ANALYSIS OF CHEROKEE GROUP CUTTINGS SAMPLES FOR GAS CONTENT -- PRODUCTION MAINTENANCE SERVICE #1 SCHERTZER-BARTON; W2 sec. 35-T.33S.-R.22E.; CHEROKEE COUNTY, KANSAS

By
K. David Newell

Kansas Geological Survey
The University of Kansas
1930 Constant Avenue
Lawrence, KS 66047-3726

November 15, 2004
Kansas Geological Survey Open-File Report 2006-39

SUMMARY

Two cuttings samples from the Pennsylvanian Cherokee Group were collected from the Production Maintenance Service #1 Schertzer-Barton well; W2 sec. 35-T.33S.-R.22E.; Cherokee County, KS. The samples calculate as having the following gas contents:

- Dry Wood (?) coal at 180' to 182' depth[1] (80 scf/ton)
- Riverton coal at 324'-326' depth[1] (89 scf/ton)

[1]assuming accompanying dark shales in sample desorb 3 scf/ton

BACKGROUND

The Production Maintenance Service #1 Schertzer-Barton well; W2 sec. 35-T.33S.-R.22E., in Cherokee County was selected for cuttings desorption tests in association with an on-going coalbed gas research project at the Kansas Geological Survey. The samples were gathered September 21, 2004, by K. David Newell of the Kansas Geological Survey, with assistance of Mike McClenning of Production Maintenance Service. Samples were obtained during normal drilling of the well, with no cessation of drilling before zones of interest (i.e., coals and dark shales in the Cherokee Group) were penetrated. The well was drilled using a air rotary rig owned by MOKAT, Inc.

The samples were canistered, with surface time and canistering times noted. Lag times for samples to reach the surface (important for assessing lost gas) were determined by a nearby well drilled by the same drilling rig.

Three cuttings samples from the Pennsylvanian Cherokee Group were collected:

- Dry Wood (?) coal at 180' to 182' depth (231 grams dry wt.)
- Riverton coal at 324'-326' depth (936 grams dry wt.)

The cuttings were caught in mesh bucket as they exited the air line emptying to the mud pit. The samples were then washed in water while in kitchen strainers to rid them of as much drilling mud as possible before the cuttings were placed in desorption canisters. Water with zephyrn chloride biocide was then added to the canisters, with a headspace of 1 to 2 inches being preserved at the top of the canister.

All samples were transported September 21 to the laboratory at the Kansas Geological Survey in Lawrence, KS, and desorption measurements were continued at approximately 68 ˚F. Desorption measurements were periodically made until the canisters produced negligible gas with daily testing for at least two successive days.

DESORPTION MEASUREMENTS

The equipment and method for measuring desorption gas is that prescribed by McLennan and others (1995). The volumetric displacement apparatus is a set of connected dispensing burettes, one of which measures the gas evolved from the desorption canister. The other burette compensates for the compression that occurs when the desorbed gas displaces the water in the measuring burette. This compensation is performed by adjusting the cylinders so that their water levels are identical, then figuring the amount of gas that evolved by reading the difference in water level using the volumetric scale on the side of the burette.

The W3 desorption canister (holding the Dry Wood(?) sample) was made in house at the Kansas Geological Survey. This canister is approximately 1 foot in length (30 cm), 2 inches in diameter (5 cm), and encloses a volume of 44 cubic inches (720 cm^3). The L canister (holding the Riverton sample) was obtained from SSD, Inc., in Grand Junction, CO. This canister is 12.5 inches high (32 cm), 3 1/2 inches (9 cm) in diameter, and encloses a volume of approximately 150 cubic inches (2450 cm^3). The desorbed gas that collected in the desorption canisters was periodically released into the volumetric displacement apparatus and measured as a function of time, temperature, and atmospheric pressure.

The time and atmospheric pressure were measured in the field using a portable weather station (model BA928) marketed by Oregon Scientific (Tualatin, OR). The atmospheric pressure was displayed in millibars on this instrument, however, this measurement was not the actual barometric pressure, but rather an altitude-compensated barometric pressure automatically converted to a sea-level-equivalent pressure. To translate this measurement to actual atmospheric pressure, a regression correlation was determined over several weeks by comparing readings from the Oregon Scientific instrument to that from a pressure transducer in the Petrophysics Laboratory in the Kansas Geological Survey in Lawrence, KS (Figure 1). The regression equation shown graphically in Figure 1 was entered into a spreadsheet and was used to automatically convert the millibar measurement to barometric pressure in pounds per square inch (psi).

A spreadsheet program written by K.D. Newell (Kansas Geological Survey) was used to convert all gas volumes at standard temperature and pressure. Conversion of gas volumes to standard temperature and pressure was by application of the perfect-gas equation, obtainable from basic college chemistry texts:

$$n = PV/RT$$

where n is moles of gas, T is degrees Kelvin (i.e., absolute temperature), V is in liters, and R is the universal gas constant, which has a numerical value depending on the units in which it is measured (for example, in the metric system R = 0.0820 liter atmosphere per degree mole). The number of moles of gas (i.e., the value n) is constant in a volumetric conversion, therefore the conversion equation, derived from the ideal gas equation, is:

$$(P_{stp}V_{stp})/(RT_{stp}) = (P_{rig}V_{rig})/(RT_{rig})$$

Customarily, standard temperature and pressure for gas volumetric measurements in the oil industry are 60 °F and 14.7 psi (see Dake, 1978, p. 13), therefore P_{stp}, V_{stp}, and T_{stp}, respectively, are pressure, volume, and temperature at standard temperature and pressure, where standard temperature is degrees Rankine (°R = 460 + °F). P_{rig}, V_{rig}, and T_{rig}, respectively, are ambient pressure, volume, and temperature measurements taken at the rig site or in the desorption laboratory.

The universal gas constant R drops out as this equation is simplified and the determination of V_{stp} becomes:

$$V_{stp} = (T_{stp}/T_{rig})\ (P_{rig}/P_{stp})\ V_{rig}$$

The conversion calculations in the spreadsheet were carried out in the English metric system, the customary measure system used in American coal and oil industry. V is therefore converted to cubic feet; P is psia; T is °R.

The desorbed gas was summed over the period for which the coal samples evolved all of their gas.

Lost gas for samples (i.e., the gas lost from the sample from the time it was drilled, brought to the surface, to the time it was canistered) were determined using the direct method (Kissel and others, 1975; also see McLennan and others, 1995, p. 6.1-6.14) in which the cumulative gas evolved is plotted against the square root of elapsed time. Time zero is assumed to be the moment that the rock is cut and its cuttings circulated off bottom.

LITHOLOGIC ANALYSIS

Upon removal from the canisters, the cuttings were washed of drilling mud, and air dried for 7 to 21 days. After drying, the cuttings were weighed and then dry sieved into 5 size fractions: >0.0930", >0.0661", >0.0460", >0.0331", and <0.0331". For large sample sizes, the cuttings were run through a sample splitter and a lesser portion (approximately 75 grams) were sieved and weighed, and the derived size-fraction ratios were applied to the entire sample.

The size fractions were then inspected and sorted by hand under a dissecting microscope. Three major lithologic categories were differentiated: coal, dark shales (generally Munsell rock colors N3 [dark gray], N2 [grayish black], and N1 [black] on dry surface), and lighter-colored lithologies and/or dark and light-colored carbonates. The lighter-colored lithologies are considered to be incapable of generating significant amounts of gas. After sorting, and for every size class, each of these three lithologic categories was weighed and the proportion of coal, dark shale, and light-colored lithologies were determined for the entire cuttings sample based on the weight percentages.

DATA PRESENTATION

Data and analyses accompanying this report are presented in the following order: 1) data tables for the desorption analyses, 2) lost-gas graphs, 3) "lithologic component sensitivity analyses" showing the interdependence of gas evolved from dark shale versus coal in each sample, 4) a summary component analysis for all samples showing relative reliability of the data from all the samples, and 5) a desorption graph for all the samples.

Data Tables of the Desorption Analyses (Table 1)

These are the basic data used for lost-gas analysis and determination of total gas desorbed from the cuttings samples. Basic temperature, volume, and barometric measurements are listed at left. Farther to the right, these are converted to standard temperature, pressure, and volumes. The volumes are cumulatively summed, and converted to scf/ton based on the total weight of coal and dark shale in the sample. At the right of the table, the time of the measurements are listed and converted to hours (and square root of hours) since the sample was drilled.

Lost-Gas Graphs (Figure 2-3)

Gas lost prior to the canistering of the sample was estimated by extrapolation of the first few data points after the sample was canistered. The linear characteristic of the initial desorption measurements was usually lost within the first hour after canistering, thus data are presented in the lost-gas graphs for only up to one hour after canistering. Lost-gas volumes derived from this analysis are incorporated in the data tables described above.

"Lithologic Component Sensitivity Analyses" (Figures 4-5)

The rapidity of penetration of a well makes collection of pure lithologies from relatively thin-bedded strata rather difficult. Mixed lithologies are more the norm rather than the exception. Some of this mixing is due to cavings from strata farther up hole. The mixing may also be due to collection of two or more successively drilled lithologies in the kitchen sieve at the exit line, or differential lifting of relatively less-dense coal compared to other lithologies, all of which are more dense than coal.

The total gas evolved from the sample is due to gas being desorbed from both the coal and dark shale. Both lithologies are capable of generating gas, albeit the coal will be richer in gas than the dark-colored shale. Even though dark-colored shale is less rich in sorbed gas than coal, if a sample has a large proportion of dark, organic-rich shale and only a minor amount of coal, the total volume of gas evolved from the dark-shale component may be considerable. The lighter-colored lithologies are considered to be incapable of generating significant amounts of gas.

The total amount of gas evolved from a cuttings sample can be expressed by the following equation:

$$\text{Total gas (cm}^3\text{)} = [\text{weight}_{\text{coal}} \text{ (grams) X gas content}_{\text{coal}} \text{ (cm}^3\text{/gram)}] + [\text{weight}_{\text{dark shale}} \text{ (grams) X gas content}_{\text{dark shale}} \text{ (cm}^3\text{/gram)}]$$

A unique solution for gas $content_{coal}$ in this equation is not possible because gas $content_{dark\ shale}$ is not known exactly. An answer can only be expressed as a linear solution to the above equation. The richer in gas the dark shales are, the poorer in gas the admixed coal has to be, and vice versa. If there is little dark shale in a sample, a relatively well constrained answer for gas $content_{coal}$ can be obtained. Conversely, if considerable dark shale is in a sample, the gas content of a coal will be hard to precisely determine.

The lithologic-component-sensitivity-analysis diagram therefore expresses the bivariant nature inherent in the determination of gas content in mixed cuttings. The gas content of dark shales in Kansas can vary greatly. Proprietary desorption analyses of dark shales in cores from southeastern Kansas have registered as much as 50 scf/ton, but can be as low as 2-4 scf/ton.

A value of 3 scf/ton for average dark shale is based on the assay of the gas content of cores of dark shales in nearby wells. However, high-gamma-ray shales (such as the Excello Shale), also colloquially known as "hot shales", typically have more organic matter and associated gas content than dark shales with no excessive gamma-ray level. Determination of gas content for a coal associated with a "hot" shale therefore carries more uncertainty than if the coal were associated with a shale without a high gamma-ray value.

In general, shale gas content does not have to be very much greater that 10 scf/ton before the associated coal starts to have a gas content less than that of the dark shale. In all the lithologic-component-sensitivity-analysis diagrams, a "break-even" point is therefore noted where the gas content of the coal is equal to that of the dark shale. This "break-even" point corresponds to the minimum gas content assignable to the coal and maximum gas content assignable to the dark shale. It can also be thought of the scf/ton gas content of the cuttings sample minus the weight of any of the lighter-colored lithologies, which are assumed to have no inherent gas content. Conversely though, to assume that all the gas evolved from a cuttings sample is derived solely from the coal would result in an erroneously high gas content for the coal.

Summary Component Analysis for all Samples (Figure 6)

This diagram is a summary of the individual "lithologic component sensitivity analyses" for each sample, all set at a common scale. The steeper the angle of the line for a sample, the more uncertainty is attached to the results (i.e., *gas* $content_{coal}$) for that sample. If the coal content is miniscule (i.e., < approximately 5%), the results are a better reflection of the *gas* $content_{dark\ shale}$.

Desorption Graph (Figure 7)

This is a desorption graph (gas content per weight vs. square root of time) for all the samples. The rate at which gas is evolved from the samples is thus comparable at a common scale. The final value represents the standard cubic feet of gas per ton (scf/ton) calculated for the sample, using the combined weight of the coal and dark shale in the sample.

RESULTS and DISCUSSION

The amount of coal in both samples is exceptionally good for an air-drilled well. The Dry Wood (?) sample has slightly better constrained results than the Riverton due to its exceptional purity. The Dry Wood (?) (180'-182') and Riverton samples (324'-326') samples respectively contained 99% and 83% coal.

Samples were also tested for their density. Approximately 5 grams of sample were weighed and then immersed in water in a 10-cc graduated cylinder, noting the amount of water displaced by the sample. Three measurements were made for each sample. The following density measurements were calculated:

unit	*depth*	*density and uncertainty*
Dry Wood (?)	180'	1.36 g/cc ± 0.04
Riverton	324'	1.35 g/cc ± 0.04

REFERENCES

Dake, L.P., 1978, Fundamentals of Reservoir Engineering, Elsevier Scientific Publishing, New York, NY, 443 p.

Kissel, F.N., McCulloch, C.M., and Elder, C.H., 1975, The direct method of determining methane content of coals for ventilation design: U.S. Bureau of Mines, Report of Investigations, RI7767.

McLennan, J.D., Schafer, P.S., and Pratt, T.J., 1995, A guide to determining coalbed gas content: Gas Research Institute, Chicago, IL, Reference No. GRI-94/0396, 180 p.

FIGURES and TABLES

Correlation of Field Barometer to KGS Petrophysics Lab Barometer

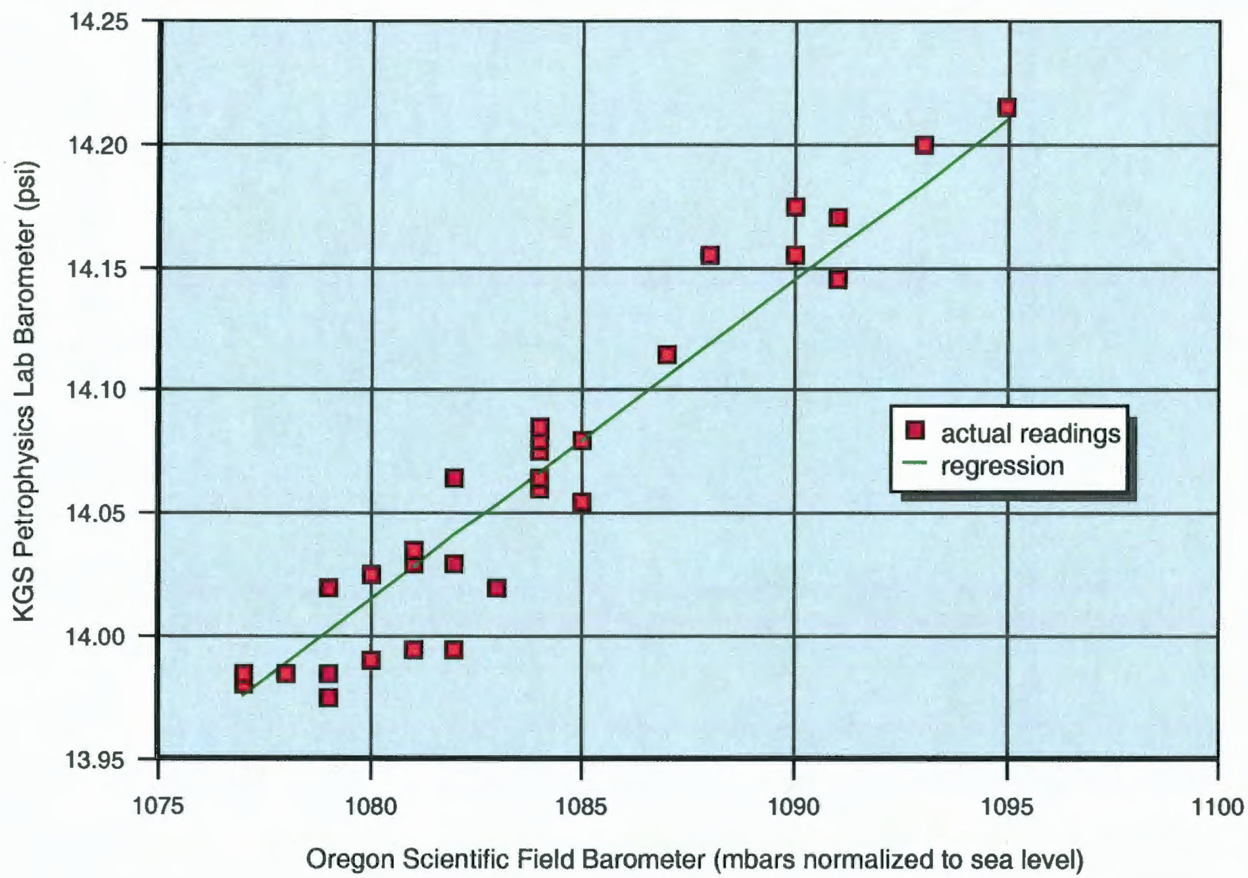


FIGURE 1.

TABLE 1 – Desorption data for PRODUCTION MAINTENANCE SERVICES #1 SCHERTZER-BARTON #1; W2 35-T.33S.-R.22E., Cherokee Co. KS.

SAMPLE: Dry Wood(?) coal (180' to 182') cuttings in canister W3

	lbs.	grams
dry sample weight:	0.5065	229.77

est. lost gas (cc) = 17

TIME OF:	off bottom	at surface	in canister
	9/21/04 8:47	9/21/04 8:48	9/21/04 8:54

elapsed time (off bottom to canistering): 6.6 minutes; 0.110 hours; 0.332080981 SQRT (hrs)

RIG/LAB MEASUREMENTS measured cc	measured T (F)	measured P	CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi) cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	CUMULATIVE VOLUMES cubic ft (@STP)	cc (@STP)	SCF/TON without lost gas	SCF/TON with lost gas	TIME OF MEASURE	TIME SINCE off bottom	in canister	SQRT hrs. (since off bottom)
4	68	1091	0.0001	528	14.161	0.000134015	3.79	0.000134015	3.79	0.53	2.90	9/21/04 8:56	0:08:37	0:02:00	0.378960567
4	68	1091	0.0001	528	14.161	0.000134015	3.79	0.00026803	7.59	1.06	3.43	9/21/04 9:02	0:14:37	0:08:00	0.493569763
2	68	1091	7E-05	528	14.161	6.70076E-05	1.90	0.000335038	9.49	1.32	3.69	9/21/04 9:05	0:17:37	0:11:00	0.54185894
8	68	1091	0.0003	528	14.161	0.00026803	7.59	0.000603068	17.08	2.38	4.75	9/21/04 9:15	0:27:22	0:20:45	0.675359986
6	68	1091	0.0002	528	14.161	0.000201023	5.69	0.000804091	22.77	3.17	5.55	9/21/04 9:26	0:38:22	0:31:45	0.799652702
7	68	1091	0.0002	528	14.161	0.000234527	6.64	0.001038618	29.41	4.10	6.47	9/21/04 9:38	0:50:07	0:43:30	0.913935325
27	68	1091	0.001	528	14.161	0.000904603	25.62	0.00194322	55.03	7.67	10.04	9/21/04 11:04	2:16:07	2:09:30	1.506190928
28	68	1090	0.001	528	14.148	0.000937246	26.54	0.002880467	81.57	11.37	13.74	9/21/04 12:20	3:32:07	3:25:30	1.880233437
30	70	1083	0.0011	530	14.057	0.000993979	28.15	0.003874445	109.71	15.30	17.67	9/21/04 16:31	7:43:07	7:36:30	2.778238851
22	72	1084	0.0008	532	14.070	0.000726848	20.58	0.004601293	130.29	18.17	20.54	9/21/04 19:20	10:32:07	10:25:30	3.245809264
49	72	1087	0.0017	532	14.109	0.001623369	45.97	0.006224662	176.26	24.58	26.95	9/22/04 6:21	21:33:07	21:26:30	4.642407182
43	72	1084	0.0015	532	14.070	0.001420657	40.23	0.007645319	216.49	30.19	32.56	9/22/04 19:54	35:06:07	34:59:30	5.924689396
42	72	1085	0.0015	532	14.083	0.001388899	39.33	0.009034218	255.82	35.67	38.04	9/23/04 16:30	55:42:07	55:35:30	7.46337353
29	72	1089	0.001	532	14.135	0.000962537	27.26	0.009996755	283.08	39.47	41.84	9/24/04 12:30	75:42:07	75:35:30	8.700686435
30	72	1090	0.0011	532	14.148	0.000996642	28.22	0.010993397	311.30	43.41	45.78	9/25/04 14:37	101:49:07	101:42:30	10.09052085
29	72	1086	0.001	532	14.096	0.000959885	27.18	0.011953283	338.48	47.20	49.57	9/26/04 20:16	131:28:07	131:21:30	11.46597624
13	72	1087	0.0005	532	14.109	0.00043069	12.20	0.012383973	350.67	48.90	51.27	9/27/04 9:58	145:10:07	145:03:30	12.04859374
22	70	1089	0.0008	530	14.135	0.000732956	20.75	0.013116929	371.43	51.79	54.16	9/28/04 20:52	180:04:07	179:57:30	13.41896461
15	70	1084	0.0005	530	14.070	0.000497448	14.09	0.013614377	385.51	53.75	56.12	9/29/04 19:57	203:09:07	203:02:30	14.25313806
12	71	1081	0.0004	531	14.031	0.00039611	11.22	0.014010487	396.73	55.32	57.69	9/30/04 14:22	221:34:07	221:27:30	14.88518092
15	71	1080	0.0005	531	14.018	0.000494679	14.01	0.014505166	410.74	57.27	59.64	10/1/04 16:40	247:52:07	247:45:30	15.74384359
13	67	1094	0.0005	527	14.200	0.000437576	12.39	0.014942742	423.13	59.00	61.37	10/4/04 9:21	312:33:07	312:26:30	17.67913868
9	67	1095	0.0003	527	14.213	0.000303214	8.59	0.015245956	431.72	60.20	62.57	10/5/04 9:18	336:30:07	336:23:30	18.34398933
9	69	1091	0.0003	529	14.161	0.000300964	8.52	0.01554692	440.24	61.38	63.75	10/6/04 9:19	360:31:07	380:24:30	18.98732765
11	70	1087	0.0004	530	14.109	0.000365805	10.36	0.015912725	450.60	62.83	65.20	10/7/04 9:20	384:32:07	384:25:30	19.60957108
10	71	1085	0.0004	531	14.083	0.000331313	9.38	0.016244038	459.98	64.14	66.51	10/8/04 9:56	409:08:07	409:01:30	20.22709267
4	70	1086	0.0001	530	14.096	0.000132898	3.78	0.016376935	463.74	64.66	67.03	10/8/04 20:06	419:18:07	419:11:30	20.47686364
25	65	1079	0.0009	525	14.005	0.000833116	23.59	0.017210051	487.33	67.95	70.32	10/16/04 20:51	612:03:07	611:56:30	24.7396836
12	65	1067	0.0004	525	13.849	0.000395448	11.20	0.017605499	498.53	69.51	71.88	10/18/04 9:18	648:30:07	848:23:30	25.46570133
2	67	1079	7E-05	527	14.005	6.63963E-05	1.88	0.017671896	500.41	69.77	72.14	10/19/04 12:46	875:58:07	675:51:30	25.99939636
2	67	1083	7E-05	527	14.057	6.66425E-05	1.89	0.017738538	502.30	70.04	72.41	10/20/04 9:22	896:34:07	696:27:30	26.39258629
5	67	1080	0.0002	527	14.018	0.000166145	4.70	0.017904683	507.00	70.69	73.06	10/21/04 9:25	720:37:07	720:30:30	26.84434039
11	68	1075	0.0004	528	13.953	0.000363137	10.28	0.01826782	517.29	72.13	74.50	10/23/04 14:20	773:32:07	773:25:30	27.81250218
0	66	1083	0	526	14.057	0	0.00	0.01826782	517.29	72.13	74.50	10/25/04 9:21	816:33:07	816:26:30	28.57537304
5	67	1079	0.0002	527	14.005	0.000165991	4.70	0.01843381	521.99	72.78	75.15	10/26/04 9:10	840:22:07	840:15:30	28.98911194
2	68	1086	7E-05	528	14.096	6.67005E-05	1.89	0.018500511	523.87	73.05	75.42	10/27/04 9:15	864:27:07	864:20:30	29.40156364
5	70	1083	0.0002	530	14.057	0.000165663	4.69	0.018666174	528.57	73.70	78.07	10/28/04 9:19	888:31:07	888:24:30	29.80802931
9	70	1073	0.0003	530	13.927	0.00029544	8.37	0.018961614	536.93	74.87	77.24	10/29/04 9:09	912:21:07	912:14:30	30.2051642
3	67	1074	0.0001	527	13.940	9.9133E-05	2.81	0.019060747	539.74	75.26	77.63	11/1/04 9:19	984:31:07	984:24:30	31.37703955
10	72	1090	0.0004	532	14.148	0.000332214	9.41	0.019392961	549.15	76.57	78.94	11/5/04 11:02	1082:14:07	1082:07:30	32.89734454
10	73	1078	0.0004	533	13.992	0.00032794	9.29	0.019720902	558.43	77.86	80.23	11/6/04 14:54	1110:06:07	1109:59:30	33.31819239
-3	69	1084	-0.0001	529	14.070	-9.98777E-05	-2.82	0.019621224	555.81	77.47	79.84	11/10/04 10:40	1201:52:07	1201:45:30	34.66797674
-2	67	1092	-7E-05	527	14.174	-6.71963E-05	-1.90	0.019554028	553.71	77.21	79.58	11/11/04 9:23	1224:35:07	1224:28:30	34.9940749

DESORPTION TERMINATED 11/11/2004 DUE TO NO MORE GAS BEING EVOLVED; sample overn dried at 150 degrees F for 1 day

SAMPLE: Riverton coal (324' to 326') cuttings in SSD canister L

	lbs.	grams
dry sample weight:	2.0566	932.87

est. lost gas (cc) = 92

TIME OF:	off bottom	at surface	in canister
	9/21/04 9:37	9/21/04 9:38	9/21/04 9:49

elapsed time (off bottom to canistering): 11.4 minutes; 0.191 hours; 0.436526695 SQRT (hrs)

RIG/LAB MEASUREMENTS measured cc	measured T (F)	measured P	CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi) cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	CUMULATIVE VOLUMES cubic ft (@STP)	cc (@STP)	SCF/TON without lost gas	SCF/TON with lost gas	TIME OF MEASURE	TIME SINCE off bottom	in canister	SQRT hrs. (since off bottom)
10	68	1091	0.0004	528	14.161	0.000335038	9.49	0.000335038	9.49	0.33	3.49	9/21/04 9:51	0:13:11	0:01:45	0.46874537
9	68	1091	0.0003	528	14.161	0.000301534	8.54	0.000636572	18.03	0.62	3.78	9/21/04 9:53	0:15:41	0:04:15	0.511262055
11	68	1091	0.0004	528	14.161	0.000368542	10.44	0.001005114	28.46	0.98	4.14	9/21/04 9:57	0:19:41	0:08:15	0.572761343
11	68	1091	0.0004	528	14.161	0.000368542	10.44	0.001373658	38.90	1.34	4.50	9/21/04 10:01	0:23:26	0:12:00	0.624944442

9	68	1091	0.0003	528	14.161	0.000301534	8.54	0.00167519	47.44	1.63	4.79	9/21/04	10:06	0:28:11	0:16:45	0.68536284
8	68	1091	0.0003	528	14.161	0.00026803	7.59	0.00194322	55.03	1.89	5.05	9/21/04	10:08	0:30:56	0:19:30	0.718021974
20	68	1091	0.0007	528	14.161	0.000670076	18.97	0.002613296	74.00	2.54	5.70	9/21/04	10:18	0:40:11	0:28:45	0.81836558
19	68	1091	0.0007	528	14.181	0.000636572	18.03	0.003249868	92.03	3.16	8.32	9/21/04	10:23	0:45:11	0:33:45	0.867787736
14	68	1091	0.0005	528	14.161	0.000469053	13.28	0.003718922	105.31	3.62	8.78	9/21/04	10:29	0:51:26	0:40:00	0.925862981
16	68	1091	0.0006	528	14.161	0.000536061	15.18	0.004254982	120.49	4.14	7.30	9/21/04	10:37	0:59:26	0:48:00	0.995266575
21	68	1091	0.0007	528	14.161	0.00070358	19.92	0.004958562	140.41	4.82	7.98	9/21/04	10:47	1:09:41	0:58:15	1.077877544
17	68	1091	0.0006	528	14.161	0.000569565	16.13	0.005528127	156.54	5.38	8.54	9/21/04	10:57	1:19:26	1:08:00	1.150603706
10	68	1091	0.0004	528	14.181	0.000335038	9.49	0.005863165	166.03	5.70	8.86	9/21/04	11:02	1:24:56	1:13:30	1.18977122
29	68	1091	0.001	528	14.181	0.00097161	27.51	0.006834775	193.54	6.65	9.81	9/21/04	11:21	1:43:11	1:31:45	1.311381799
50	68	1091	0.0018	528	14.161	0.00167519	47.44	0.008509965	240.97	8.28	11.44	9/21/04	11:53	2:15:11	2:03:45	1.501018173
39	68	1090	0.0014	528	14.148	0.00130545	38.97	0.009815415	277.94	9.55	12.70	9/21/04	12:16	2:38:11	2:28:45	1.623696058
147	70	1083	0.0052	530	14.057	0.004870495	137.92	0.01468591	415.86	14.28	17.44	9/21/04	16:33	6:55:11	6:43:45	2.630536489
84	72	1084	0.003	532	14.070	0.002775237	78.59	0.017461148	494.44	16.98	20.14	9/21/04	19:17	9:39:11	9:27:45	3.106936684
213	72	1087	0.0075	532	14.109	0.007056685	199.82	0.024517833	694.27	23.84	27.00	9/22/04	6:22	20:44:11	20:32:45	4.553722531
173	72	1084	0.0061	532	14.070	0.005715668	161.85	0.0302335	856.11	29.40	32.56	9/22/04	19:49	34:11:11	33:59:45	5.846912766
171	72	1085	0.006	532	14.083	0.005654802	160.13	0.035888302	1018.24	34.90	38.06	9/23/04	16:30	54:52:11	54:40:45	7.407409954
121	71	1089	0.0043	531	14.135	0.004023666	113.94	0.039911968	1130.18	38.81	41.97	9/24/04	12:31	74:53:11	74:41:45	8.653692211
120	71	1090	0.0042	531	14.148	0.003994077	113.10	0.043906045	1243.28	42.70	45.86	9/25/04	14:37	100:59:11	100:47:45	10.04919842
110	71	1086	0.0039	531	14.096	0.003647801	103.29	0.047553847	1346.57	48.24	49.40	9/26/04	20:17	130:39:11	130:27:45	11.43035676
48	71	1087	0.0017	531	14.109	0.001593234	45.12	0.049147081	1391.69	47.79	50.95	9/27/04	9:58	144:20:11	144:08:45	12.01400603
79	69	1089	0.0028	529	14.135	0.002636954	74.67	0.051784034	1466.36	50.36	53.52	9/28/04	20:52	179:14:11	179:02:45	13.38791951
57	70	1084	0.002	530	14.070	0.001890303	53.53	0.053674338	1519.88	52.20	55.36	9/29/04	19:58	202:20:11	202:08:45	14.2244996
40	69	1081	0.0014	529	14.031	0.001325358	37.53	0.054999696	1557.41	53.49	56.65	9/30/04	14:20	220:42:11	220:30:45	14.85607807
51	71	1080	0.0018	531	14.018	0.001681909	47.63	0.056681605	1605.04	55.12	58.28	10/1/04	16:40	247:02:11	246:50:45	15.71739129
51	67	1094	0.0018	527	14.200	0.001716643	48.61	0.058398248	1653.65	56.79	59.95	10/4/04	9:22	311:44:11	311:32:45	17.65605814
35	67	1095	0.0012	527	14.213	0.001179165	33.39	0.059577414	1687.04	57.94	61.10	10/5/04	9:20	335:42:11	335:30:45	18.32220117
32	68	1091	0.0011	528	14.161	0.001072122	30.36	0.060649535	1717.40	58.98	62.14	10/6/04	9:22	359:44:11	359:32:45	18.96671793
32	69	1087	0.0011	529	14.109	0.001066171	30.19	0.061715707	1747.59	60.02	63.18	10/7/04	9:21	383:43:11	383:31:45	19.5887652
29	70	1085	0.001	530	14.083	0.00096262	27.26	0.062678327	1774.85	60.95	64.11	10/8/04	9:58	408:20:11	408:08:45	20.20733503
13	70	1086	0.0005	530	14.096	0.000431917	12.23	0.063110245	1787.08	61.37	84.53	10/8/04	20:08	418:30:11	418:18:45	20.45734723
100	64	1079	0.0035	524	14.005	0.003338823	94.54	0.066449067	1881.62	64.82	67.78	10/16/04	20:53	611:15:11	611:03:45	24.72353242
36	64	1067	0.0013	524	13.849	0.001188609	33.66	0.067637676	1915.28	85.78	68.94	10/18/04	9:19	647:41:11	647:29:45	25.44968347
9	66	1079	0.0003	526	14.005	0.000299351	8.48	0.067937027	1923.76	66.07	69.23	10/19/04	12:47	675:09:11	674:57:45	25.9837075
7	66	1083	0.0002	526	14.057	0.000233692	6.62	0.088170719	1930.37	66.29	69.45	10/20/04	9:23	695:45:11	695:33:45	26.3771313
13	66	1080	0.0005	526	14.018	0.000432797	12.26	0.068803517	1942.63	68.71	69.87	10/21/04	9:26	719:48:11	719:36:45	26.82914564
33	67	1075	0.0012	527	13.953	0.001091478	30.91	0.069694995	1973.54	67.78	70.94	10/23/04	14:21	772:43:11	772:31:45	27.79783665
0.5	64	1083	2E-05	524	14.057	1.8756E-05	0.47	0.069711751	1974.01	67.79	70.95	10/25/04	9:23	815:45:11	815:33:45	28.56139099
18	67	1079	0.0006	527	14.005	0.000597567	16.92	0.070309318	1990.93	68.37	71.53	10/26/04	9:12	839:34:11	839:22:45	28.97532954
4	68	1086	0.0001	528	14.096	0.000133401	3.78	0.070442719	1994.71	68.50	71.66	10/27/04	9:15	863:37:11	883:25:45	29.38740755
15	68	1083	0.0005	528	14.057	0.000498872	14.13	0.07094159	2008.83	68.99	72.15	10/28/04	9:20	887:42:11	887:30:45	29.79434603
27	70	1073	0.001	530	13.927	0.000886321	25.10	0.071827911	2033.93	69.85	73.01	10/29/04	9:10	911:32:11	911:20:45	30.19166092
15	67	1074	0.0005	527	13.940	0.000495665	14.04	0.072323576	2047.97	70.33	73.49	11/1/04	9:20	983:42:11	983:30:45	31.3640408
-3	63	1090	-0.0001	523	14.148	-0.000101379	-2.87	0.072222197	2045.10	70.23	73.39	11/5/04	11:04	1081:26:11	1081:14:45	32.88520015
44	73	1078	0.0016	533	13.992	0.001442937	40.86	0.073685134	2085.96	71.64	74.80	11/6/04	14:55	1109:17:11	1109:05:45	33.30595125
-5	69	1084	-0.0002	529	14.070	-0.00018613	-4.70	0.073499004	2081.25	71.48	74.64	11/10/04	10:41	1201:03:11	1200:51:45	34.65621237
-3	67	1092	-0.0001	527	14.174	-0.000100794	-2.85	0.07339821	2078.40	71.38	74.54	11/11/04	9:24	1223:46:11	1223:34:45	34.98242019

DESORPTION TERMINATED 11/11/2004 DUE TO NO MORE GAS BEING EVOLVED; sample overn dried at 150 degrees F for 1 day

Dry Wood(?) coal (180' to 182') in canister W3

Production Maintenance Service #1 Schertzer-Barton; W2 sec. 35-T.33S.-R.22E., Cherokee County, KS

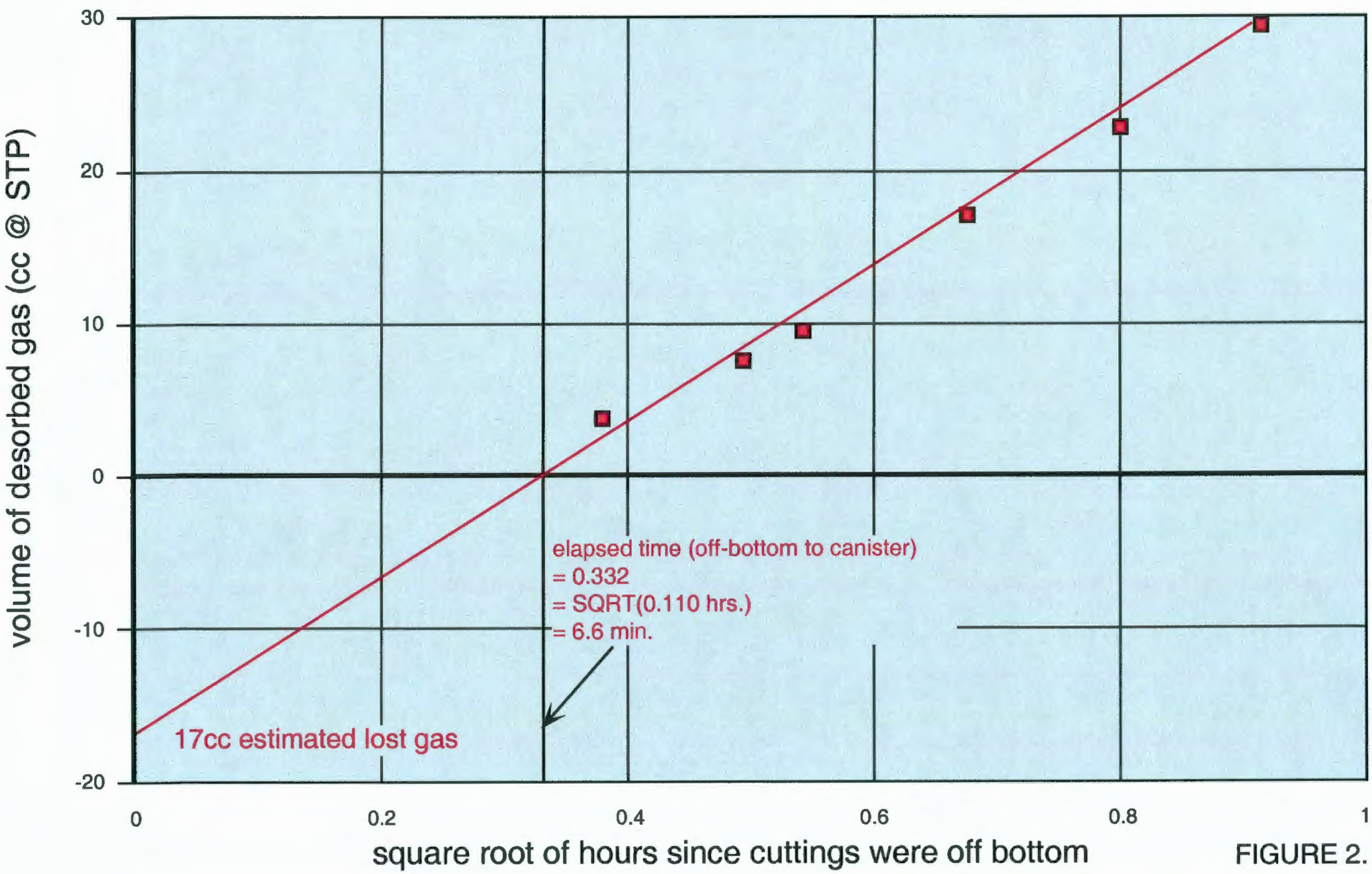


FIGURE 2.

Riverton coal (324' to 326') in SSD canister L

Production Maintenance Service #1 Schertzer-Barton; W2 sec. 35-T.33S.-R.22E., Cherokee County, KS

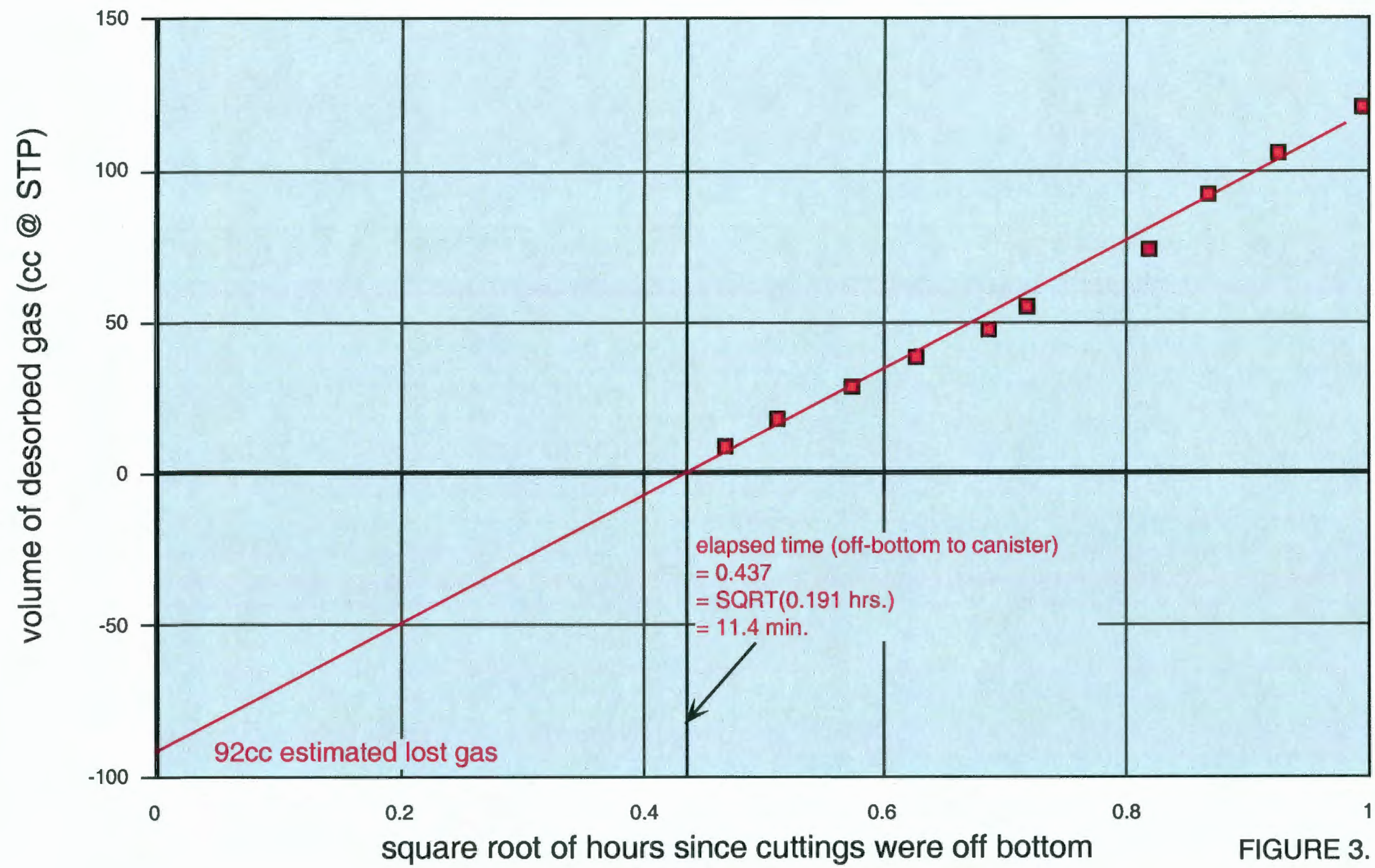


FIGURE 3.

Desorption Characteristics of Cuttings Samples

Production Maintenance Service #1 Schertzer-Barton, W2 35-T.33S.-R.22E., Cherokee Co., KS

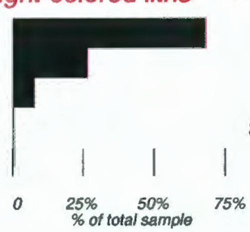
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of shale associated with Dry Wood(?) coal from 180' to 182'

$$\text{GAS CONTENT}_{coal} = \frac{\text{total gas desorbed} - ((\text{gas content}_{dark\ shale}) * (\text{weight}_{dark\ shale}))}{\text{weight}_{coal}}$$

total gas desorbed
(including estimated lost gas) = 575.4 ccs

TOTAL DRY WEIGHT OF SAMPLE = 231.13 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 1.35 grams (0.6%)
$\text{weight}_{dark\ shale}$ = 0.52 grams (0.2%)
weight_{coal} = 229.25 grams (99.2%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	154.41	99.47% / 0.23% / 0.30%
>0.0661"	59.62	98.77% / 0.19% / 1.04%
>0.0460"	16.29	98.46% / 0.12% / 1.43%
>0.0331"	0.43	90.91% / 4.55% / 4.44%
<0.0331"	0.39	90.00% / 5.00% / 5.00%
	231.13 TOTAL	



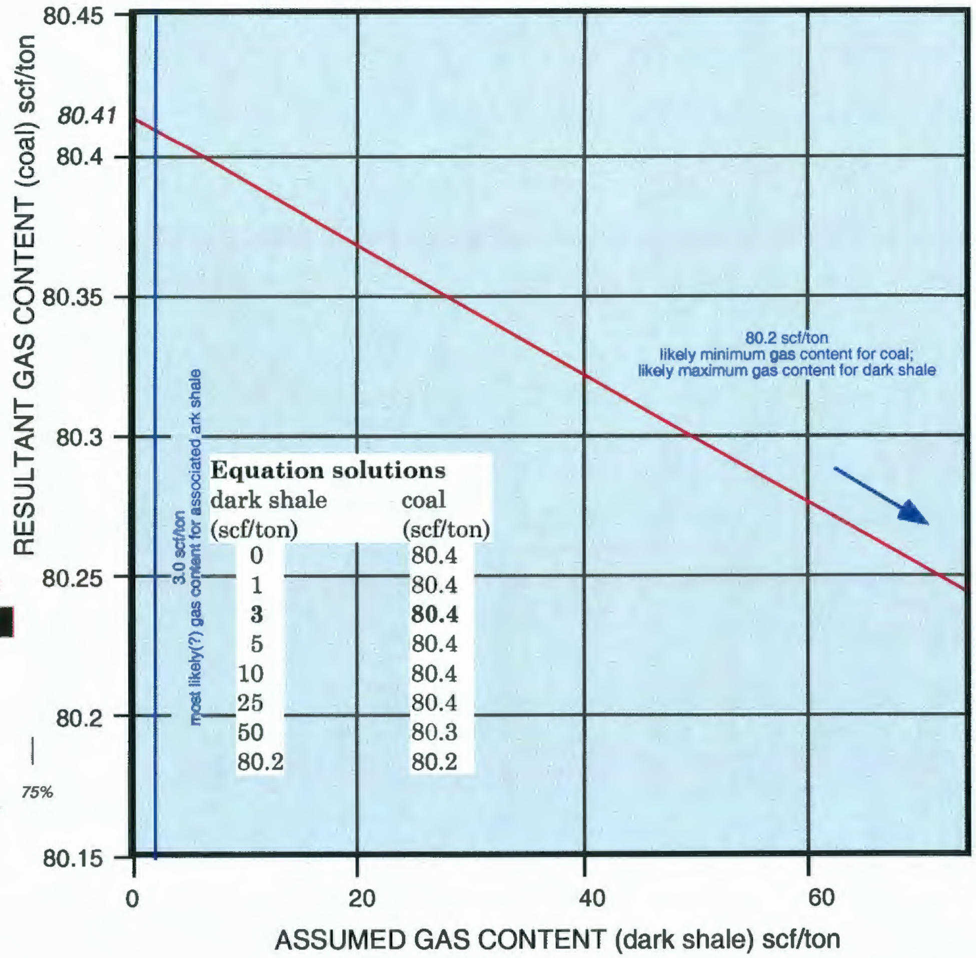


FIGURE 4.

Desorption Characteristics of Cuttings Samples

Production Maintenance Service #1 Schertzer-Barton, W2 35-T.33S.-R.22E., Cherokee Co., KS

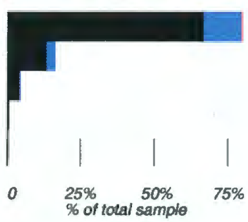
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of shale associated with Riverton coal from 324' to 326'

$$\text{GAS CONTENT}_{coal} = \frac{\text{total gas desorbed} - ((\text{gas content}_{dark\ shale}) * (\text{weight}_{dark\ shale}))}{\text{weight}_{coal}}$$

total gas desorbed
(including estimated lost gas) = 2178.0 ccs

TOTAL DRY WEIGHT OF SAMPLE = 935.59 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 2.72 grams (0.3%)
$\text{weight}_{dark\ shale}$ = 152.54 grams (16.3%)
weight_{coal} = 780.33 grams (83.4%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	739.79	83.48% / 16.27% / 0.25%
>0.0661"	150.87	80.99% / 18.49% / 0.52%
>0.0460"	40.07	89.83% / 9.98% / 0.19%
>0.0331"	3.34	94.38% / 4.49% / 1.12%
<0.0331"	1.52	92.88% / 6.97% / 0.15%
	935.59 TOTAL	



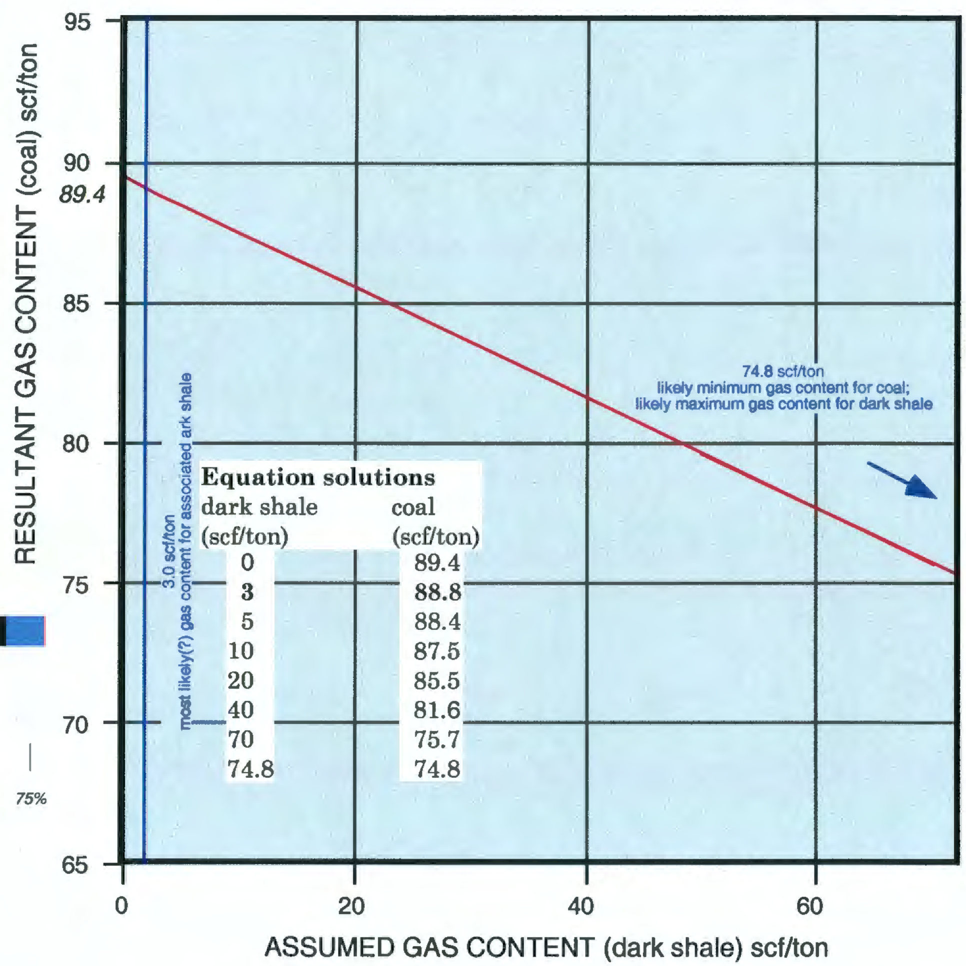


FIGURE 5.

Desorption Characteristics of Cuttings Samples

Production Maintenance Service #1 Schertzer-Barton, W2 35-T.33S.-R.22E., Cherokee Co., KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for all samples

UNIT	coal in sample	scf/ton w/ shale @ 3 scf/ton	maximum scf/ton	minimum scf/ton
Dry Wood(?)	99%	80.2	80.4	80.2
Riverton	83%	88.8	89.4	74.8

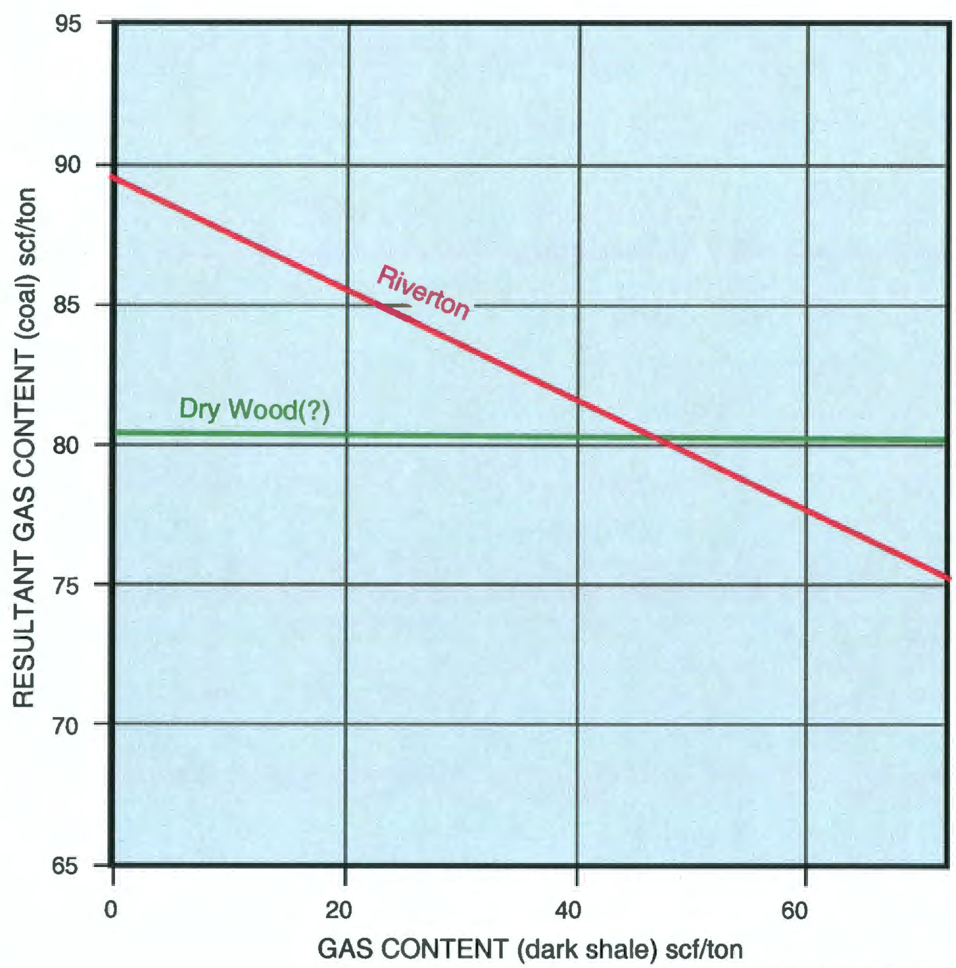


FIGURE 6.

Desorption Characteristics of Cuttings Samples

based on total weight of gas-generating lithologies (i.e., coal and dark shale) in sample
Production Maintenance Services #1 Schertzer-Barton,
W2 35-T.33S.-R.22E., Cherokee County, KS

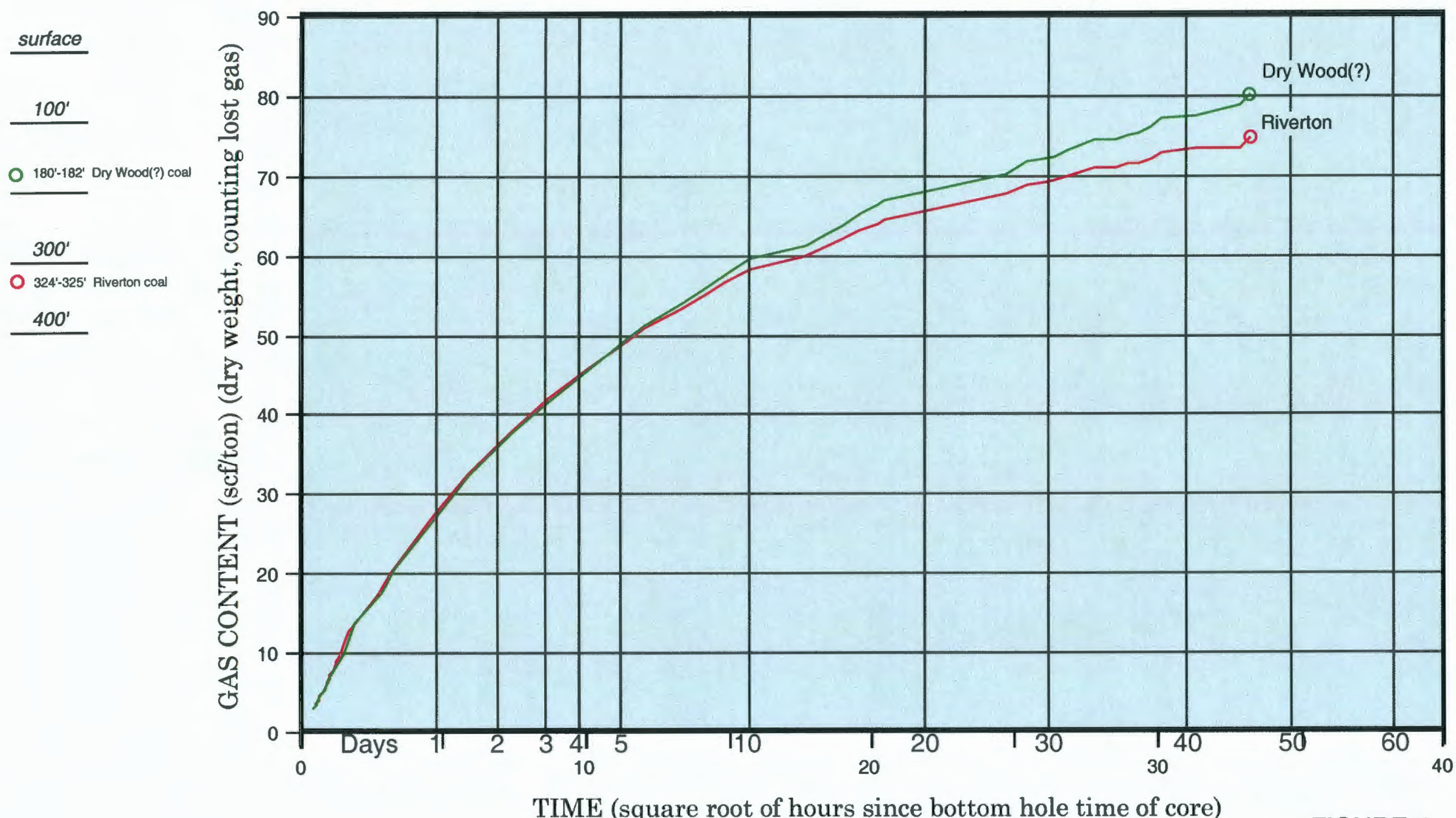


FIGURE 7.