COALBED AND COAL MINE METHANE IN THE ILLINOIS BASIN: OCCURRENCE, COMPOSITION, ORIGIN, AND CURRENT ACTIVITIES

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Keywords: coalbed methane, coal mine gas, Illinois basin

BACKGROUND

Coalbed methane generally refers to methane and other gaseous hydrocarbons associated with coal, methane being the dominant one. Other gases, in particular carbon dioxide and nitrogen, are commonly associated with the hydrocarbons in variable proportions. The gases, which are by-products of the maturation process of coal, as it became buried and exposed to elevated temperatures during geologic time[1], are stored primarily in the form of a mono-molecular layer adsorbed to the very large internal surface area of the coal. During the early stages of coal maturation, in the sub-bituminous and high volatile bituminous coal stages, water and carbon dioxide are the main by-products, with methane gradually becoming more important. In medium volatile bituminous and higher rank coals, methane becomes the dominant by-product of coal maturation.

During mining, coalbed methane is released as coal is broken up into small particles, dramatically shortening pathways to the surface, and as ambient gas pressure is reduced to about 1 atm. Also, each cut during mining exposes new coal at the face and enhances degassing. Since mixtures of 5-15% methane in air are explosive, mining regulations have long required the dilution of methane with sufficient fresh ventilation air (generally to <1% methane content) to prevent the formation of explosive mixtures. The venting of large quantities of methane into the atmosphere during and after mining has recently become a major concern because methane is a potent greenhouse gas (each gram of methane is equivalent to the impact of 21 grams of carbon dioxide, over a 100 year period[2]). US EPA estimates that each year active coal mines in the U.S. vent about $5 \cdot 10^9$ m^3 methane into the air[2].

Efforts by the coal mining industry to recover at least a portion of this coalbed methane have resulted in the sale of about $1 \cdot 10^9$ m^3 methane by 1995[2], in states with gas-rich coals such as Alabama, Colorado, Pennsylvania, Virginia, and West Virginia. No significant recovery of coalbed methane during mining has taken place yet in the Illinois basin, primarily because of the relatively low methane concentrations in the basin's coal beds.

METHANE IN ILLINOIS BASIN COALS

Even though the methane content of coals in the Illinois basin is small in comparison to such gas-rich coal fields as the Black Warrior in Alabama, or the San Juan in New Mexico and Colorado, the total methane resources in the basin are huge (>$600 \cdot 10^9$ m^3)[3], because of the huge coal resources. Several factors cause a rather uneven distribution of coalbed methane concentration within the basin. Coal rank increases systematically from lowest rank high volatile C bituminous in the northwest part of the basin to highest rank high volatile A bituminous in the southeast[4]. Everything else being equal, coalbed methane contents in lower rank coals are much smaller than in higher rank ones. Another important factor is depth. The coalbed methane content of coal tends to increase with depth, due primarily to increasing gas pressure which increases the amount of gas adsorbed to coal. The simultaneous increase in temperatures with depth tends to work somewhat against this trend. Because regional dips of coal beds in the basin are commonly only around two meters per kilometer, large portions of the major coal seams lie at shallow depths (about half at depths <160 meters), and even in the deepest part of the basin only small parts of the major coals occur at depths in excess of 400 meters. In other coal basins, the greatest methane contents generally are associated with coals that lie at depths >700 meters[5].

Table 1 lists all published methane content results as determined by desorption tests of coal samples taken from drill holes. The average methane content of 1.9 ± 0.8 (std.dev.) cm^3/g probably understates the methane content of in-situ Illinois basin coals. Likely reasons for the underestimate (see also footnote of Table 1) are: (1) the amount of gas lost before the coal sample could be sealed in a gas-tight container to make observations on gas desorption was underestimated; (2) the gas contents were not standardized to clean coal because the petrologic composition of the coal was not determined; (3) the gas contents were not standardized to in-situ p-T conditions; (4) the sample set is biased towards coals that tend to have smaller than average methane content because of either low rank or shallow depth, or both. In the past few years several operators have been testing coals in the southern portion of the basin for coalbed methane. They claim to have found significantly greater methane contents than have been reported in the literature; however, so far their specific data have been kept confidential. Because of their relatively low rank and shallow depth, the in-situ methane content of Illinois basin coals probably is generally well below 5-6 cm^3/g; more data are needed to properly account for the factors listed above.

Relatively little information is available on the chemical and isotopic composition of gas associated with in-situ coal in the Illinois basin. Tables 2 and 3 summarize available published and some unpublished data. The chemical data were not all reported on the same basis; for instance some probably include air trapped in the desorption canister when the coal sample was sealed in the container, as suggested by the presence of O_2 and N_2. Generally, methane represents the bulk of hydrocarbons. The amount of other gases varies significantly depending perhaps primarily on local geologic conditions and the sampling method. The few carbon isotopic analyses of methane associated with Illinois coals that have been published show δC^{13} values between -52 and -63‰, surprisingly light, certainly for thermogenic methane (Table 3). The possibility of fractionation due to migration from other sources, and also an at least partial biogenic origin must be contemplated.

COAL MINE METHANE IN ILLINOIS

It has long been known that the large voids left behind after room-and-pillar mining are an ideal place for methane to accumulate. In Illinois methane has been extracted from abandoned coal mines for many years, primarily in the southern portion of the basin, both by coal companies and by operators specializing in this technology. In recent years interest in recovering this gas has increased greatly. The amount of gas that can be extracted from abandoned mine workings is limited, though; its pressure is only about 1 atm, and the quality of the gas is variable, primarily because mine workings tend to be connected to the surface through drill holes and shafts that are not tightly sealed. When a shaft is sealed at the time of mine abandonment regulations require that vents be installed in the seal to prevent potentially dangerous buildup of gas pressure and to permit the mine to "breathe", as high and low pressure weather systems move through the area. When a high pressure system passes through, air is pushed into the mine through such vents, and any other openings, causing dilution by air of the mine gas (mostly methane). When a low pressure system follows, gas is then emitted through the vents. Coal mine methane has been used in the Illinois basin for such local applications as heating water for wash houses at mines, heating buildings and green houses, and running motors that drive electric generators, or other equipment. The chemical composition of gas samples taken from mine vents (Table 4) indicates variable admixtures of air to the usually large methane content of gas released by coal.

Active underground mines release considerable amounts of methane into the air[2]. Most is diluted in the ventilation air that is circulated through the mine to provide fresh air to the workers and to dilute any methane liberated from mined coal, from the coal left in pillars and around the perimeter of the mine, and from other coals and oil and gas pools below the mine. Values between 3,000 and 252,000 m^3 CH_4/day have been reported for mines in the Illinois basin (Table 5); the average is $50,000 \pm 56,000$ m^3 (std. dev.) CH_4/day. The specific emission values range between <1 and 35 m^3 CH_4 per metric ton of produced coal, and the average is 8 ± 7 m^3/ton Since these values are significantly above the methane content of in-situ coal, considerable amounts of methane apparently come from sources other than from the mined coal, anywhere from a few to over ninety percent, depending on the local geologic conditions.

ACKNOWLEDGEMENTS

Most the gas samples from abandoned coal mines were collected by Wayne Meents of the ISGS Oil and Gas Section between 1954 and 1982 and analyzed by chemists in the ISGS Analytical Chemistry Laboratory. Dennis Coleman was in charge of the ISGS Isotope Geochemistry Laboratory when most of the carbon isotope analyses on coalbed and coal mine methane samples were performed.

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Table 1. Coalbed methane content of coals in the Illinois Basin, as determined by desorption tests[6,7]

State	County	Drill hole	Analyzed or reported by	Coal seam	Depth (m)	Coal thickness (m)	Lost gas (cm^3/g)	Desorbed gas (cm^3/g)	Residual gas (cm^3/g)	Total gas (cm^3/g)
IL	Clay	n. a.	TRW	Briar Hill	328	n. a.	n. a.	n. a.	n. a.	1.00
IL	Clay	n. a.	TRW	Danville	303	n. a.	n. a.	n. a.	n. a.	1.00
IL	Clay	n. a.	TRW	Herrin	316	n. a.	n. a.	n. a.	n. a.	1.00
IL	Clay	n. a.	TRW	Seelyville	412	n. a.	n. a.	n. a.	n. a.	1.00
IL	Clay	n. a.	TRW	Springfield	332	n. a.	n. a.	n. a.	n. a.	1.00
IL	Coles	Charleston	IL Geol. Surv.	Danville	294	0.8	0.03	1.98	0.70	2.71
IL	Coles	Charleston	IL Geol. Surv.	Herrin	325	0.8	0.05	0.94	0.52	1.47
IL	Coles	Charleston	IL Geol. Surv.	Shelbyville	154	0.6	0.02	0.12	0.09	0.25
IL	Coles	Charleston	IL Geol. Surv.	Springfield	333	0.4	0.00	0.33	1.10	1.43
IL	Coles	Charleston	IL Geol. Surv.	Springfield	333	1.0	0.05	1.36	0.83	2.22
IL	Franklin	n. a.	USSteel	Herrin	183	n. a.	n. a.	n. a.	n. a.	1.95
IL	Franklin	n. a.	USSteel	Springfield	204	n. a.	n. a.	n. a.	n. a.	1.67
IL	Jefferson	n. a.	USBM	Herrin	223	n. a.	n. a.	n. a.	n. a.	1.90
IL	Jefferson	n. a.	USBM	Springfield	242	n. a.	n. a.	n. a.	n. a.	1.00
IL	Peoria	n. a.	Northern IL Gas	Colchester	40	n. a.	n. a.	n. a.	n. a.	1.02
IL	Wayne	n. a.	USBM	Herrin	275	n. a.	n. a.	n. a.	n. a.	1.90
IL	Wayne	n. a.	USBM	Herrin	296	n. a.	n. a.	n. a.	n. a.	3.40
IL	Wayne	n. a.	USBM	Springfield	308	n. a.	n. a.	n. a.	n. a.	3.10
IL	Wayne	n. a.	USBM	Springfield	326	n. a.	n. a.	n. a.	n. a.	2.70
IN	Gibson	BP 64	IN Geol. Surv.	Springfield	182	1.9	0.09	2.28	0.16	2.53
IN	Gibson	BP 59	IN Geol. Surv.	Springfield	191	1.9	0.05	2.00	0.31	2.38
IN	Knox	SDH 267	IN Geol. Surv.	Bucktown	159	0.6	0.13	1.72	n.a.	1.84[1]
IN	Knox	SDH 266	IN Geol. Surv.	Coal in Staunton Fm.	230	1.1	0.00	0.22	n.a.	0.22[1]
IN	Knox	SDH 259	IN Geol. Surv.	Danville	103	1.1	0.09	1.59	n.a.	1.69[1]
IN	Knox	SDH 267	IN Geol. Surv.	Danville	126	1.1	0.13	2.06	n.a.	2.19[1]
IN	Knox	SDH 285	IN Geol. Surv.	Danville	156	1.1	0.06	1.88	n.a.	1.94[1]
IN	Knox	SDH 259	IN Geol. Surv.	Hymera	110	0.5	0.16	2.88	n.a.	3.03[1]
IN	Knox	SDH 267	IN Geol. Surv.	Hymera	134	1.6	0.16	2.00	n.a.	2.16[1]
IN	Knox	SDH 266	IN Geol. Surv.	Seelyville	200	1.1	0.03	0.38	n.a.	0.41[1]
IN	Knox	SDH 267	IN Geol. Surv.	Seelyville	233	0.9	0.06	1.16	n.a.	1.22[1]
IN	Knox	SDH 267	IN Geol. Surv.	Springfield	163	1.1	0.16	2.34	n.a.	2.50[1]
IN	Knox	SDH 267	IN Geol. Surv.	Survant	211	0.8	0.25	2.56	n.a.	2.81[1]
IN	Posey	SDH 300	IN Geol. Surv.	Coal in Dugger Fm.	73	0.8	0.00	1.78	0.31	2.09
IN	Posey	SDH 300	IN Geol. Surv.	Danville	44	0.9	0.00	0.72	0.19	0.91
IN	Posey	SDH 301	IN Geol. Surv.	Danville	142	0.7	0.03	1.00	0.09	1.13
IN	Posey	SDH 343	IN Geol. Surv.	Danville	143	0.9	0.00	1.38	0.13	1.50
IN	Posey	SDH 302	IN Geol. Surv.	Danville	154	0.9	0.06	1.91	0.19	2.16[1]
IN	Posey	SDH 343	IN Geol. Surv.	Herrin	155	0.9	0.06	1.16	0.00	1.19
IN	Posey	SDH 301	IN Geol. Surv.	Herrin	158	1.1	0.00	0.03	0.50	0.53[1]
IN	Posey	SDH 302	IN Geol. Surv.	Herrin	171	1.5	0.06	2.41	0.19	2.66
IN	Posey	SDH 285	IN Geol. Surv.	Herrin	176	1.4	0.13	1.63	0.00	1.75[1]
IN	Posey	SDH 301	IN Geol. Surv.	Houchin Creek	222	0.5	0.03	1.38	0.41	1.81
IN	Posey	SDH 302	IN Geol. Surv.	Houchin Creek	235	0.7	0.03	1.75	0.50	2.28
IN	Posey	SDH 300	IN Geol. Surv.	Hymera	54	1.0	0.00	1.09	0.19	1.28
IN	Posey	SDH 300	IN Geol. Surv.	Seelyville	131	1.0	0.00	2.19	0.31	2.50
IN	Posey	SDH 301	IN Geol. Surv.	Seelyville	268	0.5	0.00	0.31	0.50	0.81[1]
IN	Posey	SDH 301	IN Geol. Surv.	Seelyville	272	1.5	0.13	2.13	0.41	2.66
IN	Posey	SDH 302	IN Geol. Surv.	Seelyville	284	3.5	0.09	2.69	0.50	3.28
IN	Posey	SDH 302	IN Geol. Surv.	Seelyville	285	3.5	0.16	3.38	0.91	4.44
IN	Posey	SDH 285	IN Geol. Surv.	Seelyville	287	1.8	0.13	1.22	n.a.	1.34[1]
IN	Posey	SDH 300	IN Geol. Surv.	Springfield	80	1.5	0.00	2.09	0.31	2.41
IN	Posey	SDH 301	IN Geol. Surv.	Springfield	188	1.1	0.06	0.31	0.41	0.78[1]
IN	Posey	SDH 285	IN Geol. Surv.	Springfield	202	1.2	0.16	2.53	n.a.	2.69[1]
IN	Posey	SDH 302	IN Geol. Surv.	Springfield	203	1.2	0.00	1.06	0.31	1.38[1]
IN	Posey	SDH 303	IN Geol. Surv.	Springfield	203	1.3	0.13	2.09	0.41	2.63
IN	Posey	SDH 303	IN Geol. Surv.	Springfield	204	1.3	0.16	2.00	0.19	2.38
IN	Posey	SDH 343	IN Geol. Surv.	Survant	184	1.1	0.06	1.75	0.50	2.31
IN	Posey	SDH 301	IN Geol. Surv.	Survant	240	0.4	0.06	1.44	0.50	2.00[1]
IN	Posey	SDH 302	IN Geol. Surv.	Survant	252	0.8	0.09	2.72	0.41	3.22[1]
IN	Sullivan	SDH 344	IN Geol. Surv.	Houchin Creek	177	0.7	0.06	1.44	0.13	1.63
IN	Sullivan	SDH 344	IN Geol. Surv.	Seelyville	227	1.2	0.03	2.31	0.25	2.59
IN	Sullivan	SDH 344	IN Geol. Surv.	Seelyville	230	1.1	0.03	2.06	0.34	2.44
IN	Sullivan	SDH 266	IN Geol. Surv.	Springfield	128	1.1	0.06	2.69	n.a.	2.75[1]
IN	Sullivan	SDH 344	IN Geol. Surv.	Survant	189	0.5	0.13	1.03	0.44	1.59

[1] Value may be low because of leakage from canister, and/or because measurement of lost gas or residual gas were not made.

n. a. = not available or not analyzed.

Table 2. Chemical composition of gas associated with in-situ coal in the Illinois Basin (Popp et al.[7] and ISGS database). Illinois samples are from Charleston drill hole and Indiana samples are from SDH302 drill hole.

State	County	Coal seam	Depth (m)	Thick-ness (m)	Typeof gas	$\%CO_2$	$\%O_2$	$\%N_2$	$\%CH_4$	$\%C_2H_6$	$\%C_3H_8$	$\%C_4H_{10}$	Btu/ft^3 (gross)
IL	Coles	Shelbyville	154	0.58	Released gas	17.0	-	25.0	54.0	3.0	1.0	0.0	930
IL	Coles	Danville	294	0.79	Released gas	1.9	-	15.1	80.2	2.2	0.5	0.1	867
IL	Coles	Danville	294	0.79	Residual gas	3.1	-	13.9	73.5	6.6	2.5	0.4	940
IL	Coles	Danville	294	0.79	Total gas	2.2	-	14.8	78.5	3.3	1.0	0.2	886
IL	Coles	Herrin	325	0.76	Released gas	3.7	-	0.0	88.9	4.6	2.4	0.4	1061
IL	Coles	Herrin	325	0.76	Residual gas	5.5	-	16.6	48.8	15.9	11.1	2.1	1440
IL	Coles	Herrin	325	0.76	Total gas	4.5	-	7.7	70.4	9.8	6.4	1.2	1240
IL	Coles	U.Springfield	333	0.37	Released gas	6.1	-	35.7	53.9	2.6	1.3	0.4	640
IL	Coles	U.Springfield	333	0.37	Residual gas	3.2	-	15.3	66.3	8.9	5.4	0.9	1001
IL	Coles	U.Springfield	333	0.37	Total gas	3.9	-	20.0	63.4	7.4	4.5	0.8	918
IL	Coles	L.Springfield	333	0.98	Released gas	1.4	-	21.1	70.4	4.5	2.2	0.4	862
IL	Coles	L.Springfield	333	0.98	Residual gas	2.5	-	16.2	63.2	10.7	6.1	1.3	1032
IL	Coles	L.Springfield	333	0.98	Total gas	1.8	-	19.3	67.8	6.8	3.6	0.7	926
IN	Posey	Seelyville	284	3.51	Released gas	1.3	3.7	37.0	58.0	0.02	2ppm	0.0	527
IN	Posey	Seelyville	284	3.51	Released gas	1.1	1.7	33.0	65.0	0.02	2ppm	0.0	588

Table 3. *Carbon isotopic composition of coalbed methane in some Illinois coals* (Popp et al[7] and ISGS database) and of coal mine methane from abandoned coal mines in Illinois (ISGS data base)

Lab No.	County	Drill hole or Coal Co.	Mine name and Mine Index #	Coal seam	Depth (m)	Coal thick-ness (m)	Type of gas	Number of samples analyzed	δC^{13} CH_4 (‰)
-	Coles	Charleston drill hole	-	Danville	294	0.8	released	9	-62.9 to -61.4
-	Coles	Charleston drill hole	-	Danville	294	0.8	residual	1	-59.8
-	Coles	Charleston drill hole	-	Herrin	325	0.8	released	4	-57.4 to -55.1
-	Coles	Charleston drill hole	-	Herrin	325	0.8	residual	1	-52.1
-	Coles	Charleston drill hole	-	U.Springfield	333	0.4	released	3	-57.1 to -56.5
-	Coles	Charleston drill hole	-	U.Springfield	333	0.4	residual	1	-55.4
-	Coles	Charleston drill hole	-	L.Springfield	333	1.0	released	7	-57.3 to -55.6
-	Coles	Charleston drill hole	-	L.Springfield	333	1.0	residual	1	-54.5
3549	Christian	Joe Simkins #1 Kincaid	Peabody # 7 Mine MI# 2040	Herrin	106		mine gas	1	-67.7
3540	Clinton	Pessina #1 Kampwerth	Breese-Trenton Buxton Mine 3, MI# 85	Herrin	132	2.4	mine gas	1	-65.1
3801	Gallatin	Peabody CC	Eagle Mine #2, MI# 898	Springfield	76	1.7	seapage at fault	1	-61.6
3888	Montgomery	Gerald Stieren	Crown Mine #1, MI# 707	Herrin	108	2.1	mine gas	1	-69.1
3933	Montgomery	Gerald Stieren	Crown Mine #1, MI# 707	Herrin	108	2.1	mine gas	1	-69.4
3583	Montgomery	Freeman United MC	Crown Mine #1, MI# 707	Herrin	108	2.1	mine gas	1	-69.6
3578	Saline	Albert Farris	Dering Mine #2, MI# 125	Springfield	139	1.8	mine gas	1	-62.7
3831	Saline	Albert Farris	Dering Mine #2, MI# 125	Springfield	139	1.8	mine gas	1	-60.0
3835	Saline	Albert Farris	Dering Mine #2, MI# 125	Springfield	139	1.8	mine gas	1	-62.2
3594	Saline	Wasson Mine shaft	Wasson Mine #1, MI# 45	Springfield	99	1.6	mine gas	1	-62.3
3923	Saline	M. L. Devillez #3	Wasson Mine #1, MI# 45	Springfield	110	1.6	mine gas	1	-62.2
3216	Saline	Cahaba #1 Willis	Peabody Eldorado Mine #20, MI# 46	Springfield	127	1.8	mine gas	1	-60.7
3791	Saline	Cahaba #1 Willis	Peabody Eldorado Mine #20, MI# 46	Springfield	127	1.8	mine gas	1	-61.6
3796	Saline	Cahaba #1 Willis	Peabody Eldorado Mine #20, MI# 46	Springfield	127	1.8	mine gas	1	-61.8
3797	Saline	Cahaba #1 Willis	Peabody Eldorado Mine #20, MI# 46	Springfield	127	1.8	mine gas	1	-61.8
3832	Saline	Cahaba #1 Willis	Peabody Eldorado Mine #20, MI# 46	Springfield	127	1.8	mine gas	1	-61.5
3311	Saline	Phillip Barrett, Schlafly #1 Morris	Dering Mine #2, MI# 125	Springfield	139	1.8	mine gas	1	-63.6
3215	Saline	Jade Oil & Gas	Dering Mine #2, MI# 125	Springfield	139	1.8	mine gas	1	62.2
3830	Saline	Dan January	O'Gara 10 Mine, MI# 799	Springfield	121	1.7	mine gas	1	-61.9
3614	Saline	Wilson, Sutton #1P	O'Gara 8 Mine, MI# 800	Springfield	123	1.7	mine gas	1	-60.9
3750	Saline	Wilson, Sutton #1P	O'Gara 8 Mine, MI# 800	Springfield	123	1.4	mine gas	1	-61.5
3834	Saline	Wilson, Sutton #1P	O'Gara 8 Mine, MI# 800	Springfield	123	1.4	mine gas	1	-60.5

Table 4. Chemical composition of gas collected from abandoned coal mines (Meents[8] and ISGS database)

Lab No.	State	County	Mine/drill hole	$\%CO_2$	$\%O_2$	$\%N_2$	$\%CH_4$	$\%C_2H_6$	C_3H_8	Btu/ft^3
3539	IL	Christian	Joe Simkins #1	16.3	1.1	63.1	19.0	0.45	0.09	202
3549	IL	Christian	Joe Simkins #1	22.0	1.0	58.7	11.8	0.40	0.10	189
2213	IL	Clinton	Breese-Trenton	11.8	0.4	27.1	60.3	0.20	0.10	620
3540	IL	Clinton	Pessina #1	10.2	0.3	20.7	68.8	0.00	0.00	696
2372	IL	Franklin	Zeigler	5.9	0.6	28.8	64.7	tr	0.00	655
3742	IL	Franklin	Peabody #18	0.1	14.7	60.0	25.2	0.02	0.00	255
3694	IL	Gallatin	B & W Coal	0.1	20.7	79.2	0.0	0.00	0.00	0
3887	IL	Montgomery	Gerald Stieren	4.4	0.5	30.8	64.0	0.22	0.02	652
3888	IL	Montgomery	Gerald Stieren	5.0	0.4	30.0	64.3	0.22	0.01	655
3933	IL	Montgomery	Gerald Stieren	3.4	1.2	32.3	62.9	0.16	0.00	639
3583	IL	Montgomery	Freeman United	5.9	0.8	47.5	45.4	0.39	0.02	467
3689	IL	Perry	Frank Hepp	19.0	0.8	56.8	23.4	0.00	0.00	236
3817	IL	Randolph	Moffat Coal #2	3.3	11.6	85.1	0.0	0.00	0.00	0
2371	IL	St. Clair	Peabody Coal test	0.3	tr	10.5	89.2	0.00	0.00	903
1409	IL	Saline	A. Farris. Dering Mine	6.7	1.0	14.4	77.9	0.00	0.00	788
1774	IL	Saline	A. Farris. Dering Mine	6.8	0.8	9.0	83.4	0.00	0.00	845
1918	IL	Saline	A. Farris. Dering Mine	6.6	0.2	4.9	88.3	0.00	0.00	894
1488	IL	Saline	Charter Oil #1A	0.0	0.6	12.8	75.9	9.50	0.00	960
2803	IL	Saline	A. Farris. Dering Mine	4.0	0.5	5.2	90.3	0.00	0.00	914
3577	IL	Saline	A. Farris. Dering Mine	5.0	0.3	3.7	91.1	0.00	0.00	921
3578	IL	Saline	A. Farris. Dering Mine	5.5	0.1	3.4	90.9	0.00	0.00	920
3831	IL	Saline	A. Farris. Dering Mine	5.6	0.2	2.5	91.7	0.02	0.00	928
3835	IL	Saline	A. Farris. Dering Mine	5.8	0.2	3.5	90.6	0.02	0.00	916
1408	IL	Saline	Wasson Mine shaft	7.2	0.3	48.9	43.6	0.00	0.00	441
1446	IL	Saline	Wasson Mine shaft	7.0	0.1	45.9	45.5	1.40	0.00	486
1910	IL	Saline	Wasson Mine shaft	6.2	0.6	40.7	51.0	1.50	0.00	543
3594	IL	Saline	Wasson Mine shaft	9.4	0.5	17.3	72.7	0.00	0.00	736
3923	IL	Saline	Devillez	3.3	4.1	50.8	41.8	0.01	0.00	423
3312	IL	Saline	Phillip Barret	2.7	tr	4.1	93.2	0.00	0.00	943
951	IL	Saline	W Duncan #1	5.7	0.3	7.3	85.7	0.00	0.00	870
1507	IL	Saline	Adams Unit Mine	6.2	0.2	2.2	90.2	0.00	0.00	917
1879	IL	Saline	Adams Unit Mine	5.1	0.6	4.6	89.7	0.00	0.00	908
2802	IL	Saline	Cahaba #1/Adams	6.6	1.9	9.2	82.3	0.00	0.00	833
3216	IL	Saline	Adams. Cahaba M.	5.9	0.1	2.7	91.3	0.00	0.00	924
3791	IL	Saline	Cahaba #1 Willis	6.3	0.7	4.3	88.7	0.00	0.00	897
3796	IL	Saline	Cahaba #1 Willis	6.2	0.2	2.9	90.6	0.07	0.00	917
3797	IL	Saline	Cahaba #1 Willis	6.3	0.2	2.8	90.7	0.06	0.00	918
3832	IL	Saline	Adams Mine	5.9	0.1	2.9	91.1	0.05	0.00	921
3833	IL	Saline	Adams Mine	6.3	0.1	2.8	90.8	0.02	0.00	919
3133	IL	Saline	Phillip Barret	3.3	0.4	4.1	92.2	0.00	0.00	933
3311	IL	Saline	Phillip Barret	5.9	tr	2.6	91.5	0.00	0.00	926
1559	IL	Saline	Jade Oil. Dering Mine	7.7	1.4	5.3	84.3	0.30	0.00	862
1944	IL	Saline	Jade Oil. Dering Mine	6.7	0.2	5.7	87.4	0.00	0.00	884
3215	IL	Saline	Jade Oil. Dering Mine	6.2	1.5	8.9	83.4	tr	0.00	844
1656	IL	Saline	Sahara #10 Mine	3.9	14.2	71.7	10.2	0.00	0.00	103
1924	IL	Saline	Sahara #10 Mine	8.7	3.5	64.8	23.0	0.00	0.00	233
3830	IL	Saline	Dan January	3.1	0.7	9.8	86.3	0.02	0.00	874
3770	IL	Saline	Ogara #8 Mine	8.0	4.0	22.2	65.8	0.00	0.00	666
3774	IL	Saline	Ogara #8 Mine	10.1	0.7	11.5	77.7	0.00	0.00	785
3613	IL	Saline	John Wilson	6.7	0.1	3.3	89.9	0.00	0.00	909
3614	IL	Saline	John Wilson	7.6	0.0	2.1	90.3	0.00	0.00	913
3750	IL	Saline	John Wilson #1P Sutton	6.1	0.2	3.1	90.6	0.00	0.00	917
3782	IL	Saline	John Wilson #1P	6.4	0.0	2.9	90.6	0.00	0.00	917
3834	IL	Saline	Wilson #1P Sutton	5.9	0.1	2.7	91.3	0.04	0.00	924
1518	IL	Saline	Frank Genet. Mine	8.6	0.8	0.0	90.1	0.00	0.00	913
1973	IL	Saline	Frank Genet. Mine	9.1	0.1	2.1	88.7	0.00	0.00	898
1608	IL	Saline	Sahara #1 Mine	1.4	14.6	79.4	3.8	0.00	0.00	41
1909	IL	Saline	Sahara #1 Mine	7.0	3.7	72.7	16.6	0.00	0.00	168
3091	IL	Vermilion	Bunsenville Mine	6.5	14.4	79.1	0.0	0.00	0.00	0
3134	IN	Sullivan	Old coal test hole	0.6	0.1	7.0	92.3	tr	0.00	934

Table 5. Amount of methane liberated by some coal mines in the Illinois basin (US EPA[2])

State	County	Mine	Years averaged	Coal seam	Coal thickness (m)	Mine depth (m)	Total annual emissions, average ± s.d. (thousand m^3/d)	Annual coal production, average ± s.d. (million tons)	Specific emissions, average ± s.d. (m^3/ton)
IL	Clinton	Monterey #2	1993/96	Herrin	2.3	101	10 ± 3.7	2.0 ± 0.9	2.0 ± 0.7
IL	Franklin	Old Ben 24	1993/96	Herrin	2.1	198	35 ± 6	1.3 ± 0.8	14.0 ± 9.5
IL	Franklin	Old Ben 25	1993/94	Herrin	2.1	183	34 ± 8	1.4 ± 0.1	8.8 ± 1.5
IL	Franklin	Old Ben 26	1993/96	Herrin	2.6	198	52 ± 7	2.4 ± 0.7	8.6 ± 3.8
IL	Jefferson	Orient 6	1993/96	Herrin	1.8	244	21 ± 2	1.2 ± 0.1	6.6 ± 0.8
IL	Jefferson	Rend Lake	1993/96	Herrin	2.4	183	48 ± 16	2.4 ± 0.8	7.6 ± 1.9
IL	Logan	Elkhart	1993/96	Springfield	1.7	85	11 ± 2	1.6 ± 0.2	2.7 ± 0.7
IL	Macoupin	Crown II	1993/96	Herrin	2.4	101	17 ± 2.3	1.5 ± 0.1	3.1 ± 2.1
IL	Macoupin	Monterey #1	1993/96	Herrin	2.0	91	20 ± 5	1.9 ± 0.3	3.9 ± 1.1
IL	Saline	Brushy Creek	1993/96	Herrin	1.8	76	21 ± 6	0.8 ± 0.4	10.4 ± 4.2
IL	Saline	Galatia	1993/96	Springfield	2.1	213	206 ± 56	4.6 ± 1.1	16.5 ± 3.5
IL	Wabash	Wabash	1993/96	Springfield	2.1	183	127 ± 34	2.7 ± 0.3	17.9 ± 6.7
IL	White	Pattiki	1993/96	Herrin	1.7	307	46 ± 12	1.7 ± 0.1	9.9 ± 3.1
IN	Sullivan	Buck Creek	1993/55	Springfield	1.5	91	12 ± 2	0.5 ± 0.2	10.7 ± 4.7
KY	Union	Camp No. 11	1993/96	Springfield	1.6	418	22 ± 5	2.1 ± 0.6	3.9 ± 0.6
KY	Webster	Baker	1993/96	Baker (KY 13)	2.0	274	35 ± 15	3.6 ± 1.3	3.5 ± 0.3
KY	Webster	Dotiki	1993/96	Springfield	1.8	152	18 ± 1	2.4 ± 0.4	2.6 ± 0.2
KY	Webster	Wheatcroft 9	1993/96	Springfield	2.0	274	72 ± 46	1.7 ± 1.5	15.0 ± 15