ANALYSIS OF MARMATON AND CHEROKEE GROUP CUTTINGS SAMPLES FOR GAS CONTENT -- DART CHEROKEE BASIN OPERATING COMPANY MUSTAIN #C3-33 and #D4-33, sec. 33-T.30S.-R.15E., WILSON COUNTY, KANSAS

By
K. David Newell
and
Galen A. Worthington

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

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SUMMARY

Cuttings samples from the Pennsylvanian Marmaton Group and Cherokee Group were collected from the Dart Cherokee Basin #D4-33 Mustain well (SW NE SE SE sec. 33-T.30S.-R.15E.) and #C3-33 Mustain well (S2 NE NW SE sec. 33-T.30S.-R.15E.), Wilson County, KS. The samples from the #D4-33 Mustain well calculate as having the following gas contents:

- Weir-Pittsburg coal at 1024' to 1028' depth[1, 3] (302 scf/ton)
- Weir-Pittsburg coal at 1024' to 1028' depth[2, 3] (301 scf/ton)
- Bluejacket coal at 1084' to 1086' depth[3, 4] (159 scf/ton)

The sample from the #C3-33 Mustain well calculates as having the following gas contents:

- Weir-Pittsburg coal at 1102' to 1106' depth[3, 4] (263 scf/ton)

[1]sample labeled as 1023'-1026', likely a sample from when the formation was penetrated by the drill bit
[2]sample labeled as 1035'-1038', likely a cavings sample
[3]assuming accompanying dark shales in sample desorb 3 scf/ton
[4]a slight leak was detected in the canister after desorption finished, thus this gas content should be considered a minimum gas content

BACKGROUND

The Dart Cherokee Basin #D4-33 Mustain well (SW NE SE SE sec. 33-T.30S.-R.15E.) and #C3-33 Mustain well (S2 NE NW SE sec. 33-T.30S.-R.15E.) in Wilson County, KS, were selected for cuttings desorption tests in association with an on-going coalbed gas research project at the Kansas Geological Survey. The samples were gathered April 14, 2004, by an employee of Dart Cherokee Basin L.L.C., and turned over to LeaAnn Davidson of the Kansas Geological Survey on April 15, 2004. 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 Marmaton Group and Cherokee Group) were penetrated. The well was drilled using an air rotary rig owned by McPherson Drilling.

The samples were canistered, with surface time and canistering times noted. These samples were collected in canisters that were supplied by Dart Cherokee Basin L.L.C. and the Kansas Geological Survey. Lag times for samples to reach the surface (important for assessing lost gas) were determined by using the lag times from a nearby air-drilled well (Dart Cherokee Basin #CH-1 Holder; sec. 1-T.30S.-R.14E., Wilson County, KS), which was also drilled using this drilling rig. The lag times were determined by periodically noting the time it took for cuttings to reach the surface following resumption of drilling after new pipe was added to the drill string.

Four cuttings samples from the Pennsylvanian Marmaton and Cherokee Groups were collected from the two wells:

The samples from the #D4-33 Mustain well were:

- Weir-Pittsburg coal at 1024' to 1028' depth[1] (240 grams dry wt.)
- Weir-Pittsburg coal at 1024' to 1028' depth[2] (52 grams dry wt.)
- Bluejacket coal at 1084' to 1086' depth (211 grams dry wt.)

[1]sample labeled as 1023'-1026'
[2]sample labeled as 1035'-1038'

The sample from the #C3-33 Mustain well was:

- Weir-Pittsburg coal at 1102' to 1106' depth (401 grams dry wt.)

The cuttings were caught in kitchen strainers as they exited the air-stream pipe emptying to the mud pit. The samples were then washed in water while in the 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 April 1 to the laboratory at the Kansas Geological Survey in Lawrence, KS, and desorption measurements were continued at approximately 70 ˚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 desorption canisters were obtained from SSD, Inc., in Grand Junction, CO. These canisters are 12.5 inches high (32 cm), 3 1/2 inches (9 cm) in diameter, and enclose 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. In order 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 Vstp 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 time 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) are normally 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. Lost gas, however, had to be inferred for the samples collected from this well because no desorption apparatus was on site when those samples were collected. The procedure used to infer lost gas for these samples is outlined in the section below on Lost Gas.

LITHOLOGIC ANALYSIS

Upon removal from the canisters, the cuttings were washed of drilling mud and dried in an oven at 150 ˚F for 1 to 3 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) lag time to surface for the well cuttings, 2) data tables for the desorption analyses, 3) lost-gas graphs, 4) "lithologic component sensitivity analyses" showing the interdependence of gas evolved from dark shale versus coal in each sample, 5) a summary component analysis for all samples showing relative reliability of the data from all the samples, and 6) a desorption graph for all the samples.

Graph of Lag-time to Surface for Well Cuttings (Figure 2)
Lag time of cuttings to surface varied, but there is a general trend of longer lag times for greater depth. The lag times accepted for cuttings were taken to be a visual average of the trend (defined by the scatter of data points on this graph) at the depth at which the samples were taken.

Data Tables of the Desorption Analyses (Table 1, 2)
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 3)
To infer an approximate lost-gas value for each sample, a correlation of the total gas desorbed from a sample after it had been canistered to its rate of lost gas was developed using desorption data accumulated for 42 cuttings samples obtained from air-drilled wells in the Cherokee basin in southeastern Kansas (Figure 3). The rate of lost gas used in this correlation was that amount of gas lost by the square root of 0.6 hours (the square root of 0.36 hours). By knowing the total gas given up by the sample after canistering (i.e., the total gas desorbed) a hypothetical rate of lost-gas could be calculated using the a regression line:

lost gas rate per square root of 0.36 hours = 0.1241 X (total gas desorbed in ccs) + 48.14

Once the hypothetical lost-gas rate was calculated, the lost gas could be calculated by taking the square root of the bottom-hole to canister time (derived from subtracting the lag time from the surface time), and multiplying it times the hypothetical lost-gas rate. Analysis of the lithology of the cuttings used in this correlation revealed no consistent relationship (see Figure 3), therefore further refinement of the relationship of the rate of lost gas to the total gas desorbed after canistering is not possible.

"Lithologic Component Sensitivity Analyses" (Figures 4-6)
The rapidity of penetration of an air-drilled well makes collection of unmixed 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, 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 7)

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 8)

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

Two samples of the Weir-Pittsburg coal (1024' to 1028' depth) in the #D4-33 Mustain well were taken. These samples were respectively labeled 1023'-1026' and 1035'-1038'. The former sample was likely collected as the drill bit penetrated the coal, whereas the latter sample likely represents a substantial caving of that zone. Both samples have virtually identical gas contents at approximately 3 scf/ton for the accompanying shales, which substantially boosts confidence in the gas-content results for this zone, as well as the assumption that shales that are not high-gamma ray shales at this depth indeed desorption about 3 scf/ton. The exact intersection of both analyses occurs at 300.7 scf/ton for the coal and 3.4 scf/ton for the accompanying shale.

After desorption finished, slight leaks were detected in the canisters containing the Bluejacket coal (1084'-1086' depth) from the Mustain #D4-33 well and in the Weir-Pittsburg coal (1102'-1106' depth) from the Mustain #C3-33 well. Gas contents obtained for these analyses should therefore be considered minimum gas contents.

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

FIGURE 6. Sensitivity analysis for Weir-Pittsburg coal at 1102' to 106' depth, #C3-33 Mustain.

FIGURE 7. Lithologic component sensitivity analyses for all samples.

FIGURE 8. Desorption graph for all samples.

Correlation of Field Barometer to KGS Petrophysics Lab Barometer

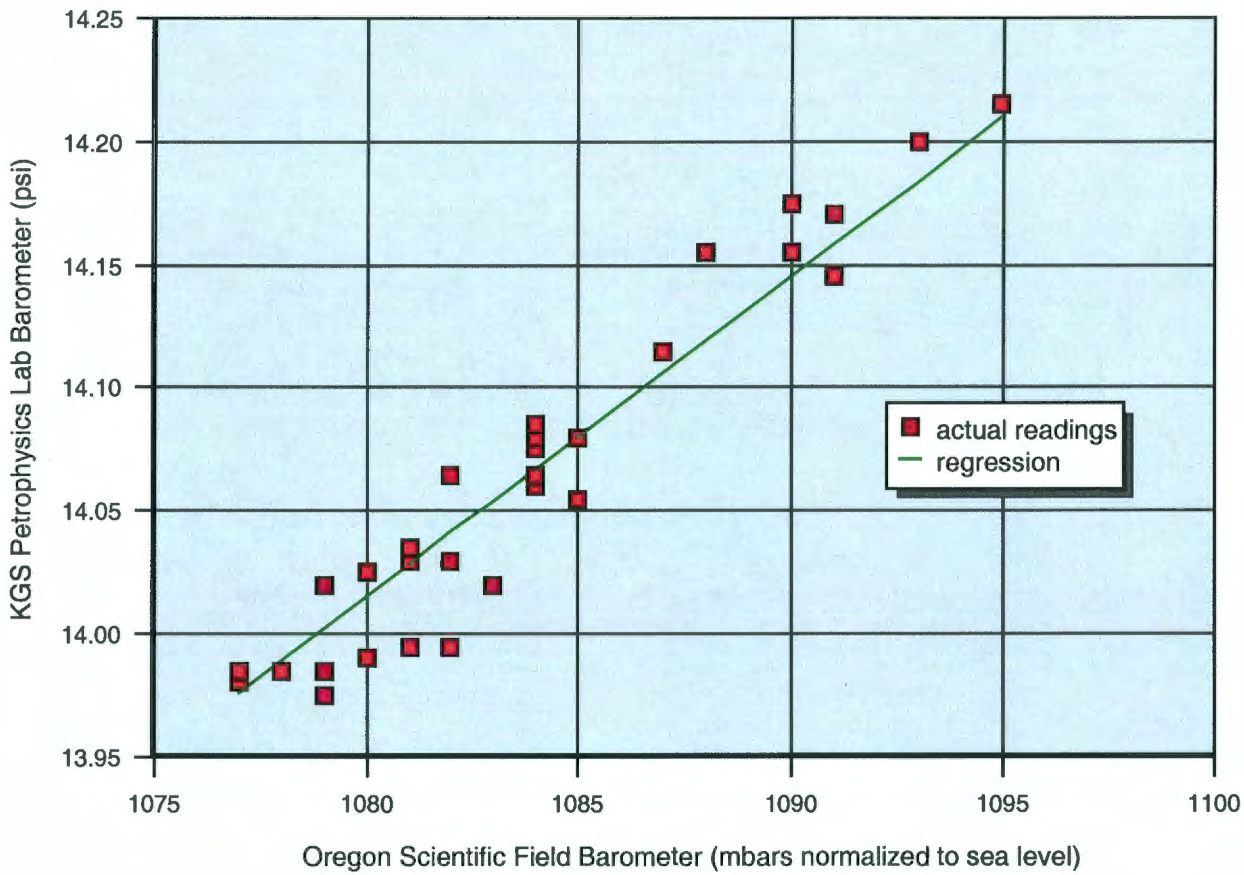


FIGURE 1.

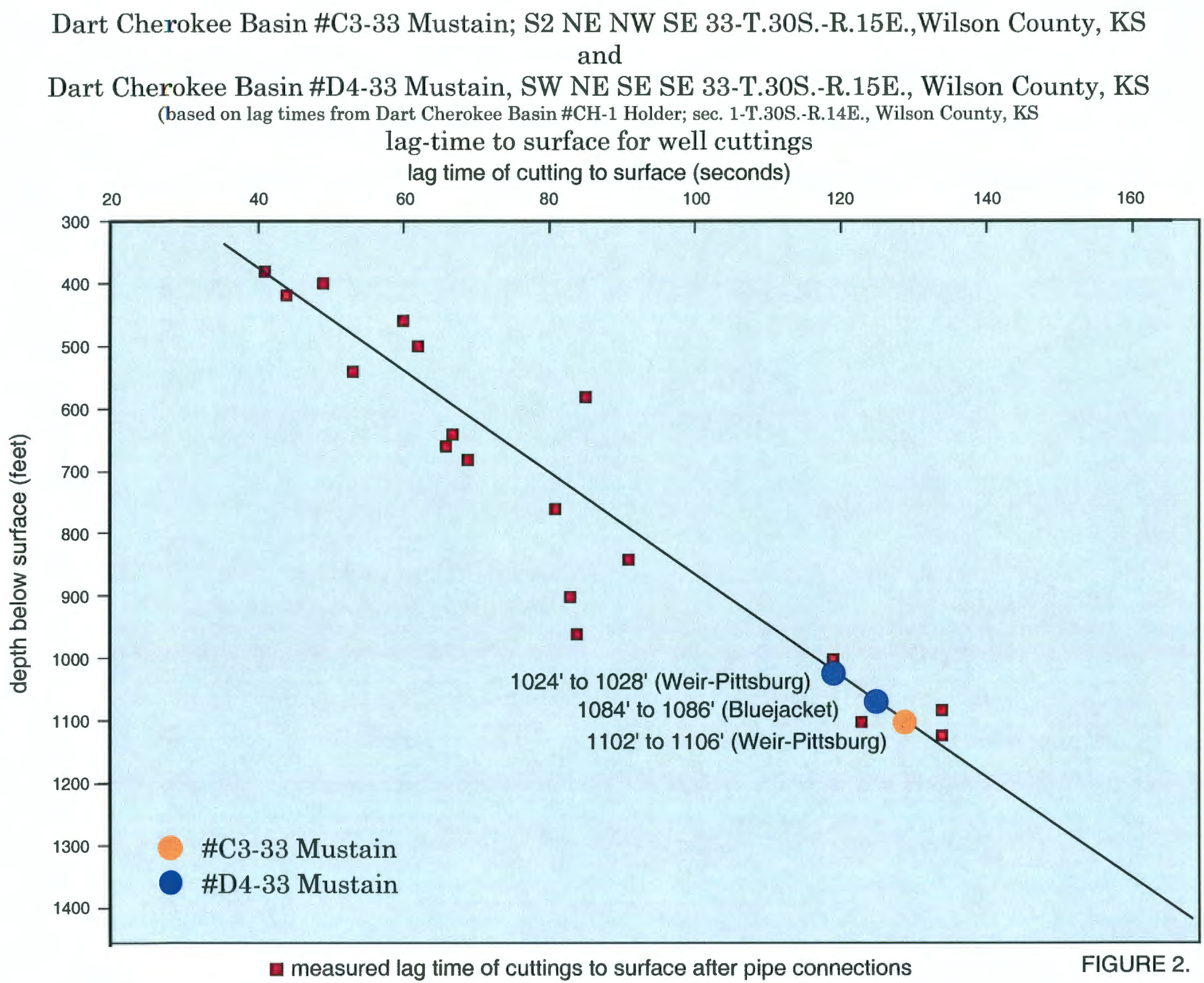

Dart Cherokee Basin #C3-33 Mustain; S2 NE NW SE 33-T.30S.-R.15E.,Wilson County, KS
and
Dart Cherokee Basin #D4-33 Mustain, SW NE SE SE 33-T.30S.-R.15E., Wilson County, KS
(based on lag times from Dart Cherokee Basin #CH-1 Holder; sec. 1-T.30S.-R.14E., Wilson County, KS
lag-time to surface for well cuttings
lag time of cutting to surface (seconds)
20
40
60
80
100
120
140
160
depth below surface (feet)
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1024' to 1028' (Weir-Pittsburg)
1084' to 1086' (Bluejacket)
1102' to 1106' (Weir-Pittsburg)
#C3-33 Mustain
#D4-33 Mustain
measured lag time of cuttings to surface after pipe connections

FIGURE 2.

TABLE 1 -- Desorption data for DART CHEROKEE BASIN MUSTAIN #D4-33; SW NE SE SE 33-T.30S.-R.15E., Wilson Co. KS.

SAMPLE: sample labeled "1023' to 1026'" (Weir-Pittsburg coal at 1024' to 1026') cuttings in Dart SSD canister

NOTE: los gas is estimated by time interval between at surface and canister times, and total gas evolved

	lbs.	grams
dry sample weight:	0.3609	163.70

est. lost gas (cc) =	TIME OF: off bottom	at surface	in canister	elapsed time (off bottom to canistering)
33	4/14/04 14:48	4/14/04 14:50	4/14/04 14:54	5.5 minutes
				0.092 hours
				0.302765035 SQRT (hrs)

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		SCF/TON	SCF/TON			TIME SINCE		
measured cc	measured T (F)	measured P	cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	cubic ft (@STP)	cc (@STP)	without lost gas	with lost gas	TIME OF MEASURE		off bottom	in canister	SQRT hrs. (since off bottom)
246	66	1076	0.0088	526	13.986	0.008225862	232.93	0.008225862	232.93	45.59	52.05	4/15/04	20:50	30:01:30	29:56:00	5.479507277
53	68	1078	0.0019	528	13.992	0.001754543	49.68	0.009980405	282.61	55.31	61.77	4/16/04	13:58	47:09:30	47:04:00	6.867192536
41	71	1081	0.0014	531	14.031	0.001353375	38.32	0.01133378	320.94	62.81	69.27	4/17/04	19:37	76:48:30	76:43:00	8.764036361
28	71	1079	0.001	531	14.005	0.000922546	26.12	0.012258326	347.06	67.92	74.38	4/18/04	16:08	97:19:30	97:14:00	9.86534338
15	68	1088	0.0005	528	14.122	0.000501175	14.19	0.012757501	361.25	70.70	77.16	4/19/04	14:09	119:20:30	119:15:00	10.92436116
23	71	1071	0.0008	531	13.901	0.000752187	21.30	0.013509688	382.55	74.87	81.33	4/20/04	13:03	142:14:30	142:09:00	11.92651109
12	68	1075	0.0004	528	13.953	0.000396149	11.22	0.013905838	393.77	77.06	83.52	4/21/04	13:19	166:30:30	166:25:00	12.90381081
8	66	1080	0.0003	526	14.018	0.000265328	7.51	0.014171166	401.28	78.54	84.99	4/22/04	18:20	193:31:30	193:26:00	13.91132632
2	66	1088	7E-05	526	14.122	6.70774E-05	1.90	0.014238243	403.18	78.91	85.37	4/23/04	14:25	215:36:30	215:31:00	14.68360764
11	69	1078	0.0004	529	13.992	0.000363462	10.29	0.014601705	413.47	80.92	87.38	4/24/04	12:15	237:26:30	237:21:00	15.40914231
3	66	1090	0.0001	526	14.148	0.000100801	2.85	0.014702506	416.33	81.48	87.94	4/26/04	11:21	284:32:30	284:27:00	16.86836289
5	65	1087	0.0002	525	14.109	0.000167859	4.75	0.014870365	421.08	82.41	88.87	4/27/04	12:36	309:47:30	309:42:00	17.6008996
11	68	1072	0.0004	528	13.914	0.000362124	10.25	0.015232488	431.33	84.42	90.88	4/28/04	15:33	336:44:30	336:39:00	18.35052225
3	68	1079	0.0001	528	14.005	9.94059E-05	2.81	0.015331894	434.15	84.97	91.43	4/29/04	14:34	359:45:30	359:40:00	18.96729642
0	66	1086	0	526	14.096	0	0.00	0.015331894	434.15	84.97	91.43	5/1/04	17:50	411:01:30	410:56:00	20.2737515
2	64	1084	7E-05	524	14.070	6.70859E-05	1.90	0.01539898	436.05	85.34	91.80	5/3/04	18:49	460:00:30	459:55:00	21.44780486
5	56	1081	0.0002	528	14.031	0.000166615	4.72	0.015585595	440.77	86.26	92.72	5/5/04	9:40	498:51:30	498:46:00	22.33513674
5	69	1079	0.0002	529	14.005	0.000165363	4.68	0.015730958	445.45	87.18	93.64	5/6/04	10:57	524:08:30	524:03:00	22.89414044
3	71	1084	0.0001	531	14.070	9.93023E-05	2.81	0.01583026	448.26	87.73	94.19	5/7/04	13:32	550:43:30	550:38:00	23.46753076
4	70	1080	0.0001	530	14.018	0.000132163	3.74	0.015962424	452.00	88.46	94.92	5/6/04	14:29	575:40:30	575:35:00	23.99322821
4	71	1078	0.0001	531	13.992	0.00013167	3.73	0.016094094	455.73	89.19	95.65	5/9/04	19:56	805:07:30	605:02:00	24.59928861
1	71	1081	4E-05	531	14.031	3.30092E-05	0.93	0.016127103	456.67	89.37	95.83	5/10/04	13:53	823:04:30	622:59:00	24.96147031
4	71	1077	0.0001	531	13.979	0.000131548	3.73	0.016258651	460.39	90.10	96.56	5/11/04	14:13	647:24:30	847:19:00	25.44422004
3	72	1076	0.0001	532	13.966	9.83841E-05	2.79	0.016357035	463.18	90.65	97.11	5/12/04	10:38	667:49:30	687:44:00	25.84231027
0	72	1081	0	532	14.031	0	0.00	0.016357035	463.18	90.65	97.11	5/13/04	14:26	695:37:30	695:32:00	26.37470379
-8	65	1088	-0.0003	525	14.122	-0.000268821	-7.61	0.016088214	455.57	89.16	95.62	5/15/04	23:25	752:36:30	752:31:00	27.43370798
4	68	1082	0.0001	528	14.044	0.00013291	3.76	0.016221124	459.33	89.90	96.35	5/17/04	9:37	786:48:30	786:43:00	28.05010398
2	70	1083	7E-05	530	14.057	8.82652E-05	1.88	0.016287389	461.21	90.26	96.72	5/18/04	14:34	815:45:30	815:40:00	28.56148339
6	72	1081	0.0002	532	14.031	0.000197683	5.60	0.016485072	466.80	91.36	97.82	5/20/04	13:53	863:04:30	662:59:00	29.37813813
6	73	1079	0.0002	533	14.005	0.000196947	5.58	0.016682019	472.38	92.45	98.91	5/21/04	13:51	887:02:30	886:57:00	29.78324473
9	72	1074	0.0003	532	13.940	0.000294604	8.34	0.016976622	480.72	94.08	100.54	5/23/04	14:59	936:10:30	936:05:00	30.59697697
3	73	1075	0.0001	533	13.953	9.61083E-05	2.78	0.017074731	483.50	94.63	101.08	5/24/04	10:24	955:35:30	955:30:00	30.91264574
0	72	1080	0	532	14.018	0	0.00	0.017074731	483.50	94.63	101.08	5/25/04	11:52	981:03:30	980:58:00	31.32185073
3	70	1075	0.0001	530	13.953	9.86636E-05	2.79	0.017173394	486.29	95.17	101.63	5/26/04	12:36	1005:47:30	1005:42:00	31.71421868
4	70	1070	0.0001	530	13.886	0.00013094	3.71	0.017304334	490.00	95.90	102.36	5/27/04	11:12	1028:23:30	1028:18:00	32.06854638
0	72	1078	0	532	13.992	0	0.00	0.017304334	490.00	95.90	102.36	5/28/04	13:11	1054:22:30	1054:17:00	32.47114103
6	71	1069	0.0002	531	13.875	0.000195856	5.55	0.01750019	495.55	96.98	103.44	5/29/04	14:20	1079:31:30	1079:26:00	32.85612576
4	71	1067	0.0001	531	13.849	0.000130327	3.69	0.017630517	499.24	97.71	104.16	5/30/04	12:48	1101:59:30	1101:54:00	33.19625983
-1	70	1077	-4E-05	530	13.979	-3.29491E-05	-0.93	0.017597568	498.31	97.52	103.98	6/1/04	10:49	1148:00:30	1147:55:00	33.88227167
-3	70	1085	-0.0001	530	14.083	-9.95814E-05	-2.82	0.017497986	495.49	96.97	103.43	6/2/04	13:35	1174:46:30	1174:41:00	34.27499088
-2	70	1090	-7E-05	530	14.148	-6.66935E-05	-1.89	0.017431293	493.60	96.60	103.06	6/3/04	11:13	1198:24:30	1196:19:00	34.58913606
3	71	1087	0.0001	531	14.109	9.95771E-05	2.82	0.01753087	496.42	97.15	103.61	6/4/04	13:43	1222:54:30	1222:49:00	34.97010628

DESORPTION TERMINATED 6/4/2004 DUE TO NO MORE GAS BEING EVOLVED; sample oven dried for 5 days

SAMPLE: sample labeled "1035' to 1038'" (Weir-Pittsburg coal at 1024' to 1026') cuttings in Dart SSD canister

NOTE: los gas is estimated by time interval between at surface and canister times, and total gas evolved

	lbs.	grams
dry sample weight:	0.1026	46.522

est. lost gas (cc) =	TIME OF: off bottom	at surface	in canister	elapsed time (off bottom to canistering)
24	4/14/04 15:01	4/14/04 15:03	4/14/04 15:05	3.8 minutes
				0.064 hours
				0.252762515 SQRT (hrs)

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		SCF/TON	SCF/TON			TIME SINCE		
measured cc	measured T (F)	measured P	cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	cubic ft (@STP)	cc (@STP)	without lost gas	with lost gas	TIME OF MEASURE		off bottom	in canister	SQRT hrs. (since off bottom)
203	66	1076	0.0072	526	13.986	0.006733266	190.66	0.006733266	190.66	131.30	147.83	4/15/04	20:53	29:51:40	29:47:50	5.464532104
41	68	1078	0.0014	528	13.992	0.001357266	38.43	0.008090554	229.10	157.77	174.29	4/16/04	13:59	48:57:40	46:53:50	6.85281775
33	71	1081	0.0012	531	14.031	0.001069302	30.65	0.009179856	259.94	179.01	195.53	4/17/04	19:37	78:35:40	76:31:50	8.751825206
20	71	1079	0.0007	531	14.005	0.000658962	16.65	0.009838817	276.80	191.86	208.38	4/18/04	16:08	97:06:40	97:02:50	9.854496999
10	68	1088	0.0004	528	14.122	0.000334117	9.46	0.010172934	288.06	198.37	214.90	4/19/04	14:09	119:07:40	119:03:50	10.91456723

19	71	1071	0.0007	531	13.901	0.000821372	17.60	0.010794306	305.66	210.49	227.02	4/20/04	13:04	142:02:40	141:58:50	11.91823999
8	68	1075	0.0003	528	13.953	0.0002641	7.48	0.011058406	313.14	215.64	232.17	4/21/04	13:20	166:18:40	166:14:50	12.89816653
6	68	1080	0.0002	528	14.018	0.000196996	5.63	0.011257402	318.77	219.52	238.05	4/22/04	18:20	193:18:40	193:14:50	13.90383661
0	66	1088	0	526	14.122	0	0.00	0.011257402	318.77	219.52	238.05	4/23/04	14:25	215:23:40	215:19:50	14.67632258
10	69	1078	0.0004	529	13.992	0.00033042	9.36	0.011587622	328.13	225.96	242.49	4/24/04	12:15	237:13:40	237:09:50	15.40220042
2	66	1090	7E-05	526	14.148	6.72007E-05	1.90	0.011655022	330.03	227.27	243.80	4/26/04	11:21	284:19:40	284:15:50	16.86202176
4	65	1087	0.0001	525	14.109	0.000134287	3.80	0.011789309	333.83	229.89	246.42	4/27/04	12:37	309:35:40	309:31:50	17.59529609
11	68	1072	0.0004	528	13.914	0.000362124	10.25	0.012151433	344.09	238.95	253.48	4/28/04	15:33	336:31:40	338:27:50	18.34469345
2	68	1079	7E-05	528	14.005	6.62708E-05	1.88	0.012217703	345.97	238.25	254.77	4/29/04	14:34	359:32:40	359:28:50	18.96165722
-1	66	1086	-4E-05	526	14.098	-3.34771E-05	-0.95	0.012184226	345.02	237.59	254.12	5/1/04	17:51	410:49:40	410:45:50	20.26888694
0	64	1084	0	524	14.070	0	0.00	0.012184226	345.02	237.59	254.12	5/3/04	18:50	459:48:40	459:44:50	21.44320664
4	66	1081	0.0001	526	14.031	0.000133292	3.77	0.012317518	348.79	240.19	256.72	5/5/04	9:40	498:38:40	498:34:50	22.33034806
4	69	1079	0.0001	529	14.005	0.000132291	3.75	0.012449809	352.54	242.77	259.30	5/8/04	10:57	523:55:40	523:51:50	22.88946871
2	71	1084	7E-05	531	14.070	6.62015E-05	1.87	0.01251601	354.41	244.06	260.59	5/7/04	13:32	550:30:40	550:28:50	23.46297319
4	70	1080	0.0001	530	14.018	0.000132163	3.74	0.012648173	358.16	246.64	263.17	5/8/04	14:30	575:28:40	575:24:50	23.9891179
3	71	1078	0.0001	531	13.992	9.87528E-05	2.80	0.012746926	380.95	248.57	265.09	5/9/04	19:57	604:55:40	604:51:50	24.59527958
1	71	1081	4E-05	531	14.031	3.30092E-05	0.93	0.012779935	361.89	249.21	265.74	5/10/04	13:53	622:51:40	622:47:50	24.95718556
4	71	1077	0.0001	531	13.979	0.000131548	3.73	0.012911483	365.61	251.77	268.30	5/11/04	14:14	847:12:40	647:08:50	25.44034416
3	72	1076	0.0001	532	13.968	9.83841E-05	2.79	0.013009867	368.40	253.69	270.22	5/12/04	10:39	667:37:40	667:33:50	25.83849411
-1	72	1081	-4E-05	532	14.031	-3.29471E-05	-0.93	0.01297692	367.46	253.05	269.58	5/13/04	14:28	695:24:40	695:20:50	26.37064867
-9	65	1088	-0.0003	525	14.122	-0.000302423	-8.56	0.012874497	358.90	247.15	263.68	5/15/04	23:27	752:25:40	752:21:50	27.43041702
4	68	1082	0.0001	528	14.044	0.00013291	3.76	0.012807407	362.66	249.74	266.27	5/17/04	9:38	786:36:40	786:32:50	28.04658823

DESORPTION TERMINATED 5/17/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 9 days

SAMPLE: 1083' to 1086' (Bluejacket coal) cuttings in Dart SSD canister

	lbs.	grams
dry sample weight:	0.2456	111.39

NOTE: los gas is estimated by time interval between at surface and canister times, and total gas evolved

est. lost gas (cc) =	TIME OF:						elapsed time (off bottom to canistering)
17	off bottom		at surface		in canister		4.0 minutes
	4/14/04	15:33	4/14/04	15:35	4/14/04	15:37	0.067 hours
							0.258196890 SQRT (hrs)

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		SCF/TON	SCF/TON			TIME SINCE		
measured cc	measured T (F)	measured P	cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	cubic ft (@STP)	cc (@STP)	without lost gas	with lost gas	TIME OF MEASURE		off bottom	in canister	SQRT hrs. (since off bottom)
105	66	1076	0.0037	526	13.986	0.003482724	98.62	0.003482724	98.62	28.36	33.25	4/15/04	20:56	29:22:45	29:18:45	5.420255222
13	68	1078	0.0005	528	13.992	0.00043036	12.19	0.003913083	110.81	31.87	36.78	4/16/04	13:59	48:25:45	46:21:45	6.813895117
14	71	1081	0.0005	531	14.031	0.000462128	13.09	0.004375211	123.89	35.63	40.52	4/17/04	19:38	78:04:45	78:00:45	8.722337225
9	71	1079	0.0003	531	14.005	0.000296533	8.40	0.004671744	132.29	38.05	42.94	4/18/04	16:09	96:35:45	96:31:45	9.82831793
1	68	1088	4E-05	528	14.122	3.34117E-05	0.95	0.004705158	133.23	38.32	43.21	4/19/04	14:10	118:38:45	118:32:45	10.8909366
10	71	1071	0.0004	531	13.901	0.000327038	9.26	0.005032194	142.50	40.98	45.87	4/20/04	13:04	141:30:45	141:28:45	11.89590286
1	68	1075	4E-05	528	13.953	3.30124E-05	0.93	0.005065206	143.43	41.25	46.14	4/21/04	13:20	185:46:45	185:42:45	12.87552588
-1	68	1080	-4E-05	528	14.018	-3.3166E-05	-0.94	0.00503204	142.49	40.98	45.87	4/22/04	18:21	192:47:45	192:43:45	13.88509393
-4	66	1088	-0.0001	528	14.122	-0.000134155	-3.80	0.004897885	138.69	39.89	44.78	4/23/04	14:26	214:52:45	214:48:45	14.65875734
4	69	1078	0.0001	529	13.992	0.000132168	3.74	0.005030053	142.43	40.97	45.88	4/24/04	12:16	236:42:45	236:38:45	15.38546392
-5	66	1090	-0.0002	526	14.148	-0.000168002	-4.76	0.004862052	137.68	39.60	44.49	4/26/04	11:22	283:48:45	283:44:45	16.84673559

DESORPTION TERMINATED 4/26/2004 DUE TO NO MORE GAS BEING EVOLVED; SLIGHT LEAK IN CANISTER DETECTED (gas content therefore in considered a minimum value); sample air dried for 28 days

TABLE 2 – Desorption data for DART CHEROKEE BASIN MUSTAIN #C3-33; S2 NE NW SE 33-T.30S.-R.15E., Wilson County, KS

SAMPLE: 1102' to 1106' (Weir-Pittsburg coal) cuttings in Dart SSD canister

	lbs.	grams
dry sample weight:	0.6160	279.43

NOTE: los gas is estimated by time interval between at surface and canister times, and total gas evolved

est. lost gas (cc) = 17

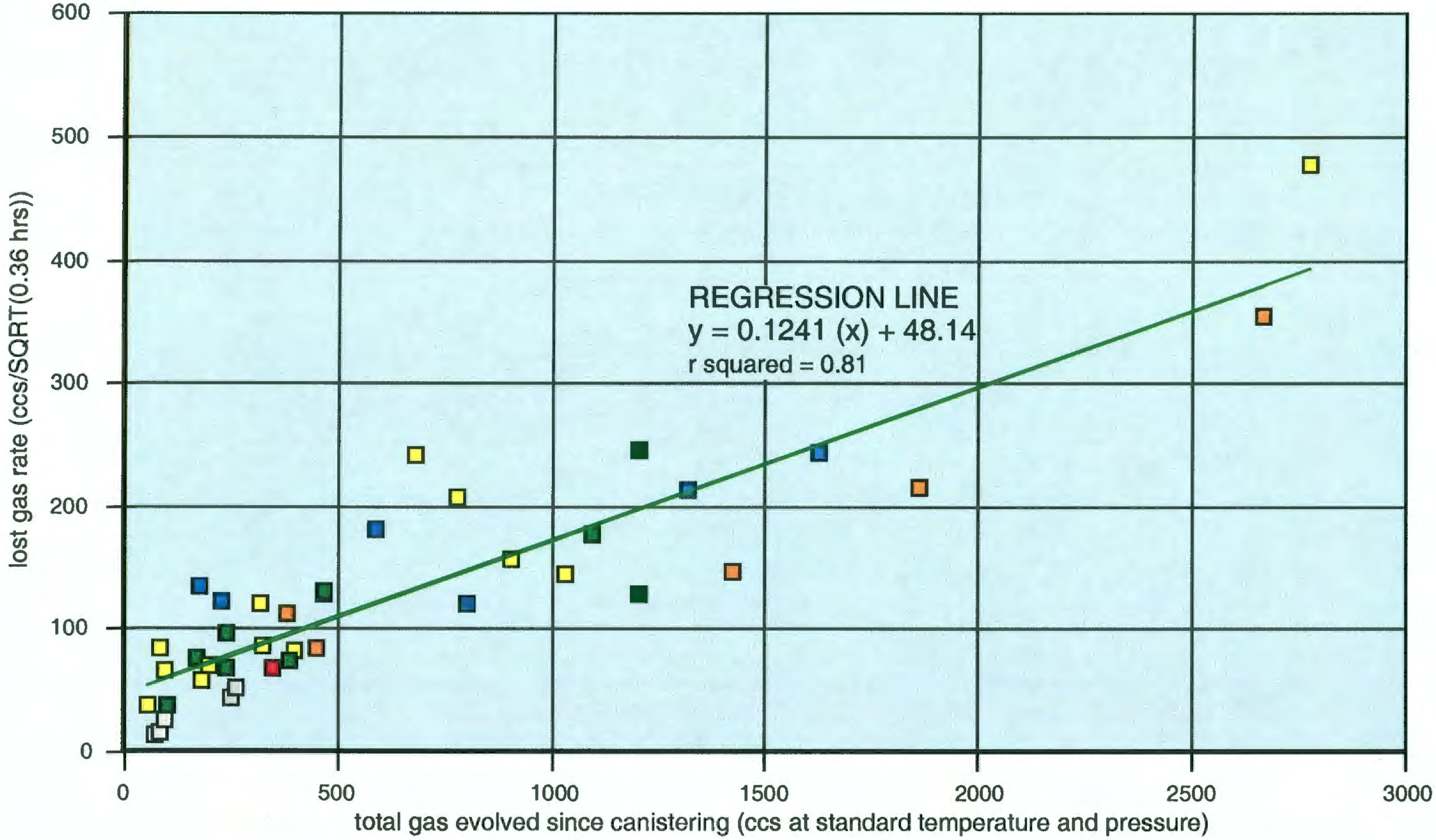
TIME OF:	off bottom	at surface	in canister
	4/14/04 19:29	4/14/04 19:32	4/14/04 19:33

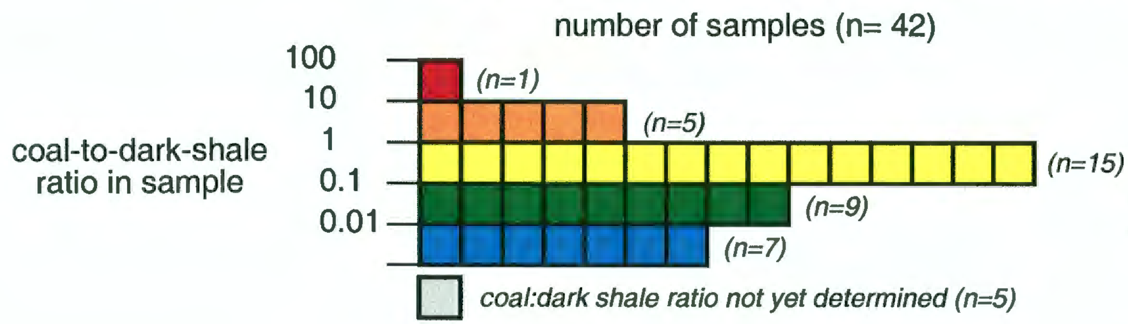
elapsed time (off bottom to canistering): 3.7 minutes; 0.061 hours; 0.247206616 SQRT (hrs)

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		SCF/TON	SCF/TON			TIME SINCE		
measured cc	measured T (F)	measured P	cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	cubic ft (@STP)	cc (@STP)	without lost gas	with lost gas	TIME OF MEASURE		off bottom	in canister	SQRT hrs. (since off bottom)
120	66	1076	0.0042	526	13.966	0.003980256	112.71	0.003980256	112.71	12.92	14.87	4/15/04	20:58	25:28:10	25:24:30	5.046726111
18	68	1078	0.0006	528	13.992	0.000595882	16.87	0.004576138	129.58	14.86	16.81	4/16/04	14:00	42:30:10	42:26:30	6.519415448
15	71	1081	0.0005	531	14.031	0.000495137	14.02	0.005071275	143.60	16.46	18.41	4/17/04	19:38	72:08:10	72:04:30	8.493298011
9	71	1079	0.0003	531	14.005	0.000296533	8.40	0.005367808	152.00	17.43	19.38	4/18/04	16:09	92:39:10	92:35:30	9.625631292
2	68	1088	7E-05	528	14.122	6.68233E-05	1.89	0.005434632	153.89	17.64	19.59	4/19/04	14:10	114:40:10	114:36:30	10.70838197
10	71	1071	0.0004	531	13.901	0.000327038	9.26	0.005761669	163.15	18.71	20.65	4/20/04	13:05	137:35:10	137:31:30	11.72971061
2	68	1075	7E-05	528	13.953	6.60249E-05	1.87	0.005827694	165.02	18.92	20.87	4/21/04	13:21	161:51:10	161:47:30	12.72213731
0	68	1080	0	528	14.018	0	0.00	0.005827694	165.02	18.92	20.87	4/22/04	16:21	188:51:10	188:47:30	13.74237162
-2	66	1088	-7E-05	526	14.122	-6.70774E-05	-1.90	0.005760617	163.12	18.70	20.65	4/23/04	14:26	210:56:10	210:52:30	14.52363973
4	69	1078	0.0001	529	13.992	0.000132188	3.74	0.005892785	166.86	19.13	21.08	4/24/04	12:16	232:46:10	232:42:30	15.25678356
-4	66	1090	-0.0001	526	14.148	-0.000134401	-3.81	0.005758383	163.06	18.69	20.64	4/26/04	11:22	279:52:10	279:48:30	16.72929898
0	65	1087	0	525	14.109	0	0.00	0.005758383	163.06	18.69	20.64	4/27/04	12:37	305:07:10	305:03:30	17.46766855
5	68	1072	0.0002	528	13.914	0.000164602	4.88	0.005922985	167.72	19.23	21.18	4/28/04	15:33	332:03:10	331:59:30	18.22231538
-2	68	1079	-7E-05	528	14.005	-6.62706E-05	-1.88	0.005656715	165.84	19.01	20.96	4/29/04	14:35	355:05:10	355:01:30	18.84372869
-1	66	1086	-4E-05	528	14.096	-3.34771E-05	-0.95	0.005823237	164.90	18.91	20.85	5/1/04	17:51	406:21:10	406:17:30	20.15819381

DESORPTION TERMINATED 5/2/2004 DUE TO NO MORE GAS BEING EVOLVED; SLIGHT LEAK IN CANISTER DETECTED (gas content therefore in considered a minimum value); sample air dried for 24 days

RELATIONSHIP of TOTAL GAS EVOLVED FROM a CUTTINGS SAMPLE to RATE of LOST-GAS
(from 42 cuttings samples from air-drilled wells, Cherokee basin, southeastern Kansas)





LOST-GAS ALGORITHM

ccs lost gas = $\sqrt{X}$ (Y)

where X = bottom-hole to canister time (in hours)
where Y = ccs lost gas at 0.36 hours
(i.e., value Y from regression equation)

FIGURE 3.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D4-33 Mustain, SW NE SE SE 33-T.30S.-R.15E., Wilson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of two samples of Weir-Pittsburg coal from 1024' to 1028' (samples labeled at well site as "1023 to 1026'" and "1035' to 1038'")

1023-1026' sample; total gas desorbed (including estimated lost gas) = 532.2 ccs

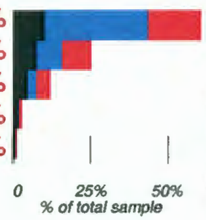
TOTAL DRY WEIGHT OF SAMPLE = 240.39 grams

$weight_{light\text{-}colored\ lithologies}$ = 76.69 grams (31.9%)

$weight_{dark\ shale}$ = 108.21 grams (45.0%)

$weight_{coal}$ = 55.49 grams (23.1%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	143.82	16.05% / 55.35% / 28.60%
>0.0661"	59.05	29.06% / 33.77% / 37.17%
>0.0460"	28.23	37.07% / 25.37% / 37.56%
>0.0331"	6.54	52.08% / 14.58% / 33.33%
<0.0331"	2.74	50.00% / 20.00% / 30.00%
	240.39 TOTAL	



1035-1038' sample; total gas desorbed (including estimated lost gas) = 392.4 ccs

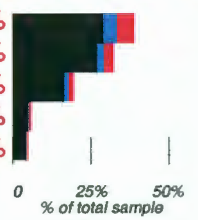
TOTAL DRY WEIGHT OF SAMPLE = 52.22 grams

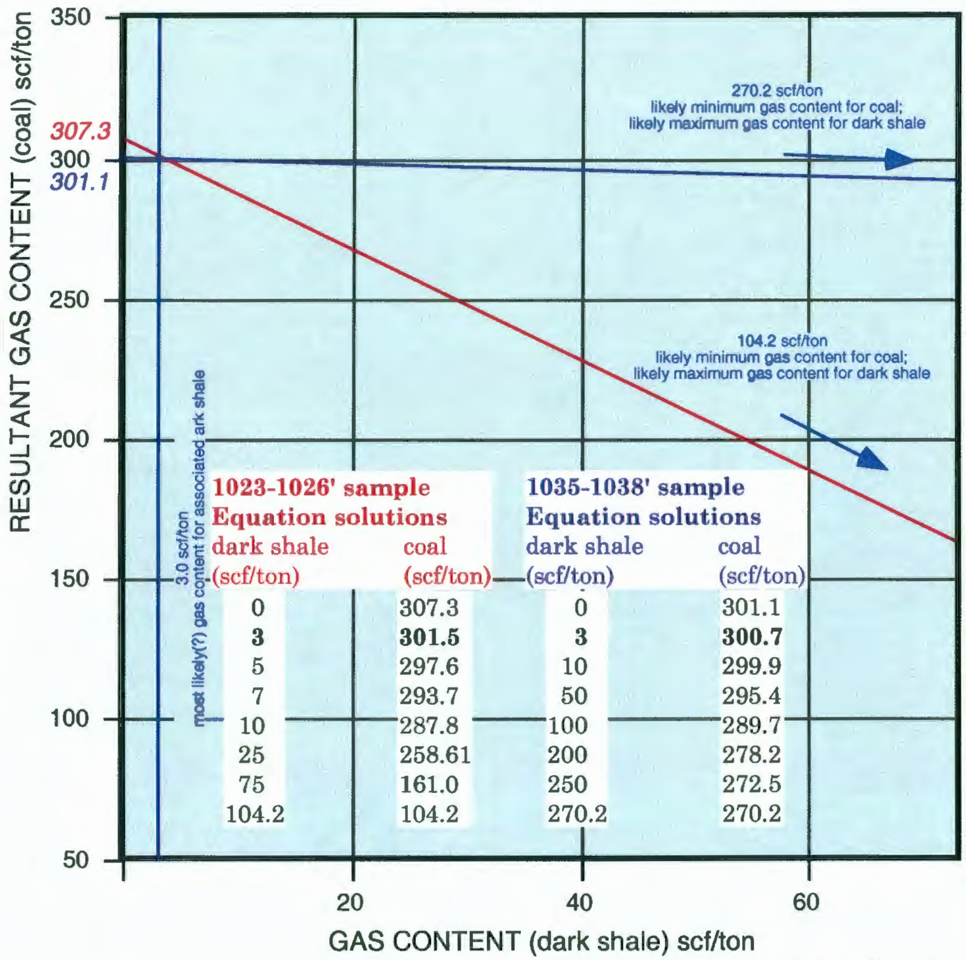
$weight_{light\text{-}colored\ lithologies}$ = 5.70 grams (10.9%)

$weight_{dark\ shale}$ = 4.77 grams (9.1%)

$weight_{coal}$ = 41.76 grams (80.0%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	20.11	73.86% / 11.42% / 14.72%
>0.0661"	16.62	83.08% / 7.41% / 9.51%
>0.0460"	10.04	83.84% / 7.86% / 8.30%
>0.0331"	2.98	82.32% / 10.98% / 6.71%
<0.0331"	2.46	90.00% / 5.00% / 5.00%
	52.22 TOTAL	





1023-1026' sample Equation solutions

dark shale (scf/ton)	coal (scf/ton)
0	307.3
3	**301.5**
5	297.6
7	293.7
10	287.8
25	258.61
75	161.0
104.2	104.2

1035-1038' sample Equation solutions

dark shale (scf/ton)	coal (scf/ton)
0	301.1
3	**300.7**
10	299.9
50	295.4
100	289.7
200	278.2
250	272.5
270.2	270.2

FIGURE 4.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D4-33 Mustain, SW NE SE SE 33-T.30S.-R.15E., Wilson County, KS

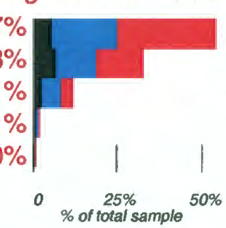
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Bluejacket coal from 1084' to 1086'
(gas contents should be considered a minimum, due to slight leak in desorption canister)

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

total gas desorbed
(including estimated lost gas) = 159.4 ccs

TOTAL DRY WEIGHT OF SAMPLE = 210.59 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 99.20 grams (47.1%)
$\text{weight}_{dark\ shale}$ = 80.87 grams (38.4%)
weight_{coal} = 30.52 grams (14.5%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	112.84	9.48% / 36.65% / 53.87%
>0.0661"	68.16	20.00% / 36.92% / 43.08%
>0.0460"	24.71	19.19% / 49.49% / 31.31%
>0.0331"	3.57	25.81% / 48.39% / 25.81%
<0.0331"	1.31	40.00% / 30.00% / 30.00%
	210.59 TOTAL	



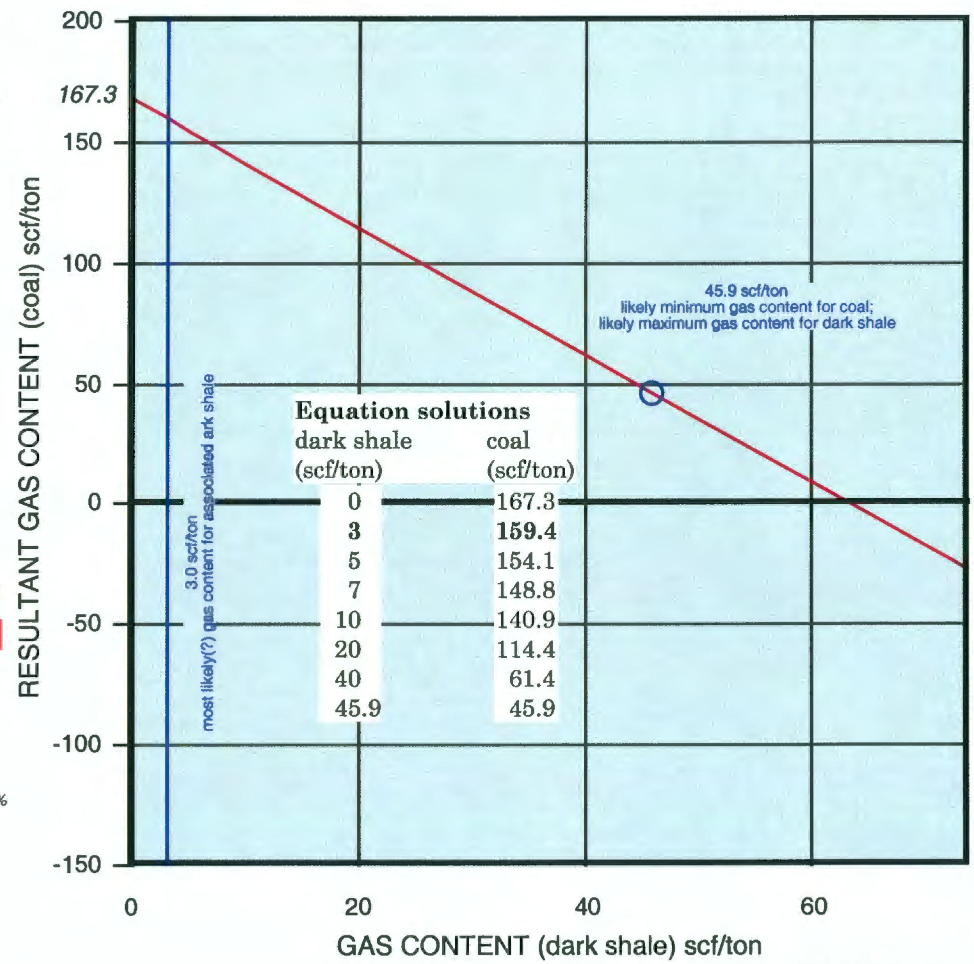


FIGURE 5.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #C3-33 Mustain; S2 NE NW SE 33-T.30S.-R.15E.,Wilson County, KS

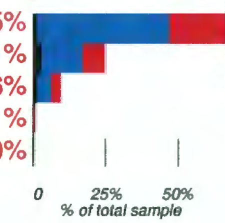
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Weir-Pittsburg coal from 1102' to 1106'
(gas contents should be considered a minimum, due to slight leak in desorption canister)

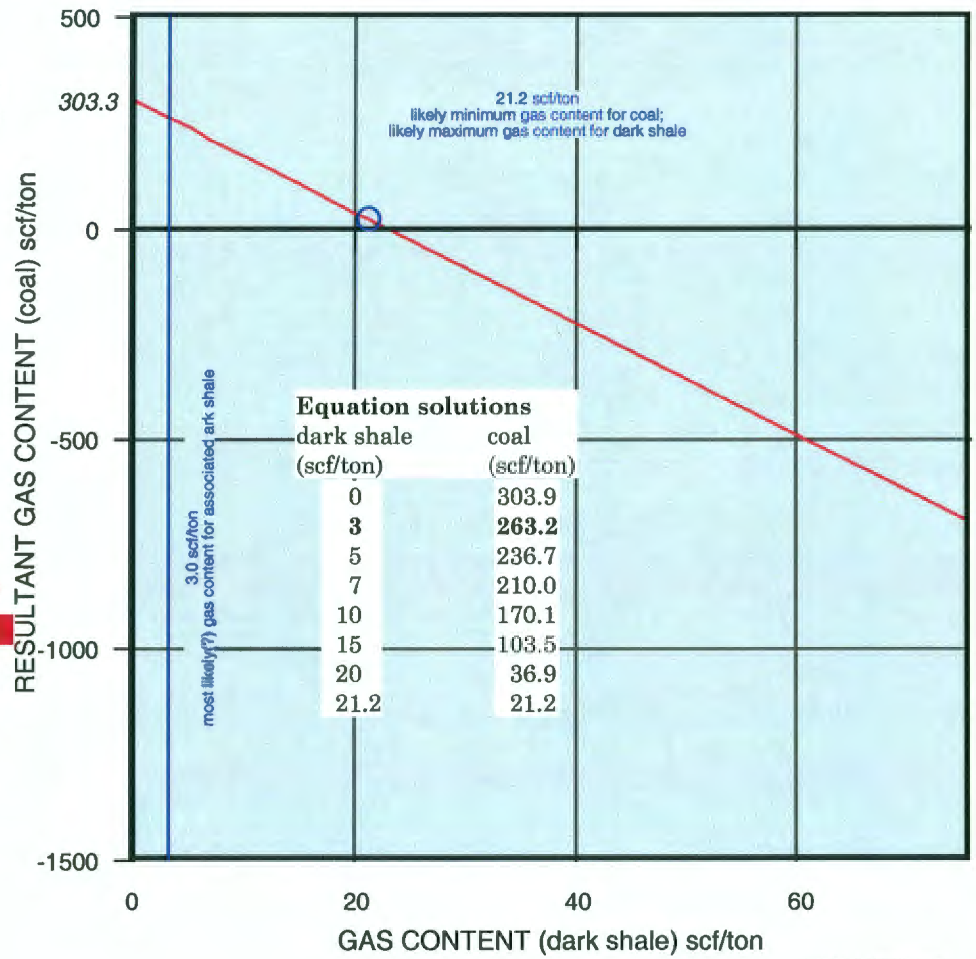
$$\text{GAS CONTENT}_{coal} = \frac{\text{total gas desorbed} - ((\text{gas content}_{dark\ shale}) * (\text{weight}_{dark\ shale}))}{\text{weight}_{coal}}$$

total gas desorbed
(including estimated lost gas) = 184.7 ccs

TOTAL DRY WEIGHT OF SAMPLE = 401.02 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 121.59 grams (30.3%)
$\text{weight}_{dark\ shale}$ = 259.92 grams (64.8%)
weight_{coal} = 19.51 grams (4.9%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	262.88	1.53% / 69.01% / 29.45%
>0.0661"	97.51	10.68% / 58.81% / 30.51%
>0.0460"	37.38	12.09% / 52.75% / 35.16%
>0.0331"	2.60	16.13% / 45.16% / 38.71%
<0.0331"	0.65	20.00% / 40.00% / 40.00%
	401.02 TOTAL	





Equation solutions

dark shale (scf/ton)	coal (scf/ton)
0	303.9
3	**263.2**
5	236.7
7	210.0
10	170.1
15	103.5
20	36.9
21.2	21.2

FIGURE 6.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #C3-33 Mustain; S2 NE NW SE 33-T.30S.-R.15E.,Wilson County, KS
and
Dart Cherokee Basin #D4-33 Mustain, SW NE SE SE 33-T.30S.-R.15E., Wilson County, 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
Weir-Pittsburg in Mustain #C3-33	5%	263.2	303.9	21.2
Weir-Pittsburg (1023'-1026' sample) in Mustain #D4-33	23%	301.5	307.3	104.2
Weir-Pittsburg (1035'-1038' sample) in Mustain #D4-33	80%	301.1	300.7	270.2
Bluejacket in Mustain #D4-33	15%	159.4	167.3	45.9

surface
100'
200'
300'
400'
500'
600'
700'
800'
900'
1000'
1100'
1102'-1106' Bluejacket in MUSTAIN #C3-33
1200'

MUSTAIN #C3-33

800'
900'
1000'
1024'-1028' Weir-Pittsburg in MUSTAIN #D4-33
1084'-1086' Bluejacket in MUSTAIN #D4-33
1200'

MUSTAIN #D4-33

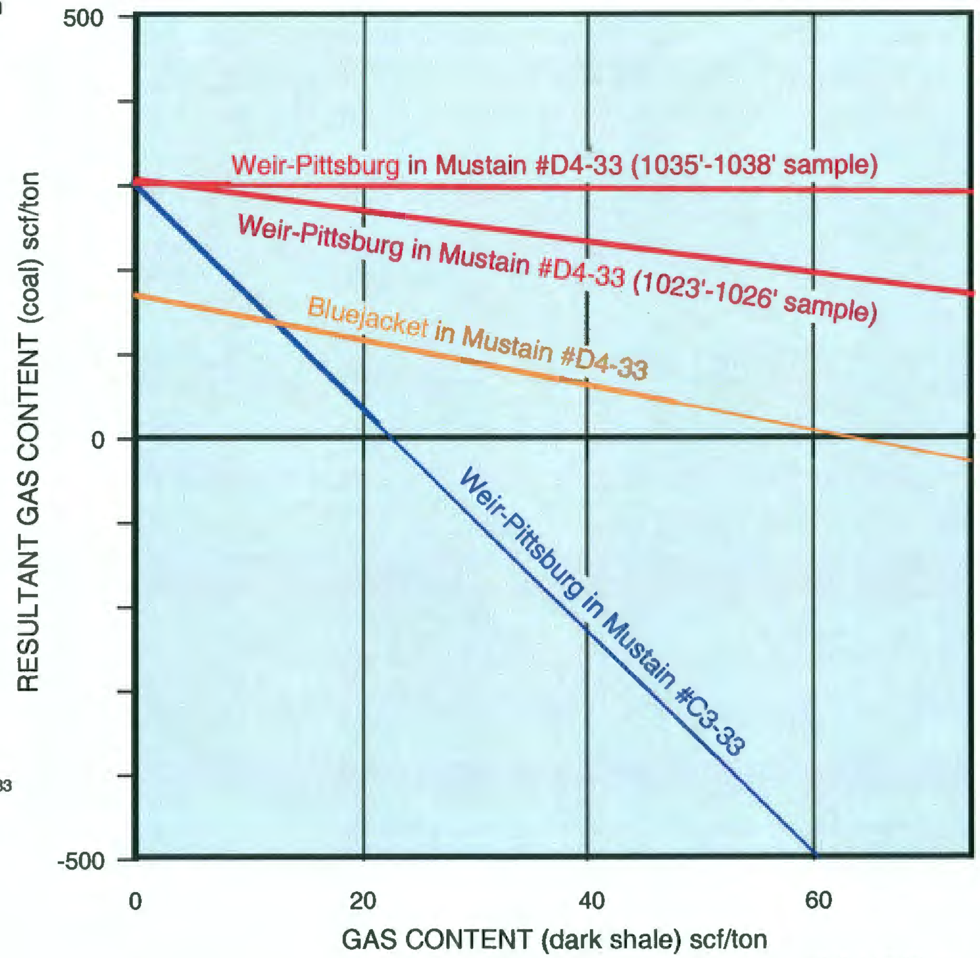


FIGURE 7.

Desorption Characteristics of Cuttings Samples

based on total weight of gas-generating lithologies (i.e., coal and dark shale) in sample
Dart Cherokee Basin #C3-33 Mustain; S2 NE NW SE 33-T.30S.-R.15E.,Wilson County, KS
and
Dart Cherokee Basin #D4-33 Mustain, SW NE SE SE 33-T.30S.-R.15E., Wilson County, KS

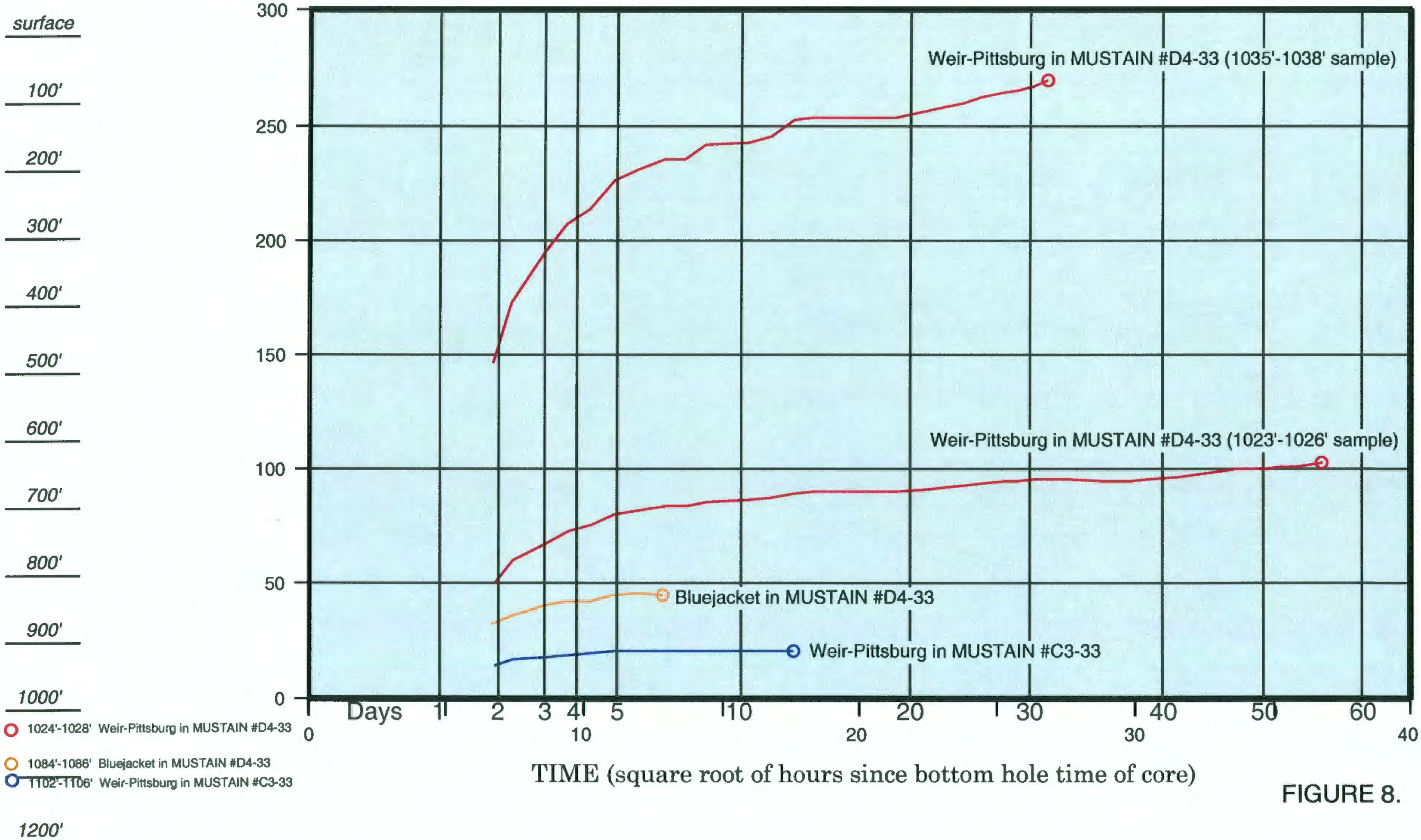


FIGURE 8.