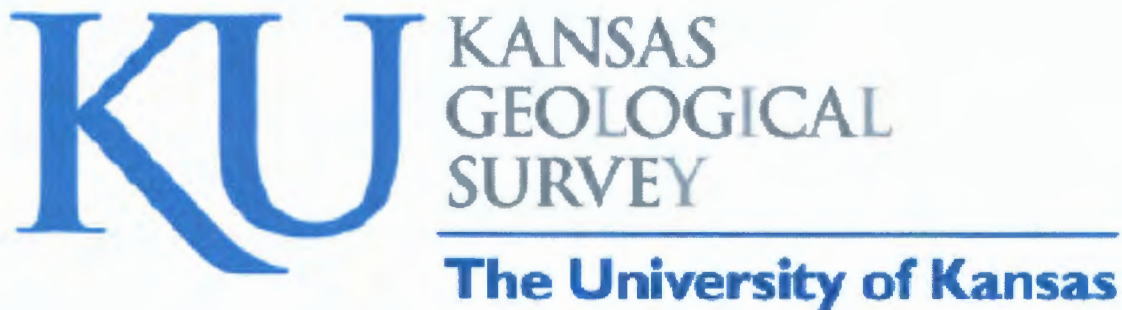


ANALYSIS OF CHEROKEE GROUP CUTTINGS SAMPLES FOR GAS CONTENT  
-- DART CHEROKEE BASIN C. BONNER #D3-7; sec. 7-T.30S.-R.14E.,  
WILSON COUNTY, KS

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## SUMMARY

Cuttings samples from the Pennsylvanian Cherokee Group were collected from the Dart Cherokee Basin C. Bonner et al. #D3-7; NW SW SE sec. 7-T.30S.-R.14E., Wilson County, KS. The samples calculate as having the following gas contents:

- Dawson coal at 789' depth<sup>1</sup> (--- scf/ton)
- Unidentified coal at 939' depth<sup>2</sup> (129 scf/ton)
- Mulberry coal at 998' depth<sup>2</sup> (94 scf/ton)
- Shale associated with "Lexington" coal at 1026' depth<sup>3</sup> (35 scf/ton)
- Mulky coal at 1096' depth<sup>1</sup> (--- scf/ton)
- Bevier coal at 1152' depth<sup>2</sup> (63 scf/ton)
- Mineral coal at 1222' depth<sup>1</sup> (--- scf/ton)
- Weir-Pittsburg coal at 1297' depth<sup>2</sup> (209 scf/ton)
- Riverton coal at 939' depth<sup>4</sup> (--- scf/ton)

<sup>1</sup>no significant coal or gas-bearing shale in sample, no significant gas evolved off sample

<sup>2</sup>assuming accompanying dark shales in sample desorb 3 scf/ton

<sup>3</sup>no significant coal in sample

<sup>4</sup>canister defective

## BACKGROUND

The Dart Cherokee Basin C. Bonner et al. #D3-7; NW SW SE sec. 7-T.30S.-R.14E., Wilson County, KS, 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 April 9, 2005, by personnel from Dart Cherokee Basin L.L.C., and turned over to LeaAnn Davidson of the Kansas Geological Survey. 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 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 lost-gas determinations) were determined by the wellsite geologist and driller.

The cuttings samples from the Pennsylvanian Cherokee Group were:

- Unidentified coal at 939' depth (136 grams)
- Mulberry coal at 998' depth (195 grams)
- Shale associated with "Lexington" coal at 1026' depth (403 grams)
- Bevier coal at 1152' depth (492 grams)
- Weir-Pittsburg coal at 1297' depth (356 grams)

If correct wellsite procedures were followed, 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 zephryn chloride biocide was then added to the canisters, with a headspace of 1 to 2 inches being preserved at the top of the canister.

Desorption measurements at the Kansas Geological Survey in Lawrence, KS 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<sup>3</sup>). 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:

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

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  $P_{\text{stp}}$ ,  $V_{\text{stp}}$ , and  $T_{\text{stp}}$ , respectively, are pressure, volume, and temperature at standard temperature and pressure, where standard temperature is degrees Rankine ( $^{\circ}\text{R} = 460 + ^{\circ}\text{F}$ ).  $P_{\text{rig}}$ ,  $V_{\text{rig}}$ , and  $T_{\text{rig}}$ , 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  $V_{\text{stp}}$  becomes:

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

The conversion calculations in the spreadsheet were carried out in the English metric system, as this is 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 air for at least a week. 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) was 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, and 4) a summary component analysis for all samples showing relative reliability of the data from 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)*

Surface and canistering times for each sample were noted by the wellsite geologist. Bottom hole time was inferred by subtracting lag time from surface time, with lag time determined from a depth-lag-time plot for a nearby well (Figure 2). 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 square-root 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 2), 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 4-8)*

The rapid penetration of an air-drilled well through relatively thin-bedded strata makes it difficult to collect lithologies that are unmixed. 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:

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

A unique solution for gas content<sub>coal</sub> in this equation is not possible because gas content<sub>dark shale</sub> 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<sub>coal</sub> 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 than 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 9)*

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<sub>coal</sub>*) for that sample. If the coal content is miniscule (i.e., < approximately 5%), the results are a better reflection of the *gas content<sub>dark shale</sub>*.

## RESULTS and DISCUSSION

The least constrained results are those from the Bevier coal at 1152'. The unidentified coal at 939' has the best constrained results. Weir-Pitt at 1297' and Mulberry at 998' have roughly comparable reliabilities (see Figure 9).

## REFERENCES

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- 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 1. Correlation of field barometer to Petrophysics Lab pressure transducer.

TABLE 1. Desorption measurements for samples.

FIGURE 2. Lag time determination for samples

FIGURE 3. Correlation of the rate of lost gas to the total gas desorbed after canistering.

FIGURE 4. Sensitivity analysis for unidentified coal at 939' depth.

FIGURE 5. Sensitivity analysis for Mulberry coal at 998' depth.

FIGURE 6. Sensitivity analysis for shale associated with "Lexington" coal at 1026' depth.

FIGURE 7. Sensitivity analysis for Bevier coal at 1152' depth.

FIGURE 8. Sensitivity analysis for Weir-Pittsburg coal at 1297' depth.

FIGURE 9. Lithologic component sensitivity analyses for all samples.  
all samples.



## Correlation of Field Barometer to KGS Petrophysics Lab Barometer

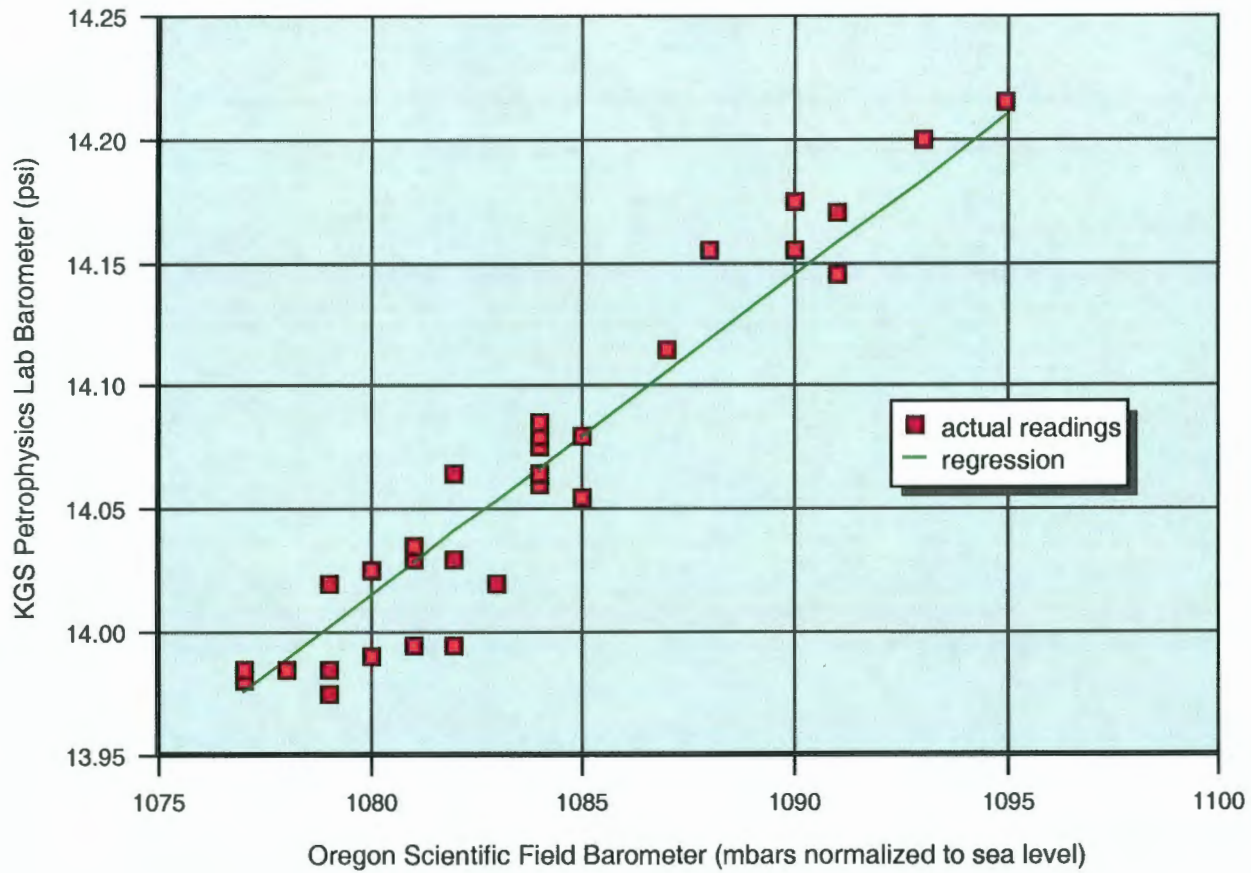


FIGURE 1.

TABLE 1 -- Desorption data for DART CHEROKEE BASIN C. BONNER et al. #D3-7; NW SW SE 7-T.30S.-R.14E.

SAMPLE: 789' to 790' (Dawson coal) cuttings in Dart SSD canister

dry sample weight: lbs. 0.3894 grams 176.62

RIGLAB MEASUREMENTS			CONVERSION OF RIGLAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON
measured cc	measured T (F)	measured P	cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	without lost gas	with lost gas	
-11	69	1072	-0.0004	529	13.914	-0.000361439	-10.23	-1.86	-1.86	
-1	70	1074	-4E-05	530	13.940	-3.28573E-05	-0.93	-0.17	-0.17	
3	71	1066	0.0001	531	13.836	9.76533E-05	2.77	0.50	0.50	
-2	73	1075	-7E-05	533	13.953	-6.54055E-05	-1.85	-0.34	-0.34	
-7	69	1091	-0.0002	529	14.161	-0.000234083	-6.63	-1.20	-1.20	

DESORPTION TERMINATED 4/15/2005 DUE TO NO GAS BEING EVOLVED; no coal in sample; sample not saved

NOTE: lost 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)

TIME OF MEASURE	TIME SINCE	SCF/TON	SCF/TON	SQRT hrs. (since off bottom)
off bottom	at surface	in canister	in canister	
4/5/05 12:42	4/5/05 12:43	4/5/05 12:47	4/5/05 12:47	
				0.299536679 SQRT (hrs)
				5.4 minutes
				0.090 hours
4/9/05 14:24	97:42:00	97:36:37		9.884331035
4/10/05 10:31	117:49:00	117:43:37		10.85433861
4/11/05 17:12	148:30:00	148:24:37		12.18605761
4/12/05 14:19	169:37:00	169:31:37		13.02369635
4/15/05 11:08	238:26:00	238:20:37		15.44128665

SAMPLE: 939' to 941' (? coal) cuttings in Dart SSD canister

dry sample weight: lbs. 0.0315 grams 14.29

RIGLAB MEASUREMENTS			CONVERSION OF RIGLAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON
measured cc	measured T (F)	measured P	cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	without lost gas	with lost gas	
11	69	1072	0.0004	529	13.914	0.000361439	10.23	22.95	22.95	
0	70	1074	0	530	13.940	0	0.00	22.95	22.95	
2.5	71	1066	9E-05	531	13.836	8.13778E-05	2.30	28.11	28.11	
-2	73	1075	-7E-05	533	13.953	-6.54055E-05	-1.85	23.96	23.96	
-9	69	1091	-0.0003	529	14.161	-0.000300964	-8.52	4.85	4.85	
-2	70	1089	-7E-05	530	14.135	-6.66324E-05	-1.89	0.62	0.62	

DESORPTION TERMINATED 4/16/2005 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 35 days

NOTE: lost 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)

TIME OF MEASURE	TIME SINCE	SCF/TON	SCF/TON	SQRT hrs. (since off bottom)
off bottom	at surface	in canister	in canister	
4/5/05 14:10	4/5/05 14:11	4/5/05 14:15	4/5/05 14:15	
				0.279880927 SQRT (hrs)
				4.7 minutes
				0.078 hours
4/9/05 14:24	96:13:19	96:08:37		9.809278487
4/10/05 10:31	116:20:19	116:15:37		10.78603779
4/11/05 17:12	147:01:19	146:56:37		12.1526059
4/12/05 14:19	168:08:19	168:03:37		12.96682733
4/15/05 11:08	236:57:19	236:52:37		15.39335174
4/16/05 15:38	265:27:19	265:22:37		16.29279834

SAMPLE: 998' to 1000' (Mulberry coal) cuttings in Dart SSD canister

dry sample weight: lbs. 0.2467 grams 111.91

RIGLAB MEASUREMENTS			CONVERSION OF RIGLAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON
measured cc	measured T (F)	measured P	cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	without lost gas	with lost gas	
56	69	1072	0.002	529	13.914	0.001840053	52.10	14.92	14.92	
5	70	1074	0.0002	530	13.940	0.000164286	4.65	16.25	16.25	
7	71	1066	0.0002	531	13.836	0.000227858	6.45	18.10	18.10	
1	73	1075	4E-05	533	13.953	3.27028E-05	0.93	18.38	18.38	
-2	69	1091	-7E-05	529	14.161	-6.68809E-05	-1.89	17.82	17.82	
1	70	1089	4E-05	530	14.135	3.33162E-05	0.94	18.09	18.09	
1	71	1089	4E-05	531	14.135	3.32534E-05	0.94	18.36	18.36	
4	72	1082	0.0001	532	14.044	0.00013191	3.74	19.43	19.43	
1	70	1076	4E-05	530	13.966	3.29185E-05	0.93	19.69	19.69	
2	70	1072	7E-05	530	13.914	6.55922E-05	1.86	20.23	20.23	
-3	67	1081	-0.0001	527	14.031	-9.97791E-05	-2.83	19.42	19.42	
-5	63	1083	-0.0002	523	14.057	-0.00016788	-4.75	18.06	18.06	

DESORPTION TERMINATED 4/28/2005 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 33 days

NOTE: lost 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)

TIME OF MEASURE	TIME SINCE	SCF/TON	SCF/TON	SQRT hrs. (since off bottom)
off bottom	at surface	in canister	in canister	
4/5/05 14:46	4/5/05 14:48	4/5/05 14:51	4/5/05 14:51	
				0.299536679 SQRT (hrs)
				5.4 minutes
				0.090 hours
4/9/05 14:33	95:46:56	95:41:33		9.786839236
4/10/05 10:32	115:45:56	115:40:33		10.7594403
4/11/05 17:13	146:26:56	146:21:33		12.10160687
4/12/05 14:20	167:33:56	167:28:33		12.94471149
4/15/05 11:09	236:22:58	236:17:33		15.37472674
4/16/05 15:37	264:50:56	264:45:33		16.27417859
4/17/05 11:03	284:16:56	284:11:33		16.86067087
4/18/05 11:25	308:38:56	308:33:33		17.56840599
4/20/05 22:46	367:59:56	367:54:33		19.18329713
4/21/05 17:12	386:25:56	386:20:33		19.65787939
4/22/05 16:11	409:24:56	409:19:33		20.23401976
4/24/05 13:45	454:58:56	454:53:33		21.33031229

SAMPLE: 1026' to 1034' (Lexington?) "coal" cuttings in Dart SSD canister

dry sample weight: lbs. 0.8738 grams 396.36

RIGLAB MEASUREMENTS			CONVERSION OF RIGLAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON
measured cc	measured T (F)	measured P	cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	without lost gas	with lost gas	
306	69	1072	0.0108	529	13.914	0.010054576	284.71	23.01	25.52	
43	70	1074	0.0015	530	13.940	0.001412863	40.01	26.25	26.25	
39	71	1066	0.0014	531	13.836	0.001269494	35.95	29.15	31.66	
11	73	1075	0.0004	533	13.953	0.00035973	10.19	29.98	32.48	
2.0	69	1091	0.0007	529	14.181	0.000688009	18.94	31.51	34.01	
2	70	1089	7E-05	530	14.135	6.86324E-05	1.89	31.68	34.16	

DESORPTION TERMINATED 4/28/2005 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 33 days

NOTE: lost 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)

TIME OF MEASURE	TIME SINCE	SCF/TON	SCF/TON	SQRT hrs. (since off bottom)
off bottom	at surface	in canister	in canister	
4/5/05 15:17	4/5/05 15:19	4/5/05 15:23	4/5/05 15:23	
				0.319722102 SQRT (hrs)
				6.1 minutes
				0.102 hours
4/9/05 14:46	95:28:12	95:22:04		9.770875089
4/10/05 10:33	115:15:12	115:09:04		10.73561052
4/11/05 17:13	145:55:12	145:49:04		12.0797351
4/12/05 14:21	167:03:12	166:57:04		12.92491135
4/15/05 11:10	235:52:12	235:46:57		15.35805977
4/16/05 15:36	264:18:12	264:12:04		16.25740857



1.5	71	1089	5E-05	531	14.135	4.98802E-05	1.41	0.013881984	393.09	31.77	34.28	4/17/05	11:03	283:45:12	283:39:04	16.84497947
5	72	1082	0.0002	532	14.044	0.000164888	4.87	0.014046872	397.76	32.15	34.68	4/18/05	11:26	308:08:12	308:02:04	17.553822
0	70	1076	0	530	13.986	0	0.00	0.014046872	397.76	32.15	34.68	4/20/05	21:11	365:53:12	365:47:04	19.12816423
1	70	1072	4E-05	530	13.914	3.27961E-05	0.93	0.014079668	398.69	32.23	34.73	4/21/05	17:13	385:55:12	385:49:04	19.64484665
-4	67	1081	-0.0001	527	14.031	-0.000133039	-3.77	0.01394663	394.92	31.92	34.43	4/22/05	16:11	408:53:12	408:47:04	20.22094624
-7	63	1083	-0.0002	523	14.057	-0.000235033	-6.66	0.013711597	388.27	31.38	33.89	4/24/05	13:45	454:27:12	454:21:04	21.31791109

DESORPTION TERMINATED 4/28/2005 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 33 days

SAMPLE: 1096' to 1097' (Mulky coal) cuttings in Dart SSD canister  
 lbs. grams  
 dry sample weight: 0.0000 0

NOTE: lost 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)  
 0 off bottom at surface in canister 8.9 minutes  
 4/5/05 16:39 4/5/05 16:41 4/5/05 16:48 0.148 hours

RIG/LAB MEASUREMENTS		CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON	TIME SINCE		0.384418753			
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	SORT hrs. (since off bottom)	
1	69	1072	4E-05	529	13.914	3.28581E-05	0.93	3.28581E-05	0.93	#DIV/0!	4/9/05	14:36	93:56:41	93:47:49	9.692508562
-0.5	70	1074	-2E-05	530	13.940	-1.64286E-05	-0.47	1.64295E-05	0.47	#DIV/0!	4/10/05	10:33	113:53:41	113:44:49	10.67214703
3	71	1066	0.0001	531	13.836	9.76533E-05	2.77	0.000114083	3.23	#DIV/0!	4/11/05	17:14	144:34:41	144:25:49	12.02406152
-2	73	1075	-7E-05	533	13.953	-6.54055E-05	-1.85	4.86773E-05	1.38	#DIV/0!	4/12/05	14:21	165:41:41	165:32:49	12.8722462
-9	69	1091	-0.0003	529	14.161	-0.000300964	-8.52	-0.000252287	-7.14	#DIV/0!	4/15/05	11:11	234:31:41	234:22:49	15.31430885
-1	70	1089	-4E-05	530	14.135	-3.33162E-05	-0.94	-0.000285603	-8.09	#DIV/0!	4/16/05	15:35	262:55:41	262:46:49	16.21505645

DESORPTION TERMINATED 4/16/2005 DUE TO NO GAS BEING EVOLVED; no coal in sample; sample not saved

SAMPLE: 1152' to 1154' (Bevier coal) cuttings in Dart SSD canister  
 lbs. grams  
 dry sample weight: 0.7814 354.42

NOTE: lost 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)  
 15 off bottom at surface in canister 4.4 minutes  
 4/6/05 8:08 4/6/05 8:10 4/6/05 8:12 0.073 hours

RIG/LAB MEASUREMENTS		CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON	TIME SINCE		0.270287912			
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	SORT hrs. (since off bottom)	
53	69	1072	0.0019	529	13.914	0.001741479	49.31	0.001741479	49.31	4.46	4/9/05	14:41	78:32:51	78:28:28	8.862702748
1	70	1074	4E-05	530	13.940	3.28573E-05	0.93	0.001774336	50.24	4.54	4/10/05	10:34	98:25:51	98:21:28	9.921231442
3	71	1066	0.0001	531	13.836	9.76533E-05	2.77	0.001871989	53.01	4.79	4/11/05	17:15	129:06:51	129:02:28	11.36284149
-3	73	1075	-0.0001	533	13.953	-9.81083E-05	-2.78	0.001773881	50.23	4.54	4/12/05	14:22	150:13:51	150:09:28	12.25686882
-10	69	1091	-0.0004	529	14.161	-0.000334405	-9.47	0.001439476	40.76	3.68	4/15/05	11:12	219:03:51	218:59:28	14.80081642
-2	70	1089	-7E-05	530	14.135	-6.86324E-05	-1.89	0.001372844	38.87	3.51	4/16/05	15:33	247:24:51	247:20:28	15.72940452

DESORPTION TERMINATED 4/16/2005 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 20 days

SAMPLE: 1222' to 1223' (Mineral coal) cuttings in Dart SSD canister  
 lbs. grams  
 dry sample weight: 0.0000 0.00

NOTE: lost 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)  
 0 off bottom at surface in canister 7.1 minutes  
 4/6/05 8:49 4/6/05 8:51 4/6/05 8:56 0.119 hours

RIG/LAB MEASUREMENTS		CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON	TIME SINCE		0.344399639			
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	SORT hrs. (since off bottom)	
10	69	1072	0.0004	529	13.914	0.000328581	9.30	0.000328581	9.30	#DIV/0!	4/9/05	14:53	78:03:36	77:56:29	8.835157044
-1.5	70	1074	-5E-05	530	13.940	-4.92859E-05	-1.40	0.000279295	7.91	#DIV/0!	4/10/05	10:34	97:44:36	97:37:29	9.886522813
1	71	1066	4E-05	531	13.836	3.25511E-05	0.92	0.000311846	8.83	#DIV/0!	4/11/05	17:18	128:26:36	128:19:29	11.33328431
-2	73	1075	-7E-05	533	13.953	-6.54055E-05	-1.85	0.000246441	6.98	#DIV/0!	4/12/05	14:22	149:32:36	149:25:29	12.22879118
-9	69	1091	-0.0003	529	14.161	-0.000300964	-8.52	-5.45236E-05	-1.54	#DIV/0!	4/15/05	11:13	218:23:36	218:16:29	14.778137
-2	70	1089	-7E-05	530	14.135	-6.86324E-05	-1.89	-0.000121156	-3.43	#DIV/0!	4/16/05	15:31	246:41:36	246:34:29	15.70647425

DESORPTION TERMINATED 4/16/2005 DUE TO NO GAS BEING EVOLVED; no coal in sample; sample not saved

SAMPLE: 1297' to 1298' (Weir-Pittsburg coal) cuttings in Dart SSD canister  
 lbs. grams  
 dry sample weight: 0.0887 40.24

NOTE: lost 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)  
 31 off bottom at surface in canister 6.9 minutes  
 4/6/05 9:37 4/6/05 9:40 4/6/05 9:44 0.115 hours

RIG/LAB MEASUREMENTS		CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON	TIME SINCE		0.339118499			
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	SORT hrs. (since off bottom)	
44	69	1072	0.0018	529	13.914	0.001445756	40.94	0.001445756	40.94	32.59	4/9/2005	2:57:00	#VALUE!	#VALUE!	#VALUE!
1	70	1074	4E-05	530	13.940	3.28573E-05	0.93	0.001478613	41.87	33.34	4/10/05	10:35	96:57:24	96:50:30	9.846657639
5	71	1066	0.0002	531	13.836	0.000162756	4.81	0.001641369	46.48	37.00	4/11/05	17:16	127:38:24	127:31:30	11.29778739
-1	73	1075	-4E-05	533	13.953	-3.27028E-05	-0.93	0.001608666	45.55	36.27	4/12/05	14:23	148:45:24	148:38:30	12.19658422



-8	69	1091	-0.0003	529	14.161	-0.000267524	-7.58	0.001341142	37.98	30.24	54.92	4/15/05 11:13	217:35:24	217:28:30	14.75093217
-1	70	1089	-4E-05	530	14.135	-3.33162E-05	-0.94	0.001307826	37.03	29.48	54.17	4/16/05 15:30	245:52:24	245:45:30	15.68034864

DESORPTION TERMINATED 4/16/2005 DUE TO NO GAS BEING EVOLVED

SAMPLE: 1336' to 1338' (Riverton(?) coal) cuttings in Dart SSD canister

dry sample weight: lbs. 0.6578 grams 298.36

NOTE: lost 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 canister)

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)				CUMULATIVE VOLUMES		SCF/TON	SCF/TON	TIME OF MEASURE				TIME SINCE	SCF/TON
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	SCF/TON	
0	69	1072	0	529	13.914	0	0.00	0	0.00	0.00	0.00	4/9/05 14:53	76:47:20	76:42:56	8.762926959	
1	70	1074	4E-05	530	13.940	3.28573E-05	0.93	3.28573E-05	0.93	0.10	0.10	4/10/05 10:34	96:28:20	96:23:56	9.822027399	
4	71	1066	0.0001	531	13.836	0.000130204	3.69	0.000163062	4.62	0.50	0.50	4/11/05 17:16	127:10:20	127:05:56	11.27706621	
-8	73	1075	-0.0003	533	13.953	-0.000261622	-7.41	-9.85604E-05	-2.79	-0.30	-0.30	4/12/05 14:22	148:16:20	148:11:56	12.17670818	
-1	69	1091	-4E-05	529	14.181	-3.34405E-05	-0.95	-0.000132001	-3.74	-0.40	-0.40	4/15/05 11:13	217:07:20	217:02:56	14.73506777	

SAMPLE DECANISTERED 4/15/2005 DUE TO BAD GASKET ON CANISTER; no valid data obtained; sample air dried for 10 days

Dart Cherokee Basin #D3-7 C. Bonner, NW SW SE 7-T.30S.-R.14E., 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

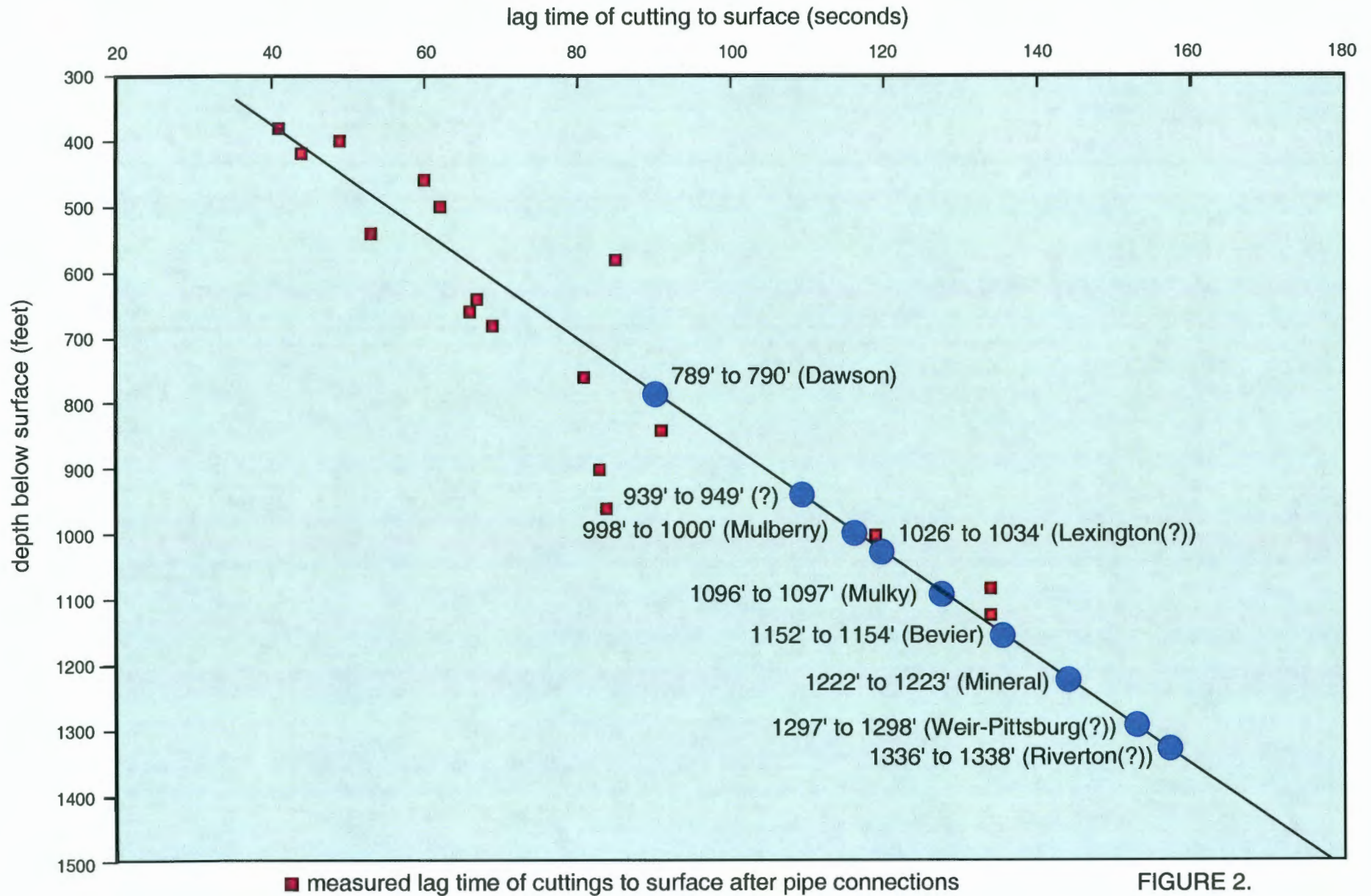
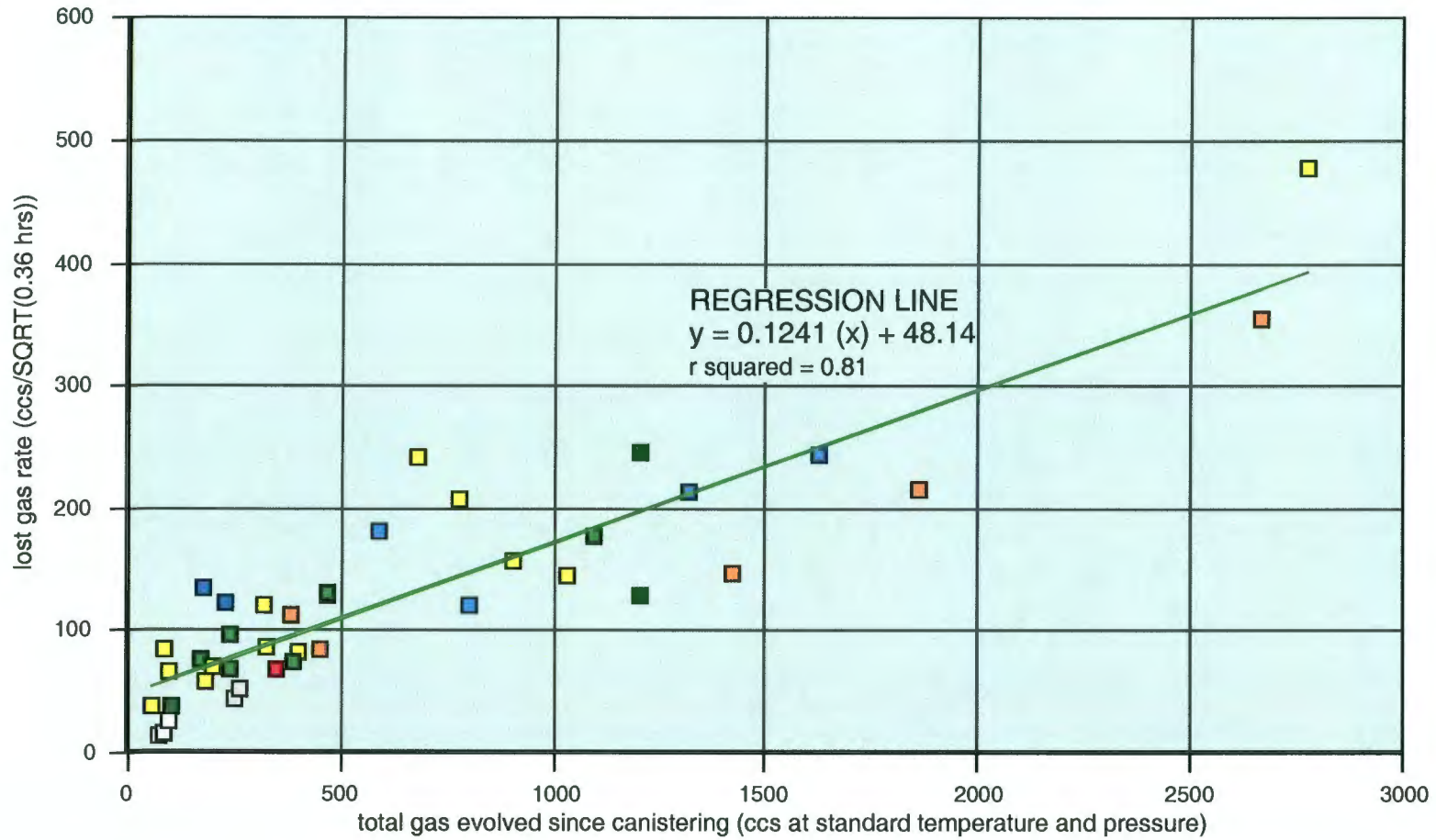
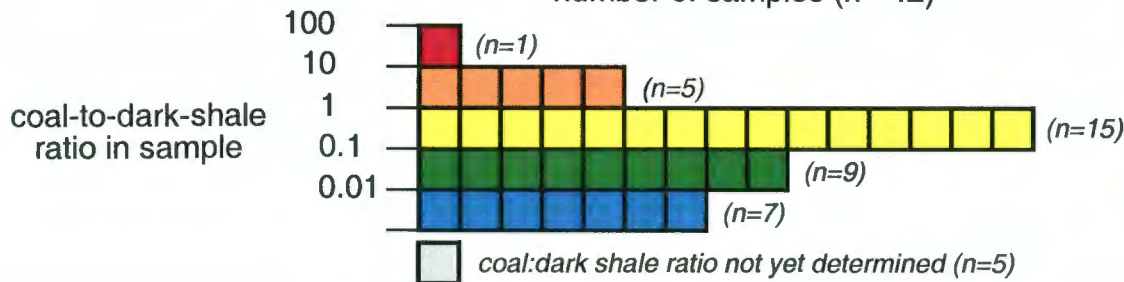


FIGURE 2.

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)



number of samples (n= 42)



LOST-GAS ALGORITHM

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

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 #D3-7 C. Bonner et al., NW SW SE 7-T.30S.-R.14E., Wilson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of ? coal from 939' to 941'

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

total gas desorbed  
(including estimated lost gas) = 38.5 ccs

TOTAL DRY WEIGHT OF SAMPLE = 136.18 grams

weight<sub>light-colored lithologies</sub> = 121.89 grams (89.5%)

weight<sub>dark shale</sub> = 4.81 grams (3.5%)

weight<sub>coal</sub> = 9.48 grams (7.0%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	67.19	4.43% / 3.54% / 92.03%
>0.0661"	41.64	10.42% / 4.40% / 85.18%
>0.0460"	21.81	8.58% / 1.82% / 89.60%
>0.0331"	3.98	4.90% / 3.92% / 91.18%
<0.0331"	1.55	6.06% / 3.03% / 90.91%

**136.18 TOTAL**

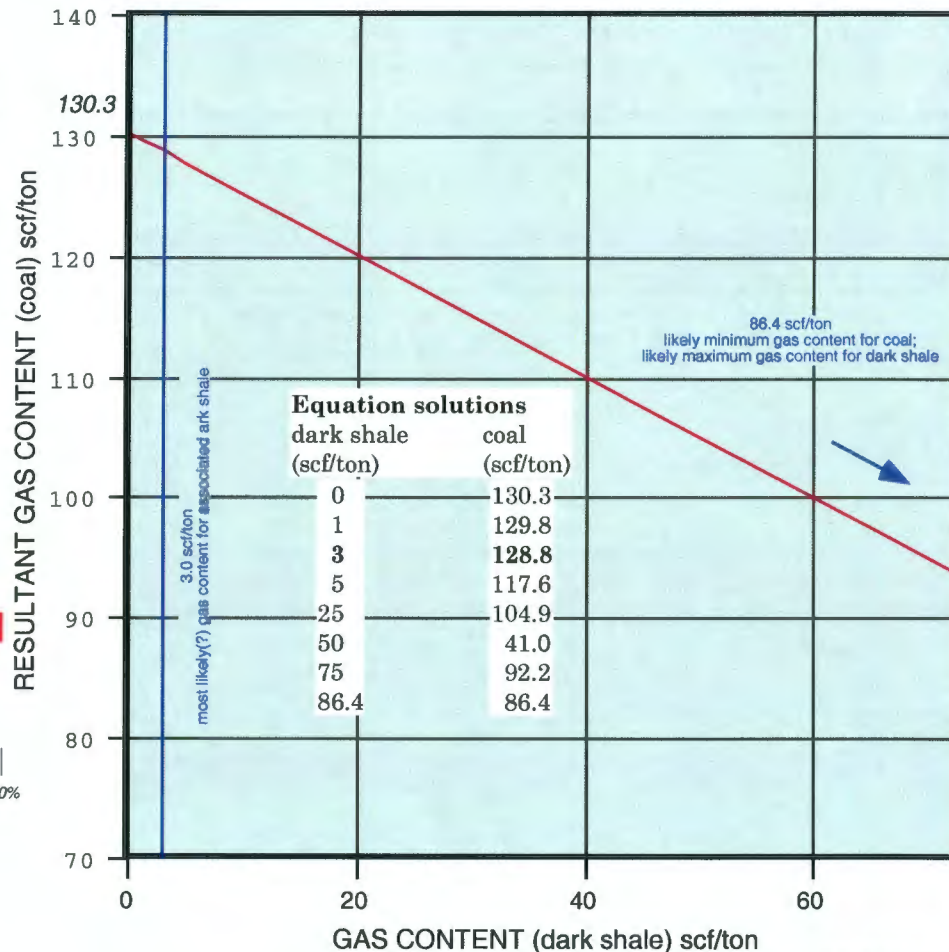
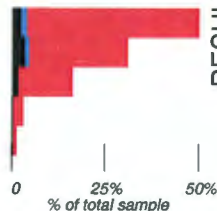


FIGURE 4.

# Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D3-7 C. Bonner, NW SW SE 7-T.30S.-R.14E., Wilson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Mulberry coal from 998' to 1000'

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

total gas desorbed  
(including estimated lost gas) = 87.7 ccs

TOTAL DRY WEIGHT OF SAMPLE = 195.02 grams

weight<sub>light-colored lithologies</sub> = 83.11 grams (42.6%)

weight<sub>dark shale</sub> = 84.73 grams (43.5%)

weight<sub>coal</sub> = 27.17 grams (13.9%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	98.00	6.37% / 41.80% / 51.83%
>0.0661"	58.88	17.15% / 46.57% / 36.28%
>0.0460"	26.51	28.22% / 38.17% / 33.61%
>0.0331"	7.30	34.00% / 46.00% / 20.00%
<0.0331"	4.66	20.00% / 65.00% / 15.00%

**195.02 TOTAL**

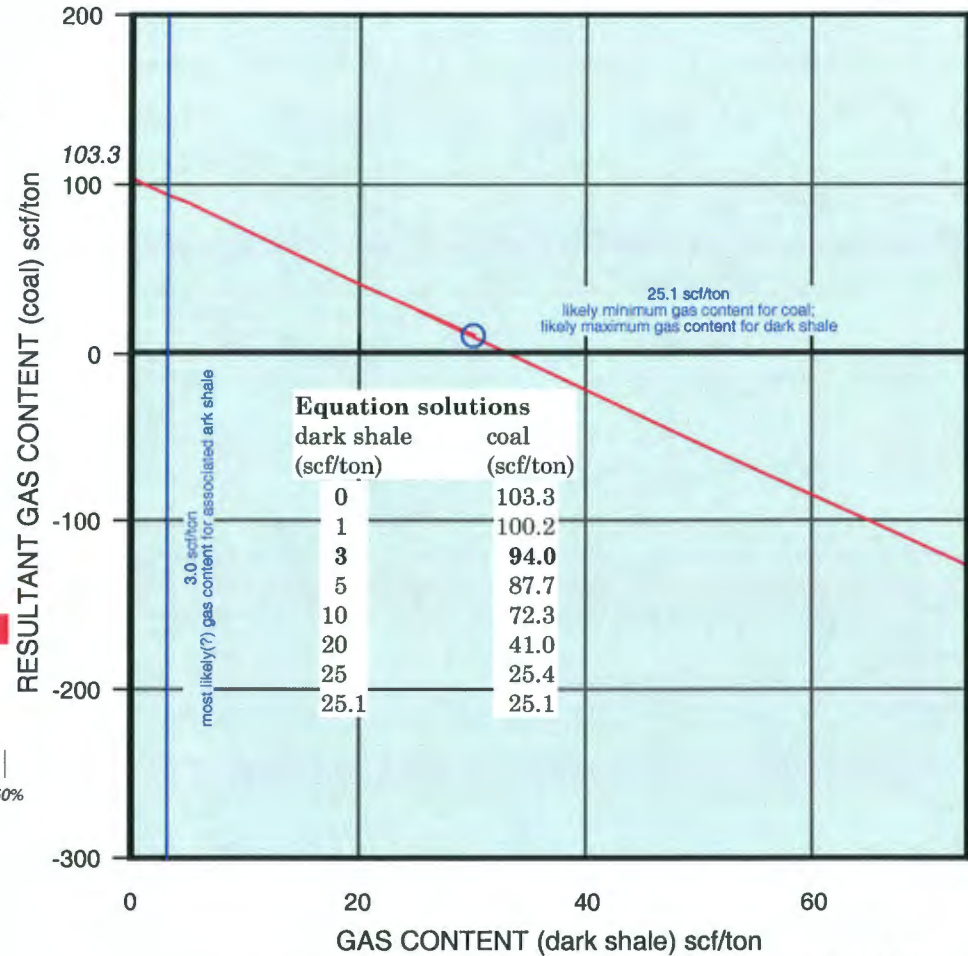
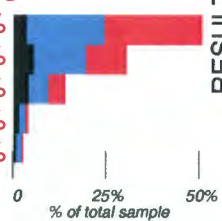


FIGURE 5.

# Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D3-7 C. Bonner et al., NW SW SE 7-T.30S.-R.14E., Wilson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of Lexington "coal" from 1026' to 1034'

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

total gas desorbed  
(including estimated lost gas) = 429.7 ccs

TOTAL DRY WEIGHT OF SAMPLE = 402.56 grams

weight<sub>light-colored lithologies</sub> = 6.20 grams (1.5%)  
weight<sub>dark shale</sub> = 396.36 grams (98.5%)  
weight<sub>coal</sub> = 0.00 grams (0.0%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	201.70	0.00% / 99.00% / 1.00%
>0.0661"	104.90	0.00% / 98.31% / 1.69%
>0.0460"	70.55	0.00% / 98.25% / 1.75%
>0.0331"	18.68	0.00% / 95.45% / 4.44%
<0.0331"	6.72	0.00% / 95.00% / 5.00%
<b>402.56 TOTAL</b>		

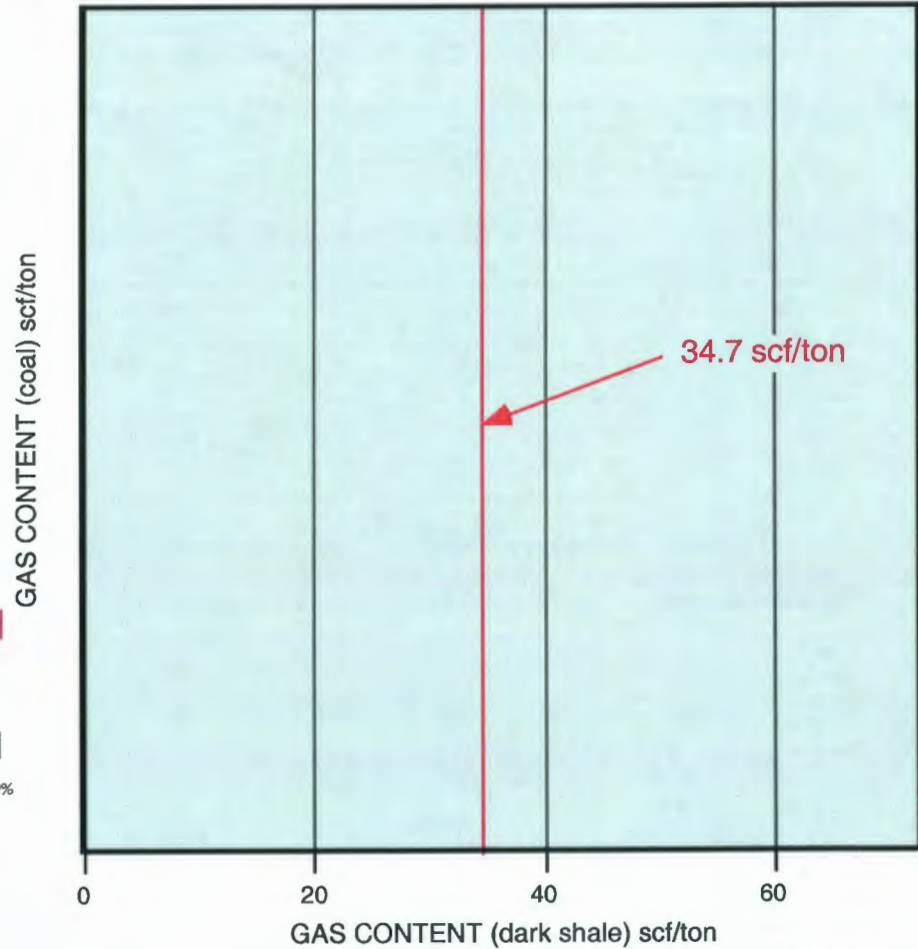
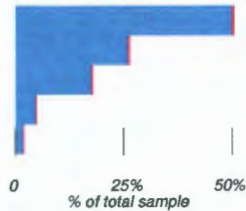


FIGURE 6.



# Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D3-7 C. Bonner et al., NW SW SE 7-T.30S.-R.14E., Wilson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Bevier coal from 1152' to 1154'

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

total gas desorbed  
(including estimated lost gas) = 68.0 ccs

TOTAL DRY WEIGHT OF SAMPLE = 492.21 grams

weight<sub>light-colored lithologies</sub> = 83.11 grams (28.0%)

weight<sub>dark shale</sub> = 84.73 grams (68.2%)

weight<sub>coal</sub> = 27.17 grams (3.8%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	212.66	3.85% / 77.59% / 18.56%
>0.0661"	106.48	3.99% / 68.80% / 27.21%
>0.0460"	98.90	3.46% / 63.51% / 33.01%
>0.0331"	42.17	4.21% / 50.53% / 45.26%
<0.0331"	32.01	3.00% / 42.00% / 55.00%

**492.21 TOTAL**

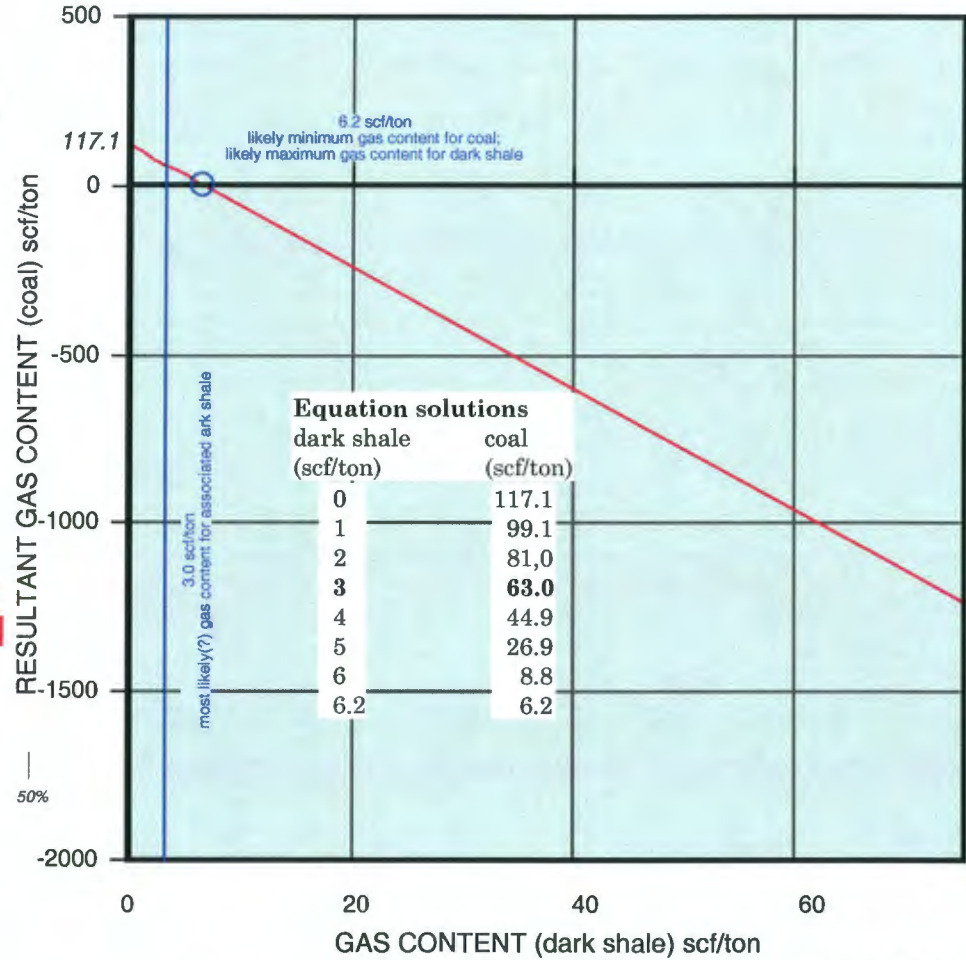
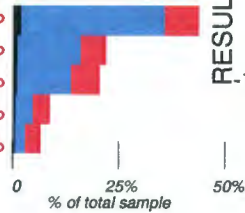


FIGURE 7.

# Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D3-7 C. Bonner et al., NW SW SE 7-T.30S.-R.14E., Wilson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Weir-Pittsburg coal from 1297' to 1298'

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

total gas desorbed  
(including estimated lost gas) = 77.5 ccs

TOTAL DRY WEIGHT OF SAMPLE = 356.31 grams

weight<sub>light-colored lithologies</sub> = 316.07 grams (88.7%)

weight<sub>dark shale</sub> = 28.75 grams (8.1%)

weight<sub>coal</sub> = 11.49 grams (3.2%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	165.34	1.09% / 9.46% / 89.47%
>0.0661"	90.66	4.83% / 6.27% / 88.90%
>0.0460"	63.66	5.20% / 7.74% / 87.06%
>0.0331"	23.92	5.74% / 6.76% / 85.50%
<0.0331"	12.73	5.00% / 7.00% / 88.00%
<b>356.31 TOTAL</b>		

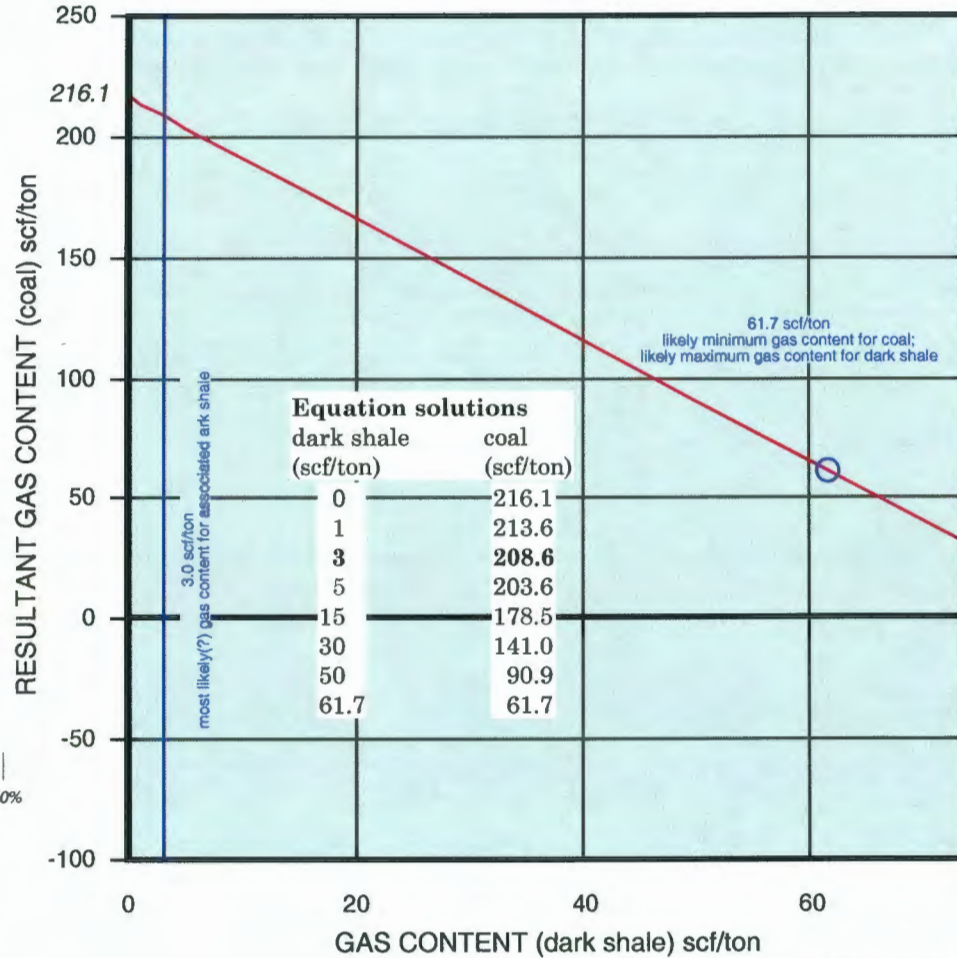
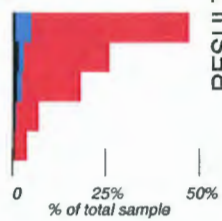


FIGURE 8.

# Desorption Characteristics of Cuttings Samples

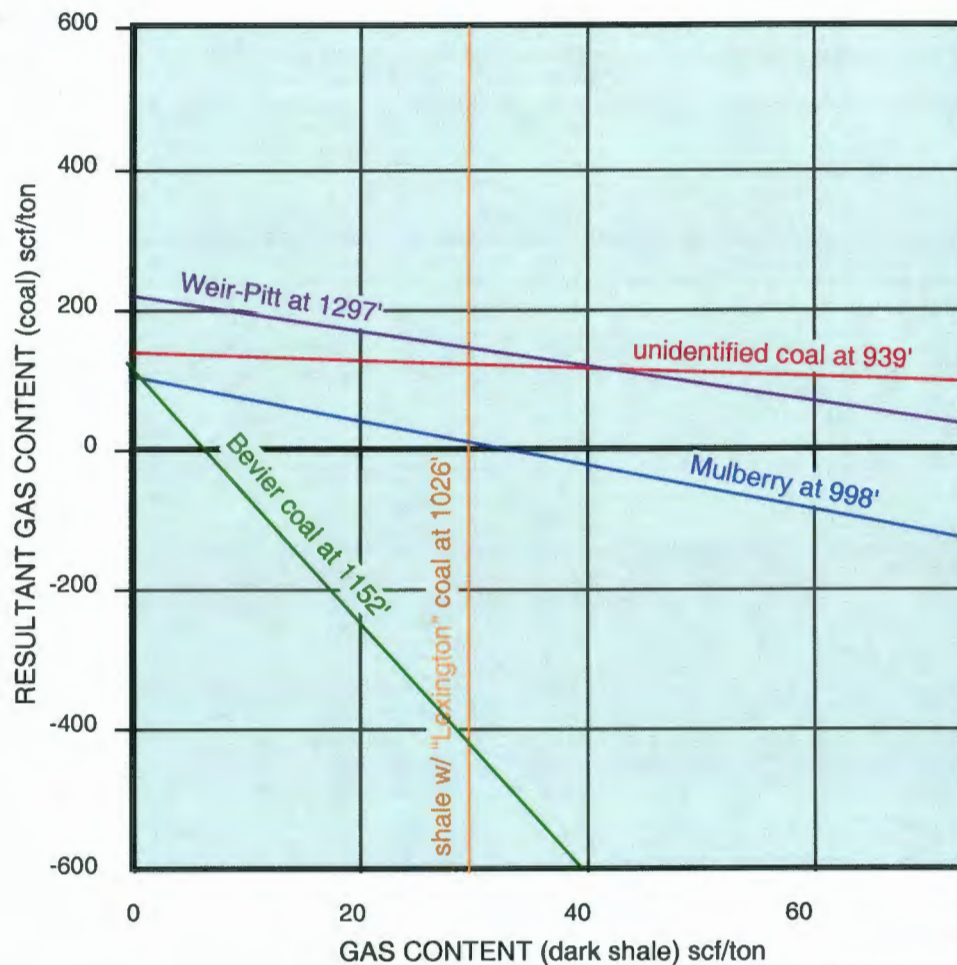
Dart Cherokee Basin #D3-7 C. Bonner et al., NW SW SE 7-T.30S.-R.14E., Wilson County, KS

surface

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for all samples

100'	UNIT	coal in sample	dk sh in sample	scf/ton w/ shale @ 3 scf/ton	maximum scf/ton	minimum scf/ton
200'						
300'	789' Dawson	----	----	no valid data		
	939' ? coal	7%	4%	128.8	130.3	86.4
	998' Mulberry	14%	44%	94.0	103.3	25.1
	1026' sh w/"L'ton"	0%	99%	----	----	34.7
400'	1096' Mulky	----	----	no valid data		
	1152' Bevier	4%	68%	63.0	117.1	6.2
	1222' Mineral	----	----	no valid data		
500'	1297' Weir-Pitt	3%	8%	208.6	216.1	61.7
	1336' Riverton	----	----	no valid data		

scf/ton  
w/ shale  
@ 20 scf/ton



- 789' Dawson
- 800'
- 900'
- 939' unidentified coal
- 1000'
- 998' Mulberry
- 1026' sh. w/ Lexington
- 1096' Mulky
- 1152' Bevier
- 1200'
- 1222' Mulky
- 1297' Weir-Pitt
- 1336' Riverton

FIGURE 9.