Results of Coalbed-Methane Drilling, Mylan Park, Monongalia County, West Virginia

By Leslie F. Ruppert, Nick Fedorko, Peter D. Warwick, William C. Grady, James Q. Britton, William A. Schuller, and Robert D. Crangle, Jr.

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Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
millimeter (mm)	0.03937	inch (in.)
	Volume	
cubic inch (in^3)	16.39	cubic centimeter (cm^3)
cubic inch (in^3)	16.39	milliliter (mL)
cubic foor (ft^3)	0.02832	cubic meter (m^3)
cubic centimeter (cm^3 or cc)	0.06102	cubic inch (in^3)
milliliter (mL)	0.06102	cubic inch (in^3)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
	Pressure	
inch of mercury at 60°F (in Hg)	3.377	kilopascal (kPa)
pound per square inch (lb/in^2 or PSIA)	6.895	kilopascal (kPa)
	Calorific value	
British thermal unit (Btu)	1,055.056	joule (J)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F–32)/1.8

Gas desorption volumes are provided in cubic centimeters, which is abbreviated using the standard industry abbreviation, cc, instead of cm^3.

Gas content measurements are provided in both standard cubic feet per ton (SCF/ton) and cubic centimeters per gram (cc/g). The abbreviations are those used by the oil and gas industry.

Hydrostatic pressure for coal is measured in pounds per square inch of area (PSIA, an industry abbreviation).

The Langmuir volume is the maximum gas capacity of the coal and is measured in standard cubic feet per ton (SCF/ton) or cubic centimers per gram (cc/g).

The Langmuir pressure is the pressure at which the coal absorbs half of its maximum gas capacity; it is measured in pounds per square inch of area (PSIA).

The isotopic composition of carbon (carbon 13, ^{13}C) in methane is reported as the deviation (expressed as $\delta^{13}C$) in units of parts per thousand (per mil) relative to the Vienna Peedee belemnite (VPDB) standard.

The isotopic composition of hydrogen (deuterium, ^{2}H) in methane is reported as the deviation (expressed as $\delta^{2}H$) in per mil relative to the Vienna standard mean ocean water (VSMOW).

Results of Coalbed-Methane Drilling, Mylan Park, Monongalia County, West Virginia

By Leslie F. Ruppert,[1] Nick Fedorko,[2] Peter D. Warwick,[1] William C. Grady,[3] James Q. Britton,[3] William A. Schuller,[4] and Robert D. Crangle, Jr.[1]

Abstract

The Department of Energy National Energy Technology Laboratory funded drilling of a borehole (39.64378°N., 80.04376°W.) to evaluate the potential for coalbed-methane and carbon-dioxide sequestration at Mylan Park, a public park in Monongalia County, W. Va. The total depth of the borehole was 2,525 feet (ft) and contained 1,483.41 ft of Pennsylvanian coal-bearing strata, 739.67 ft of Mississippian strata, and 301.93 ft of Devonian strata.

The drill site was located directly over abandoned mines in the Pittsburgh and Sewickley coal beds. Coal cores from remaining Pittsburgh and Sewickley coal-bed-mine pillars were cut and retrieved for desorption from both mines. In addition, coals were cored and desorbed from the Redstone, Pittsburgh roof coal interval, Little Pittsburgh, Elk Lick, Brush Creek, Upper Kittanning, Middle Kittanning, Clarion, Upper Mercer, Lower Mercer, and Quakertown coal beds and coal zones. All coals are Pennsylvanian in age and are high-volatile A bituminous in rank. A total of 34.75 ft of coal was desorbed over a maximum period of 662 days, although most of the coal was desorbed for about 275 days.

Measured raw-total-gas contents ranged from 0.43 standard cubic feet per ton (SCF/ton, an industry abbreviation) for the mined Sewickley coal bed to 130.98 SCF/ton for the Upper Kittanning coal bed. Volumes of residual gas were not measured; therefore, the gas volumes reported here should be regarded as minimum volumes.

The amount of oxygen in the gas samples collected from the desorption canisters ranged from 2.55 to 20.13 percent. Methane contents ranged from 0 percent for one single canister from the Pittsburgh (WV–02–B3–4) and Little Pittsburgh (WV–02–CB3–2) coal beds to almost 81 percent for two canisters from the Clarion coal zone (WV–02–B3–16 and WV–02–B3–17), which suggests that all of the gas samples were contaminated to some degree by air. Therefore, all gas compositions reported have been normalized to remove the air. With a single exception (the Quakertown coal zone), the coals from the Mylan Park study area are thermogenic in origin with the isotopic composition of carbon (carbon 13, ^{13}C) in methane (expressed as $\delta^{13}C$ in units of parts per thousand (per mil) relative to the Vienna Peedee belemnite (VPDB) standard) ranging from -32.39 to -50.66 per mil and ratios of methane to hydrocarbons of higher molecular weight ranging from 10 to 53. The Quakertown coal zone has a C_1/C_{2+} ratio of 913, suggesting that it contains some microbial gas.

High-pressure carbon-dioxide adsorption isotherms were measured on composite coal samples of the Upper Kittanning coal bed and the Middle Kittanning and Clarion coal zones. Assuming that the reservoir pressure in the Mylan Park coals is equivalent to the normal hydrostatic pressure, the estimated maximum carbon-dioxide adsorption pressures range from a low of about 300 pounds per square inch (lb/in^2) in coals from the Clarion coal zone to 500 lb/in^2 for coals from the Upper Kittanning coal bed. The estimated maximum methane adsorption isotherms show that the coals from the Upper Kittanning coal bed and the Middle Kittanning coal zone are undersaturated in methane, but coals from the Clarion coal zone are close to saturation.

Introduction

Personnel at Mylan Park, Monongalia County, W. Va. (fig. 1), requested funding from the U.S. Department of Energy's National Energy Technology Laboratory (DOE–NETL) to evaluate the potential of using coalbed methane to power the park's electric lights and equipment. NETL responded and provided funding to drill a borehole within the park boundaries to evaluate the potential for coalbed-methane and carbon-dioxide sequestration. Drilling started on September 23, 2002, and was completed on November 14, 2002, running 5-day, 12-hour shifts per week with some down time. The West Virginia Geological and Economic Survey (WVGES) and EG&G Technical Services, Inc., Morgantown, W. Va., coordinated the borehole drilling, electric logging, and the methane desorption

[1]U.S. Geological Survey, Reston, Va.
[2]Consultant, Moatsville, W. Va.
[3]West Virginia Geological and Economic Survey, Morgantown, W. Va.
[4]EG&G Technical Services, Inc., Morgantown, W. Va.

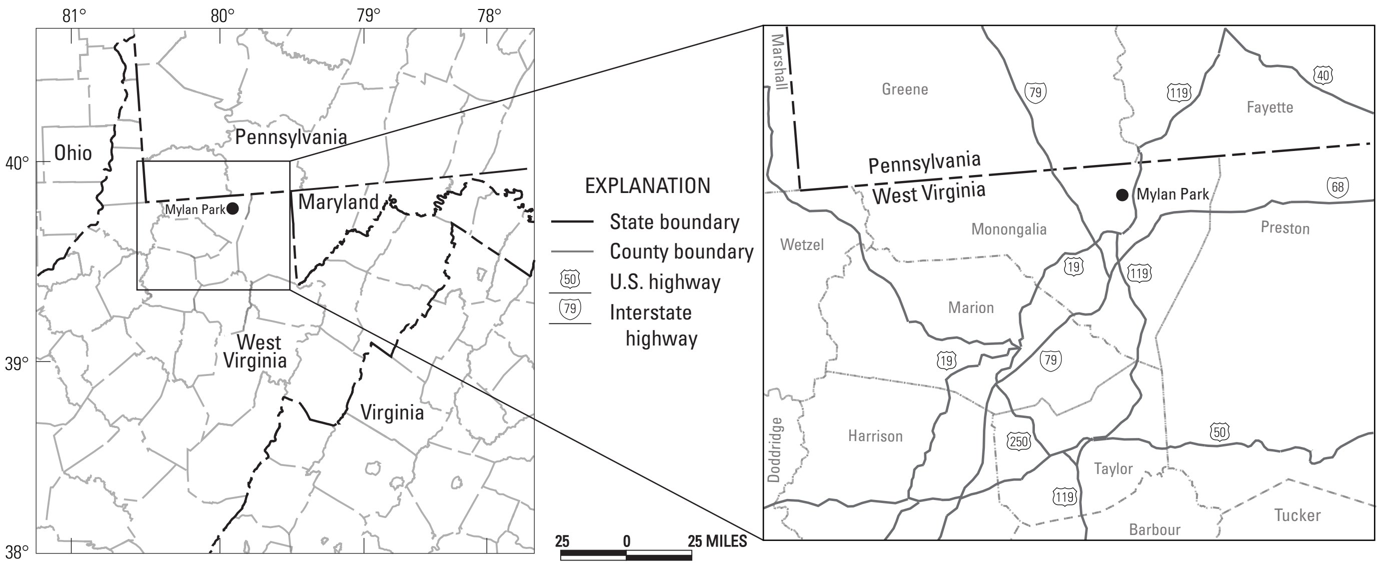


Figure 1. Generalized location map of the Mylan Park study area in Monongalia County, W. Va.

work. The geologist's log was published in appendix 1 of Ruppert and others (2004) and additional drilling descriptions can be obtained through the West Virginia Geological and Economic Survey (2007). The borehole was drilled by L.J. Hughes & Sons, Summersville, W. Va., and Marshall J. Miller and Associates of Bluefield, Va., electric logged the hole. U.S. Geological Survey (USGS) personnel conducted all methane desorption work. After desorption was completed, the coal was analyzed in the WVGES laboratory. In addition, the return fluids and cuttings were logged throughout drilling by Hydrocarbon Well Logging Services of Parkersburg, W. Va. The 2,525 feet (ft) of core contained 1,483.41 ft of Pennsylvanian coal-bearing strata, 739.67 ft of Mississippian strata, and 301.93 ft of Devonian strata (fig. 2).

System (and series)		Group or formation	Coal bed or zone
Permian (part)		Dunkard Group	
Pennsylvanian	Upper	Monongahela Group	Sewickley coal bed Redstone coal bed Pittsburgh roof coal interval Pittsburgh coal bed
	Middle	Conemaugh Group	Little Pittsburgh coal bed Elk Lick coal bed Brush Creek coal bed
		Allegheny Group	Upper Kittanning coal bed Middle Kittanning coal zone Clarion coal zone
	Lower	Pottsville Group	Upper Mercer coal bed Lower Mercer coal bed Quakertown coal zone
Mississippian	Upper	Mauch Chunk Group	
	Middle	Greenbrier Formation	
	Lower	Pocono Group	
Devonian (part)		Berea Formation	
		Venango Group	

Methods

Desorption Methods

Procedures modified from Stricker and others (2000), Gas Research Institute (1995), and Barker and others (2002) were followed throughout the coring and desorption to measure gas contents of the coals. During coring, both the time that the coal was retrieved off the bottom (base of the borehole) and the temperature of water circulating in the borehole were recorded in order to estimate the amount of lost gas (the volume of gas desorbed between the time the core was retrieved from the bottom and the time that the coal was sealed in a desorption canister) and reservoir temperature, respectively. As soon as the core barrel was recovered at the surface, the core was extracted onto a wooden core holder, quickly described (coal versus rock), and measured. The coal was removed from the wooden core holder in a graduated curved polyvinyl-chloride (PVC) scoop to keep it intact, weighed, and placed in thin (approximately 4-mm thick) sheet plastic sleeves with holes to maintain the stratigraphic integrity of the coal during desorption. Within 10 to 23 minutes of reaching the surface, coal intervals from the Sewickley, Redstone, and Pittsburgh coal beds were placed in 2-ft-long aluminum canisters and 1-ft-long PVC canisters and cores from other coal beds were placed in 1-ft-long PVC canisters (table 1). All of the canisters were filled with distilled water in order to eliminate headspace (the volume of air left in the canister), sealed, and placed in water baths kept at reservoir temperature (68°F–70°F, as estimated from the temperature of circulating borehole water). This temperature was roughly equivalent to measured reservoir temperatures in other boreholes within Monongalia County, W. Va.

Desorbed gas volumes were initially measured after 10 minutes from the time that the canisters were sealed. To obtain volumes, the canister valves were opened and the volumetric displacement of water in a graduated manometer was recorded. In addition, the ambient air and water-bath temperature and the atmospheric pressure were recorded during each desorption measurement to correct desorbed gas volumes according to standard temperature and pressure (STP). Each canister was measured approximately every 10 minutes for the first half hour to hour, and then every 20 to 30 minutes for the first day. Canisters were not monitored overnight, but measured upon reaching the drill site in the morning. After approximately 3 weeks, the canisters were moved to a laboratory at the USGS where they were measured once a day for 2 weeks. Over the course of the desorption, the canisters were measured less frequently because less gas was desorbed from the coals. Toward the end of the desorption tests, the canisters were measured bimonthly. See appendix A for desorption data for all of the coal samples.

Lost gas was estimated using the graphical methods found in Barker and others (2002). Diffusion rates of coals from the Mylan Park study area were low; thus, lost gas volumes were very low, ranging from 0 cubic centimeters (cc, an abbreviation commonly used in oil and gas geochemical reports) for most of the coal intervals to about 60 cc in the coal from the Elk Lick coal bed (canister 1, WV–01–B3–6). See appendix A for lost gas amounts.

Table 1. Coal bed or zone name, depth of sample, and canister number for desorbed coal samples from the Mylan Park borehole, Monongalia County, W. Va.

Coal bed or coal zone	Depth of sample (feet)	Canister number
Sewickley coal bed	346.80–347.20	Canister 1: WV–02–CB3–10
	347.20–348.20	Canister 2: WV–02–B3–1
	348.20–350.20	Canister 3: WV–02–US4–2
	350.20–352.20	Canister 4: WV–02–US4–1
Redstone coal bed	405.30–407.30	Canister 1: WV–02–US4–5
	407.30–408.00	Canister 2: WV–02–B3–2
Pittsburgh roof coal interval	426.96–427.96	Canister 1: WV–02–B3–3
	432.35–433.25	Canister 2: WV–02–B3–5
Pittsburgh coal bed	433.85–434.35	Canister 1: WV–02–B3–4
	434.35–436.35	Canister 2: WV–02–US4–30
	436.35–438.35	Canister 3: WV–02–US4–14
	438.35–440.35	Canister 4: WV–02–US4–8
	440.35–442.35	Canister 5: WV–02–US4–6
Little Pittsburgh coal bed	468.50–469.25	Canister 1: WV–02–CB3–2
Elk Lick coal bed	659.93–660.60	Canister 1: WV–02–B3–6
Brush Creek coal bed	920.40–921.10	Canister 1: WV–02–B3–7
	921.10–921.80	Canister 2: WV–02–B3–8
Upper Kittanning coal bed	1,121.70–1,122.70	Canister 1: WV–02–B3–9
	1,122.70–1,123.40	Canister 2: WV–02–B3–10
Middle Kittanning coal zone	1,184.10–1,185.10	Canister 1: WV–02–B3–11
	1,185.10–1,185.40	Canister 2: WV–02–CB3–12
	1,188.00–1,189.00	Canister 3: WV–02–B3–12
	1,189.00–1,190.00	Canister 4: WV–02–B3–13
	1,190.00–1,190.45	Canister 5: WV–02–CB3–11
Clarion coal zone	1,270.50–1,271.50	Canister 1: WV–02–B3–14
	1,271.50–1,272.35	Canister 2: WV–02–B3–15
	1,278.70–1,279.70	Canister 3: WV–02–B3–16
	1,279.70–1,280.80	Canister 4: WV–02–B3–17
Upper Mercer coal bed	1,324.40–1,325.15	Canister 1: WV–02–B3–18
Lower Mercer coal bed	1,357.50–1,358.50	Canister 1: WV–02–B3–19
Quakertown coal zone	1,465.00–1,465.60	Canister 1: WV–02–B3–20
	1,475.60–1,476.43	Canister 2: WV–02–B3–21

Figure 2 (facing page). Generalized stratigraphic column showing Pennsylvanian coal beds and coal zones from which samples were desorbed for coalbed-methane content in the Mylan Park study area, Monongalia County, W. Va. (Based on Rice and others, 1994.)

Table 2. Selected proximate analyses for coals from the Mylan Park borehole, Monongalia County, W. Va.

Coal bed or zone	Depth of sample (feet)	Moisture (percent)	Volatile matter, dry (percent)	Volatile matter, as-received (percent)	Volatile matter, mineral-matter free (percent)	Ash, dry (percent)	Ash, as-received (percent)	Fixed carbon, dry (percent)	Fixed carbon, as received (percent)	Fixed carbon, moist, mineral-matter free (percent)	Calorific value (British thermal units)
Sewickley coal bed	346.80–352.20	1.29	29.60	29.22	39.40	21.08	20.81	49.10	48.46	60.60	11,498
Redstone coal bed	405.30–408.00	0.68	28.25	28.10	48.18	27.80	27.47	43.95	43.75	51.82	10,572
Pittsburgh roof coal interval	426.96–433.25	1.63	36.55	36.34	80.21	83.05	82.18	47.39	46.96	86.94	12,231
Pittsburgh coal bed	433.85–442.35	0.52	34.63	34.45	38.41	9.84	9.79	55.53	55.24	61.59	13,557
Little Pittsburgh coal bed	468.50–469.25	1.15	23.73	23.99	53.64	24.30	43.15	32.04	31.71	46.36	7,880
Elk Lick coal bed	659.93–660.60	0.85	30.08	29.79	41.90	24.30	24.07	45.62	45.25	58.10	10,990
Brush Creek coal bed	920.40–921.80	0.95	22.53	22.32	39.83	43.43	43.02	34.04	33.71	60.17	8,471
Upper Kittanning coal bed	1,121.70–1,123.40	0.97	30.92	30.62	34.07	9.25	9.16	59.84	59.22	65.93	13,785
Middle Kittanning coal zone	1,184.10–1,190.45	0.52	30.44	30.24	37.40	18.61	18.52	50.95	50.68	62.60	12,232
Clarion coal zone	1,270.50–1,280.80	1.01	31.05	30.74	36.21	14.22	14.12	54.69	54.14	63.79	10,735
Upper Mercer coal bed	1,324.40–1,325.15	0.72	24.75	24.55	32.25	10.96	10.86	60.30	59.87	67.71	13,611
Lower Mercer coal bed	1,357.50–1,358.50	0.49	21.60	21.50	31.14	30.62	30.47	47.78	47.54	68.86	10,629
Quakertown coal zone	1,465.00–1,476.43	0.58	20.92	20.78	43.78	35.37	35.11	38.24	38.04	56.22	9,290

Residual gas was not measured because coal cores were the property of the WVGES and all of the coal was used for proximate (table 2), petrographic, geochemical, and adsorption analyses. Although desorption tests were conducted over a long period of time, the volumes of residual gas in the coal may be substantial; therefore, the reported raw and dry, ash-free (daf) total gas volumes cited in this report should be regarded as minimum volumes. For example, Diamond and others (1986) report that residual gas can average up to 20 percent of the total gas content. A.K. Markowski (Pennsylvania Bureau of Topographic and Geologic Survey, oral commun., 2004) reports that residual gas she measured in cores from Pennsylvania and West Virginia can be as high as 35 percent. In a companion study (see Ruppert and others, this volume, chap. G.4), residual gas contents were as high as 40 percent of the total gas content.

Gas Analyses

Gas was sampled intermittently throughout the desorption process, starting within 1 to 2 days after the canisters were sealed. Gas volumes were measured in the manometer and samples were collected directly from the manometer with a short (approximately 5-in-long) piece of plastic tubing and bled into Tedlar bags. The bags were shipped to the

Table 3. Comparison of gas constituents analyzed in coal samples from the Mylan Park borehole, Monongalia County, W. Va., by the Department of Energy National Energy Technology Laboratory and Isotech Laboratories, Inc.

Constituents of gas	Department of Energy, National Energy Technical Laboratory	Isotech Laboratories, Inc.
Carbon monoxide (CO)	x	x
Nitrogen (N_2)	x	x
Oxygen (O_2)	x	x
Carbon dioxide (CO_2)	x	x
Hydrogen (H_2)	x	x
Helium (He)		x
Argon (Ar)		x
Methane (CH_4 (or C_1))	x	x
Ethane (C_2H_6 (or C_2))	x	x
Ethylene (C_2H_4)		x
Propane (C_3H_8 (or C_3))	x	x
iso-butane (iC_4H_{10} (or iC_4))	x	x
n-butane (nC_4H_{10} (or nC_4))	x	x
iso-pentane (iC_5H_{12} (or iC_5))	x	x
n-pentane (nC_5H_{12} (or nC_5))	x	x
Hexane (C_{6+})	x	x

Table 4. Isotopic composition of carbon and hydrogen (deuterium) in methane in gas samples from coal beds or zones from the Mylan Park borehole, Monongalia County, W. Va.

[By convention, isotope compositions are reported as the deviation (δ) of values in units of parts per thousand (per mil) relative to a known reference standard. The reference standard for isotopes of carbon (carbon-13, ^{13}C) is the Vienna Peedee belemnite (VPDB) and the reference standard for hydrogen (deuterium, ^{2}H) is the Vienna standard mean ocean water (SMOW). See Kendall and Caldwell (1998) for fundamental information on isotope analyses. Other abbreviations are as follows: nd, no data]

Sample number	Canister number(s)	Coal bed or zone	$\delta^{13}C_1$ (per mil)	δ^2H (per mil)
46862	WV–02–US–4, WV–02–US–6, WV–02–US–8, WV–02–US–14, WV–02–US–30	Pittsburgh coal bed	-50.66	-224.0
46861	WV–02–B3–7, WV–02–B3–8	Brush Creek coal bed	-47.46	-184.8
60588	WV–02–B3–7, WV–02–B3–8	Brush Creek coal bed	-47.06	-180.3
60589	WV–02–B3–9, WV–02–B3–10	Upper Kittanning coal bed	-41.06	-178.1
46859	WV–02–B3–11, WV–02–CB3–12	Middle Kittanning coal zone	-43.45	-182.3
60590	WV–02–B3–11, WV–02–CB3–12	Middle Kittanning coal zone	-41.43	-179.9
46858	WV–02–CB3–11, WV–02–B3–12, WV–02–B3–13	Middle Kittanning coal zone	-44.65	-182.2
60597	WV–02–CB3–11	Middle Kittanning coal zone	-32.39	-175.7
60591	WV–02–B3–12, WV–02–B3–13	Middle Kittanning coal zone	-41.68	-182.6
46857	WV–02–B3–14, WV–02–B3–15	Clarion coal zone, upper split	-45.46	-185.8
48349	WV–02–B3–14, WV–02–B3–15	Clarion coal zone, upper split	-42.24	-187.5
60592	WV–02–B3–14	Clarion coal zone, upper split	-35.52	-176.0
60593	WV–02–B3–15	Clarion coal zone, upper split	-41.02	-185.5
46860	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	-44.65	-186.4
48350	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	-45.24	-190.1
60594	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	-41.82	-187.2
60595	WV–02–B3–18	Upper Mercer coal bed	-42.12	-186.0
60596	WV–02–B3–19	Lower Mercer coal bed	-36.15	-185.9
48348	WV–02–B3–20, WV–02–B3–21	Quakertown coal zone	-48.20	nd

DOE–NETL labs for the initial analyses; additional analyses were performed by a commercial laboratory (Isotech Laboratories, Inc.). Table 3 shows gas constituents analyzed by both laboratories, as follows: CO, N_2, O_2, Ar, CO_2, H_2, He, methane (CH_4, also denoted as C_1), ethane (C_2H_6, also denoted as C_2), ethylene (C_2H_4), propane (C_3H_8, also denoted as C_3), *iso*-butane (iC_4H_{10}, also denoted as iC_4), *n*-butane (nC_4H_{10}, also denoted as nC_4), *iso*-pentane (iC_5H_{12}, also denoted as iC_5), *n*-pentane (nC_5H_{12}, also denoted as nC_5), and hexanes (denoted as C_{6+}). Results for hydrocarbon species were reported in parts per million (ppm) and converted to weight percent for this report.

In addition, if samples contained sufficient gas, the isotopic composition of carbon (carbon 13, ^{13}C) in methane (reported as the deviation (expressed as $\delta^{13}C$) in units of parts per thousand (per mil) relative to the Vienna Peedee belemnite (VPDB) standard) and the isotopic composition of hydrogen (deuterium, ^{2}H) in methane (reported as the deviation (expressed as $\delta^{2}H$) in per mil relative to the Vienna standard mean ocean water (VSMOW)) were analyzed to determine gas origin (biogenic versus thermogenic) following the method in Bernard and others (1978). Enough gas was present in coals from the Pittsburgh, Brush Creek, Upper Kittanning, Middle Kittanning, Clarion, Upper Mercer, Lower Mercer, and Quakertown coal beds and coal zones to perform isotopic analyses (see table 4).

The use of a short tube to collect gases from the manometer and evacuate it into gas collection bags did not preclude air contamination in the samples. To remove the air, we normalized all of the gas analyses (table 5) to an air-free basis (table 6) by zeroing out oxygen. An examination of the air-free analyses shows a significant nitrogen depletion in many of the samples (table 6) that were run by Isotech Laboratories, Inc. The laboratory reports show no systematic errors in the analyses of coals from the Mylan Park study area (Steve Pelphrey, Isotech Laboratories, Inc., oral commun., 2004). We do not have an explanation for the nitrogen depletion; however, it does not affect either the accuracy of the hydrocarbon analyses or the ratio of methane to hydrocarbons of higher molecular weight.

Table 5. Raw gas geochemistry analyses for coal samples from core retrieved from the Mylan Park borehole, Monongalia County, W. Va.

[These analyses are raw and uncorrected for air contamination. Abbreviations are as follows: cc, cubic centimeters; He, helium; H_2, hydrogen; Ar, argon; O_2, oxygen; CO_2, carbon dioxide; N_2, nitrogen; CO, carbon monoxide; C_1, methane; C_2, ethane + ethylene; C_2H_4, ethylene; C_3, propane; iC_4, *iso*-butane; nC_4, *n*-butane; iC_5, *iso*-pentane; nC_5, *n*-pentane; C_{6+}, hexanes. Argon, a constituent in air, is required for recalculating gas chemistry to an air-free basis. Because argon is not reported by the Department of Energy National Energy Technology Laboratory, the mean argon content (0.4999 weight percent) in the gas samples analyzed by Isotech Laboratories, Inc., was used for the calculation]

Sample number	Canister numbers	Coal bed or zone	Depth (feet)	Gas, cumulative volume (cc)	Sampling date	He (percent)	H_2 (percent)
DOE–MP No. 3	WV–02–B3–3	Pittsburgh roof coal interval	426.96–427.96	35	10/4/2002	nd	0.0611
DOE–MP No. 5	WV–02–B3–4	Pittsburgh coal bed	433.85–434.35	18	10/7/2002	nd	0.0405
DOE–MP No. 2	WV–02–US–4, WV–02–US–6, WV–02–US–8, WV–02–US–14, WV–02–US–30, WV–02–B3–4	Pittsburgh coal bed	433.85–442.35	47	10/2/2002	nd	0.0411
46862	WV–02–US–4, WV–02–US–6, WV–02–US–8, WV–02–US–14, WV–02–US–30	Pittsburgh coal bed	433.85–440.35	106	10/11/2002	0.0041	0.0000
DOE–MP No. 1	WV–02–CB3–2	Little Pittsburgh coal bed	468.50–469.25	71	10/2/2002	nd	0.0528
DOE–MP No. 11	WV–02–CB3–2	Little Pittsburgh coal bed	468.50–469.25	231	10/10/2002	nd	0.0344
DOE–MP No. 4	WV–02–B3–6	Elk Lick coal bed	659.93–660.60	127	10/4/2002	nd	0.0412
DOE–MP No. 6	WV–02–B3–6	Elk Lick coal bed	659.93–660.60	169	10/7/2002	nd	0.0501
DOE–MP No. 12	WV–02–B3–6	Elk Lick coal bed	659.93–660.60	309	10/10/2002	nd	0.0000
60587	WV–02–B3–6	Elk Lick coal bed	659.93–660.60	1,222	11/25/2003	0.0021	0.0000
DOE–MP No. 7	WV–02–B3–7, WV–02–B3–8	Brush Creek coal bed	920.40–921.80	294	10/8/2002	nd	0.0398
46861	WV–02–B3–7, WV–02–B3–8	Brush Creek coal bed	920.40–921.80	578	10/11/2002	0.0035	0.0000
60588	WV–02–B3–7, WV–02–B3–8	Brush Creek coal bed	920.40–921.80	3,199	11/25/2003	0.0000	0.1520
DOE–MP No. 14	WV–02–B3–9	Upper Kittanning coal bed	1,121.70–1,122.70	407	10/10/2002	nd	0.0509
DOE–MP No. 13	WV–02–B3–10	Upper Kittanning coal bed	1,122.70–1,123.40	302	10/10/2002	nd	0.0101
DOE–MP No. 10	WV–02–B3–9, WV–02–B3–10	Upper Kittanning coal bed	1,121.70–1,123.40	709	10/10/2002	nd	0.0406
60589	WV–02–B3–9, WV–02–B3–10	Upper Kittanning coal bed	1,121.70–1,123.40	5,522	11/25/2003	0.0000	0.0932
DOE–MP No. 9	WV–02–B3–11, WV–02–CB3–12	Middle Kittanning coal zone	1,184.10–1,185.40	436	10/10/2002	nd	0.1806
DOE–MP No. 8	WV–02–B3–11	Middle Kittanning coal zone	1,184.10–1,185.10	341	10/10/2002	nd	0.2958
46859	WV–02–B3–11, WV–02–CB3–12	Middle Kittanning coal zone	1,184.10–1,185.40	543	10/11/2002	0.0035	0.0000
60590	WV–02–B3–11, WV–02–CB3–12	Middle Kittanning coal zone	1,184.10–1,185.40	3,562	11/25/2003	0.0000	0.0174
46858	WV–02–B3–12, WV–02–B3–13, WV–02–CB3–11	Middle Kittanning coal zone	1,188.00–1,190.45	1,141	10/11/2002	0.0027	0.0028
48351	WV–02–B3–12, WV–02–B3–13, WV–02–CB3–11	Middle Kittanning coal zone	1,188.00–1,190.45	4,173	11/27/2002	0.0028	0.0071
DOE–MP No. 18	WV–02–CB3–11	Middle Kittanning coal zone	1,190.00–1,190.45	84	10/10/2002	nd	0.2654
60597	WV–02–CB3–11	Middle Kittanning coal zone	1,190.00–1,190.45	1,753	11/25/2003	0.0028	0.0000

Table 5. Raw gas geochemistry analyses for coal samples from core retrieved from the Mylan Park borehole, Monongalia County, W. Va.—Continued

Ar (percent)	O_2 (percent)	CO_2 (percent)	N_2 (percent)	CO (percent)	C_1 (percent)	C_2 (percent)	C_2H_4 (percent)	C_3 (percent)	*i*C_4 (percent)	*n*C_4 (percent)	*i*C_5 (percent)	*n*C_5 (percent)	C_{6+} (percent)
nd	17.3448	0.0815	81.2209	0	1.2840	0.0060	nd	0.0013	0.0001	0.0000	0	0.0001	0.0001
nd	19.9511	0.0405	79.9662	0	0	0	nd	0.0002	0	0	0	0	0
nd	19.4312	0.1749	79.5248	0	0.8229	0	nd	0.0020	0	0	0	0.0001	0.0001
0.8770	18.3600	0.0650	70.7700	0	9.7400	0.1420	0	0.0347	0.0029	0.0037	0	0	0
nd	19.6140	0.4009	79.8066	0	0	0.0076	nd	0.0012	0.0001	0.0001	0.0001	0.0001	0.0003
nd	14.1525	3.7671	65.9533	0	15.2173	0	nd	0.0206	0.0031	0.0022	0.0014	0.0003	0.0005
nd	15.6981	0.0824	63.0805	0	20.9067	0	nd	0.0044	0.0004	0.0005	0.0003	0.0001	0.0002
nd	10.4639	0.0902	46.0049	0	42.9680	0	nd	0.0087	0.0009	0.0012	0.0006	0.0002	0.0004
nd	6.6976	0.9494	32.8688	0	58.5756	0.0001	nd	0.0220	0.0028	0.0039	0.0014	0.0007	0.0007
0.8780	19.2100	0.3800	79.5300	0	0.0032	0	0	0	0	0	0	0	0
nd	14.4324	0.0299	58.7755	0	26.2353	0	nd	0.0476	0.0029	0.0048	0.0013	0.0006	0.0017
0.5240	12.7200	0.0690	33.1600	0	52.3700	1.0400	0	0.0924	0.0055	0.0097	0.0015	0	0
0.5810	11.8600	0.4100	49.4100	0	36.7500	0.7530	0.0032	0.0715	0.0046	0.0073	0	0	0
nd	12.6828	0.0713	50.9453	0	34.9822	1.0594	nd	1.8170	0.0883	0.1419	0.0176	0.0098	0.0051
nd	7.7976	0.0406	31.8902	0	58.2238	0.0002	nd	0.2720	0.0146	0.0225	0.0026	0.0014	0.0006
nd	14.3313	0.0305	56.5128	0	28.1142	0.0001	nd	0.1523	0.0097	0.0129	0.0019	0.0009	0.0025
0.3330	6.7200	0.2700	27.7700	0	62.4100	2.0100	0.0049	0.3330	0.0160	0.0265	0.0031	0.0017	0.0040
nd	12.4332	0.0401	58.7644	0	27.2648	0.0001	nd	0.2709	0.0320	0.0411	0.0082	0.0036	0.0074
nd	8.5360	0.0306	34.3888	0	54.1125	0.0002	nd	0.3643	0.0421	0.0612	0.0096	0.0048	0.0025
0.5270	13.2500	0.0630	35.0400	0	48.0100	2.4600	0	0.5500	0.0322	0.0509	0.0065	0.0035	0.0020
0.2090	4.3200	0.1700	15.7300	0	75.0300	3.6200	0.0026	0.7770	0.0379	0.0719	0.0074	0.0048	0.0024
0.3380	8.2300	0.0560	20.6300	0	66.5500	3.3900	0	0.7020	0.0296	0.0561	0.0063	0.0035	0.0025
0.3790	8.2500	0.4400	28.8300	0	58.2400	3.1800	0	0.5960	0.0176	0.0466	0.0044	0.0030	0.0021
nd	7.6962	0.0306	31.2542	0	57.9969	2.2864	nd	3.7223	0.3586	0.4998	0.0726	0.0340	0.0150
0.3230	8.3800	0.0910	23.0700	0	62.4800	4.5500	0.0046	0.9760	0.0383	0.0673	0.0072	0.0037	0.0018

Table 5. Raw gas geochemistry analyses for coal samples from core retrieved from the Mylan Park borehole, Monongalia County, W. Va.—Continued

[These analyses are raw and uncorrected for air contamination. Abbreviations are as follows: cc, cubic centimeters; He, helium; H_2, hydrogen; Ar, argon; O_2, oxygen; CO_2, carbon dioxide; N_2, nitrogen; CO, carbon monoxide; C_1, methane; C_2, ethane + ethylene; C_2H_4, ethylene; C_3, propane; iC_4, *iso*-butane; nC_4, *n*-butane; iC_5, *iso*-pentane; nC_5, *n*-pentane; C_{6+}, hexanes. Argon, a constituent in air, is required for recalculating gas chemistry to an air-free basis. Because argon is not reported by the Department of Energy National Energy Technology Laboratory, the mean argon content (0.4999 weight percent) in the gas samples analyzed by Isotech Laboratories, Inc., was used for the calculation]

Sample number	Canister numbers	Coal bed or zone	Depth (feet)	Gas, cumulative volume (cc)	Sampling date	He (percent)	H_2 (percent)
DOE–MP No. 15	WV–02–B3–11, WV–02–B3–12	Middle Kittanning coal zone	1,184.10–1,185.10 1,188.00–1,189.00	548	10/10/2002	nd	0.3736
DOE–MP No. 17	WV–02–B3–12	Middle Kittanning coal zone	1,188.00–1,189.00	295	10/10/2002	nd	0.5355
DOE–MP No. 16	WV–02–B3–13	Middle Kittanning coal zone	1,189.00–1,190.00	334	10/10/2002	nd	0.4429
60591	WV–02–B3–12, WV–02–B3–13	Middle Kittanning coal zone	1,188.00–1,190.00	6,294	11/25/2003	0.0000	0.0694
46857	WV–02–B3–14, WV–02–B3–15	Clarion coal zone, upper split	1,270.50–1,272.35	390	10/11/2002	0.0029	0.0000
48349	WV–02–B3–14, WV–02–B3–15	Clarion coal zone, upper split	1,270.50–1,272.35	1,691	11/27/2002	0.0034	0.0000
60592	WV–02–B3–14	Clarion coal zone, upper split	1,270.50–1,271.50	1,102	11/25/2003	0.0035	0.0014
60593	WV–02–B3–15	Clarion coal zone, upper split	1,271.50–1,272.35	2,696	11/25/2003	0.0000	0.0328
DOE–MP No. 19	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	1,278.70–1,280.80	652	10/11/2002	nd	0.0105
46860	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	1,278.70–1,280.80	891	10/11/2002	0.0029	0.0000
48350	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	1,278.70–1,280.80	4,198	11/27/2002	0.0030	0.0049
60594	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	1,278.70–1,280.80	7,309	11/25/2003	0.0000	0.0877
DOE–MP No. 21	WV–02–B3–18	Upper Mercer coal bed	1,324.40–1,325.15	232	10/11/2002	nd	0.0408
48346	WV–02–B3–18	Upper Mercer coal bed	1,324.40–1,325.15	1,072	11/27/2002	0.0035	0.0000
60595	WV–02–B3–18	Upper Mercer coal bed	1,324.40–1,325.15	1,790	11/25/2003	0.0010	0.0227
DOE–MP No. 20	WV–02–B3–19	Lower Mercer coal bed	1,357.50–1,358.50	133	10/11/2002	nd	0.0810
48347	WV–02–B3–19	Lower Mercer coal bed	1,357.50–1,358.50	505	11/27/2002	0.0039	0.0000
60596	WV–02–B3–19	Lower Mercer coal bed	1,357.50–1,358.50	1,098	11/25/2003	0.0025	0.0000
DOE–MP No. 23	WV–02–B3–20	Quakertown coal zone	1,465.00–1,465.60	42	10/15/2002	nd	0.0305
DOE–MP No. 22	WV–02–B3–21	Quakertown coal zone	1,475.60–1,476.43	45	10/15/2002	nd	0.0304
48348	WV–02–B3–20, WV–02–B3–21	Quakertown coal zone	1,465.60–1,476.43	1,829	11/27/2002	0.0032	0.0000

Table 5. Raw gas geochemistry analyses for coal samples from core retrieved from the Mylan Park borehole, Monongalia County, W. Va.—Continued

Ar (percent)	O_2 (percent)	CO_2 (percent)	N_2 (percent)	CO (percent)	C_1 (percent)	C_2 (percent)	C_2H_4 (percent)	C_3 (percent)	iC_4 (percent)	nC_4 (percent)	iC_5 (percent)	nC_5 (percent)	C_{6+} (percent)
nd	12.0365	0.0202	49.3881	0	36.3216	1.4945	nd	3.0139	0.2094	0.3292	0.0579	0.0295	0.0148
nd	6.0116	0.0202	24.0466	0	66.0674	2.8290	nd	3.9796	0.3128	0.4840	0.0691	0.0339	0.0169
nd	4.9224	0.0201	19.4782	0	71.5810	3.0803	nd	3.9548	0.2400	0.4433	0.0598	0.0344	0.0192
0.1490	2.8000	0.2000	10.3600	0	79.8500	5.3000	0	1.1200	0.0472	0.0824	0.0092	0.0049	0.0025
0.5060	12.4000	0.0610	33.8300	0	49.9600	2.5200	0	0.6120	0.0342	0.0619	0.0071	0.0043	0.0032
0.3060	7.7500	0.1300	18.6000	0	68.5000	3.8600	0	0.7470	0.0344	0.0592	0.0059	0.0031	0.0018
0.4210	9.6900	0.1900	33.0500	0	51.6600	3.9600	0.0045	0.9270	0.0226	0.0663	0.0034	0.0026	0.0017
0.6310	13.0100	0.6300	54.5700	0	28.3000	2.2000	0.0025	0.5520	0.0137	0.0489	0.0032	0.0025	0.0021
nd	12.7708	0.4393	51.3760	0	33.8148	1.3283	nd	2.2426	0.1286	0.1703	0.0334	0.0173	0.0114
0.4790	11.5600	0.0610	34.0700	0	51.0600	2.3300	0	0.3850	0.0175	0.0268	0.0041	0.0028	0.0032
0.4160	8.6800	0.5400	31.4800	0	55.5200	2.8700	0	0.4390	0.0148	0.0285	0.0030	0.0025	0.0021
0.1430	2.5500	0.1900	8.5300	0	80.7200	6.2300	0.0068	1.3500	0.0628	0.1070	0.0108	0.0061	0.0031
nd	11.3887	0.0102	45.9935	0	41.2890	1.0817	nd	1.6966	0.0892	0.1400	0.0194	0.0102	0.0061
0.8950	19.2300	0.1200	70.7100	0	8.5700	0.3760	0	0.0819	0.0041	0.0075	0	0	0.0019
0.1900	4.4500	0.1000	11.5100	0	77.2900	5.2600	0.0047	1.0300	0.0463	0.0801	0.0083	0.0053	0.0026
nd	15.1205	0.0304	60.7555	0	23.2780	0.5769	nd	1.3178	0.0850	0.1370	0.0210	0.0110	0.0063
0.9450	20.1300	0.0740	76.1700	0	2.6000	0.0513	0	0.0215	0	0.0036	0	0	0.0014
0.3290	8.1800	0.0710	23.7400	0	63.1900	3.6600	0.0016	0.7220	0.0330	0.0586	0.0062	0.0035	0.0016
nd	16.3499	0.0407	64.0353	0	19.5262	0.0102	nd	0.0605	0.0033	0.0040	0.0023	0.0008	0.0016
nd	14.3437	0.0406	56.7153	0	28.8395	0.0203	nd	0.0876	0.0045	0.0049	0.0029	0.0008	0.0016
0.8670	19.2800	0.1000	69.5100	0	10.2300	0.0049	0	0.0052	0	0	0	0	0.0011

Table 6. Gas geochemistry analyses corrected for air contamination for coal samples from core retrieved from the Mylan Park borehole, Monongalia County, W. Va.

[These analyses are corrected for air contamination and presented to two decimal points. Abbreviations are as follows: cc, cubic centimeters; H_2, hydrogen; Ar, argon; CO, carbon monoxide; O_2, oxygen; N_2, nitrogen; CO, carbon monoxide; C_1, methane; C_2, ethane + ethylene; C_2H_4, ethylene; C_3, propane; iC_4, *iso*-butane; nC_4, *n*-butane; iC_5, *iso*-pentane; nC_5, *n*-pentane; C_{6+}, hexanes; C_{2+}, methane + ethane + ethylene + propane + *iso*-butane + *n*-butane + *iso*-pentane + *n*-pentane + hexanes. Argon, a constituent in air, is required for recalculating gas chemistry to an air-free basis. Because argon is not reported by the Department of Energy National Energy Technology Laboratory, the mean argon content (0.4999 weight percent) in the gas samples analyzed by Isotech Laboratories, Inc., was used for the calculations]

Sample number	Canister numbers	Coal bed or zone	Depth (feet)	Gas, cumulative volume (cc)	Sampling date	H_2 (percent)	Ar (percent)
DOE–MP No. 3	WV–02–B3–3	Pittsburgh roof coal interval	426.96–427.96	35	10/4/2002	0.34	nd
DOE–MP No. 5	WV–02–B3–4	Pittsburgh coal bed	433.85–434.35	18	10/7/2002	0.71	nd
DOE–MP No. 2	WV–02–US–4, WV–02–US–6, WV–02–US–8, WV–02–US–14, WV–02–US–30, WV–02–B3–4	Pittsburgh coal bed	433.85–442.35	47	10/2/2002	0.51	nd
46862	WV–02–US–4, WV–02–US–6, WV–02–US–8, WV–02–US–14, WV–02–US–30	Pittsburgh coal bed	433.85–440.35	106	10/11/2002	0	0.47
DOE–MP No. 1	WV–02–CB3–2	Little Pittsburgh coal bed	468.50–469.25	71	10/2/2002	0.74	nd
DOE–MP No. 11	WV–02–CB3–2	Little Pittsburgh coal bed	468.50–469.25	231	10/10/2002	0.11	nd
DOE–MP No. 4	WV–02–B3–6	Elk Lick coal bed	659.93–660.60	127	10/4/2002	0.16	nd
DOE–MP No. 6	WV–02–B3–6	Elk Lick coal bed	659.93–660.60	169	10/7/2002	0.10	0.05
DOE–MP No. 12	WV–02–B3–6	Elk Lick coal bed	659.93–660.60	309	10/10/2002	0	0.28
60587	WV–02–B3–6	Elk Lick coal bed	659.93–660.60	1,222	11/25/2003	0	0.26
DOE–MP No. 7	WV–02–B3–7, WV–02–B3–8	Brush Creek coal bed	920.40–921.80	294	10/8/2002	0.13	nd
46861	WV–02–B3–7, WV–02–B3–8	Brush Creek coal bed	920.40–921.80	578	10/11/2002	0	0
60588	WV–02–B3–7, WV–02–B3–8	Brush Creek coal bed	920.40–921.80	3,199	11/25/2003	0.35	0.12
DOE–MP No. 14	WV–02–B3–9	Upper Kittanning coal bed	1,121.70–1,122.70	407	10/10/2002	0.12	nd
DOE–MP No. 13	WV–02–B3–10	Upper Kittanning coal bed	1,122.70–1,123.40	302	10/10/2002	0.02	0.23
DOE–MP No. 10	WV–02–B3–9, WV–02–B3–10	Upper Kittanning coal bed	1,121.70–1,123.40	709	10/10/2002	0.13	nd
60589	WV–02–B3–9, WV–02–B3–10	Upper Kittanning coal bed	1,121.70–1,123.40	5,522	11/25/2003	0.14	0.05
DOE–MP No. 9	WV–02–B3–11, WV–02–CB3–12	Middle Kittanning coal zone	1,184.10–1,185.40	436	10/10/2002	0.45	nd
DOE–MP No. 8	WV–02–B3–11	Middle Kittanning coal zone	1,184.10–1,185.10	341	10/10/2002	0.51	0.19
46859	WV–02–B3–11, WV–02–CB3–12	Middle Kittanning coal zone	1,184.10–1,185.40	543	10/11/2002	0	0
60590	WV–02–B3–11, WV–02–CB3–12	Middle Kittanning coal zone	1,184.10–1,185.40	3,562	11/25/2003	0.02	0.02
46858	WV–02–B3–12, WV–02–B3–13, WV–02–CB3–11	Middle Kittanning coal zone	1,188.00–1,190.45	1,141	10/11/2002	0.00	0
48351	WV–02–B3–12, WV–02–B3–13, WV–02–CB3–11	Middle Kittanning coal zone	1,188.00–1,190.45	4,173	11/27/2002	0.01	0.02
DOE–MP No. 18	WV–02–CB3–11	Middle Kittanning coal zone	1,190.00–1,190.45	84	10/10/2002	0.39	0.22

Table 6. Gas geochemistry analyses corrected for air contamination for coal samples from core retrieved from the Mylan Park borehole, Monongalia County, W. Va.—Continued

CO_2 (percent)	O_2 (percent)	N_2 (percent)	CO (percent)	C_1 (percent)	C_2 (percent)	C_2H_4 (percent)	C_3 (percent)	iC_4 (percent)	nC_4 (percent)	iC_5 (percent)	nC_5 (percent)	C_{6+} (percent)	C_{2+} (percent)	C_1/C_{2+} (ratio)
0.45	0	92.02	nd	7.13	0.03	0	0.01	0.00	0.00	0.00	0.00	0.00	0.04	169
0.71	0	98.53	nd	0.00	0.00	0	0.00	0	0	0	0	0	0.00	0
2.15	0	87.17	nd	10.12	0.00	0	0.03	0.00	0.00	0.00	0.00	0.00	0.03	361
0.53	0	18.80	nd	78.69	1.15	0	0.28	0.02	0.03	0	0	0	1.48	53
5.61	0	93.50	nd	0.00	0.11	0	0.02	0.00	0.00	0.00	0.00	0.00	0.13	0
11.68	0	40.92	nd	47.19	0.00	0	0.06	0.01	0.01	0.00	0.00	0.00	0.09	541
0.32	0	17.81	nd	81.67	0.00	0	0.02	0.00	0.00	0.00	0.00	0.00	0.02	3533
0.18	0	13.95	nd	85.69	0.00	0	0.02	0.00	0.00	0.00	0.00	0.00	0.02	3572
1.40	0	11.68	nd	86.59	0.00	0	0.03	0.00	0.01	0.00	0.00	0.00	0.05	1859
4.56	0	95.11	nd	0.04	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0
0.10	0	15.87	nd	83.71	0.00	0	0.15	0.01	0.02	0.00	0.00	0.01	0.19	446
0.13	0	0	nd	97.72	1.94	0	0.17	0.01	0.02	0.00	0	0	2.14	46
0.94	0	11.98	nd	84.68	1.73	0.01	0.16	0.01	0.02	0	0	0	1.93	44
0.17	0	8.75	nd	83.47	2.53	0	4.34	0.21	0.34	0.04	0.02	0.01	7.49	11
0.07	0	4.58	nd	94.59	0.00	0	0.44	0.02	0.04	0.00	0.00	0.00	0.51	185
0.10	0	9.82	nd	89.38	0.00	0	0.48	0.03	0.04	0.01	0.00	0.01	0.57	156
0.40	0	4.00	nd	91.88	2.96	0.01	0.49	0.02	0.04	0.00	0.00	0.01	3.53	26
0.10	0	30.83	nd	67.71	0.00	0	0.67	0.08	0.10	0.02	0.01	0.02	0.90	75
0.05	0	4.46	nd	93.94	0.00	0	0.63	0.07	0.11	0.02	0.01	0.00	0.84	112
0.12	0	0	nd	93.80	4.81	0	1.07	0.06	0.10	0.01	0.01	0.00	6.07	15
0.21	0	0	nd	94.07	4.54	0.00	0.97	0.05	0.09	0.01	0.01	0.00	5.67	17
0.08	0	0	nd	94.00	4.79	0	0.99	0.04	0.08	0.01	0.00	0.00	5.92	16
0.70	0	0	nd	93.11	5.08	0	0.95	0.03	0.07	0.01	0.00	0.00	6.15	15
0.05	0	3.77	nd	85.30	3.36	0	5.47	0.53	0.74	0.11	0.05	0.02	10.28	8

Table 6. Gas geochemistry analyses corrected for air contamination for coal samples from core retrieved from the Mylan Park borehole, Monongalia County, W. Va.—Continued

[These analyses are corrected for air contamination and presented to two decimal points. Abbreviations are as follows: cc, cubic centimeters; H_2, hydrogen; Ar, argon; CO, carbon monoxide; O_2, oxygen; N_2, nitrogen; CO, carbon monoxide; C_1, methane; C_2, ethane + ethylene; C_2H_4, ethylene; C_3, propane; iC_4, *iso*-butane; nC_4, *n*-butane; iC_5, *iso*-pentane; nC_5, *n*-pentane; C_{6+}, hexanes; C_{2+}, methane + ethane + ethylene + propane + *iso*-butane + *n*-butane + *iso*-pentane + *n*-pentane + hexanes. Argon, a constituent in air, is required for recalculating gas chemistry to an air-free basis. Because argon is not reported by the Department of Energy National Energy Technology Laboratory, the mean argon content (0.4999 weight percent) in the gas samples analyzed by Isotech Laboratories, Inc., was used for the calculations]

Sample number	Canister numbers	Coal bed or zone	Depth (feet)	Gas, cumulative volume (cc)	Sampling date	H_2 (percent)	Ar (percent)
60597	WV–02–CB3–11	Middle Kittanning coal zone	1,190.00–1,190.45	1,753	11/25/2003	0	0
DOE–MP No. 15	WV–02–B3–11, WV–02–B3–12	Middle Kittanning coal zone	1,184.10–1,185.10 1,188.00–1,189.00	548	10/10/2002	0.81	nd
DOE–MP No. 17	WV–02–B3–12	Middle Kittanning coal zone	1,188.00–1,189.00	295	10/10/2002	0.70	0.29
DOE–MP No. 16	WV–02–B3–13	Middle Kittanning coal zone	1,189.00–1,190.00	334	10/10/2002	0.54	0.33
60591	WV–02–B3–12, WV–02–B3–13	Middle Kittanning coal zone	1,188.00–1,190.00	6,294	11/25/2003	0.08	0.03
46857	WV–02–B3–14, WV–02–B3–15	Clarion coal zone, upper split	1,270.50–1,272.35	390	10/11/2002	0	0
48349	WV–02–B3–14, WV–02–B3–15	Clarion coal zone, upper split	1,270.50–1,272.35	1,691	11/27/2002	0	0
60592	WV–02–B3–14	Clarion coal zone, upper split	1,270.50–1,271.50	1,102	11/25/2003	0.00	0
60593	WV–02–B3–15	Clarion coal zone, upper split	1,271.50–1,272.35	2,696	11/25/2003	0.09	0.13
DOE–MP No. 19	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	1,278.70–1,280.80	652	10/11/2002	0.02	nd
46860	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	1,278.70–1,280.80	891	10/11/2002	0	0
48350	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	1,278.70–1,280.80	4,198	11/27/2002	0.01	0.05
60594	WV–02–B3–16, WV–02–B3–17	Clarion coal zone, lower split	1,278.70–1,280.80	7,309	11/25/2003	0.10	0.03
DOE–MP No. 21	WV–02–B3–18	Upper Mercer coal bed	1,324.40–1,325.15	232	10/11/2002	0.09	nd
48346	WV–02–B3–18	Upper Mercer coal bed	1,324.40–1,325.15	1,072	11/27/2002	0	0.41
60595	WV–02–B3–18	Upper Mercer coal bed	1,324.40–1,325.15	1,790	11/25/2003	0.03	0
DOE–MP No. 20	WV–02–B3–19	Lower Mercer coal bed	1,357.50–1,358.50	133	10/11/2002	0.27	nd
48347	WV–02–B3–19	Lower Mercer coal bed	1,357.50–1,358.50	505	11/27/2002	0	1.21
60596	WV–02–B3–19	Lower Mercer coal bed	1,357.50–1,358.50	1,098	11/25/2003	0	0
DOE–MP No. 23	WV–02–B3–20	Quakertown coal zone	1,465.00–1,465.60	42	10/15/2002	0.13	nd
DOE–MP No. 22	WV–02–B3–21	Quakertown coal zone	1,475.60–1,476.43	45	10/15/2002	0.09	nd
48348	WV–02–B3–20, WV–02–B3–21	Quakertown coal zone	1,465.60–1,476.43	1,829	11/27/2002	0	0.07

Table 6. Gas geochemistry analyses corrected for air contamination for coal samples from core retrieved from the Mylan Park borehole, Monongalia County, W. Va.—Continued

CO_2 (percent)	O_2 (percent)	N_2 (percent)	CO (percent)	C_1 (percent)	C_2 (percent)	C_2H_4 (percent)	C_3 (percent)	*i*C_4 (percent)	*n*C_4 (percent)	*i*C_5 (percent)	*n*C_5 (percent)	C_{6+} (percent)	C_{2+} (percent)	C_1/C_{2+} (ratio)
0.13	0	0	nd	91.58	6.67	0.01	1.43	0.06	0.10	0.01	0.01	0.00	8.28	11
0.04	0	9.74	nd	78.31	3.22	0	6.50	0.45	0.71	0.12	0.06	0.03	11.10	7
0.03	0	2.15	nd	86.69	3.71	0	5.22	0.41	0.64	0.09	0.04	0.02	10.14	9
0.02	0	1.39	nd	88.07	3.79	0	4.87	0.30	0.55	0.07	0.04	0.02	9.64	9
0.23	0	0	nd	92.08	6.11	0.01	1.29	0.05	0.10	0.01	0.01	0.00	7.58	12
0.11	0	0	nd	93.79	4.73	0	1.15	0.06	0.12	0.01	0.01	0.01	6.09	15
0.18	0	0	nd	93.39	5.26	0	1.02	0.05	0.08	0.01	0.00	0.00	6.42	15
0.33	0	0	nd	90.88	6.97	0.01	1.63	0.04	0.12	0.01	0.00	0.00	8.78	10
1.66	0	16.01	nd	74.65	5.80	0.01	1.46	0.04	0.13	0.01	0.01	0.01	7.45	10
1.05	0	8.98	nd	80.58	3.17	0	5.34	0.31	0.41	0.08	0.04	0.03	9.37	9
0.11	0	0	nd	94.74	4.32	0	0.71	0.03	0.05	0.01	0.01	0.01	5.14	18
0.91	0	0	nd	93.38	4.83	0	0.74	0.02	0.05	0.01	0.00	0.00	5.65	17
0.21	0	0	nd	90.90	7.02	0.01	1.52	0.07	0.12	0.01	0.01	0.00	8.76	10
0.02	0	7.38	nd	86.16	2.26	0	3.54	0.19	0.29	0.04	0.02	0.01	6.35	14
1.30	0	0	nd	93.13	4.09	0	0.89	0.04	0.08	0	0	0.02	5.12	18
0.12	0	0	nd	92.18	6.27	0.01	1.23	0.06	0.10	0.01	0.01	0.00	7.68	12
0.10	0	14.66	nd	77.76	1.93	0	4.40	0.28	0.46	0.07	0.04	0.02	7.20	11
1.88	0	28.69	nd	66.14	1.31	0	0.55	0.00	0.09	0	0	0.04	1.98	33
0.10	0	0	nd	93.27	5.40	0.00	1.07	0.05	0.09	0.01	0.01	0.00	6.62	14
0.18	0	13.55	nd	85.76	0.04	0	0.27	0.01	0.02	0.01	0.00	0.01	0.36	236
0.13	0	10.05	nd	89.34	0.06	0	0.27	0.01	0.02	0.01	0.00	0.01	0.38	235
0.97	0	0	nd	98.82	0.05	0	0.05	0	0	0	0	0.01	0.11	913

Adsorption Analyses

After desorption measurements were completed in December 2003, the canisters were unsealed and taken to the WVGES laboratory at West Virginia University in Morgantown, W. Va. The coals were split into representative subsamples for petrographic, geochemical, and proximate analyses. In addition, samples from all canisters of the Upper Kittanning coal bed and the Clarion coal zone and from all but one of the canisters for the Middle Kittanning coal zone were selected for high-pressure carbon-dioxide adsorption analyses because the coal beds were relatively thick (1.70–3.95 ft), deep (1,112.70–1,280.80 ft), and contained abundant gas (85.69–130.98 standard cubic feet per ton (SCF/ton), or 2.68–4.09 cubic centimeters per gram (cc/g), on an as-received basis (arb)). (See sections below.) These analyses were performed to determine the maximum carbon-dioxide sorption capacity in coals from the Mylan Park study area.

Samples for high-pressure carbon-dioxide adsorption analyzes were sent to RMB Earth Science Consultants, Ltd. (Delta, British Columbia, Canada), where they were crushed to -60 mesh and placed in an equilibrium moisture bath for 21 days. Isotherm analyses were conducted in a high-pressure volumetric adsorption apparatus at the reservoir temperature of 70°F. A known volume of gas was used to dose 100-gram (g) coal samples from the Upper Kittanning coal bed and the Middle Kittanning and Clarion coal zones, and the amount of gas adsorbed on equilibrated samples was determined using a series of pressure measurements. See Yee and others (1993) for detailed information on gas adsorption theory and analyses.

Desorption Results and Gas Chemistry by Coal Bed and Coal Zone

Sewickley Coal Bed (Mined)

A 5.40-ft-long sample of coal from a remaining pillar in an abandoned underground mine of the Sewickley coal bed was cored and retrieved to the surface from a depth of 346.80 to 352.20 ft at 11:39[5] hours on September 27, 2002. A total of 7 or 8 measurements was taken on each canister over 3 days (fig. 3) until desorption was suspended because the coal-bed-gas volumes could not be detected or measured. The measured raw-total-gas content for the Sewickley coal bed (using a weighted average) was 0.07 SCF/ton (0.00 cc/g). The overall moisture content was 1.29 percent and the ash yield was 21.08 weight percent (dry basis (db)) (table 2). Because the gas content was so low (fig. 3), the ash yields of the coal within individual canisters were not determined and the total gas content on a dry, ash-free basis (dafb) could not be determined. See tables A1, A2, A3, and A4 in appendix A for raw data.

- Canister 1 (WV–02–CB3–10; 346.80–347.20 ft)—No gas was desorbed over the 3 days.
- Canister 2 (WV–02–B3–1; 347.20–348.20 ft)—A measured gas volume was recorded only on the first measurement. The measured raw-total-gas content of the coal was 0.40 SCF/ton (0.01 cc/g) (based on the single measurement).
- Canister 3 (WV–02–US4–2; 348.20–350.20 ft)—The measured gas volumes were recorded on the first and second measurements. The measured raw-total-gas content of the coal was 0.01 SCF/ton (0.00 cc/g) (based on the two measurements).
- Canister 4 (WV–02–US4–1; 350.20–352.20 ft)—A measured gas volume was recorded only on the first measurement. The measured raw-total-gas content of the coal was 0.02 SCF/ton (0.00 cc/g) (based on the single measurement).

Gas chemistry of the Sewickley coal bed.—There was insufficient gas from the Sewickley coal bed canisters to analyze for chemical constituents.

Redstone Coal Bed

A 2.70-ft-long sample of the Redstone coal bed was cored and retrieved to the surface from a depth of 405.30 to 408.00 ft at 15:01 hours on September 30, 2002, and placed into one 2-ft-long aluminum canister and one 1-ft-long PVC canister for desorption. The measured raw-total-gas content of the Redstone coal bed (using a weighted average) was low—0.5 SCF/ton (0.02 cc/g)—which can be attributed to gas migration due to the mining of the overlying Sewickley coal bed, the mining of the Pittsburgh coal bed, and a relatively shallow depth. The overall moisture content was 0.68 percent and the ash yield was 27.80 weight percent (db) (table 2). Because gas contents were low (fig. 4), the ash yields of the coal in the individual canisters and the total gas content (dafb) could not be determined. See tables A5 and A6 in appendix A for raw data.

- Canister 1 (WV–02–US4–5; 405.30–407.30 ft)—A total of 27 desorption measurements was taken from the coal over 23 days. The measured raw-total-gas content of the coal was 0.46 SCF/ton (0.01 cc/g).

[5]For this study, a 24-hour clock was used for reporting time.

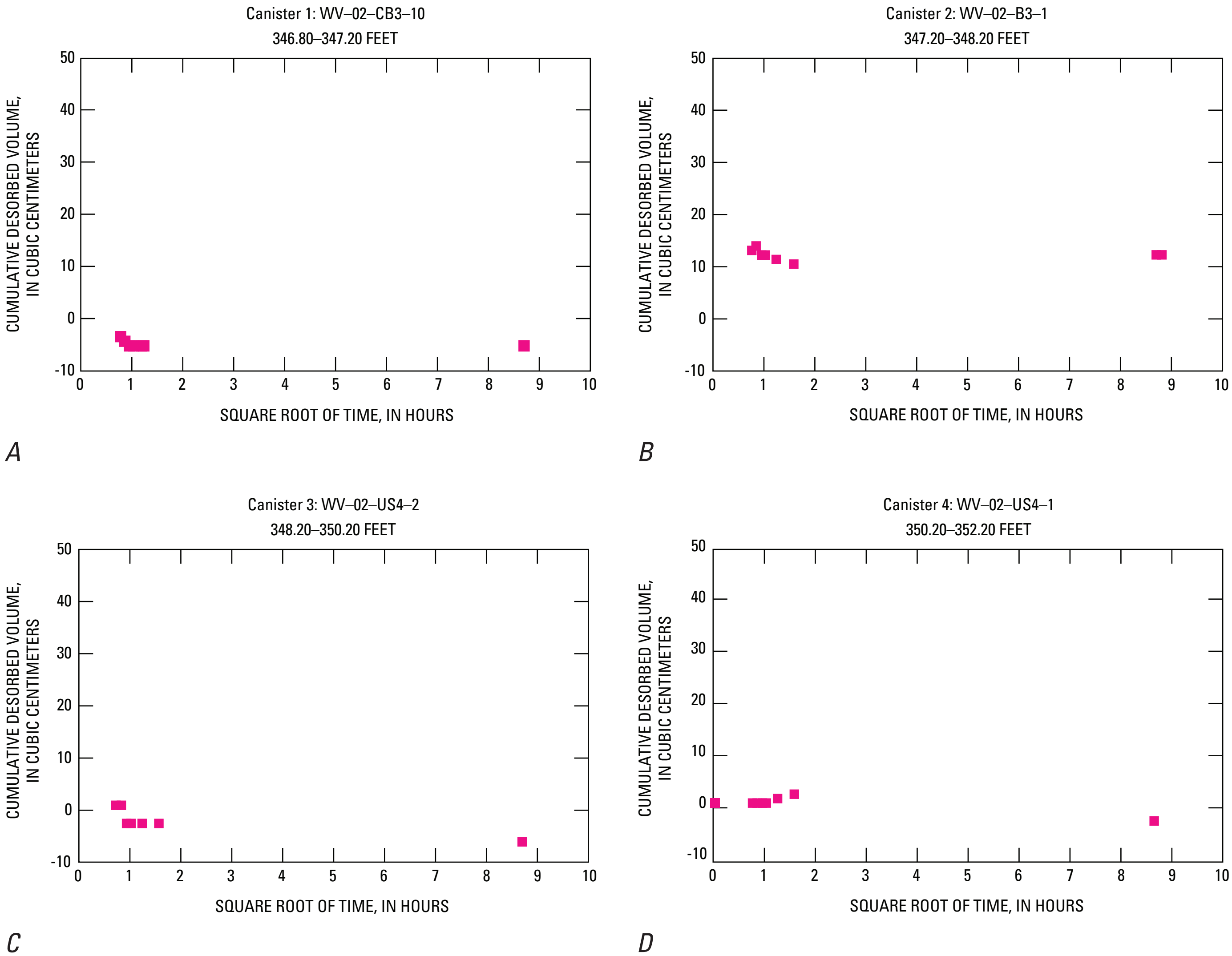


Figure 3. Graphs showing cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Sewickley coal bed plotted against the square root of time (in hours). Note the virtual absence of desorbed gas. Canister numbers and coal sample depths are shown. Because coal-bed gas migrates from coal during mining, these analyses should not be regarded as representative of the Sewickley coal bed in areas where it has not been previously mined. See tables A1, A2, A3, and A4 in appendix A for the desorption data from which these graphs were derived.

- Canister 2 (WV–02–B3–2; 407.30–408.00 ft)—A total of 6 desorption measurements was taken from the coal on September 30, 2002. A measured gas volume was recorded only on the second measurement. The measured raw-total-gas content of the coal was 0.57 SCF/ton (0.02 cc/g) (based on the single measurement).

Gas chemistry of the Redstone coal bed.—There was insufficient gas from the Redstone coal bed canisters to analyze for chemical constituents.

Pittsburgh Roof Coal Interval

Throughout the northern Appalachian basin, the Pittsburgh roof coal interval (or sequence) typically consists of interbedded shale, mudstone, and thin coal beds that overlie the thick, minable Pittsburgh coal bed. In the Mylan Park study area, the roof interval above the Pittsburgh coal bed is 7.29 ft, of which 1.90 ft is coal. The interval was cored and retrieved from a depth of 426.96 to 433.85 ft at 17:52 hours on September 30, 2002. Only coal samples were desorbed:

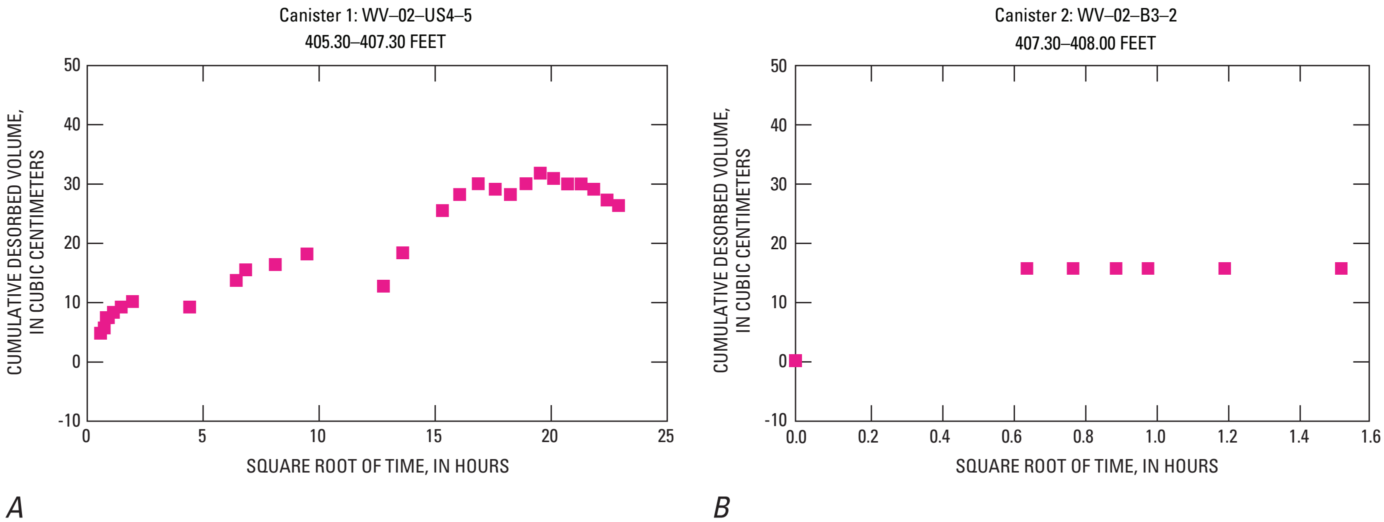


Figure 4. Graphs showing cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Redstone coal bed plotted against the square root of time (in hours). Virtually no gas was emitted. The canister numbers and coal sample depths are shown. See tables A5 and A6 in appendix A for the desorption data from which these graphs were derived.

a 1-ft-long coal sample of the Pittsburgh roof coal interval from 426.96 to 427.96 ft and a 0.90-ft-long coal sample from 432.35 to 433.25 ft were placed in two 1-ft-long PVC canisters (fig. 5). The measured raw-total-gas content of the coals from the sampled portion of the Pittsburgh roof coal interval (using a weighted average) was 1.25 SCF/ton (0.04 cc/g). The overall moisture content was 1.63 percent and the ash yield was 83.05 weight percent (db) (table 2). The total gas content (dafb) could not be determined because the ash yield of coal from the Pittsburgh roof coal interval was not determined. See tables A7 and A8 in appendix A for raw data.

- Canister 1 (WV–02–B3–3, 426.96–427.96 ft)—A total of 30 desorption measurements was taken from the coal over 26 days (fig. 5). The measured raw-total-gas content of the coal was 1.29 SCF/ton (0.04 cc/g).

- Canister 2 (WV–02–B3–5; 432.35–433.25 ft)—A total of 40 desorption measurements was taken from the coal over 38 days. The measured raw-total-gas content of the coal was 1.20 SCF/ton (0.04 cc/g).

Gas chemistry of the Pittsburgh roof coal interval.—A single gas sample was analyzed from the coal in the Pittsburgh roof coal interval (table 5). It contained only about 7 percent methane, even after correcting for air contamination (table 6). Although air contamination could have occurred in the gas sampling procedure, the low gas content is more likely attributed to a significant migration of gas out of the Pittsburgh roof coal interval and into the underlying void spaces within the mined Pittsburgh coal bed. In addition, some of the gas from the coals in the Pittsburgh roof coal interval could have migrated upward and escaped into the mined Sewickley coal bed.

Pittsburgh Coal Bed (Mined)

An 8.75-ft-long coal pillar from an abandoned Pittsburgh coal bed mine was cored and retrieved to the surface from a depth of 433.85 to 442.35 ft at 17:52 hours on September 30, 2002, and placed in four 2-ft-long, 4-inch-diameter aluminum canisters and one 1-ft-long PVC canisters for desorption. Desorption measurements were taken from each canister over 12 days (fig. 6). The measured raw-total-gas content of the Pittsburgh coal bed (using a weighted average) at Mylan Park was 1.0 SCF/ton (0.03 cc/g). The overall moisture content of the coal was 0.52 percent and the ash yield was 9.84 weight percent (db) (table 2). The ash yields of the coals within the five individual canisters were not determined, thus the total gas content (dafb) was not determined. See tables A9, A10, A11, A12, and A13 in appendix A for raw data.

- Canister 1 (WV–02–B3–4; 433.85–434.35 ft)—A total of 15 desorption measurements was taken from the coal (fig. 6). The measured raw-total-gas content of the coal was 0.53 SCF/ton (0.02 cc/g).

- Canister 2 (WV–02–US4–30; 434.35–436.35 ft)—A total of 14 desorption measurements was taken from the coal. The measured raw-total-gas content of the coal was 0.29 SCF/ton (0.01 cc/g).

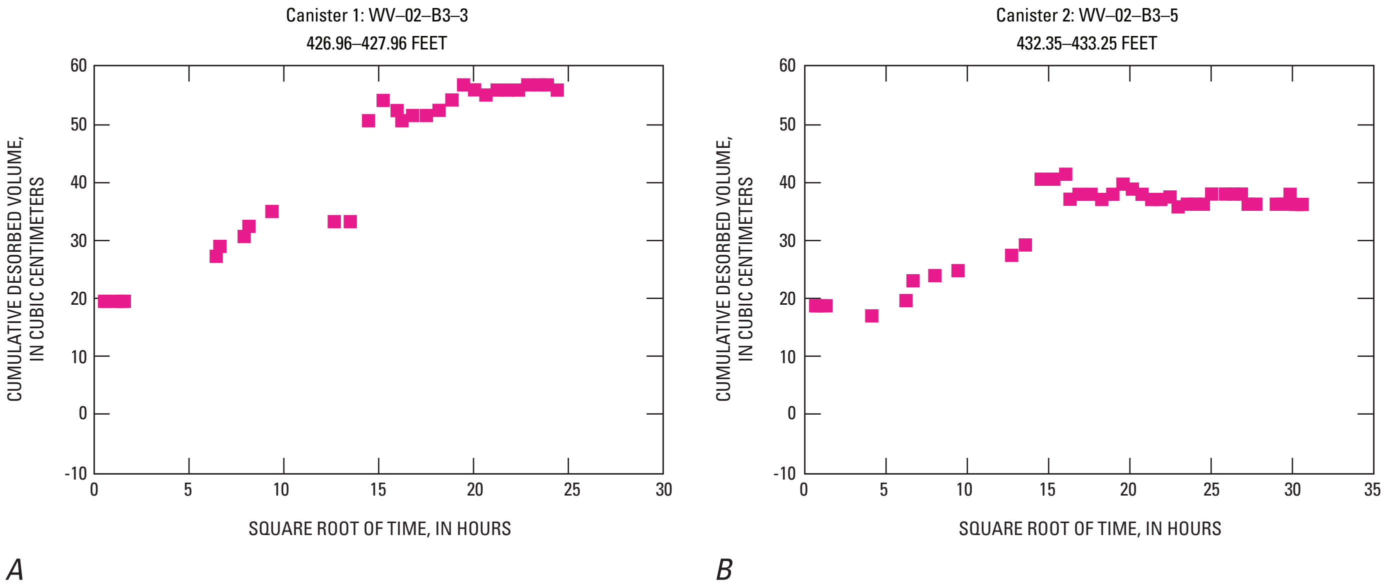


Figure 5. Graphs showing cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Pittsburgh roof coal interval plotted against the square root of time (in hours). The canister numbers and coal sample depths are shown. Because coal-bed gas migrates from coal during mining, these analyses should not be regarded as representative of the coals from the Pittsburgh roof coal interval in the area where the Sewickley and (or) Pittsburgh coal beds (higher or lower in the section, respectively) have not been previously mined. See tables A7 and A8 in appendix A for the desorption data from which these graphs were derived.

- Canister 3 (WV–02–US4–14; 436.35–438.35 ft)—A total of 14 desorption measurements was taken from the coal. The measured raw-total-gas content of the coal was 0.52 SCF/ton (0.02 cc/g).
- Canister 4 (WV–02–US4–8; 438.35–440.35 ft)—A total of 14 desorption measurements was taken from the coal. The measured raw-total-gas content of the coal was 0.36 SCF/ton (0.01 cc/g).
- Canister 5 (WV–02–US4–6; 440.35–442.35 ft)—A total of 14 desorption measurements was taken from the coal. The measured raw-total-gas content of coal was 0.73 SCF/ton (0.02 cc/g).

Gas chemistry of the Pittsburgh coal bed.—Because the Pittsburgh coal bed had been mined in this location, there was little desorbed gas. Three coal-bed-gas samples from the Pittsburgh coal bed were analyzed for gas chemistry (table 5) and the results were recalculated to an air-free basis (table 6). Only one sample (sample 46862 taken on October 11, 2002) contained abundant methane (about 79 percent) on an air-free basis.

Little Pittsburgh Coal Bed

A total of 0.75 ft of coal from the Little Pittsburgh coal bed was cored and retrieved to the surface from a depth of 468.50 to 469.50 ft at 13:48 hours on October 1, 2002, and placed into a 1-ft-long PVC canister. A total of 47 desorption measurements was taken over 64 days (fig. 7). The measured raw-total-gas content of the coal bed (using a weighted average) was 13.52 SCF/ton (0.42 cc/g). The overall moisture content was 1.15 percent and the ash yield of the coal was 43.69 weight percent (db) (table 2). The total gas content (dafb) was 25.44 SCF/ton (0.79 cc/g). See table A14 in appendix A for raw data.

Gas chemistry of the Little Pittsburgh coal bed.—Two coal-bed-gas samples from the Little Pittsburgh coal bed were analyzed (table 5) and recalculated to an air-free basis (table 6). Both samples were contaminated by air to varying degrees, either through the gas sampling procedure or by interaction with air from mining in the overlying Pittsburgh coal bed. Sample DOE–MP No. 11 contained 47 percent methane (on an air-free basis) (table 6); the second sample did not confirm the presence of methane after recalculation.

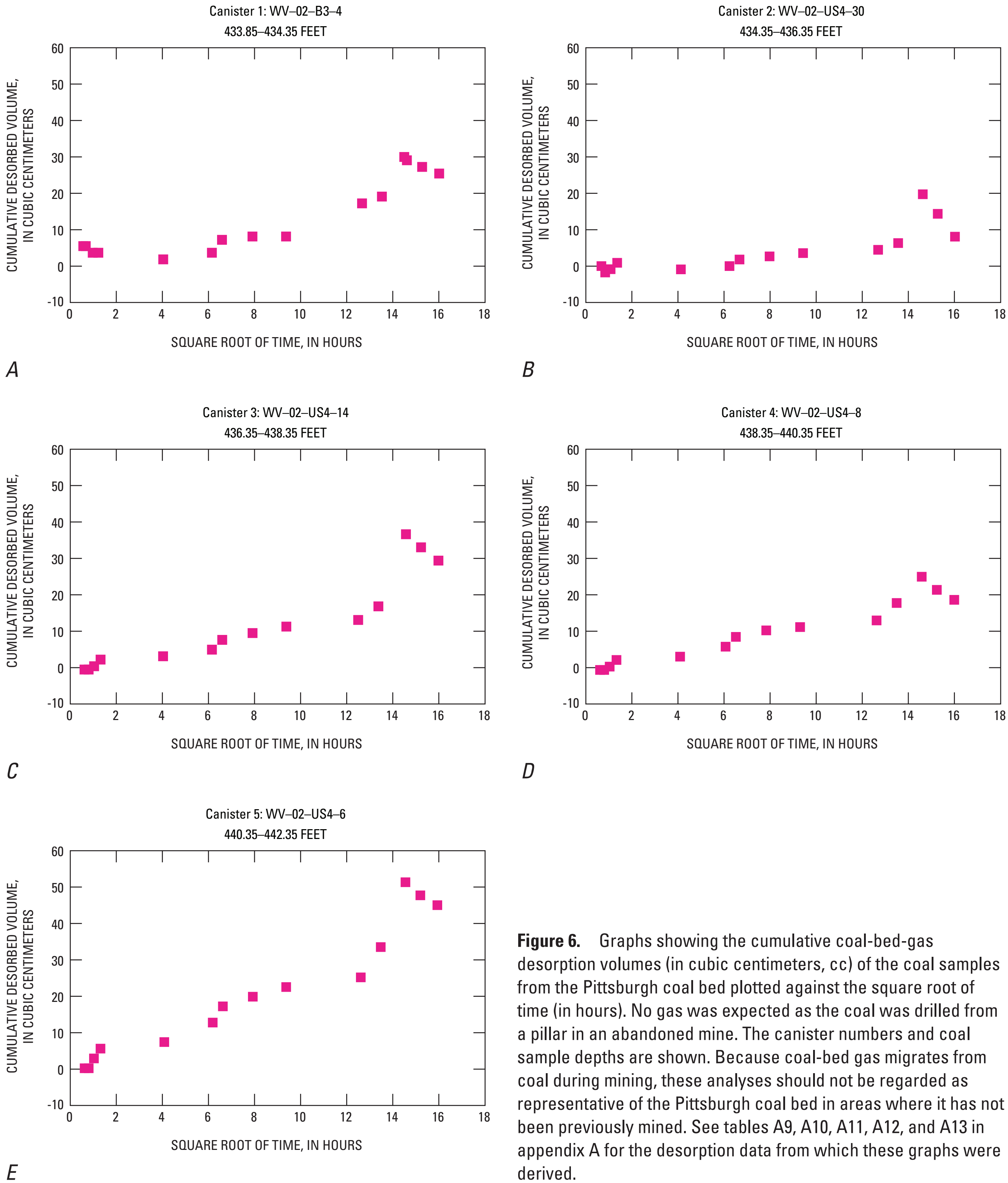


Figure 6. Graphs showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Pittsburgh coal bed plotted against the square root of time (in hours). No gas was expected as the coal was drilled from a pillar in an abandoned mine. The canister numbers and coal sample depths are shown. Because coal-bed gas migrates from coal during mining, these analyses should not be regarded as representative of the Pittsburgh coal bed in areas where it has not been previously mined. See tables A9, A10, A11, A12, and A13 in appendix A for the desorption data from which these graphs were derived.

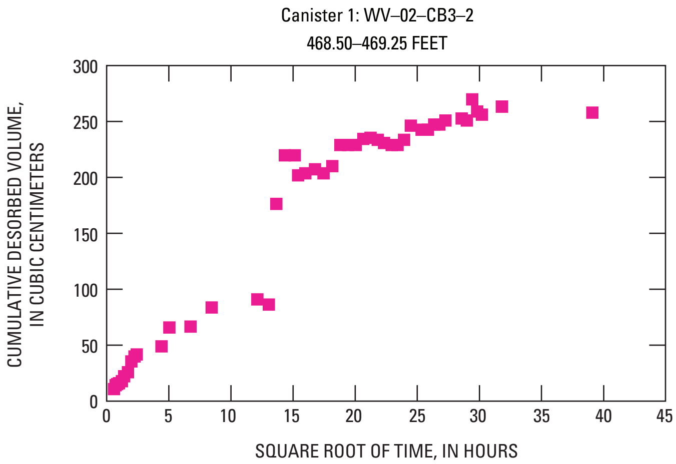


Figure 7. Graph showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal sample from the Little Pittsburgh coal bed plotted against the square root of time (in hours). The canister number and coal sample depth is shown. See table A14 in appendix A for the desorption data from which this graph was derived.

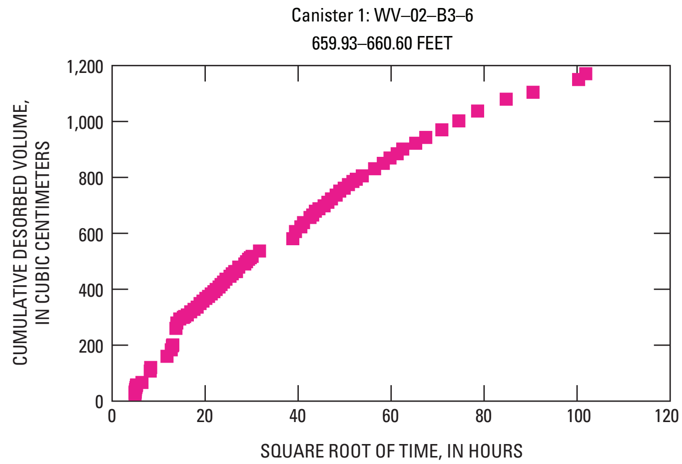


Figure 8. Graph showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal sample from the Elk Lick coal bed plotted against the square root of time (in hours). The canister number and coal sample depth is shown. See table A15 in appendix A for the desorption data from which this graph was derived.

Elk Lick Coal Bed

A 0.67-ft-long sample of coal from the Elk Lick coal bed was cored and retrieved to the surface from a depth of 659.93 to 660.60 ft and placed into a 1-ft-long PVC canister (WV–02–B3–6) at 15:20 hours on October 1, 2002, for desorption. A total of 78 desorption measurements was taken over 431 days. The gas desorption profile (fig. 8) shows that gas continued to be released from the coal when the experiment was halted because of time constraints. The measured lost gas for the Elk Lick coal bed was 60 cc, the highest lost gas volume in this study. The measured raw-total-gas content of the coal bed (using a weighted average) was 62.68 SCF/ton (1.96 cc/g). The overall moisture content of the coal was 0.85 percent and the ash yield was 24.3 weight percent (db) (table 2). The total gas content (dafb) was 82.88 SCF/ton (2.59 cc/g). See table A15 in appendix A for raw data.

Gas chemistry of the Elk Lick coal bed.—Four gas samples from the Elk Lick coal bed were analyzed (table 5) and recalculated to an air-free basis (table 6). All of the samples had high nitrogen contents. Sample 60587 had a very low methane content (<1 percent on an air-free basis). Samples DOE–MP No. 4, DOE–MP No. 6, and DOE–MP No. 12 had methane contents ranging from 82 to 87 percent (on an air-free basis) (table 6).

Brush Creek Coal Bed

A 1.4-ft-long sample of coal from the Brush Creek coal bed was cored and retrieved to the surface from a depth of 920.40 to 921.80 ft at 17:46 hours on October 7, 2002, and placed into two 1-ft-long PVC canisters for desorption. Gas continued to be released from the coal when the experiment was halted 425 days later because of time constraints (fig. 9). There was no measured lost gas for the Brush Creek coal bed. The measured raw-total-gas content of the coal bed (using a weighted average) was 67.38 SCF/ton (2.11 cc/g) (dafb). The overall moisture content of the coal was 0.95 percent and the ash yield was 43.43 weight percent (db) (table 2). The total gas content (dafb) was 67.38 SCF/ton (2.11 cc/g). See tables A16 and A17 in appendix A for raw data.

- Canister 1 (WV–02–B3–7; 920.40–921.10 ft)—A total of 78 desorption measurements was taken from the coal over 425 days. The measured raw-total-gas content was 40.97 SCF/ton (1.28 cc/g). The moisture content of the coal was 1.10 percent, the ash yield of the coal was 62.67 weight percent (db), and the total gas content (dafb) was 112.64 SCF/ton (3.52 cc/g).

- Canister 2 (WV–02–B3–8; 921.10–921.80 ft)—A total of 83 desorption measurements was taken from

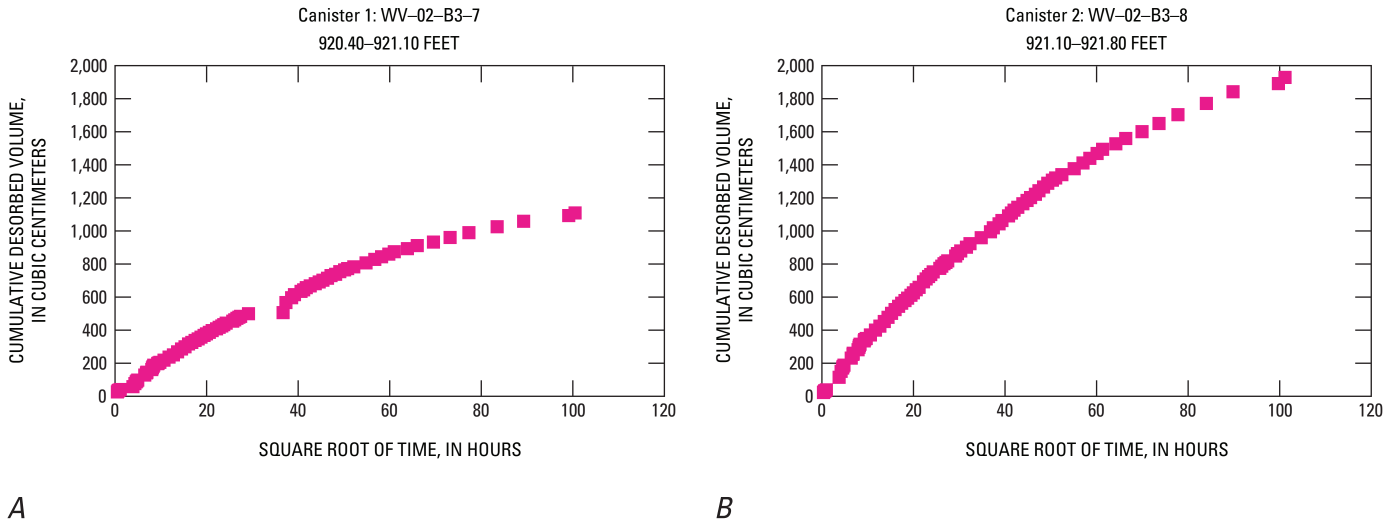


Figure 9. Graphs showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Brush Creek coal bed plotted against the square root of time (in hours). The canister numbers and coal sample depths are shown. Note the differences in the amount of gas released from the coal in the two samples. Canister 1 contained bony coal and dark-gray shale, whereas canister 2 contained comparatively purer coal. See tables A16 and A17 in appendix A for the desorption data from which these graphs were derived.

the coal over 425 days. The measured raw-total-gas content was 107.09 SCF/ton (3.35 cc/g). The moisture content of the coal was 0.90 percent, the ash yield was 12.34 weight percent (db), and the total gas content (dafb) was 122.14 SCF/ton (3.82 cc/g).

Gas chemistry of the Brush Creek coal bed.—Three coal-bed-gas samples from the Brush Creek coal bed were analyzed (table 5) and recalculated to an air-free basis (table 6). The methane contents of the samples ranged from 84 to 98 percent (on an air-free basis) (table 6).

Upper Kittanning Coal Bed

A 1.70-ft-long coal sample from the Upper Kittanning coal bed was cored and retrieved to the surface from a depth of 1,121.70 to 1,123.40 ft at 9:05 hours on October 9, 2002, and placed in two 1-ft-long PVC canisters. A total of 82 desorption measurements was taken over 424 days for each canister (fig. 10). The measured raw-total-gas content (using a weighted average) was 130.98 SCF/ton (4.09 cc/g). The overall moisture content of the coal in the two canisters was 0.97 percent and the ash yield was 9.25 weight percent (db) (table 2). The total gas content (dafb) was 142.25 SCF/ton (4.45 cc/g). See tables A18 and A19 in appendix A for raw data.

- Canister 1 (WV–02–B3–9; 1,121.70–1,122.70 ft)—The measured raw-total-gas content of the coal was 136.33 SCF/ton (4.26 cc/g). The moisture content was 1.07 percent, the ash yield was 6.65 weight percent (db), and the total gas content (dafb) was 146.14 SCF/ton (4.57 cc/g).
- Canister 2 (WV–02–B3–10; 1,122.70–1,123.40 ft)—The measured raw-total-gas content was 123.34 SCF/ton (3.85 cc/g). The moisture content was 1.24 percent, the ash yield was 12.55 weight percent (db), and the total gas content (dafb) was 140.77 SCF/ton (4.40 cc/g).

Gas chemistry of the Upper Kittanning coal bed.—Four coal-bed-gas samples from the Upper Kittanning coal bed were analyzed (table 5) and recalculated to an air-free basis (table 6). Even after correcting for air, the nitrogen contents were relatively high, ranging from 4 to almost 10 percent (table 6). The methane contents for two individual canisters (WV–02–B3–9 and WV–02–B3–10) and for the cumulative coal bed sample ranged from 83 to 95 percent (on an air-free basis) (table 6).

Middle Kittanning Coal Zone

A 3.75-ft-thick sample of coal from two splits of the Middle Kittanning coal zone was cored and retrieved to the surface in two runs from a depth of 1,184.10 to 1,190.45 ft at 13:38 and 13:31 hours on October 9, 2002, and placed in five 1-ft-long PVC canisters. A total of 78 or 79 desorption measurements was taken over 424 days and gas continued

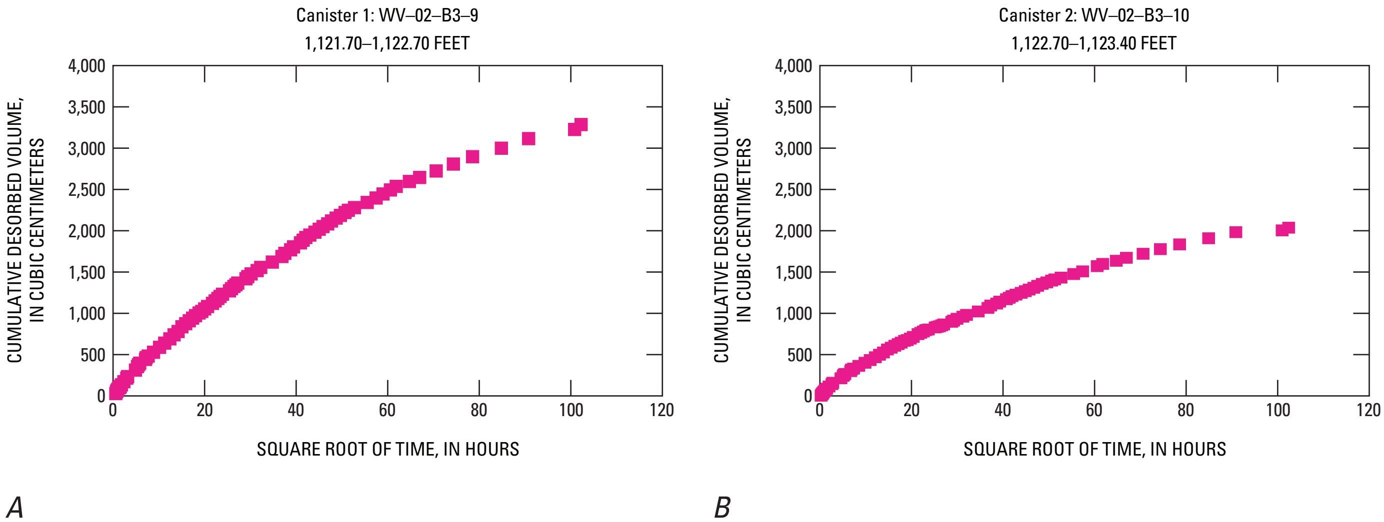


Figure 10. Graphs showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Upper Kittanning coal bed plotted against the square root of time (in hours). The canister numbers and coal sample depths are shown. See tables A18 and A19 in appendix A for the desorption data from which these graphs were derived.

to be released from the coal when the experiment was halted (fig. 11) due to project time constraints. The measured raw-total-gas content (using a weighted average) was 113.54 SCF/ton (3.59 cc/g). The overall moisture content of coals from the Middle Kittanning coal zone was 0.52 percent and the ash yield was 18.61 weight percent (db) (table 2). The total gas content (dafb) was 138.94 SCF/ton (4.40 cc/g). Estimated lost gas for the five canisters ranged from 0 to 40 cc. See tables A20, A21, A22, A23, and A24 in appendix A for raw data.

- Canister 1 (WV–02–B3–11; 1,184.10–1,185.10 ft)—A total of 78 desorption measurements was taken from the coal over 424 days. The measured raw-total-gas content of the coal in the canister was 95.36 SCF/ton (2.98 cc/g). The moisture content was 0.65 percent, the ash yield was 21.18 weight percent (db), and the total gas content (dafb) was 121.03 SCF/ton (3.78 cc/g). This canister had 20 cc of estimated lost gas.

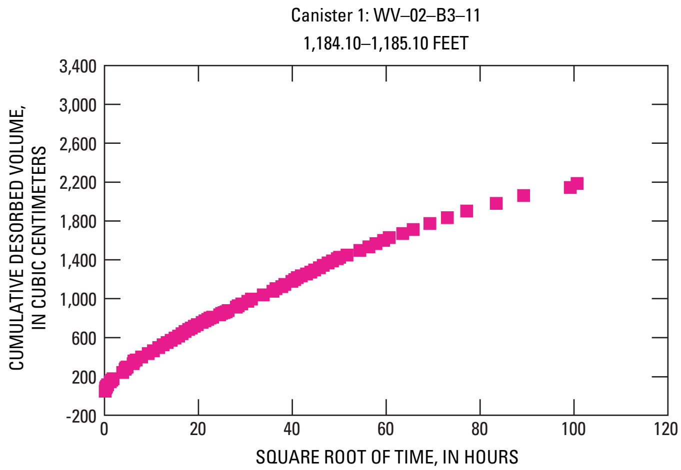
- Canister 2 (WV–02–CB3–12; 1,185.10–1,185.40 ft)—A total of 78 desorption measurements was taken from the coal over 424 days. The measured raw-total-gas content of the coal in the canister was 103.42 SCF/ton (3.23 cc/g). The moisture content was 0.82 percent, the ash yield was 29.10 weigh percent (db), and the total gas content (dafb) was 146.14 SCF/ton (4.57 cc/g). This canister had 20 cc of estimated lost gas.

- Canister 3 (WV–02–B3–12; 1,188.00–1,189.00 ft)—A total of 78 desorption measurements was taken from the coal over 424 days. The measured raw-total-gas content of the coal was 104.81 SCF/ton (3.28 cc/g). The moisture content was 0.62 percent, the ash yield was 29.10 weight percent (db), and the total gas content (dafb) was 139.31 SCF/ton (4.35 cc/g). This canister had 40 cc of estimated lost gas.

- Canister 4 (WV2–02–B3–13; 1,189.00–1,190.00 ft)—A total of 79 desorption measurements was taken from the coal over 424 days. The measured raw-total-gas content of the coal was 138.96 SCF/ton (4.34 cc/g). The moisture content was 0.75 percent, the ash yield was 24.73 weight percent, and the total gas content (dafb) was 150.78 SCF/ton (4.71 cc/g). This canister had no estimated lost gas.

- Canister 5 (WV–02–CB3–11; 1,190.00–1,190.45 ft)—A total of 78 desorption measurements was taken from the coal over 424 days. The measured raw-total-gas content of the coal was 124.19 SCF/ton (3.88 cc/g). The moisture content was 0.88 percent, the ash yield was 16.34 percent (db), and the total gas content (dafb) was 148.61 SCF/ton (4.64 cc/g). This canister had 5 cc of lost gas.

Gas chemistry of the Middle Kittanning coal zone.—The Middle Kittanning coal zone contains both an upper (1,184.10–1,185.40 ft) and a lower (1,188.00–1,190.45 ft) split, separated by a 2.60-ft-thick parting of interbedded shale and sandstone parting (Ruppert and others, 2004; West Virginia Geological and Economic Survey, 2007). Twelve coal-bed-gas samples were analyzed for the Middle Kittanning coal zone (table 5). The methane contents of the coals ranged from 68 to 94 percent (on an air-free basis) (table 6).



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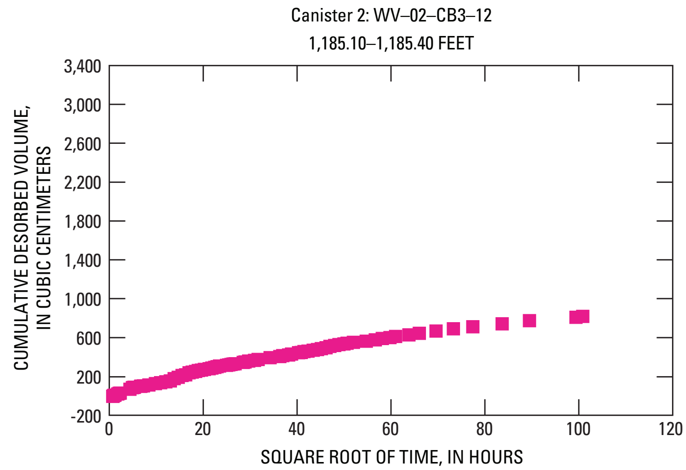

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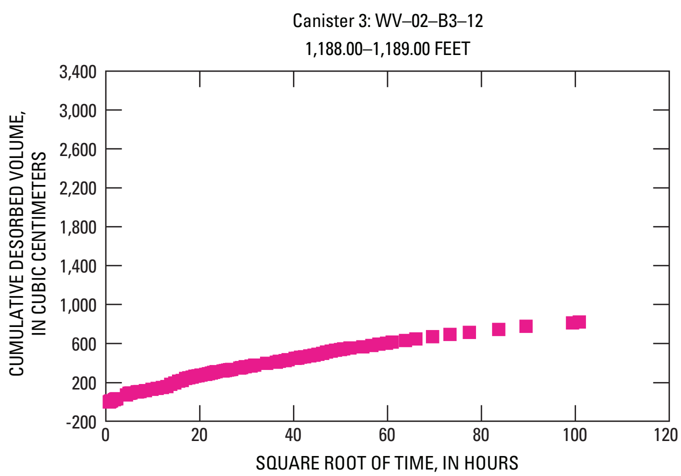

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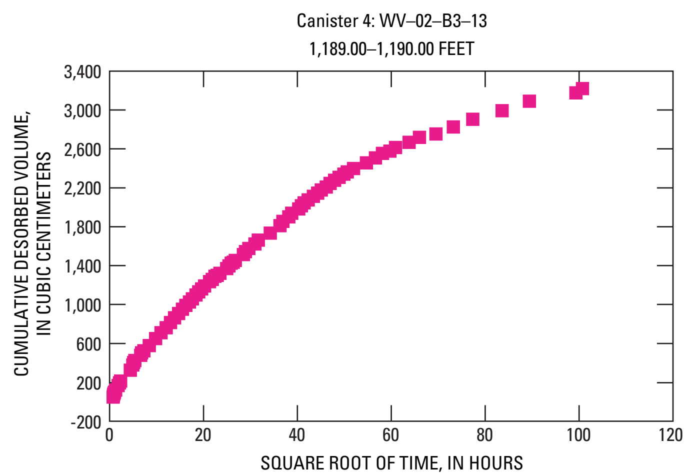

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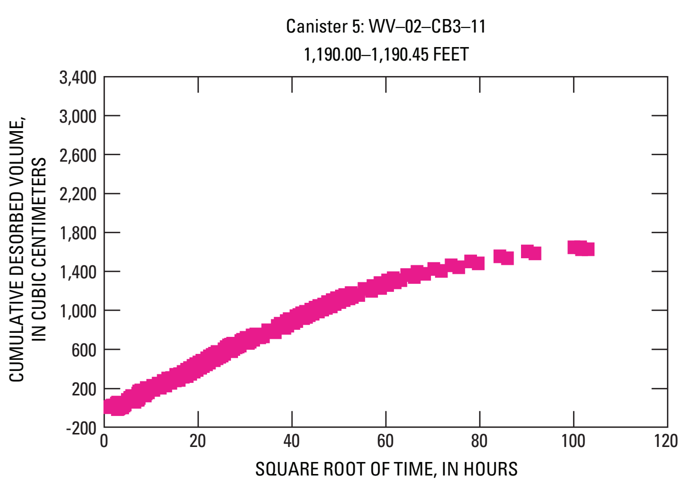

E

Figure 11. Graphs showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Middle Kittanning coal zone plotted against the square root of time (in hours). The canister numbers and coal sample depths are shown. See tables A20, A21, A22, A23, and A24 in appendix A for the desorption data from which these graphs were derived.

Clarion Coal Zone

A 3.95-ft-long coal sample from the two splits of the Clarion coal zone was cored and retrieved to the surface from a depth of 1,270.50 to 1,280.80 ft on October 10, 2002. The top split (1,270.50–1,272.35 ft) was retrieved and placed in two 1-ft-long PVC canisters at 8:24 hours. The bottom split (1,278.70–1,280.80 ft) was retrieved in a second run and placed in two 1-ft-long PVC canisters at 10:28 hours. Gas continued to be released from canisters 1, 3, and 4 (samples WV–02–B3–14, WV–02–B3–16, and WV–02–B3–17, respectively) 423 days later (fig. 12) when they were opened. The coal in canister 2 (WV–02–B3–15) continued to desorb small amounts of gas until desorption ended 662 days later. The measured raw-total-gas content for coals from the Clarion coal zone (using a weighted average) was 85.69 SCF/ton (2.68 cc/g). The overall moisture content was 1.01 percent and the ash yield was 14.26 weight percent (db) (table 2). The total gas content (dafb) was 124.42 SCF/ton (3.89 cc/g). There was no estimated lost gas for any of the canisters. See tables A25, A26, A27, and A28 in appendix A for raw data.

- Canister 1 (WV–02–B3–14; 1,270.50–1,271.50 ft)—A total of 75 desorption measurements was taken over

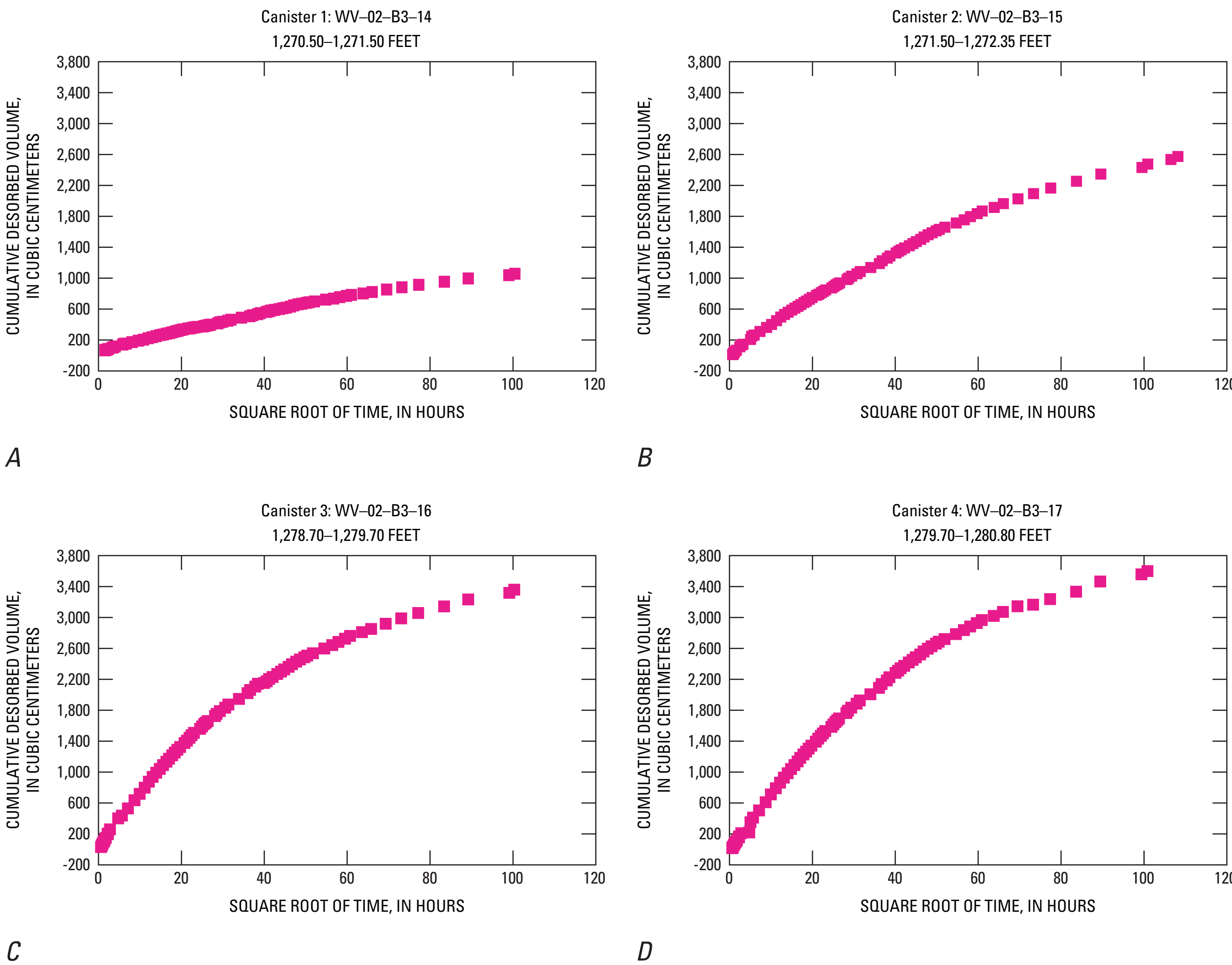

Figure 12. Graphs showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Clarion coal zone plotted against the square root of time (in hours). The canister numbers and coal sample depths are shown. See tables A25, A26, A27, and A28 in appendix A for the desorption data from which these graphs were derived.

423 days. The measured raw-total-gas content was 49.14 SCF/ton (1.54 cc/g). The moisture content was 0.68 percent, the ash yield was 63.69 weight percent (db), and the total gas content (dafb) was 135.58 SCF/ton (4.24 cc/g).

- Canister 2 (WV–02–B3–15; 1,271.50–1,272.35 ft)—A total of 77 desorption measurements was taken over 662 days before gas finished desorbing. The measured raw-total-gas content was 70.52 SCF/ton (2.20 cc/g). The moisture content was 1.00 percent, the ash yield was 63.69 weight percent (db), and the total gas content (dafb) was 81.64 SCF/ton (2.55 cc/g).
- Canister 3 (WV–02–B3–16; 1,278.70–1,279.70 ft)—A total of 75 desorption measurements was taken over 423 days. The measured raw-total-gas content was 134.84 SCF/ton (4.21 cc/g). The moisture content was 0.67 percent, the ash yield was 10.84 weight percent (db), and the total gas content (dafb) was 151.15 SCF/ton (4.72 cc/g).
- Canister 4 (WV–02–B3–17; 1,279.70–1,280.80 ft)—A total of 75 desorption measurements was taken over 423 days. The measured raw-total-gas content was 125.35 SCF/ton (3.92 cc/g). The moisture content was 0.71 percent, the ash yield was 17.96 weight percent (db), and the total gas content (dafb) was 152.82 SCF/ton (4.78 cc/g).

Gas chemistry of the Clarion coal zone.—Like the Middle Kittanning coal zone, the Clarion coal zone also contains both an upper (1,270.50–1,272.35 ft) and a lower (1,278.70–1,280.8 ft) split, separated by a 6.35-ft-thick parting of interbedded shale, claystone, mudstone, and sandstone (Ruppert and others, 2004; West Virginia Geological and Economic Survey, 2007). Four coal-bed-gas samples were analyzed for the upper split and four coal-bed-gas samples were analyzed for the lower split (table 5). The methane contents of coals from the upper split ranged from 75 to 94 percent (on an air-free basis) (table 6). The methane contents of the coals of the lower split ranged from 81 to 95 percent (on an air-free basis) (table 6).

Upper Mercer Coal Bed

A 0.75-ft-long coal sample from the Upper Mercer coal bed was cored and retrieved to the surface from a depth of 1,324.40 to 1,325.15 ft at 14:31 hours on October 10, 2002, and placed in a 1-ft-long PVC canister. A total of 71 desorption measurements was taken over 423 days (fig. 13) and gas continued to be released from the coal when the experiment was halted due to time constraints. The canister had 10 cc of estimated lost gas. The measured raw-total-gas content of coal from the Upper Mercer coal bed (using a weighted average) was 95.02 SCF/ton (2.97 cc/g). The overall moisture content was 0.72 percent, the ash yield was 10.94 weight percent (db) (table 2), and the total gas content (dafb) was 106.67 SCF/ton (3.33 cc/g). See table A29 in appendix A for raw data.

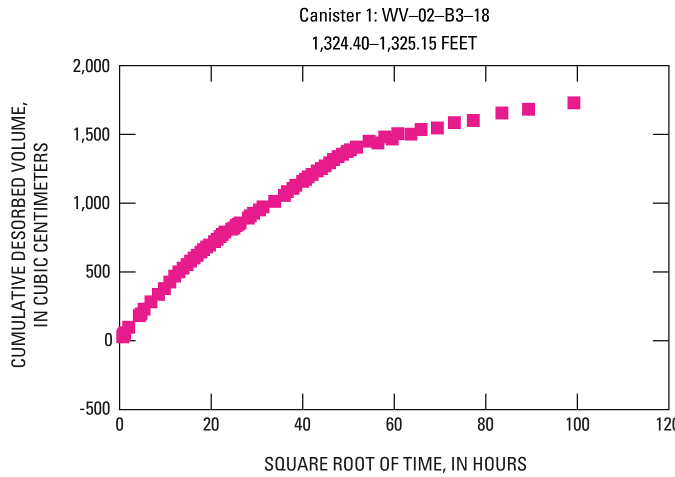

Figure 13. Graph showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal sample from the Upper Mercer coal bed plotted against the square root of time (in hours). The canister number and coal sample depth is shown. See table A29 in appendix A for the desorption data from which this graph was derived.

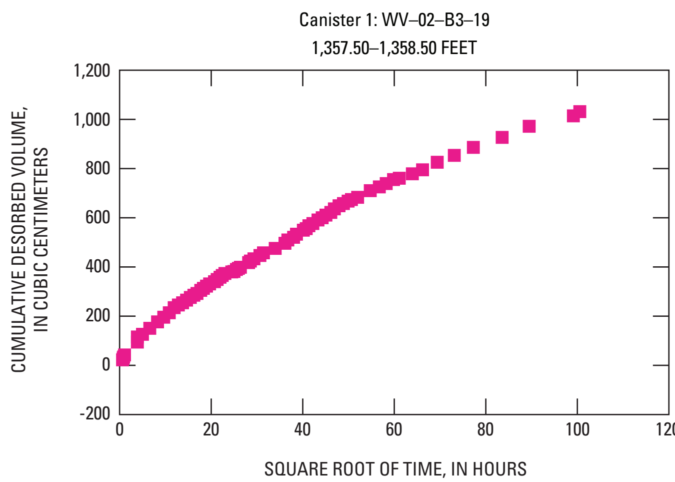

Figure 14. Graph showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal sample from the Lower Mercer coal bed plotted against the square root of time (in hours). The canister number and coal sample depth is shown. The higher ash yield (30.62 weight percent, dry basis) resulted in substantially lower gas volumes than the coal from the Upper Mercer coal bed (ash yield of 10.96 weight percent, dry basis) (table 2). See table A30 in appendix A for the desorption data from which this graph was derived.

Gas chemistry of the Upper Mercer coal bed.—Three coal-bed-gas samples from the Upper Mercer coal bed were analyzed (table 5) and recalculated to an air-free basis (table 6). Methane contents ranged from 86 to 93 percent (on an air-free basis) (table 6).

Lower Mercer Coal Bed

A 1.00-ft-long coal sample from the Lower Mercer coal bed was cored and retrieved to the surface from a depth of 1,357.50 to 1,358.50 ft at 17:51 hours on October 10, 2002, and placed in a single PVC canister. A total of 86 desorption measurements was taken over 423 days and gas continued to be released from the coal when the experiment was halted due to time constraints (fig. 14). There was no estimated lost gas. The measured raw-total-gas content of the coal from the Lower Mercer coal bed (using a weighted average) was 35.27 SCF/ton (1.10 cc/g). The overall moisture content was 0.49 percent, the ash yield was 30.62 weight percent (db) (table 2), and the total gas content (dafb) was 50.84 SCF/ton (1.59 cc/g). See table A30 in appendix A for raw data.

Gas chemistry of the Lower Mercer coal bed.—Three samples of the Lower Mercer coal-bed gas were analyzed (table 5) and recalculated to an air-free basis (table 6). Methane contents ranged from 66 to 93 percent (on an air-free basis) (table 6).

Quakertown Coal Zone

A 1.73-ft-long sample of coal from two splits of the Quakertown coal zone was cored and retrieved to the surface from a depth of 1,465.00 to 1,476.43 ft at 11:46 hours on October 15, 2002. The 0.3-ft-long sample of coal from the top of the top split was inadvertently placed in the core box and not desorbed. The remaining 1.43 ft of coal was placed in two 1-ft-long PVC canisters. A total of 71 desorption measurements was taken over 418 days and gas continued to be released from the coal when the experiment was halted due to time constraints (fig. 15). The measured raw-total-gas content (weighted average) was 67.84 SCF/ton (2.12 cc/g). The overall moisture content of the coals was 0.82 percent and the ash yield was 35.37 weight percent (db) (table 2). The total gas content (dafb) was 88.17 SCF/ton (2.76 cc/g). See tables A31 and A32 in appendix A for raw data.

- Canister 1 (WV–02–B3–20; 1,465.00–1,465.60 ft)—The measured raw-total-gas content was 85.90 SCF/ton (2.68 cc/g). The moisture content was 1.05 percent, the ash yield was 33.48 percent, and the total gas content (dafb) was 75.65 SCF/ton (2.36 cc/g). Estimated lost gas for this canister was 10 cc.

- Canister 2 (WV–02–B3–21; 1,475.60–1,476.43 ft)—The measured raw-total-gas content was 50.33 SCF/ton (1.57 cc/g). The moisture content was 0.47 percent, the ash yield was 27.74 weight percent, and the total gas content (dafb) was 75.65 SCF/ton (2.36 cc/g). Estimated lost gas for this canister was 10 cc.

Gas chemistry of the Quakertown coal zone.—Three coal-bed-gas samples from the Quakertown coal zone were analyzed (table 5) and recalculated to an air-free basis (table 6). Methane contents for the samples ranged from 86 to 99 percent (on an air-free basis) (table 6). Two of the gas samples, DOE–MP No. 23 (from canister WV–02–B2–20) and DOE–MP No. 22 (from canister WV–02–B3–21), which were analyzed by the DOE–NETL laboratory on October 15, 2002, contained high nitrogen contents (14 and 10 percent, respectively) after normalizing to an air-free basis (table 6). In contrast, a composite gas sample (sample 48348, table 6) that was taken about two weeks later and analyzed by Isotech Laboratories, Inc., contained no nitrogen. These differences are currently not explainable with available data.

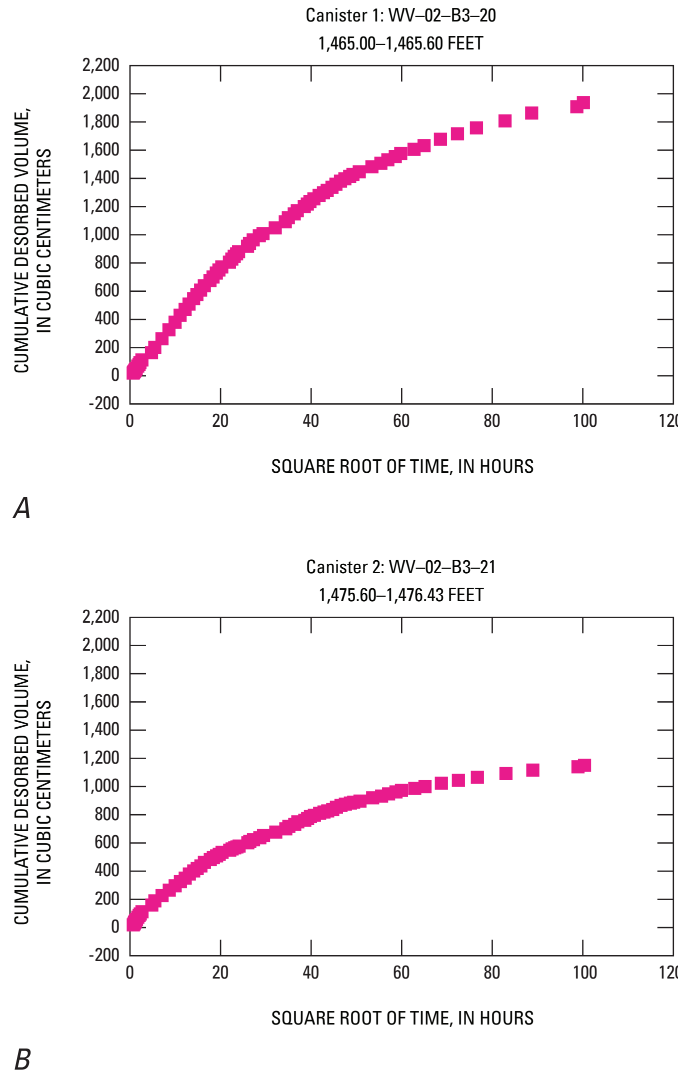

Figure 15. Graphs showing the cumulative coal-bed-gas desorption volumes (in cubic centimeters, cc) of the coal samples from the Quakertown coal zone plotted against the square root of time (in hours). The canister numbers and coal sample depths are shown. See tables A31 and A32 in appendix A for the desorption data from which these graphs were derived.

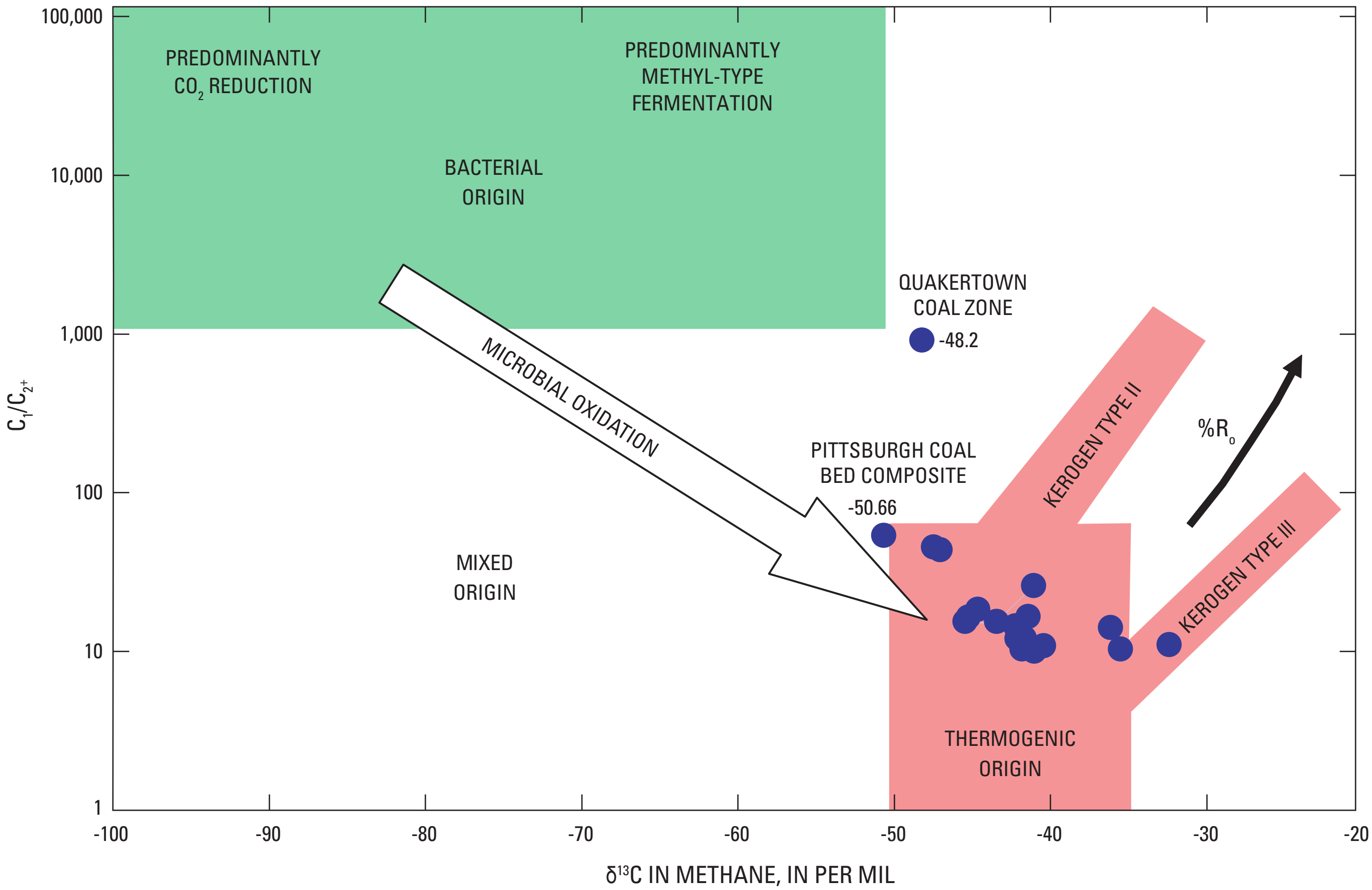

Figure 16. Bernard diagram for Mylan Park coal-bed-gas samples (modified from Bernard and others, 1978; Faber and Stahl, 1984; Whiticar, 1994). This diagram plots the isotopic composition of carbon (carbon 13, ^{13}C) in methane reported as the deviation in units ($\delta^{13}C$) of parts per thousand (per mil) relative to the Vienna Peedee belemnite (VPDB) standard against the ratio of methane (C_1) to the sum of the higher molecular gases (C_{2+}, which includes ethane, propane, *iso*-butane, *n*-butane, *iso*-pentane, 2-methylbutane, *n*-pentane, and hexane). The diagram shows that, with the exception of the Quakertown coal-bed-gas sample, methane from coal beds at the Mylan Park study area is thermogenic. Note that the coal-bed-gas sample from the Quakertown coal zone falls in the mixing zone, suggesting a mixed thermal and biogenic origin. Abbreviations are as follows: $\%R_o$, percent vitrinite reflectance.

Isotope Analyses

The isotopic composition of methane was measured in selected samples throughout the desorption experiment. Coal-bed-gas samples from the following coal beds and coal zones were analyzed: Pittsburgh, Brush Creek, Upper Kittanning, Middle Kittanning, Clarion, Upper Mercer, Lower Mercer, and Quakertown (table 4). The graph showing the isotopic composition of carbon in methane (reported as the deviation (expressed as $\delta^{13}C$) in units of parts per thousand (per mil) relative to the Vienna Peedee belemnite (VPDB) standard) plotted against the ratio of methane (C_1) to the sum of the higher molecular gases (C_{2+}) shows that methane from all of the coals beds or zones, with the exception of the Quakertown coal zone, is thermogenic in origin (figs. 16 and 17). Coal-bed gas from the Quakertown coal zone plots in the mixing or transitional zone, suggesting that it has been partially oxidized by microbial activity.

Adsorption Results

High-pressure carbon-dioxide-adsorption isotherms were analyzed on coals from the Upper Kittanning coal bed and the Middle Kittanning and Clarion coal zones to determine their maximum carbon-dioxide-sorption capacity as a function of pressure. Only three of the samples (canister 1, WV–02–B3–14; canister 3, WV–02–B3–16; and canister 4, WV–02–B3–17) from the Clarion coal zone were analyzed. (The coal in canister 2, WV–02–B3–15, from the Clarion coal zone was mislabeled in the field as a split of the Lower Kittanning coal bed. The correct correlation was made after opening the canister and comparing the coal to the electric log.)

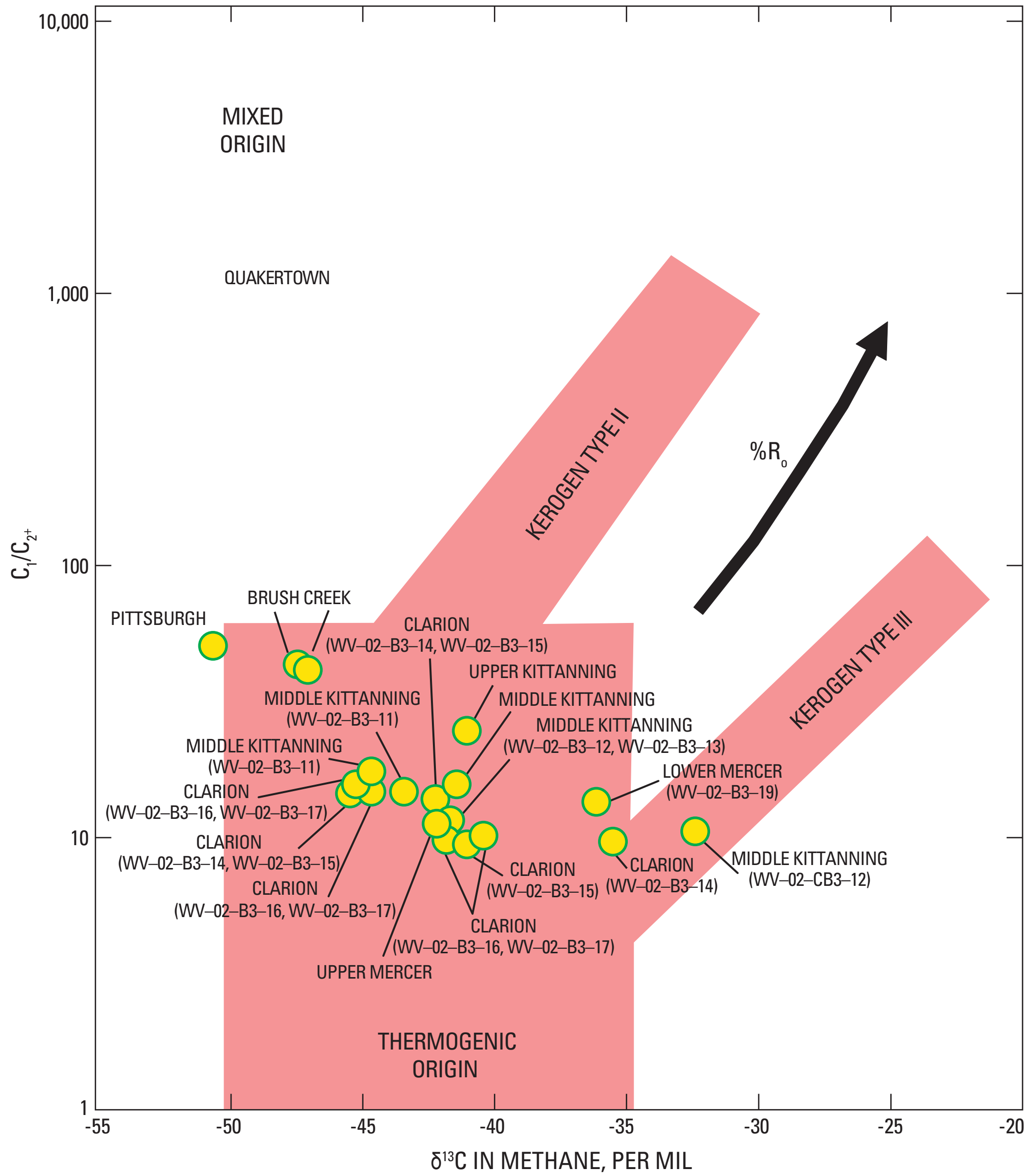

Figure 17. Enlargement of the thermogenic sector of the Bernard diagram (fig. 16) showing where composite coal-bed-gas samples from entire coal beds and coal zones (for example, Pittsburgh, Brush Creek, Upper Kittanning, Middle Kittanning, Upper Mercer, and Quakertown coal beds and zones), individual canisters (for example, Clarion coal zone sample WV–02–CB3–14), or composite samples from one or two canisters from a single coal bed or coal zone (for example, Clarion coal zone samples WV–02–CB3–16 and WV–02–CB3–17; Middle Kittanning coal zone samples WV–02–CB3–12 and WV–02–CB3–13) plot on the diagram. As on figure 16, this diagram plots the isotopic composition of carbon (carbon 13, ^{13}C) in methane (reported as the deviation in units ($\delta^{13}C$) of parts per thousand (per mil) relative to the Vienna Peedee belemnite (VPDB) standard) against the ratio of methane (C_1) to the sum of the higher molecular gases (C_{2+}, which includes ethane, propane, *iso*-butane, *n*-butane, *iso*-pentane, 2-methylbutane, *n*-pentane, and hexane). Abbreviations are as follows: %R_o, percent vitrinite reflectance.

The Upper Kittanning coal bed and Middle Kittanning and Clarion coal zones were chosen for high-pressure carbon-dioxide-adsorption isotherm analyses because the samples were relatively thick (1.7–3.95 ft), were retrieved from a deep part of the borehole (1,112.70–1,270.50 ft), and contained abundant gas (85.69–130.98 SCF/ton (dafb) or 2.68–4.09 cc/g). Methane adsorption analyses were not performed on the three coals because of cost considerations. However, Ronald W. Stanton (U.S. Geological Survey, unpub. data, 2001) and Gluskoter and others (2002) have shown that there is a direct relationship between the rank of the coal and its carbon-dioxide and methane adsorption (fig. 18). The diagram shown in figure 18 indicates that the high-volatile A bituminous coals from the Mylan Park study area can adsorb about twice as much carbon dioxide as methane. This relationship allowed us to estimate the maximum amount of methane that could be adsorbed onto the coals and the degree of methane saturation at reservoir pressures.

Reservoir pressure was not measured in the Mylan Park borehole, so normal hydrostatic pressure was calculated by multiplying a constant for hydrostatic pressure per foot (0.433) by the depth to the coal. It is important to note we may have overestimated total reservoir pressure by using hydrostatic pressure because much of the northern Appalachian basin is known to be underpressured (Roen and Walker, 1996).

Upper Kittanning Coal Bed

The coals of the Upper Kittanning coal bed in the Mylan Park study area were calculated to have a hydrostatic pressure of 486 pounds per square inch of area (PSIA) based on a mean depth of 1,122.50 ft for the coal bed. This corresponds to a maximum carbon-dioxide adsorption of about 500 SCF/ton on an as-received basis (arb) (15.63 cc/g, arb) (fig. 19). On an as-received basis, the calculated Langmuir volume is 831.8 SCF/ton (24.45 cc/g), the Langmuir pressure is 327.1 PSIA, the moisture content is 1.84 percent, and the ash yield is 8.58 weight percent. Figure 19 also shows data on the following bases: (1) dry, ash-free; (2) as-received; and (3) ash-free, moisture included. The estimated maximum methane adsorption is approximately one half of the maximum carbon-dioxide adsorption (fig. 19), which corresponds to approximately 250 SCF/ton (7.81 cc/g) (arb), indicating that the Upper Kittanning

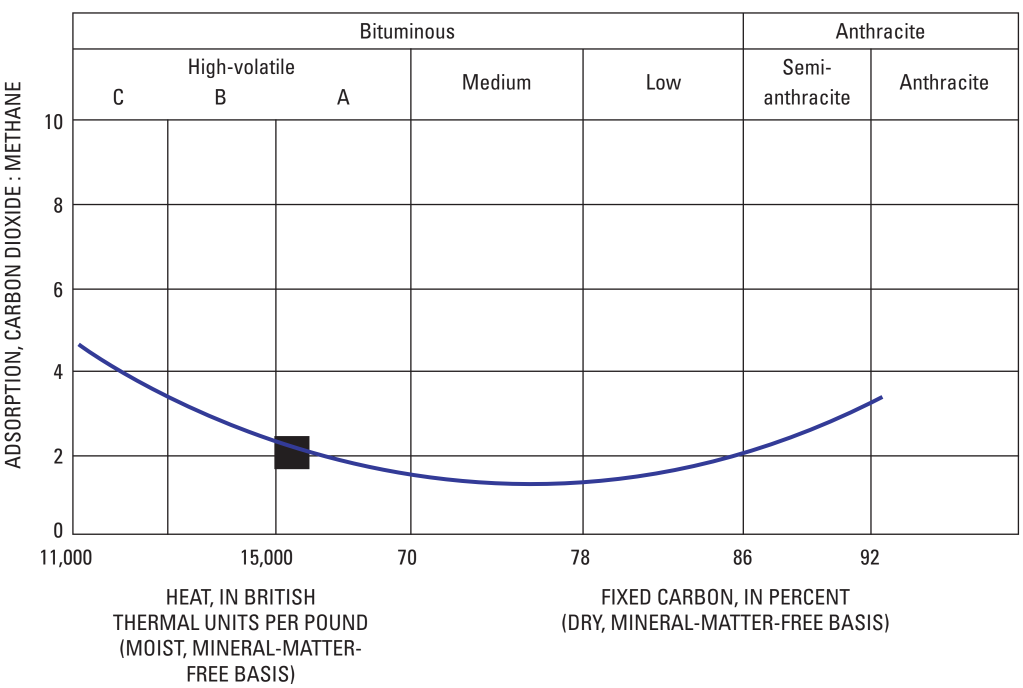

Figure 18. Graph showing the relation between carbon dioxide and methane variation with coal rank (modified from Gluskoter and others, 2002). On the basis of high-volatile A bituminous rank of the coals from Mylan Park (black square), the plot shows that the estimated ratio of carbon dioxide to methane is 2 to 1.

coal bed is undersaturated in methane (measured raw-total-gas was 130.98 SCF/ton or 4.09 cc/g, arb).

Middle Kittanning Coal Zone

The Middle Kittanning coal zone is not as attractive as a repository of carbon dioxide as the Upper Kittanning coal bed. The coals of the Middle Kittanning coal zone were calculated to have a hydrostatic pressure of 514 PSIA based on a mean depth of 1,184.10 ft. This corresponds to a maximum carbon-dioxide adsorption of about 400 SCF/ton or 12.5 cc/g (arb) (fig. 20). On an as-received basis, the calculated Langmuir volume is 580.0 SCF/ton (17.05 cc/g), the Langmuir pressure is 253.6 PSIA, the moisture content is 1.96 percent, and the ash yield is 19.91 weight percent. Figure 20 also shows data on the following bases: (1) dry, ash-free; (2) as-received; and (3) ash-free, moisture included. The estimated maximum methane adsorption is approximately one half of the maximum carbon-dioxide adsorption (fig. 20), which corresponds to approximately 200 SCF/ton or 6.25 cc/g (arb), indicating that the Middle Kittanning coal zone coals in the Mylan Park study area also are undersaturated in methane (measured raw-total-gas was 113.54 SCF/ton or 3.59 cc/g, arb).

Clarion Coal Zone

The coals of the Clarion coal zone were calculated to have a hydrostatic pressure of 552 PSIA based on a mean depth of 1,271.50 ft. This depth corresponds to a maximum carbon-dioxide adsorption of about 300 SCF/ton or 9.38 cc/g (arb) (fig. 21). On an as-received basis, the calculated Langmuir volume is 449.4 SCF/ton (17.05 cc/g), the Langmuir pressure is 265.9 PSIA, the moisture content is 1.57 percent, and the ash yield is 26.57 weight percent. Figure 21 also shows data on the following bases: (1) dry, ash-free; (2) as-received; and (3) ash-free, moisture included. The estimated maximum methane adsorption is approximately one half of the maximum carbon-dioxide adsorption (fig. 21), which corresponds to approximately 150 SCF/ton or 6.25 cc/g (arb), indicating that these Clarion coal zone coals are undersaturated in methane (measured raw-total-gas was 86.69 SCF/ton or 3.89 cc/g, arb).

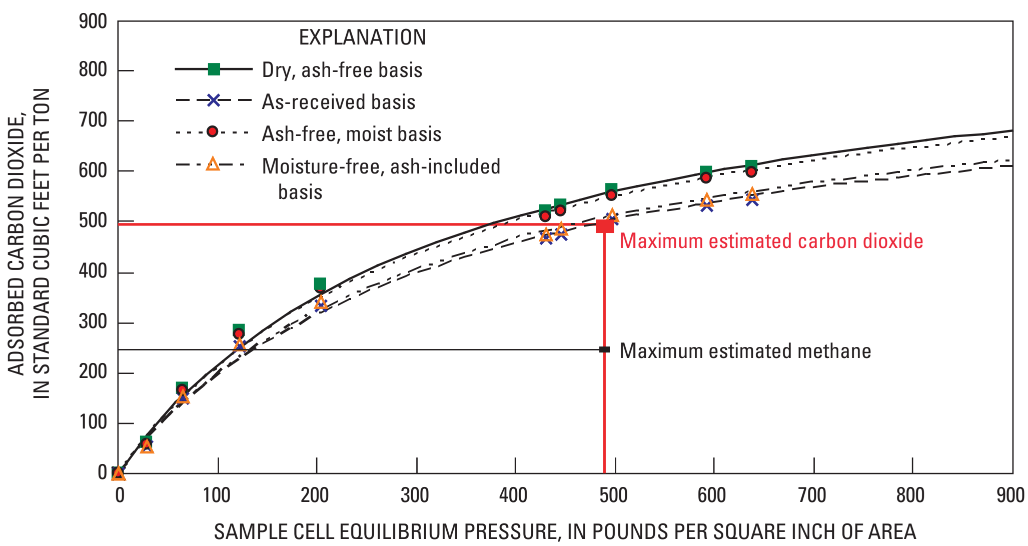

Figure 19. Graph showing the maximum carbon-dioxide (red line) and methane (solid black line) adsorption curves for coal samples from the Upper Kittanning coal bed (from 1,121.70 to 1,123.40 feet) in the Mylan Park borehole, on an as-received basis (arb). The calculated hydrostatic pressure of 486 pounds per square inch of area (PSIA) intersects the as-received carbon-dioxide isotherm at about 500 standard cubic feet per ton (SCF/ton) or 15.63 cubic centimeters per gram (cc/g), which is a measure of the maximum amount of carbon dioxide that can be adsorbed to coal from the Upper Kittanning coal bed. The maximum methane adsorption is approximately half of that, or about 250 SCF/ton (7.81 cc/g) (arb).

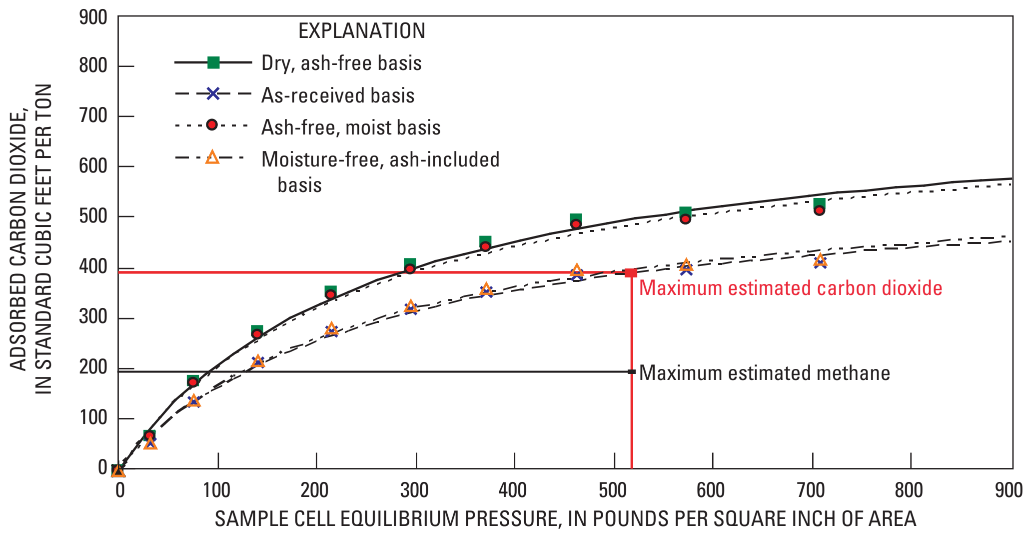

Figure 20. Graph showing the maximum carbon-dioxide (red line) and methane (solid black line) adsorption curves for coal samples from the Middle Kittanning coal zone (from 1,184.10 to 1,190.45 feet) in the Mylan Park borehole, on an as-received basis (arb). The calculated hydrostatic pressure of 514 pounds per square inch of area (PSIA) intersects the as-received carbon-dioxide isotherm at about 400 standard cubic feet per ton (SCF/ton) or 12.5 cubic centimeters per gram (cc/g), which is a measure of the maximum amount of carbon dioxide that can be adsorbed to coal from the Middle Kittanning coal zone. The maximum methane adsorption is approximately half of that, or about 200 SCF/ton (6.15 cc/g) (arb).

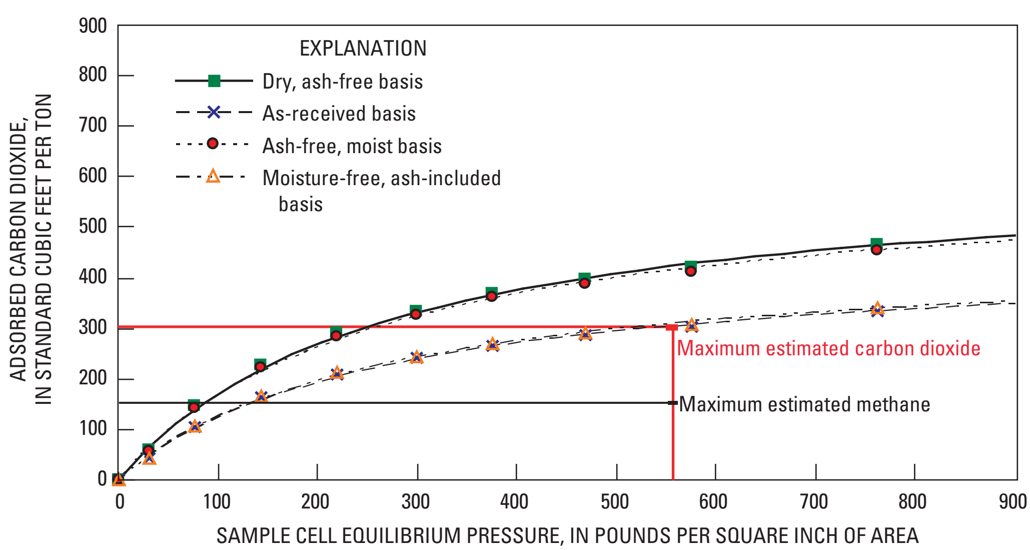

Figure 21. Graph showing the maximum carbon-dioxide (red line) and methane (solid black line) adsorption curves for coal samples from the Clarion coal zone (from 1,270.50 to 1,271.50 feet) in the Mylan Park borehole, on an as-received basis (arb). The calculated hydrostatic pressure of 552 pounds per square inch of area (PSIA) intersects the as-received carbon-dioxide isotherm at about 300 standard cubic feet per ton (SCF/ton) or 9.38 cubic centimeters per gram (cc/g), which is a measure of the maximum amount of carbon dioxide that can be adsorbed to coal from the Clarion coal zone. The maximum methane adsorption is approximately half of that, or about 150 SCF/ton (4.69 cc/g) (arb).

Conclusions

1. The measured raw-total-gas contents for coals in the Mylan Park, W. Va., study area, range from 0.07 SCF/ton (0.00 cc/g) for the mined Sewickley coal bed to 130.98 SCF/ton (4.09 cc/g) for the Upper Kittanning coal bed.
2. The total coal-bed-gas values are minimum values because residual gas, which can be significant, was not measured. In a companion study (Ruppert and others, this volume, chap. G.4), the measurement of residual gas resulted in increased total gas resources of up to 40 percent.
3. The coal-bed-gas contents of the coal beds in the Mylan Park study area did not increase systematically with depth. All gas contents increased to the depth of the Upper Kittanning coal bed (1,121.70–1,123.40 ft) and then decreased to 113.54 SCF/ton (3.59 cc/g) for the Middle Kittanning coal zone, 85.69 SCF/ton (2.68 cc/g) for the Clarion coal zone, 95.02 SCF/ton (2.97 cc/g) for the Upper Mercer coal bed, 35.27 SCF/ton (1.10 cc/g) for the Lower Mercer coal bed, and 67.84 SCF/ton (2.12 cc/g) for the Quakertown coal zone.
4. The gas contents had to be normalized to an air-free basis, despite efforts to prevent air contamination during gas sampling. The mean methane content of all of the coals in the Mylan Park study area was 79.45 percent (air-free basis).
5. High-pressure carbon-dioxide-adsorption isotherms show that coals of the Upper Kittanning coal bed have a greater potential for carbon-dioxide sequestration than those from the Middle Kittanning and Clarion coal zones. The maximum amount of carbon dioxide that can be adsorbed to coals of the Upper Kittanning coal bed is about 500 SCF/ton or 15.36 cc/g (arb) at the calculated hydrostatic pressure of 486 PSIA, which is higher than 400 SCF/ton or 9.38 cc/g (arb) for the Middle Kittanning coal zone coals and 300 SCF/ton or 9.38 cc/g (arb) for the Clarion coal zone coals.
6. The coals from individual coal beds and coal zones at the Mylan Park study area desorbed slowly, which may imply slow methane-resource production rates.

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Appendix A. Desorption Data for Coal Samples Retrieved From a Borehole at Mylan Park, Monongalia County, W. Va.

The original data for each canister in this study may be accessed by clicking on the link below. The tables follow the terminology, abbreviations, and format of the data spreadsheets found in Barker and others (2002), which also contains a detailed discussion of their use; therefore, the terminology may not be identical to that found in the text of this report. Coal samples from individual canisters from the Sewickley coal bed, Redstone coal bed, Pittsburgh coal roof interval, and Pittsburgh coal bed were not analyzed for ash content because the measured gas contents were very low; thus, dry, ash-free total gas content was not determined. See table headnotes for an explanation of abbreviations.

CLICK HERE TO ACCESS APPENDIX A DATA