted from Englund, 1969a). Coal-bed thicknesses shown where known.

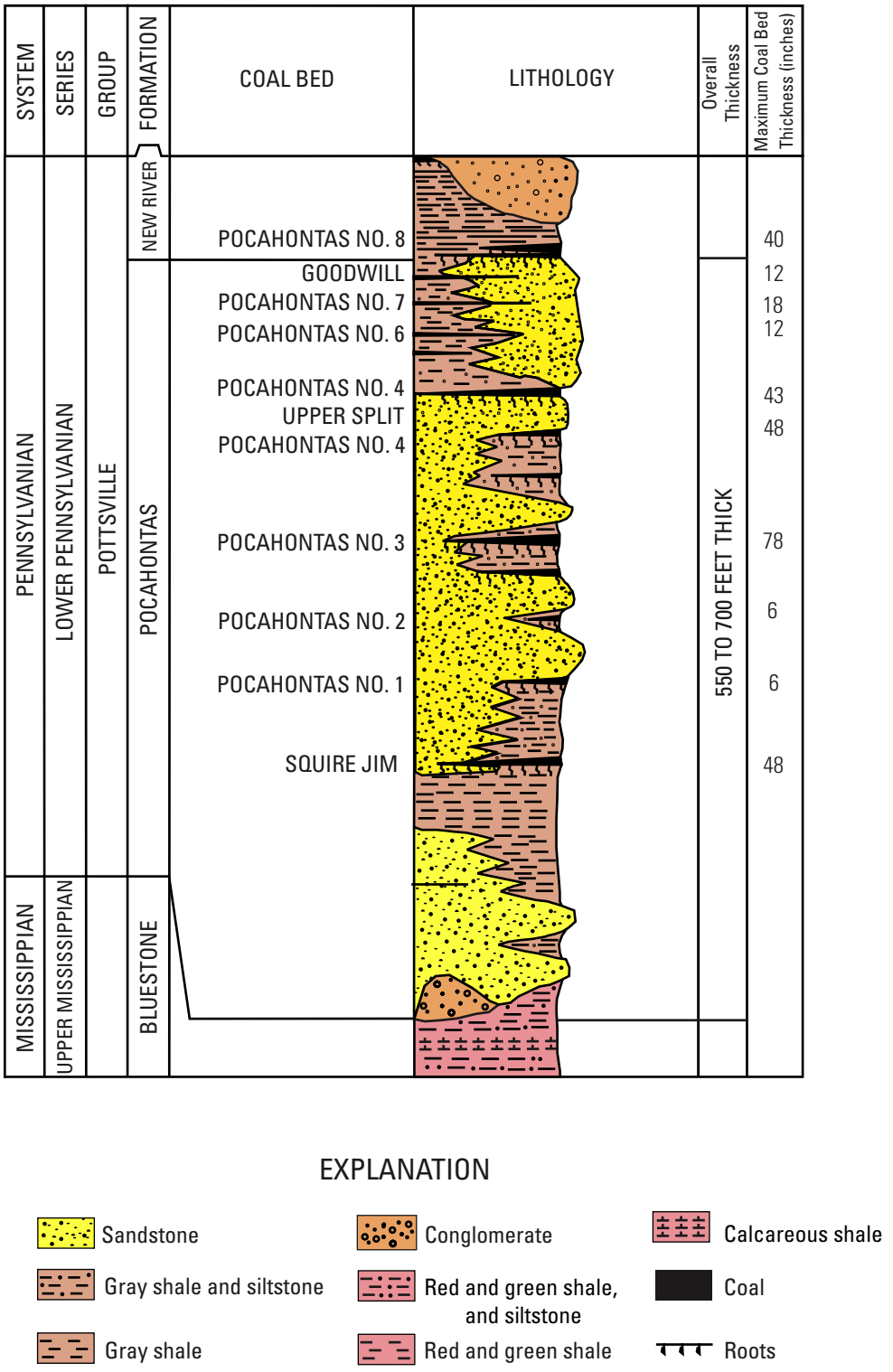

Figure 9. Generalized stratigraphic column of the uppermost Bluestone Formation, Pocahontas Formation, and the lower part of the New River Formation in Buchanan and Tazewell Counties, Va. (adapted from Englund, 1981). Coal-bed thicknesses shown where known.

Pocahontas Formation (fig. 8) extends from the top of the Mississippian Bluestone Formation (Mauch Chunk Group) to the base of the New River Formation (Pineville Sandstone Member) or, where present, the base of the Pocahontas No. 8 coal bed of the New River Formation (Englund and Thomas, 1990).

Campbell (1896) named the Pocahontas Formation for the town of Pocahontas in Tazewell County, Va., where the formation is about 700 ft thick. In adjacent southern West Virginia, the formation achieves a maximum thickness of about 750 ft (Arkle and others, 1979) and in Buchanan County, Va., the formation may be as much as 900 ft thick (Englund and Thomas, 1990; Nolde, 1994a). The Pocahontas Formation thins to the southeast along structural strike in Virginia, to a point where its lower beds intertongue and grade into the upper beds of the Bluestone Formation (Miller, 1974; Englund, 1979).

Across strike, the contact of the Pocahontas with the overlying New River and Lee Formations ranges from conformable on the southeast to unconformable on the northwest. On the eastern boundary, the Pocahontas Formation extends to the Allegheny structural front, where it is either folded to vertical, overturned to the northwest, or is partially covered by the westernmost thrust sheet of the Appalachian Valley and Ridge Province (Miller and Meissner, 1977). There, the base of the New River Formation is conformably located at the base of the Pocahontas No. 8 coal bed (Englund and Thomas, 1990). On the west, the Pocahontas Formation is truncated by a major erosional unconformity. The unconformity that occurs within the lower part of the New River Formation near the eastern edge of the Appalachian Plateaus changes into a major systemic unconformity between the Mississippian and Pennsylvanian strata as it descends stratigraphically to the west (Englund, 1969e; Englund and Thomas, 1990; Thomas and Englund, 1999). This erosional unconformity cuts down progressively across the entire Pocahontas Formation and the contained coal beds to where it erodes into the underlying Bluestone Formation in the central and western parts of the Appalachian Basin. Above the unconformity, basal quartz arenites and quartz-pebble conglomerates of the Pennsylvanian Lee and New River Formations, interpreted to represent beach-barrier and offshore-bar deposits by Englund and Thomas (1990), progressively onlap this surface to the northwest and reflect a major time-transgressive episode of relative sea-level rise. The unconformity is well illustrated on the western sides of cross sections *A–A´* and *B–B´* (figs. 10 and 11) at the base of the Middlesboro "A" quartz-arenite tongue. In West Virginia, this unconformity is at the base of the Pineville Sandstone Member of the New River Formation (cross sections *C–C´* and *D–D´*, figs. 12 and 13). In each of the sections (figs. 10–13) the Pocahontas No. 3 coal bed is used as a datum. Overlying coal beds were correlated primarily by their position in stratigraphic sequence using StratiFact[2] (a commercial software package).

The apparent rank (see American Society for Testing and Materials, 1996) classification map of the Pocahontas No. 3 coal bed illustrates a regular variation from high-volatile A bituminous rank in Wise County, Va., to semianthracite in a few locations to the northeast, in McDowell and Mercer Counties, W. Va. (figs. 2, 3). This range in rank mimics changes in thermal maturation observable in conodonts and coal in the Valley and Ridge province of southwestern Virginia (Campbell, 1925; Epstein and others, 1976). For example, in the southwesternmost part of the Valley and Ridge province of Virginia, relatively low thermal maturation is illustrated by the occurrence of oil in the Rose Hill and Ben Hur fields in Lee County. In contrast, the rank of Mississippian coal in the Valley coal fields of Montgomery County, Va., and in adjacent areas is as high as semianthracite (Campbell, 1925).

ASSESSMENT METHODOLOGY

PREVIOUS RESOURCE STUDIES

Brown and others (1952) estimated remaining measured, indicated, and inferred coal resources of the Pocahontas No. 3 coal bed in Virginia as 198.3 million short tons, as of January 1, 1951. The Energy Information Administration (1981) added 600 million short tons of coal to Virginia's calculated reserve base to account for additional resources of the Pocahontas No. 3 coal bed that were identified by deep drilling and mining in Buchanan County since the work of Brown and others (1952). Englund and Thomas (1980) estimated the original resources for the Pocahontas No. 3 coal bed in Tazewell County to be about 369 million short tons.

In the early part of this century, the U.S. Bureau of Mines (Dowd and others, 1952) and the WVGES, in a series of county reports (Hennen, 1915, 1919; Krebs, 1916; Reger, 1926; Price, 1939), identified an original resource of about 2.9 billion short tons of Pocahontas No. 3 coal. With the result of additional drilling and mining, Rehbein and others (1981) identified about 3 billion short tons of coal resources in the Pocahontas No. 3 coal bed. All of the data on which these studies were based, however, cannot be documented and reproduced readily from any accessible database.

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[2]StratiFact is a product of GRG Corporation, StratiFact Software, 5 Harlan Street, Wheat Ridge, CO 80033.

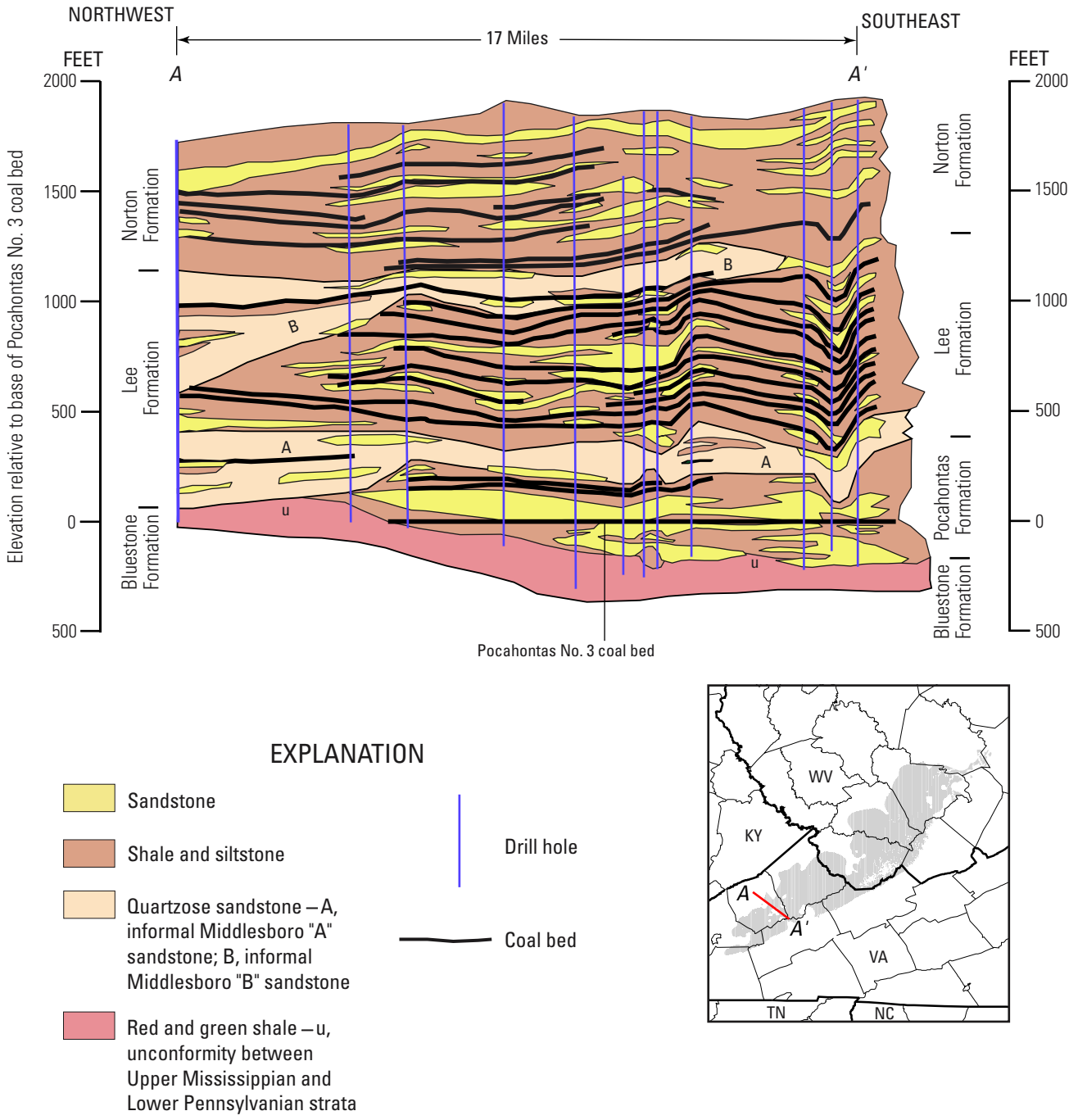

Figure 10. Cross section *A-A′* (fig. 7) trending northwest to southeast (cross strike) showing the unconformity (u) between the Upper Mississippian and Lower Pennsylvanian strata in southwestern Virginia. See figure 2 for county names. Vertical exaggeration X30.

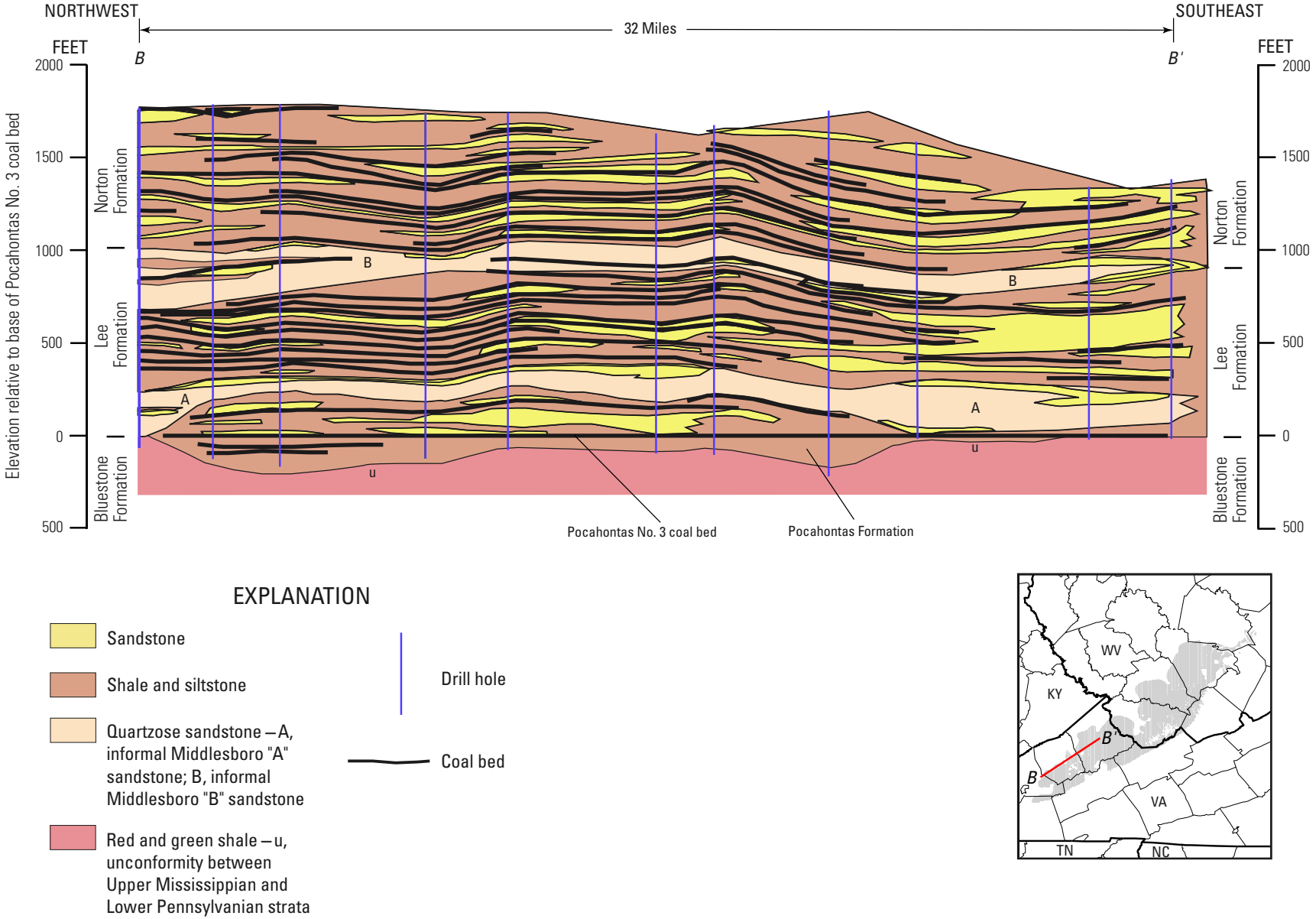

Figure 11. Cross section *B-B′* (fig. 7) trending southwest to northeast (along strike) showing the unconformity between the Upper Mississippian and Lower Pennsylvanian strata in southwestern Virginia. See figure 2 for county names. Vertical exaggeration X30.

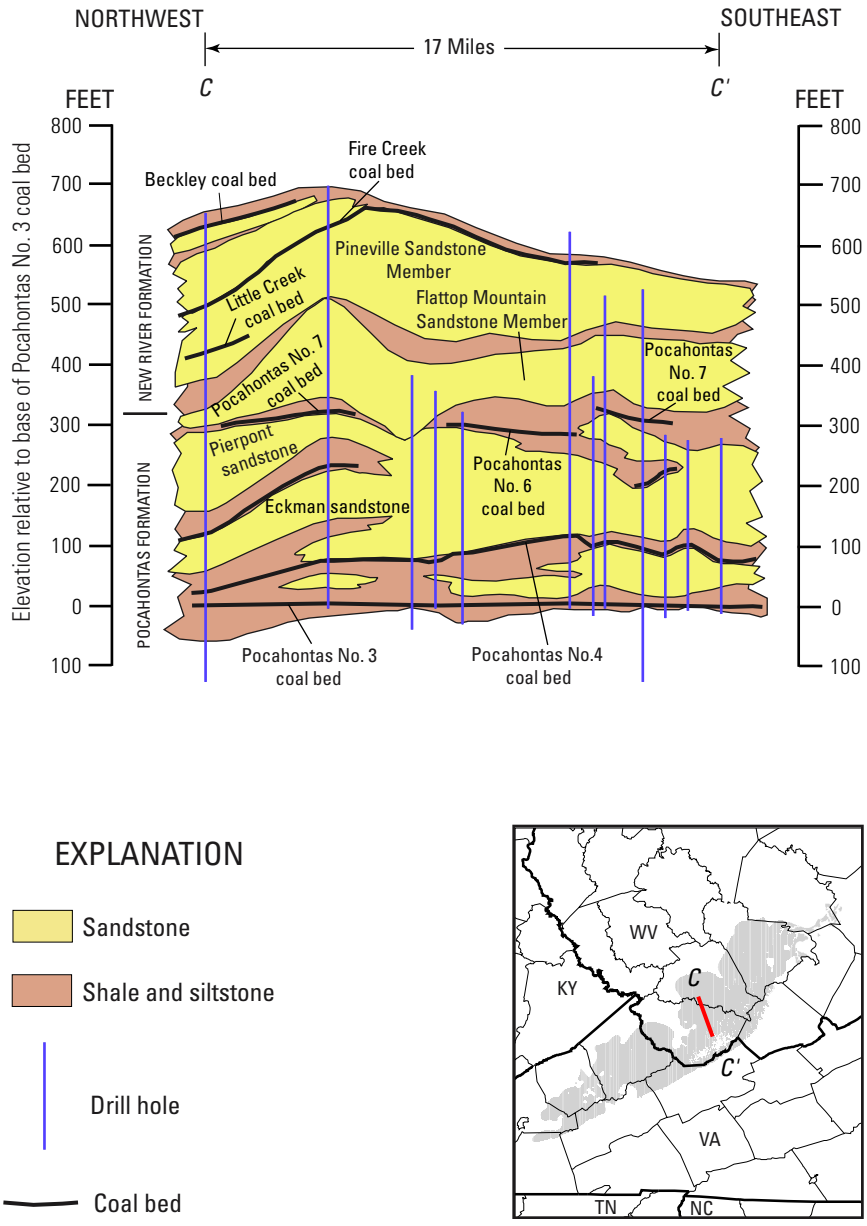

Figure 12. Cross section *C-C′* (fig. 7) trending northwest to southeast (cross strike) showing the unconformity at the base of the Pineville Sandstone Member of the New River Formation in West Virginia. The Eckman and Pierpont sandstones are informally named units. See figure 2 for county names. Vertical exaggeration X30.

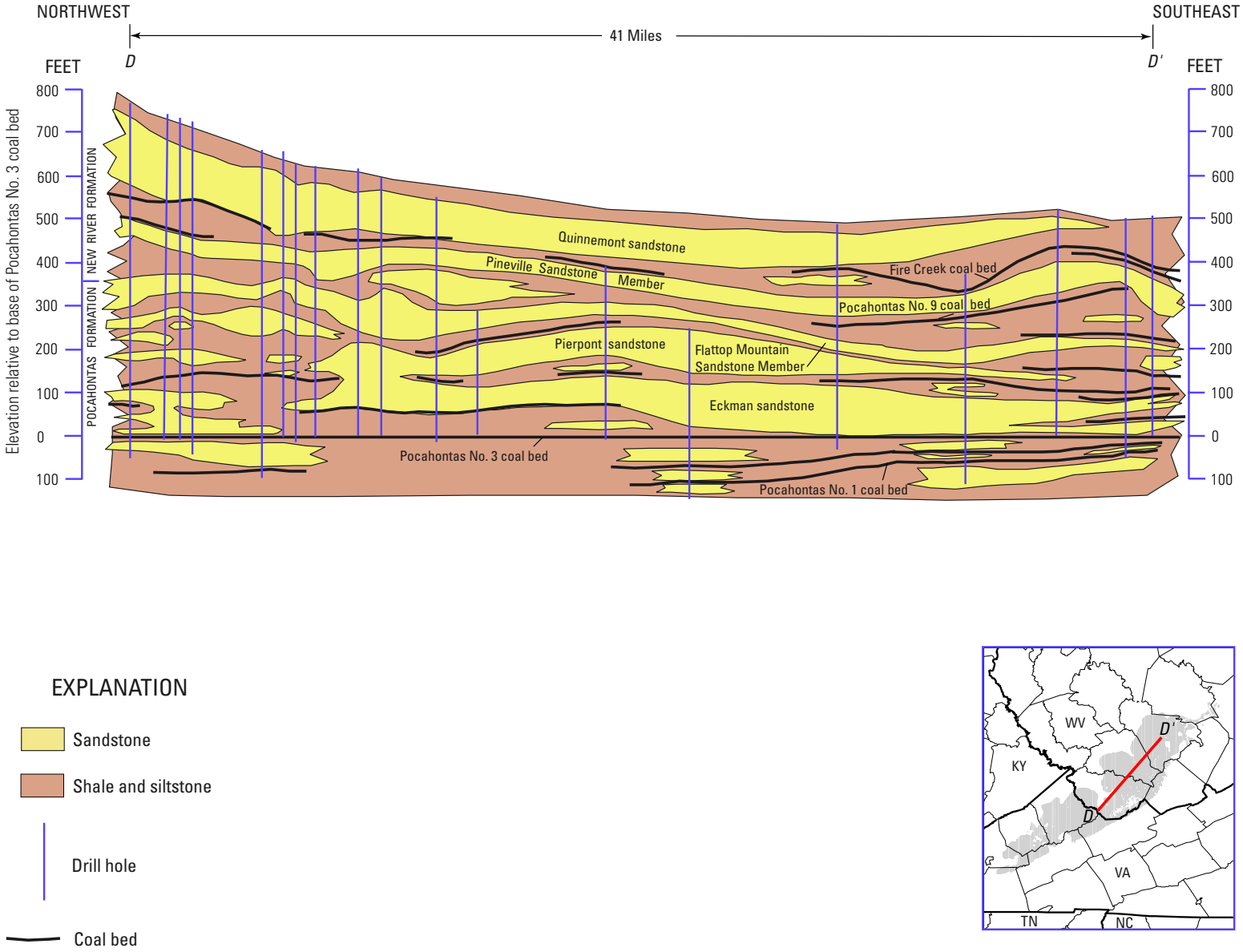

Figure 13. Cross section *D-D´* (fig. 7) trending southwest to northeast (along strike) showing stratigraphic relation of the Pineville Sandstone Member to other units, and the extent of the Pocahontas No. 3 coal bed. The Eckman, Pierpont, and Quinnemont sandstones are informal units. See figure 2 for county names. Vertical exaggeration X30.

Table 2. Estimates of original coal resources for the Pocahontas No. 3 coal bed in southern West Virginia by the West Virginia Geological and Economic Survey.

COUNTY	COAL RESOURCES (Millions of short tons)	
	County Reports and year of estimate by Hennen (1915, 1909), Krebs (1916), Reger (1926), and Price (1939)	Revisions by Rehbein and others (1981)
Fayette	77.9 (1919)	nd
Greenbrier	46.6 (1939)	nd
McDowell	1,079.5 (1915)	1,293
Mercer	307.8 (1926)	233
Raleigh	662.9 (1916)	486
Summers	16.7 (1926)	nd
Wyoming	671.3 (1915)	1,050
TOTAL	2,900	3,100

VIRGINIA

The Pocahontas No. 3 coal bed is in parts of Tazewell, Buchanan, Dickenson, Russell, Scott, and Wise Counties, Va. (fig. 2). At present, this coal is mined economically only in Tazewell and Buchanan Counties, where it is thickest. The area underlain by potentially minable Pocahontas No. 3 coal in Tazewell and Buchanan Counties is approximately 100 mi^2 and 200 mi^2, respectively. In 1951, Brown and others (1952) estimated that the remaining measured, indicated, and inferred coal resources (called "reserves" at that time) of the Pocahontas No. 3 coal bed in Virginia totaled about 198 million short tons. Of this amount, they reported that 114 million short tons remained in Buchanan County, but at depths of 1,000 to 2,000 ft, and that 84 million short tons remained in adjacent Tazewell County at depths of 1,000 ft or less. Up to that time, almost all of the mining in the Pocahontas No. 3 coal bed had occurred adjacent to areas where it is exposed in northeastern Tazewell County.

More recently, Englund and Thomas (1980) estimated that under 1,000 ft or less of overburden, 70 million short tons of Pocahontas No. 3 coal in Tazewell County remained as a resource out of an original resource of 225 million short tons. They estimated the total original resource in Tazewell County (both shallow and deep) for the Pocahontas No. 3 coal bed as 369 million short tons. Of that amount, they estimated 143 million short tons at depths greater than 1,000 ft. To account for the additional resources of the Pocahontas No. 3 coal bed that were identified by deep drilling and mining in Buchanan County since the work of Brown and others (1952), the Energy Information Administration (1981) added 600 million short tons of coal to Virginia's estimated reserve base. Original resources for the Pocahontas No. 3 coal bed in Virginia may be calculated, crudely, as about 1,082 million (or 1.1 billion) short tons (Buchanan County: 114 + 600 = 714; Tazewell County: 225 + 143 = 368). Approximately 140 million short tons of Pocahontas No. 3 coal were mined in Virginia from 1951 to 1997 (Elizabeth V.M. Campbell, VDMR, written commun., 1997). Accordingly, based on this older information, as of January 1, 1997, the remaining resource of Pocahontas No. 3 coal bed in Virginia is primarily in Tazewell and Buchanan Counties and is approximately 661 million short tons. ([Buchanan, 114 + 600 = 714] + [Tazewell shallow, 84 + Tazewell deep, 143 = 227] = 941 million short tons, minus 280 million short tons cumulative production since 1951 [140 x 2], if loss in mining was about 50 percent.)

WEST VIRGINIA

In the early 1900's, the WVGES identified an original resource of almost 2.9 billion short tons for the Pocahontas No. 3 coal bed in parts of seven counties in southern West Virginia (fig. 2, table 2). Most of the resources are in Wyoming, Raleigh, McDowell, and Mercer Counties, in an area of about 650 mi^2. This estimate is of the amount of coal in the ground that existed prior to the beginning of mining; that is, the original coal resources. However, as the result of additional drilling, data from mining, and a slightly different methodology, Rehbein and others (1981) identified more total resources in the Pocahontas No. 3 coal bed from the four major counties than was reported in previous publications for the seven counties, with a very significant increase for Wyoming County (fig. 2, table 2).

Dowd and others (1952) and Wallace and others (1952, 1953, 1954) estimated the remaining recoverable coal reserves for the Pocahontas No. 3 coal bed in the four major

counties, Raleigh, McDowell, Wyoming, and Mercer Counties, W. Va., as of 1949 to 1953 (see U.S. Bureau of Mines (USBM) column on table 3), as about 1 billion short tons. Englund (1969a,b,c,d) used these USBM reserve estimates in his summary descriptions of the stratigraphy and sulfur content of the low-sulfur coal beds in these counties.

Rehbein and others (1981) reported a remaining resource of approximately 1.2 billion short tons for the Pocahontas No. 3 coal bed (table 3) in Raleigh, Wyoming, and McDowell Counties out of an estimated original resource for those counties in excess of 2.8 billion short tons. These three counties contained almost all of the remaining unmined resources of Pocahontas No. 3 coal. At the time of the report by Rehbein and others (1981), no undisturbed areas remained in Mercer County. Rehbein and others (1981) reported that 850 million short tons or more of coal had been extracted from the seven-county area (and an equivalent amount lost in mining) since 1883, when the first official production records were kept.

COAL AVAILABILITY AND RECOVERABILITY STUDIES

During the past decade, the USGS and USBM, together with thirteen State geological surveys, have collaborated on numerous selected 7.5-minute quadrangle studies in the major coal basins nationwide in order to make detailed estimates of the relative amount of coal that is available for mining and the relative amount of coal that is potentially economically recoverable in these quadrangles. The purposes of these studies are to develop economic models that can be applied regionally and nationally, and to refine estimates of that part of the national coal endowment that is potentially economically recoverable.

Coal availability studies for selected 7.5-minute quadrangles in the Appalachian Basin coal region, designed and funded by the USGS, were conducted in cooperation with State geological surveys to determine in detail the current restrictions to mining and the availability of remaining resources in these quadrangle areas. In the Pocahontas basin, available coal resource studies were made for all coal beds of potentially minable thickness in the Beckley 7.5-minute quadrangle in Raleigh County, W. Va. (Loud, 1988); the War 7.5-minute quadrangle in McDowell County, W. Va. (Loud and others, 1990); the Crumpler 7.5-minute quadrangle in McDowell, Mercer, and Wyoming Counties, W. Va. (Loud, 1999); and the Vansant 7.5-minute quadrangle in Buchanan County, Va. (Elizabeth V.M. Campbell and Roy S. Sites, VDMR, unpub. data, 1988; table 4).

Restrictions (factors that make a coal resource unavailable) are of two general types: land-use or surface-mining restrictions, and technological or underground-mining restrictions. Land-use restrictions commonly apply to surface mines, and to underground mines where subsidence is a problem, and include proximity to existing oil and gas wells, cemeteries, streams and lakes, towns and communities, highways, railroads, communication towers, pipelines and power lines, and pre-emptive land-use designations such as Federally owned and managed lands. Technological restrictions include mine buffers, interburden thickness between coal beds, geological restrictions such as poor mine roof or floor, channels, coal that is too thin to mine effectively with existing equipment, and coal that is too deep to mine. (See Chapter J, this report.)

Follow-up coal recoverability studies of several of these quadrangles were conducted by the former USBM (and are now being conducted by the USGS) to determine the amount of coal potentially economically recoverable, that is, the potential coal reserve, over a range of delivered price assumptions. Coal recoverability studies (for example, Rohrbacher and others, 1994; see Chapter J, this report) were designed by the former USBM to estimate the economically recoverable reserves for the 7.5-minute quadrangles previously studied for coal availability studies. The USBM subtracted potential future mining and washing losses from available coal tonnage to determine technically recoverable coal resources by bed for each quadrangle studied. The calculated recoverable resources were further restricted by mine operating costs in order to determine the amount of economically recoverable coal (coal reserves) at several assumed market prices.

Calculations of recoverability for the Pocahontas No. 3 coal bed in the Beckley and Vansant quadrangles indicate that, depending on the amount of previous mining, about half of the original coal resource may remain as a technically recoverable resource. “Original resources,” as used by Rohrbacher and others (1994), contain a large amount of non-coal rock and are designated herein as “original coal bed tonnage.” The current recoverability studies (table 4) reflect the degree of mining of the Pocahontas No. 3 coal bed in the individual quadrangles studied. The Beckley quadrangle, which has had limited mining of the Pocahontas No. 3 coal bed, contains the largest percentage of recoverable original resource. The Crumpler 7.5-minute quadrangle, where the Pocahontas No. 3 coal bed is almost entirely mined out, contains only a few million recoverable tons of Pocahontas No. 3 coal.

Based on previous studies, original resources for the Pocahontas No. 3 coal bed in Virginia and West Virginia are estimated at about 4.2 billion short tons: 1.1 billion short tons for Virginia (see calculation under Virginia section in Previous Resource Studies), and 3.1 billion short tons for West Virginia (table 2). Remaining resources for Virginia are about 661.4 million short tons and remaining resources in West Virginia, reduced by estimated production from the estimate of Rehbein and others (1981), are about 1.1 billion short tons. Restrictions on resources and from mining and washing losses range from about 32 percent in the Vansant quadrangle to 69 percent in the Beckley quadrangle, and

Table 3. Estimated remaining resources of the Pocahontas No. 3 coal bed in southern West Virginia, by county, as of 1949 to 1951, and revised in 1981.

COUNTY	REMAINING COAL RESOURCES (Millions of short tons)	
	U.S. Bureau of Mines and year of estimate (Dowd and others, 1952; Wallace and others, 1952, 1953, 1954)	Revisions by Rehbein and others (1981)
Raleigh	181 (1949)	336
Mercer	26.1 (1953)	Insignificant
Wyoming	456.4 (1951)	574
McDowell	351 (1951)	336
TOTAL	1,000	1,200

Table 4. Original and available resources and recoverable resources calculated for the Pocahontas No. 3 coal bed in the Beckley, Crumpler, War, and Vansant quadrangles.

[Abbreviations are as follows: nd, no data available.]

QUADRANGLE	ORIGINAL COAL RESOURCES (Millions of short tons)	REMAINING AVAILABLE RESOURCES (Millions of short tons)	TECHNICALLY RECOVERABLE RESOURCES (Millions of short tons)	ORIGINAL RESOURCE AVAILABLE (Percent)	ORIGINAL RESOURCE RECOVERABLE (Percent)
	U.S. Geological Survey and State agencies (E.V.M. Campbell and R.S. Sites, Virginia Division of Mineral Resources, unpub. data, 1988; Loud, 1988, 1999; Loud and others, 1990; Teeters, 1997)		U.S. Bureau of Mines (Rohrbacher and others,1994)		
Beckley, W.Va.	143.5	106.8	76.5	74.4	53.3
Crumpler, W.Va.	259.1	5.7	2.6	2.2	1.0
War, W.Va.	136.4	107.4	nd	78.8	nd
Vansant, Va.	289.0	178.8	120.6	61.9	41.7

average about 50 percent (Rohrbacher and others, 1994). Although only two quadrangles were studied, the restrictions and washing and mining losses for these two quadrangles average about 50 percent (see Chapter J, this report), which is the general rule of thumb for recoverability for underground mining. Based on previous studies, about 330 million short tons of Pocahontas No. 3 coal may remain as a technically recoverable resource for Virginia and about 550 million short tons for West Virginia. (Technically recoverable resource for Virginia: 661.4 million short tons × 0.50 = 331 million short tons. Technically recoverable resource for West Virginia: 1.1 billion short tons × 0.50 = 550 million short tons.)

The previous discussion was based on the data compilations, studies, interpretations of resources, and the reports prepared by the geologists cited herein over many decades of the 20th century. The basic data on which these studies were based, however, cannot be documented and reproduced readily by any accessible database. One benefit of the present assessment of the Pocahontas No. 3 coal bed is that it is supported by a digital geographic information system (GIS) that allows flexibility of output as well as easy access to the basic data supporting the assessment (Milici, 1998; Milici and others, 1998).

DATABASES

The current coal assessment project is designed to improve resource estimates for the Nation's energy resources by using digital stratigraphic and coal-quality databases to produce digital map products that are displayed by a geographic information system (GIS). Two databases, a stratigraphic database and a coal-geochemistry database, contain the data used to assess the Pocahontas No. 3 coal bed. The stratigraphic database (Appendix 1; fig. 6) includes records for approximately 1,132 measured sections, core holes, diamond drill holes, and coal-bed-thickness measurements from mines. The public stratigraphic database can be downloaded in ASCII format from Appendix 1.

The coal-geochemistry database (Appendix 2) consists of 194 public analyses for in-ground coal samples compiled from USGS, WVGES, and The Pennsylvania State University databases (see Appendix 4). Additional information on data sources, handling, averaging, and formatting are described in the metadata and references in Appendixes 2, 3 and 4. Most (193) of the sample localities are located by latitude to longitude coordinates (fig. 14). A few are considered reliable and accurate only to a county scale. Thirty-six of the samples have been analyzed for trace-elements and all the samples have been analyzed using American Society for Testing and Materials (ASTM) standards for analyses of ash yield, sulfur content, and gross calorific value (British thermal units per pound or Btu/lb). Some of the Pocahontas No. 3 coal-bed samples were collected in intervals or benches and were aggregated to obtain representative analyses of the "whole coal bed" chemistry at any one location. The geochemical database can be downloaded in ASCII format from Appendix 2.

RESULTS AND DISCUSSIONS

GEOCHEMISTRY

Most of the samples in the geochemical database are from mined areas of the Pocahontas No. 3 coal bed in West Virginia and Virginia, as well as from the northeastern outcrop of the bed in West Virginia (figs. 14, 32). Steps for processing and eliminating data can be found in the metadata file in Appendix 3.

Two sets of statistics and geochemical maps are presented for each chemical parameter because both point data (located by latitude and longitude in Map A in figs. 15–31) and data aggregated on a county basis (Map B in figs. 15–31) are contained in the geochemical database (Appendix 2). All of the analyses in the geochemical database for the Pocahontas No. 3 coal bed are nonproprietary. Statistical parameters (means, ranges, standard deviations, and number of analyses) are shown in tables 25 through 18. Ash yield, sulfur content, and sulfur-dioxide (SO_2) are classified into categories of low (>0 to ≤8 weight percent ash; >0 to ≤1 weight percent sulfur; >0 to ≤1.2 lbs SO_2 per million Btu), medium (>8 to ≤15 weight percent ash; >1 to <3 weight percent sulfur; >1.2 to ≤2.5 lbs SO_2 per million Btu), and high (>15 weight percent ash; ≥3 weight percent sulfur; >2.5 lbs SO_2 per million Btu). Ash yield and sulfur content are classified according to Wood and others (1983). Sulfur-dioxide levels are classified according to past and present clean air regulations, the most current of which are the Clean Air Act Amendments of 1990 (Public Law 101-549). Ash yield, sulfur content, and sulfur-dioxide levels are presented as both data points (Map A, figs. 15–17), and as county means (Map B, figs. 15–17). Gross calorific value, total moisture, and trace elements reported in figures 18 through 31 are classified into five data categories, or quintiles, each representing 20 percent of the data values. Because the 20-percent intervals are based on different sets of data (point data in Appendix 2 versus county means in tables 5–21), the ranges of the 20-percent intervals will be different for each data set and each chemical parameter.

Use of Pocahontas No. 3 coal as a coking coal is enhanced because it is very low in ash and sulfur, has a very high calorific value, and contains few trace-element impuri-

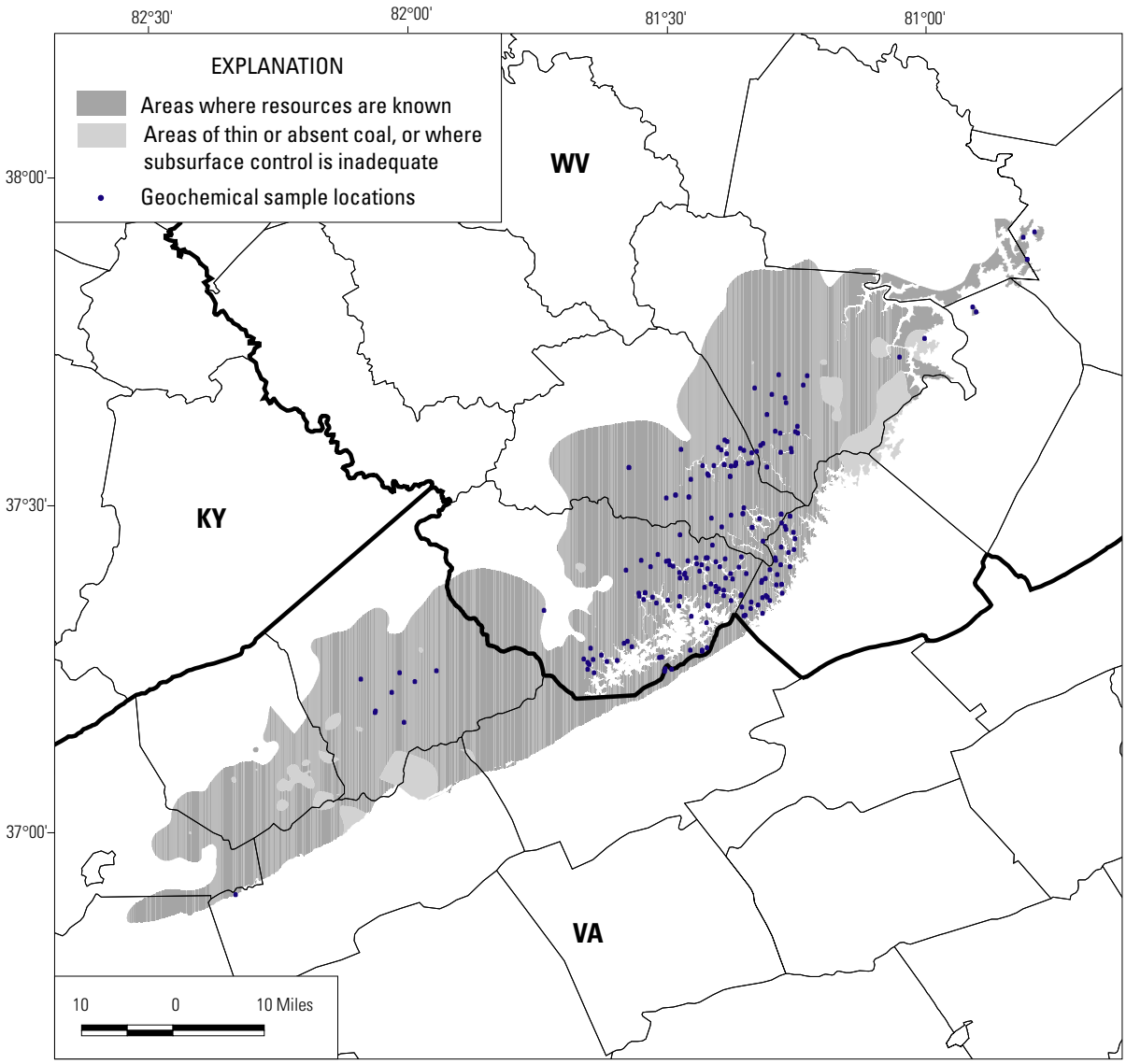

Figure 14. Map showing point locations for geochemical samples of the Pocahontas No. 3 coal bed for which records are publicly available and located by latitude and longitude. All of the geochemical data can be downloaded in ASCII format from Appendix 2. See figure 2 for county names.

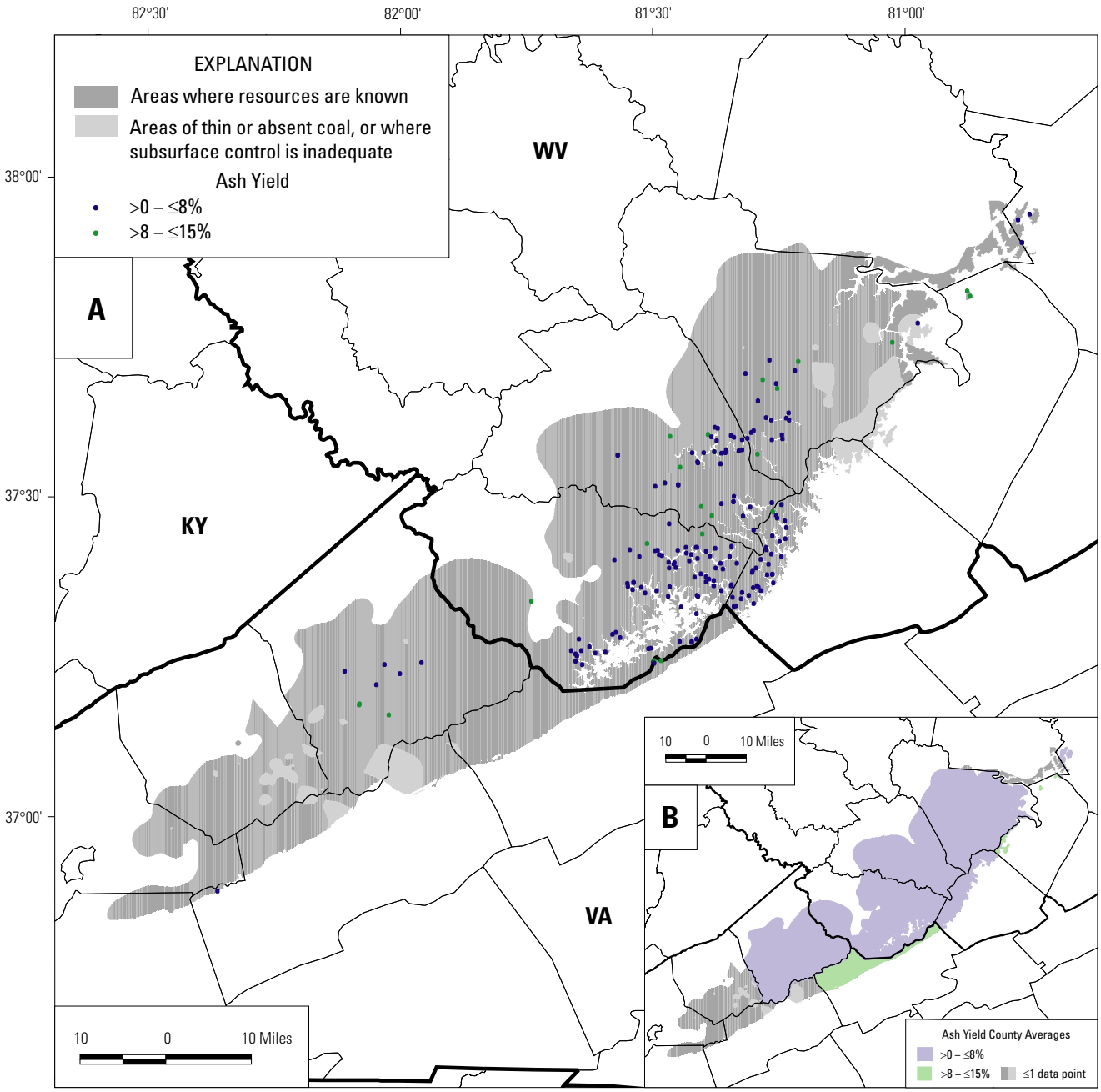

Figure 15. Maps showing ash yield (weight percent, as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows ash yields of 194 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for ash yields using all 194 records in the geochemical database, including those that are located only to a county level; ash yields range from 2.90 to 13.43 weight percent with a mean value of 5.75±2.24 weight percent (table 5). Ash yields tend to be highest in the southern part of the coal bed (Virginia, with a mean value of 7.34±3.25 weight percent) and lowest in the northern part (West Virginia, with a mean value of 5.65±2.13 weight percent). Ash yields are classified into low (>0 to ≤8 weight percent), medium (>8 to ≤15 weight percent), and high (>15 weight percent) categories as specified by Wood and others (1983). See figure 2 for county names.

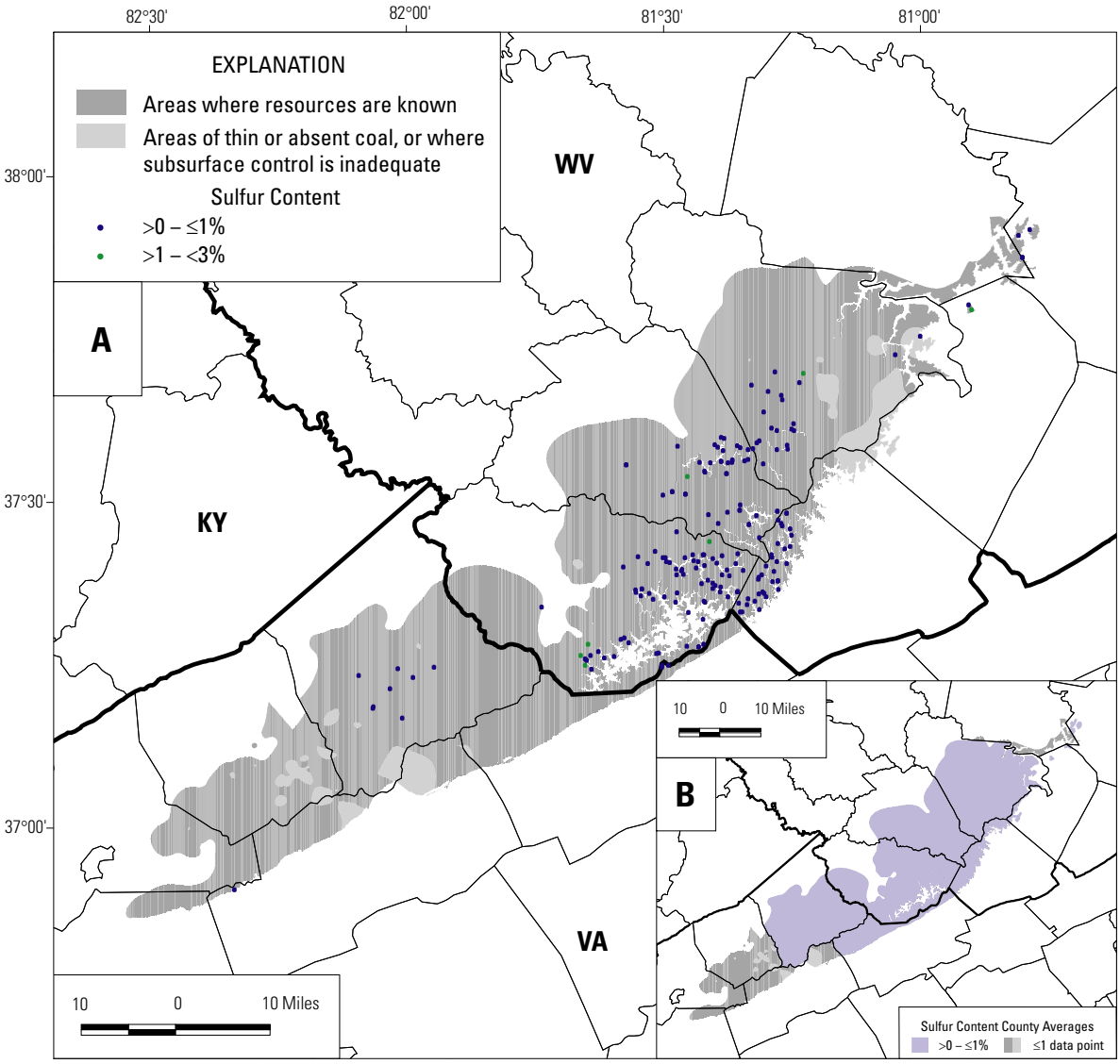

Figure 16. Maps showing sulfur content (weight percent, as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows sulfur contents of 194 geochemical samples for which records are publicly available and are located by latitude and longitude (Appendix 2). Map B shows county averages for sulfur contents using all 194 records in the geochemical database, including those that are located only to a county level; sulfur contents range from 0.40 to 1.15 weight percent with a mean value of 0.66±0.16 weight percent (table 6). In general, the Pocahontas No. 3 coal bed is a very low sulfur coal; means for both states are nearly identical (table 6). Sulfur contents are classified into low (>0 to ≤1 weight percent), medium (>1 to <3 weight percent), and high (≥3 weight percent) categories as specified by Wood and others (1983). See figure 2 for county names.

Table 5. Ash yield (weight percent; American Society for Testing and Materials method) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	5.75	2.90	13.43	2.24	194
VA	na	7.34	3.64	12.40	3.25	12
WV	na	5.65	2.90	13.43	2.13	182
VA	Buchanan	7.34	3.64	12.40	3.73	8
VA	Russell	nd	3.80	3.80	nd	1
VA	Tazewell	8.53	7.60	9.60	1.01	3
WV	Greenbrier	5.10	2.90	7.39	2.00	5
WV	McDowell	5.03	2.90	13.43	1.68	77
WV	Mercer	4.59	3.26	11.21	1.64	34
WV	Raleigh	6.53	3.13	12.58	2.57	22
WV	Summers	10.81	8.20	13.42	3.69	2
WV	Wyoming	6.98	3.41	10.84	1.80	42

Table 6. Sulfur content (weight percent; American Society for Testing and Materials method) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	0.66	0.40	1.15	0.16	194
VA	na	0.65	0.40	0.90	0.14	12
WV	na	0.66	0.41	1.15	0.16	182
VA	Buchanan	0.70	0.56	0.90	0.12	8
VA	Russell	nd	0.40	0.40	nd	1
VA	Tazewell	0.60	0.50	0.70	0.10	3
WV	Greenbrier	0.89	0.60	1.10	0.19	5
WV	McDowell	0.64	0.41	1.15	0.16	77
WV	Mercer	0.62	0.50	0.93	0.11	34
WV	Raleigh	0.75	0.54	1.08	0.13	22
WV	Summers	0.90	0.70	1.10	0.28	2
WV	Wyoming	0 .65	0.49	1.10	0.14	42

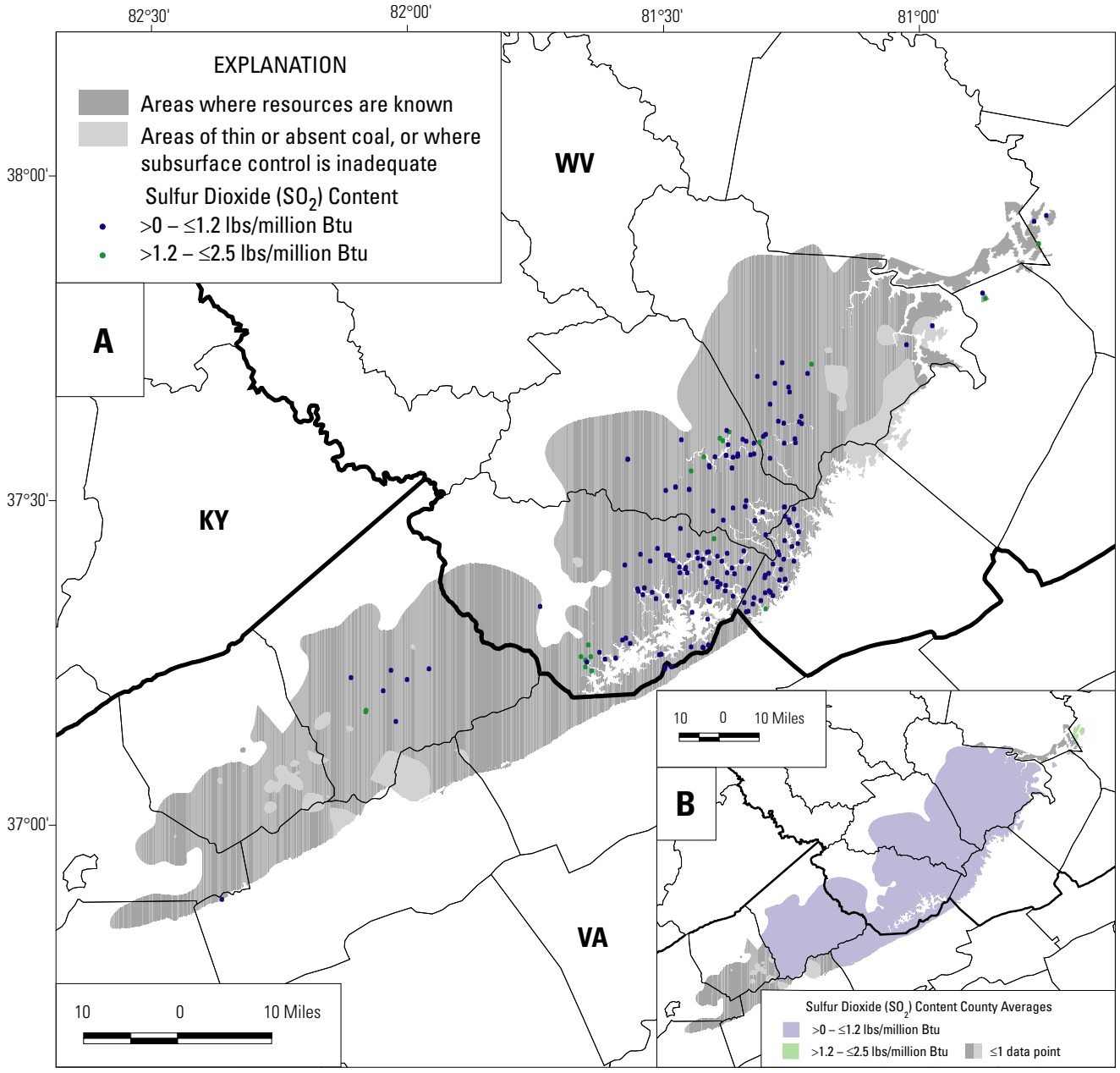

Figure 17. Maps showing sulfur-dioxide (SO_2) content (lbs/million Btu) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows SO_2 contents of 194 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for SO_2 contents using all 194 records in the geochemical database, including those that are located only to a county level; SO_2 values range from 0.56 to 1.66 lbs/million Btu with a mean value of 0.91±0.22 lbs/million Btu (table 7). The values are classified into three categories, low (0 to ≤1.2 lbs/million Btu), medium (>1.2 to ≤2.5 lbs/million Btu), and high (>2.5 lbs/million Btu), based on past and present U.S. Environmental Protection Agency regulations. The Pocahontas No. 3 coal bed is a compliant coal even under present U.S. statutes (Clean Air Act Amendments of 1990, Public Law 101-549). See figure 2 for county names.

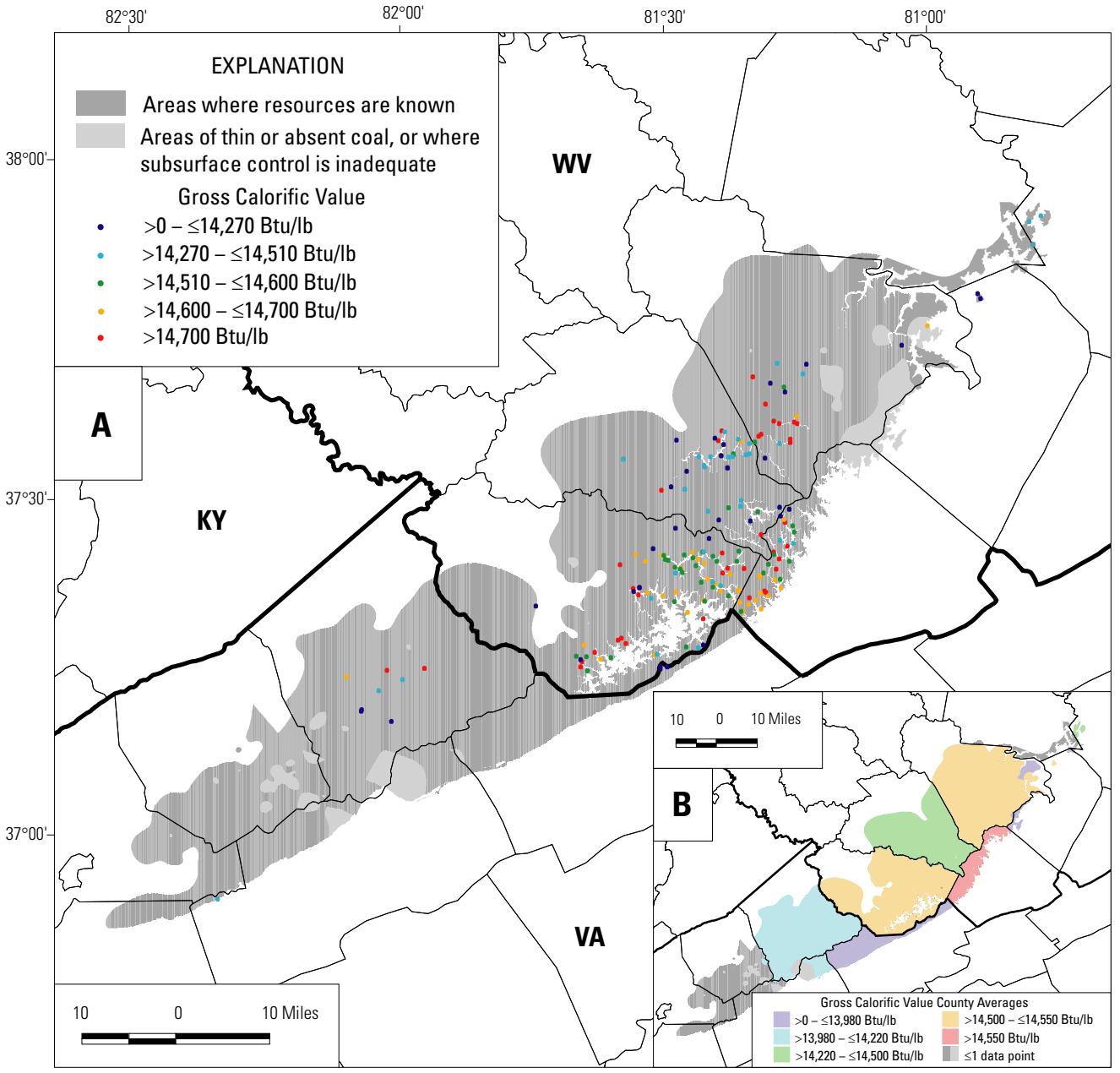

Figure 18. Maps showing gross calorific value (Btu/lb, as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows gross calorific values of 194 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for gross calorific values using all 194 records in the geochemical database, including those that are located only to a county level; gross calorific values range from 13,380 to 15,190 Btu/lb with a mean value of 14,490±340 Btu/lb (table 8). Calorific value tends to increase towards the north and east with the slightly higher calorific values being in West Virginia. The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 7. Sulfur-dioxide (SO_2) content (lbs/million Btu) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	0.91	0.56	1.66	0.22	194
VA	na	0.92	0.56	1.34	0.21	12
WV	na	0.91	0.56	1.66	0.22	182
VA	Buchanan	0.99	0.76	1.34	0.20	8
VA	Russell	nd	0.56	0.56	nd	1
VA	Tazewell	0.86	0.72	1.00	0.14	3
WV	Greenbrier	1.23	0.84	1.55	0.27	5
WV	McDowell	0.88	0.56	1.66	0.23	77
WV	Mercer	0.84	0.69	1.27	0.16	34
WV	Raleigh	1.03	0.75	1.58	0.19	22
WV	Summers	1.32	1.05	1.60	0.39	2
WV	Wyoming	0 .90	0.67	1.61	0.20	42

Table 8. Gross calorific value (Btu/lb; American Society for Testing and Materials method) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	14,490	13,380	15,190	340	194
VA	na	14,170	13,470	14,770	440	12
WV	na	14,510	13,380	15,190	320	182
VA	Buchanan	14,220	13,470	14,770	530	8
VA	Russell	nd	14,350	14,350	nd	1
VA	Tazewell	13,980	13,910	14,060	70	3
WV	Greenbrier	14,500	14,240	15,020	300	5
WV	McDowell	14,550	13,380	15,050	270	77
WV	Mercer	14,650	13,700	15,170	270	34
WV	Raleigh	14,550	13,680	15,190	370	22
WV	Summers	13,580	13,390	13,780	270	2
WV	Wyoming	14,350	13,650	14,940	300	42

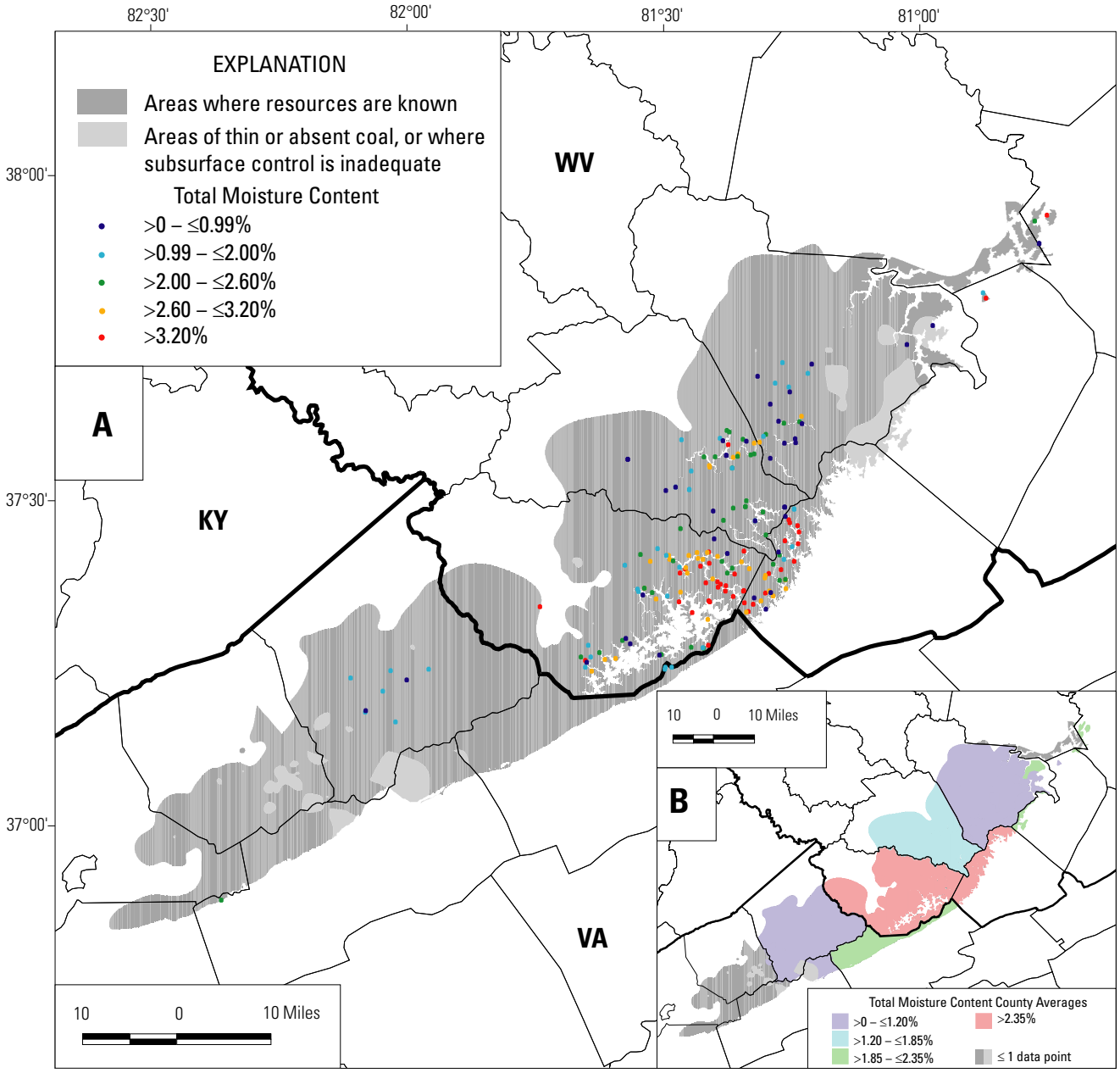

Figure 19. Maps showing total moisture content (weight percent, as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. ASTM (American Society for Testing and Materials) moisture replaced by equilibrium moisture values where available. Map A shows total moisture contents of 194 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for total moisture contents using all 194 records in the geochemical database, including those that are located only to a county level; total moisture contents range from 0.16 to 5.00 weight percent with a mean value of 2.22±1.08 weight percent (table 9). The values are classified into five categories, each representing 20 percent of the data values. The Pocahontas No. 3 coal bed is a bituminous coal and the moisture content is relatively low. See figure 2 for county names.

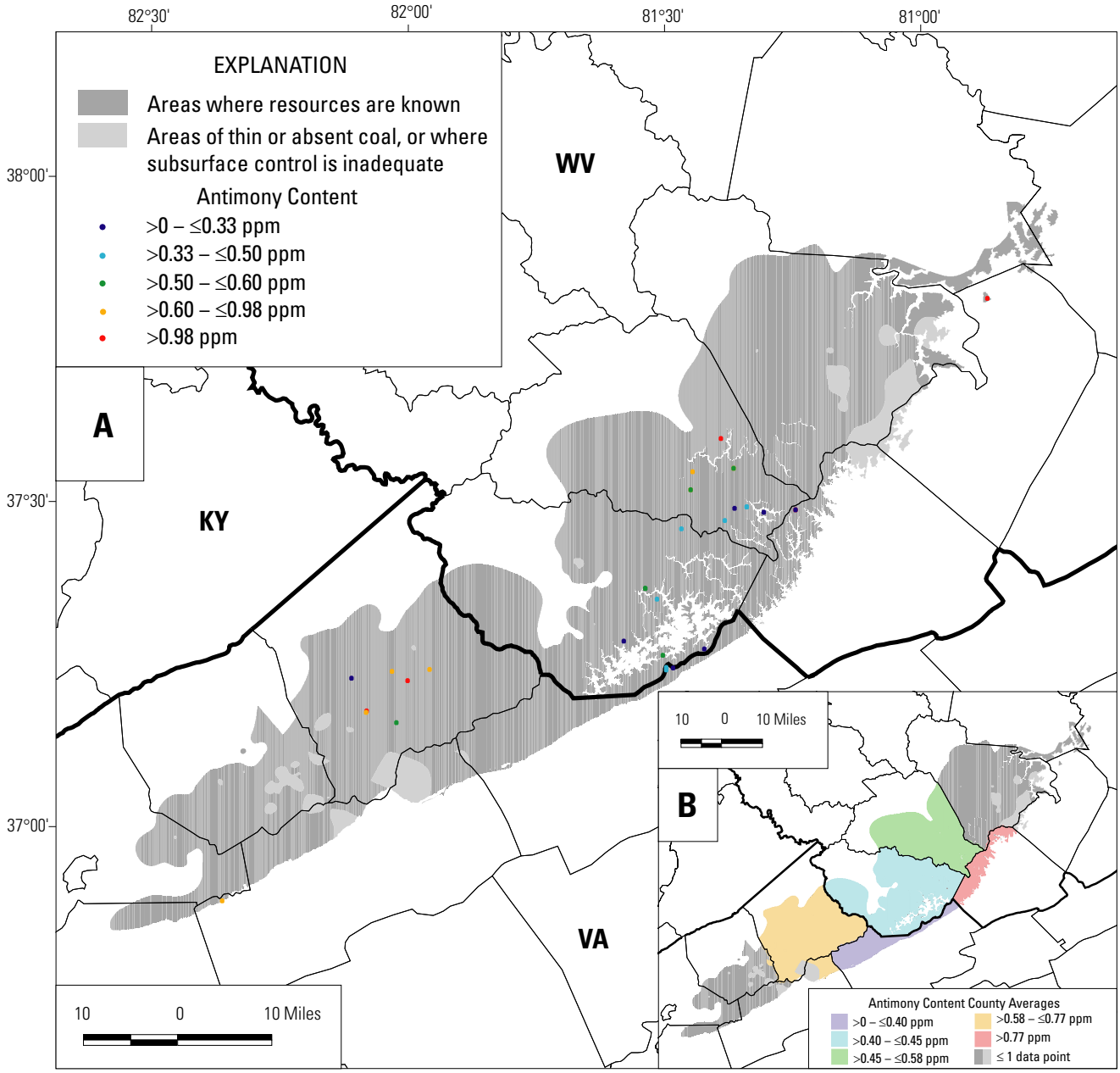

Figure 20. Maps showing antimony content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows antimony contents of 32 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for antimony contents using all 33 records in the geochemical database, including those that are located only to a county level; antimony contents range from 0.19 to 1.6 ppm with a mean value of 0.62±0.34 ppm (table 10). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 9. Total moisture content (weight percent) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[ASTM (American Society for Testing and Materials) moisture replaced by equilibrium moisture values where available. Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	2.22	0.16	5.00	1.08	194
VA	na	1.49	0.80	2.50	0.51	12
WV	na	2.27	0.16	5.00	1.10	182
VA	Buchanan	1.20	0.80	1.56	0.29	8
VA	Russell	nd	2.50	2.50	nd	1
VA	Tazewell	1.93	1.90	2.00	0.06	3
WV	Greenbrier	2.35	0.56	5.00	1.77	5
WV	McDowell	2.66	0.26	4.50	0.98	77
WV	Mercer	2.56	0.16	3.78	1.07	34
WV	Raleigh	1.21	0.38	2.90	0.77	22
WV	Summers	2.35	1.20	3.50	1.63	2
WV	Wyoming	1.85	0.44	3.30	0.88	42

Table 10. Antimony content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	0.62	0.19	1.6	0.34	33
VA	na	0.64	0.20	1.1	0.31	11
WV	na	0.62	0.19	1.6	0.37	22
VA	Buchanan	0.77	0.20	1.1	0.32	7
VA	Russell	nd	0.49	0.49	nd	1
VA	Tazewell	0.40	0.32	0.50	0.092	3
WV	Greenbrier	nd	0.60	0.60	nd	1
WV	McDowell	0.45	0.23	0.60	0.15	7
WV	Mercer	0.87	0.23	1.5	0.90	2
WV	Summers	nd	1.6	1.6	nd	1
WV	Wyoming	0 .58	0.19	1.1	0.25	11

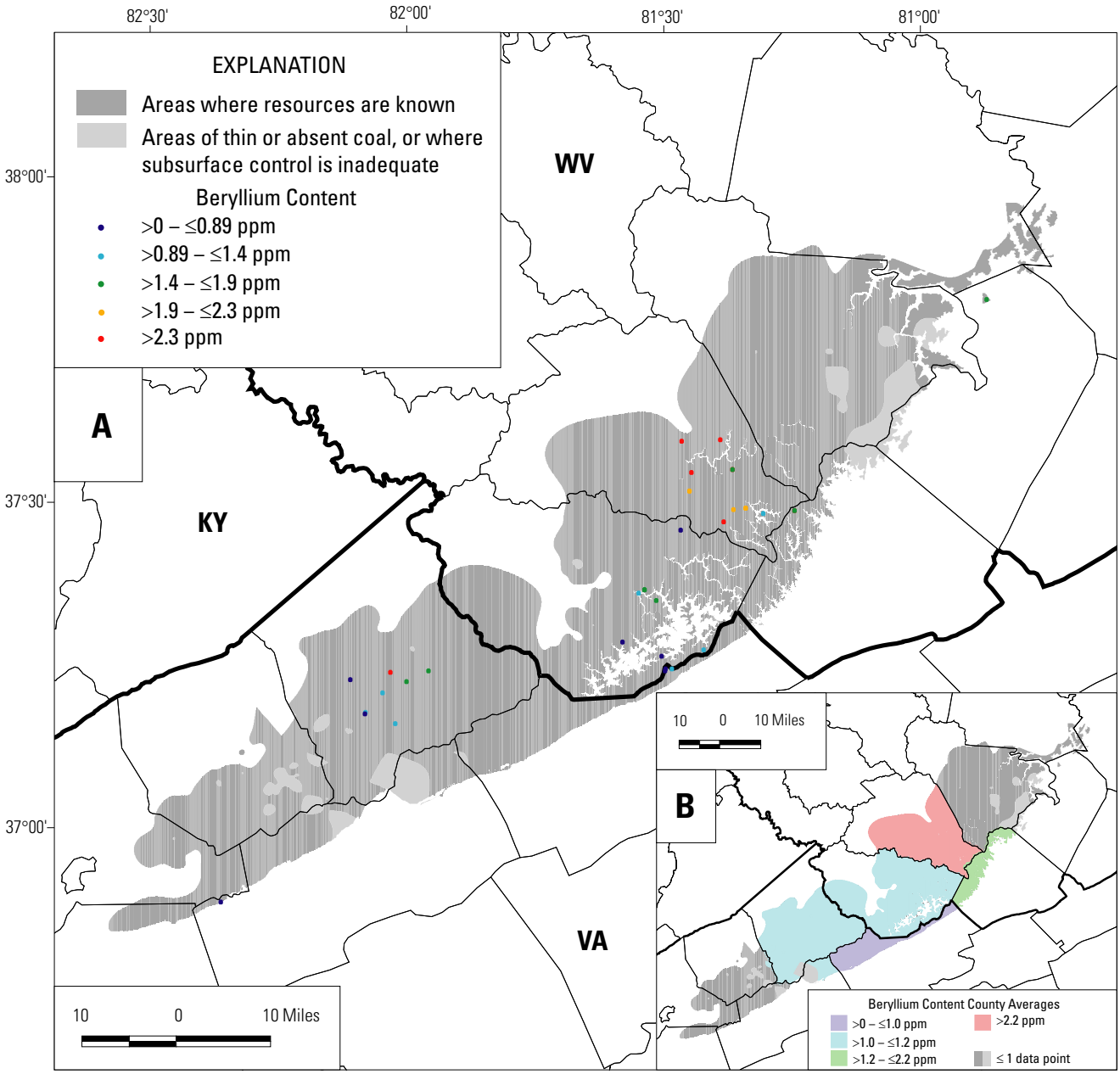

Figure 21. Maps showing beryllium content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows beryllium contents of 35 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for beryllium contents using all 36 records in the geochemical database, including those that are located only to a county level; beryllium contents range from 0.28 to 3.7 ppm with a mean value of 1.7±0.86 ppm (table 11). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

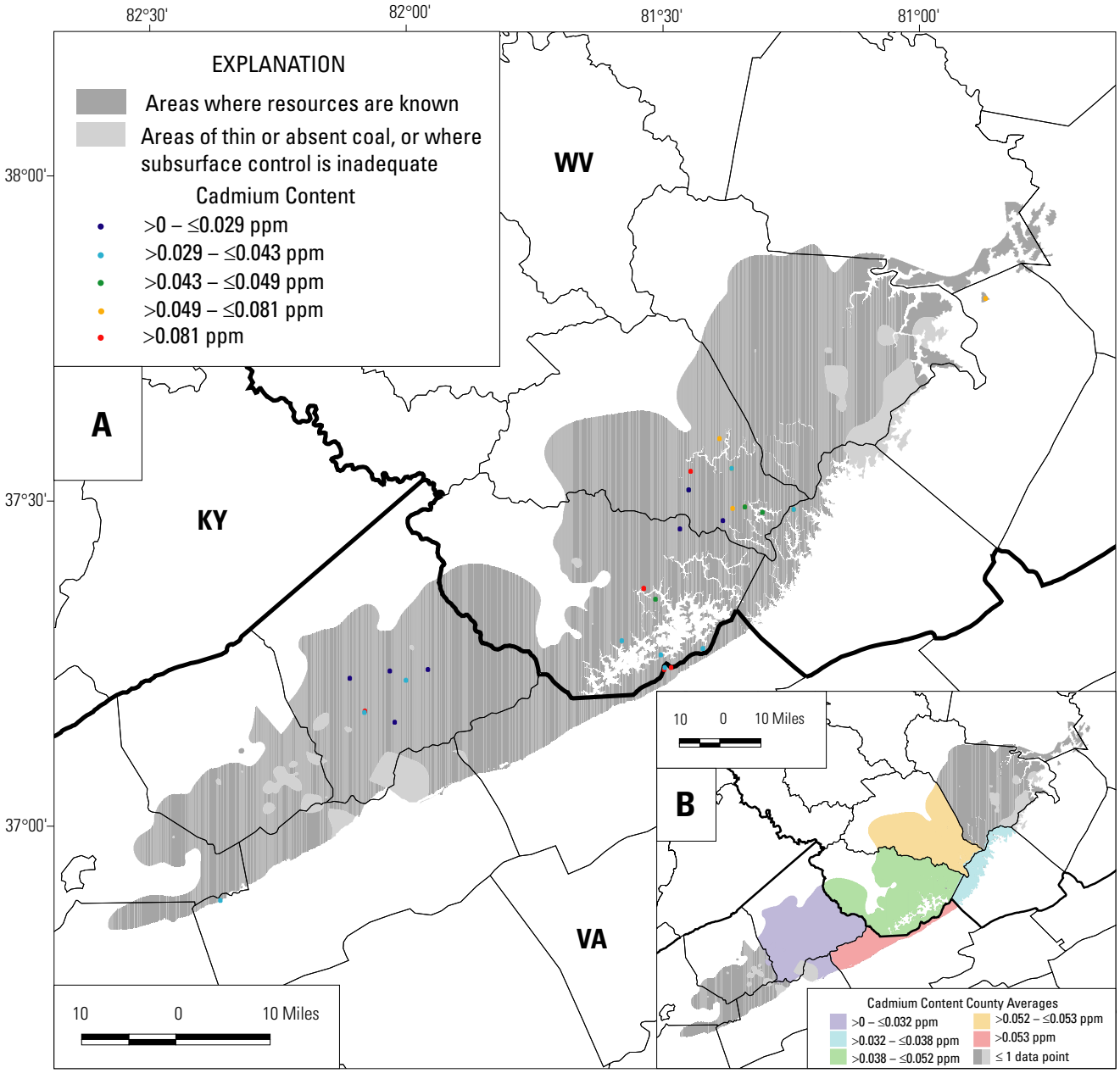

Figure 22. Maps showing cadmium content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows cadmium contents of 32 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for cadmium contents using all 33 records in the geochemical database, including those that are located only to a county level; cadmium contents range from 0.0083 to 0.11 ppm with a mean value of 0.048±0.026 ppm (table 12). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 11. Beryllium content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	1.7	0.28	3.7	0.86	36
VA	na	1.1	0.28	2.4	0.56	12
WV	na	1.9	0.61	3.7	0.87	24
VA	Buchanan	1.2	0.28	2.4	0.66	8
VA	Russell	nd	0.75	0.75	nd	1
VA	Tazewell	1.0	0.82	1.4	0.31	3
WV	Greenbrier	nd	2.1	2.1	nd	1
WV	McDowell	1.2	0.61	1.7	0.47	8
WV	Mercer	2.2	1.5	2.8	0.98	2
WV	Summers	nd	1.9	1.9	nd	1
WV	Wyoming	2.4	0.95	3.7	0.79	12

Table 12. Cadmium content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	0.048	0.0083	0.11	0.026	33
VA	na	0.040	0.0083	0.093	0.026	11
WV	na	0.052	0.017	0.11	0.026	22
VA	Buchanan	0.032	0.0083	0.082	0.024	7
VA	Russell	nd	0.037	0.037	nd	1
VA	Tazewell	0.060	0.043	0.093	0.029	3
WV	Greenbrier	nd	0.049	0.049	nd	1
WV	McDowell	0.052	0.017	0.11	0.038	7
WV	Mercer	0.038	0.034	0.043	0.0065	2
WV	Summers	nd	0.072	0.072	nd	1
WV	Wyoming	0 .053	0.020	0.098	0.023	11

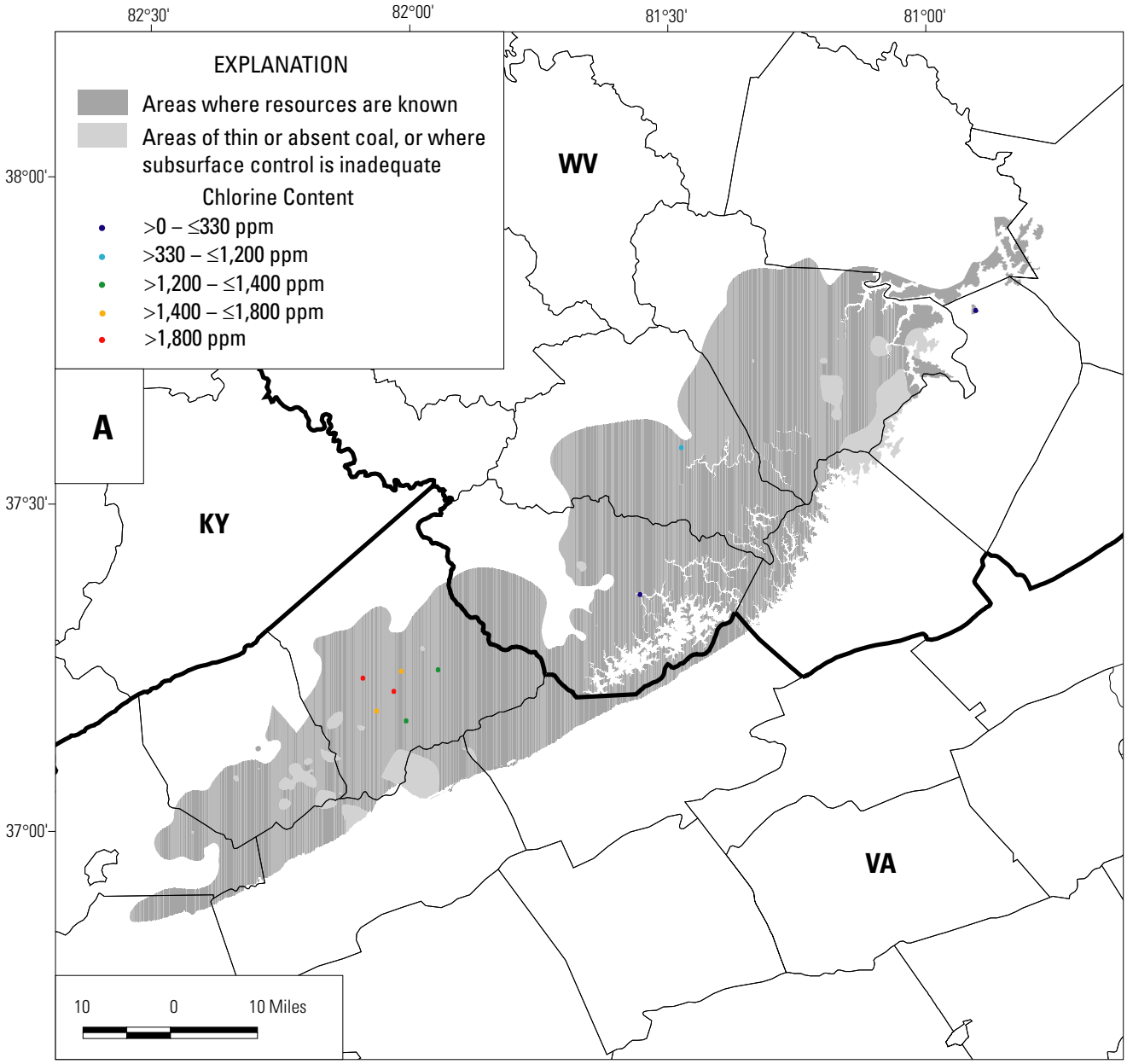

Figure 23. Map showing chlorine content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map shows chlorine contents of 9 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Chlorine values range from 98 to 2,800 ppm with 6 out of the 10 data values reported for Buchanan County, Va., and one data value each was reported for the four other counties (table 13); therefore, county averages were not mapped. Buchanan County, Va., has a mean value of 1,800±520 ppm. The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

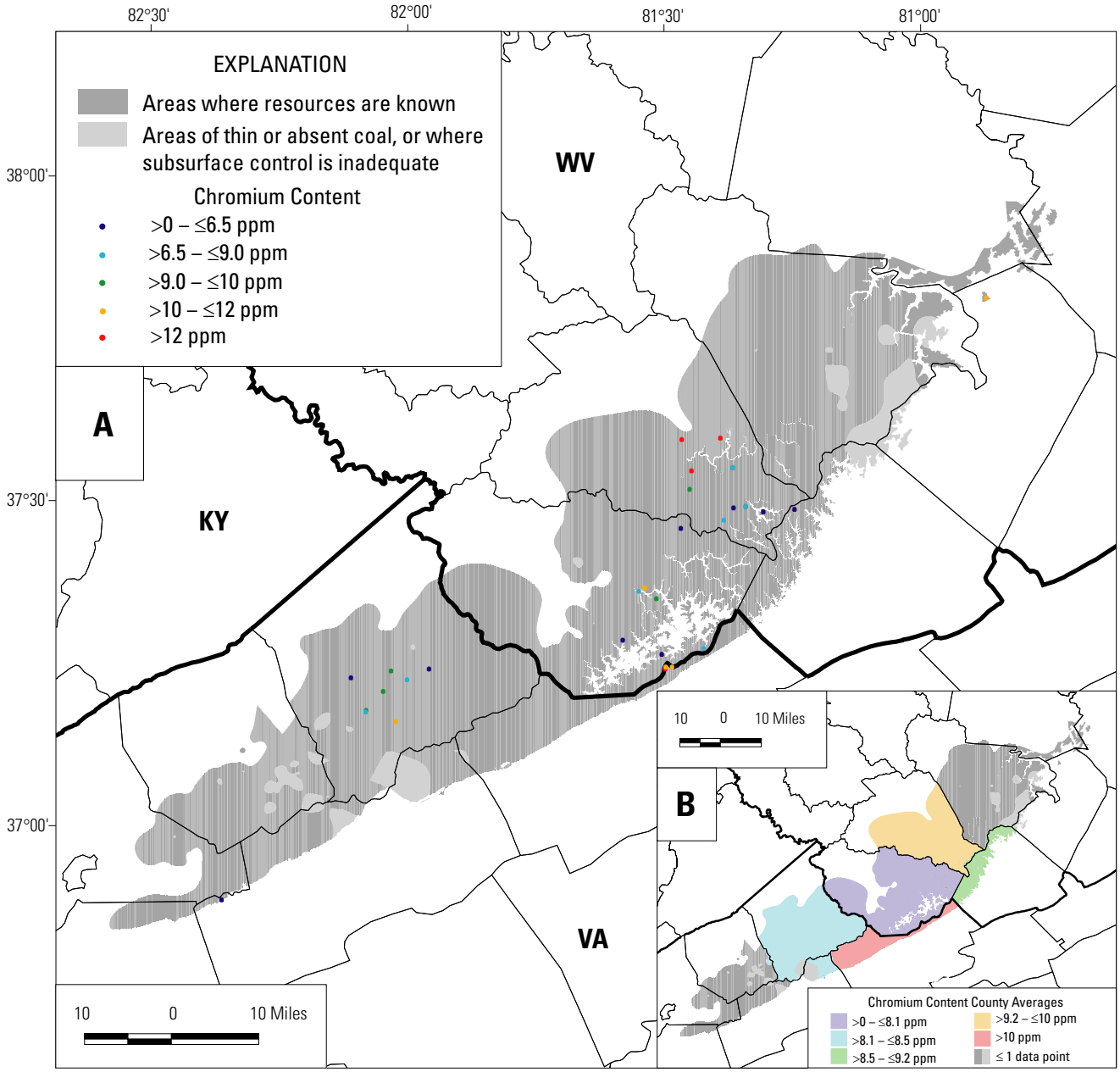

Figure 24. Maps showing chromium content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows chromium contents of 35 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for chromium contents using all 36 records in the geochemical database, including those that are located only to a county level; chromium contents range from 3.8 to 17 ppm with a mean value of 9.4±3.0 ppm (table 14). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 13. Chlorine content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county. No data are available for Maryland.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	1,500	98	2,800	900	10
VA	na	1,800	1,300	2,700	520	6
WV	na	1,100	98	2,800	1,200	4
VA	Buchanan	1,800	1,300	2,700	520	6
WV	Greenbrier	nd	2,800	2,800	nd	1
WV	McDowell	nd	98	98	nd	1
WV	Summers	nd	330	330	nd	1
WV	Wyoming	nd	980	980	nd	1

Table 14. Chromium content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	9.4	3.8	17	3.0	36
VA	na	9.1	3.8	13	9.1	12
WV	na	9.5	4.0	17	3.1	24
VA	Buchanan	8.5	3.8	12	2.4	8
VA	Russell	nd	4.4	4.4	nd	1
VA	Tazewell	12	11	13	1.0	3
WV	Greenbrier	nd	11	11	nd	1
WV	McDowell	8.1	4.0	12	2.8	8
WV	Mercer	9.2	6.3	12	4.1	2
WV	Summers	nd	11	11	nd	1
WV	Wyoming	10	6.5	17	3.3	12

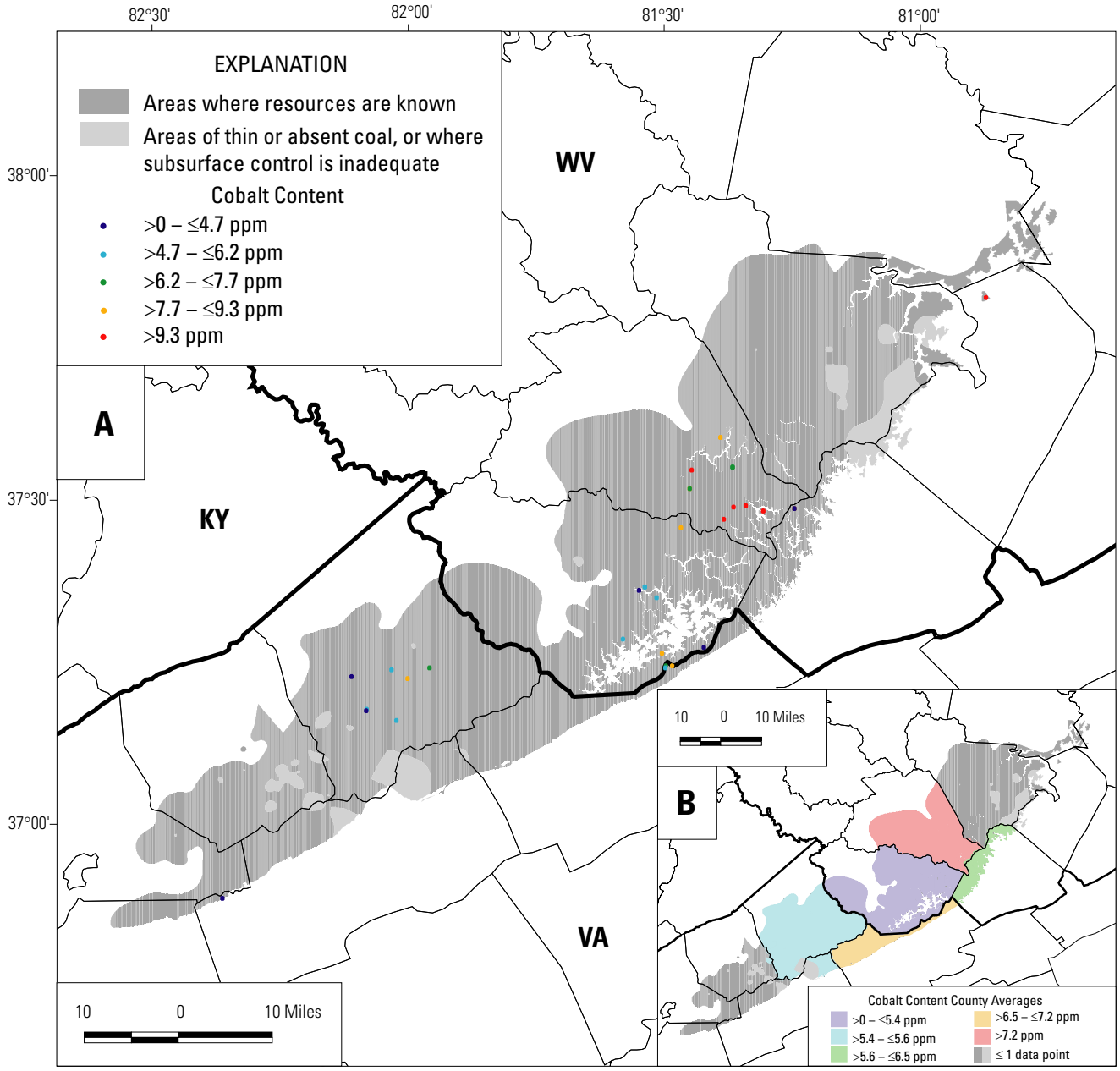

Figure 25. Maps showing cobalt content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows cobalt contents of 34 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for cobalt contents using all 34 records in the geochemical database, including those that are located only to a county level; cobalt contents range from 0.74 to 13 ppm with a mean value of 6.9±2.9 ppm (table 15). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

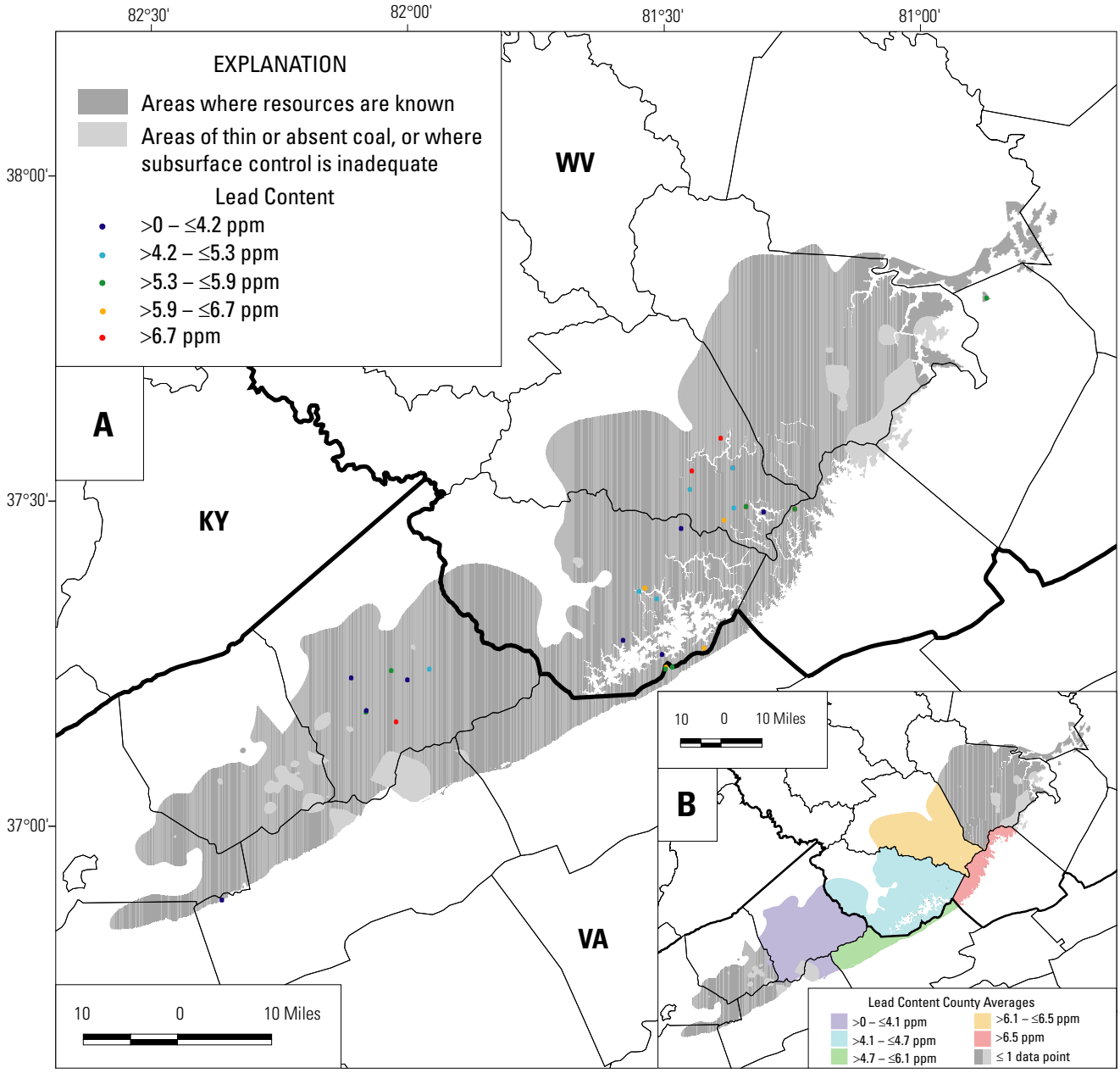

Figure 26. Maps showing lead content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows lead contents of 33 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for lead contents using all 34 records in the geochemical database, including those that are located only to a county level; lead contents range from 1.2 to 11 ppm with a mean value of 5.4±2.1 ppm (table 16). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 15. Cobalt content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	6.9	0.74	13	2.9	34
VA	na	5.7	1.7	8.9	2.3	11
WV	na	7.5	0.74	13	3.0	23
VA	Buchanan	5.6	2.6	8.9	2.1	7
VA	Russell	nd	1.7	1.7	nd	1
VA	Tazewell	7.2	6.2	8.0	0.90	3
WV	Greenbrier	nd	2.7	2.7	nd	1
WV	McDowell	5.4	0.74	9.1	2.8	8
WV	Mercer	6.5	4.7	8.4	2.6	2
WV	Summers	nd	9.4	9.4	nd	1
WV	Wyoming	9.4	7.0	13	1.7	11

Table 16. Lead content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	5.4	1.2	11	2.1	34
VA	na	4.5	1.2	7.2	2.1	11
WV	na	5.8	1.6	11	2.0	23
VA	Buchanan	4.1	1.2	7.2	2.4	7
VA	Russell	nd	2.6	2.6	nd	1
VA	Tazewell	6.1	5.8	6.5	0.40	3
WV	Greenbrier	nd	4.4	4.4	nd	1
WV	McDowell	4.7	1.6	6.5	1.7	8
WV	Mercer	6.9	5.5	8.4	2.0	2
WV	Summers	nd	5.9	5.9	nd	1
WV	Wyoming	6.5	4.2	11	2.1	11

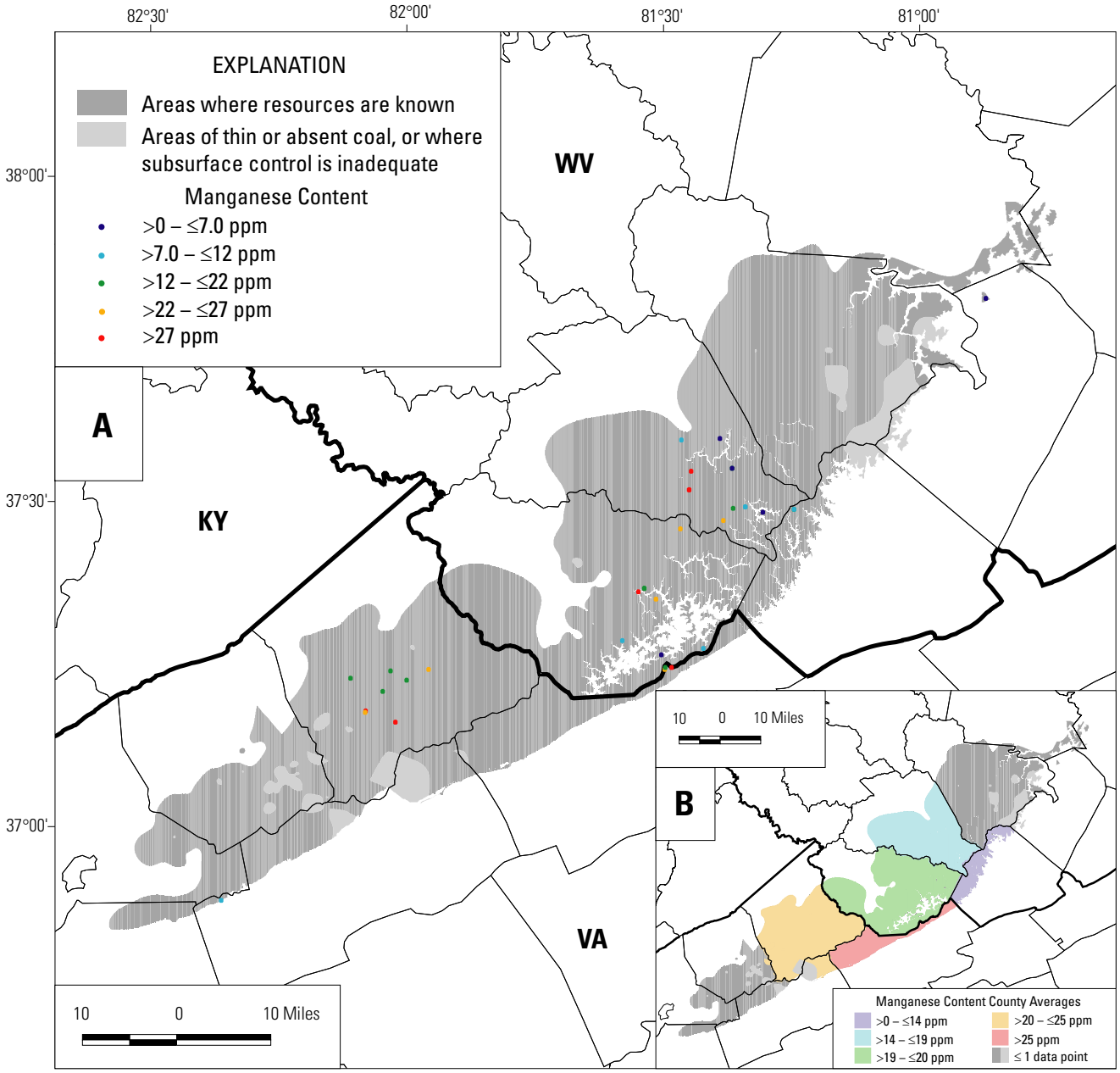

Figure 27. Maps showing manganese content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows manganese contents of 33 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for manganese contents using all 36 records in the geochemical database, including those that are located only to a county level; manganese contents range from 2.3 to 52 ppm with a mean value of 20±13 ppm (table 17). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

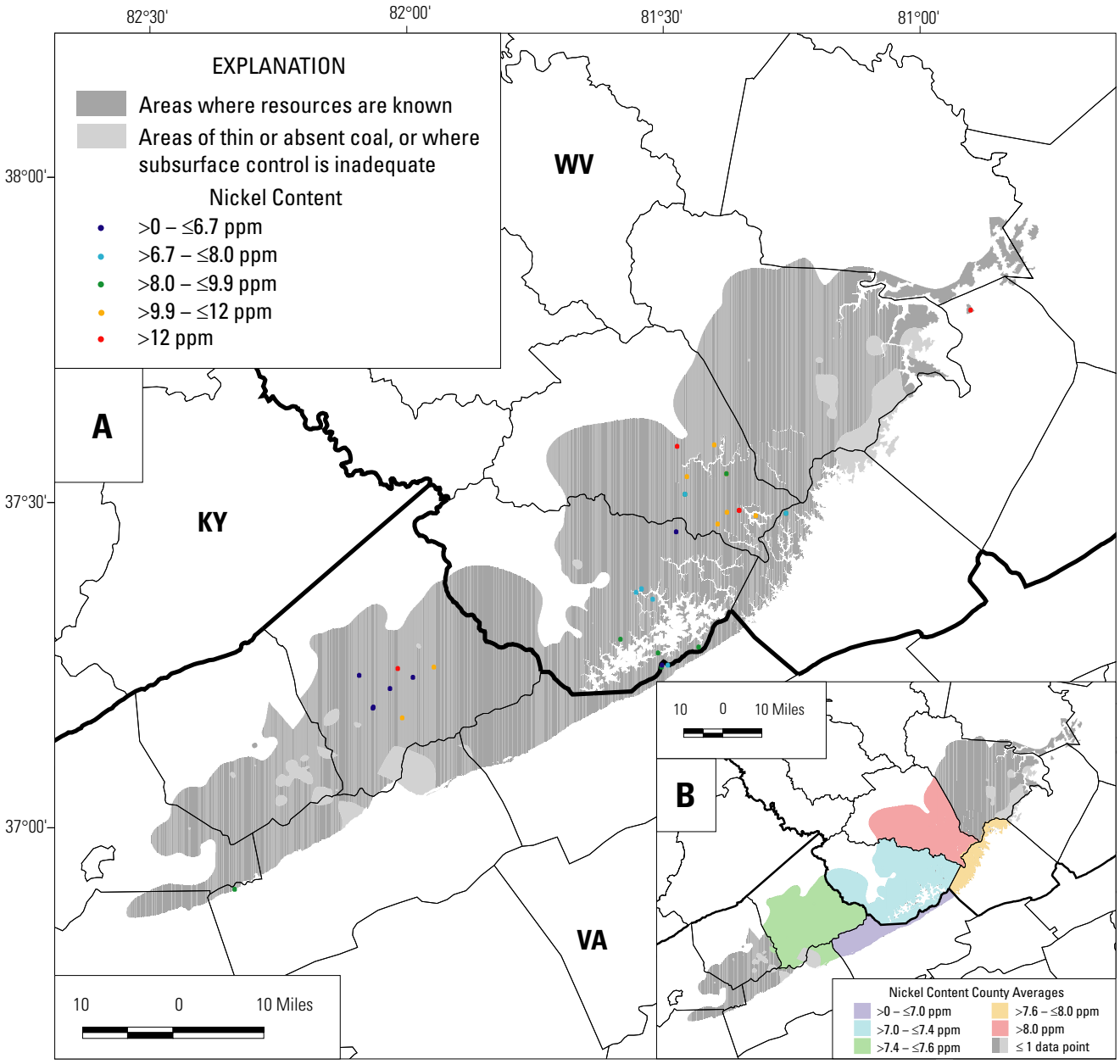

Figure 28. Maps showing nickel content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows nickel contents of 35 geochemical samples for with records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for nickel contents using all 36 records in the geochemical database, including those that are located only to a county level; nickel contents range from 3.2 to 15 ppm with a mean value of 9.0±3.0 ppm (table 18). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 17. Manganese content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	20	2.3	52	13	36
VA	na	24	10	46	10	12
WV	na	17	2.3	52	13	24
VA	Buchanan	25	14	46	11	8
VA	Russell	nd	10	10	nd	1
VA	Tazewell	26	19	33	7.1	3
WV	Greenbrier	nd	2.3	2.3	nd	1
WV	McDowell	20	3.0	40	12	8
WV	Mercer	14	8.0	20	8.4	2
WV	Summers	nd	4.3	4.3	nd	1
WV	Wyoming	19	4.8	52	15	12

Table 18. Nickel content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	9.0	3.2	15	3.0	36
VA	na	7.5	3.2	13	2.9	12
WV	na	9.8	3.8	15	2.8	24
VA	Buchanan	7.6	3.2	13	3.5	8
VA	Russell	nd	8.6	8.6	nd	1
VA	Tazewell	7.0	5.1	8.9	1.9	3
WV	Greenbrier	nd	6.7	6.7	nd	1
WV	McDowell	7.4	3.8	8.7	1.6	8
WV	Mercer	8.0	7.0	9.1	1.5	2
WV	Summers	nd	13	13	nd	1
WV	Wyoming	12	7.8	15	2.0	12

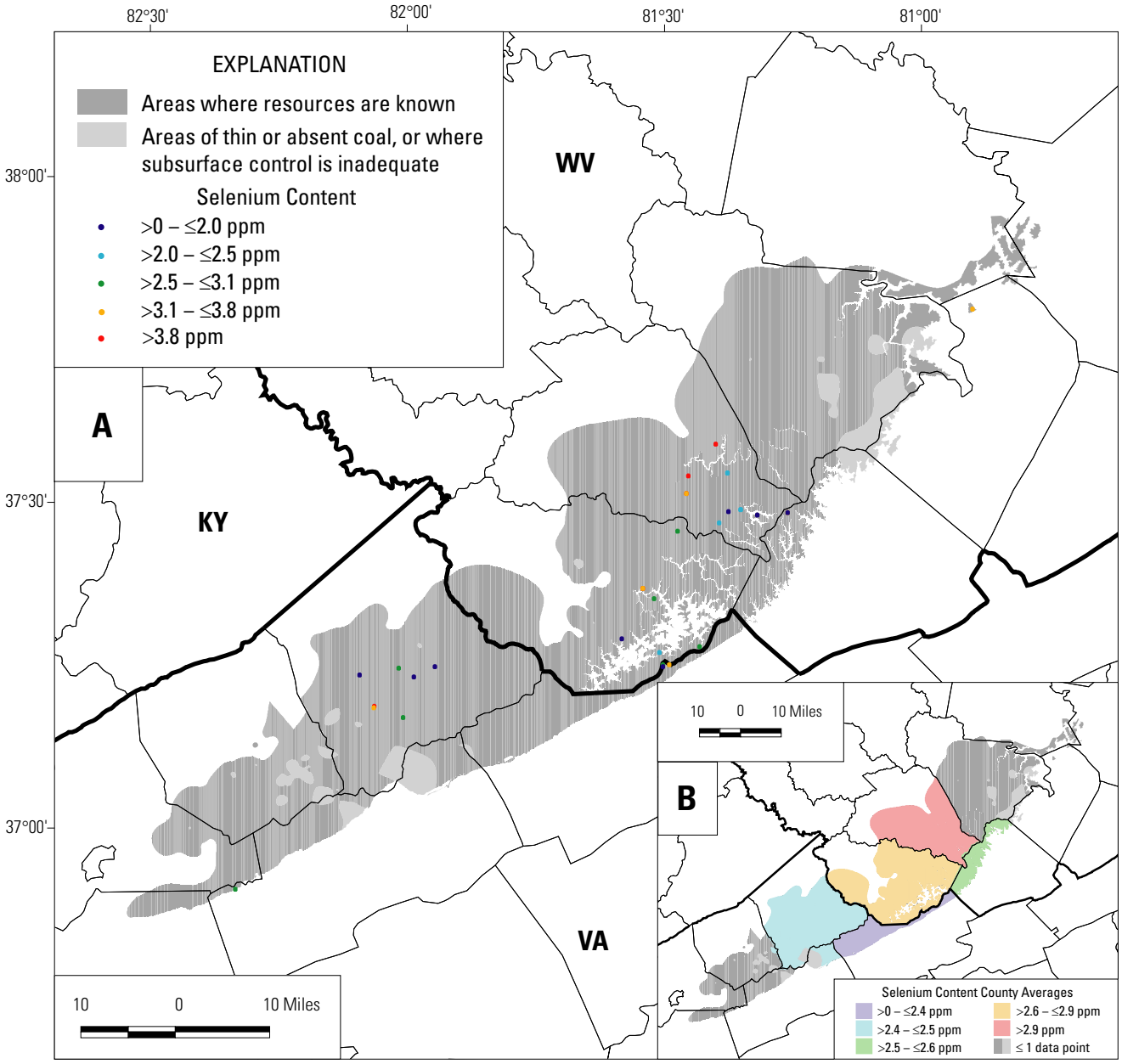

Figure 29. Maps showing selenium content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows selenium contents of 32 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for selenium contents using all 33 records in the geochemical database, including those that are located only to a county level; selenium contents range from 1.1 to 7.9 ppm with a mean value of 2.9±1.2 ppm (table 19). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

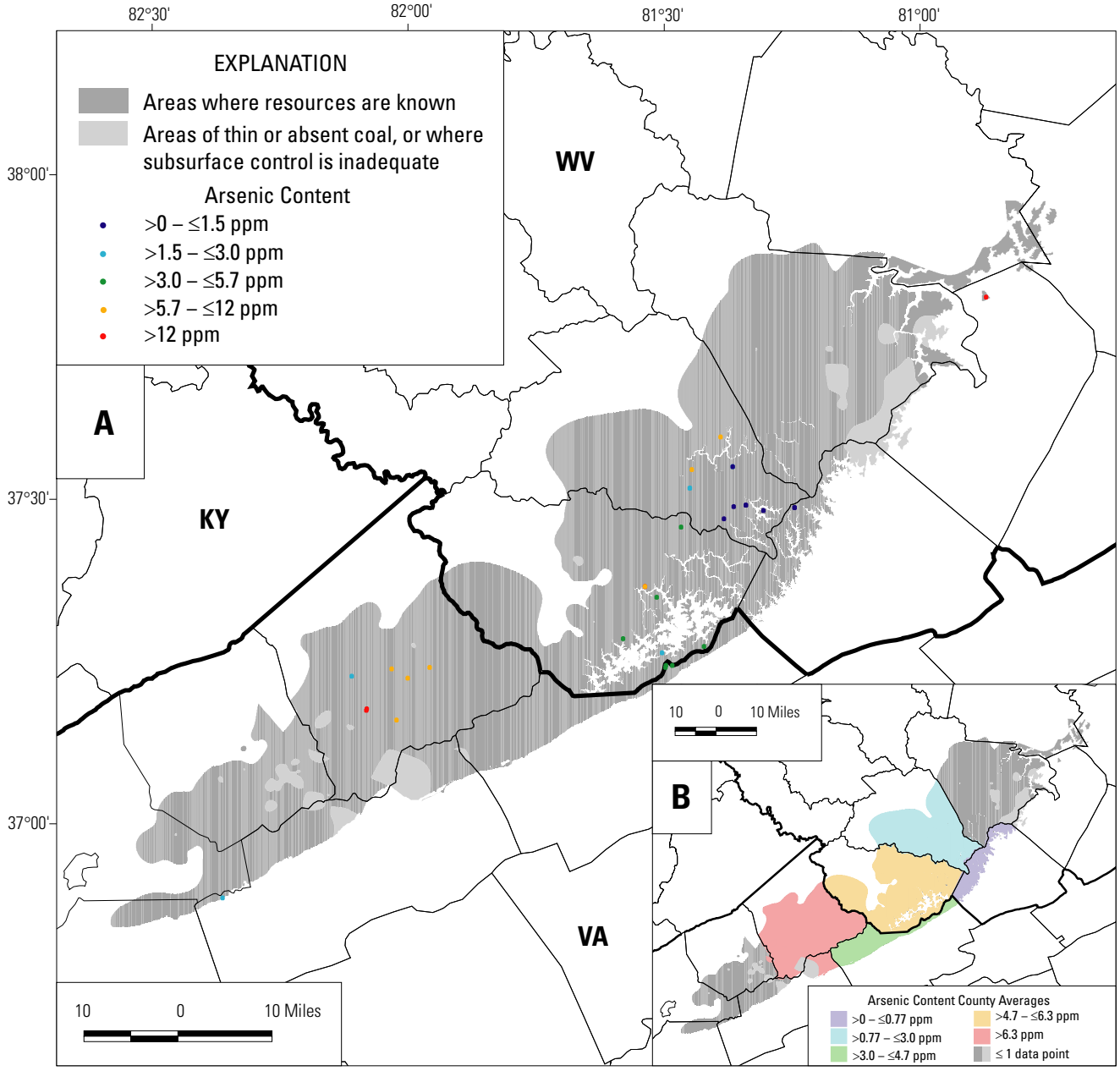

Figure 30. Maps showing arsenic content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows arsenic contents of 32 geochemical samples for which records are publicly available and located by latitude and longitude. Map B shows county averages for arsenic contents using all 33 records in the geochemical database, including those that are located only to a county level; arsenic contents range from 0.30 to 35 ppm with a mean value of 7.1±8.1 ppm (table 20). Arsenic contents tend to be highest in Buchanan County, Va., and McDowell County, W. Va. The values are classified into five categories, each representing 20 percent of the data values. See table 2 for county names.

Table 19. Selenium content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	2.9	1.1	7.9	1.2	33
VA	na	2.5	1.1	3.9	0.94	11
WV	na	3.1	1.6	7.9	1.4	22
VA	Buchanan	2.5	1.2	3.9	1.0	7
VA	Russell	nd	2.9	2.9	nd	1
VA	Tazewell	2.4	1.1	3.2	1.1	3
WV	Greenbrier	nd	3.8	3.8	nd	1
WV	McDowell	2.9	2.0	4.0	0.67	7
WV	Mercer	2.6	1.8	3.4	1.1	2
WV	Summers	nd	3.3	3.3	nd	1
WV	Wyoming	3.2	1.6	7.9	1.8	11

Table 20. Arsenic content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	7.1	0.30	35	8.1	33
VA	na	8.9	2.7	29	7.7	11
WV	na	6.2	0.30	35	8.3	22
VA	Buchanan	12	2.7	29	8.7	7
VA	Russell	nd	2.7	2.7	nd	1
VA	Tazewell	4.7	3.9	5.1	1.0	3
WV	Greenbrier	nd	22	22	nd	1
WV	McDowell	6.3	3.0	13	3.8	7
WV	Mercer	0.77	0.30	1.2	0.67	2
WV	Summers	nd	35	35	nd	1
WV	Wyoming	3.0	1.2	12	3.5	11

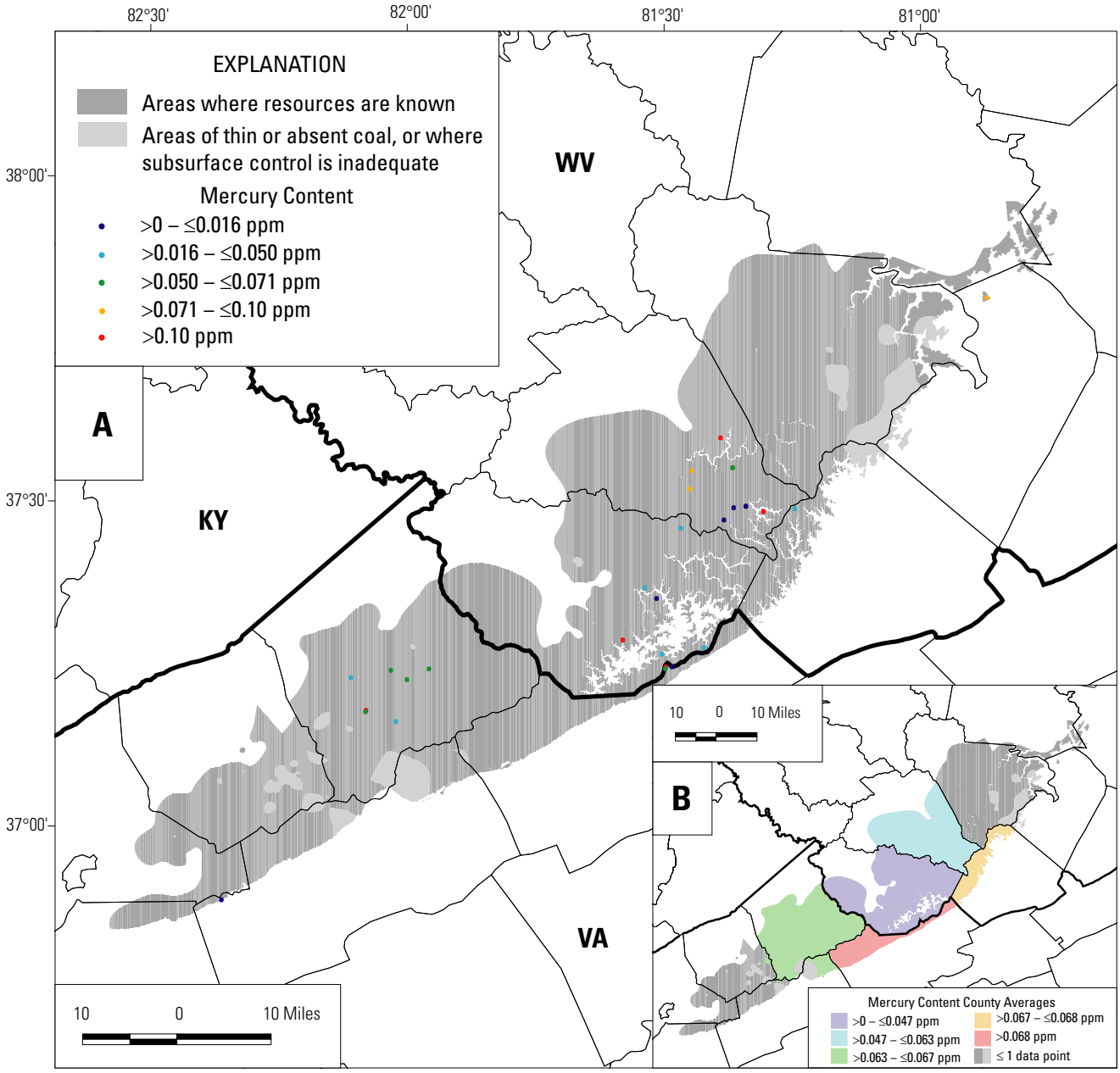

Figure 31. Maps showing mercury content (parts per million (ppm), as-received whole-coal basis) of the Pocahontas No. 3 coal bed in Virginia and West Virginia. Map A shows mercury contents of 32 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 2). Map B shows county averages for mercury contents using all 33 records in the geochemical database, including those located only to a county level; mercury contents range from 0.0049 to 0.18 ppm with a mean value of 0.064±0.044 ppm (table 21). The values are classified into five categories, each representing 20 percent of the data values. In general, mercury content tends to be correlated with ash yield and sulfur content. See figure 2 for county names.

Table 21. Mercury content (parts per million) means, ranges, and standard deviations for samples of the Pocahontas No. 3 coal bed on an as-received whole-coal basis, by State and county.

[Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of Samples
ALL	na	0.064	0.0049	0.18	0.044	33
VA	na	0.063	0.0050	0.15	0.040	11
WV	na	0.064	0.0049	0.18	0.047	22
VA	Buchanan	0.067	0.050	0.11	0.021	7
VA	Russell	nd	0.016	0.016	nd	1
VA	Tazewell	0.071	0.0050	0.15	0.073	3
WV	Greenbrier	nd	0.18	0.18	nd	1
WV	McDowell	0.047	0.015	0.12	0.037	7
WV	Mercer	0.068	0.050	0.086	0.026	2
WV	Summers	nd	0.080	0.080	nd	1
WV	Wyoming	0 .063	0.0049	0.14	0.047	11

ties as is indicated by the following detailed geochemical analyses.

The map of ash yield (weight percent, as-received whole-coal basis) (fig. 15A) shows that the Pocahontas No. 3 coal bed is a low-ash coal with an overall mean value of 5.75±2.24 weight percent for 194 samples (table 5). The trend of higher ash yields along the eastern outcrop illustrated on the county average map in figure 15B is deceiving because the areas with the highest averages are based on few data samples (table 5). Mean ash yields range from 5.65±2.13 weight percent (based on 182 samples in West Virginia) to 7.34±3.25 weight percent (based on 12 samples in Virginia).

The sulfur content distributions (weight percent, as-received whole-coal basis) of the Pocahontas No. 3 coal shown in figure 16A and figure 16B are similar to those of the ash yield. The Pocahontas No. 3 is a low-sulfur coal (fig. 16; table 6) with a mean sulfur content of 0.66±0.16 weight percent.

Figure 17 shows that, overall, the Pocahontas No. 3 coal as mined meets 2000 compliance coal standards (see table 7) of less than or equal to emissions of 1.2 lbs of sulfur dioxide (SO_2) per million Btu as specified in the Clean Air Act Amendments of 1990 (Public Law 101-549). The mean SO_2 value calculated for the Pocahontas No. 3 coal bed is 0.91±0.22 lbs of SO_2 per million Btu.

The Pocahontas No. 3 coal bed is also very high in gross calorific value. The mean calorific value for the Pocahontas No. 3 coal bed is 14,490±340 Btu/lb and ranges from 13,380 Btu/lb to 15,190 Btu/lb for 194 analyses (fig. 18; table 8). Gross calorific values tend to decrease from northeast to southwest (fig. 18).

The Pocahontas No. 3 coal bed is mainly low-volatile bituminous and tends to increase from high-volatile A bituminous in the southwest to low-volatile bituminous rank in the northeast, with small "bulls-eye-shaped" pods of semianthracite observed along the eastern front in McDowell and Mercer Counties, W. Va. (figs. 3, 14). Because the Pocahontas No. 3 coal bed is low-volatile bituminous in rank, the total moisture (fig. 19; table 9) tends to be relatively low with a mean of 2.22±1.08 weight percent for the entire bed (194 analyses).

The Clean Air Act Amendments of 1990 listed 12 elements that may adversely affect the environment. These elements include antimony, beryllium, cadmium, chlorine, chromium, cobalt, lead, manganese, nickel, selenium, arsenic, and mercury. Thirty-six representative Pocahontas No. 3 coal bed samples were analyzed for these 12 elements (figs. 20–31; tables 10–21).

ARSENIC AND MERCURY

Two of the elements thought to have particularly toxic effects are arsenic (fig. 30; table 20) and mercury (fig. 31; table 21). Arsenic concentrations (ppm (parts per million), as-received whole-coal basis) for 33 Pocahontas No. 3 coal bed samples range from 0.30 to 35 ppm with a mean of 7.1±8.1 ppm (table 20). In comparison to the Appalachian Basin mean of 35 ppm arsenic (Finkelman and others, 1994)

and the U.S. mean of 24±5.5 ppm arsenic (Finkelman, 1993), the Pocahontas No. 3 coal bed has much lower arsenic concentrations, which probably correlate to the low sulfur content of the coal.

Thirty-three samples of Pocahontas No. 3 coal were analyzed for mercury on an as-received whole-coal basis (fig. 31). Mercury concentrations range from 0.0049 to 0.18 ppm with the overall bed mean of 0.064±0.044 ppm (table 21). These values are significantly lower than the Appalachian Basin mean of 0.21 ppm (Finkelman and others, 1994) and the U.S. mean of 0.17±10 ppm (Finkelman, 1993).

RESOURCES

GEOGRAPHIC INFORMATION SYSTEM (GIS)

The basis for the resource calculations for the Pocahontas No. 3 coal bed are data in a geographic information system (GIS) that show the extent of the coal and mined-out areas (fig. 32), the geologic structure (fig. 7), the thickness of the coal bed (fig. 5), and the overburden thickness (fig. 33). The GIS also contains files for measured, indicated, and inferred reliability categories for coal-resource data points. Because of their digital format, the resource data and map products may be revised quickly as additional resources are discovered, developed, and depleted, and as additional exploration and coal quality information is acquired. If the databases are kept current, revised digital map products will illustrate the location, thickness, and quality of remaining coal and provide the basis for monitoring coal reserves and overall resource depletion.

The GIS used in this study allows flexibility of output as well as easy access to the basic data supporting the assessment. Point data for coal thickness and structure maps (figs. 4–6) were obtained from a composite digital stratigraphic database currently maintained by the USGS. The WVGES compiled much of the basic stratigraphic, coal thickness, and structural data used in this report from WVGES county reports (Hennen, 1915, 1919; Krebs, 1916; Reger, 1926; Price, 1939) and from unpublished field notes. These data were combined with records in the National Coal Resources Data System (NCRDS), and with data compiled by the VDMR from coal-bed methane test wells drilled recently in Virginia. All of the digital stratigraphic data for the Pocahontas No. 3 coal bed provided by the WVGES were verified with original published sources by the USGS and WVGES. Data without adequate geographic locations (latitude and longitude) were removed from the database and data duplicated by the WVGES and the NCRDS were combined or deleted. Logs of cores, wells, and measured sections were correlated across the Pocahontas basin.

The WVGES supplied the USGS with coal outcrop lines (showing areal extent) and mined-out areas (fig. 32) that were compiled from unpublished maps of 7.5-minute quadrangles. These data were scanned and, where necessary, combined with data published in the WVGES county reports (Krebs, 1916; Hennen, 1919; Price, 1939). Line data from these county reports were digitized manually. The unpublished maps for West Virginia include the Amonate, Anawalt, Beckley, Bramwell, Crab, Crumpler, Gary, Keystone, Lester, Matoaka, McGraws, Mullens, Odd, Orchard, Pineville, Rhodell, Tazewell North, War, and Welch 7.5-minute quadrangles.

For Virginia, the VDMR compiled the Pocahontas No. 3 coal bed outcrop line and mined-out areas and supplied the USGS with digital map data (Spears and others, 1997). The VDMR also interpreted geophysical logs of recently drilled coal-bed methane tests and provided the USGS with stratigraphic, structural, coal-bed-thickness, and elevation data.

RESOURCE CALCULATIONS

Stratigraphic information for both Virginia and West Virginia, including coal thickness data, was entered into StratiFact, a commercial software package. This software was used to effect stratigraphic correlations and to produce isoline maps. StratiFact-derived files for coal-bed thickness (isopachs) (fig. 5) and geologic structure (fig. 7) were combined with other data in a spreadsheet and imported (using EarthVision[3] software) for the purpose of making the structure and isopach grids. All digital map files were projected into the Albers Equal Area projection. A 135-m^2 grid was applied to the isopach, structure, and overburden data. The overburden values were derived by digitally subtracting the geologic structure-contour map from 1:100,000-scale digital elevation models (DEMs) (fig. 33). All areal digital coverages, including mined and unmined areas, coal-bed thickness categories in 1.17-ft increments; overburden categories of as much as 200, 500, 1,000, 2,000, 3,000, and >3,000 ft deep; and geographic data, such as county and quadrangle boundaries, were exported and combined in ArcInfo[4]. Circles for measured (<0.25 mi), indicated (>0.25–0.75 mi), inferred (>0.75–3 mi), and hypothetical resources (>3 mi) were constructed from coal thickness data points to define

[3]EarthVision is a product of Dynamic Graphics, Inc., 1015 Atlantic Avenue, Alameda, CA 94501.

[4]ArcInfo is a product of ESRI, 380 New York Street, Redlands, CA 92373-8100.

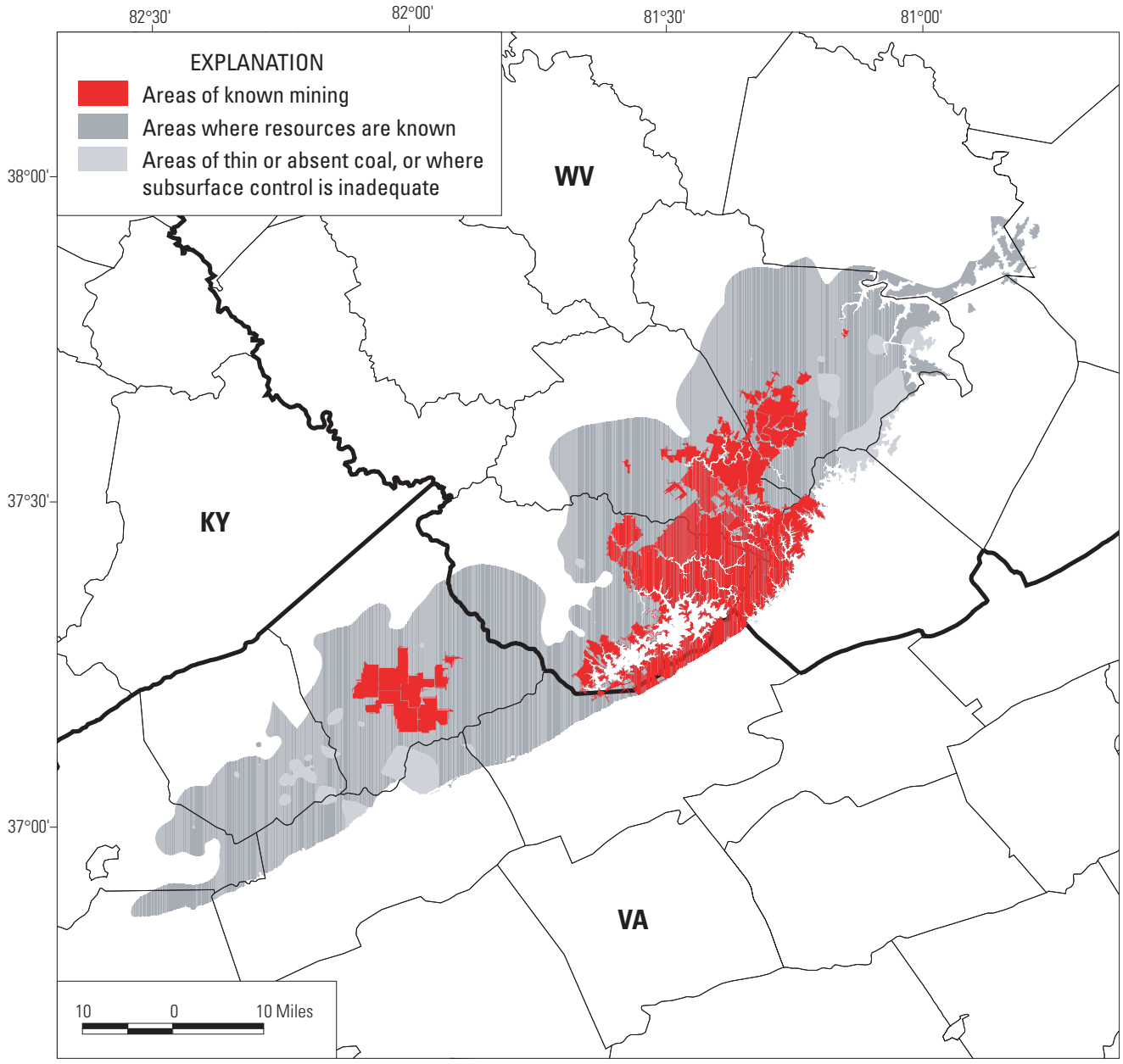

Figure 32. Map showing areal extent of the Pocahontas No. 3 coal bed in Virginia and West Virginia and areas of known mining. See figure 2 for county names.

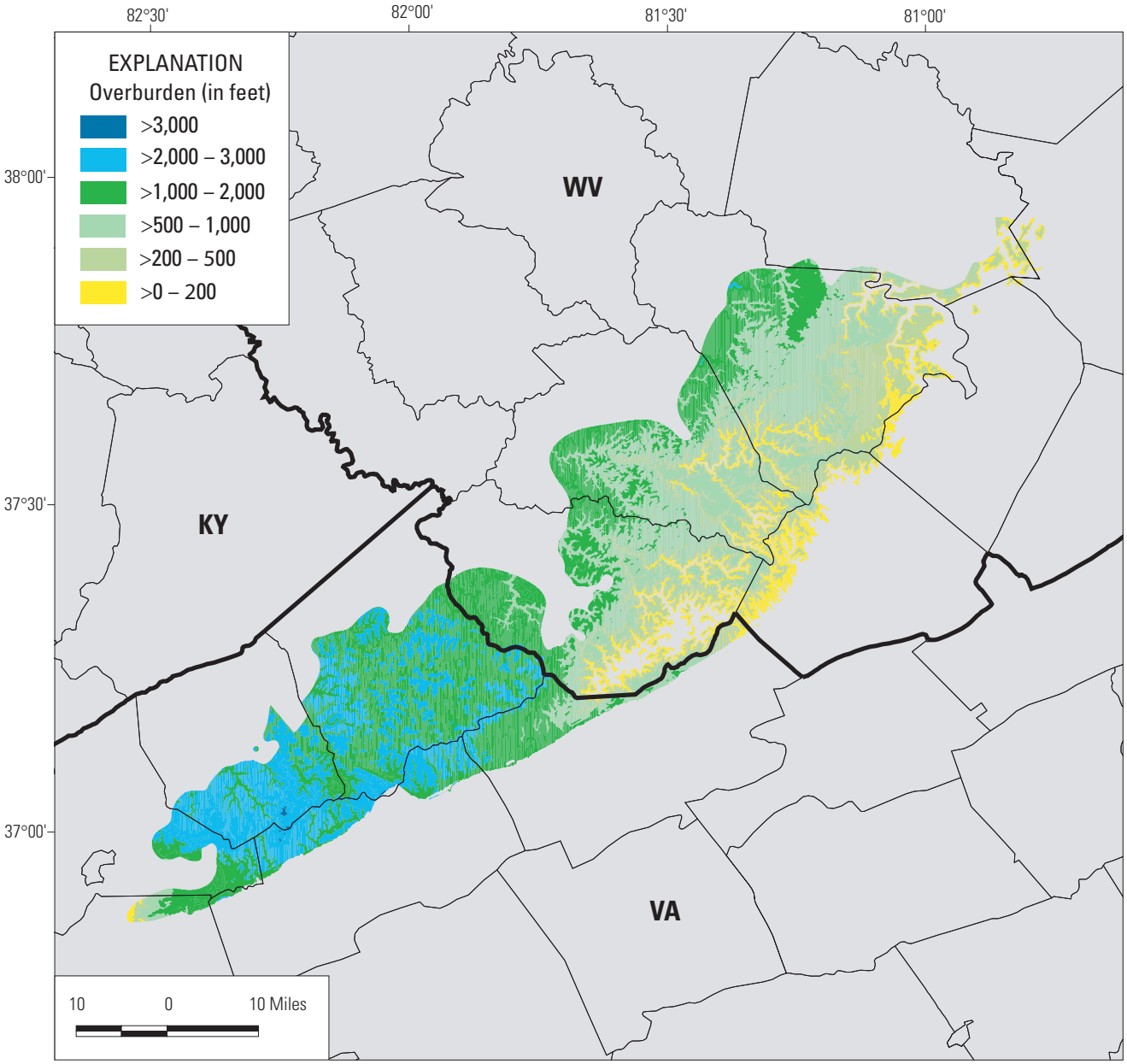

Figure 33. Map showing overburden thickness of the Pocahontas No. 3 coal bed in Virginia and West Virginia. The overburden thickness map was calculated by subtracting the structure-contour grid on the top of the Pocahontas No. 3 coal bed from topography. The contour intervals for overburden thickness are variable, based on criteria from Wood and others (1983). See figure 2 for county names.

Table 22. Comparison of previous resource studies with the results of this study (billions of short tons).

PREVIOUS STUDIES		PRESENT STUDY	
Virginia (revised from Brown and others, 1952)	West Virginia (Rehbein and others, 1981)	Virginia	West Virginia
Original resources			
1.1	3.1	2.9	4.3
Remaining resources			
0.66	1.2	2.5	2.6
Technically recoverable resources (assuming 50 percent recoverability)			
0.33	0.55	1.25	1.3

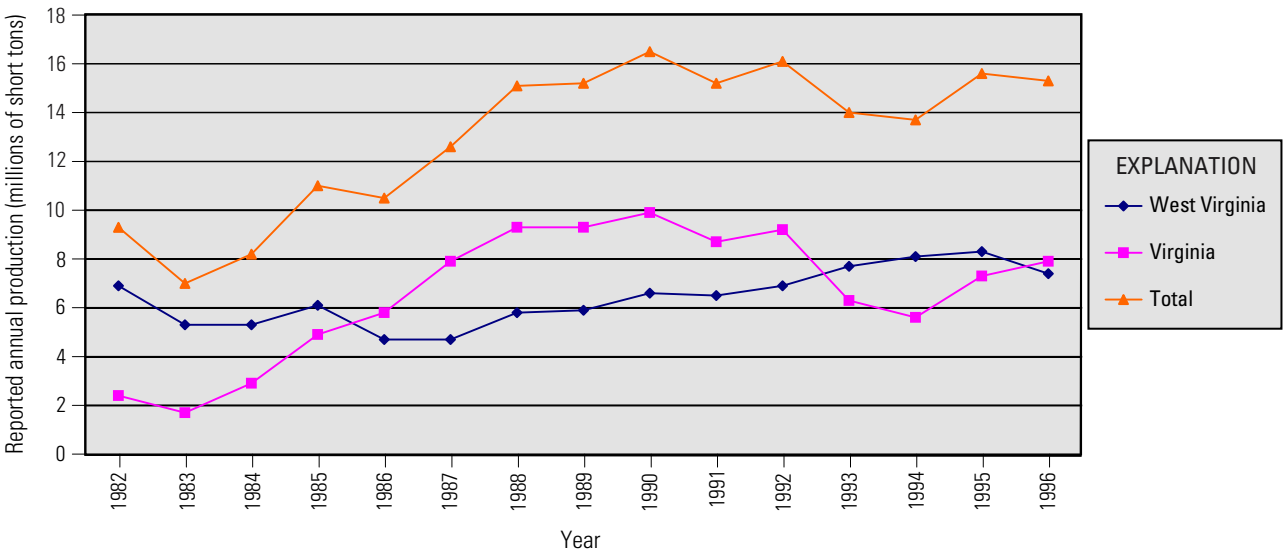

Figure 34. Graph showing Pocahontas No. 3 coal bed production in West Virginia and Virginia from 1982 to 1996. Sources: Elizabeth V.M. Campbell (Virginia Division of Mineral Resources, written commun., 1997), Sandra G. Neuzil (U.S. Geological Survey, written commun., 1998).

areas by reliability categories. These circles were combined with the other data in ArcInfo to form attributed resource polygons in accordance with the guidelines established by Wood and others (1983). Resources were calculated by multiplying the average coal thickness for each attributed polygon by 0.445 short tons/ft-m^2 (representing the weight of the coal per unit volume). This file was then exported into a spreadsheet and tonnages of original and remaining resources were summed for each county by reliability, thickness, and overburden categories (Appendixes 5 and 6).

Original resources for the Pocahontas No. 3 coal bed (all categories) are about 2.9 billion short tons for Virginia and 4.3 billion short tons for West Virginia, for a total of 7.2 billion short tons (Appendix 5). Much of the resource is too thin and too deep to be mined under economic and technological conditions as of 1999. Much of the resource is inferred or hypothetical. Assuming 50 percent recoverability, as of 1996, about 400 million short tons of Pocahontas No. 3 coal had been mined or lost in mining in Virginia (Brown and others, 1952; Elizabeth V.M. Campbell, VDMR, written commun., 1997) and about 2.2 billion short tons had been mined or lost in mining in West Virginia (Rehbein and others, 1981; Gayle H. McColloch, Jr., WVGES, written commun., 1998), for a total of 2.6 billion short tons for both States. Remaining resources are calculated as 5.1 billion short tons, with 2.5 billion short tons in Virginia and 2.6 billion short tons in West Virginia (Appendix 6). For West Virginia, there is a discrepancy of about 0.5 billion short tons between the remaining resources calculated in Appendix 5 (2.6 billion short tons) and subtraction of mined and lost-in-mining (2.2 billion short tons) from 4.3 billion short tons of original resources (4.3 – 2.2 = 2.1 billion short tons). Some of this difference is probably the result of the incomplete mine coverage available for this project. About 160 million short tons of Pocahontas No. 3 coal have been mined or lost in mining since 1988 (at 50 percent recovery). The remainder of the difference is most likely within the large amounts of inferred and hypothetical coal calculated in this study.

The differences in resource estimates derived from previous studies and the current study (table 22) result mostly from a great increase in data utilized for the current study, especially for Virginia. In Virginia, much of the data used in the present assessment were from boreholes and coal-bed methane wells drilled since the prior assessments. Although much of the data used for West Virginia were compiled from the old West Virginia county reports, the combination of the data into one dataset, as well as the addition of relatively new data, has resulted in an increase in the resource numbers. Technically recoverable coal, however, is not necessarily economically recoverable coal, and tonnages of the latter should be much smaller. At current production rates (fig. 34), there is sufficient Pocahontas No. 3 coal to support a mining industry for many years, providing that the industry is capable of operating in an economically competitive fashion with western coal supplies and with other fuels, such as natural gas.

Although much of the Pocahontas No. 3 coal bed is mined out, a large area of unmined coal is in eastern Buchanan County, Va., and in McDowell County, W. Va., generally at depths of 1,000 to 2,000 ft. This mountainous area, which is between areas of extensive mining, is currently being exploited for its coal-bed methane resources. An additional area of relatively thick unmined coal is in Raleigh County, W. Va., near Beckley. There, the trend of the coal bed swings from northeast to easterly, and the coal bed is from 500 ft to about 1,000 ft underground.

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APPENDIX 1

POCAHONTAS NO. 3 COAL BED STRATIGRAPHIC DATABASE

[This ASCII file contains all of the public records used to model the Pocahontas No. 3 coal bed and includes (1) record identifier, (2) longitude (decimal degrees), (3) latitude (decimal degrees), (4) elevation of the Pocahontas No. 3 coal bed (feet above mean sea level), (5) Pocahontas No. 3 coal bed thickness (ft), excluding parting. Records that contain a -999 in the elevation or thickness field represent invalid or unavailable data.]

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APPENDIX 2

POCAHONTAS NO. 3 COAL BED GEOCHEMICAL DATABASE

[This ASCII file contains all of the public records used to model the coal quality for the Pocahontas No. 3 coal bed and includes NCAID (record identifier), Source, State, county, longitude (decimal degrees), latitude (decimal degrees), coal province, coal region, coal field, district, coal formation, coal group, coal bed, sample thickness (ft), system, series/epoch, comments, map, collector, pointid (field identification number), estimated rank, lab code, sample type, analytical type, value represented, total moisture (percent), volatile matter (percent), fixed carbon (percent), ASTM ash (American Society for Testing and Materials; percent), hydrogen (percent), carbon (percent), nitrogen (percent), oxygen (percent), sulfur (percent), SO_2 (lbs/million Btu), gross calorific value (Btu/lb), air dried loss (percent), sulfate sulfur (percent), pyritic sulfur (percent), organic sulfur (percent), free swelling index, ash deformation temperature (degrees Fahrenheit), ash softening temperature (degrees Fahrenheit), ash fluid temperature (degrees Fahrenheit), USGS ash (U.S. Geological Survey; percent), Si (percent), Al (percent), Ca (percent), Mg (percent), Na (percent), K (percent), Fe (percent), Ti (percent), S (percent), Ag (ppm), As (ppm), B (ppm), Ba (ppm), Be (ppm), Br (ppm), Cd (ppm), Ce (ppm), Cl (ppm), Co (ppm), Cr (ppm), Cs (ppm), Cu (ppm), Dy (ppm), Er (ppm), Eu (ppm), F (ppm), Ga (ppm), Gd (ppm), Ge (ppm), Hf (ppm), Hg (ppm), La (ppm), Li (ppm), Lu (ppm), Mn (ppm), Mo (ppm), Nb (ppm), Nd (ppm), Ni (ppm), Pb (ppm), Pr (ppm), Rb (ppm), Sb (ppm), Sc (ppm), Se (ppm), Sm (ppm), Sn (ppm), Sr (ppm), Ta (ppm), Tb (ppm), Th (ppm), Tl (ppm), U (ppm), V (ppm), W (ppm), Y (ppm), Yb (ppm), Zn (ppm), Zr (ppm).]

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APPENDIX 3

METADATA FOR THE POCAHONTAS NO. 3 COAL BED GEOCHEMICAL DATABASE

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APPENDIX 4

REFERENCES FOR THE POCAHONTAS NO. 3 COAL BED GEOCHEMICAL DATABASE

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*All contact information current as of February 13, 2001.

APPENDIX 5

ORIGINAL COAL RESOURCES BY OVERBURDEN, RELIABILITY, AND COAL-BED-THICKNESS CATEGORIES, AND BY STATE AND COUNTY, FOR THE POCAHONTAS NO. 3 COAL BED

[Resources are rounded to millions of short tons and two significant figures. Reliability categories are as follows: identified, resources calculated for area within 3 mi of a coal-thickness measurement; hypothetical, resources calculated for area farther than 3 mi from a coal-thickness measurement. Asterisk indicates less than 10,000 short tons; St., State.]

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APPENDIX 6

REMAINING COAL RESOURCES BY OVERBURDEN, RELIABILITY, AND COAL-BED-THICKNESS CATEGORIES, AND BY STATE AND COUNTY, FOR THE POCAHONTAS NO. 3 COAL BED

[Resources are rounded to millions of short tons and two significant figures. Reliability categories are as follows: identified, resources calculated for area within 3 mi of a coal-thickness measurement; hypothetical, resources calculated for area farther than 3 mi from a coal-thickness measurement. Asterisk indicates less than 10,000 short tons; St., State.]

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