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Chapter C

A Digital Resource Model of the Upper Pennsylvanian Pittsburgh Coal Bed, Monongahela Group, Northern Appalachian Basin Coal Region

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Maryland Geological Survey
Ohio Division of Geological Survey
Pennsylvania Bureau of Topographic and Geologic Survey
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

CONTENTS

FIGURES

TABLES

CHAPTER C—A DIGITAL RESOURCE MODEL OF THE UPPER PENNSYLVANIAN PITTSBURGH COAL BED, MONONGAHELA GROUP, NORTHERN APPALACHIAN BASIN COAL REGION

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ABSTRACT

The assessment of the Upper Pennsylvanian Pittsburgh coal bed was carried out in partnership with the State geological surveys of Pennsylvania, West Virginia, Ohio, and Maryland. The resource model indicates that of the original 34 billion short tons of Pittsburgh coal, 16 billion short tons remain. Although most of the remaining coal is thinner (3.5- to 7.0-ft, 42- to 84-inch category), deeper (500 to 2,000 ft), and higher in ash yield and sulfur content than previously mined coal, there are blocks of extensive, thick (6 to 8 ft) coal in southwestern Pennsylvania and the northern panhandle of West Virginia.

INTRODUCTION

The Upper Pennsylvanian Pittsburgh coal bed and its geologically equivalent non-coal strata (herein collectively referred to as the Pittsburgh coal-bed horizon), which often can be recognized by the presence of carbonaceous or mottled shale, are located in the northern Appalachian Basin coal region (fig. 1). The coal-bed horizon is extensive and continuous, extending over 11,000 mi^2 through 53 counties in Pennsylvania, West Virginia, Ohio, and Maryland (fig. 2). The far eastern boundary of the coal-bed horizon is bounded by Allegany County, Md., and Somerset and Cambria Counties, Pa. The western boundary is in Lawrence County, Ohio, and the northeastern and northwestern boundaries are in Armstrong County, Pa., and Carroll County, Ohio, respectively. Wayne County, W. Va. contains the southernmost occurrence of the Pittsburgh coal-bed horizon. The Pittsburgh coal bed itself extends over 5,000 mi^2. The coal bed thins to the west and reaches its maximum thickness in western Maryland and northeastern West Virginia. The Pittsburgh coal bed is a high-rank, high-volatile A bituminous, medium-ash, and medium-sulfur coal that is used for both metallurgical and steam purposes.

The Pittsburgh coal bed is the most extensively mined coal bed in the Appalachian Basin coal region. It is one of many minable coal beds that were deposited throughout Pennsylvanian and Permian time (330–265 Ma) in a subsiding foreland basin that was filled in with sediments eroded from an ancient landmass located to the east (Hatcher and others, 1989). (See Chapter B, this report, for additional information.) The Pittsburgh coal bed was formed during a hiatus in active clastic deposition, which allowed for the development of a huge peat mire that was destined to become one of the most valuable energy resources in the world.

The assessment model of the Pittsburgh coal bed is a cooperative effort between the U.S. Geological Survey (USGS), the Pennsylvania Bureau of Topographic and Geologic Survey (PAGS), the West Virginia Geological and Economic Survey (WVGES), the Ohio Division of

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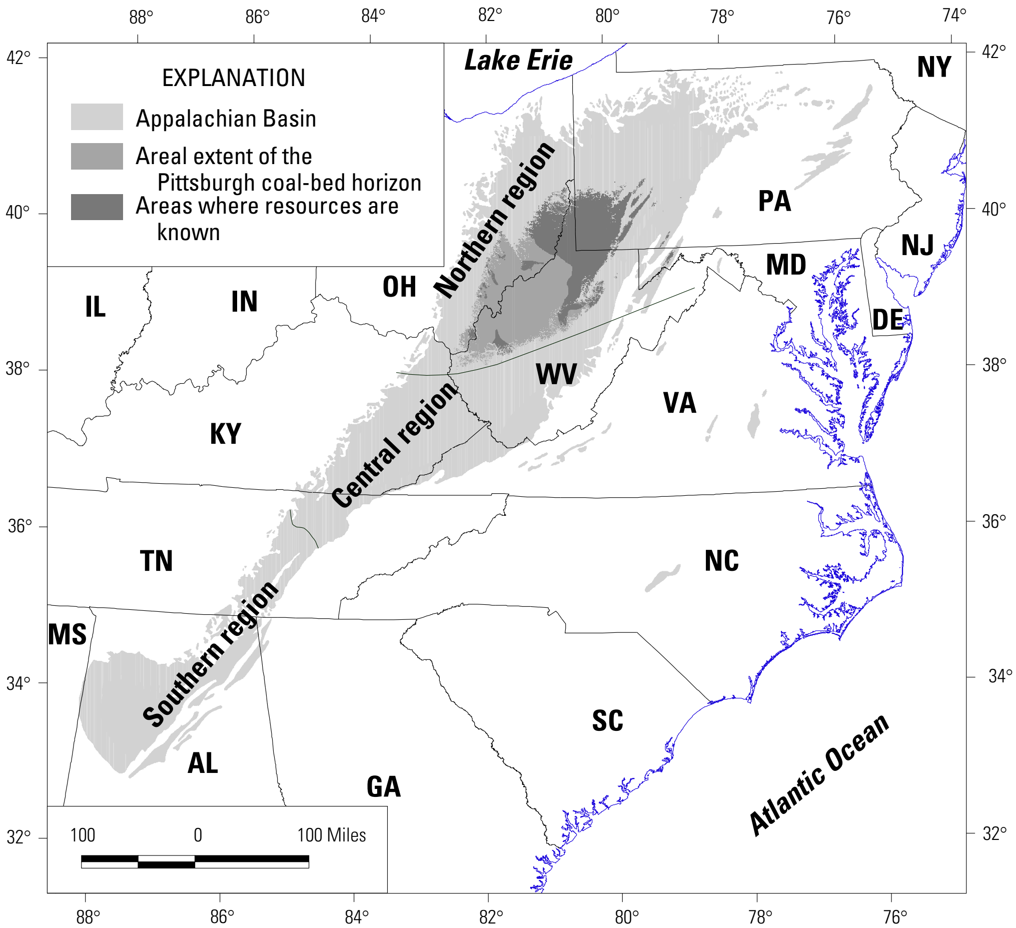

Figure 1. Map showing location of the northern and central coal regions in the Appalachian Basin. The Pittsburgh coal bed and geologically equivalent non-coal strata (collectively referred to as the Pittsburgh coal-bed horizon) are in the northern coal region.

Geological Survey (OGS), and the Maryland Geological Survey (MGS).

ACKNOWLEDGMENTS

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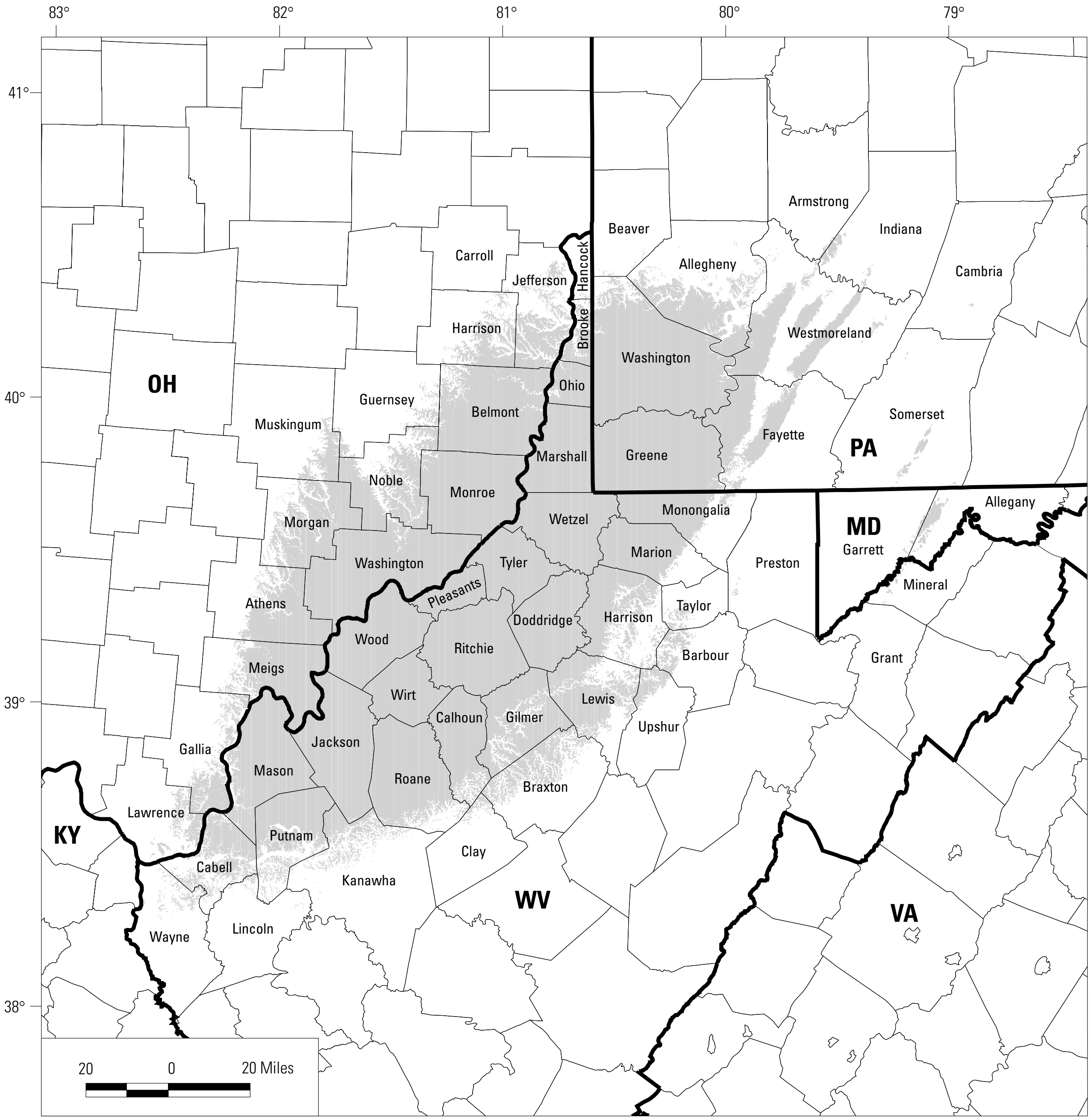

Figure 2. Map showing extent of the Pittsburgh coal-bed horizon (light gray). The Pittsburgh coal-bed horizon extends over 11,000 mi^2 through 53 counties in Pennsylvania, West Virginia, Ohio, and Maryland.

GEOLOGY

GEOLOGY OF THE MONONGAHELA GROUP

The Pittsburgh coal-bed horizon is at the base of the Upper Pennsylvanian Monongahela Group and divides the Monongahela Group from the underlying Conemaugh Group strata (fig. 3) in the Appalachian Basin. The Monongahela Group, first described by Rogers (1858) from exposures along the Monongahela River near Pittsburgh, Pa., includes the interval of the Pittsburgh coal bed at its base. The Monongahela Group ranges in thickness from about 200 ft in western Ohio to 430 ft in north-central West Virginia and consists of interbedded sandstone, siltstone, shale, limestone (nonmarine to marginal marine), and coal. Of the four coal beds (Pittsburgh, Redstone, Sewickley, and Uniontown) in the Monongahela Group that are, or have been, extensively mined, the Pittsburgh coal bed is the thickest and most extensive.

The Monongahela Group and other northern and central Appalachian Basin (fig. 1) Pennsylvanian sediments were deposited on an aggrading and prograding coastal plain within a foreland basin adjacent to the Alleghanian fold and thrust belt (Dominic, 1991). The distribution of some of the sediments, particularly the channel sands, may have been controlled in part by deep, Early Cambrian basement faults that were reactivated during the Alleghany orogeny (Root and Hoskins, 1977; Root, 1995). (For specific details, see Chapter B, this report.).

GEOLOGY OF THE PITTSBURGH COAL BED

The coal bed is composed of distinct subdivisions—a roof division and a lower division (called “main bench” in this report) (fig. 4). Stevenson (1876) first described the divisions, but the informal division terminology is still used by mining companies today. The roof division can contain multiple partings and varies in thickness from about 14 ft in Allegheny County, Pa., to less than 1 inch in Harrison County, W. Va. The roof division (fig. 5) pinches out completely to the south of Harrison County. The main bench is mined and is composed of the following four megascopically and petrographically distinct layers (Cross, 1954, fig. 4) that are recognizable on a regional scale: (1) breast, (2) bearing-in, (3) brick, and (4) bottom. Because the Pittsburgh roof division is rarely mined, roof coal has been omitted from resource calculations; resources are based on the main bench coal only.

The presence of (1) distinct, megascopically recognizable subdivisions, (2) interconnected mines, and (3) analyses of microfossil assemblages (Cross, 1954) that can be traced over the extent of the Pittsburgh coal bed indicates that the coal bed was deposited over a continuous surface. The surface of coal deposition was extensive and is estimated to be over 5,000 mi^2. In the geologic past, the coal may have extended far to the east and west of its present location; erosional remnants are reported in northern Allegheny, Armstrong, and Indiana Counties, Pa., and Jefferson County, Ohio (White and others, 1927). The coal was uplifted and later eroded, as surrounding sediments were folded and faulted during the Late Carboniferous (260 Ma) Alleghany orogeny (mountain-building event).

MINING HISTORY

The first reference to the Pittsburgh coal bed, named by H.D. Rodgers of the First Geological Survey of Pennsylvania (White, 1898), was on a 1751 map (Eavenson, 1938). Historic records indicate that the coal bed was first mined in the late 1750's from drift mines located about 200 ft above the Monongahela River across from Pittsburgh, Pa. The coal was poured into trenches dug into the hillside, rolled to the edge of the river, and then loaded onto boats where it was transported to the city. By the early 19th century, Pittsburgh coal became the city’s primary fuel source: about 250,000 bushels (approximately 400 short tons) of coal were consumed daily for domestic and light industrial use (Puglio, 1983). The primary reason for the switch from wood to coal was one of economics. In 1809, a cord of wood cost $2.00 and a bushel of coal cost $0.06, delivered. The coal was plentiful and laborers, working in mines within a mile of Pittsburgh, earned about $1.60 per week and could produce as many as 100 bushels of coal daily (Eavenson, 1938).

Pittsburgh coal was first mined in Maryland in 1804 near the town of Frostburg. By 1826, Pittsburgh coal was hauled 10 mi to Cumberland, Md., loaded onto flat boats, and shipped to Washington, D.C. In West Virginia, coal was mined locally in the early 19th century in Moundsville, Fairmont, Morgantown, and Clarksburg, and commercially in the mid 19th century after the railroads were built. Development of the Pittsburgh coal in Ohio more closely followed that of Pennsylvania because coal could be transported to markets along the Ohio and Muskingum Rivers.

With the introduction of canals and rail lines in Maryland, Ohio, West Virginia, and Pennsylvania in the mid to late 19th century, Pittsburgh coal production increased rapidly (fig. 6; Appendix 1). Maryland production increased from 1,700 short tons in 1812 to 2,200,000 in 1880; by 1898, production had increased to 4,000,000 short tons (Nicholls, 1898). Eavenson (1938) reports that between 1820 and 1880, Pittsburgh coal production increased from 35,000 to 1,600,000 short tons in Ohio; 37,100 to 1,100,000

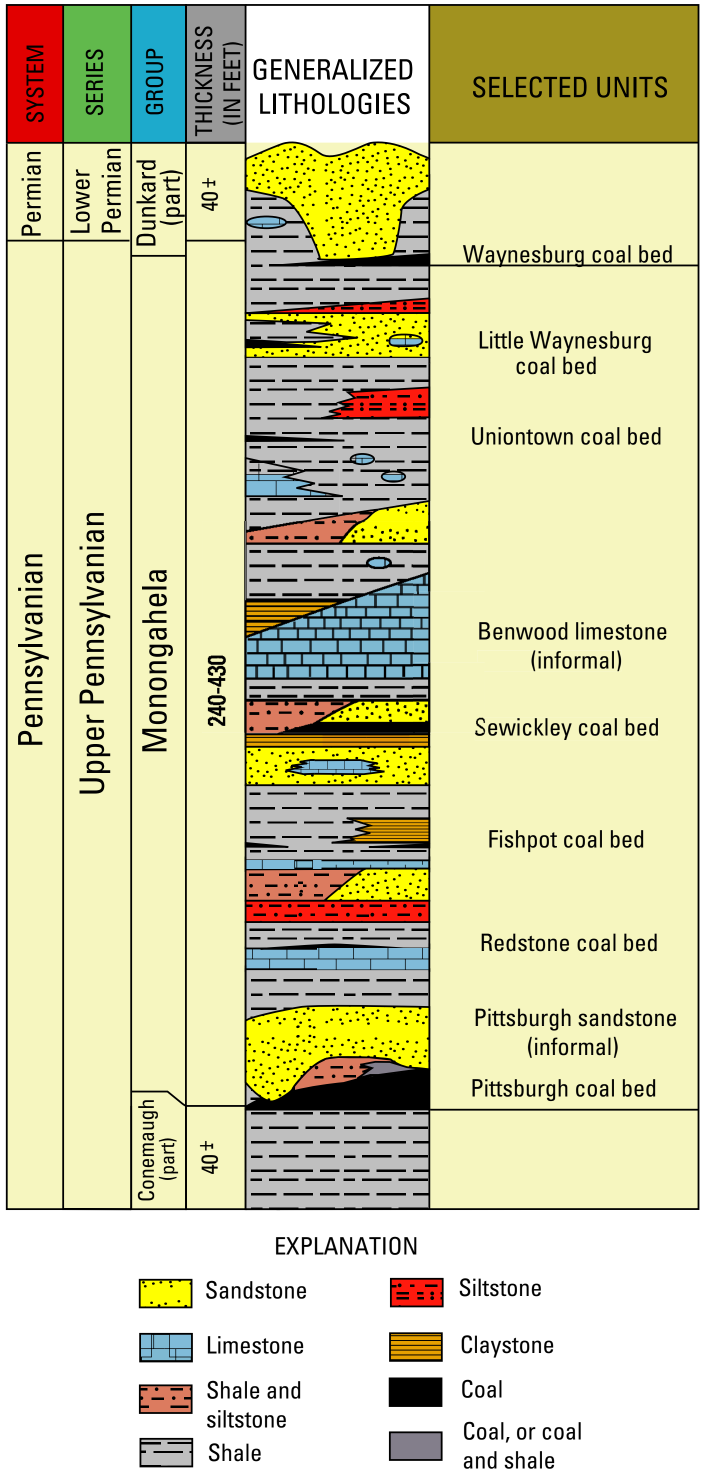

Figure 3. Generalized stratigraphic column of the Upper Pennsylvanian Monongahela Group showing major coal beds and the lower sandstone member of the Pittsburgh Formation, which is informally referred to as the Pittsburgh sandstone. The Pittsburgh coal bed is at the base of the Monongahela Group and separates it from the underlying Conemaugh Group in the northern Appalachian Basin coal region.

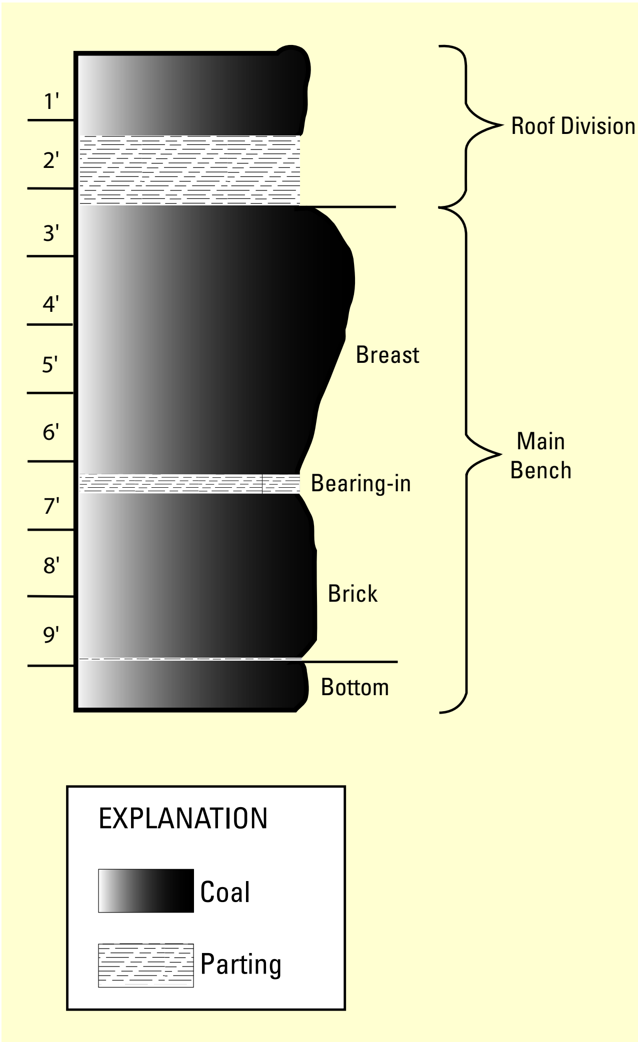

Figure 4. Stratigraphic column showing subdivisions of the Pittsburgh coal bed, first described by Stevenson (1876), near Riverville, Pa. Partings between the main bench and the roof division coal can be single or multiple. Each subdivision is visually and petrographically distinct and recognizable over the areal extent of the coal bed. Roof division coal is well developed and present in Pennsylvania and northern West Virginia, but is rarely mined and is not included in resource estimates. Modified from Cross (1954).

short tons in West Virginia; and 200,000 to 12,000,000 short tons in Pennsylvania (fig. 6; Appendix 1). Production increased throughout the 20th century and recent annual production data by State (fig. 7; Appendix 2) and by State and county (figs. 8–11; Appendixes 3–6) show that, except for Maryland, which is essentially mined-out except for re-mining, Pittsburgh coal production remains high. The coal bed remains the second largest producer in the Nation and the top-producing bed in the Appalachian Basin coal region (Energy Information Administration, 1997).

ASSESSMENT METHODOLOGY

DATABASES

Two databases, a stratigraphic database and a geochemical database, are the primary tools used to assess the Pittsburgh coal bed. The stratigraphic database, which was used to construct cross sections and structure-contour and isopach maps, contains data for over 5,000 drill cores, mine and outcrop descriptions, and an additional 2,000 records that contain only coal elevation data (fig. 12; Appendix 7). Approximately one-half of the records in the stratigraphic database hold detailed descriptions and measurements of the Pittsburgh coal bed, which include coal, parting, and impure, nonbanded (bone) coal data; the other records hold only total coal-bed thickness data. The Pittsburgh roof division, where present in Pennsylvania and northern West Virginia, is identified in the majority of stratigraphic records. The stratigraphic information on the main bench of the Pittsburgh coal bed can be downloaded in ASCII format from Appendix 7.

The Pittsburgh coal bed geochemical database (Appendixes 8, 9) consists of data from in-ground, mine, tipple, and delivered samples on an as-received basis and was derived from a variety of sources including the USGS, U.S. Bureau of Mines, The Pennsylvania State University, and other Federal and State sources as well as published analyses (see Appendix 10). Additional information on data sources, handling, averaging, and formatting are detailed in Appendix 9. About one-third of the 3,377 analyses entered into the database are located by precise latitude and longitude coordinates (fig. 13). The others are considered to be reliable and accurate at least to a county scale. One-hundred-sixty-four records contain analyses for as many as 86 different trace elements; the remaining records contain ash yield, sulfur content, and gross calorific value (British thermal units per pound, Btu/lb). Because many of the Pittsburgh coal bed samples were collected in intervals or benches, they were aggregated to obtain representative analyses of the complete chemistry at any one location. The geochemical database, metadata, and references can be downloaded in ASCII format from Appendixes 8, 9, and 10, respectively.

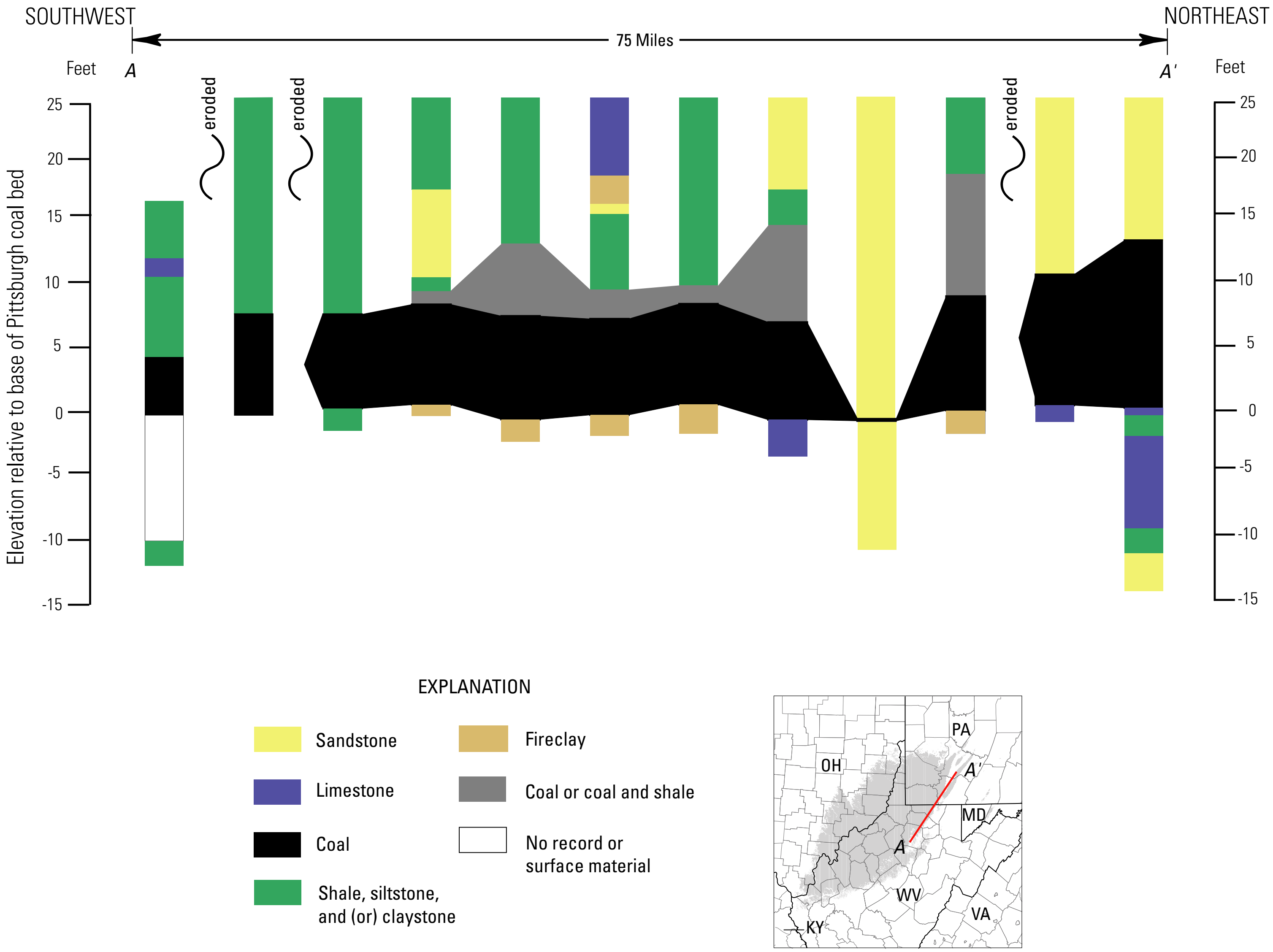

Figure 5. Generalized cross section of the Pittsburgh coal bed trending southwest from Harrison County, W. Va., northeast to Allegheny County, Pa. (fig. 2). The cross section shows the generalized thickening of the Pittsburgh roof division (coal, or coal and shale facies). The roof division can contain multiple partings and varies in thickness (fig. 4). Columns represent individual coal cores on the line of section *A-A′*. Vertical exaggeration X9900.

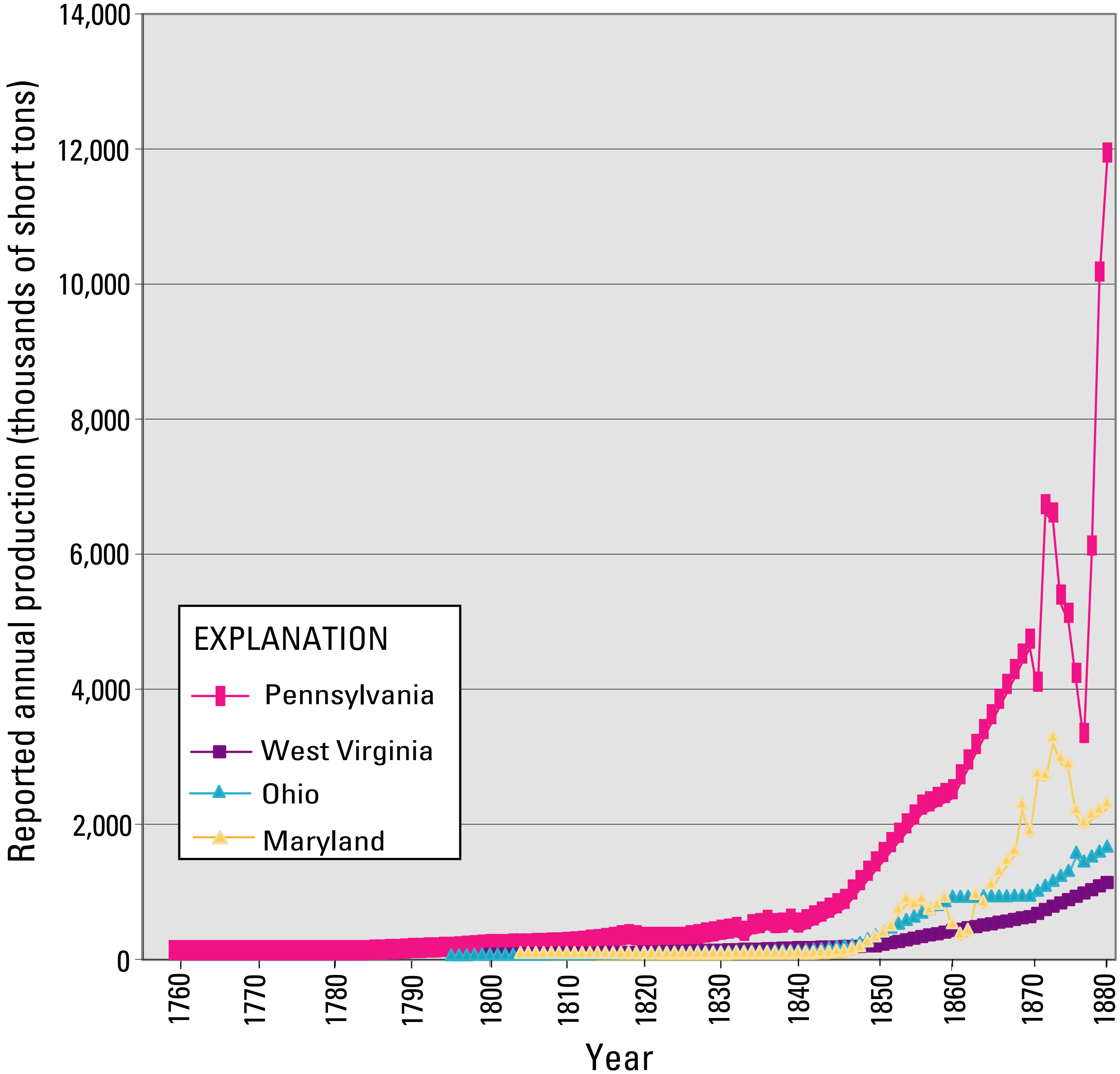

Figure 6. Graph showing historic reported annual production (in thousands of short tons) from the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland from 1750 to 1880. Sources: United States Congress (1789–1822), United States Census Office, 8th Census (1860), Beatty (1849), Scharf (1882), Clark and Campbell (1905); also see Appendix 1.

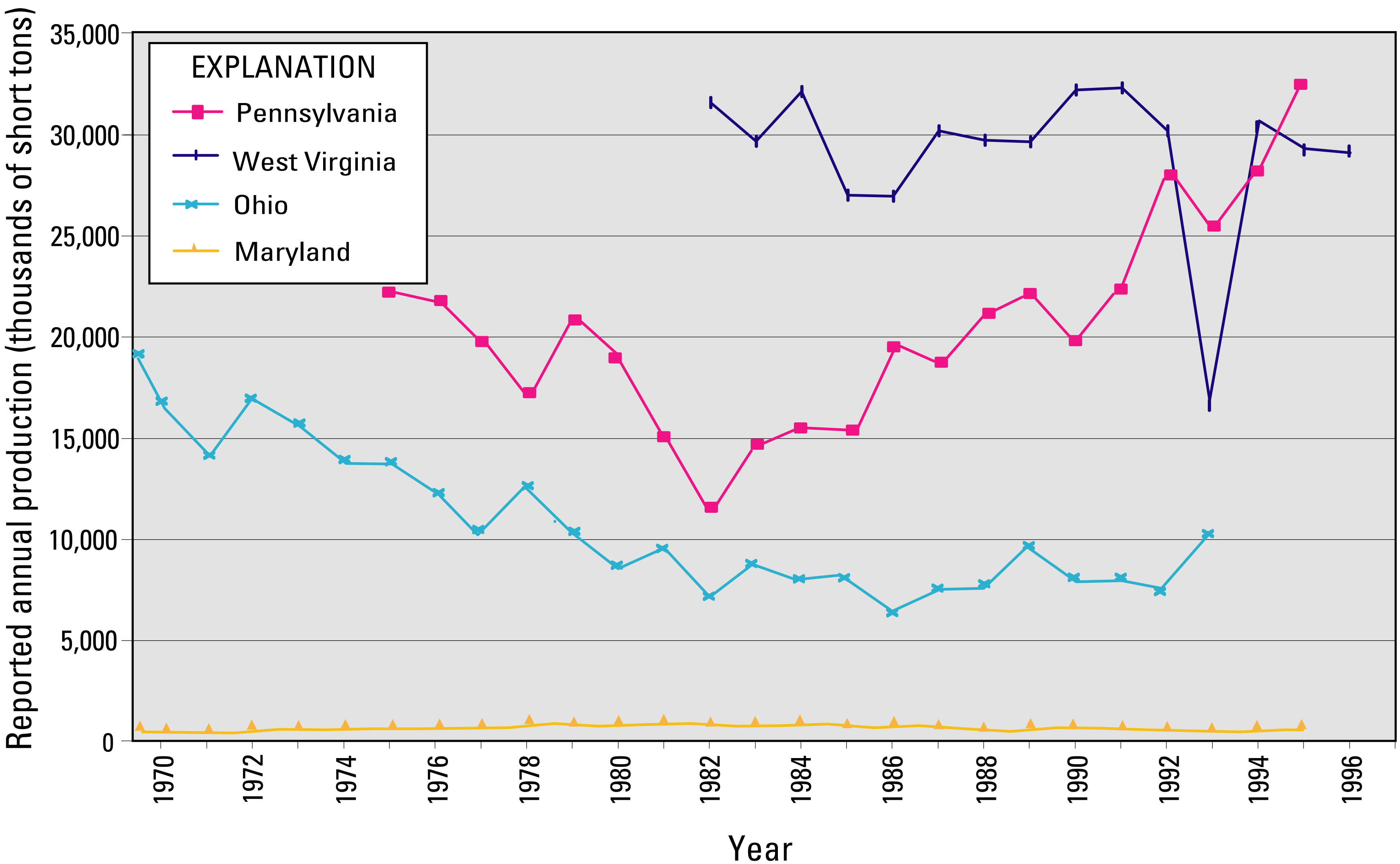

Figure 7. Graph showing recent reported annual production (in thousands of short tons) from the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland, assembled from State agencies. Sources: Ohio Division of Labor Statistics (1969–1981, 1982–1993), Maryland Bureau of Mines (1969–1995), Commonwealth of Pennsylvania (1975–1995), Gayle H. McColloch (West Virginia Geological and Economic Survey, unpublished search of West Virginia Office of Miner's Health, Safety, and Training—Safety Information System (MHST-SIS) database, 1997); also see Appendix 2.

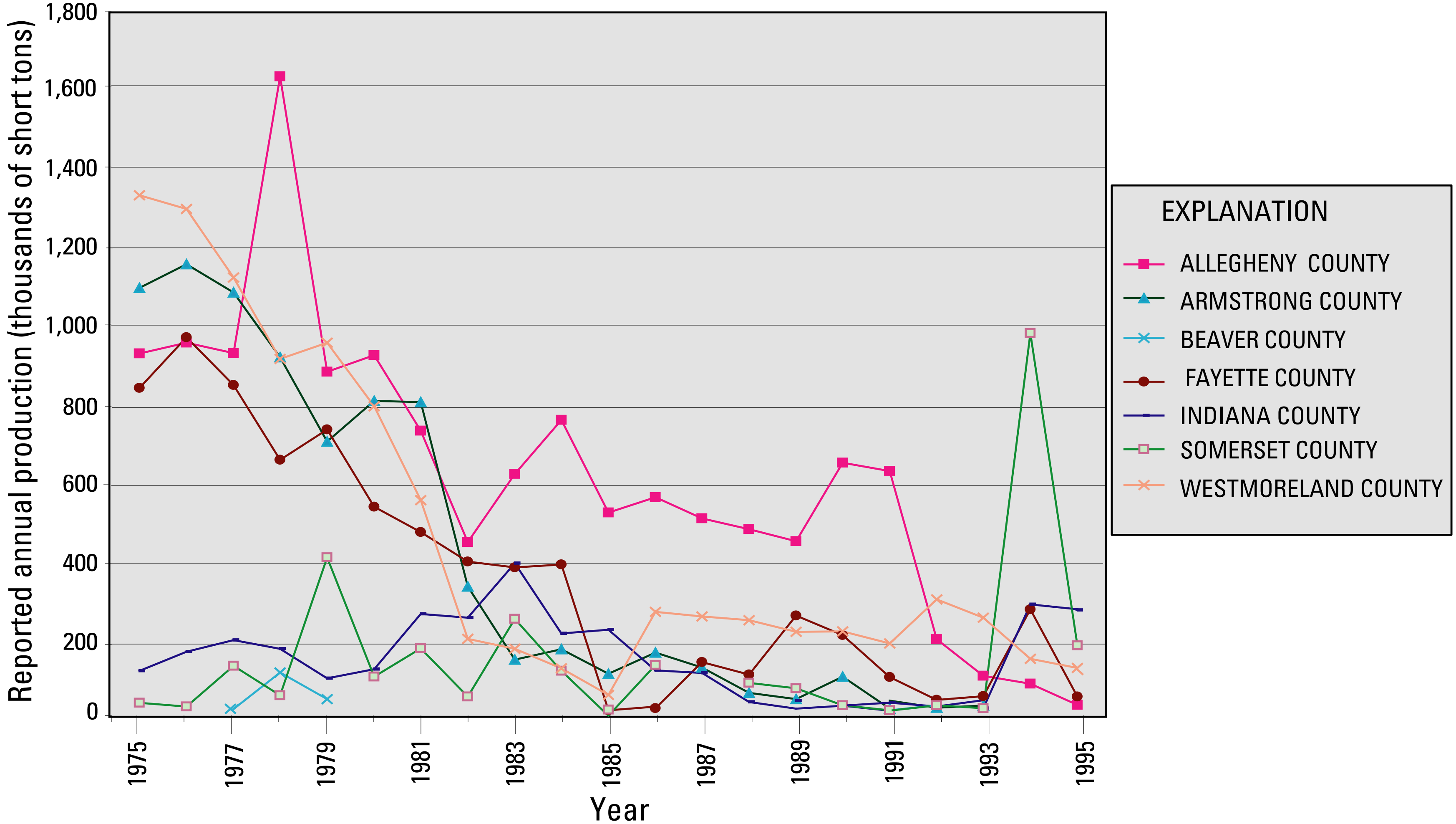

Figure 8. Graph showing recent reported annual production (in thousands of short tons) from the Pittsburgh coal bed in selected Pennsylvania counties from 1975 to 1995. Production of the Pittsburgh coal bed is significantly greater in Greene and Washington Counties and is not plotted on this figure, to allow for the comparison of production among other counties. Bedford, Jefferson, and Lawrence Counties produced <350,000 short tons of Pittsburgh coal between 1975 and 1995 and are also not plotted on this figure. Source: Commonwealth of Pennsylvania (1975–1995); also see Appendix 3.

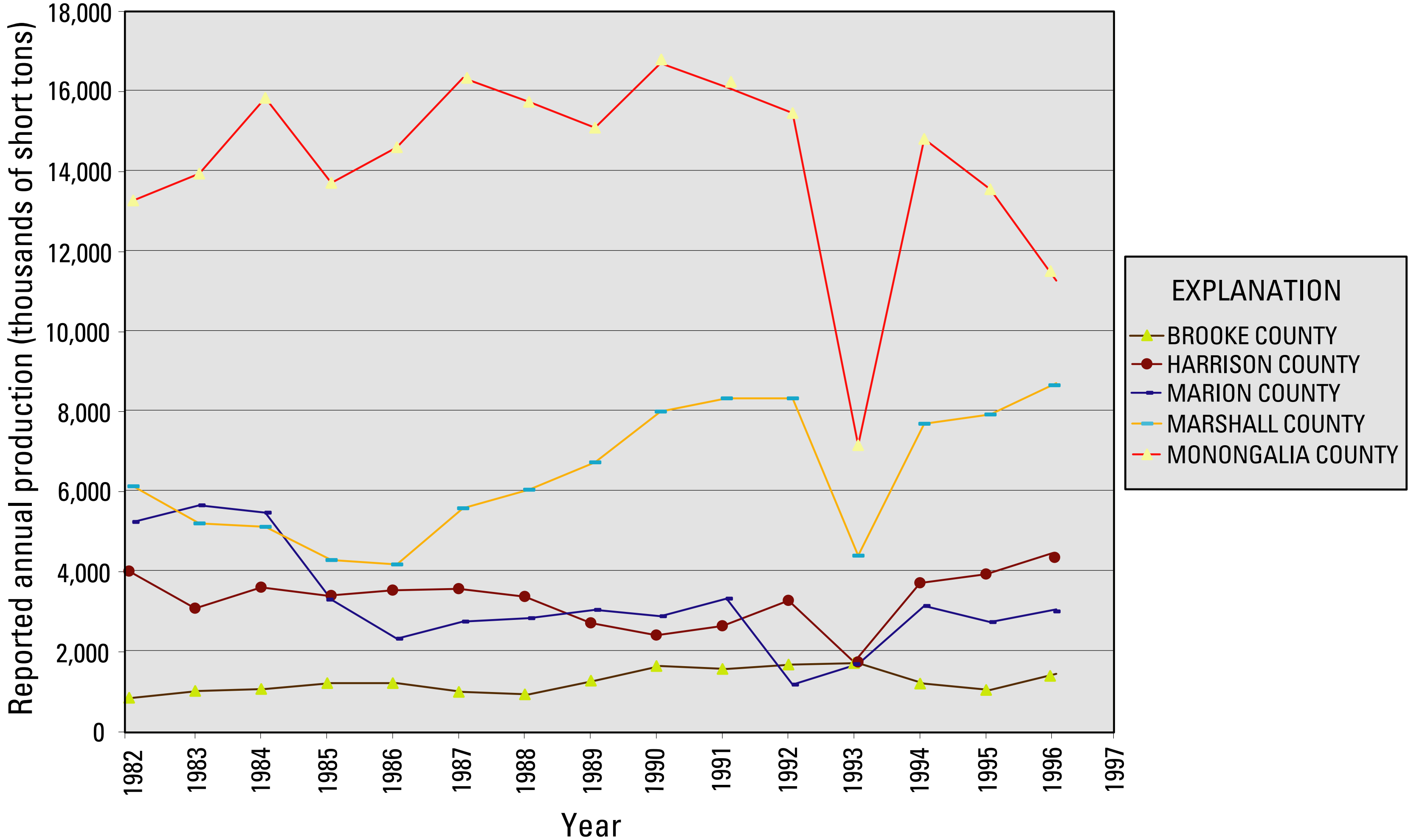

Figure 9. Graph showing recent reported annual production (in thousands of short tons) from the Pittsburgh coal bed in West Virginia's top-producing counties. Source: Gayle H. McColloch (West Virginia Geological and Economic Survey, unpublished search of West Virginia Office of Miner's Health, Safety, and Training—Safety Information System (MHST-SIS) database, 1997); also see Appendix 4.

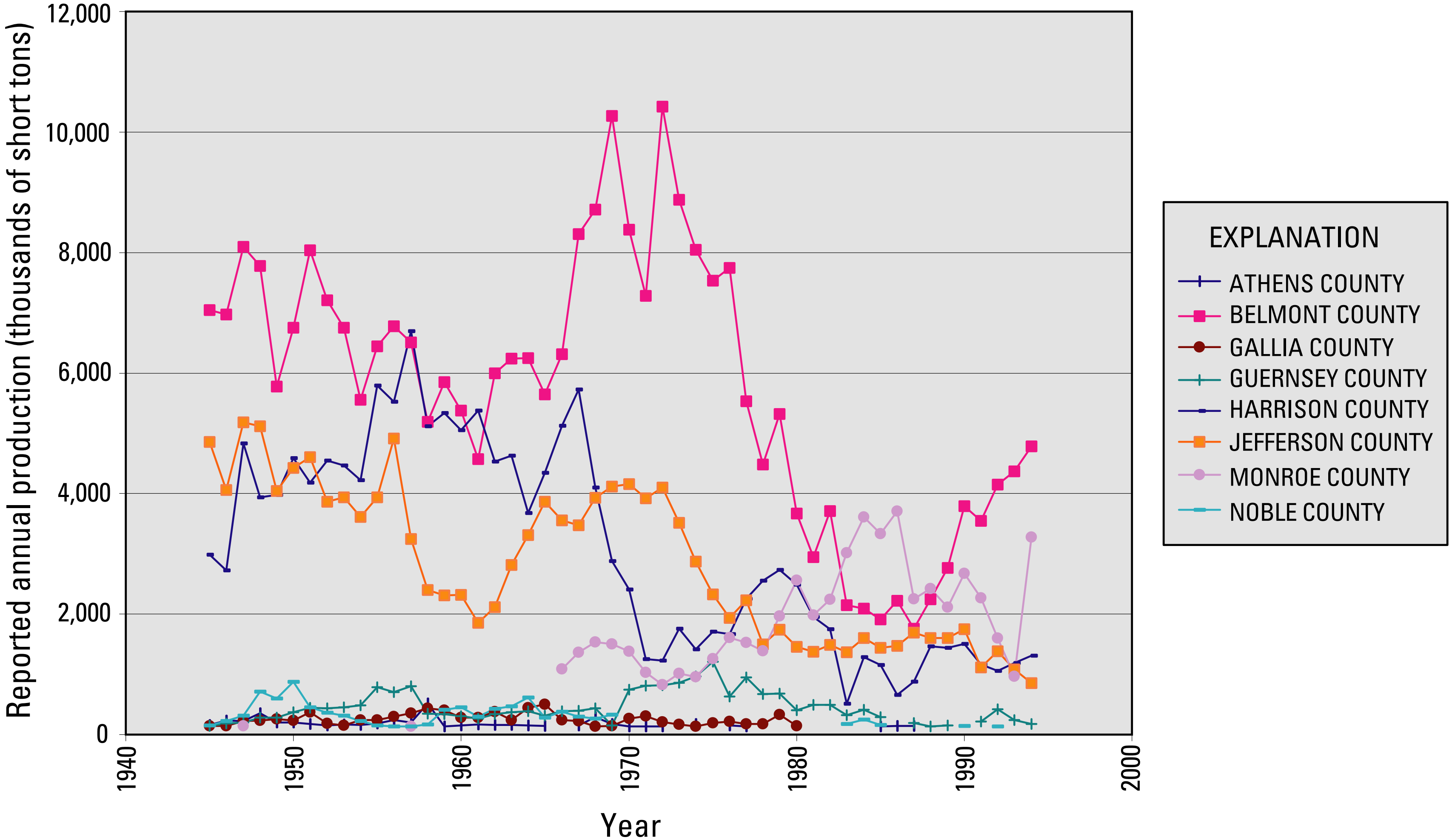

Figure 10. Graph showing recent reported annual production (in thousands of short tons) from the Pittsburgh coal bed in Ohio's top-producing counties from 1945 to the present. Meigs and Washington Counties are not included on this figure because their significant Pittsburgh coal bed production occurred before 1969. Source: Ohio Division of Labor Statistics (1945–1946, 1947–1965, 1966–1981, 1982–1993); also see Appendix 5.

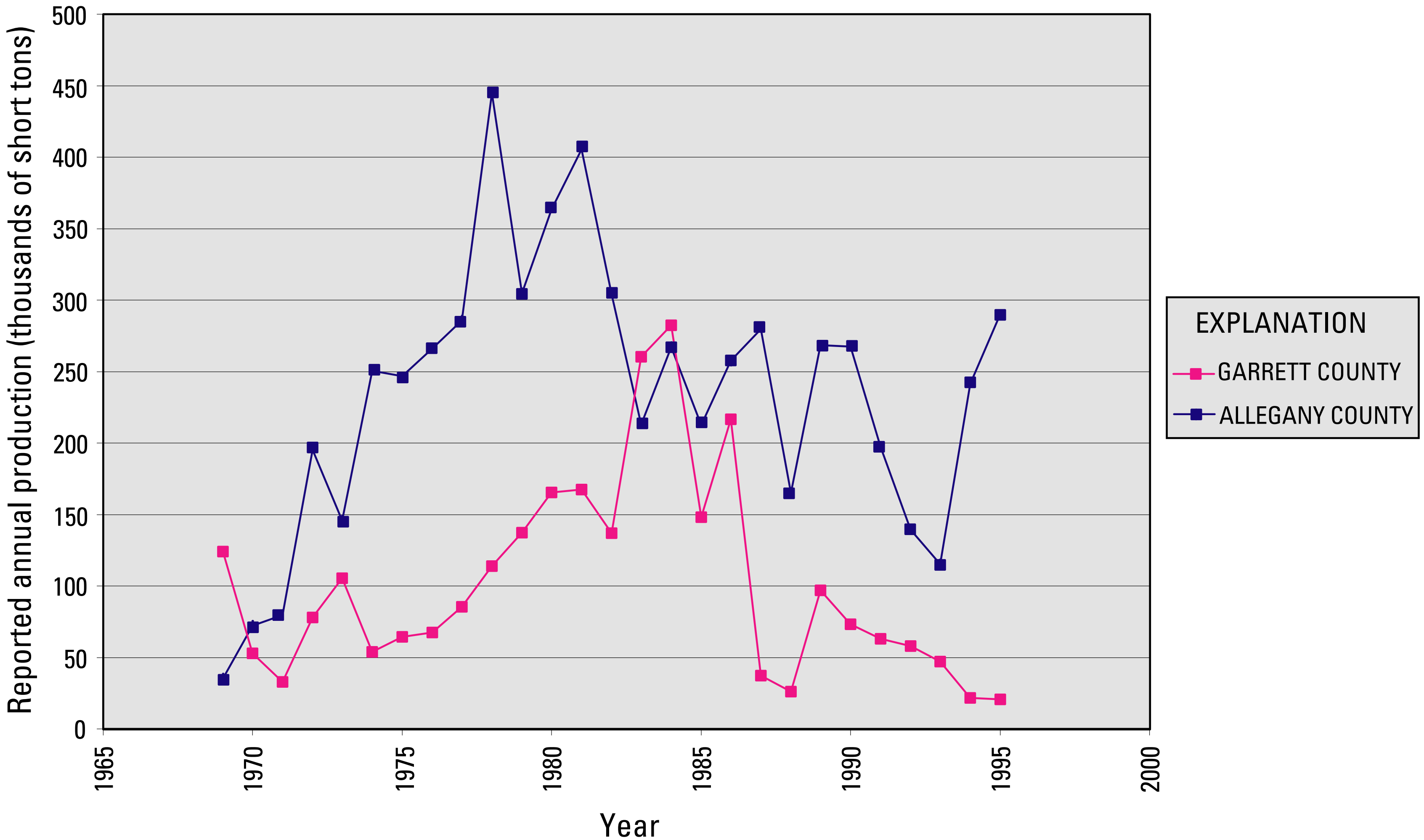

Figure 11. Graph showing recent reported annual production (in thousands of short tons) from the Pittsburgh coal bed in Maryland, by county. Source: Maryland Bureau of Mines (1969–1995); also see Appendix 6.

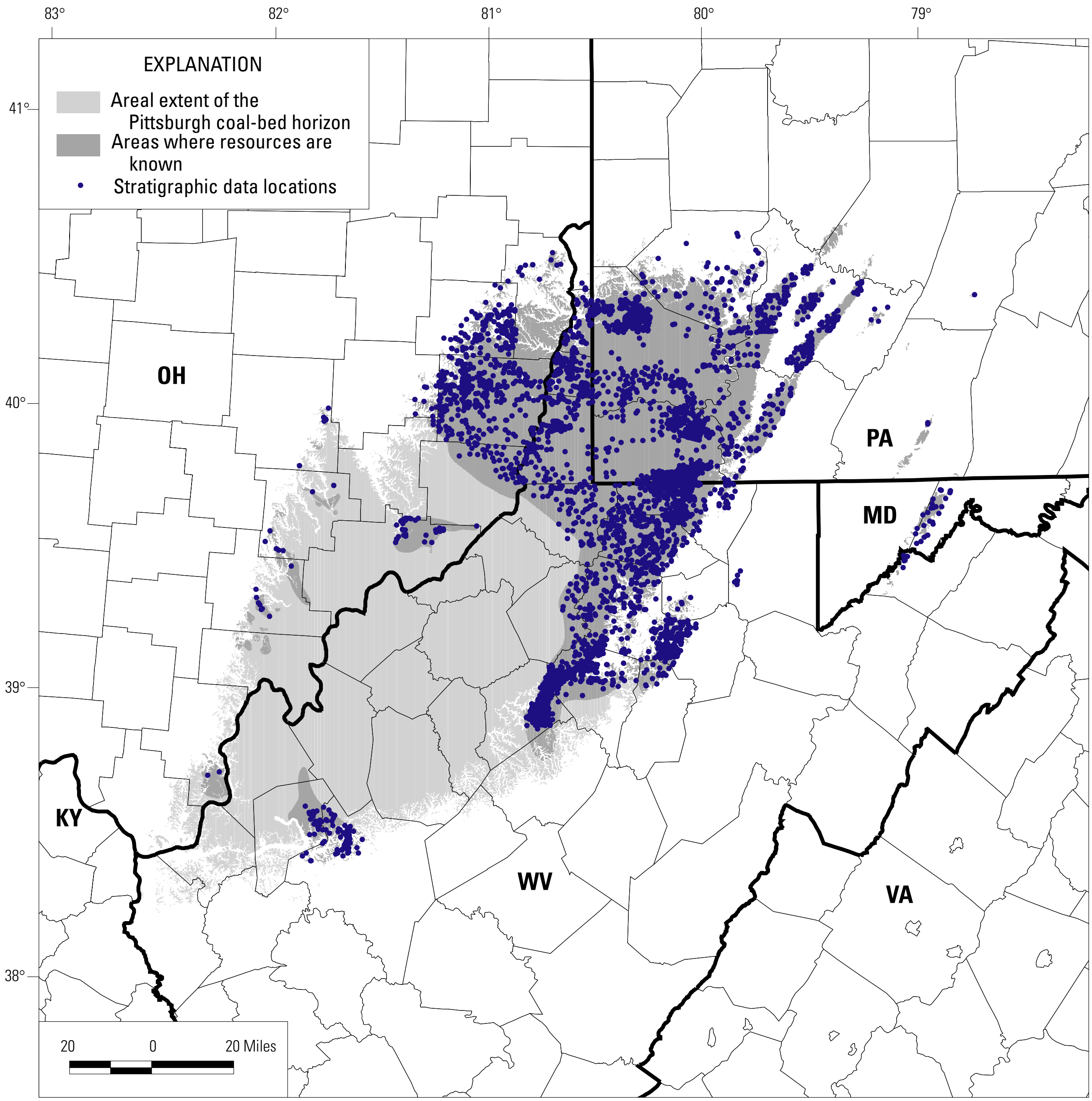

Figure 12. Map showing point locations of stratigraphic records that are publicly available and were used to model the coal resources of the Pittsburgh coal bed. Point identifier or record name, latitude, longitude, coal elevation, and coal thickness for all records can be downloaded from Appendix 7 in ASCII format. See figure 2 for county names.

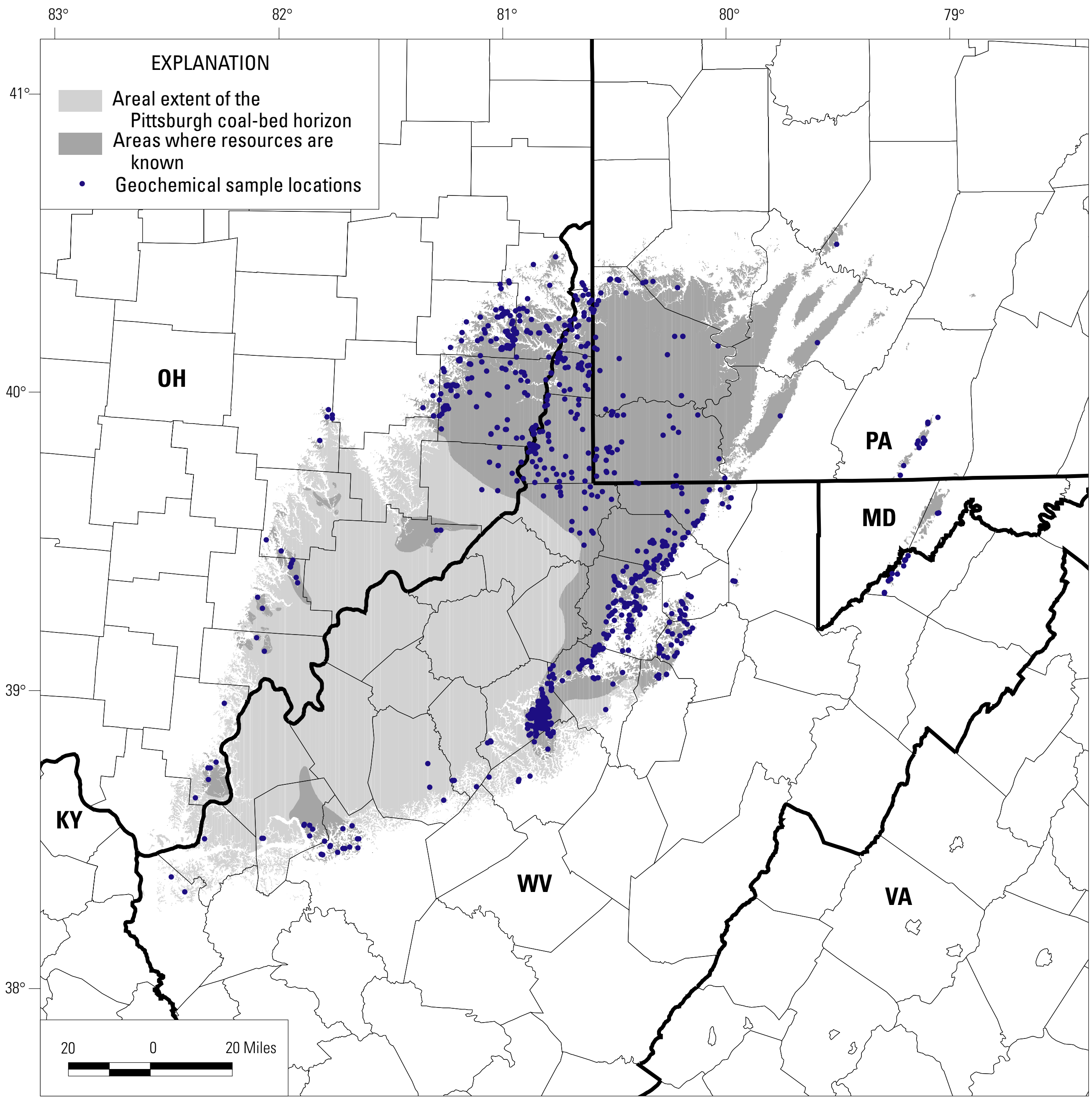

Figure 13. Map showing point locations of geochemical samples of the Pittsburgh coal bed for which records are publicly available and located by latitude and longitude. All publicly available geochemical data can be downloaded in ASCII format from Appendix 8. See figure 2 for county names.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

The Pittsburgh coal bed map, which shows areal extent, areas of inadequate subsurface control, thin or absent coal (Pittsburgh coal-bed horizon), and mined areas of the coal (fig. 14), was completed by collecting and digitally converting, transforming, and combining data from over 100 paper maps at scales ranging from 1:24,000 to 1:250,000 (see Appendix 11). The Pittsburgh coal-bed horizon was differentiated from the Pittsburgh coal bed (areas where resources are known) based on published maps from the WVGES, OGS, and field observations (Appendix 11). The digital maps were then manually edited and combined to create a single GIS data set (coverage) for each State; all were combined to create a single GIS coverage for the areal extent of the Pittsburgh coal-bed horizon.

The mined areas coverage for Pennsylvania was compiled from a map created by a commercial firm (J.T. Boyd, Pittsburgh, Pa.) and State geological survey information. In West Virginia, WVGES open-file maps at 1:24,000 scale (see Ruppert and others, 1997) were digitized to complete the mined areas. In southeastern Ohio, USGS topographic maps were used to identify strip mines and disturbed areas because mined-area coverages were not available for eight counties (Athens, Gallia, Guernsey, Meigs, Morgan, Muskingum, Noble, and Washington). Currentness of mined area information varies based on the dates of release of the data sources. The combined areas of known resources and mines were used to limit structure-contour, overburden-thickness, and coal-isopach GIS coverages for presentation purposes.

Mined areas include areas that could be re-mined, given favorable economic and regulatory conditions. Re-mining, which commonly involves removing pillars from abandoned mines, is the primary source of Pittsburgh coal production in Maryland and in Somerset County, Pa.

Structure contours of the Pittsburgh coal bed (fig. 15; Appendix 12) were generated from all records in the stratigraphic database. Because of the paucity of available stratigraphic data in Fayette and Westmoreland Counties, Pa., and Wetzel County, W. Va., over 2,000 additional data records containing latitude, longitude, and elevation of the Pittsburgh coal bed were digitized from published structure-contour maps (Shaulis, 1985; Skema, 1988; Fedorko, 1990a–k). The structure contours are presented in 50-ft intervals on the top of the Pittsburgh coal bed main bench.

Overburden thickness (fig. 16; Appendix 13) was calculated by subtracting the structure-contour grid (created for the top of the Pittsburgh coal bed) from a grid created from USGS 1:250,000- and 1:100,000-scale digital elevation models (Appendix 13). The contour intervals used for overburden thickness (0–200 ft, >200–500 ft, >500–1,000 ft, and >1,000–2,000 ft) are based on criteria from Wood and others (1983). Although the maximum depth in the classification is 2,000 ft, the greatest overburden thickness is actually about 1,450 ft and is in Wetzel County, W. Va. (fig. 2).

Thickness contours, or isopach lines (fig. 17; Appendix 14) of the main bench of the Pittsburgh coal bed were generated from 4,553 stratigraphic records. Thickness values of the main bench of the Pittsburgh coal bed locations (x and y coordinates) were exported from the database. Identified partings and bone coal with thicknesses more than 0.38 in were generally excluded (Wood and others, 1983) and therefore are not included in the summation of coal thickness. The isopach map was contoured into 1.17-ft (14-in) intervals for presentation here (Appendix 14).

RESOURCE MODELING AND METHODOLOGY

The original and remaining resources were calculated for the Pittsburgh coal bed using the thickness and overburden coverages discussed previously. USGS reliability category coverages (measured, indicated, inferred, and hypothetical of Wood and others, 1983) were generated around all available thickness data points and combined into a single coverage for resource calculations.

To retain all criteria necessary for resource calculations (Wood and others, 1983), contour-line coverages for coal bed and overburden thicknesses were combined with mined-area and reliability coverages, and a county-line coverage (USGS, 1:100,000 digital line graphs). Resources were calculated by multiplying the area of each polygon by the average coal thickness within the polygon (using a thickness coverage contoured into 1.17-ft intervals) and then multiplying by a tonnage factor of 0.445 short tons/ft-m^2 (representing the weight of the coal per unit volume). The coverage's attributes were exported to a spreadsheet for the summation of original and remaining resources for each county by reliability, thickness of coal, and overburden thickness categories. In the eight Ohio counties (Athens, Gallia, Guernsey, Meigs, Morgan, Muskingum, Noble, and Washington) where the percentages of surface mining were visually estimated from areas of disturbance on 7.5-minute quadrangle topographic maps, remaining coal resources were determined by reducing the areas used to calculate original resources by these percentages.

Original and remaining resources, by county, thickness, and USGS reliability categories, are shown in Appendixes 15 and 16. Table 1 shows resource totals by State and county only. Original and remaining State resource totals are shown graphically by thickness in figure 18, by overburden in figure 19, and by reliability categories in figure 20.

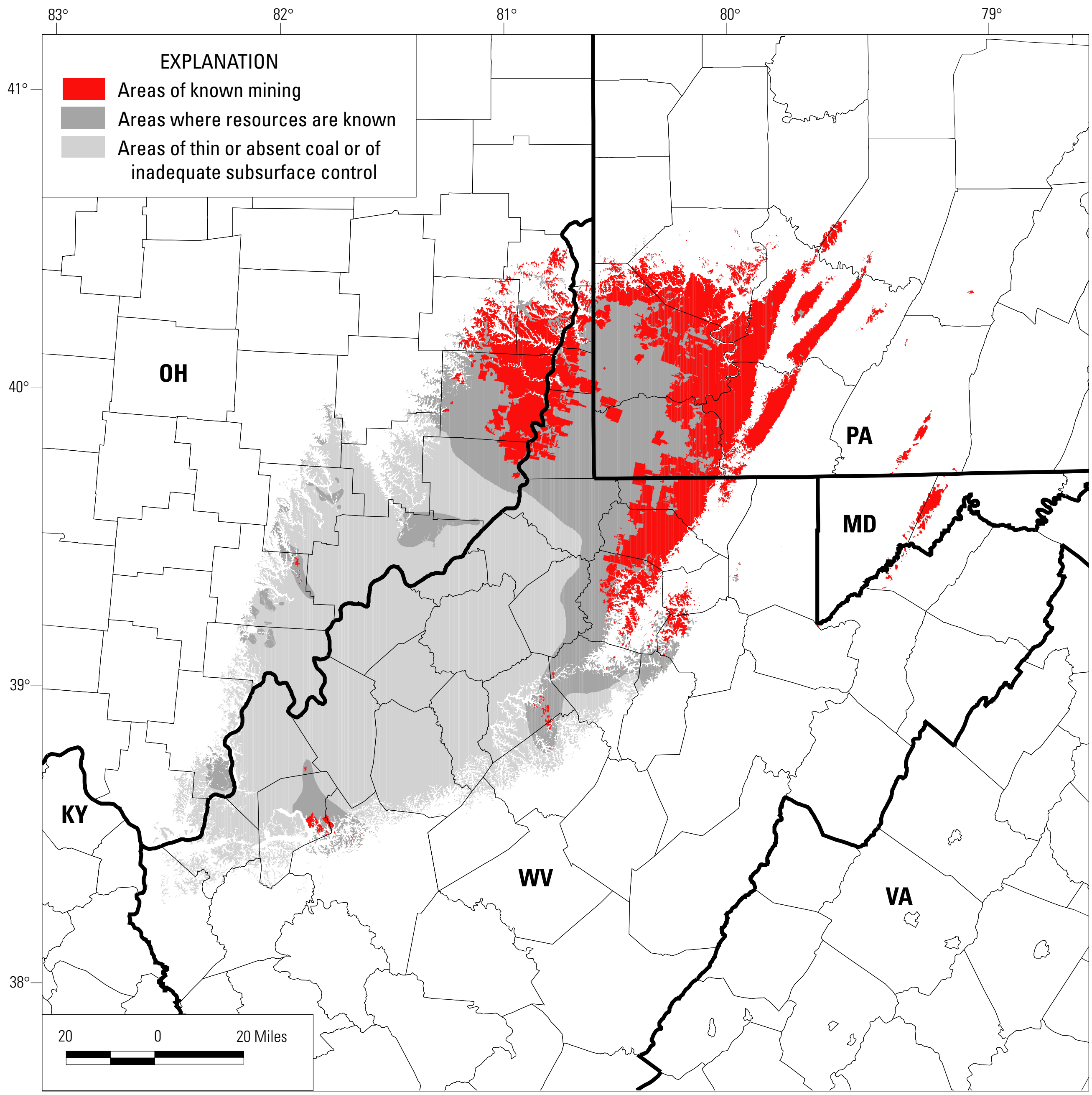

Figure 14. Map showing areal extent of the Pittsburgh coal bed where resources are known (dark gray), the Pittsburgh coal-bed horizon (light gray), and mined areas (red). Mined areas include those areas that could be reopened given favorable economic circumstances. Currentness of mined areas is dependent on the date of the source of information (Appendix 11; Ruppert and others, 1997). See figure 2 for county names.

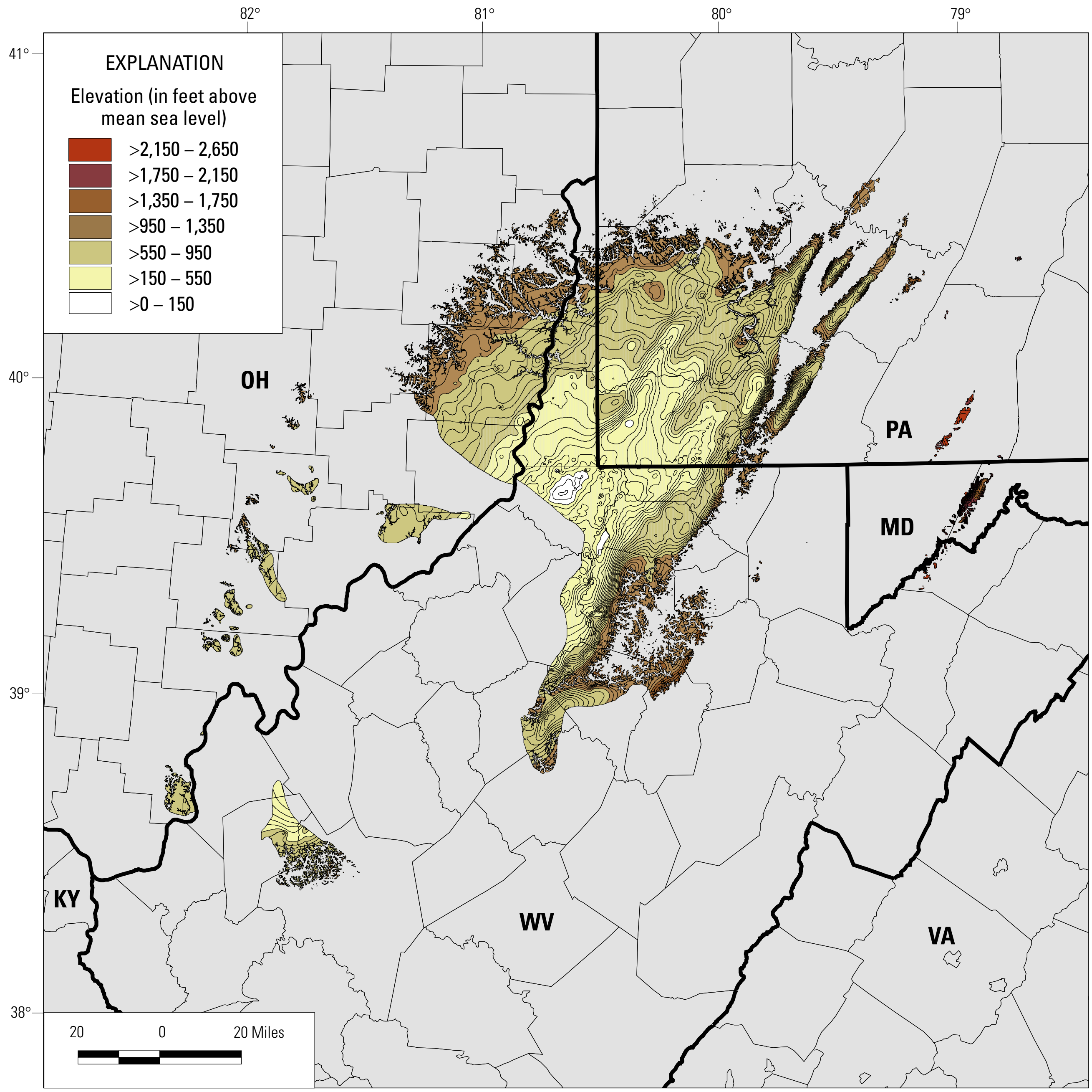

Figure 15. Structure-contour map of the Pittsburgh coal bed. The contour elevations are presented on the top of the coal bed at 50-ft intervals; however, for visual acuity, most contours were colored in 400-ft intervals. Approximately 7,000 elevations were used to generate the map. Structure is not shown on the Pittsburgh coal-bed horizon because of the paucity of data (Appendix 12; Tewalt, Ruppert, Bragg, Carlton, Brezinski, Yarnell, and Wallack, 1997). See figure 2 for county names.

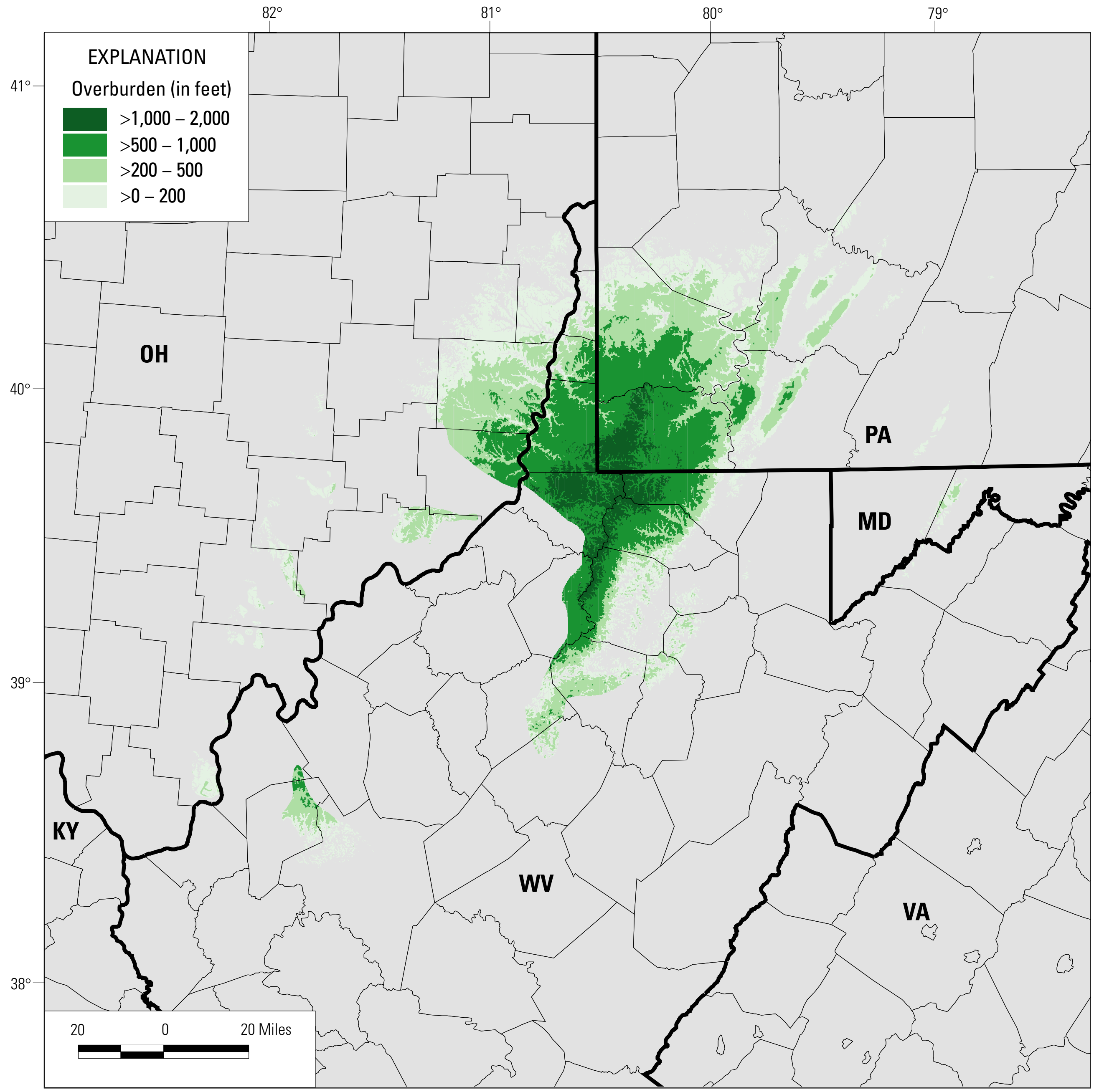

Figure 16. Overburden thickness map of the Pittsburgh coal bed. The overburden thickness was calculated by subtracting the structure-contour grid on the top of the Pittsburgh coal bed from DEM (digital elevation models) topography. The contour intervals for overburden thickness are variable, based on criteria from Wood and others (1983). Although the deepest category is classified as 1,000 to 2,000 ft, the greatest overburden thickness is actually about 1,450 ft and is in Wetzel County, W. Va. (Appendix 13; Tewalt, Ruppert, Bragg, Carlton, Brezinski, Yarnell, and Wallack, 1997). See figure 2 for county names.

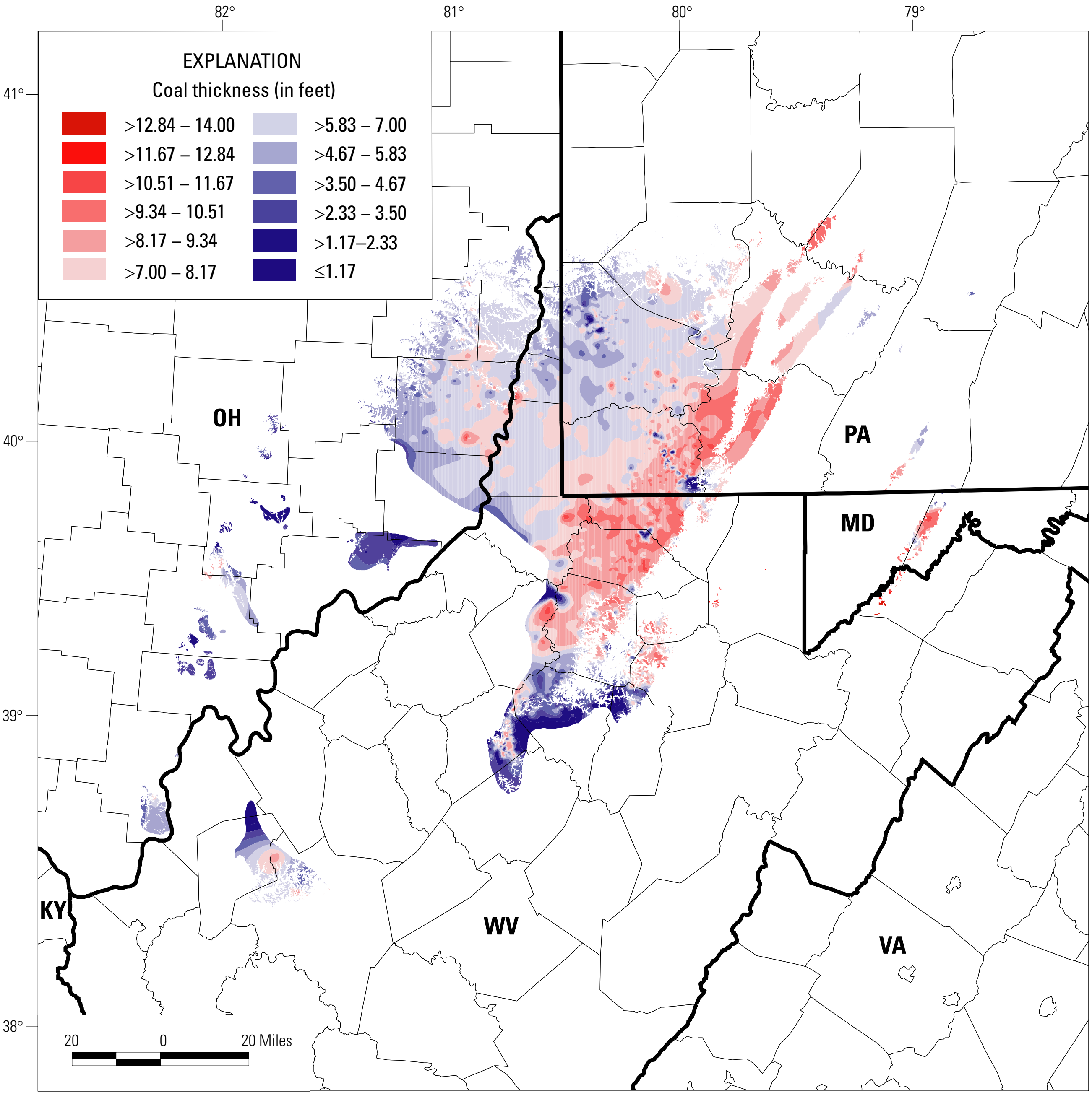

Figure 17. Map showing thickness contours (isopachs) of the main bench of the Pittsburgh coal bed. The thickness isopachs, presented in 1.17-ft intervals, were generated from 4,553 stratigraphic records. The Pittsburgh coal bed tends to thin toward the west and southwest (Appendix 14; Tewalt, Ruppert, Bragg, Carlton, Brezinski, Yarnell, and Wallack, 1997). See figure 2 for county names.

Table 1. Original and remaining resources by State and county for the Pittsburgh coal bed, rounded to millions of short tons.

[In some counties, the sum of inferred and hypothetical resources (Wood and others, 1983) is greater than 70 percent of the total county resource; these county names and totals are shown in bold and italicized type.]

State/County	Original	Remaining	State/County	Original	Remaining
PENNSYLVANIA			Preston	16	11
Allegheny	1,400	29	***Putnam***	***320***	***260***
Armstrong	***42***	***2.5***	Taylor	110	2.1
Beaver	***9.6***	***5.1***	Upshur	76	75
Cambria	2.1	0	***Wetzel***	***1,700***	***1,700***
Fayette	***2,200***	***1.8***	West Virginia Total	13,000	7,800
Greene	4,200	2,600			
Indiana	***160***	***3.4***	OHIO		
Somerset	***96***	***0***	***Athens***	***200***	***190***
Washington	4,800	2,300	Belmont	2,900	1,400
Westmoreland	***1,900***	***31***	Gilmer	240	210
Pennsylvania Total	15,000	5,000	Carroll	0.014	0.014
			Gallia	***180***	***160***
WEST VIRGINIA			Guernsey	66	44
Barbour	***290***	***130***	Harrison	520	98
Braxton	***68***	***61***	***Jefferson***	***810***	***120***
Brooke	280	110	***Meigs***	***30***	***27***
Doddridge	***610***	***610***	***Monroe***	***910***	***730***
Gilmer	240	210	***Morgan***	***47***	***39***
Grant	***0.58***	***0***	Muskingum	13	11
Hancock	5.4	1.1	Noble	30	29
Harrison	1,900	1,000	***Washington***	***190***	***180***
Kanawha	***290***	***270***	Ohio Total	5,900	3,200
Lewis	450	450			
Marion	2,000	680	MARYLAND		
Marshall	2,000	1,500	Allegany	240	0
Mineral	38	0	Garrett	21	0
Monongalia	1,700	500	Maryland Total	261	0
Ohio	590	200			
			TOTAL	**34,000**	**16,000**

PREVIOUS RESOURCE STUDIES

Most of the State geological surveys have published resource estimates for the Pittsburgh coal bed dating back into the early 1900's. Estimates of resources from this study compare reasonably well with historic figures, which have been rounded to two significant digits for purposes of discussion.

The West Virginia Geological and Economic Survey, in a series of county reports (Grimsley, 1907; Hennen and White, 1909, 1911, 1912; Hennen and others, 1913; Krebs and Teets, 1913; Reger and White, 1916; Hennen and Gawthrop, 1917; Reger and Teets, 1918; Reger and Tucker, 1924), identified total original Pittsburgh resources in 26 counties to be about 13.7 billion short tons. The USGS studied 20 of these counties; the USGS estimate of original coal resources matched the West Virginia county reports' estimate of 13 billion short tons for those 20 counties. The Ohio Division of Geological Survey (Brant and DeLong, 1960) published Pittsburgh "reserve" estimates totaling 5.5 billion tons in 13 counties (reserves were calculated from coal greater than 1.17 ft thick). The USGS estimate in Ohio totals 5.9 billion tons, a difference of about 6 percent. In Pennsylvania, Reese and Sisler (1928) estimated resources to be 14 billion tons for the Pittsburgh coal, whereas the USGS estimate totals 15 billion tons, with an absolute difference of about 330 million tons or 2 percent.

RESULTS AND DISCUSSION

The Pittsburgh coal bed was deposited on a single stratigraphic horizon and was of minable thickness over a large part of southwestern Pennsylvania, southeastern Ohio, western Maryland, and northern West Virginia (figs. 14, 17). There is a very distinct thickening of the Pittsburgh coal bed to the east (figs. 5, 17) which may be the result of accommodation space increases from tectonic loading or sea-level rise. Although the Pittsburgh coal bed was removed by erosion from Maryland west to Monongalia County, W. Va., and thickens eastward (fig. 21), it is regionally extensive and relatively thick (5–7 ft) in southern Pennsylvania, northern West Virginia (including part of the northern panhandle), and in adjacent areas in eastern Ohio, where large blocks are available for mining (figs. 22, 23). The remaining blocks are deeper (500–2,000 ft overburden categories) (figs. 16, 23) than much of the coal that has been

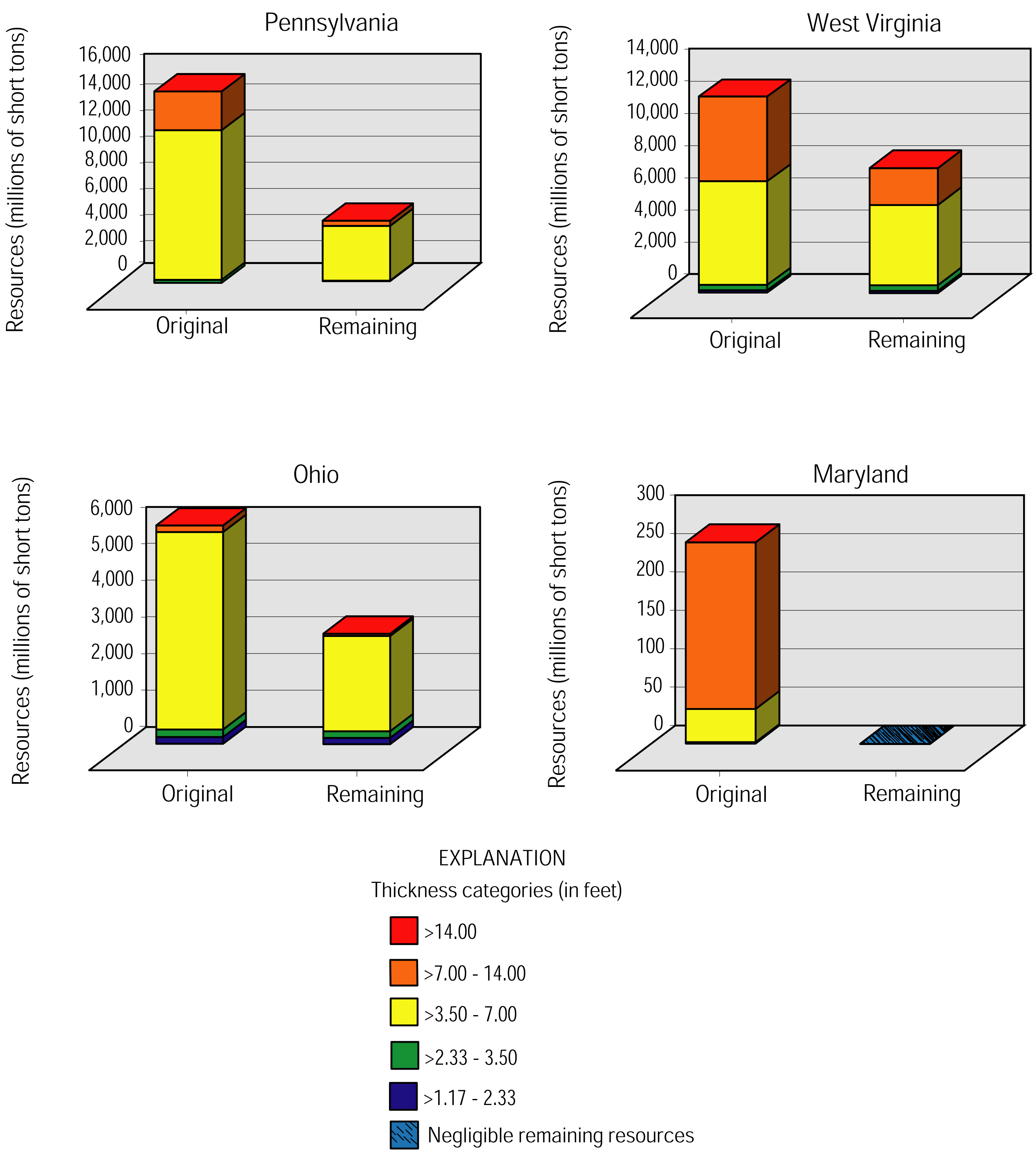

Figure 18. Bar graphs showing original and remaining Pittsburgh coal bed resources (millions of short tons), by State and USGS thickness categories. Note that a large percentage of the Pittsburgh coal thicker than 84 inches (7 ft) has been mined. The majority of remaining Pittsburgh coal is in the 42- to 84-inch (3.5- to 7-ft) category.

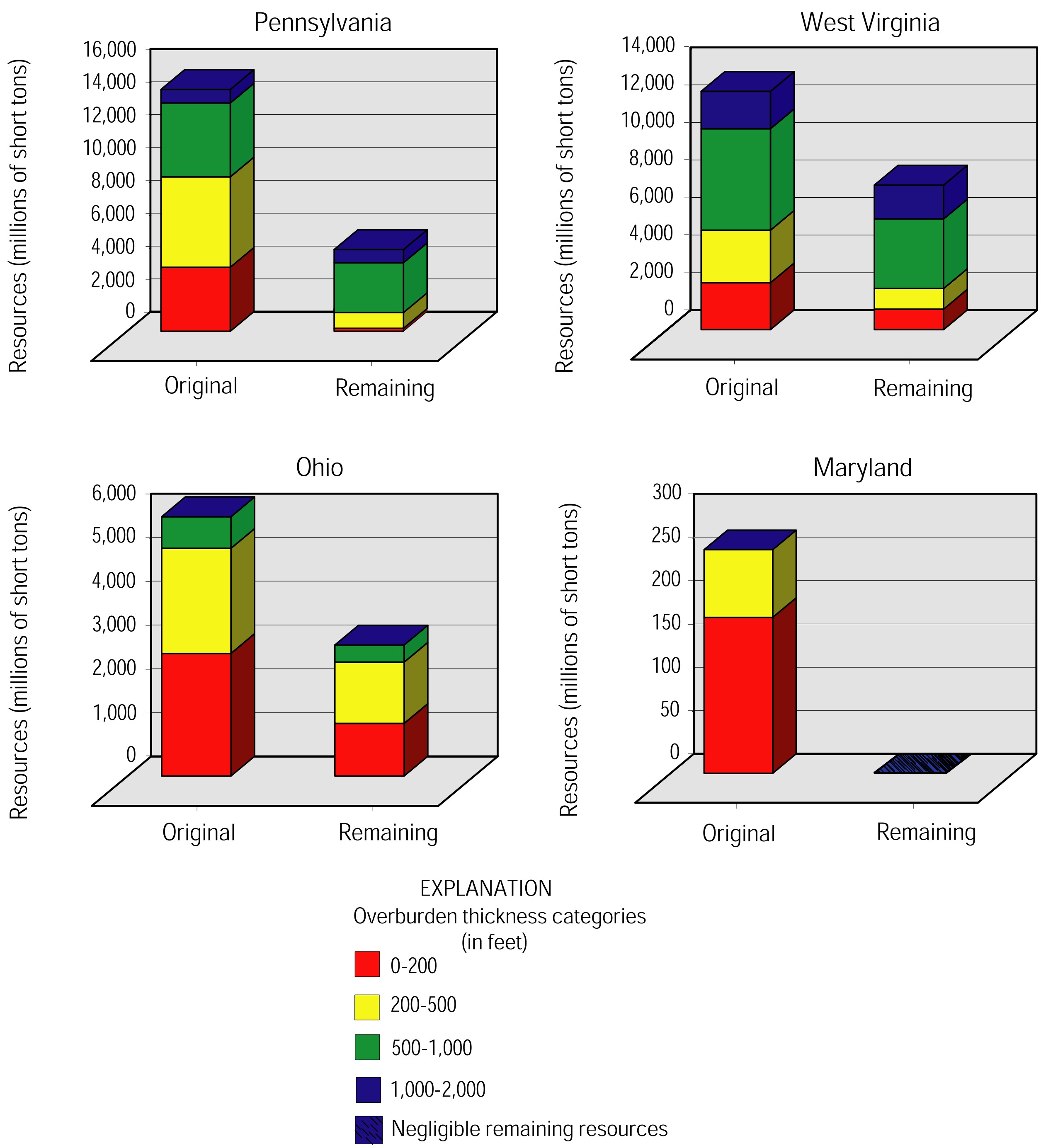

Figure 19. Bar graphs showing original and remaining Pittsburgh coal bed resources (millions of short tons), by State and USGS overburden thickness categories. Although the deepest overburden category is classified as up to 2,000 ft, the greatest overburden thickness is actually about 1,450 ft and is in Wetzel County, W. Va. (fig. 16).

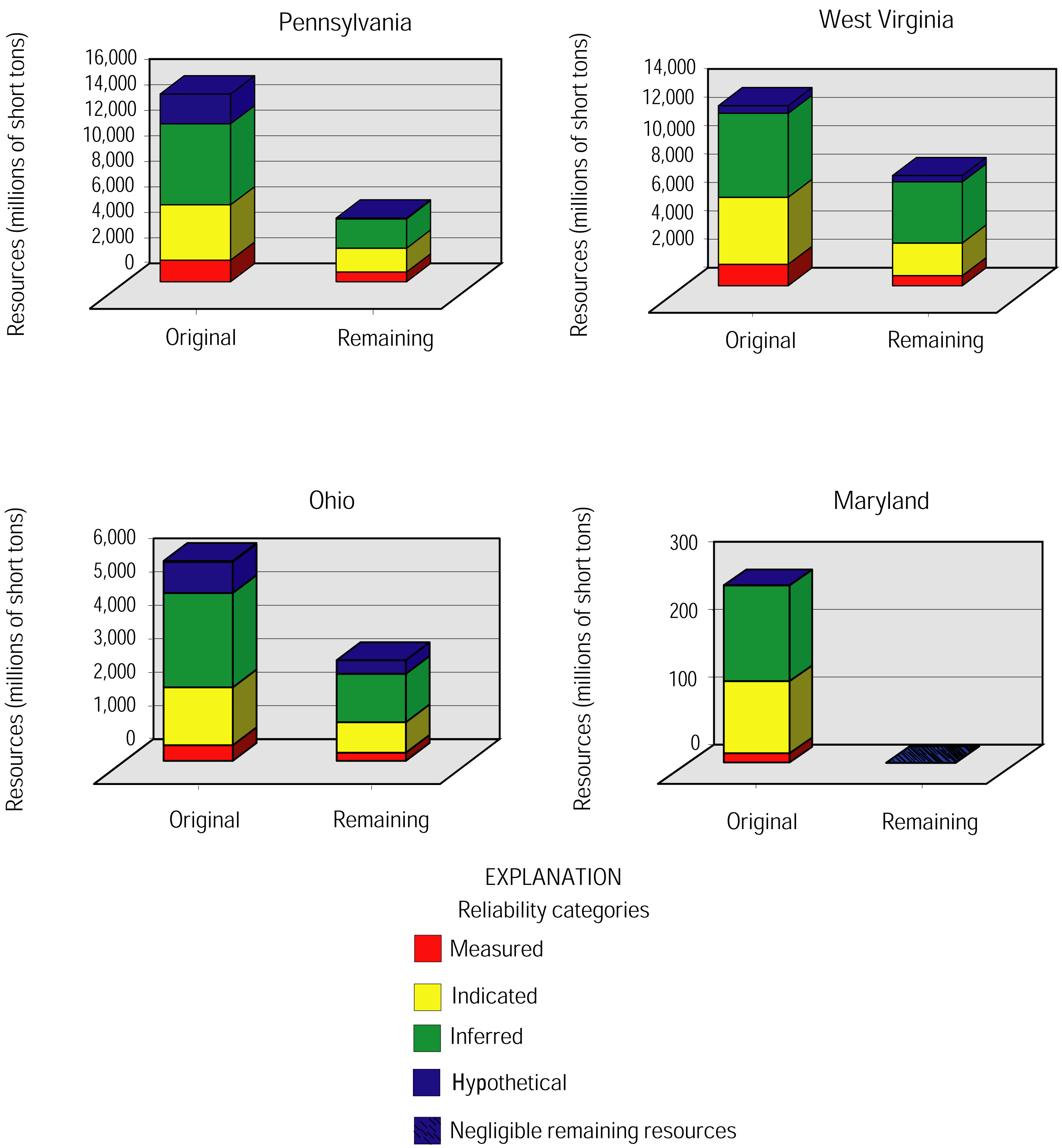

Figure 20. Bar graphs showing original and remaining Pittsburgh coal bed resources (millions of short tons), by State and USGS reliability categories. Measured resources are located within 0.25 mile of a thickness measurement, indicated resources are between 0.25 and 0.75 mile of a thickness measurement, inferred resources are between 0.75 and 3 miles of a thickness measurement, and hypothetical resources are beyond 3 miles of a thickness measurement.

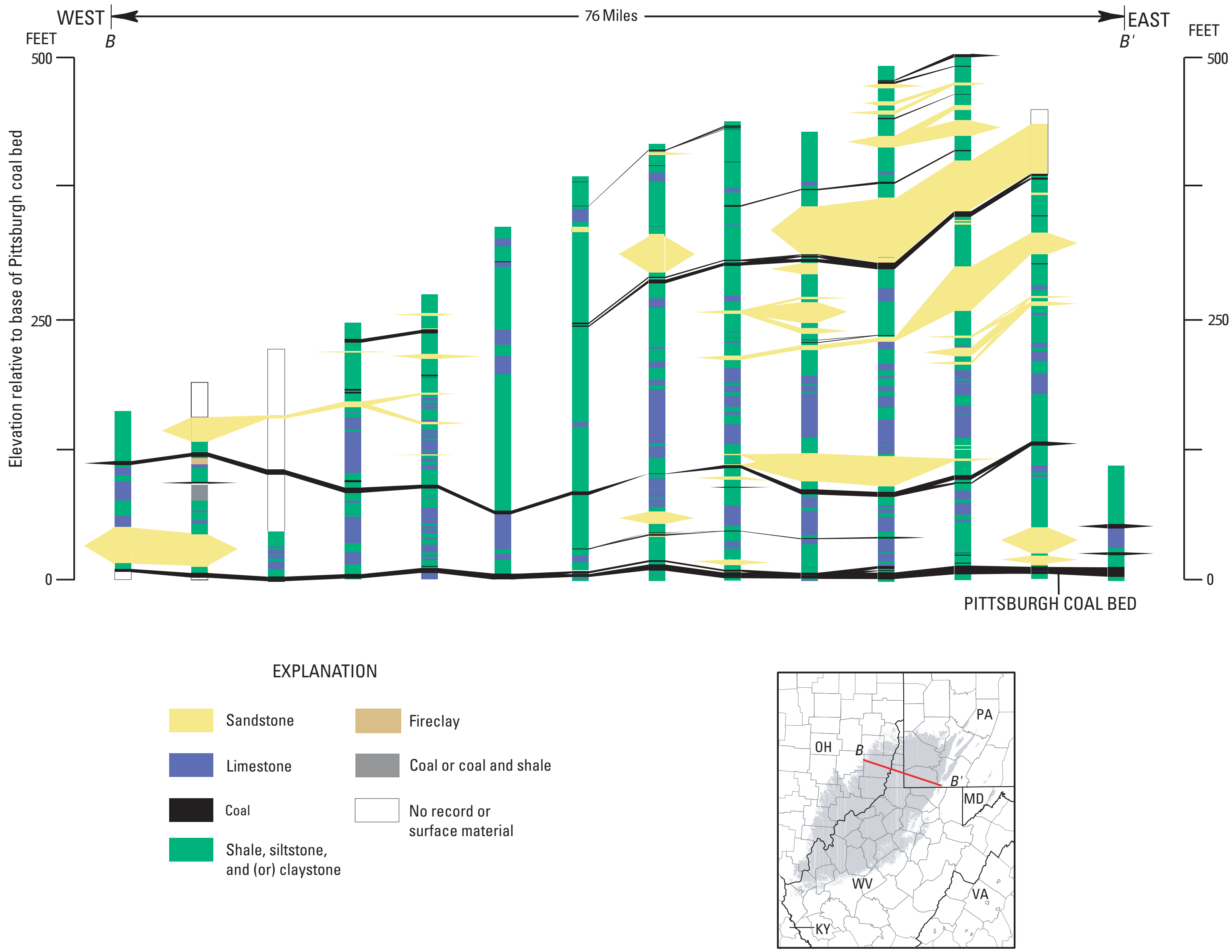

Figure 21. Generalized cross section trending west to east through the Pittsburgh coal bed. Note that the Pittsburgh coal is thicker to the east. The westward thinning may be the result of increased accommodation space from tectonic loading or sea-level rise. Columns represent individual coal cores on the line of section *B-B′*. Vertical exaggeration X398.

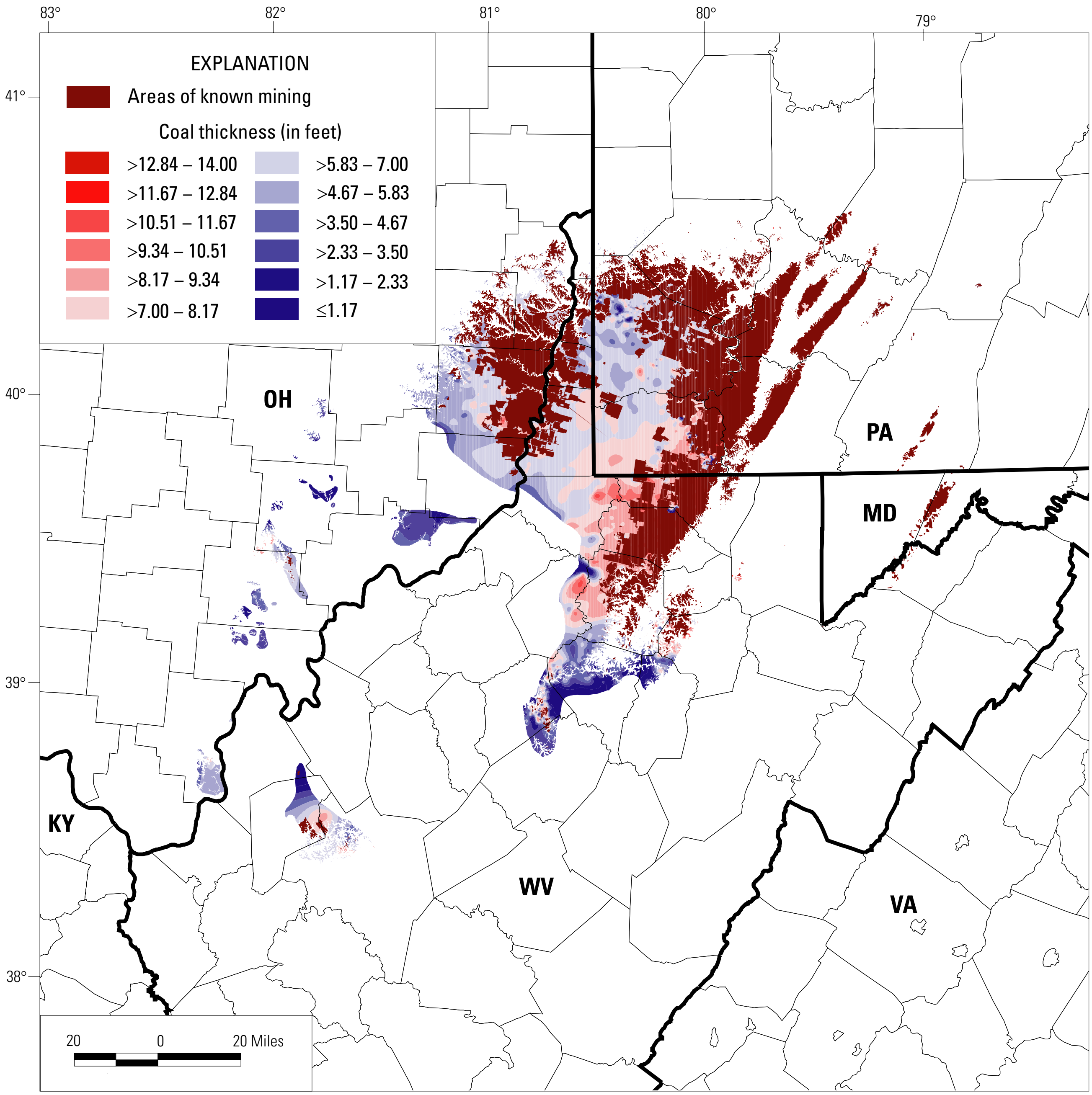

Figure 22. Map showing mined areas overlying thickness contours of the Pittsburgh coal bed. Note the relatively thick (5-7 ft) block of unmined coal in southwestern Pennsylvania and the northern panhandle of West Virginia (fig. 17). See figure 2 for county names.

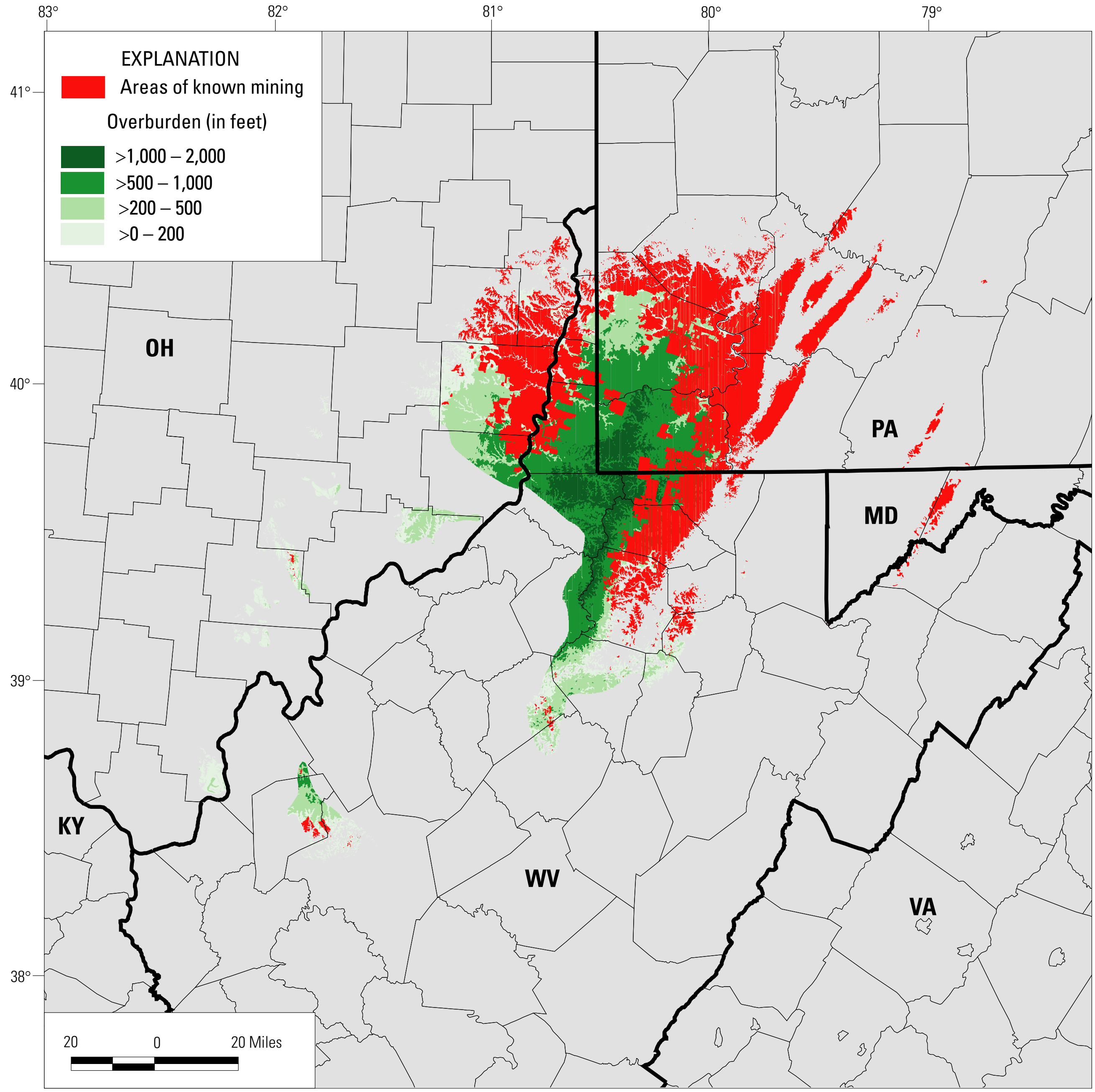

Figure 23. Map showing mined areas overlying the overburden thickness map of the Pittsburgh coal bed. Note that much of the thick and shallow coal has been mined (fig. 16). The large block of thick (5-7 ft) unmined coal in southwestern Pennsylvania and the northern panhandle of West Virginia (fig. 22) tends to be overlain by relatively thick overburden. See figure 2 for county names.

mined, but given favorable economics it could be longwall mined.

One notable exception to the thickness trend can be observed on the regional scale as a somewhat linear, northwest-trending area of thin or absent coal in Greene and Washington Counties, Pa. (figs. 2, 17, 24). A relationship exists between the coal thinning and the distribution and thickness of sandstone overlying the Pittsburgh coal as mapped by Roen and Kreimeyer (1973) and unpublished USGS working maps of John B. Roen (U.S. Geological Survey, unpub. data, 1977) (figs. 3, 25). This sandstone is informally called the Pittsburgh sandstone and represents a large, west-northwest-trending, meandering fluvial system as indicated by the presence of associated siltstone and mudstone that may have originated as crevasse splays (Linger, 1979). The area where the Pittsburgh sandstone is thickest and the coal is thin may represent an incised channel. Smaller, auxiliary sandstone channels exhibiting basal scour and sharp lateral contacts occasionally produce local thinning and erosional cut-outs of the underlying Pittsburgh coal bed (Hoover, 1967; Kent, 1969) that can affect longwall mining operations.

GEOCHEMISTRY

Most of the sample localities in the geochemical database are located along the edges of the extent of the Pittsburgh coal bed and in areas that have been mined; therefore, they may not be representative of the entire Pittsburgh coal resource (figs. 13, 14). Steps for processing and eliminating data analyses can be found in the metadata file in Appendix 9.

Of the 3,377 analyses in the geochemical database, only about one-third are publicly available point data (located by latitude and longitude; Appendix 8) and are shown on the maps labeled A in figures 26 to 29, and 31 to 43. All data, both public and proprietary, are represented by the county average maps labeled B on the same figures and were used to generate the statistical parameters in tables 2 to 18. Ash yield, sulfur content, and sulfur-dioxide (SO_2) content data 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). All analyses are on a n as-received whole-coal basis. Ash yield and sulfur content are classified according to Wood and others (1983). Sulfur-dioxide content is classified according to past and present Clean Air Acts. Ash yield, sulfur content, and sulfur-dioxide content are presented as both data points (Map A, fig. 26–28), and as county means (Map B, figs. 26–28). Calorific value, total moisture, and trace elements reported in figures 29 and 31 to 43, 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 shown in Appendix 8 versus county means shown in tables 2–18), the ranges of the 20-percent intervals will be different for each data set and each chemical parameter. Some general trends can be observed in maps of ash yield, sulfur content, and calorific value presented on an as-received whole-coal basis.

The map of ash yield (weight percent, as-received basis) (fig. 26A) shows a general trend towards higher values to the north and west. This trend is most clearly seen in the county average map (fig. 26B). Overall, the Pittsburgh is classified as a medium-ash coal bed (mean value for 3,273 samples is 9.02±2.9 weight percent, as-received basis); however, there is a large regional variation observed when examining ash yield statistics broken down by States (table 2). Mean ash yields range from 7.44±1.61 weight percent in Maryland to 9.97±2.91 weight percent in Ohio.

Sulfur contents (weight percent, as-received basis) of the Pittsburgh coal generally are higher in the west than in the east along the coal bed extent (fig. 27). Overall, the Pittsburgh is a medium sulfur coal (fig. 27; table 3) with a mean sulfur content of 2.80±1.13 weight percent for 3,348 samples. When examined on a State scale, the Pittsburgh coal bed ranges from a low-sulfur coal in Maryland (mean of 0.87±0.1 weight percent) to a high-sulfur coal in Ohio (mean of 3.48±1.04 weight percent). It is easy to understand why the eastern part of the Pittsburgh coal bed has been mined. The coal was relatively low in ash and sulfur, thick, and under relatively thin cover from its northernmost extent in Armstrong and Indiana Counties, Pa., southward through Maryland, and into Harrison and Barbour Counties, W. Va. (shown on figs. 2, 22, 23, 26, 27).

The electric power industry is Federally mandated to comply with the Clean Air Act Amendments of 1990 (Public Law 101-549), which legislate the amount of sulfur dioxide that can be released into the environment. Conversion of sulfur content to pounds of sulfur dioxide (SO_2) per million Btu (fig. 28) shows that, overall, the Pittsburgh coal as mined does not meet year 2000 coal compliance standards (fig. 28; table 4) of less than or equal to 1.2 pounds of SO_2 per million Btu. The mean SO_2 value calculated for the Pittsburgh coal bed is 4.34±1.81 lbs/million Btu and ranges from 1.27±0.19 lbs/ million Btu in Maryland to 5.64±1.65 lbs/million Btu in Ohio. Coal from the Pittsburgh coal bed is physically washed or cleaned to remove sulfur and mineral matter. Although washing effectively decreases the amount of sulfur dioxide generated by the coal, it remains noncompliant. However, usage continues because the coal has such a high calorific value.

Calorific values tend to decrease from east to west (fig. 29). The mean calorific value for the Pittsburgh coal bed is 13,130±680 Btu/lb and ranges from 14,020±420 Btu/lb in Maryland to 12,380±610 Btu/lb in Ohio (fig. 29; table 5).

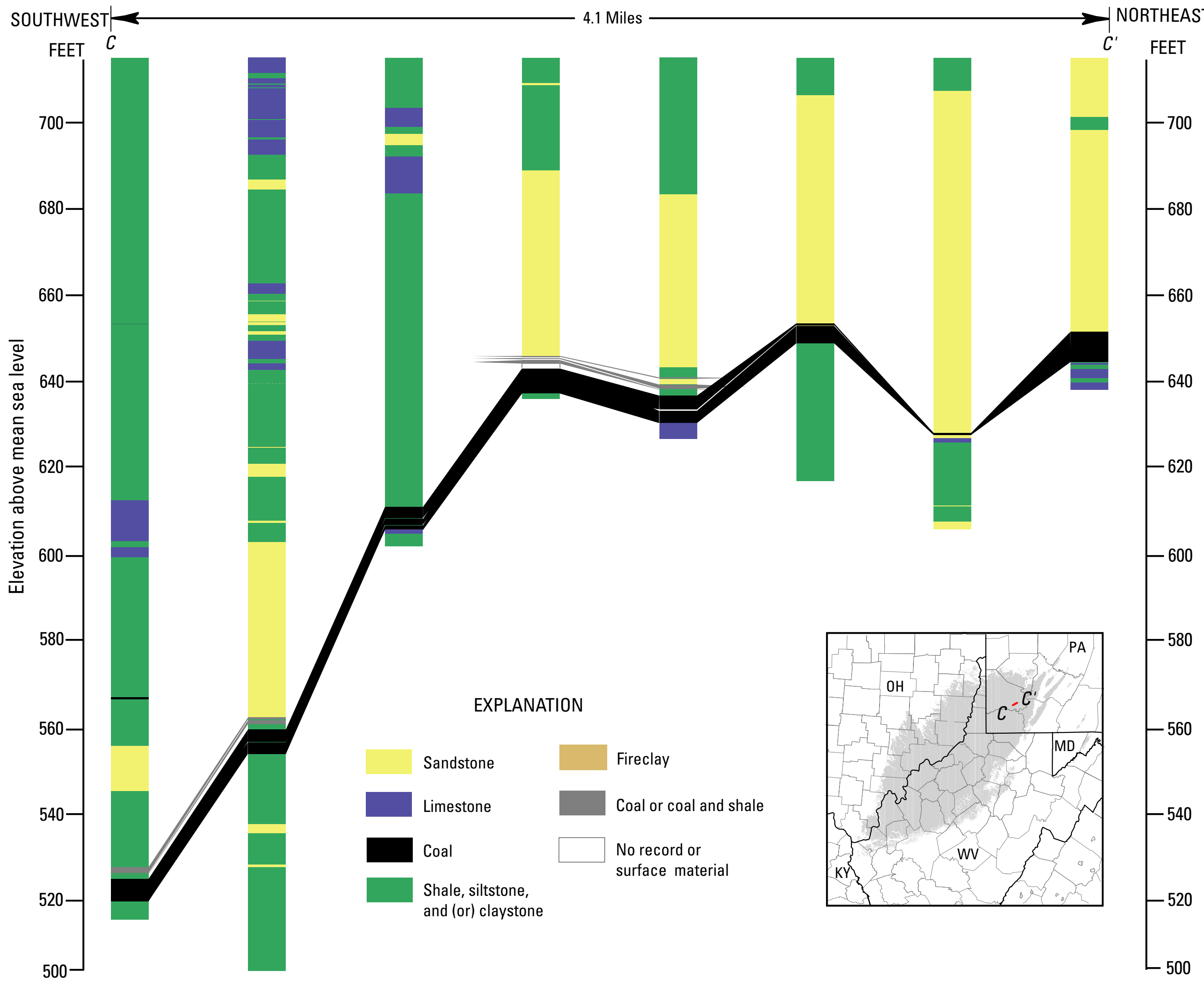

Figure 24. Generalized cross section running southwest to northeast through Washington County, Pa., across the trend of thinning or absent coal. The coal thins where directly overlain by a sandstone, informally referred to as the Pittsburgh sandstone, shown in yellow. Columns represent individual coal cores along the line of section *C-C′*. Vertical exaggeration X120.

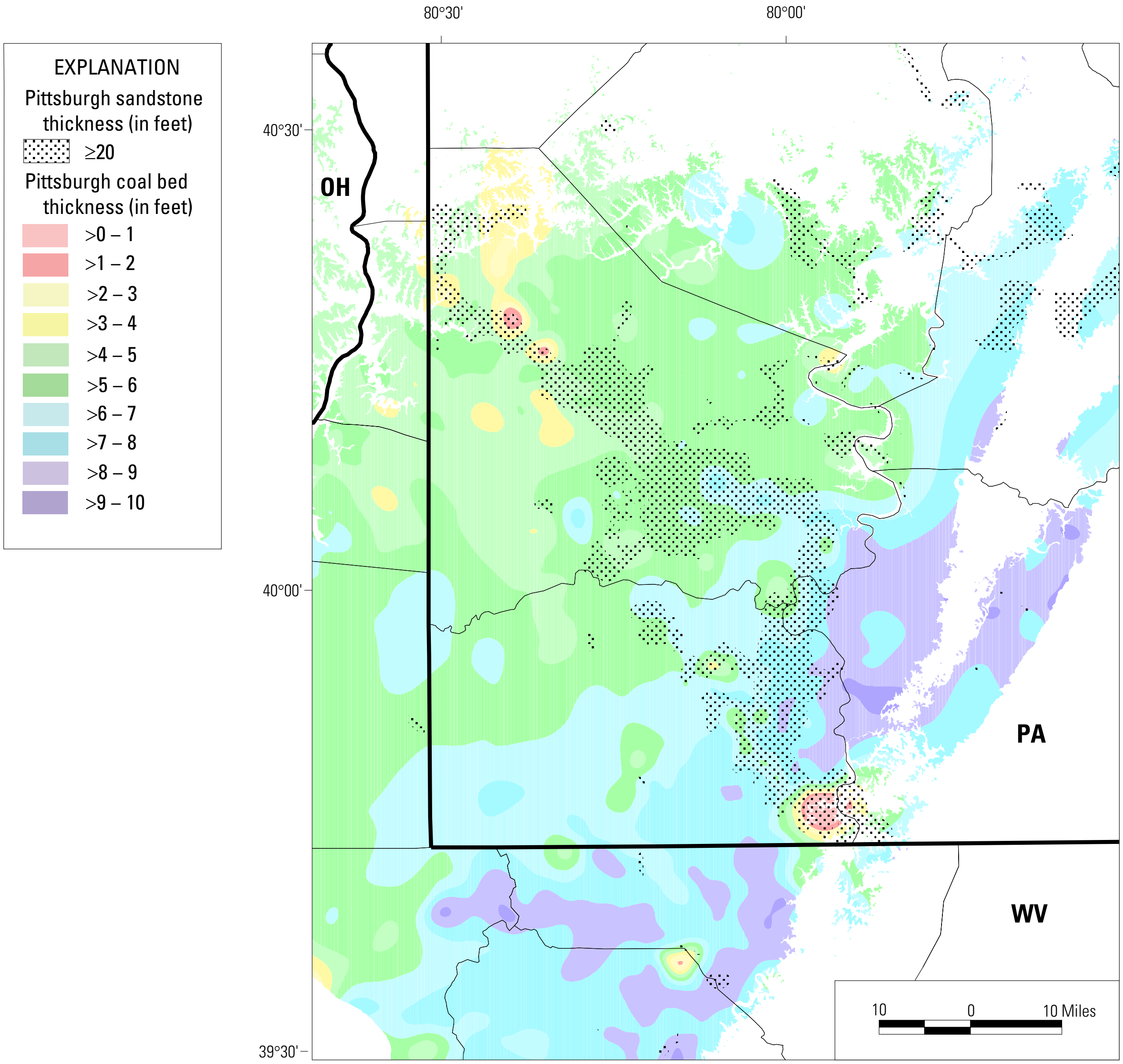

Figure 25. Map showing thickness contours of the Pittsburgh coal bed in southwestern Pennsylvania overlain by the thickness of the informally named Pittsburgh sandstone as mapped by Roen and Kreimeyer (1973) and working maps of John B. Roen (U.S. Geological Survey, unpub. data, 1977). The sandstone is thickest along the northwest-trending area of thinning coal in Greene and Washington Counties, Pa. (fig. 2). The sandstone represents an incised, north-northwest-flowing channel system. Small, auxiliary channels produced thinning and erosional cut-outs of the Pittsburgh coal bed. These thinning trends tend to limit the placement of extensive longwall underground mines. See figure 2 for county names.

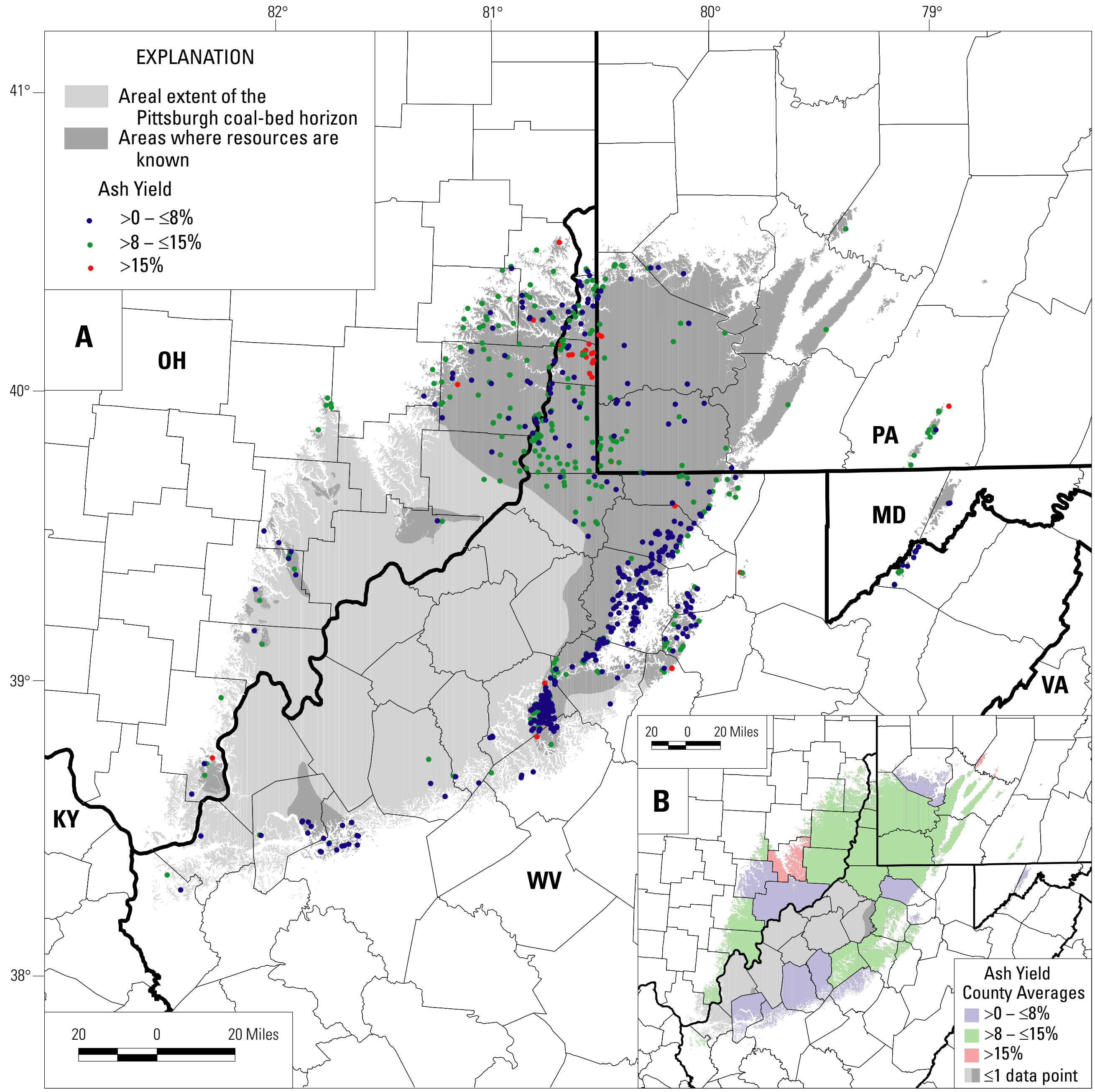

Figure 26. Maps showing ash yield (weight percent, as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows ash yields of the 925 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for ash yields using all 3,273 records in the geochemical database, including those that are located only to a county level; ash yields range from 1.85 to 33.20 weight percent with a mean value of 9.02±2.90 weight percent (table 2). Ash yields are classified into low (>0 to ≤8 percent), medium (>8 to ≤15 percent), and high (>15 percent) categories as specified by Wood and others (1983). Ash yields tend to be highest in the western part of the coal bed and lowest in the eastern part. See figure 2 for county names.

Table 2. Ash yield (weight percent; American Society for Testing and Materials method) means, ranges, and standard deviations for samples of the Pittsburgh 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	9.02	1.85	33.20	2.90	3,273
PA	na	9.90	1.85	29.72	3.90	578
WV	na	8.45	3.90	33.20	2.36	1,968
OH	na	9.97	3.50	24.10	2.91	694
MD	na	7.44	5.70	13.62	1.61	33
PA	Allegheny	7.87	3.89	13.62	2.44	64
PA	Armstrong	18.39	9.48	29.72	4.80	35
PA	Beaver	nd	11.85	11.85	nd	1
PA	Fayette	8.46	6.18	13.00	1.45	86
PA	Greene	9.46	5.44	17.04	2.44	76
PA	Indiana	15.68	10.27	23.14	2.98	29
PA	Somerset	9.94	5.83	15.50	2.60	30
PA	Washington	8.93	1.85	18.80	3.18	183
PA	Westmoreland	9.85	5.02	22.72	2.83	74
WV	Barbour	8.89	3.90	13.66	1.65	137
WV	Braxton	7.82	5.30	17.00	2.32	27
WV	Brooke	9.00	4.50	14.40	1.96	78
WV	Cabell	nd	7.80	7.80	nd	1
WV	Calhoun	7.00	4.70	9.30	3.25	2
WV	Gilmer	8.74	4.28	33.20	3.58	265
WV	Hancock	8.30	7.70	9.00	0.66	3
WV	Harrison	8.21	4.21	13.33	1.38	500
WV	Kanawha	6.19	4.43	9.69	1.40	13
WV	Lewis	8.11	4.07	13.24	1.92	66
WV	Marion	7.16	4.32	16.58	1.38	260
WV	Marshall	9.06	6.31	13.67	1.59	104
WV	Mineral	7.97	4.91	11.75	1.95	17
WV	Monongalia	8.78	4.85	18.33	1.53	314
WV	Ohio	11.89	5.80	30.36	6.01	57
WV	Preston	7.61	6.42	8.21	1.03	3
WV	Putnam	7.28	5.22	9.70	1.09	28
WV	Roane	6.92	3.90	8.50	2.06	4
WV	Taylor	7.96	5.86	12.03	1.30	53
WV	Upshur	10.60	6.55	16.12	3.42	12
WV	Wayne	10.70	6.50	14.90	5.94	2
WV	Wetzel	9.59	5.50	15.13	2.75	22
OH	Athens	8.51	4.60	12.80	2.34	15
OH	Belmont	9.65	3.50	21.70	2.33	259
OH	Carroll	7.19	5.46	8.92	2.45	2
OH	Gallia	11.07	7.00	16.48	3.37	10
OH	Guernsey	10.24	5.57	13.92	1.69	67
OH	Harrison	10.20	4.20	18.31	2.60	59
OH	Jefferson	9.74	4.20	22.10	3.06	233
OH	Meigs	10.16	6.90	13.33	2.11	10
OH	Monroe	13.50	5.90	24.10	5.33	28
OH	Morgan	6.15	6.00	6.30	0.21	2
OH	Muskingum	12.48	10.20	14.40	1.97	4
OH	Noble	18.24	15.71	19.87	2.22	3
OH	Washington	7.70	6.60	8.80	1.56	2
MD	Allegany	7.44	5.70	13.62	1.61	33

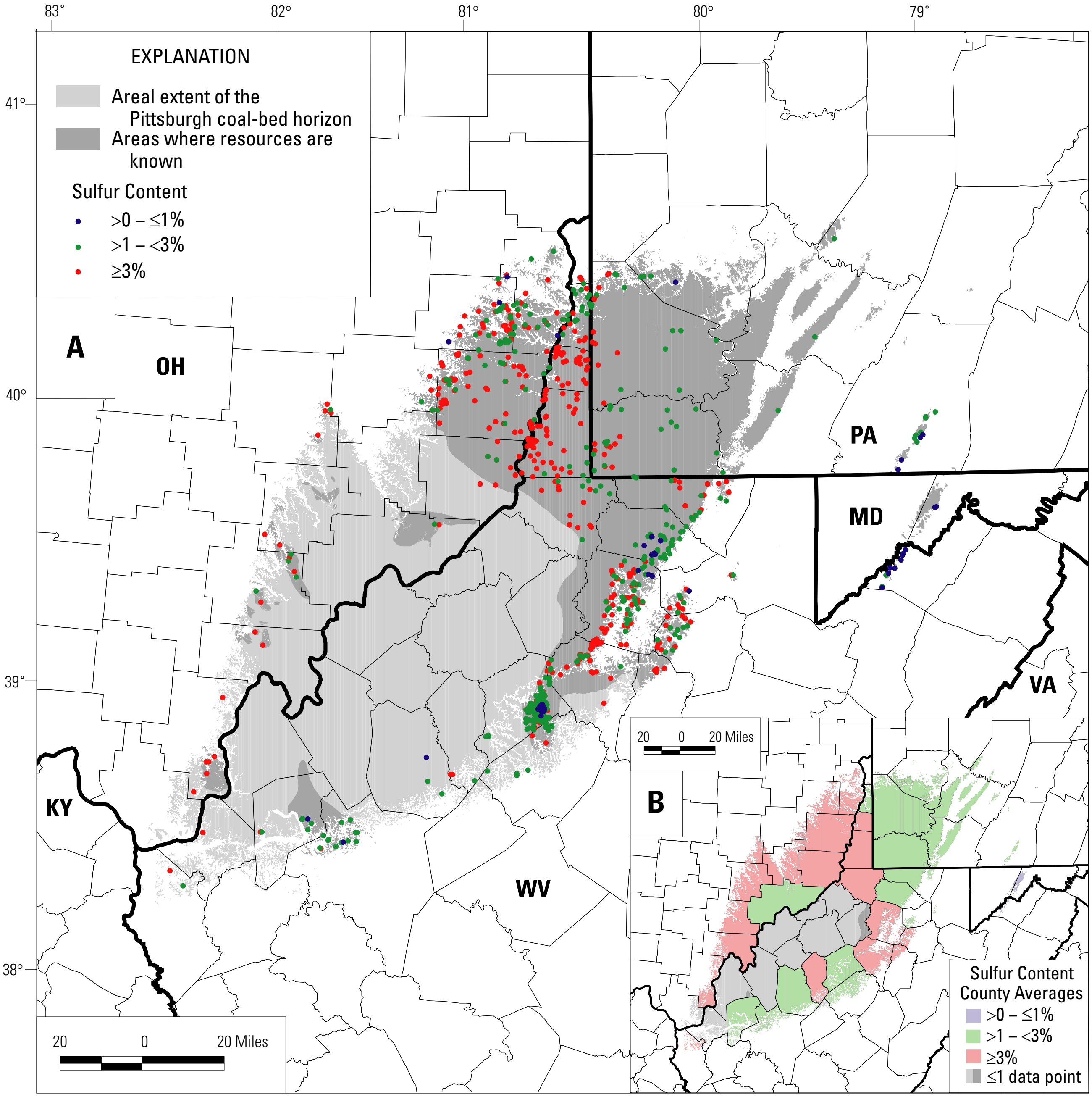

Figure 27. Maps showing sulfur content (weight percent, as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows sulfur contents of the 1,017 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for sulfur contents using all 3,348 records in the geochemical database, including those that are located only to a county level; sulfur contents range from 0.40 to 6.75 weight percent with a mean value of 2.80±1.13 weight percent (table 3). Sulfur contents are classified into low (>0 to ≤1 percent), medium (>1 to <3 percent), and high (≥3 percent) categories as specified by Wood and others (1983). In general, sulfur content decreases west to east, much like ash yield. See figure 2 for county names.

Table 3. Sulfur content (weight percent; American Society for Testing and Materials method) means, ranges, and standard deviations for samples of the Pittsburgh 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	2.80	0.40	6.75	1.13	3,348
PA	na	1.89	0.47	5.40	0.93	564
WV	na	2.81	0.40	6.75	1.01	1,964
OH	na	3.48	0.60	6.41	1.04	788
MD	na	0.87	0.70	1.16	0.10	32
PA	Allegheny	1.59	0.77	3.89	0.71	64
PA	Armstrong	2.10	0.71	3.60	0.64	25
PA	Beaver	nd	3.24	3.24	nd	1
PA	Fayette	1.51	0.47	3.25	0.69	86
PA	Greene	2.34	0.97	5.40	0.99	76
PA	Indiana	1.60	0.78	2.60	0.46	29
PA	Somerset	1.27	0.72	2.54	0.47	26
PA	Washington	2.28	0.73	5.21	1.08	183
PA	Westmoreland	1.41	0.68	2.96	0.50	74
WV	Barbour	3.08	0.81	5.60	0.87	137
WV	Braxton	2.53	0.98	6.75	1.02	27
WV	Brooke	2.87	1.13	5.40	0.89	78
WV	Cabell	nd	3.20	3.20	nd	1
WV	Calhoun	3.40	2.50	4.30	1.27	2
WV	Gilmer	2.29	0.60	6.22	0.87	265
WV	Hancock	3.30	2.30	4.50	1.11	3
WV	Harrison	3.18	0.74	6.30	0.74	498
WV	Kanawha	1.77	0.60	3.06	0.71	13
WV	Lewis	3.46	1.68	5.30	0.76	66
WV	Marion	1.74	0.60	4.24	0.73	258
WV	Marshall	4.11	1.69	6.08	0.69	104
WV	Mineral	0.96	0.68	1.21	0.15	17
WV	Monongalia	2.79	1.07	5.36	0.54	314
WV	Ohio	3.98	2.71	6.36	0.72	57
WV	Preston	1.13	1.10	1.14	0.02	3
WV	Putnam	2.16	0.67	3.34	0.57	28
WV	Roane	2.05	1.00	3.80	1.22	4
WV	Taylor	2.52	0.40	3.60	0.72	53
WV	Upshur	3.74	2.94	5.71	0.83	12
WV	Wayne	3.55	1.90	5.20	2.33	2
WV	Wetzel	4.15	1.90	6.17	1.29	22
OH	Athens	3.41	1.50	5.70	0.97	15
OH	Belmont	3.92	1.10	6.41	0.94	293
OH	Carroll	1.81	1.71	1.92	0.15	2
OH	Gallia	3.64	1.90	4.90	0.81	10
OH	Guernsey	3.44	1.85	5.51	0.77	67
OH	Harrison	3.06	0.60	6.10	0.99	118
OH	Jefferson	3.10	0.70	6.30	0.97	234
OH	Meigs	3.74	2.44	4.96	0.95	10
OH	Monroe	3.69	1.10	6.30	1.47	28
OH	Morgan	3.75	3.40	4.10	0.49	2
OH	Muskingum	4.20	2.70	5.90	1.43	4
OH	Noble	5.21	5.12	5.30	0.09	3
OH	Washington	2.45	1.20	3.70	1.77	2
MD	Allegany	0.87	0.70	1.16	0.10	32

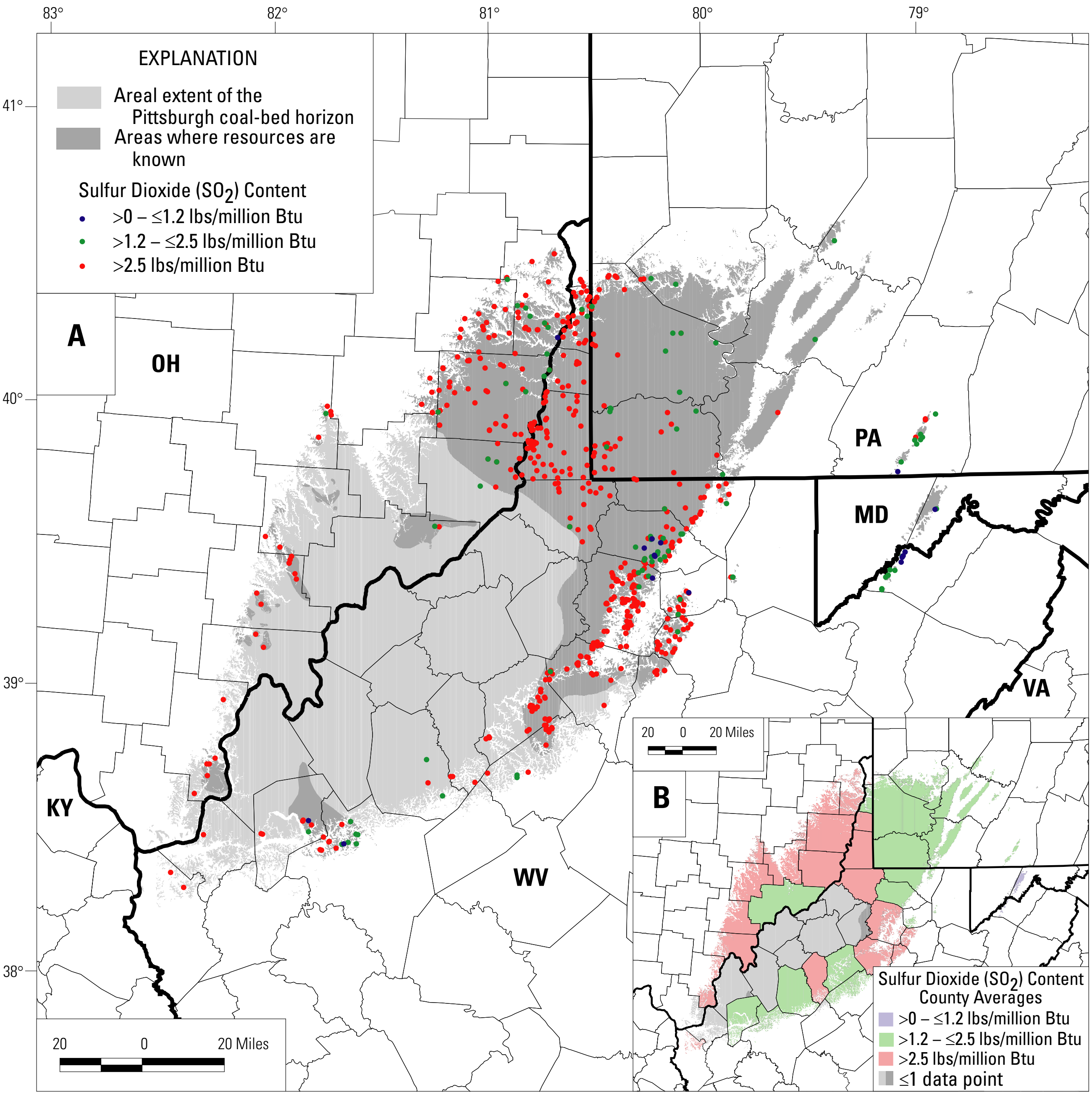

Figure 28. Maps showing sulfur-dioxide (SO_2) content (lbs/million Btu, as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows SO_2 contents of the 652 geochemical samples for which records are publicly available and located to latitude and longitude (Appendix 8). Map B shows county averages for SO_2 contents using all 2,893 records in the geochemical database, including those that are located only to a county level; SO_2 contents range from 0.57 to 10.47 lbs/million Btu with a mean value of 4.34±1.81 lbs/million Btu (table 4). 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. See figure 2 for county names.

Table 4. Sulfur-dioxide (SO_2) content (lbs/million Btu) means, ranges, and standard deviations for samples of the Pittsburgh 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	4.34	0.57	10.47	1.81	2,893
PA	na	2.92	0.80	9.04	1.57	499
WV	na	4.27	0.57	10.00	1.54	1,689
OH	na	5.64	1.02	10.47	1.65	685
MD	na	1.27	1.01	1.80	0.19	20
PA	Allegheny	2.46	1.09	6.16	1.15	62
PA	Armstrong	4.66	2.47	6.16	1.94	3
PA	Fayette	2.25	0.80	4.93	1.06	84
PA	Greene	3.59	1.42	9.04	1.59	75
PA	Indiana	2.26	1.54	3.36	0.58	15
PA	Somerset	1.90	1.01	3.86	0.74	26
PA	Washington	3.64	1.03	8.90	1.83	164
PA	Westmoreland	2.14	0.96	4.54	0.79	70
WV	Barbour	4.59	1.15	8.69	1.38	137
WV	Braxton	3.56	1.43	5.27	0.94	26
WV	Brooke	4.47	1.77	8.29	1.44	76
WV	Cabell	nd	4.90	4.90	nd	1
WV	Calhoun	4.97	3.53	6.40	2.03	2
WV	Gilmer	3.41	1.42	4.64	0.71	52
WV	Hancock	4.98	3.67	6.68	1.54	3
WV	Harrison	4.75	1.04	8.90	1.16	484
WV	Kanawha	2.63	0.89	4.67	1.08	13
WV	Lewis	5.43	2.45	7.92	1.06	52
WV	Marion	2.56	0.85	6.80	1.11	256
WV	Marshall	6.35	2.59	9.66	1.10	102
WV	Mineral	1.34	1.00	1.64	0.19	16
WV	Monongalia	4.14	1.59	8.10	0.85	310
WV	Ohio	5.79	4.07	9.47	1.00	36
WV	Preston	1.68	1.66	1.72	0.04	3
WV	Putnam	3.29	0.98	5.10	0.90	28
WV	Roane	3.00	1.48	5.61	1.81	4
WV	Taylor	3.70	0.57	5.48	1.07	53
WV	Upshur	5.80	4.31	9.18	1.48	12
WV	Wayne	5.73	2.82	8.64	4.12	2
WV	Wetzel	6.27	2.77	10.00	2.06	21
OH	Athens	5.69	2.63	9.32	1.62	15
OH	Belmont	6.13	1.80	10.33	1.45	257
OH	Carroll	2.91	2.83	2.98	0.10	2
OH	Gallia	6.21	3.19	8.10	1.50	10
OH	Guernsey	5.78	3.13	8.96	1.20	67
OH	Harrison	5.23	1.02	9.48	1.59	57
OH	Jefferson	5.01	1.02	10.47	1.59	228
OH	Meigs	6.41	4.01	8.98	1.83	10
OH	Monroe	6.02	1.66	10.02	2.40	28
OH	Morgan	6.00	5.41	6.59	0.84	2
OH	Muskingum	7.19	4.65	10.01	2.47	4
OH	Noble	9.48	9.14	9.75	0.31	3
OH	Washington	3.98	1.88	6.07	2.96	2
MD	Allegany	1.27	1.01	1.80	0.18	20

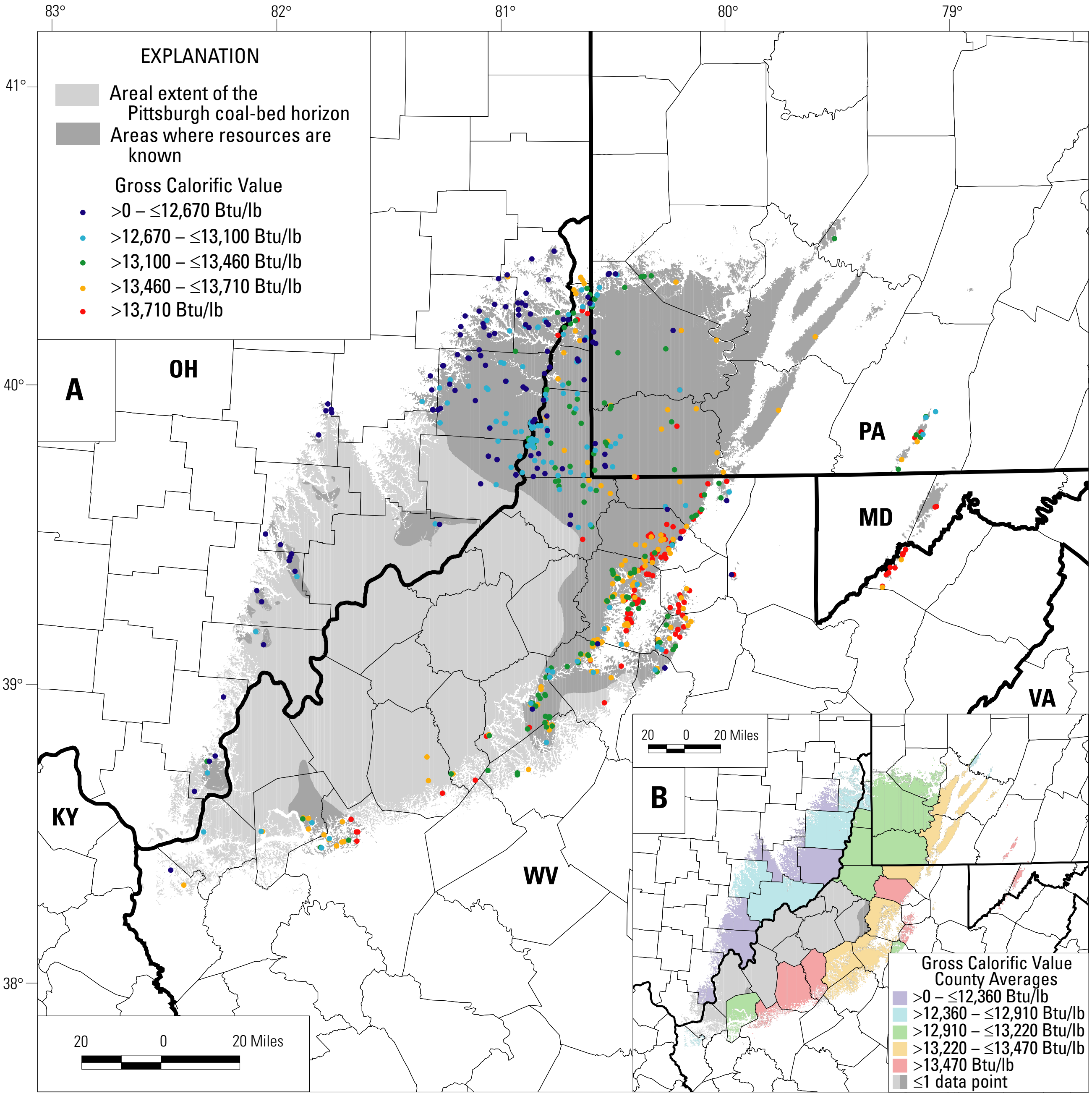

Figure 29. Maps showing gross calorific value (Btu/lb, as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows gross calorific values of the 652 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for gross calorific values using all 2,898 records in the geochemical database, including those analyses that are located only to a county level; gross calorific values range from 10,670 to 14,780 Btu/lb with a mean value of 13,130±680 Btu/lb (table 5). The values are classified into five categories, each representing 20 percent of the data values. Gross calorific value tends to increase to the east. See figure 2 for county names.

Table 5. Gross calorific value (Btu/lb; American Society for Testing and Materials method) means, ranges, and standard deviations for samples of the Pittsburgh 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	13,130	10,670	14,780	680	2,898
PA	na	13,170	10,780	14,400	650	503
WV	na	13,410	11,190	14,780	430	1,689
OH	na	12,380	10,670	13,740	610	685
MD	na	14,020	12,870	14,480	420	21
PA	Allegheny	13,100	10,890	14,150	710	62
PA	Armstrong	12,160	11,350	13,440	1,120	3
PA	Fayette	13,400	11,000	13,990	430	84
PA	Greene	13,220	11,940	13,960	430	75
PA	Indiana	12,760	11,910	13,520	490	15
PA	Somerset	13,490	11,940	14,400	580	30
PA	Washington	12,980	10,780	14,340	770	164
PA	Westmoreland	13,320	11,160	14,270	560	70
WV	Barbour	13,500	12,370	14,170	340	137
WV	Braxton	13,390	12,400	13,970	350	26
WV	Brooke	12,910	11,520	14,090	480	76
WV	Cabell	nd	13,050	13,050	nd	1
WV	Calhoun	13,800	13,430	14,170	530	2
WV	Gilmer	13,240	11,590	13,990	460	52
WV	Hancock	13,190	12,550	13,530	550	3
WV	Harrison	13,410	11,820	14,170	330	484
WV	Kanawha	13,510	12,880	13,890	320	13
WV	Lewis	13,230	11,960	13,960	450	52
WV	Marion	13,690	11,890	14,250	320	256
WV	Marshall	13,020	12,070	13,740	290	102
WV	Mineral	14,190	13,540	14,780	420	16
WV	Monongalia	13,470	11,670	14,350	400	310
WV	Ohio	12,980	11,190	13,670	510	36
WV	Preston	13,450	12,760	13,800	600	3
WV	Putnam	13,150	12,420	13,700	280	28
WV	Roane	13,720	13,530	14,180	310	4
WV	Taylor	13,630	12,640	14,040	340	53
WV	Upshur	13,010	11,860	13,640	610	12
WV	Wayne	12,760	12,040	13,480	1,020	2
WV	Wetzel	13,120	12,330	13,740	390	21
OH	Athens	12,030	11,140	12,950	530	15
OH	Belmont	12,510	10,680	13,600	530	257
OH	Carroll	12,460	12,050	12,870	580	2
OH	Gallia	11,790	10,800	13,300	840	10
OH	Guernsey	11,870	10,790	12,850	510	67
OH	Harrison	12,360	10,890	13,550	540	57
OH	Jefferson	12,500	10,670	13,740	570	228
OH	Meigs	11,750	10,960	13,100	700	10
OH	Monroe	12,330	10,900	13,530	840	28
OH	Morgan	12,510	12,440	12,580	100	2
OH	Muskingum	11,700	11,390	12,020	270	4
OH	Noble	11,000	10,670	11,610	520	3
OH	Washington	12,480	12,190	12,760	400	2
MD	Allegany	14,020	12,870	14,480	420	21

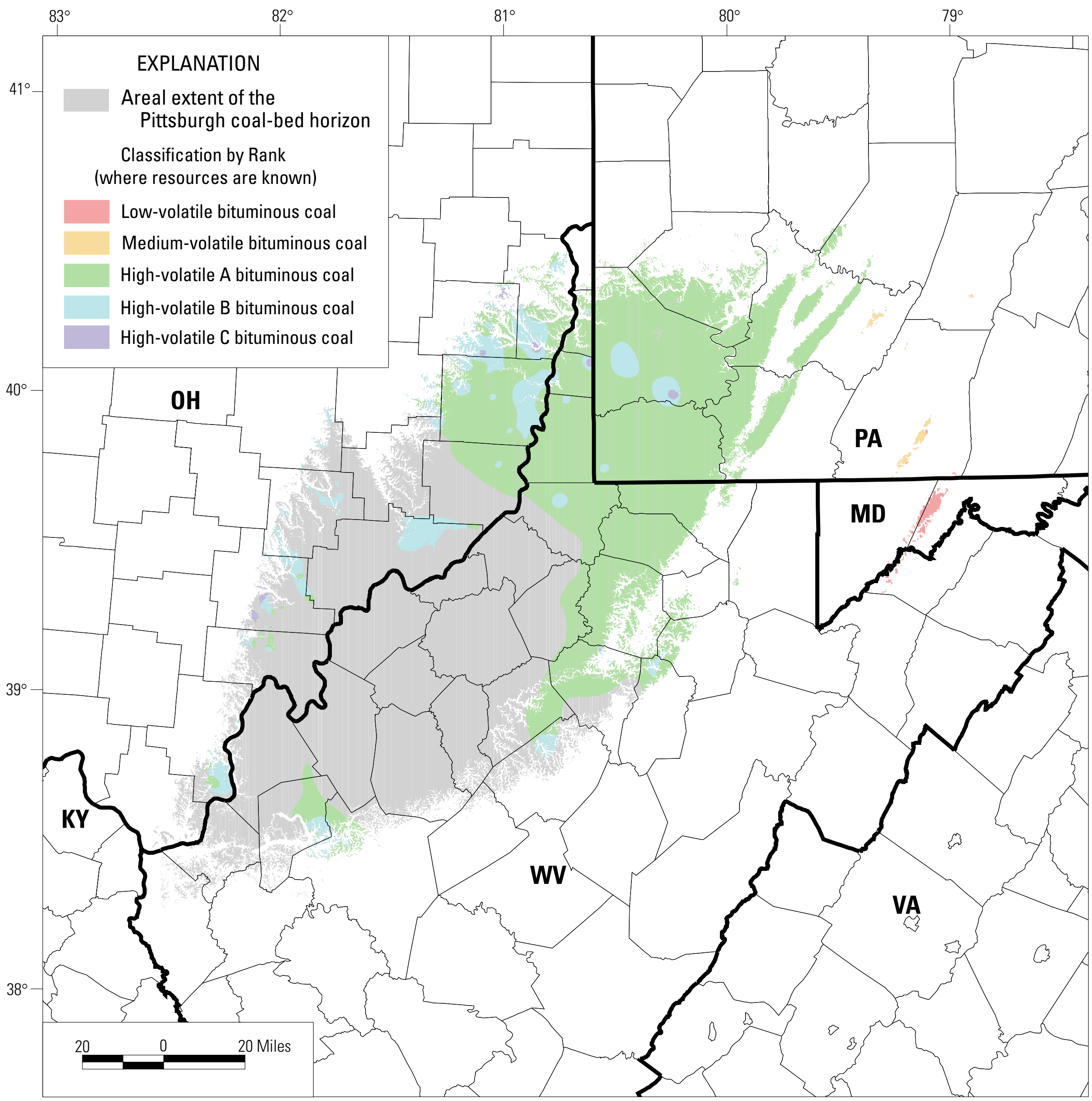

Figure 30. Map showing apparent rank of the Pittsburgh coal bed based on 706 analyses. The coal tends to decrease in rank from low-volatile bituminous in the east to high-volatile C bituminous in the west. Small, bullseye-shaped pods of high-volatile B (Greene and Washington Counties, Pa.; and Wetzel and Ohio Counties, W. Va.; fig. 2) and high-volatile C (Greene County, Pa., and Ohio County, W. Va.; fig. 2) are observed. Methodology for rank determinations is based on the percentage of fixed carbon in the sample. When dry, mineral-matter-free (dmmf) fixed carbon is greater than 69 percent, rank is determined on dmmf fixed carbon; when dmmf fixed carbon is less than 69 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.

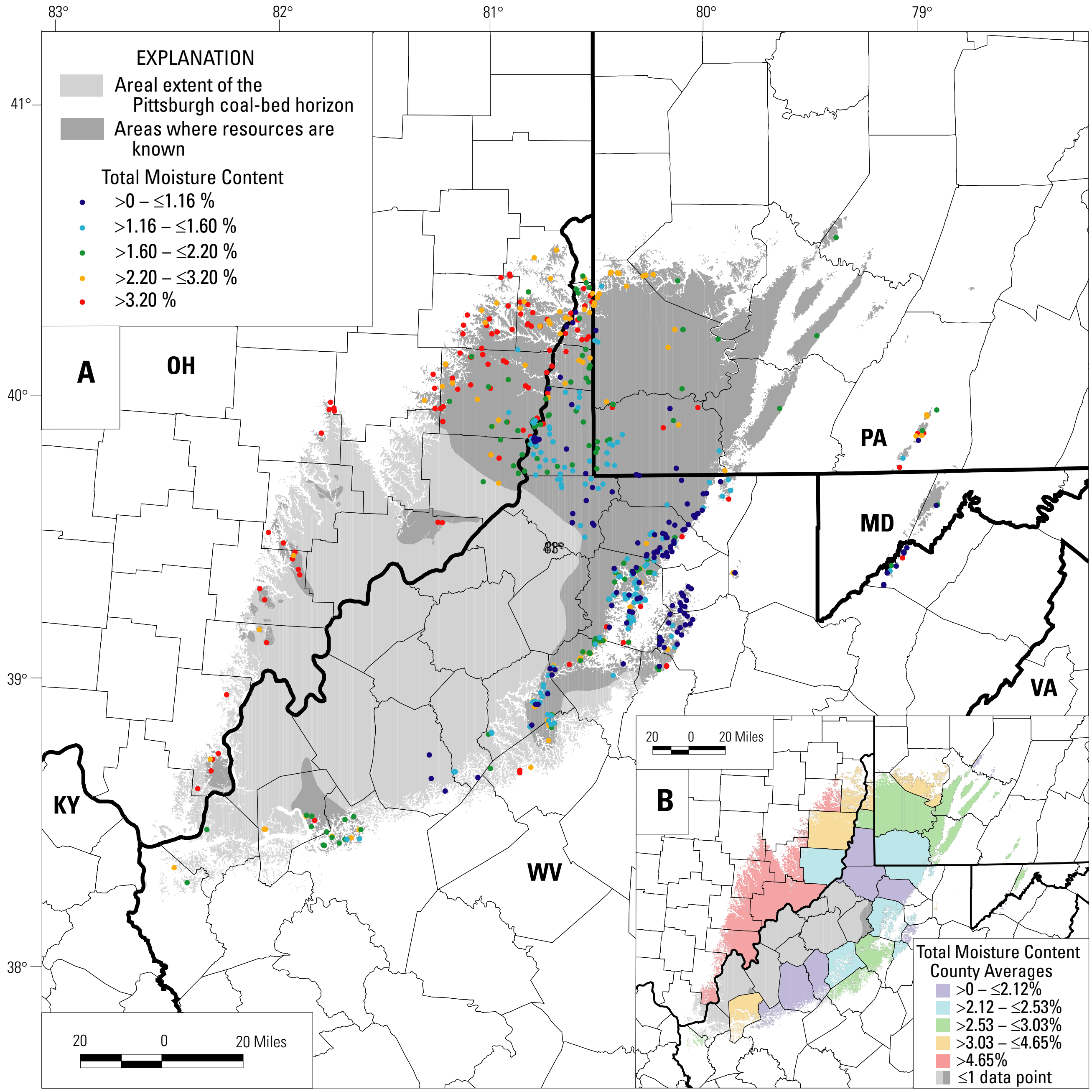

Figure 31. Maps showing total moisture content (weight percent, as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. ASTM (American Society for Testing and Materials) moisture replaced by equilibrium moisture values where available for the Pittsburgh coal bed. Map A shows total moisture contents of the 650 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for total moisture contents using all 2,951 records in the geochemical database, including those that are located only to a county level; total moisture contents range from 0.30 to 11.50 weight percent with a mean value of 2.90±1.46 weight percent (table 6). The values are classified into five categories, each representing 20 percent of the data values. The Pittsburgh coal bed is a bituminous coal and the moisture content is relatively low. See figure 2 for county names.

Table 6. Total moisture content (weight percent) means, ranges, and standard deviations for samples of the Pittsburgh 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 for the Pittsburgh coal bed. Abbreviations are as follows: na, not applicable; nd, no data available.]

STATE	COUNTY	Mean	Minimum	Maximum	Standard deviation	No. of samples
ALL	na	2.90	0.30	11.50	1.46	2,951
PA	na	2.86	0.90	11.50	1.17	527
WV	na	2.39	0.30	10.20	1.18	1,699
OH	na	4.18	1.40	10.90	1.52	692
MD	na	2.77	1.16	4.20	0.65	33
PA	Allegheny	2.52	2.20	2.75	0.25	4
PA	Fayette	nd	2.08	2.08	nd	1
PA	Greene	2.13	0.90	5.80	0.78	75
PA	Indiana	2.05	1.18	3.86	0.64	16
PA	Somerset	2.86	1.00	5.80	1.10	30
PA	Washington	3.03	1.01	7.70	1.21	178
PA	Westmoreland	1.86	1.80	1.91	0.08	2
WV	Barbour	2.31	1.00	3.60	0.87	8
WV	Braxton	2.57	1.32	4.40	0.91	26
WV	Brooke	4.52	2.65	6.10	1.74	3
WV	Gilmer	3.17	2.30	4.10	0.90	3
WV	Harrison	2.05	1.40	5.00	1.17	9
WV	Kanawha	2.47	0.60	10.20	1.21	488
WV	Lewis	2.90	2.50	3.30	0.40	3
WV	Marion	2.12	0.45	6.94	0.87	259
WV	Mineral	1.27	1.16	1.37	0.15	2
WV	Monongalia	0.93	0.70	1.25	0.29	3
WV	Ohio	nd	1.61	1.61	nd	1
WV	Preston	nd	0.66	0.66	nd	1
WV	Taylor	2.10	1.50	2.70	0.85	2
WV	Upshur	nd	3.50	3.50	nd	1
WV	Wetzel	1.03	0.80	1.23	0.22	4
OH	Belmont	2.90	1.60	7.29	1.30	20
OH	Gallia	6.03	5.40	6.41	0.48	4
OH	Guernsey	4.60	3.70	5.80	1.08	3
OH	Harrison	4.33	2.80	6.90	1.50	11
OH	Jefferson	3.25	1.90	6.25	1.32	8
OH	Monroe	2.06	1.70	2.50	0.23	8
OH	Muskingum	5.37	5.20	5.60	0.21	3
MD	Allegany	nd	1.90	1.90	nd	1

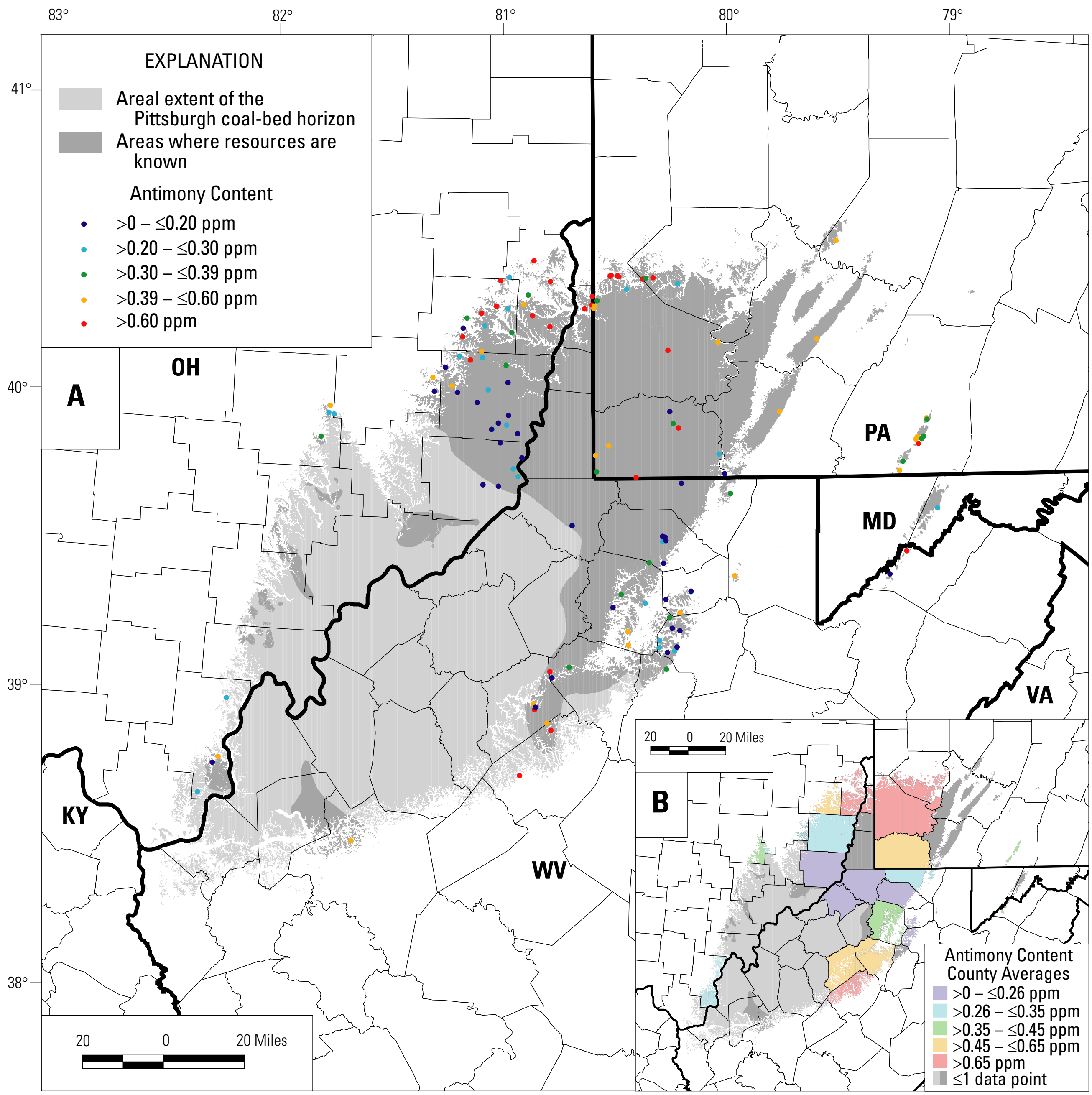

Figure 32. Maps showing antimony content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows antimony contents of the 139 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for antimony contents using all 139 records in the geochemical database. Antimony contents range from 0.12 to 1.5 ppm with a mean value of 0.42±0.28 ppm (table 7). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 7. Antimony content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	0.42	0.12	1.5	0.28	139
PA	na	0.57	0.20	1.5	0.34	35
WV	na	0.40	0.12	1.5	0.29	47
OH	na	0.35	0.15	0.99	0.19	56
MD	na	nd	0.26	0.26	nd	1
PA	Allegheny	0.78	0.30	1.2	0.50	4
PA	Fayette	nd	0.53	0.53	nd	1
PA	Greene	0.45	0.20	1.1	0.30	9
PA	Indiana	nd	0.58	0.58	nd	1
PA	Somerset	0.43	0.32	0.64	0.11	9
PA	Washington	0.72	0.25	1.5	0.41	10
PA	Westmoreland	nd	0.57	0.57	nd	1
WV	Barbour	0.25	0.20	0.35	0.06	9
WV	Braxton	0.95	0.49	1.5	0.50	3
WV	Brooke	0.94	0.72	1.1	0.21	3
WV	Gilmer	0.56	0.20	0.88	0.34	3
WV	Harrison	0.39	0.20	0.59	0.16	6
WV	Kanawha	nd	0.49	0.49	nd	1
WV	Lewis	0.46	0.20	0.79	0.30	3
WV	Marion	0.21	0.16	0.30	0.052	5
WV	Mineral	0.45	0.18	0.72	0.38	2
WV	Monongalia	0.29	0.20	0.39	0.13	2
WV	Preston	nd	0.49	0.49	nd	1
WV	Taylor	0.26	0.17	0.40	0.11	4
WV	Upshur	nd	0.39	0.39	nd	1
WV	Wetzel	0.18	0.12	0.29	0.073	4
OH	Belmont	0.27	0.15	0.73	0.13	20
OH	Gallia	0.35	0.20	0.60	0.18	4
OH	Guernsey	0.32	0.20	0.46	0.14	3
OH	Harrison	0.46	0.20	0.99	0.23	10
OH	Jefferson	0.53	0.30	0.99	0.26	8
OH	Monroe	0.26	0.20	0.40	0.074	8
OH	Muskingum	0.39	0.29	0.48	0.096	3
MD	Allegany	nd	0.26	0.26	nd	1

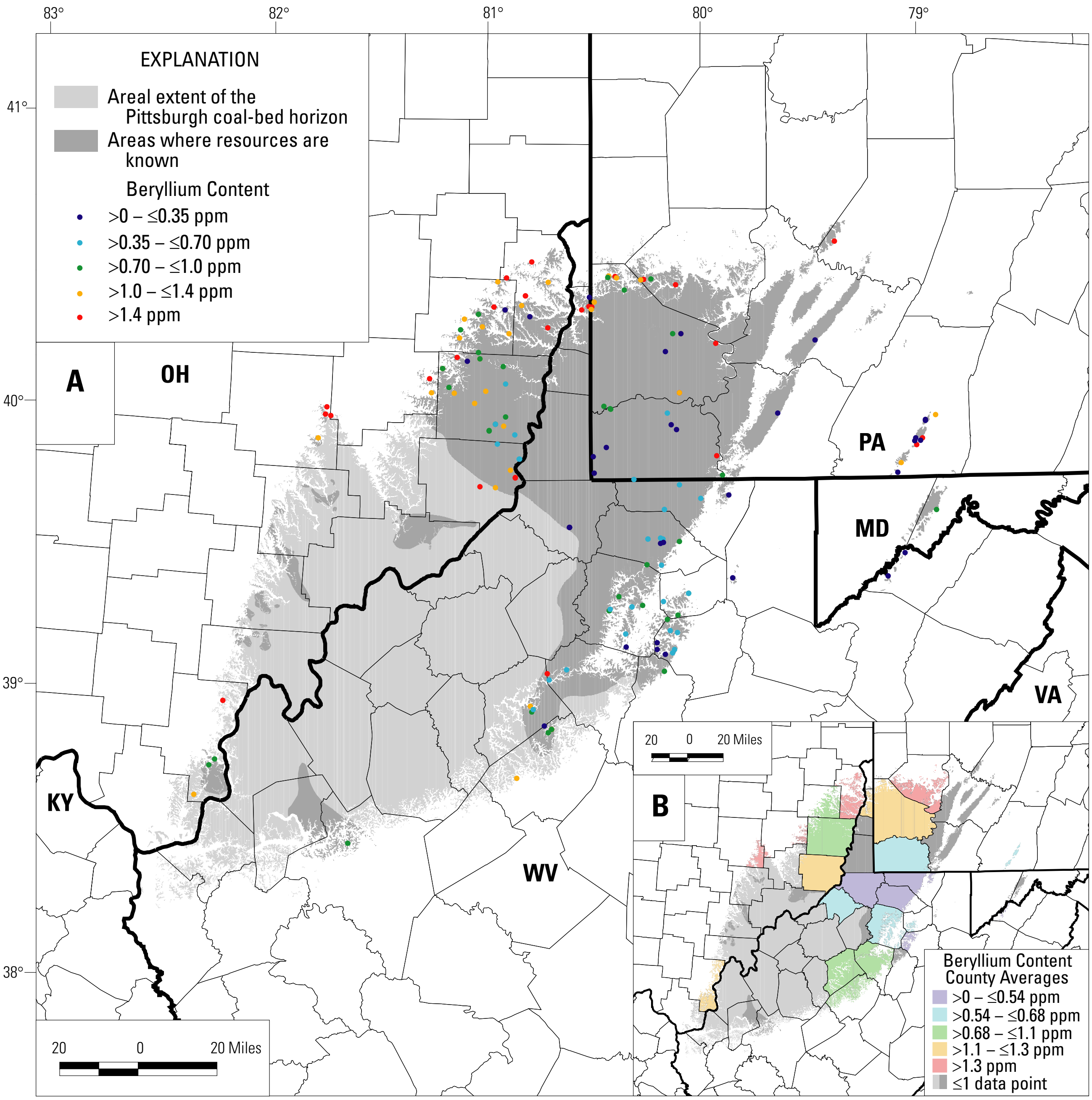

Figure 33. Maps showing beryllium content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows beryllium contents of the 163 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for beryllium contents using all 164 records in the geochemical database, including those that are located only to a county level; beryllium contents range from 0.065 to 2.8 ppm with a mean value of 0.90±0.58 ppm (table 8). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 8. Beryllium content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	0.90	0.065	2.8	0.58	164
PA	na	0.88	0.066	2.3	0.66	44
WV	na	0.65	0.065	2.1	0.41	63
OH	na	1.2	0.091	2.8	0.56	56
MD	na	nd	0.82	0.82	nd	1
PA	Allegheny	1.5	1.0	1.9	0.38	4
PA	Fayette	nd	0.10	0.10	nd	1
PA	Greene	0.53	0.092	1.9	0.55	11
PA	Indiana	nd	1.7	1.7	nd	1
PA	Somerset	0.63	0.066	1.8	0.70	10
PA	Washington	1.2	0.11	2.3	0.51	16
PA	Westmoreland	nd	0.11	0.11	nd	1
WV	Barbour	0.50	0.32	0.71	0.17	9
WV	Braxton	1.1	0.35	1.7	0.40	7
WV	Brooke	1.3	0.11	2.1	1.1	3
WV	Gilmer	0.88	0.68	1.1	0.23	3
WV	Harrison	0.68	0.32	0.97	0.24	11
WV	Kanawha	nd	0.75	0.75	nd	1
WV	Lewis	0.83	0.42	1.5	0.60	3
WV	Marion	0.54	0.27	0.88	0.17	11
WV	Mineral	0.23	0.18	0.28	0.068	2
WV	Monongalia	0.41	0.097	0.66	0.29	3
WV	Preston	nd	0.12	0.12	nd	1
WV	Taylor	0.67	0.47	0.84	0.16	4
WV	Upshur	nd	0.84	0.84	nd	1
WV	Wetzel	0.11	0.065	0.14	0.035	4
OH	Belmont	1.0	0.12	2.2	0.43	20
OH	Gallia	1.3	0.88	1.8	0.39	4
OH	Guernsey	1.7	1.3	2.0	0.40	3
OH	Harrison	1.1	0.091	1.8	0.44	10
OH	Jefferson	1.4	0.093	2.2	0.65	8
OH	Monroe	1.3	0.44	2.8	0.81	8
OH	Muskingum	1.7	1.1	2.1	0.55	3
MD	Allegany	nd	0.82	0.82	nd	1

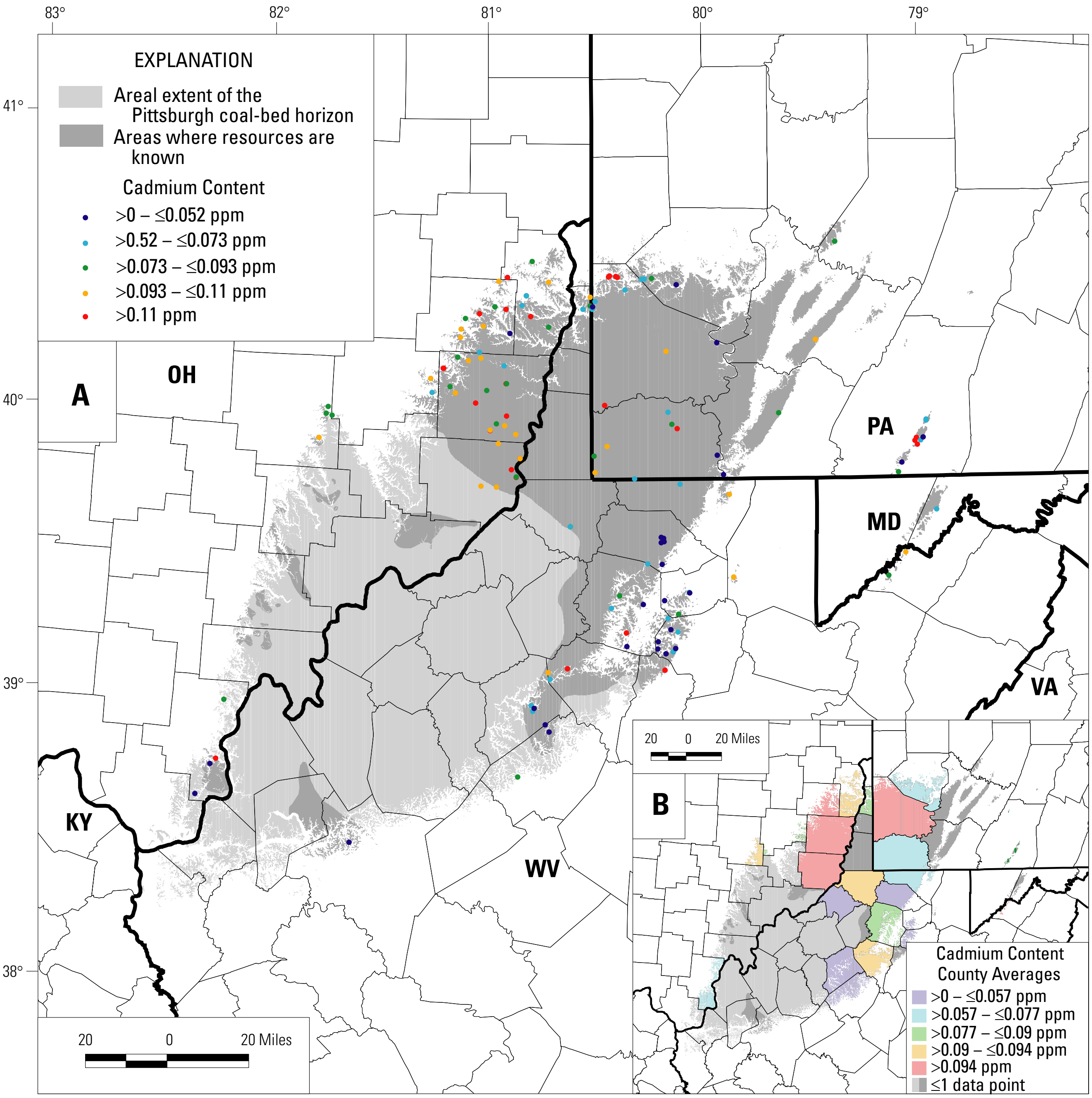

Figure 34. Maps showing cadmium content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows cadmium contents of the 140 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for cadmium contents using all 140 records in the geochemical database. Cadmium content ranges from 0.020 to 0.27 ppm with a mean value of 0.081±0.44 ppm (table 9). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 9. Cadmium content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	0.081	0.020	0.27	0.044	140
PA	na	0.084	0.022	0.20	0.047	36
WV	na	0.068	0.020	0.27	0.044	47
OH	na	0.092	0.028	0.27	0.042	56
MD	na	nd	0.054	0.054	nd	1
PA	Allegheny	0.063	0.034	0.090	0.023	4
PA	Fayette	nd	0.040	0.040	nd	1
PA	Greene	0.071	0.033	0.12	0.032	9
PA	Indiana	nd	0.082	0.082	nd	1
PA	Somerset	0.082	0.022	0.18	0.061	9
PA	Washington	0.10	0.045	0.20	0.052	11
PA	Westmoreland	nd	0.11	0.11	nd	1
WV	Barbour	0.051	0.027	0.078	0.017	9
WV	Braxton	0.054	0.042	0.074	0.017	3
WV	Brooke	0.087	0.067	0.11	0.020	3
WV	Gilmer	0.053	0.049	0.057	0.0040	3
WV	Harrison	0.085	0.046	0.20	0.057	6
WV	Kanawha	nd	0.020	0.020	nd	1
WV	Lewis	0.094	0.068	0.12	0.024	3
WV	Marion	0.032	0.025	0.046	0.0080	5
WV	Mineral	0.068	0.056	0.081	0.018	2
WV	Monongalia	0.077	0.057	0.097	0.028	2
WV	Preston	nd	0.049	0.049	nd	1
WV	Taylor	0.057	0.034	0.092	0.025	4
WV	Upshur	nd	0.27	0.27	nd	1
WV	Wetzel	0.091	0.059	0.11	0.024	4
OH	Belmont	0.094	0.047	0.21	0.039	20
OH	Gallia	0.074	0.028	0.14	0.053	4
OH	Guernsey	0.079	0.055	0.10	0.024	3
OH	Harrison	0.11	0.052	0.27	0.062	10
OH	Jefferson	0.094	0.054	0.15	0.031	8
OH	Monroe	0.077	0.042	0.15	0.037	8
OH	Muskingum	0.092	0.084	0.10	0.0083	3
MD	Allegany	nd	0.054	0.054	nd	1

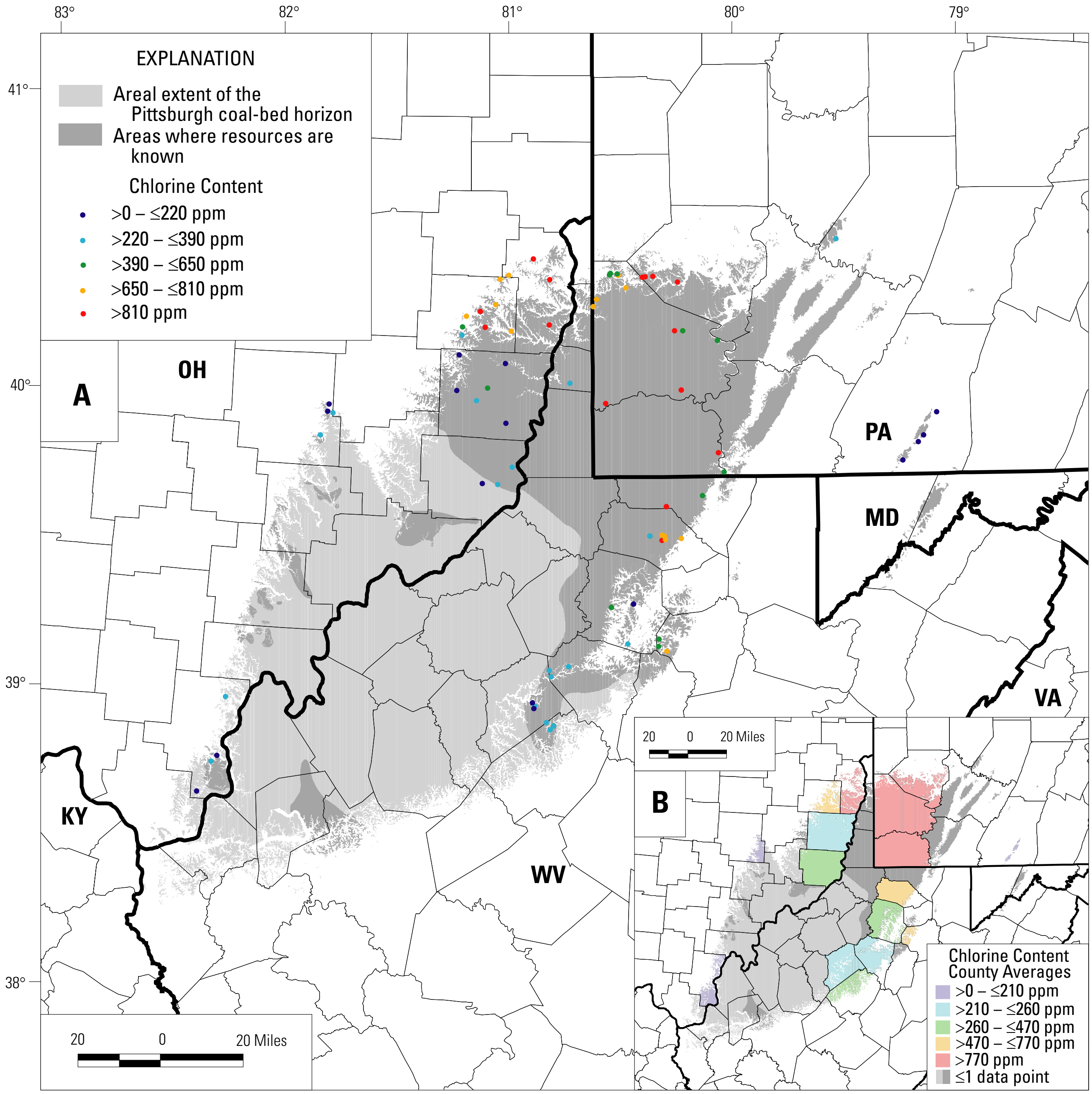

Figure 35. Maps showing chlorine content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows chlorine contents of the 85 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for chlorine contents using all 88 records in the geochemical database, including those that are located only to a county level; chlorine contents range from 48 to 1,500 ppm with a mean value of 550±350 ppm (table 10). The values are classified into five categories, each representing 20 percent of the data values. Chlorine values tend to be higher in the northern part of the coal bed. See figure 2 for county names.

Table 10. Chlorine content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	550	48	1,500	350	88
PA	na	710	48	1,500	390	25
WV	na	510	99	1,300	290	34
OH	na	470	62	1,300	330	29
PA	Allegheny	930	850	1,100	86	4
PA	Greene	860	650	1,100	290	2
PA	Indiana	nd	300	300	nd	1
PA	Somerset	84	48	99	24	4
PA	Washington	840	490	1,500	310	14
WV	Barbour	560	440	690	130	3
WV	Braxton	470	340	680	140	6
WV	Gilmer	220	180	260	40	3
WV	Harrison	300	99	530	200	5
WV	Lewis	260	240	290	24	3
WV	Marion	740	200	1,300	340	12
WV	Monongalia	nd	590	590	nd	1
WV	Ohio	nd	390	390	nd	1
OH	Belmont	230	62	500	170	6
OH	Gallia	210	100	320	110	4
OH	Guernsey	nd	260	260	nd	1
OH	Harrison	770	350	1,300	290	8
OH	Jefferson	850	790	930	60	4
OH	Monroe	280	210	350	68	3
OH	Muskingum	210	170	230	31	3

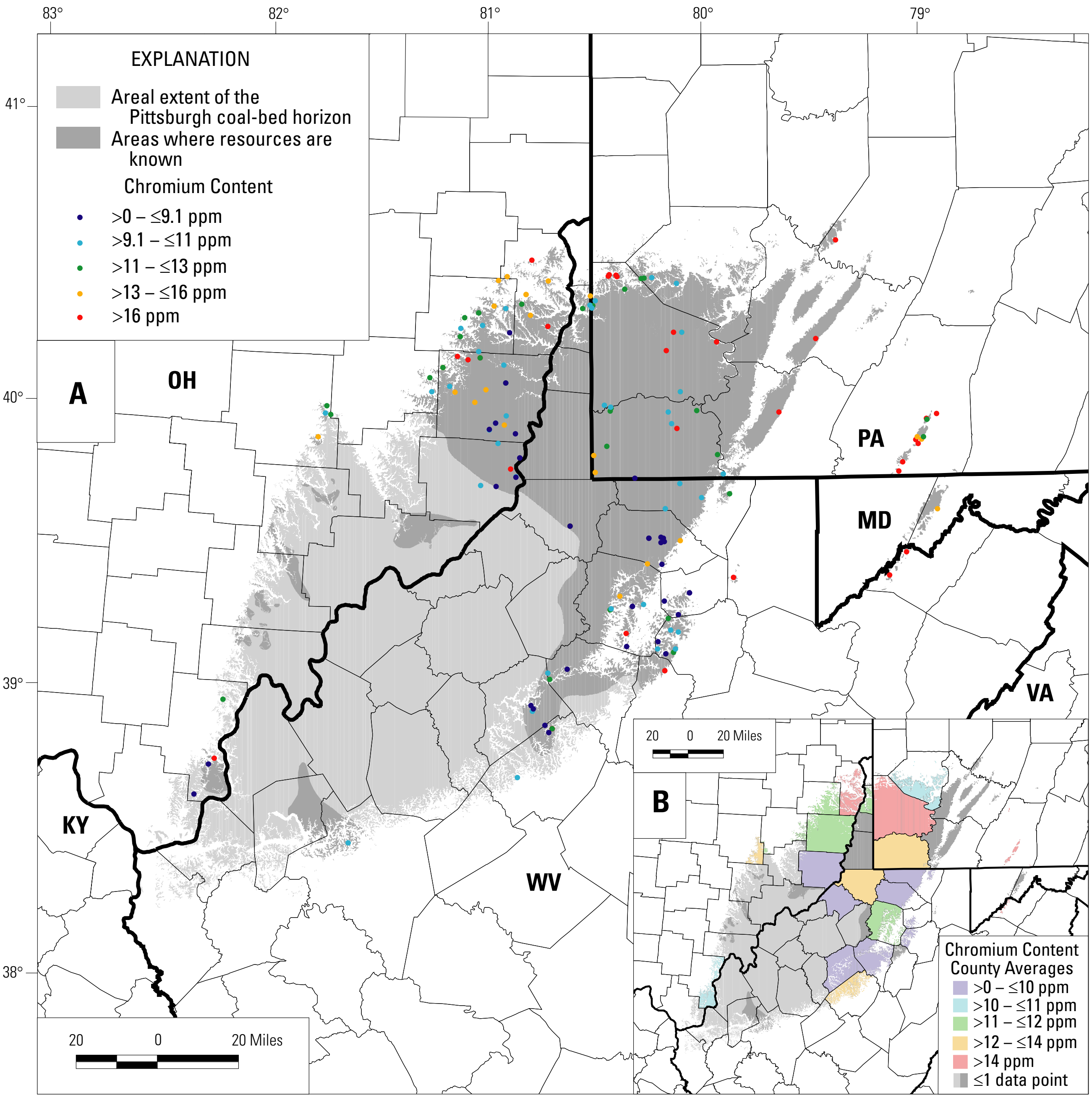

Figure 36. Maps showing chromium content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows chromium contents of the 165 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for chromium contents using all 166 records in the geochemical database, including those that are located only to a county level; chromium contents range from 2.5 to 32 ppm with a mean value of 13±4.8 ppm (table 11). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 11. Chromium content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	13	2.5	32	4.8	166
PA	na	15	7.8	28	4.5	46
WV	na	12	4.4	32	5.0	63
OH	na	12	2.5	20	4.2	56
MD	na	nd	16	16	nd	1
PA	Allegheny	11	10	12	0.93	4
PA	Fayette	nd	18	18	nd	1
PA	Greene	13	7.8	28	4.8	13
PA	Indiana	nd	21	21	nd	1
PA	Somerset	18	12	24	4.0	10
PA	Washington	15	10	24	4.1	16
PA	Westmoreland	nd	17	17	nd	1
WV	Barbour	10	7.4	12	1.7	9
WV	Braxton	14	7.9	27	6.8	7
WV	Brooke	12	10	14	1.8	3
WV	Gilmer	8.0	6.1	11	2.5	3
WV	Harrison	12	4.4	20	4.2	11
WV	Kanawha	nd	9.6	9.6	nd	1
WV	Lewis	10	7.3	12	2.4	3
WV	Marion	9.1	7.2	16	2.4	11
WV	Mineral	25	19	32	9.2	2
WV	Monongalia	10	9.2	12	1.2	3
WV	Preston	nd	22	22	nd	1
WV	Taylor	8.5	7.5	9.1	0.71	4
WV	Upshur	nd	21	21	nd	1
WV	Wetzel	14	9.1	19	4.3	4
OH	Belmont	12	4.9	20	4.1	20
OH	Gallia	11	6.4	20	6.2	4
OH	Guernsey	12	10	13	1.7	3
OH	Harrison	12	7.0	16	2.7	10
OH	Jefferson	15	12	18	1.9	8
OH	Monroe	8.5	2.5	20	5.7	8
OH	Muskingum	13	11	14	1.4	3
MD	Allegany	nd	16	16	nd	1

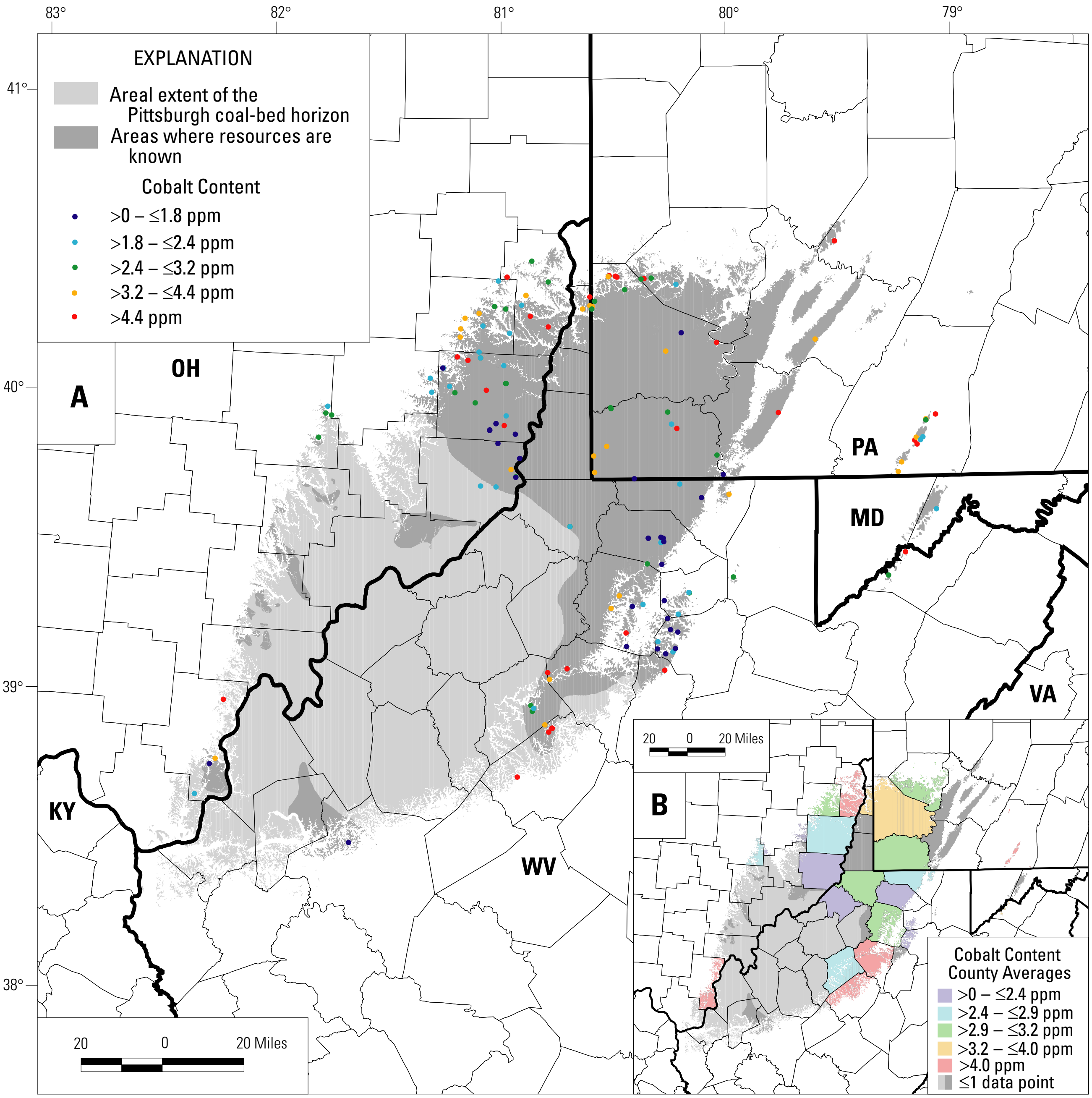

Figure 37. Maps showing cobalt content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows cobalt contents of the 152 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for cobalt contents using all 153 records in the geochemical database, including those that are located only to a county level; cobalt contents range from 0.64 to 13 ppm with a mean value of 3.4±2.3 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 12. Cobalt content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	3.4	0.64	13	2.3	153
PA	na	3.8	0.69	8.8	1.8	39
WV	na	3.5	0.64	13	3.0	57
OH	na	3.0	0.84	8.8	1.6	56
MD	na	nd	2.3	2.3	nd	1
PA	Allegheny	3.0	2.1	4.5	1.1	4
PA	Fayette	nd	5.9	5.9	nd	1
PA	Greene	3.2	1.3	8.7	2.0	11
PA	Indiana	nd	6.6	6.6	nd	1
PA	Somerset	4.2	2.2	8.8	2.0	10
PA	Washington	4.0	0.69	6.3	1.6	11
PA	Westmoreland	nd	3.3	3.3	nd	1
WV	Barbour	1.9	1.4	3.2	0.54	9
WV	Braxton	8.7	3.4	13	3.8	7
WV	Brooke	3.9	3.3	5.1	1.0	3
WV	Gilmer	2.8	2.0	3.2	0.67	3
WV	Harrison	2.7	0.79	5.9	1.8	8
WV	Kanawha	nd	1.4	1.4	nd	1
WV	Lewis	6.7	3.5	9.9	3.2	3
WV	Marion	1.3	0.64	2.0	0.53	8
WV	Mineral	4.0	3.1	5.0	1.4	2
WV	Monongalia	2.3	0.64	3.8	1.6	3
WV	Preston	nd	2.7	2.7	nd	1
WV	Taylor	2.2	1.8	2.6	0.31	4
WV	Upshur	nd	10	10	nd	1
WV	Wetzel	3.2	2.4	4.2	0.84	4
OH	Belmont	2.9	0.88	8.8	1.8	20
OH	Gallia	4.1	1.6	8.6	3.2	4
OH	Guernsey	2.4	2.0	3.1	0.57	3
OH	Harrison	3.0	2.1	4.1	0.77	10
OH	Jefferson	4.2	2.2	6.5	1.6	8
OH	Monroe	2.2	0.84	4.4	1.1	8
OH	Muskingum	2.5	2.1	2.7	0.32	3
MD	Allegany	nd	2.3	2.3	nd	1

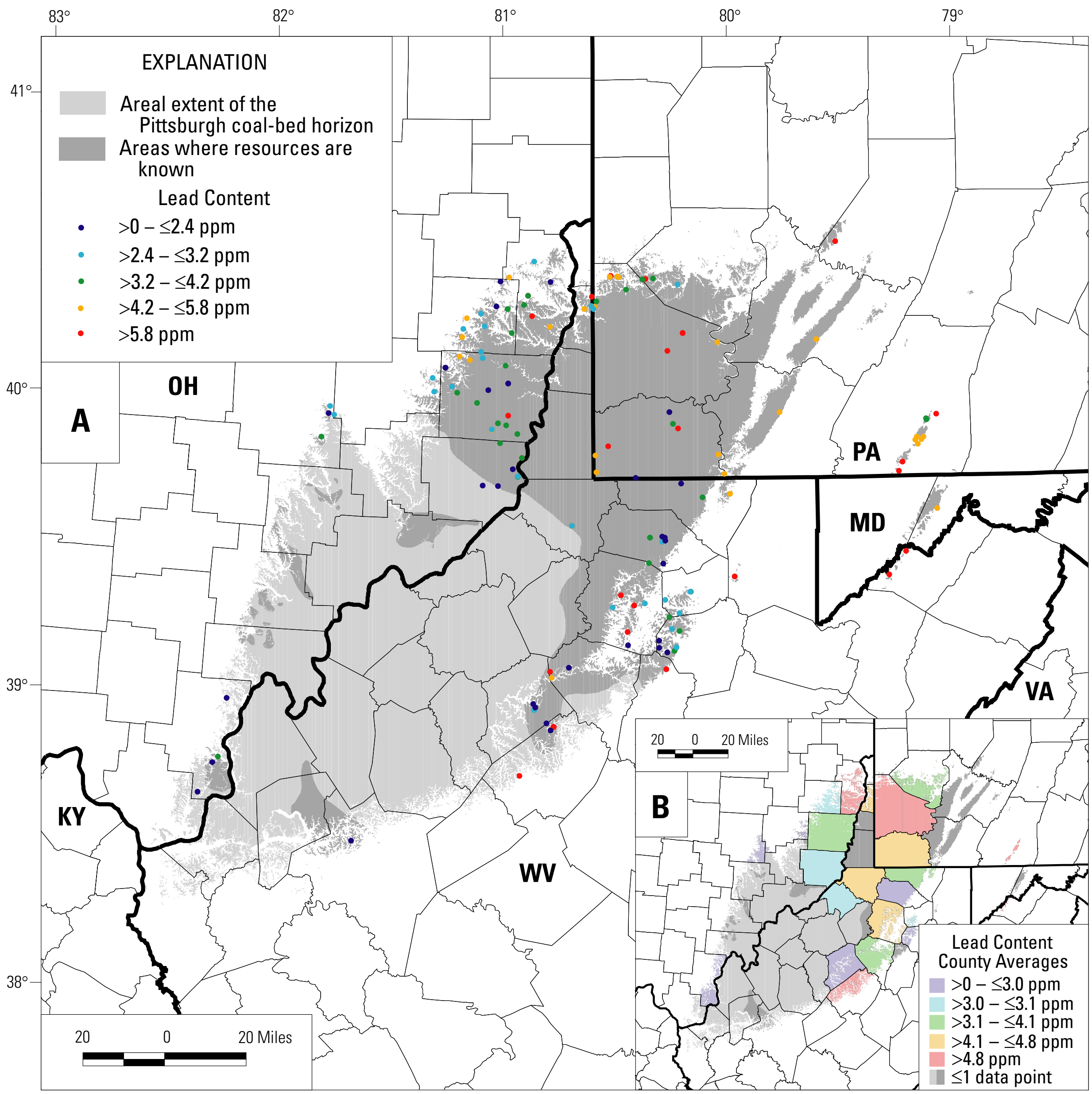

Figure 38. Maps showing lead content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows lead contents of the 151 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for lead contents using all 152 records in the geochemical database, including those that are located only to a county level; lead contents range from 0.47 to 14 ppm with a mean value of 4.2±2.4 ppm (table 13). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 13. Lead content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	4.2	0.47	14	2.4	152
PA	na	5.2	2.1	9.1	1.8	38
WV	na	4.3	0.50	14	2.7	57
OH	na	3.3	0.47	11	2.0	56
MD	na	nd	4.4	4.4	nd	1
PA	Allegheny	4.1	3.2	6.0	1.3	4
PA	Fayette	nd	5.6	5.6	nd	1
PA	Greene	4.8	2.1	8.6	2.0	9
PA	Indiana	nd	7.1	7.1	nd	1
PA	Somerset	5.5	4.0	9.1	1.8	10
PA	Washington	5.4	2.7	9.1	1.8	12
PA	Westmoreland	nd	5.1	5.1	nd	1
WV	Barbour	2.6	0.50	4.0	1.2	9
WV	Braxton	7.4	1.2	14	4.4	7
WV	Brooke	4.8	3.0	6.8	1.9	3
WV	Gilmer	2.1	1.4	2.5	0.62	3
WV	Harrison	4.6	0.54	7.6	2.4	8
WV	Kanawha	nd	1.4	1.4	nd	1
WV	Lewis	4.0	1.2	6.2	2.6	3
WV	Marion	3.0	2.0	5.6	1.3	8
WV	Mineral	8.5	6.1	11	3.3	2
WV	Monongalia	4.0	2.2	5.7	1.7	3
WV	Preston	nd	7.0	7.0	nd	1
WV	Taylor	3.1	2.5	3.8	0.54	4
WV	Upshur	nd	7.3	7.3	nd	1
WV	Wetzel	4.6	2.7	7.0	1.8	4
OH	Belmont	3.4	0.92	11	2.2	20
OH	Gallia	2.0	1.1	4.0	1.4	4
OH	Guernsey	3.0	2.9	3.1	0.14	3
OH	Harrison	3.1	1.4	4.7	0.95	10
OH	Jefferson	4.8	1.8	11	3.1	8
OH	Monroe	2.9	0.47	5.9	1.7	8
OH	Muskingum	2.6	1.6	3.4	0.91	3
MD	Allegany	nd	4.4	4.4	nd	1

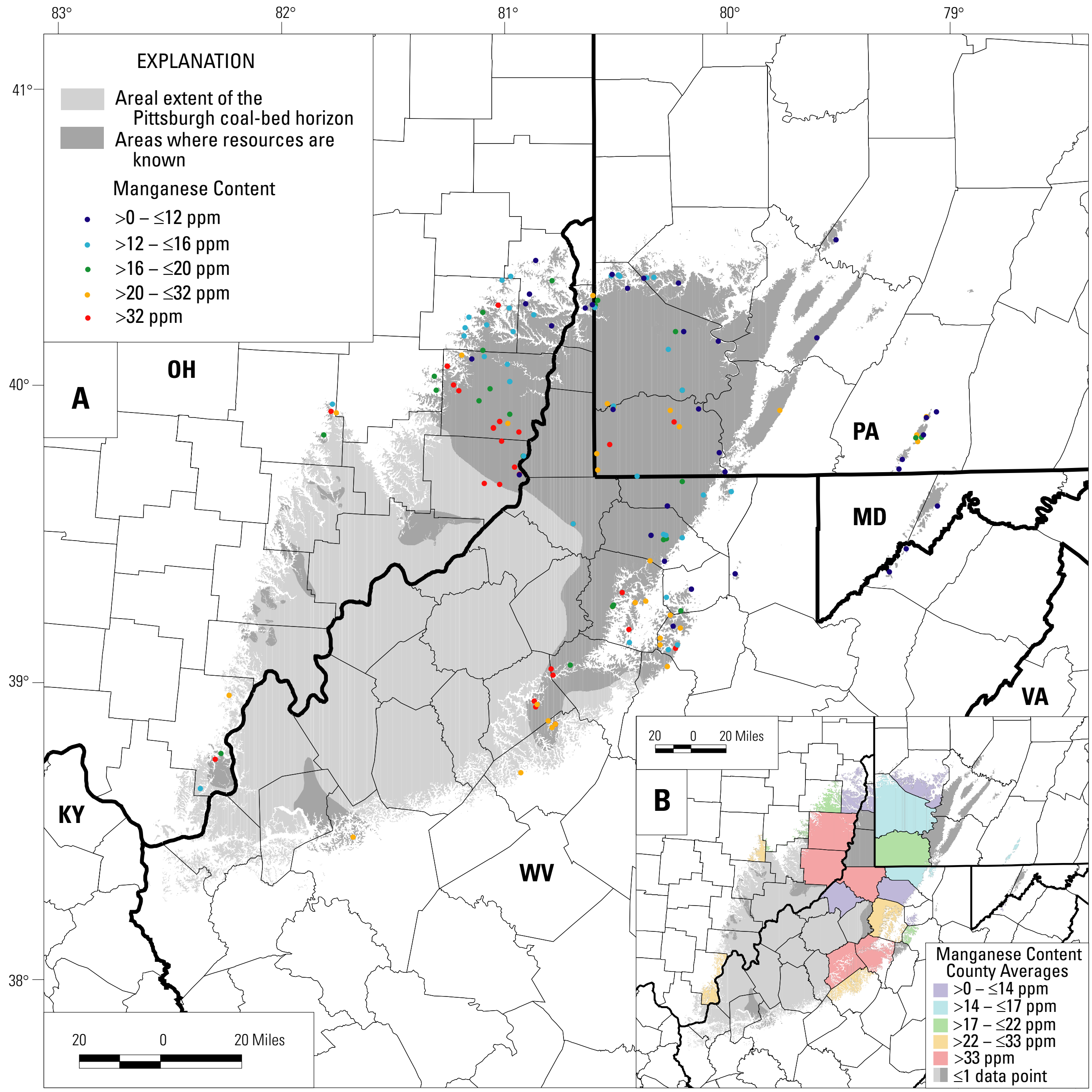

Figure 39. Maps showing manganese content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows manganese contents for the 165 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for manganese contents using all 166 records in the geochemical database, including those located only to a county level; manganese contents range from 3.3 to 130 ppm with a mean value of 23±17 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 14. Manganese content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	23	3.3	130	17	166
PA	na	16	3.3	38	8.2	46
WV	na	24	3.3	66	14	63
OH	na	28	6.5	130	23	56
MD	na	nd	6.0	6.0	nd	1
PA	Allegheny	9.5	3.3	14	5.2	4
PA	Fayette	nd	23	23	nd	1
PA	Greene	20	4.7	38	10	13
PA	Indiana	nd	10	10	nd	1
PA	Somerset	16	6.6	32	9.4	10
PA	Washington	15	7.0	28	4.9	16
PA	Westmoreland	nd	6.4	6.4	nd	1
WV	Barbour	22	11	35	7.7	9
WV	Braxton	33	21	49	11	7
WV	Brooke	14	7.4	22	7.6	3
WV	Gilmer	37	27	48	11	3
WV	Harrison	30	15	59	13	11
WV	Kanawha	nd	26	26	nd	1
WV	Lewis	43	19	59	22	3
WV	Marion	14	6.0	20	4.6	11
WV	Mineral	4.3	3.3	5.3	1.4	2
WV	Monongalia	17	15	19	1.7	3
WV	Preston	nd	6.2	6.2	nd	1
WV	Taylor	13	8.6	20	4.9	4
WV	Upshur	nd	30	30	nd	1
WV	Wetzel	39	16	66	22	4
OH	Belmont	39	12	130	31	20
OH	Gallia	24	16	37	9.0	4
OH	Guernsey	19	17	22	2.5	3
OH	Harrison	18	13	43	8.9	10
OH	Jefferson	12	7.0	17	3.3	8
OH	Monroe	37	6.5	82	24	8
OH	Muskingum	23	16	34	10	3
MD	Allegany	nd	6.0	6.0	nd	1

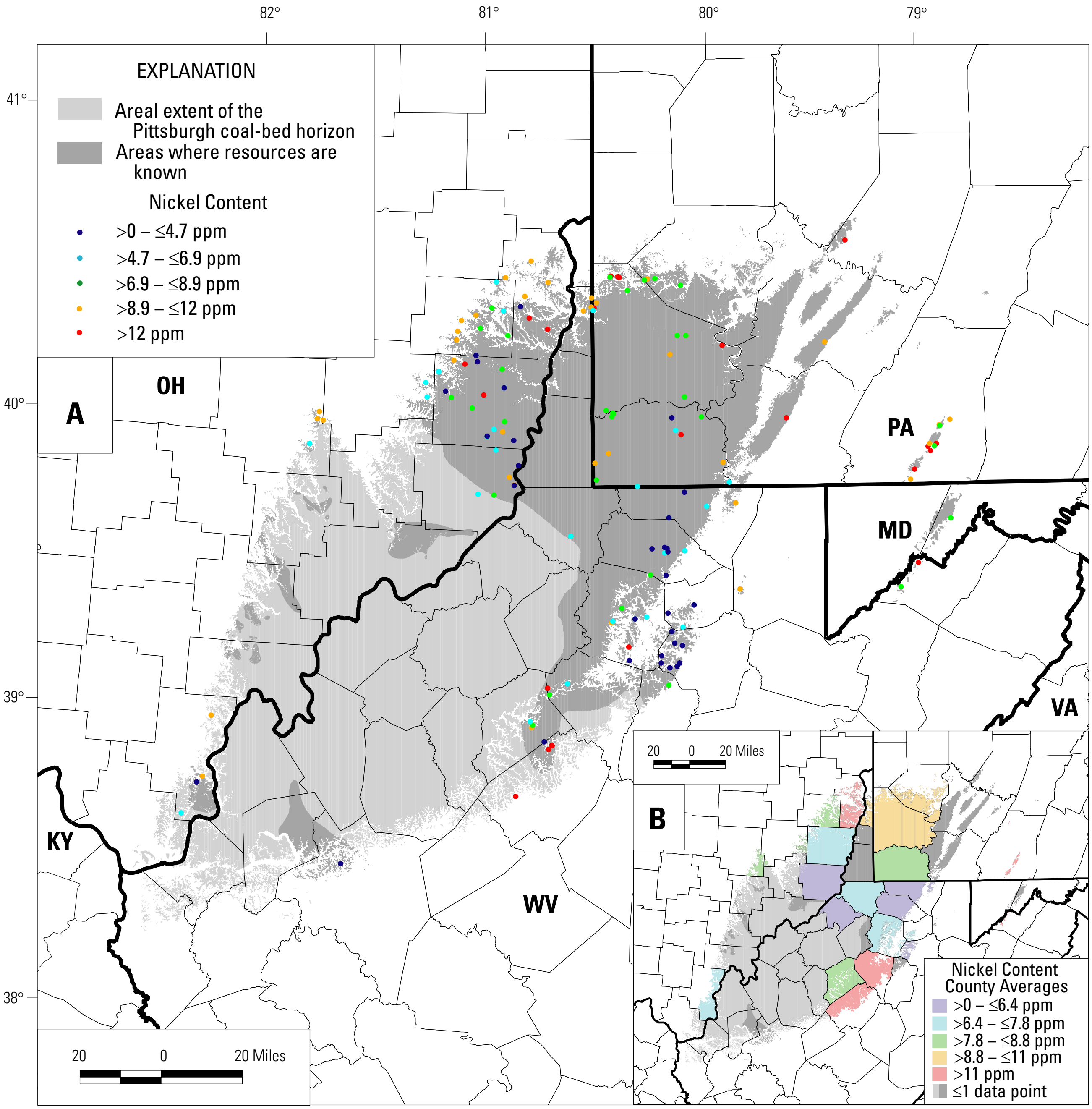

Figure 40. Maps showing nickel content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows nickel contents of the 165 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for nickel contents using all 166 records in the geochemical database, including those that are located only to a county level; nickel contents range from 2.4 to 25 ppm with a mean value of 8.8±4.6 ppm (table 15). The values are classified into five categories, each representing 20 percent of the data values. See figure 2 for county names.

Table 15. Nickel content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	8.8	2.4	25	4.6	166
PA	na	11	3.6	23	4.5	46
WV	na	8.0	3.6	25	5.1	63
OH	na	8.0	2.4	23	3.5	56
MD	na	nd	8.6	8.6	nd	1
PA	Allegheny	8.9	7.5	12	2.1	4
PA	Fayette	nd	14	14	nd	1
PA	Greene	8.8	3.6	20	4.1	13
PA	Indiana	nd	22	22	nd	1
PA	Somerset	13	7.3	23	4.9	10
PA	Washington	11	6.6	20	4.0	16
PA	Westmoreland	nd	11	11	nd	1
WV	Barbour	4.0	3.6	4.5	0.36	9
WV	Braxton	17	4.7	25	6.3	7
WV	Brooke	11	9.1	12	1.5	3
WV	Gilmer	7.9	6.3	10	1.9	3
WV	Harrison	7.8	3.8	18	3.9	11
WV	Kanawha	nd	4.6	4.6	nd	1
WV	Lewis	12	6.9	21	7.9	3
WV	Marion	4.9	3.9	6.3	0.74	11
WV	Mineral	12	8.9	15	4.5	2
WV	Monongalia	6.4	3.8	11	3.7	3
WV	Preston	nd	9.7	9.7	nd	1
WV	Taylor	5.0	3.7	6.1	1.2	4
WV	Upshur	nd	8.9	8.9	nd	1
WV	Wetzel	6.9	5.7	8.1	1.4	4
OH	Belmont	7.3	4.0	15	3.1	20
OH	Gallia	6.9	3.6	9.4	2.9	4
OH	Guernsey	8.1	6.1	12	3.3	3
OH	Harrison	8.0	3.9	12	2.3	10
OH	Jefferson	12	4.7	23	5.3	8
OH	Monroe	6.2	2.4	11	3.1	8
OH	Muskingum	8.8	6.9	9.9	1.6	3
MD	Allegany	nd	8.6	8.6	nd	1

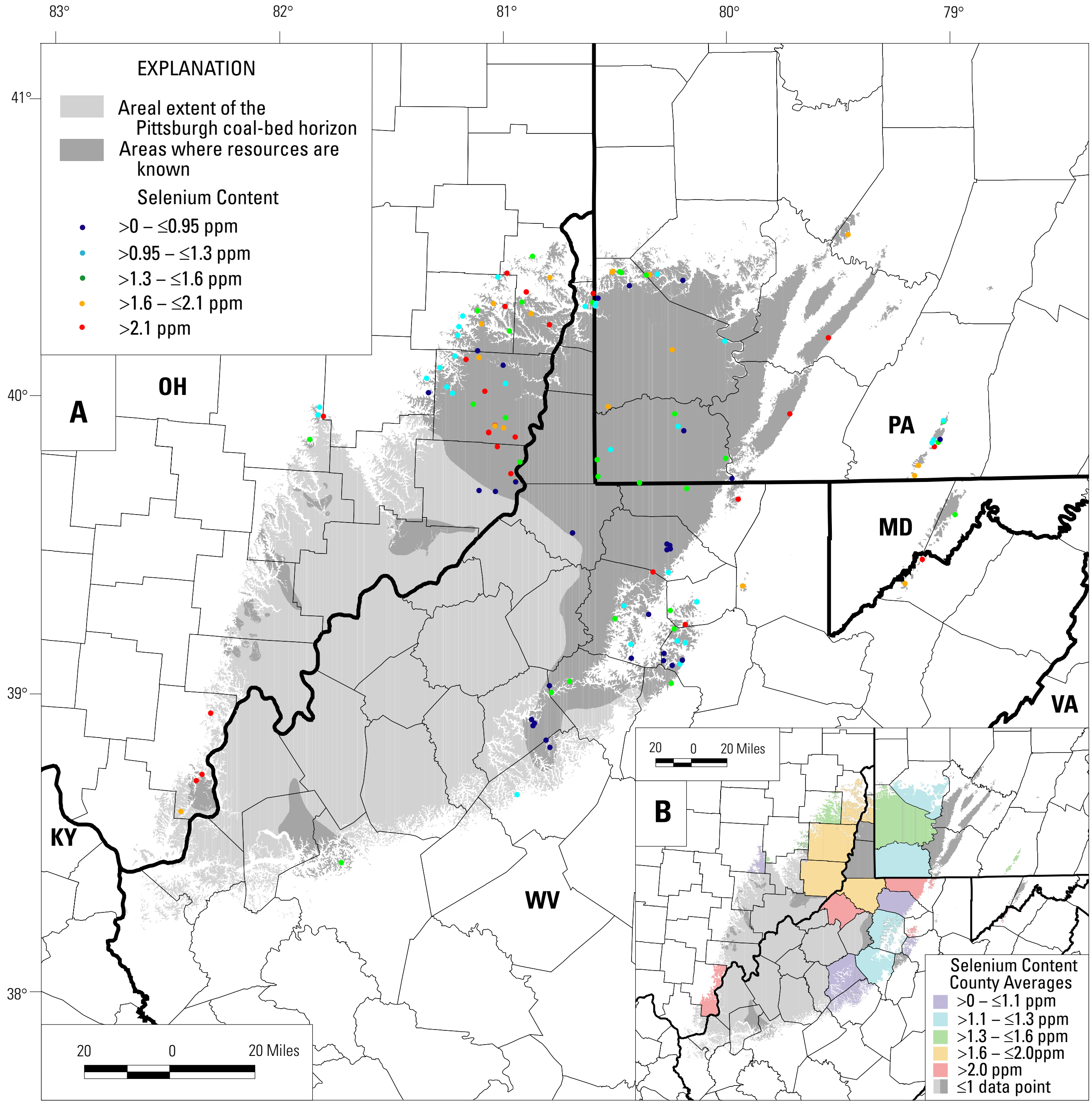

Figure 41. Maps showing selenium content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows selenium contents of the 140 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for selenium contents using all 140 records in the geochemical database. Selenium contents range from 0.20 to 3.7 ppm with a mean value of 1.5±0.77 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 16. Selenium content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	1.5	0.20	3.7	0.77	140
PA	na	1.4	0.50	2.4	0.47	36
WV	na	1.3	0.20	3.7	0.82	47
OH	na	1.7	0.48	3.7	0.84	56
MD	na	nd	1.4	1.4	nd	1
PA	Allegheny	1.3	0.50	2.1	0.65	4
PA	Fayette	nd	2.2	2.2	nd	1
PA	Greene	1.2	0.72	1.6	0.31	9
PA	Indiana	nd	1.8	1.8	nd	1
PA	Somerset	1.4	0.74	1.9	0.39	9
PA	Washington	1.5	0.74	2.1	0.46	11
PA	Westmoreland	nd	2.4	2.4	nd	1
WV	Barbour	0.95	0.46	1.4	0.33	9
WV	Braxton	0.73	0.20	1.3	0.56	3
WV	Brooke	1.8	1.1	3.0	1.0	3
WV	Gilmer	0.69	0.52	0.81	0.15	3
WV	Harrison	1.1	0.52	2.2	0.60	6
WV	Kanawha	nd	1.4	1.4	nd	1
WV	Lewis	1.3	0.81	1.6	0.43	3
WV	Marion	0.74	0.35	1.0	0.28	5
WV	Mineral	2.3	2.1	2.6	0.35	2
WV	Monongalia	2.7	1.6	3.7	1.5	2
WV	Preston	nd	1.7	1.7	nd	1
WV	Taylor	1.7	1.1	3.0	0.92	4
WV	Upshur	nd	1.6	1.6	nd	1
WV	Wetzel	2.0	0.56	3.5	1.3	4
OH	Belmont	1.8	0.54	3.7	0.94	20
OH	Gallia	2.6	2.0	3.4	0.70	4
OH	Guernsey	1.1	0.75	1.4	0.35	3
OH	Harrison	1.4	0.89	2.2	0.38	10
OH	Jefferson	2.0	1.4	2.6	0.46	8
OH	Monroe	1.9	0.79	3.7	1.1	8
OH	Muskingum	0.81	0.48	1.5	0.56	3
MD	Allegany	nd	1.4	1.4	nd	1

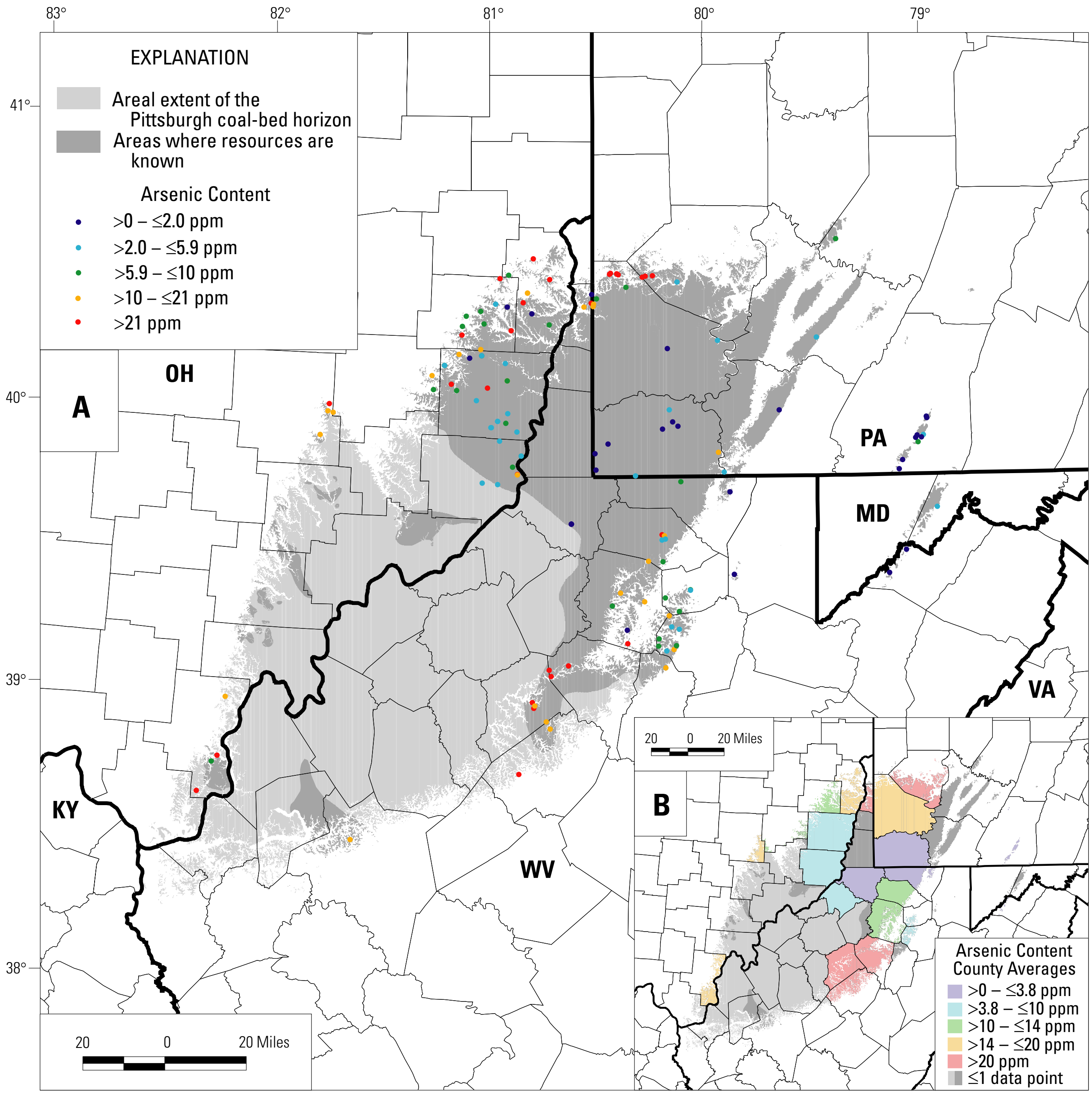

Figure 42. Maps showing arsenic content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows arsenic contents of the 140 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for arsenic content using all 140 records in the geochemical database. Arsenic contents range from 0.33 to 61 ppm with a mean value of 12±13 ppm (table 17). The values are classified into five categories, each representing 20 percent of the data values. Arsenic contents tend to be highest in the southeastern, north-central, and northwestern parts of the coal bed where ash contents are relatively high. See figure 2 for county names.

Table 17. Arsenic content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	12	0.33	61	13	140
PA	na	9.4	0.33	61	13	36
WV	na	13	0.33	58	14	47
OH	na	13	0.45	51	11	56
MD	na	nd	2.7	2.7	nd	1
PA	Allegheny	22	5.3	33	12	4
PA	Fayette	nd	0.50	0.50	nd	1
PA	Greene	2.7	0.46	11	3.4	10
PA	Indiana	nd	6.5	6.5	nd	1
PA	Somerset	1.9	0.33	10	3.2	9
PA	Washington	20	0.55	61	18	10
PA	Westmoreland	nd	3.2	3.2	nd	1
WV	Barbour	9.0	2.7	21	5.6	9
WV	Braxton	27	12	52	22	3
WV	Brooke	26	0.53	58	29	3
WV	Gilmer	26	14	36	11	3
WV	Harrison	12	0.99	23	7.3	6
WV	Kanawha	nd	18	18	nd	1
WV	Lewis	31	22	39	8.8	3
WV	Marion	14	2.2	42	16	5
WV	Mineral	0.57	0.45	0.69	0.17	2
WV	Monongalia	3.6	0.48	6.7	4.4	2
WV	Preston	nd	0.62	0.62	nd	1
WV	Taylor	7.8	5.1	10	2.1	4
WV	Upshur	nd	14	14	nd	1
WV	Wetzel	0.53	0.33	0.71	0.17	4
OH	Belmont	9.7	0.58	51	12	20
OH	Gallia	19	9.9	31	9.5	4
OH	Guernsey	11	7.3	14	3.6	3
OH	Harrison	14	0.45	37	12	10
OH	Jefferson	18	0.47	44	15	8
OH	Monroe	10	4.0	25	7.9	8
OH	Muskingum	19	12	31	11	3
MD	Allegany	nd	2.7	2.7	nd	1

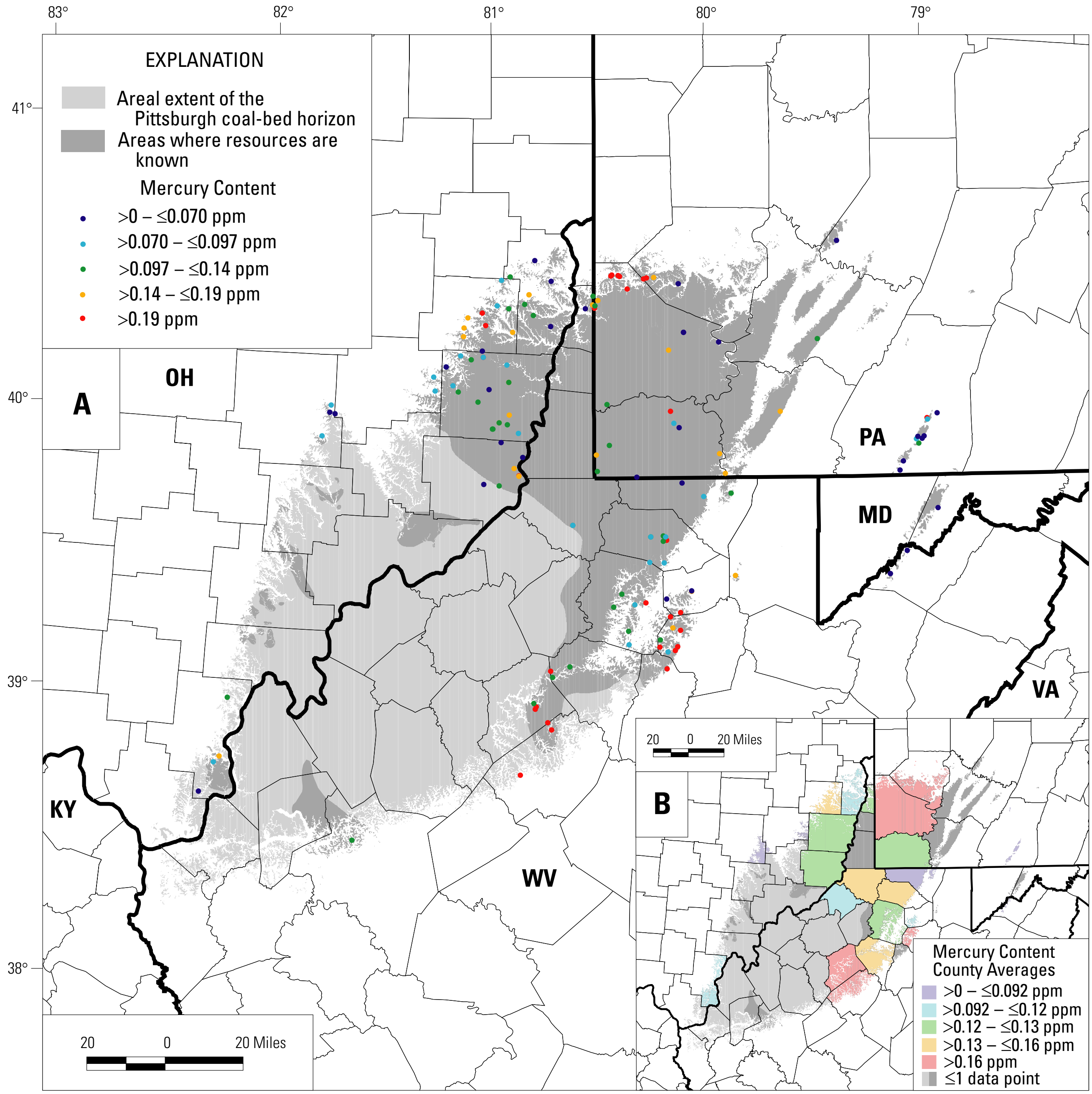

Figure 43. Maps showing mercury content (parts per million (ppm), as-received whole-coal basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows mercury contents of the 148 geochemical samples for which records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for mercury content based on all 149 records in the geochemical database, including those located only to a county level; mercury contents range from 0.0024 to 0.55 ppm with a mean value of 0.14±0.092 ppm (table 18). The values are classified into five categories, each representing 20 percent of the data values. In general, mercury content tends to be correlated with sulfur content. See figure 2 for county names.

Table 18. Mercury content (parts per million) means, ranges, and standard deviations for samples of the Pittsburgh 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	0.14	0.0024	0.55	0.092	149
PA	na	0.15	0.0024	0.55	0.12	39
WV	na	0.16	0.025	0.54	0.099	53
OH	na	0.12	0.029	0.30	0.054	56
MD	na	nd	0.030	0.030	nd	1
PA	Allegheny	0.23	0.067	0.40	0.14	4
PA	Fayette	nd	0.18	0.18	nd	1
PA	Greene	0.13	0.030	0.23	0.059	9
PA	Indiana	nd	0.060	0.060	nd	1
PA	Somerset	0.078	0.0024	0.21	0.060	10
PA	Washington	0.21	0.020	0.55	0.14	13
PA	Westmoreland	nd	0.14	0.14	nd	1
WV	Barbour	0.18	0.068	0.30	0.075	9
WV	Braxton	0.37	0.22	0.54	0.16	3
WV	Brooke	0.12	0.069	0.15	0.043	3
WV	Gilmer	0.23	0.12	0.29	0.099	3
WV	Harrison	0.12	0.074	0.21	0.049	8
WV	Kanawha	nd	0.099	0.099	nd	1
WV	Lewis	0.16	0.099	0.25	0.077	3
WV	Marion	0.15	0.078	0.39	0.10	8
WV	Mineral	0.044	0.030	0.059	0.021	2
WV	Monongalia	0.092	0.070	0.13	0.031	3
WV	Preston	nd	0.16	0.16	nd	1
WV	Taylor	0.11	0.025	0.21	0.098	4
WV	Upshur	nd	0.24	0.24	nd	1
WV	Wetzel	0.14	0.079	0.25	0.077	4
OH	Belmont	0.12	0.049	0.24	0.044	20
OH	Gallia	0.10	0.049	0.19	0.061	4
OH	Guernsey	0.082	0.070	0.094	0.012	3
OH	Harrison	0.15	0.029	0.30	0.077	10
OH	Jefferson	0.11	0.058	0.17	0.048	8
OH	Monroe	0.12	0.068	0.21	0.054	8
OH	Muskingum	0.072	0.044	0.097	0.027	3
MD	Allegany	nd	0.030	0.030	nd	1

The decrease in calorific values from east to west may reflect the combined effects of higher ash yield (fig. 26) and rank changes from low-volatile bituminous through medium-volatile bituminous to high-volatile C bituminous (fig. 30) resulting from regional metamorphism that occurred during Permian tectonism (Puglio, 1983). Because the Pittsburgh coal is bituminous in rank, total moisture (fig. 31; table 6) tends to be relatively low, with a mean of 2.90±1.46 weight percent for the entire bed (2,951 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. One-hundred and sixty-four representative Pittsburgh coal bed samples were analyzed for these 12 elements (figs. 32–43, tables 7–18). All analyses are on an as-received whole-coal basis.

ARSENIC AND MERCURY

Two of the elements thought to have particularly adverse effects include arsenic and mercury. Mean arsenic concentrations (parts per million (ppm), as-received whole-coal basis) for 140 Pittsburgh coal bed samples ranged from 9.4±13 ppm in Pennsylvania to 13±11 ppm in Ohio and West Virginia (analyses were not available for Maryland), with a mean of 12±14 ppm (fig. 42, table 17). This compares to the Appalachian Basin coal mean of 35 ppm arsenic (Finkelman and others, 1994) and the U.S. coal mean of 24±5.5 ppm arsenic (Finkelman, 1993).

Mean mercury concentrations (ppm, as-received whole-coal basis) for 149 Pittsburgh coal bed samples ranged from 0.12±0.054 ppm in Ohio to 0.16±0.099 ppm in West Virginia (fig. 43, table 18). These values are slightly 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

Based on our resource calculations, the original total resource of the Pittsburgh coal bed was 34 billion short tons (table 1). This total resource estimate includes 3.7 billion short tons of measured, 10.9 billion short tons of indicated, 15.2 billion short tons of inferred, and 3.8 billion short tons of hypothetical coal (fig. 20; Appendixes 15, 16). About 16 billion short tons remain in Pennsylvania, Ohio, and West Virginia but much of the remaining coal is thinner (fig. 22), under deeper cover (fig. 23), and higher in ash (fig. 44) and sulfur (fig. 45) than the coal that has already been mined. Totals for each category of measured, indicated, inferred, and hypothetical remaining resources are approximately half of the totals for the original categories (fig. 20).

In Maryland, the original resource of 260 million short tons of Pittsburgh coal (table 1), which had underlain much of western Allegany County and part of eastern Garrett County, has essentially been mined (figs. 2, 14; Appendixes 15, 16). The Pittsburgh coal, or Fourteen-Foot or Big Vein as it is called in Maryland, was extensively mined from the mid 1800's; production began to decline as early as 1907 as the coal was depleted (Vokes and Edwards, 1957). The coal, with a thickness range of 3 to 14 ft (fig. 17), was overlain by less than 500 ft of overburden (fig. 16). The coal was very low in ash (7.44±1.61 weight percent, as-received basis; table 2) and sulfur (0.87±0.1 weight percent, as-received whole-coal basis; table 3), and high in calorific value (14,020±420 Btu/lb, as-received whole-coal basis; table 5). All of the recent Pittsburgh coal bed production in Maryland (fig. 11; Appendix 6) is from very small surface mines and the re-mining of abandoned underground mine pillars. Therefore, the assumption was made that the area was mined out, and remaining resources were not assessed for this study.

Only about one-third of the original coal resource remains in Pennsylvania. Of the 16 billion original short tons, about 5 billion short tons remain (table 1). In Armstrong, Cambria, Indiana, and Somerset Counties, where overburden thickness was less than 200 ft (figs. 2, 16), there are no significant remaining resources. Although some Pittsburgh coal bed production is reported in these counties (Appendix 3), much of the coal is produced from the re-mining of abandoned underground mines. The largest remaining resource and the largest current mining operations are in Greene and Washington Counties, Pa. (2.6 and 2.3 billion short tons remaining, respectively). The resource is under relatively deep cover (500–1,000 ft; figs. 16, 23), but coal-bed thickness varies little (6–8 ft; figs. 7, 22) in the eastern and western parts of these counties, allowing for large-longwall mining. Although the ash and sulfur content of the unmined coal is moderate (figs. 44, 45), coal washing will remove some of the pyrite, one of the primary sources of sulfur. Examination of sulfur contents of coal delivered to power plants from the largest mines in Greene and Washington Counties shows that washing is effective: mean values, averaged over annual contracts, show an average reduction to about 1.4 weight percent sulfur (Federal Energy Regulatory Commission, 1995).

About one third of the Pittsburgh coal has been mined in West Virginia. From an original resource of 13 billion short tons, 7.8 billion short tons remain. Of the 18 counties in West Virginia with calculated original resources, only Mineral County, which contained thick (mean thickness of 10 ft; fig. 17) and shallow (<200 ft deep, fig. 16) coal is mined out. About 60 percent of the original Pittsburgh resource and 50 percent of the Pittsburgh production in West Virginia is in Marion, Marshall, Harrison, and

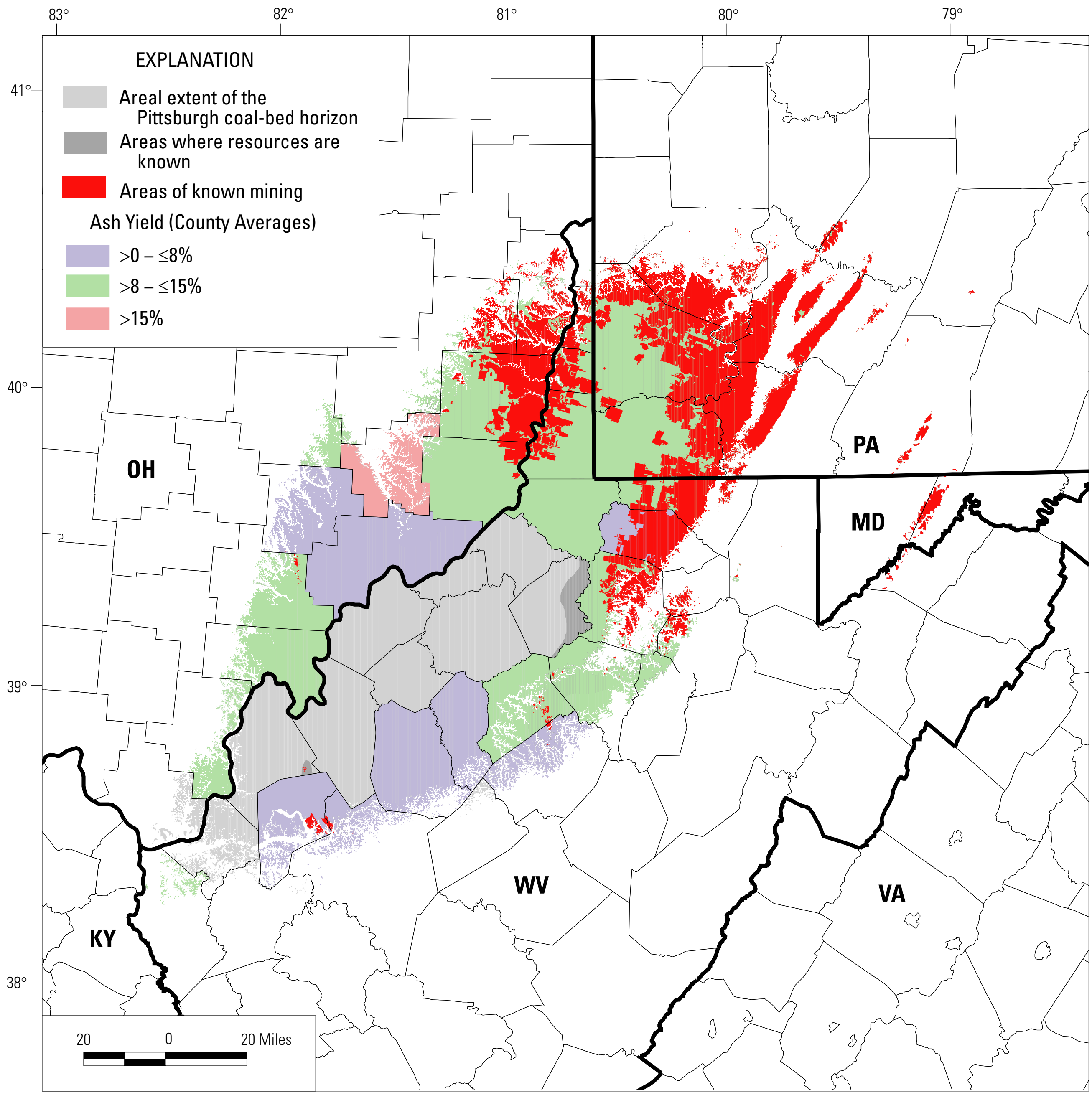

Figure 44. Map showing mined areas overlying county averages of ash yield (weight percent, as-received basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Remaining coal tends to have higher ash yield than the coal that has previously been mined (fig. 26). See figure 2 for county names.

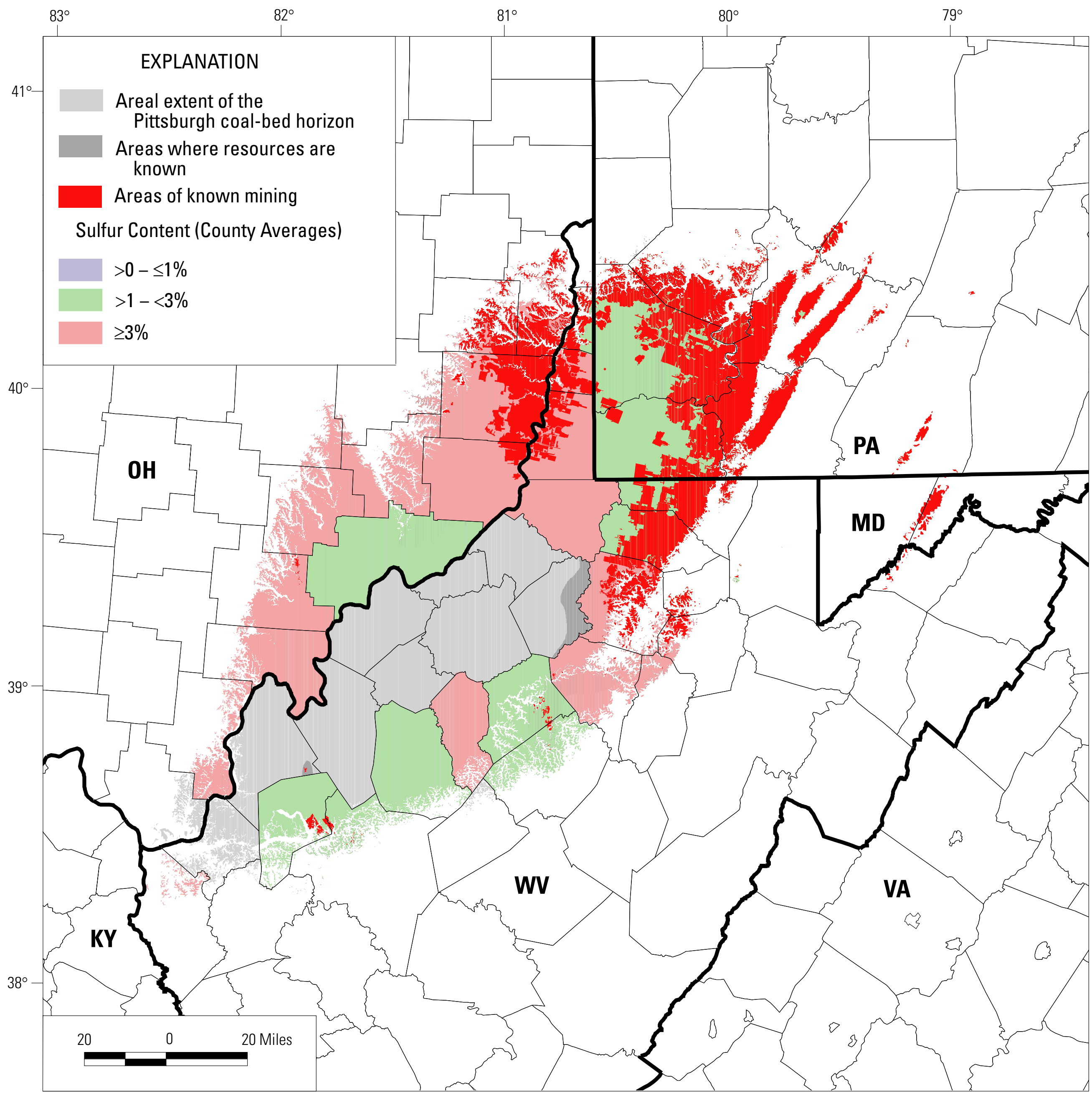

Figure 45. Map showing mined areas overlying county averages of sulfur content (weight percent, as-received basis) of the Pittsburgh coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Remaining coal tends to be higher in sulfur than the coal that has previously been mined (fig. 27). See figure 2 for county names.

Monongalia Counties (Appendixes 4, 15). Much of the remaining coal in these counties is under deep cover (>1,000 ft; figs. 2, 16). Northern Wetzel County, which has the largest remaining resource, has never been mined, probably because the coal is relatively high in ash (mean of 9.59±2.75 weight percent; table 2; figs. 2, 44) and sulfur (mean of 4.15±1.29 weight percent; table 3; figs. 2, 45) and is under deep cover (>1,000 ft, fig. 23).

The Pittsburgh coal bed thins towards the west and the south in Ohio (fig. 17), but in comparison to Pennsylvania and northern West Virginia, significant resources remain under shallow cover (fig. 16). Our resource estimates show that about 85 percent of Ohio's total original resource of 5.9 billion short tons was located in Belmont, Monroe, Jefferson, and Harrison Counties (Appendix 15). Although a substantial percentage of the coal remains in Monroe and Belmont Counties and much smaller amounts in Jefferson and Harrison Counties, the remaining coal tends to be thinner (figs. 2, 22). As discussed previously, values for ash yield and sulfur content are higher in Ohio than in West Virginia, Pennsylvania, and Maryland (tables 2, 3).

CONCLUSIONS

The Upper Pennsylvanian Pittsburgh coal bed of the Monongahela Group is the thickest and most extensive coal bed in the Appalachian Basin. Despite two centuries of mining, about 16 billion short tons of resources remain, with the largest remaining block in southwestern Pennsylvania and adjacent areas of West Virginia. Much of the remaining resource to the south of Marion County, W. Va., and west through much of Ohio is high in ash and sulfur, and is not likely to be extensively mined in the near future given current economic trends.

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APPENDIX 1

HISTORIC REPORTED ANNUAL PRODUCTION (IN SHORT TONS) OF THE PITTSBURGH COAL BED IN PENNSYLVANIA, WEST VIRGINIA, OHIO, AND MARYLAND FROM 1759 TO 1880

[Sources: United States Congress (1789-1822), Beatty (1849), United States Census Office, 8th Census (1860), Scharf (1882), Clark and Campbell (1905). Abbreviations are as follows: nd, no data available.]

Year	PA	WV	OH	MD
1750	nd	nd	nd	nd
1751	nd	nd	nd	nd
1752	nd	nd	nd	nd
1753	nd	nd	nd	nd
1754	nd	nd	nd	nd
1755	nd	nd	nd	nd
1756	nd	nd	nd	nd
1757	nd	nd	nd	nd
1758	nd	nd	nd	nd
1759	50	nd	nd	nd
1760	50	nd	nd	nd
1761	100	nd	nd	nd
1762	100	nd	nd	nd
1763	100	nd	nd	nd
1764	100	nd	nd	nd
1765	100	nd	nd	nd
1766	100	nd	nd	nd
1767	100	nd	nd	nd
1768	100	nd	nd	nd
1769	100	nd	nd	nd
1770	100	nd	nd	nd
1771	100	nd	nd	nd
1772	100	nd	nd	nd
1773	100	nd	nd	nd
1774	100	nd	nd	nd
1775	150	nd	nd	nd
1776	150	nd	nd	nd
1777	150	nd	nd	nd
1778	200	nd	nd	nd
1779	200	nd	nd	nd
1780	400	nd	nd	nd
1781	600	nd	nd	nd
1782	800	nd	nd	nd
1783	1,000	nd	nd	nd
1784	3,000	nd	nd	nd
1785	5,000	nd	nd	nd
1786	10,000	nd	nd	nd
1787	15,000	nd	nd	nd
1788	20,000	nd	nd	nd
1789	25,000	nd	nd	nd
1790	30,000	nd	nd	nd
1791	34,000	nd	nd	nd
1792	38,000	nd	nd	nd
1793	42,000	nd	nd	nd
1794	46,000	nd	nd	nd
1795	50,000	nd	1,000	nd
1796	57,000	nd	2,000	nd
1797	64,000	nd	3,000	nd
1798	71,000	nd	5,000	nd
1799	79,000	nd	7,000	nd
1800	87,000	7,600	8,000	nd
1801	89,000	9,200	8,600	nd
1802	92,000	10,000	8,900	nd
1803	94,000	10,800	9,200	nd
1804	97,000	12,400	9,800	100
1805	100,000	14,000	10,500	300
1806	104,000	15,700	11,200	500
1807	108,000	17,400	11,900	700
1808	112,000	19,100	12,600	900
1809	116,000	20,800	13,300	1,100
1810	120,000	22,500	14,000	1,300
1811	130,000	23,900	16,000	1,500
1812	142,000	25,300	18,000	1,700
1813	154,000	26,700	20,000	1,900
1814	167,000	28,100	22,000	2,100
1815	180,000	29,500	24,200	2,300
1816	200,000	31,000	26,400	2,500
1817	220,000	32,500	28,600	2,600
1818	240,000	34,000	30,800	2,700
1819	220,000	35,500	33,000	2,900
1820	200,000	37,100	35,000	3,000
1821	200,000	40,200	36,500	3,000
1822	200,000	43,300	38,000	3,000
1823	200,000	46,400	39,500	3,000
1824	200,000	49,500	41,000	3,000
1825	200,000	52,600	42,500	3,000
1826	220,000	55,800	44,000	3,000
1827	240,000	59,000	45,500	3,000
1828	260,000	62,200	47,000	3,000
1829	280,000	65,500	48,500	3,000
1830	300,000	68,800	50,000	3,000
1831	320,000	72,100	51,800	3,000
1832	340,000	75,400	53,600	12,000
1833	286,620	78,700	55,400	11,600
1834	380,000	82,000	57,200	11,200
1835	400,000	85,300	59,000	10,800
1836	452,160	88,700	60,900	10,400
1837	403,000	92,100	62,800	10,000
1838	406,000	95,500	64,700	9,600
1839	461,542	99,000	66,700	9,200
1840	410,093	102,500	68,666	8,880
1841	460,000	105,500	76,200	9,000
1842	510,400	108,500	83,700	9,000
1843	570,000	111,500	90,840	12,421
1844	630,000	114,500	105,200	18,345
1845	690,000	117,500	119,700	30,372
1846	760,000	120,500	134,700	36,707
1847	900,000	123,500	149,700	65,222
1848	1,039,000	126,500	179,400	98,032
1849	1,178,000	129,500	237,000	175,497
1850	1,317,000	132,600	295,100	242,517
1851	1,456,000	155,100	351,000	317,460
1852	1,596,000	177,600	407,000	411,707
1853	1,735,000	200,000	463,000	657,862
1854	1,874,000	222,600	519,000	812,727
1855	2,012,000	245,100	575,000	735,137
1856	2,151,286	267,600	632,000	817,659
1857	2,208,000	290,200	689,000	654,017
1858	2,266,000	312,800	746,000	722,686
1859	2,323,000	334,500	803,000	833,349
1860	2,380,460	358,300	861,760	438,000
1861	2,603,000	378,000	864,000	287,073
1862	2,826,000	398,000	866,200	346,201
1863	3,049,000	418,000	868,400	877,313
1864	3,272,000	438,000	870,600	755,764
1865	3,496,000	458,000	872,800	1,025,208
1866	3,719,000	479,000	875,000	1,217,668
1867	3,942,000	500,000	877,200	1,381,429
1868	4,165,000	522,000	879,400	1,529,879
1869	4,389,000	543,000	881,500	2,216,300
1870	4,613,625	565,370	883,500	1,819,824
1871	3,978,000	616,000	956,000	2,670,338
1872	6,608,000	666,000	1,028,000	2,647,156
1873	6,479,000	716,000	1,100,000	3,198,911
1874	5,268,000	766,000	1,172,000	2,899,392
1875	5,000,000	817,000	1,245,000	2,808,018
1876	4,107,000	867,000	1,518,000	2,126,873
1877	3,216,563	917,000	1,391,000	1,939,575
1878	5,992,345	967,000	1,464,000	2,068,925
1879	10,044,926	1,017,000	1,536,000	2,132,233
1880	11,809,516	1,067,342	1,608,484	2,228,917

APPENDIX 2

RECENT REPORTED ANNUAL PRODUCTION (IN SHORT TONS) OF THE PITTSBURGH COAL BED IN PENNSYLVANIA, WEST VIRGINIA, OHIO, AND MARYLAND ASSEMBLED FROM STATE AGENCIES

[Sources: Ohio Division of Labor Statistics (1969–1981, 1982–1993), Maryland Bureau of Mines (1969–1995), Commonwealth of Pennsylvania (1975–1995), Gayle H. McColloch (West Virginia Geological and Economic Survey, unpublished search of West Virginia Office of Miner's Health, Safety, and Training—Safety Information System (MHST-SIS) database, 1997). Abbreviations are as follows: nd, no data available or the absence of production.]

YEAR	PA	WV	OH	MD
1969	nd	nd	19,006,547	159,244
1970	nd	nd	16,927,133	125,107
1971	nd	nd	14,194,385	112,300
1972	nd	nd	17,206,464	273,140
1973	nd	nd	15,837,057	251,338
1974	nd	nd	14,038,495	304,378
1975	22,460,125	nd	13,821,817	311,117
1976	22,045,281	nd	13,861,225	333,801
1977	20,099,064	nd	12,504,552	370,922
1978	17,657,136	nd	10,639,611	558,866
1979	21,123,118	nd	12,527,177	441,998
1980	19,243,068	nd	10,509,844	528,789
1981	15,614,723	nd	8,634,026	572,819
1982	12,193,147	31,609,864	9,481,217	441,015
1983	15,189,441	29,693,071	7,167,608	473,037
1984	15,973,251	32,158,234	8,910,840	549,714
1985	15,881,358	27,015,958	8,073,156	360,521
1986	19,845,008	26,976,029	8,054,355	474,088
1987	19,106,842	30,211,307	6,517,825	316,888
1988	21,447,966	29,733,701	7,600,733	191,101
1989	22,384,479	29,659,061	7,880,306	365,263
1990	20,143,702	32,222,996	9,605,854	340,670
1991	22,606,817	32,324,689	8,107,746	260,295
1992	28,037,191	30,206,461	8,333,978	197,265
1993	25,599,152	16,909,501	7,579,390	162,158
1994	28,237,174	30,701,324	10,141,216	262,912
1995	32,416,168	29,326,727	nd	310,630
1996	nd	29,129,379	nd	nd

APPENDIX 3

RECENT REPORTED ANNUAL PRODUCTION (IN SHORT TONS) OF THE PITTSBURGH COAL BED IN PENNSYLVANIA, BY COUNTY

[Source: Commonwealth of Pennsylvania (1975–1995). Abbreviations are as follows: nd, no data available or the absence of production.]

Year	Allegheny	Armstrong	Beaver	Bedford	Fayette	Greene	Indiana	Jefferson	Lawrence	Somerset	Washington	Westmoreland	Total annual production
1975	920,142	1,085,948	nd	nd	832,830	6,017,580	118,562	nd	nd	37,412	12,127,195	1,320,456	22,460,125
1976	947,761	1,146,483	nd	nd	961,348	5,826,854	166,573	nd	nd	28,498	11,682,232	1,285,532	22,045,281
1977	921,531	1,074,549	21838	nd	840,944	5,472,645	196,003	1,159	nd	131,027	10,327,334	1,112,034	20,099,064
1978	1,620,121	911,413	114,775	330	651,659	4,868,611	173,734	nd	nd	56,340	8,353,039	907,114	17,657,136
1979	874,650	697,856	47,506	nd	728,772	6,778,916	100,193	nd	nd	405,553	10,542,277	947,395	21,123,118
1980	916,025	800,458	nd	23,709	533,656	6,776,167	122,658	nd	nd	103,676	9,179,827	786,892	19,243,068
1981	724,991	797,415	nd	67,513	469,539	5,442,246	262,089	nd	nd	174,772	7,126,374	549,784	15,614,723
1982	444,200	332,106	nd	60,019	395,101	4,789,794	253,194	nd	38,065	54,039	5,627,080	199,549	12,193,147
1983	616,186	147,015	nd	69,730	379,914	7,100,357	390,062	nd	nd	249,363	6,062,150	174,664	15,189,441
1984	752,635	172,655	nd	37,400	386,930	8,060,535	213,001	nd	30,863	118,227	6,076,182	124,823	15,973,251
1985	518,334	110,777	nd	nd	19,387	8,071,842	222,428	nd	nd	5,633	6,874,909	58,048	15,881,358
1986	557,231	164,881	nd	50,357	23,661	10,635,426	119,976	nd	nd	133,810	7,891,540	268,126	19,845,008
1987	503,546	127,286	nd	nd	141,154	12,153,220	113,278	nd	nd	nd	5,812,245	256,113	19,106,842
1988	476,590	63,409	nd	3,654	109,209	14,501,028	39,374	nd	nd	88,551	5,919,820	246,331	21,447,966
1989	446368	47,024	nd	4,226	257,925	15,381,696	23,549	nd	nd	74,867	5,931,173	217,651	22,384,479
1990	644,060	104,316	nd	7,150	209,048	14,386,898	30,755	nd	nd	31,999	4,510,892	218,584	20,143,702
1991	623,621	22,678	nd	8,515	102,658	17,190,933	17,688	nd	nd	18,588	4,434,341	187,795	22,606,817
1992	198,252	5,069	nd	8,180	45,481	21,900,565	8,603	nd	nd	30,976	5,540,600	299,465	28,037,191
1993	105,920	10,610	nd	nd	54,158	22,322,740	24,003	nd	nd	23,915	2,804,700	253,106	25,599,152
1994	86,349	nd	nd	nd	273,631	25,497,120	286,509	nd	nd	971,974	972,609	148,982	28,237,174
1995	32,971	nd	nd	nd	53,261	28,571,658	251,576	nd	nd	182,764	3,198,171	125,767	32,416,168
Total	12,931,484	7,821,948	184,119	340,783	7,470,266	251,746,831	3,133,808	1,159	68,928	2,921,984	140,994,690	9,688,211	437,304,211

APPENDIX 4

RECENT REPORTED ANNUAL PRODUCTION (IN SHORT TONS) OF THE PITTSBURGH COAL BED IN WEST VIRGINIA, BY COUNTY

[Source: Gayle H. McColloch (West Virginia Geological and Economic Survey, unpublished search of West Virginia Office of Miner's Health, Safety, and Training—Safety Information System (MHST-SIS) database, 1997). Abbreviations are as follows: nd, no data available or absence of production.]

Year	Barbour	Braxton	Brooke	Gilmer	Grant	Harrison	Lewis	Marion	Marshall	Mason	Mineral
1982	795,925	28,910	850,512	131,920	nd	4,018,214	84,653	5,252,296	6,133,214	25,335	227,504
1983	254,865	34,061	1,030,433	12,326	nd	3,089,116	174,850	5,665,579	5,208,207	29,727	164,809
1984	340,870	30,663	1,075,568	175,640	48,195	3,612,495	125,268	5,474,064	5,128,803	112,207	137,536
1985	413,098	13,494	1,216,169	205,969	nd	3,409,760	72,034	3,301,292	4,297,481	193,296	128,049
1986	432,771	12,470	1,217,961	262,581	nd	3,538,835	23,153	2,326,601	4,183,935	208,626	107,062
1987	456,810	30,272	1,003,402	42,822	nd	3,570,830	112,592	2,758,932	5,584,136	133,565	95,285
1988	356,867	4,093	942,865	45,136	nd	3,382,734	147,045	2,843,140	6,053,531	97,119	52,167
1989	185,876	6,364	1,286,519	45,994	nd	2,719,074	87,821	3,045,551	6,739,998	181,875	139,809
1990	153,385	1,283	1,652,621	52,245	nd	2,421,942	664	2,892,045	8,001,136	229,011	67,287
1991	120,276	910	1,577,539	43,794	nd	2,648,379	nd	3,335,359	8,334,540	nd	63,157
1992	103,170	1,000	1,687,464	54,536	nd	3,280,152	nd	1,187,819	8,329,445	nd	nd
1993	34,390	nd	1,718,553	57,345	nd	1,746,529	nd	1,700,655	4,400,851	nd	nd
1994	10,836	nd	1,210,003	36,352	nd	3,717,668	nd	3,147,131	7,699,040	nd	nd
1995	17,157	nd	1,051,098	32,190	nd	3,945,917	nd	2,749,901	7,934,648	nd	3,794
1996	65,744	nd	1,448,299	29,936	nd	4,467,707	nd	3,062,744	8,718,336	nd	36,294
Total	3,742,040	163,520	18,969,006	1,228,786	48,195	49,569,352	828,080	48,743,109	96,747,301	1,210,761	1,222,753

Year	Monongalia	Ohio	Preston	Putnam	Taylor	Upshur	Total annual production
1982	13,275,642	681,323	83,332	0	21,084	nd	31,609,864
1983	13,952,945	0	61,901	0	14,252	nd	29,693,071
1984	15,845,497	7,300	34,915	nd	9,213	nd	32,158,234
1985	13,717,838	0	21,535	nd	25,943	nd	27,015,958
1986	14,603,160	nd	18,347	nd	38,093	2,434	26,976,029
1987	16,335,147	nd	24,721	2,268	51,761	8,764	30,211,307
1988	15,739,466	nd	22,963	nd	46,575	nd	29,733,701
1989	15,093,840	nd	11,717	nd	114,623	nd	29,659,061
1990	16,703,259	nd	9,182	nd	38,936	nd	32,222,996
1991	16,105,253	nd	16,396	nd	35,501	nd	32,281,104
1992	15,456,538	nd	71,567	nd	34,770	nd	30,206,461
1993	7,157,802	nd	75,965	nd	9,381	8,030	16,909,501
1994	14,810,101	nd	23,639	nd	427	46,127	30,701,324
1995	13,562,578	nd	10,647	nd	153	18,644	29,326,727
1996	11,275,943	nd	8,447	nd	nd	15,929	29,129,379
Total	213,635,009	688,623	495,274	2,268	440,712	99,928	437,834,717

APPENDIX 5

RECENT REPORTED ANNUAL PRODUCTION (IN SHORT TONS) OF THE PITTSBURGH COAL BED IN OHIO, BY COUNTY

[Source: Ohio Division of Labor Statistics (1945–1946, 1947–1965, 1966–1981, 1982–1993). Abbreviations are as follows: nd, no data available or the absence of production.]

Year	Athens	Belmont	Carroll	Columbiana	Coshocton	Gallia	Guernsey	Harrison
1945	22,607	7,042,777	nd	nd	nd	10,262	10,021	2,987,318
1946	99,508	6,973,031	nd	nd	nd	9,716	47,509	2,722,043
1947	88,426	8,093,922	nd	nd	nd	86,770	63,343	4,829,448
1948	222,977	7,780,079	nd	16,202	nd	96,676	147,677	3,936,241
1949	61,019	5,774,334	nd	nd	nd	121,199	143,966	3,978,882
1950	63,233	6,755,753	nd	nd	nd	99,719	234,945	4,584,899
1951	37,083	8,042,005	nd	nd	nd	235,555	305,983	4,183,526
1952	19,684	7,211,037	nd	nd	nd	44,919	301,288	4,548,108
1953	33,226	6,753,384	nd	nd	nd	19,180	314,466	4,465,388
1954	22,233	5,556,628	nd	1,164	nd	103,119	346,181	4,223,993
1955	51,559	6,441,682	nd	nd	nd	108,971	654,065	5,789,427
1956	104,187	6,774,805	nd	nd	nd	162,999	572,937	5,523,823
1957	65,724	6,505,513	nd	nd	nd	216,712	665,319	6,693,356
1958	381,523	5,187,782	nd	nd	nd	304,214	212,449	5,119,049
1959	745	5,848,020	nd	nd	nd	272,525	205,197	5,339,901
1960	15,843	5,378,878	nd	nd	nd	147,702	168,607	5,053,557
1961	29,824	4,568,716	nd	nd	nd	146,542	133,903	5,374,620
1962	27,869	5,995,494	nd	nd	nd	244,429	201,398	4,530,564
1963	23,087	6,237,506	nd	nd	nd	108,266	238,045	4,628,277
1964	12,965	6,252,036	nd	nd	nd	308,973	253,691	3,675,933
1965	10,275	5,649,212	nd	nd	nd	365,865	177,777	4,345,029
1966	nd	6,317,130	nd	nd	nd	109,560	252,877	5,125,353
1967	19,531	8,302,765	nd	nd	nd	93,397	261,114	5,723,409
1968	152,787	8,711,012	nd	nd	nd	3,700	298,455	4,097,870
1969	41,345	10,264,412	nd	nd	nd	5,954	13,374	2,877,866
1970	1,640	8,375,901	nd	nd	nd	129,695	611,563	2,406,992
1971	1,628	7,279,442	nd	nd	nd	172,046	677,632	1,248,966
1972	1,400	10,423,188	nd	nd	nd	70,902	687,441	1,230,107
1973	nd	8,875,581	nd	nd	nd	30,282	726,585	1,757,509
1974	36,944	8,048,048	nd	nd	nd	1,800	826,533	1,416,114
1975	nd	7,531,342	nd	nd	nd	55,767	1,074,184	1,709,807
1976	14,957	7,743,577	nd	nd	nd	82,176	494,111	1,664,039
1977	550	5,532,454	nd	nd	nd	39,275	811,023	2,257,145
1978	nd	4,483,018	nd	nd	nd	42,163	533,246	2,556,292
1979	nd	5,324,677	nd	nd	nd	192,023	546,866	2,730,031
1980	nd	3,670,331	nd	nd	nd	7,810	269,675	2,488,620
1981	nd	2,947,885	nd	nd	nd	nd	354,714	1,954,563
1982	nd	3,708,378	nd	nd	nd	nd	361,825	1,745,972
1983	nd	2,147,438	23,482	nd	nd	nd	190,475	508,633
1984	nd	2,090,383	6,350	nd	nd	nd	278,359	1,285,857
1985	2,316	1,915,730	15,872	nd	nd	nd	152,887	1,159,001
1986	10,048	2,218,187	24,597	nd	nd	nd	nd	655,457
1987	9,588	1,758,741	1,399	nd	nd	nd	53,261	878,907
1988	nd	2,243,423	2,807	nd	nd	nd	647	1,467,048
1989	nd	2,767,465	nd	72,315	26	nd	14,630	1,438,760
1990	nd	3,793,953	nd	4,620	nd	nd	nd	1,505,577
1991	nd	3,547,439	nd	21,834	54,006	nd	83,802	1,159,695
1992	nd	4,148,303	nd	nd	nd	nd	281,758	1,059,777
1993	nd	4,372,011	nd	nd	nd	nd	105,529	1,190,425
1994	nd	4,781,323	nd	nd	nd	nd	44,490	1,313,764
Total	1,686,331	288,146,131	74,507	116,135	54,032	4,250,863	15,405,823	153,146,938

APPENDIX 5—CONTINUED

Year	Hocking	Jackson	Jefferson	Lawrence	Mahoning	Meigs	Monroe	Morgan
1945	nd	nd	4,853,777	477	21,812	106,828	nd	95,759
1946	11,281	nd	4,056,386	nd	nd	107,118	nd	34,822
1947	nd	nd	5,180,661	23,349	nd	110,300	4,183	33,349
1948	nd	nd	5,117,101	28,652	nd	221,679	nd	11,367
1949	nd	nd	4,042,752	35,057	nd	87,926	nd	2,652
1950	nd	nd	4,425,568	96,640	nd	157,236	nd	3,769
1951	nd	nd	4,607,002	78,322	nd	55,469	nd	23,663
1952	nd	nd	3,865,442	69,320	nd	263,166	nd	1,121
1953	nd	nd	3,941,322	116,639	nd	45,512	nd	870
1954	nd	nd	3,614,317	81,310	nd	188,151	nd	836
1955	nd	nd	3,935,836	155,017	nd	149,525	nd	18,307
1956	nd	nd	4,913,506	120,592	nd	167,487	nd	2,849
1957	nd	nd	3,245,596	nd	nd	159,263	894	nd
1958	nd	nd	2,397,088	84,630	nd	25,405	nd	5,695
1959	nd	nd	2,306,509	1,160	nd	353,826	nd	2,042
1960	nd	nd	2,315,518	46	nd	171,285	nd	575
1961	nd	nd	1,856,490	28,229	nd	39,071	nd	760
1962	nd	nd	2,111,449	10,582	nd	43,284	nd	5,994
1963	nd	nd	2,812,410	20,590	nd	74,418	nd	4,966
1964	nd	nd	3,309,761	661	nd	31,073	nd	10,415
1965	nd	nd	3,864,674	5,282	nd	3,651	nd	15,881
1966	nd	nd	3,558,031	7,664	nd	nd	952,374	31,644
1967	nd	nd	3,472,615	47	nd	50,376	1,225,523	4,163
1968	nd	nd	3,931,523	25	nd	23,967	1,401,388	519
1969	nd	nd	4,117,826	nd	nd	nd	1,368,687	703
1970	nd	nd	4,158,172	nd	nd	nd	1,240,834	366
1971	nd	nd	3,918,436	nd	nd	1,508	892,756	nd
1972	nd	nd	4,100,759	nd	nd	nd	690,695	nd
1973	nd	nd	3,517,126	nd	nd	nd	881,941	nd
1974	nd	nd	2,875,582	nd	nd	nd	823,971	nd
1975	nd	nd	2,323,040	nd	nd	nd	1,125,702	nd
1976	nd	nd	1,933,538	nd	nd	nd	1,475,351	nd
1977	nd	nd	2,225,882	nd	nd	nd	1,387,303	nd
1978	nd	nd	1,495,179	nd	52,781	nd	1,252,749	nd
1979	nd	4,832	1,742,134	nd	nd	nd	1,827,728	nd
1980	nd	nd	1,454,266	nd	nd	nd	2,421,916	nd
1981	nd	nd	1,376,602	nd	nd	nd	1,849,036	nd
1982	nd	nd	1,491,113	nd	nd	nd	2,108,205	nd
1983	nd	nd	1,367,710	nd	nd	nd	2,877,716	nd
1984	nd	nd	1,603,914	nd	nd	nd	3,474,096	nd
1985	nd	nd	1,437,901	nd	nd	4,749	3,194,227	nd
1986	nd	nd	1,471,725	nd	nd	nd	3,571,638	nd
1987	nd	nd	1,690,635	nd	nd	nd	2,116,550	nd
1988	nd	nd	1,600,901	nd	nd	nd	2,283,919	nd
1989	nd	nd	1,604,182	nd	nd	nd	1,980,914	nd
1990	nd	nd	1,751,056	nd	nd	nd	2,540,848	nd
1991	nd	nd	1,110,544	nd	nd	nd	2,128,435	nd
1992	nd	nd	1,379,305	nd	nd	nd	1,461,650	nd
1993	nd	nd	1,082,055	nd	nd	nd	827,377	nd
1994	nd	nd	856,902	nd	nd	nd	3,142,743	nd
Total	11,281	4,832	141,421,819	964,291	74,593	2,642,273	52,531,349	313,087

APPENDIX 5—CONTINUED

Year	Muskingum	Noble	Perry	Tuscarawas	Vinton	Washington	Wayne	Total annual production
1945	nd	13,416	nd	1,521	nd	264	nd	15,168,784
1946	nd	87,682	nd	nd	nd	nd	nd	14,151,042
1947	40	180,163	nd	nd	nd	686	nd	18,696,587
1948	nd	576,944	nd	nd	3,598	184,254	nd	18,345,395
1949	nd	460,684	nd	nd	nd	156,541	nd	14,866,961
1950	nd	742,323	nd	nd	nd	136,533	nd	17,302,568
1951	nd	316,177	nd	nd	nd	106,896	nd	17,993,632
1952	nd	229,412	nd	nd	nd	167,797	nd	16,723,246
1953	nd	174,943	nd	nd	nd	138,492	24,409	16,029,784
1954	nd	92,842	nd	nd	nd	60,317	nd	14,293,045
1955	nd	13,601	nd	nd	nd	147,753	nd	17,467,698
1956	nd	337	nd	2,489	nd	238,039	nd	18,586,006
1957	nd	79	nd	nd	nd	nd	nd	17,554,413
1958	nd	29,285	nd	nd	nd	50,939	nd	13,800,017
1959	nd	273,658	nd	nd	nd	57	nd	14,605,599
1960	nd	313,924	nd	nd	nd	nd	nd	13,567,895
1961	nd	163,003	nd	nd	nd	nd	nd	12,343,119
1962	nd	293,104	nd	nd	nd	nd	nd	13,466,129
1963	nd	334,016	nd	nd	nd	nd	nd	14,483,544
1964	nd	482,047	nd	nd	nd	2,769	nd	14,342,288
1965	nd	150,403	nd	nd	nd	nd	nd	14,590,014
1966	nd	245,808	nd	nd	nd	121,968	nd	16,724,375
1967	nd	161,365	nd	nd	nd	131,816	nd	19,448,088
1968	nd	132,124	nd	nd	nd	96,085	nd	18,851,423
1969	nd	197,137	nd	nd	nd	117,274	nd	19,006,547
1970	nd	nd	nd	nd	nd	nd	nd	16,927,133
1971	nd	nd	nd	nd	nd	nd	nd	14,194,385
1972	nd	nd	nd	nd	nd	nd	nd	17,206,464
1973	46,060	nd	nd	nd	nd	nd	nd	15,837,057
1974	7,529	nd	nd	nd	nd	nd	nd	14,038,495
1975	nd	nd	nd	nd	nd	nd	nd	13,821,817
1976	100,028	nd	124,940	nd	226,532	nd	nd	13,861,225
1977	172,232	nd	76,711	nd	nd	nd	nd	12,504,552
1978	176,913	nd	45,292	nd	nd	nd	nd	10,639,611
1979	156,907	nd	nd	nd	nd	nd	nd	12,527,177
1980	176,922	nd	18,324	nd	nd	nd	nd	10,509,844
1981	149,245	nd	nd	nd	nd	nd	nd	8,634,026
1982	63,742	nd	nd	nd	nd	nd	nd	9,481,217
1983	10,016	40,155	nd	nd	nd	nd	nd	7,167,608
1984	59,886	110,011	nd	nd	nd	nd	nd	8,910,840
1985	167,197	21,291	nd	nd	nd	nd	nd	8,073,156
1986	100,717	nd	nd	nd	nd	nd	nd	8,054,355
1987	6,757	nd	nd	nd	nd	nd	nd	6,517,825
1988	nd	nd	nd	nd	nd	nd	nd	7,600,733
1989	nd	nd	nd	25	nd	nd	nd	7,880,306
1990	nd	7,810	nd	nd	nd	nd	nd	9,605,854
1991	nd	nd	nd	nd	nd	nd	nd	8,107,746
1992	nd	1,193	nd	nd	nd	nd	nd	8,333,978
1993	nd	nd	nd	nd	nd	nd	nd	7,579,390
1994	nd	nd	nd	nd	nd	nd	nd	10,141,216
Total	1,394,191	5,844,937	265,267	4,035	230,130	1,858,480	24,409	670,564,209

APPENDIX 6

RECENT REPORTED ANNUAL PRODUCTION (IN SHORT TONS) OF THE PITTSBURGH COAL BED IN MARYLAND, BY COUNTY

[Source: Maryland Bureau of Mines (1969–1995). Abbreviations are as follows: nd, no data available or the absence of production.]

Year	Allegany	Garrett	Total annual production
1969	35,120	124,124	159,244
1970	72,247	52,860	125,107
1971	79,520	32,780	112,300
1972	195,132	78,008	273,140
1973	145,870	105,468	251,338
1974	250,562	53,816	304,378
1975	246,612	64,504	311,117
1976	266,257	67,544	333,801
1977	285,646	85,276	370,922
1978	444,902	113,963	558,866
1979	304,793	137,204	441,998
1980	363,470	165,319	528,789
1981	405,326	167,492	572,819
1982	303,939	137,076	441,015
1983	212,808	260,229	473,037
1984	267,287	282,427	549,714
1985	212,436	148,086	360,521
1986	257,588	216,499	474,088
1987	279,658	37,230	316,888
1988	165,141	25,960	191,101
1989	268,385	96,878	365,263
1990	267,527	73,143	340,670
1991	197,215	63,080	260,295
1992	139,170	58,095	197,265
1993	115,154	47,004	162,158
1994	241,365	21,547	262,912
1995	290,051	20,580	310,630
Total	6,313,184	2,736,191	9,049,375

APPENDIX 7

PITTSBURGH COAL BED STRATIGRAPHIC DATABASE

[This ASCII file contains all of the public records used to model the Pittsburgh coal bed and includes (1) record identifier, (2) longitude (decimal degrees), (3) latitude (decimal degrees), (4) elevation of the Pittsburgh coal bed (feet above mean sea level), and (5) Pittsburgh coal bed main bench thickness (feet), excluding parting. Records that contain a –999 in the elevation or thickness field represent invalid or unavailable data. Continued work on the Pittsburgh stratigraphic database following the calculation of resources has resulted in the recorrelation of the Pittsburgh roof division, which in turn alters the thickness of the main bench in the following datapoints: 11, 11-5, 21-4, 400610-801330, 400736-801630, D-049-225A, D-049-225B, D-049-226, D-061-649B, D-069-179A, V-23-066, V-23-092, V-92-089, and V-92-085. Revised thickness values are included in an additional field in the ArcView SHAPE file.]

CLICK HERE TO GO TO APPENDIX 7

APPENDIX 8

PITTSBURGH COAL BED GEOCHEMICAL DATABASE

[This ASCII file contains all of the public records used to model the coal quality for the Pittsburgh coal bed and includes NCAID (northern and central Appalachian index number used for bed data records), source, State, county, longitude (decimal degrees), latitude (decimal degrees), coal province, coal region, coal field, district, coal formation, coal group, coal bed, sample thickness (feet), system, series/epoch, comments, map, collector, pointid (field identification number), estimated rank, lab code, sample type, analytical type, value represented, moisture (percent), 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), Hardgrove grindability index, equilibrium moisture (percent), 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), Au (ppm), B (ppm), Ba (ppm), Be (ppm), Bi (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), Ho (ppm), In (ppm), La (ppm), Li (ppm), Lu (ppm), Mn (ppm), Mo (ppm), Nb (ppm), Nd, (ppm), Ni (ppm), P (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), Tm (ppm), U (ppm), V (ppm), W (ppm), Y (ppm), Yb (ppm), Zn (ppm), Zr (ppm)].

CLICK HERE TO GO TO APPENDIX 8

APPENDIX 9

METADATA FOR THE PITTSBURGH COAL BED GEOCHEMICAL DATABASE

CLICK HERE TO GO TO APPENDIX 9

APPENDIX 10

REFERENCES FOR THE PITTSBURGH GEOCHEMICAL DATABASE

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APPENDIX 11

TEXT FROM *AREAL EXTENT OF THE PITTSBURGH COAL BED HORIZON AND MINED AREAS OF THE PITTSBURGH COAL BED IN PENNSYLVANIA, OHIO, WEST VIRGINIA, AND MARYLAND*[1]

By Leslie F. Ruppert,[2] Susan J. Tewalt,[2] and Linda J. Bragg[2]

INTRODUCTION

This map (fig. 14)[3] is one of many Geographic Information System (GIS) products of the National Coal Resource Assessment that is being conducted by the U.S. Geological Survey in cooperation with State geological surveys and other Federal and State agencies. The base of the Pittsburgh coal bed and its equivalent horizon is used to subdivide Upper Pennsylvanian Series strata into the overlying Monongahela Group and the underlying Conemaugh Group in the Appalachian Basin. This map depicts the Pittsburgh coal bed and stratigraphically equivalent non-coal strata, herein referred to as the Pittsburgh coal-bed horizon.

The Pittsburgh coal-bed horizon is in eastern Ohio, central and northern West Virginia, western Pennsylvania, and western Maryland. This map, consisting of the original-extent GIS layer and the mined-area layer, will be combined with coal isopach and coal-bed structure layers for calculating remaining coal resources.

On this map, four types of information are shown: (1) original extent of the Pittsburgh coal bed and its laterally equivalent horizon; (2) known mined areas of the Pittsburgh coal bed; (3) areas of inadequate subsurface control, areas of impure coal, and areas where the Pittsburgh coal bed is absent; and (4) areas where mining has occurred and (or) known resources exist.

METHODS

AREAL EXTENT OF THE PITTSBURGH COAL-BED HORIZON

The areal extent of the Pittsburgh coal-bed horizon was digitized from multiple sources using ArcInfo[4] and ArcEdit[4]. The digital maps were edited manually in Arcedit and appended to create a single GIS data set (coverage) for each state and then all were combined to create a single GIS coverage for the areal extent of the Pittsburgh coal-bed horizon.

In West Virginia, the areal extent of the coal-bed horizon was digitized from maps in county and other reports that show coal extents or outcrops for multiple beds at scales of 1:62,500 and 1:24,000 (see references). In Gilmer and Kanawha Counties, West Virginia, the contact between the Monongahela and Conemaugh Groups (Cardwell and others, 1968) was used for the areal extent of the Pittsburgh coal-bed horizon.

The coverage for areas of inadequate subsurface control, impure and absent Pittsburgh coal, and areas where mining has occurred and (or) resources are known were obtained from three types of sources. In Wetzel, Doddridge, the southeastern part of Gilmer, and the northwestern part of Kanawha Counties, lines labeled “Approximate edge where the Pittsburgh coal bed of commercial thickness and purity disappear” (Hennen, 1912) were digitized from the West Virginia county report maps. In Putnam and western Braxton Counties, the lines were digitized from Lotz (1970). Modifications of the published lines in the county reports and Lotz (1970) were made on the basis of geologic field work (C. Blaine Cecil, U.S. Geological Survey, oral commun., 1997; Nick Fedorko, West Virginia Geological and Economic Survey, oral commun., 1997) in Roane, Calhoun, Clay, eastern Kanawha, western Braxton, southern Lewis, and western Upshur Counties.

In Ohio, available 1:62,500-scale maps were mosaicked into resource areas by the Ohio Division of Geologic

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[1]Modified from U.S. Geological Survey Open-File Report 96-280 (Ruppert, L., Tewalt, S., and Bragg, L., 1997, Areal extent of the Pittsburgh coal bed and horizon and mined areas of the Pittsburgh coal bed; digitally compiled by J. Tully, J. Pierce, A. Weller, and J. Yarnell: U.S. Geological Survey Open-File Report 96–280, 1 sheet, scale 1:425,000.

[2]U.S. Geological Survey, National Center, MS 956, Reston, VA 20192.

[3]Figure numbers refer to those found in the original publication and are not shown here.

[4]ArcView and ArcInfo are products of ESRI, 380 New York Street, Redlands, CA 92373-8100.

Survey (ODGS) and digitized. In southern Ohio (Resource Area 13), where coal resource maps were not available, the contact between the Monongahela and Conemaugh Groups, as shown on the Geologic Map of Ohio (Bownocker, 1920), was used for the areal extent of the Pittsburgh coal-bed horizon. Areas of inadequate subsurface control, impure or absent coal, and areas where mining has occurred and (or) resources are known were digitized from the <14-inch isopach line delineated on isopach maps of the Pittsburgh coal bed (Bronsdon, 1955). Because different criteria were used to delineate the lines of known resources from areas of inadequate subsurface control and impure or absent coal in Ohio and West Virginia, an offset is observed at the State boundaries.

In Pennsylvania, county reports, which included reduced 1:24,000-scale maps, were digitized (see Data Sources). In Maryland, the cropline of the Pittsburgh coal bed was taken from the Monongahela-Conemaugh contact on the Geologic Map of Maryland (Cleaves and others, 1968) and revised using the map of Berryhill and others (1956) in Allegheny County, and a 1:100,000 compilation map that includes Garrett County (David K. Brezinski, Maryland Geological Survey, unpub. mapping, 1997). The cropline of the Pittsburgh coal bed was then built for polygon topology. Each polygon was labeled as either coal bearing or devoid of coal.

MINED AREAS OF THE PITTSBURGH COAL BED

The mined data were acquired from various sources. The primary source in the northern part of the Pittsburgh coal-bed horizon was a proprietary computer-aided design (CAD) file from the John T. Boyd Company (Pittsburgh, Pa.) which provided data for Ohio, much of Pennsylvania, and northern West Virginia. Mined areas that were not included in the John T. Boyd Company map in Greene, Westmoreland, Fayette, and Allegheny Counties, Pa., were obtained from the Pennsylvania Topographic and Geologic Survey State map (Gray, Shepps, and others, 1960) and county reports (Dodge and Glover; 1984; Dodge, 1985; Shaulis, 1985; Skema, 1987, 1988). West Virginia Geological and Economic Survey Open-file mine maps (1977a-b, 1982, 1983a-b, 1985a-j, 1987a-c, 1988, 1990, 1993, 1995a-c, 1996a-c) were used for the mined area coverage south of Monongalia and Marion Counties. In Maryland, the Pittsburgh coal bed is assumed to be mined out at the scale represented by this map (David K. Brezinski, Maryland Department of Natural Resources, Maryland Geological Survey, oral commun., 1996).

The John T. Boyd map (1995a-c) was georeferenced using state boundaries and reference points with Arcedit, appended with digitized West Virginia data, and both data sets were cleaned manually. The three sets of data were combined to create a single coverage and built for polygon topology. Each polygon was labeled as mined or unmined.

The two coverages, one for the areal extent and one for the mined areas of the Pittsburgh coal bed were then combined in ArcEdit. The boundaries of the mined coverage did not match those of the areal extent coverage. Therefore, the boundaries of the areal extent were used in lieu of the boundaries of the mined cover. The resulting coverage, a combination of the mined and areal extent covers, was built for polygon topology.

This combined polygon cover was then labeled by polygon in two categories. The first category defined polygons as part of the original areal extent of the Pittsburgh coal bed. The second category showed whether or not a given polygon that was part of that original bed had been mined. This final coverage was used to produce this map.

DATA SOURCES

AREAL EXTENT OF THE PITTSBURGH COAL BED HORIZON

MARYLAND

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———1955c, Ohio coal resource map—Isopach map of Pittsburgh (No. 8) coal, Area 9: Columbus, Ohio Division of Geologic Survey, scale 1:62,500.

———1955d, Ohio coal resource map—Isopach map of Pittsburgh (No. 8) coal, Area 10: Columbus, Ohio Division of

Geologic Survey, scale 1:62,500.

———1955e, Ohio coal resource map—Isopach map of Pittsburgh (No. 8) coal, Area 11: Columbus, Ohio Division of Geologic Survey, scale 1:62,500.

———1955f, Ohio coal resource map—Isopach map of Pittsburgh (No. 8) coal, Area 12: Columbus, Ohio Ohio Division of Geologic Survey, scale 1:62,500.

———1955g, Ohio coal resource map—Isopach map of Pittsburgh (No. 8) coal, Area 14: Columbus, Ohio Division of Geologic Survey, scale 1:62,500.

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MINED AREAS OF THE PITTSBURGH COAL BED

PENNSYLVANIA

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OHIO

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WEST VIRGINIA

NORTHERN PART

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APPENDIX 12

TEXT FROM SHEET 1 OF *MAP SHOWING STRUCTURE CONTOURS AND OVERBURDEN THICKNESS ISOPLETHS OF THE PITTSBURGH COAL BED IN PENNSYLVANIA, OHIO, WEST VIRGINIA, AND MARYLAND*[1]

By Susan J. Tewalt,[2] Leslie F. Ruppert,[2] Linda J. Bragg,[2] Richard W. Carlton,[3] David K. Brezinski,[4] Jeanette Yarnell,[5] and Rachel N. Wallack[6]

INTRODUCTION

This map depicts the structure contours (fig. 15)[7] and overburden thickness isopleths (fig. 16) of the main bench of the Pittsburgh coal bed. The structure contours and overburden thickness isopleths are the second and third geographic information system (GIS) layers generated for the U.S. Geological Survey's National Coal Resource Assessment in the Appalachian Basin.

The assessment of top-producing coal beds in the northern and central parts of the basin is being conducted in partnership with the State geological surveys of Ohio, Pennsylvania, West Virginia, Maryland, Kentucky, and Virginia as well as in cooperation with other Federal and State agencies.

Within areas of known or mined Pittsburgh coal resources (Ruppert and others, 1997), figure 15 shows structure contours (50-ft contour interval) on top of the main bench. Figure 16 shows overburden thickness isopleths in these same areas.

METHODS

The first Appalachian Basin GIS coverage (Ruppert and others, 1997) depicts the areas of known resources and mined areas of the Pittsburgh coal-bed horizon (which are defined as the coal and non-coal equivalents at the base of the Upper Pennsylvanian Monongahela Group). This GIS coverage was used as a clipping polygon in the presentation of the structure, point, and overburden thickness isopleth coverages shown in figures 12, 15, and 16. Additional data points (including proprietary data) therefore exist, but are not shown.

Structure contours on the top of the main bench of the Pittsburgh coal-bed were generated from a basin-wide database consisting of 6,993 verified drill core, mine, and outcrop records of the Pittsburgh coal bed. The majority of the stratigraphic data were collected by the State geological surveys and stored in the U.S. Geological Survey's National Coal Resource Data System (NCRDS). Data were downloaded to StratiFact[8], a geological database manager. The paucity of available stratigraphic data in Fayette and Westmoreland Counties, Pa., necessitated obtaining latitude, longitude, and elevation data of random points from published structure-contour maps on the base of the main bench (Shaulis, 1985; Skema, 1988). In addition, data were digitized at regular intervals from structure-contour maps of Wetzel County, W. Va. (Fedorko, 1990 a-k). All of these data were entered into the StratiFact database. The elevation of the Pittsburgh coal-bed horizon was exported from the stratigraphic database as an ASCII file of x, y and z format, where z is the elevation of the top of the main bench. In 2,000 points with unavailable bed thickness, only the elevation on the bottom of the main bench was known and therefore used. Coordinates were converted from latitude and longitude to meters in the Albers Equal Area Projection and subsequently placed into a grid using Interactive Surface Modeling[9]. The grid was created using a 300-meter cell size and was extrapolated to the x and y extent of the input data. During placement in the grid, the z values were constrained to the elevations of the input data. The resulting grid was contoured into 50-foot intervals and exported to ArcInfo, using conversion programs that were developed by

[1]Modified from U.S. Geological Survey Open-File Report 97-864 (Tewalt, Susan, Ruppert, Leslie, Bragg, Linda, Carlton, Richard, Brezinski, David, Yarnell, Jeanette, and Wallack, Rachel, 1997, Map showing structure contours and overburden thickness isopleths of the Pittsburgh coal bed in Pennsylvania, Ohio, West Virginia, and Maryland; digital compilation by Susan Tewalt, John Tully, and Rachel Wallack: U.S. Geological Survey Open-File Report 97-864, 2 sheets, scale 1:425,000).

[2]U.S. Geological Survey, National Center, MS 956, Reston, VA 20192.

[3]Ohio Division of Geological Survey, retired.

[4]Maryland Geological Survey, 2300 St. Paul Steet, Baltimore, MD 21218.

[5]Current address: SLR Alaska, 2525 Blueberry Road, Suite 206, Anchorage, AL 99503

[6]Current address: Intertox, Inc., 2819 Elliott Avenue, Seattle, WA 98121.

[7]Figure numbers refer to those found in the original publication and are not shown here.

[8]StratiFact is a product of GRG Corporation, StratiFact Software, 5 Harlan Street, Wheat Ridge, CO 80033, http://www.stratifact.com.

[9]Interactive Surface Modeling is a product of Dynamic Graphics, Inc., 1015 Atlantic Avenue, Alameda, CA 94501, http://www.dgi.com.

the Illinois State Geological Survey[10]. The point location data also were exported from the database as ASCII files and imported into ArcInfo. Structure contours are shaded by 400-ft intervals using color for visual acuity.

Figure 5 is a regional-strike section which uses the base of the Pittsburgh coal bed as a datum. The section shows the inferred original extent (present-day eroded areas are indicated) of the main bench of the Pittsburgh coal bed, and also a local cutout which is located in Greene County, Pa.

ACKNOWLEDGMENTS

The authors would like to thank the following: Nick Fedorko (West Virginia Geological and Economic Survey) and J.R. Shaulis, V.W. Skema, and A.D. Glover (Pennsylvania Bureau of Topographic and Geologic Survey). In addition, the critical reviews of C. Blaine Cecil and Paul C. Lyons (USGS) were very helpful and are gratefully acknowledged.

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[10]Illinois State Geological Survey, 615 E. Peabody, Champaign, IL 61820.

APPENDIX 13

TEXT FROM SHEET 2 OF *MAP SHOWING STRUCTURE CONTOURS AND OVERBURDEN THICKNESS ISOPLETHS OF THE PITTSBURGH COAL BED IN PENNSYLVANIA, OHIO, WEST VIRGINIA, AND MARYLAND*[1]

By Susan J. Tewalt,[2] Leslie F. Ruppert,[2] Linda J. Bragg,[2] Richard W. Carlton,[3] David K. Brezinski,[4] Jeanette Yarnell,[5] and Rachel N. Wallack[6]

INTRODUCTION

This map depicts structure contours (fig. 15)[7] and overburden thickness isopleths (fig. 16) of the main bench of the Pittsburgh coal bed. The structure contours and overburden thickness isopleths are the second and third geographic information system (GIS) layers generated for the U.S. Geological Survey's National Coal Resource Assessment in the Appalachian Basin.

The assessment of top-producing coal beds in the northern and central parts of the basin is being conducted in partnership with the State geological surveys of Ohio, Pennsylvania, West Virginia, Maryland, Kentucky, and Virginia, as well as in cooperation with other Federal and State agencies.

Within areas of known or mined Pittsburgh coal-bed resources (Ruppert and others, 1997), figure 15 shows structure contours (50-ft contour interval) on the top of the main bench. Figure 16 shows overburden thickness isopleths within the same.

METHODS

The overburden thickness was calculated by subtracting the structure contour grid on the top of the main bench of the Pittsburgh coal bed from a grid composed of U.S. Geological Survey 1:250,000- and 1:100,000-scale digital elevation models (DEM). The contour intervals for overburden thickness are variable, based on criteria from Wood and others (1983).

Digital elevation models were imported to ArcInfo[8] as grids, appended together, and resampled to a 100-meter cell size. The grid file was output in ASCII format and imported to Geographic Resources Analysis Support System (GRASS)[8]. The subtraction of structure elevations (see fig. 15) from topography was performed at a 300-meter cell size, then contoured at selected intervals (Wood and others, 1983). Contour lines were exported back to ArcInfo and all of the polygons were attributed according to overburden interval. The areas of known resources and mined areas of the Pittsburgh coal-bed horizon (Ruppert and others, 1997) were used to constrain the overburden isopleths in this map. Small polygons (with an area less than one grid cell size or 90,000 square meters) were removed using ArcEdit[9]. This map, therefore, presents generalized overburden with local hilltops and small upstream reaches removed.

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[2]U.S. Geological Survey, National Center, MS 956, Reston, VA 20192.

[3]Ohio Division of Geological Survey, retired.

[4]Maryland Geological Survey, 2300 St. Paul Steet, Baltimore, MD 21218.

[5]Current address: SLR Alaska, 2525 Blueberry Road, Suite 206, Anchorage, AL 99503.

[6]Current address: Intertox, Inc., 2819 Elliott Avenue, Seattle, WA 98121.

[7]Figure numbers refer to those found in the original publication and are not shown here.

[8]GRASS was developed by the U.S. Army Corps of Engineers, Construction Engineering Research Laboratory, Environmental Division, P.O. Box 9005, Champaign, IL 61826.

[9]ArcView and ArcInfo are products of ESRI, 380 New York Street, Redlands, CA 92373-8100.

APPENDIX 14

TEXT FROM *MAP SHOWING GENERALIZED THICKNESS CONTOURS OF THE PITTSBURGH COAL BED IN PENNSYLVANIA, OHIO, WEST VIRGINIA, AND MARYLAND*[1]

By Susan J. Tewalt,[2] Leslie F. Ruppert,[2] Linda J. Bragg,[2] Richard W. Carlton,[3] David K. Brezinski,[4] and Rachel N. Wallack[5]

INTRODUCTION

This map (fig. 17)[6] is one of four geographic information system (GIS) products that will be used in the calculation of resources of the main bench of the Pittsburgh coal bed, which is one of the top-producing coal beds in the northern part of the Appalachian Basin. It was prepared as part of the National Coal Resource Assessment that is being conducted by the U.S. Geological Survey (USGS) in cooperation with State geological surveys and other Federal and State agencies. This map (fig. 17) depicts the thickness of the main bench in 1.17-ft contour intervals. In addition, the map includes a generalized stratigraphic column of the Monongahela Group of the map area (fig. 3) and a schematic representation of the thickness of a sandstone unit in the lower member of the Pittsburgh Formation overlying the Pittsburgh coal bed (figs. 24, 25). The main bench isopach contours have been clipped to a GIS layer representing the areas of the Pittsburgh coal-bed horizon where known resources exist or mining has occurred (Ruppert and others, 1997).

METHODS

The thickness contours, or isopach lines, were generated from a StratiFact[7] stratigraphic database consisting of 4,553 drill core, mine, and outcrop records of the main bench of the Pittsburgh coal bed. All of the stratigraphic records were verified against original published sources, or, if unpublished, against drillers' and (or) geologists' logs and field notes. Approximately half of the stratigraphic records included detailed descriptions and measurements of the coal bed, including coal, parting, and impure, non-banded (bone) coal; the other records included only total coal-bed thickness. The Pittsburgh coal bed has historically been divided into nine megascopically recognizable divisions or units (Stevenson, 1875). The uppermost unit, the Pittsburgh roof division, was identified in the vast majority of stratigraphic records over its extent in Pennsylvania and northern West Virginia. Identification of the roof division was based both on original descriptions and graphic examination of cross sections in StratiFact using the database records.

Thicknesses of the main bench were exported from the database as an ASCII file of x, y, and z format, where z is the thickness of coal, in feet. The coal in the roof division was not included in the summation of coal thickness because it is rarely mined. In addition, partings and bone coal more than 0.38 inch in thickness were generally excluded (Wood and others, 1983). Therefore, thicknesses represented on this map include the inherent errors of (1) differentiation among coal, bone, and parting in core, outcrop, and measured sections; (2) possible inclusion of roof division coal thicknesses, if improperly identified; and (3) absence of information on included bone and parting intervals where only total bed thickness is available. Coordinates were converted from latitude and longitude to meters in the Albers Equal Area Projection and subsequently gridded using Interactive Surface Modeling (ISM)[8] software. The grid was created with a 300-meter cell size and was extrapolated to the x, y extent of the input data. During gridding, the z values were constrained to the thicknesses of the input data. The contour lines from this grid were export-

[1]Modified from U.S. Geological Survey Open-File Report 97–748 (Tewalt, Susan, Ruppert, Leslie, Bragg, Linda, Carlton, Richard, Brezinski, David, and Wallack, Rachel, 1997, Map showing generalized thickness contours of the Pittsburgh coal bed in Pennsylvania, Ohio, West Virginia, and Maryland; digital compilation by Susan Tewalt, Leslie Ruppert, and Rachel Wallack: U.S. Geological Survey Open-File Report 97–748, 1 sheet, scale 1:425,000.)

[2]U.S. Geological Survey, National Center, MS 956, Reston, VA 20192.

[3]Ohio Division of Geological Survey, retired.

[4]Maryland Geological Survey, 2300 St. Paul Steet, Baltimore, MD 21218.

[5]Current address: Intertox, Inc., 2819 Elliott Avenue, Seattle, WA 98121.

[6]Figure numbers refer to those found in the original publication and are not shown here.

[7]StratiFact is a product of GRG Corporation, 4175 Harlan Street, Suite 200, Wheat Ridge, CO 80033.

[8]Interactive Surface Modeling (ISM) software is a product of Dynamic Graphics, Inc., 1015 Atlantic Avenue, Alameda, CA 94501-1154.

ed to ArcInfo[9], using conversion programs that were developed by the Illinois State Geological Survey[10]. Locations of publicly available stratigraphic records were exported from the database in ASCII format and imported into ArcInfo.

DISCUSSION

Although the main bench of the Pittsburgh coal bed does thin immediately to the west of Maryland, it is regionally extensive and relatively thick (5-7 ft) in southern Pennsylvania, northern West Virginia including part of the panhandle, and in adjacent areas in eastern Ohio. One exception in the thickness trend can be observed as a somewhat linear, northwest-trending area of thinner or absent coal in Greene and Washington Counties, Pa. A relationship exists between this feature and an overlying sandstone unit shown in the schematic of the distribution and thickness of sandstone in the lower member of the Pittsburgh Formation as derived from Roen and Kreimeyer (1973) and working maps of John B. Roen (USGS, unpub. data, 1977) (fig. 25). This relationship is suggestive of postdepositional fluvial erosion of the Pittsburgh coal-bed horizon.

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

[10]Illinois State Geological Survey, 615 E. Peabody, Champaign, IL 61820.

ACKNOWLEDGMENTS

Scientific contributions were made by the following: Nick Fedorko (West Virginia Geological and Economic Survey) and J. Shaulis and V. Skema (Pennsylvania Bureau of Topographic and Geologic Survey). The technical reviews of C. Blaine Cecil and Paul C. Lyons (USGS) were very helpful and are gratefully acknowledged.

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APPENDIX 15

ORIGINAL COAL RESOURCES BY OVERBURDEN, RELIABILITY, AND COAL-BED-THICKNESS CATEGORIES, AND BY STATE AND COUNTY, FOR THE PITTSBURGH COAL BED

[Resources are rounded to millions of short tons and two significant figures. Reliability categories are as follows: measured, resources calculated within 0.25 mi of a coal-thickness measurement; indicated, resources calculated for area between 0.25 and 0.75 mi from a coal-thickness measurement; inferred, resources calculated for area between 0.75 and 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.]

CLICK HERE TO GO TO APPENDIX 15

APPENDIX 16

REMAINING COAL RESOURCES BY OVERBURDEN, RELIABILITY, AND COAL-BED-THICKNESS CATEGORIES, AND BY STATE ANDCOUNTY, FOR THE PITTSBURGH COAL BED

[Remaining resources for Athens, Gallia, Guernsey, Meigs, Morgan, Muskingum, Noble, and Washington Counties in Ohio have been calculated by equally reducing the area of all resource polygons (regardless of reliability or thickness values) by visual estimates of disturbance from 7.5-minute topographic quadrangles. Resources are rounded to millions of short tons and two significant figures. Reliability categories are as follows: measured, resources calculated within 0.25 mi of a coal-thickness measurement; indicated, resources calculated for area between 0.25 and 0.75 mi from a coal-thickness measurement; inferred, resources calculated for area between 0.75 and 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 17

SELECTED REFERENCES FOR THE PITTSBURGH COAL BED

[Specific references used in the USGS Pittsburgh coal-bed assessment are found in the References Cited section of Chapter C. West Virginia Geological and Economic Survey Open-File Report 07 contains overlay maps that were compiled in different years, but are catalogued under one report number.]

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