ANALYSIS OF CHEROKEE GROUP CUTTINGS SAMPLES FOR GAS CONTENT -- DART CHEROKEE BASIN OPERATING COMPANY #C4-34 EDENS; NE SE sec. 34-T.29S-R.14E., WILSON COUNTY, KANSAS

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SUMMARY

Cuttings samples from the Pennsylvanian Cherokee Group were collected from the Dart Cherokee Basin Edens #C4-34, 34-T.29S-R.14E., Wilson County, KS. The samples calculate as having the following gas contents:

- shale at 819' associated with Mulberry coal[1] (37 scf/ton)
- Little Osage Shale at 878' depth[1] (39 scf/ton)
- Excello Shale/Mulky coal at 891' depth[2] (--- scf/ton)
- Bevier coal at 939' depth[3] (--- scf/ton)
- unidentified coal at 958' depth[4] (148 scf/ton)
- Mineral coal at 997' depth[3] (--- scf/ton)
- Tebo coal at 1020' depth[5] (221 scf/ton)
- Weir-Pittsburg coal at 1054' depth[6] (--- scf/ton)
- Rowe coal at 1195' depth[4] (487 scf/ton)

[1]no significant coal in sample
[2]results difficult to interpret due to no significant coal, and concomitant high gas content of shale in sample; gas content in range of 50-55 scf/ton is indicated for entire interval
[3]no significant coal or dark shale in sample
[4]assuming accompanying dark shales in sample desorb 3 scf/ton
[5]assuming accompanying dark shales in sample desorb 20 scf/ton
[6]results are suspect due to small size of sample

BACKGROUND

The Dart Cherokee Basin Edens #C4-34, 34-T.29S-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 January 27, 2006 by personnel from Dart Cherokee Basin L.L.C., and soon 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 were determined b the wellsite geologist and driller.

The cuttings samples from the Pennsylvanian Cherokee Group were:

- shale at 819' associated with Mulberry coal (215 grams)
- Little Osage Shale at 878' depth (494 grams)
- Excello Shale/Mulky coal at 891' depth (389 grams)
- Bevier coal at 939' depth (188 grams)
- unidentified coal at 958' depth (513 grams)
- Mineral coal at 997' depth (394 grams)
- Tebo coal at 1020' depth (133 ~~scf/ton~~ grams)

- Weir-Pittsburg coal at 1054' depth[6] (25 grams)
- Rowe coal at 1195' depth[4] (839 ~~scf/ton~~ 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 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.

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^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, Kansas (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, 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 ran 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.

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)
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 2). 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 2), therefore further refinement of the relationship of the rate of lost gas to the total gas desorbed after canistering is not possible at this point in time.

"Lithologic Component Sensitivity Analyses" (Figures 3-8)
The rapidity of penetration of an air-drilled 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:

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

A unique solution for gas content_{coal} in this equation is not possible because gas $\text{content}_{\text{dark shale}}$ 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 visa 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 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*$_{coal}$) for that sample. If the coal content is miniscule (i.e., < approximately 5%), the results are a better reflection of the *gas content*$_{dark\ shale}$.

RESULTS and DISCUSSION

Samples with less that 1% coal and/or less than 5% dark shale are considered to have invalid results due to insufficient quantities of gas-generating lithologies. The best constrained data are that associated with the unidentified coal at 958", followed bythe Tebo coal at 1020'.

The least constrained data are associated with the Mulky coal/Excello Shale at 891'. The small amount of coal in the sample (1.6%), in combination with the large amount of dark shale (88.6%) imparts considerable uncertainty in reasonably determining the gas content of the coal. Overall, however, this interval has a 50 to 55 scf/ton gas content.

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

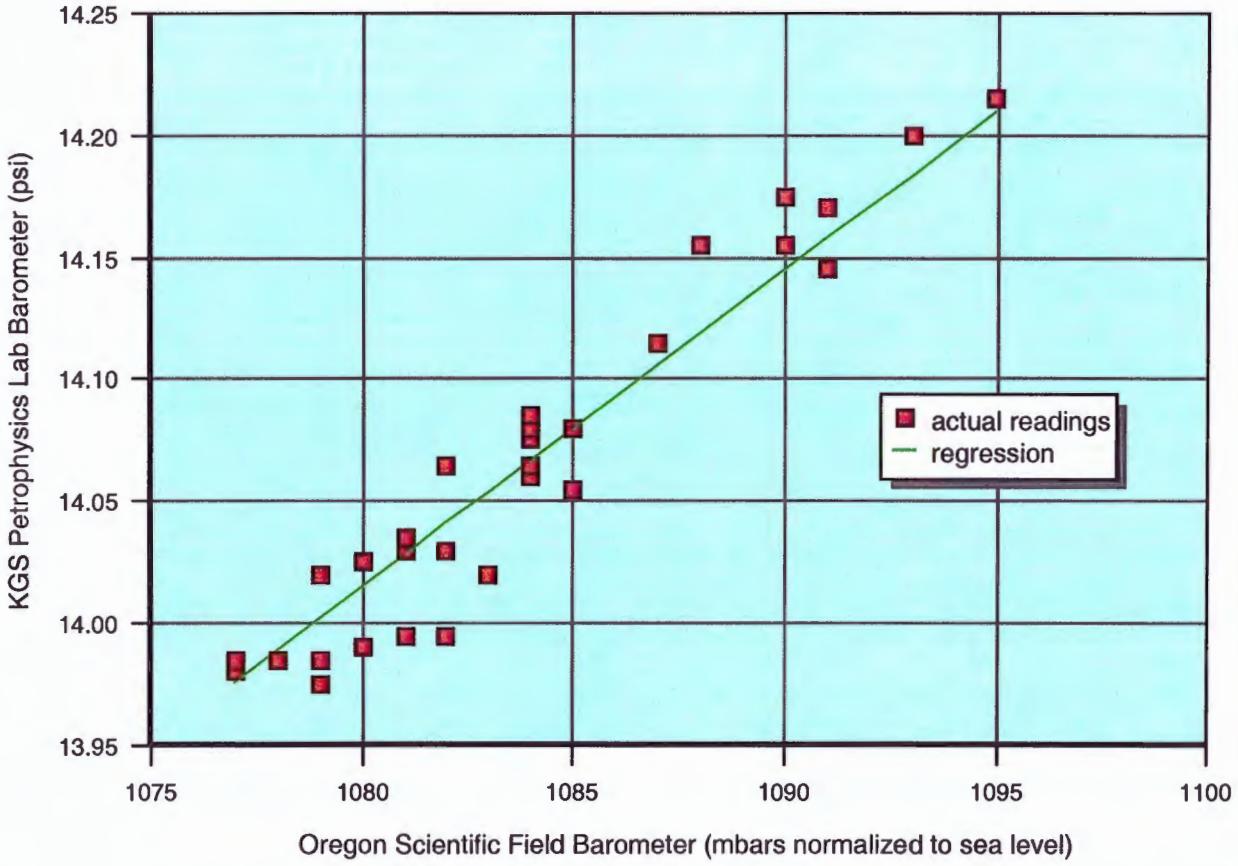


FIGURE 1.

TABLE 1 -- Desorption data for DART Edens #C4-34 (NE SE 34-T.29S-R.14E.), Wilson County, KS

SAMPLE: 619', shale associated with Mulberry coal, in canister #1

	lbs.	grams
dry sample weight:	0.3372	152.96

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)	
9	off bottom		at surface		in canister		1.0	minutes
	1/25/06	10:33	1/25/06	10:30	1/25/06	10:34	0.017	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		0.129099445	SQRT (hrs)
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)	
143	67	1085	0.0051	527	14.083	0.004773736	135.18	0.004773736	135.18	26.31	30.20	1/27/06	17:35	55:02:00	55:01:00	7.41844548	
0	67	1072	0	527	13.914	0	0.00	0.004773736	135.18	26.31	30.20	1/28/06	13:40	75:07:00	75:06:00	8.666987174	
22	67	1081	0.0008	527	14.031	0.000731713	20.72	0.005505449	155.90	32.65	34.54	1/30/06	15:35	125:02:00	125:01:00	11.1818305	
11	67	1080	0.0004	527	14.018	0.000365518	10.35	0.005870967	166.25	34.62	36.70	2/3/06	16:20	221:47:00	221:46:00	14.89239179	
- 7	67	1091	-2E-04	527	14.161	-0.00023497	-6.65	0.005635996	159.59	33.43	35.31	2/7/06	18:15	319:42:00	319:41:00	17.8801566	
- 4	67	1088	-1E-04	527	14.122	-0.0001339	-3.79	0.005502095	155.80	32.63	34.52	2/10/06	12:47	386:14:00	386:13:00	19.65261998	

Sample air dried for approximately one week

SAMPLE: 878', Little Osage Shale, in canister #5

	lbs.	grams
dry sample weight:	0.4873	221.02

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)	
20	off bottom		at surface		in canister		4.0	minutes
	1/25/06	10:56	1/25/06	11:01	1/25/06	11:02	0.067	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		0.258196890	SQRT (hrs)
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)	
205	67	1085	0.0072	527	14.083	0.006643467	193.76	0.006643467	193.78	28.09	30.99	1/27/06	17:18	54:20:00	54:16:00	7.371114796	
44	67	1081	0.0016	527	14.031	0.001463427	41.44	0.008306894	235.22	34.10	37.00	1/30/06	15:36	124:38:00	124:34:00	11.16393001	
14	67	1080	0.0005	527	14.018	0.000465205	13.17	0.008772099	248.40	36.01	38.90	2/3/06	16:20	221:22:00	221:18:00	14.87639597	
- 5	67	1091	-2E-04	527	14.161	-0.00016764	-4.75	0.008604262	243.64	35.32	38.22	2/7/06	16:15	317:17:00	317:13:00	17.81244663	
0	67	1088	0	527	14.122	0	0.00	0.008604262	243.64	35.32	38.22	2/10/06	12:46	385:50:00	385:46:00	19.64264069	

Sample air dried for approximately one week

SAMPLE: 891', Mulky coal, in canister #8

	lbs.	grams
dry sample weight:	0.7734	350.83

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		4.0	minutes
	1/25/06	11:06	1/25/06	11:06	1/25/06	11:10	0.067	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		0.258196890	SQRT (hrs)
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)	
391	67	1085	0.0138	527	14.083	0.013052662	369.61	0.013052662	369.61	33.75	36.58	1/27/06	17:29	54:23:00	54:19:00	7.374505833	
127	67	1081	0.0045	527	14.031	0.004223981	119.61	0.017276643	489.22	44.67	47.51	1/30/06	15:40	124:09:00	124:06:00	11.14226189	
50	67	1080	0.0018	527	14.018	0.001661446	47.05	0.01893809	536.26	48.97	51.80	2/3/06	16:23	220:52:00	220:49:00	14.86158359	
18	67	1091	0.0006	527	14.161	0.000604213	17.11	0.019542302	553.37	50.53	53.36	2/7/06	16:18	316:47:00	316:44:00	17.79840817	
10	67	1088	0.0004	527	14.122	0.000334751	9.48	0.019877053	562.85	51.40	54.23	2/10/06	12:51	385:20:00	385:17:00	19.62990915	
10	66	1074	0.0004	526	13.940	0.000331071	9.37	0.020208125	572.23	52.25	55.09	2/14/06	15:10	483:39:00	483:36:00	21.99204402	
- 2	68	1095	-7E-05	526	14.213	-6.7253E-05	-1.90	0.020140871	570.32	52.08	54.91	2/19/06	14:03	602:32:00	602:29:00	24.54855441	
5	66	1082	0.0002	526	14.044	0.000166769	4.72	0.02030764	575.05	52.51	55.34	2/24/06	14:43	723:12:00	723:09:00	26.8923781	
5	66	1075	0.0002	526	13.953	0.00016569	4.69	0.02047333	579.74	52.94	55.77	2/27/06	17:24	797:53:00	797:50:00	28.24882673	
- 4	67	1094	-1E-04	527	14.200	-0.00013464	-3.81	0.020338691	575.93	52.59	55.42	3/3/06	16:59	893:26:00	893:25:00	29.89091278	
6	67	1074	0.0002	527	13.940	0.000198266	5.61	0.020536957	581.54	53.10	55.94	3/7/06	16:18	988:45:00	988:42:00	31.44439537	
- 3	67	1089	-1E-04	527	14.135	-0.00010052	-2.85	0.02043644	578.69	52.85	55.66	3/14/06	15:27	1155:56:00	1155:53:00	33.99901959	
5	66	1068	0.0002	526	13.862	0.000164611	4.66	0.020601051	583.35	53.27	56.10	3/30/06	15:37	1540:06:00	1540:03:00	39.24410784	
- 1	66	1074	-4E-05	526	13.940	-3.3107E-05	-0.94	0.020567944	582.42	53.19	56.02	4/5/06	14:42	1683:11:00	1683:08:00	41.02661738	
- 1	66	1071	-4E-05	526	13.901	-3.3015E-05	-0.93	0.020534929	581.48	53.10	55.93	4/14/06	16:16	1900:47:00	1900:44:00	43.59797396	

Sample air dried for approximately one week

SAMPLE: 939', Bevier coal, in canister #15

	lbs.	grams
dry sample weight:	0.0101	4.59

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)	
14	off bottom		at surface		in canister		4.0	minutes
	1/25/06	11:22	1/25/06	11:25	1/25/06	11:26	0.067	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		0.258196890	SQRT (hrs)
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)	
34	67	1085	0.0012	527	14.083	0.001135014	32.14	0.001135014	32.14	224.54	322.35	1/27/06	17:26	54:04:00	54:00:00	7.353003921	
4	67	1081	0.0001	527	14.031	0.000133039	3.77	0.001268053	35.91	250.86	348.67	1/30/06	15:39	124:17:00	124:13:00	11.14624351	
- 1	67	1080	-4E-05	527	14.018	-3.3229E-05	-0.94	0.001234824	34.97	244.29	342.10	2/3/06	16:22	221:00:00	220:56:00	14.86606875	
- 8	67	1091	-3E-04	527	14.161	-0.00026854	-7.60	0.000966265	27.36	191.16	266.97	2/7/06	16:16	316:54:00	316:50:00	17.80168531	
- 4	67	1088	-1E-04	527	14.122	-0.0001339	-3.79	0.000832365	23.57	164.67	262.46	2/10/06	12:50	385:28:00	385:24:00	19.63330504	

Sample air dried for approximately one week

SAMPLE: 958', unidentified coal, in canister #21

	lbs.	grams
dry sample weight:	0.0917	41.61

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		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
69	67	1085	0.0024	527	14.083	0.002303411	65.23	0.002303411	65.23	50.21
18	67	1081	0.0006	527	14.031	0.000598675	16.95	0.002902085	82.18	63.27
7	67	1080	0.0002	527	14.018	0.000232603	6.59	0.003134686	88.76	66.34
- 2	67	1091	-7E-05	527	14.161	-6.7135E-05	-1.90	0.003067553	86.86	66.67
2	67	1088	7E-05	527	14.122	6.69501E-05	1.90	0.003134503	88.76	66.33
5	66	1074	0.0002	526	13.940	0.000165536	4.69	0.003300039	93.45	71.94
- 9	68	1095	-3E-04	528	14.213	-0.00030264	-8.57	0.002997399	84.88	65.34
0	66	1082	0	526	14.044	0	0.00	0.002997399	84.88	65.34
3	66	1075	0.0001	526	13.953	9.94139E-05	2.82	0.003096813	87.69	67.51
- 8	67	1094	-3E-04	527	14.200	-0.00026928	-7.63	0.002827536	80.07	61.64
4	67	1074	0.0001	527	13.940	0.000132177	3.74	0.002959713	83.81	64.52

Sample air dried for approximately one week

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

est. lost gas (cc) =	TIME 0F:						elapsed time (off bottom to canistering)
13	off bottom		at surface		in canister		3.0 minutes
	1/25/06	11:31	1/25/06	11:33	1/25/06	11:34	0.050 hours

SCF/TON		TIME SINCE			0.223606798 SQRT (hrs)
with lost gas	TIME OF MEASURE	off bottom	in canister	SQRT hrs. (since off bottom)	
60.22	1/27/06 17:29	53:58:00	53:55:00	7.346200832	
73.27	1/30/06 15:40	124:09:00	124:06:00	11.14226189	
78.34	2/3/06 16:23	220:52:00	220:49:00	14.86156359	
78.86	2/7/06 16:18	316:47:00	316:44:00	17.79840817	
78.34	2/10/06 12:51	385:20:00	385:17:00	19.62990915	
81.95	2/14/06 15:10	483:39:00	483:36:00	21.99204402	
75.35	2/19/06 14:03	602:32:00	602:29:00	24.54655441	
75.35	2/24/06 14:43	723:12:00	723:09:00	26.8923781	
77.52	2/27/06 17:24	797:53:00	797:50:00	26.24682873	
71.65	3/3/06 16:59	893:26:00	893:25:00	29.69091278	
74.53	3/7/06 16:16	988:45:00	988:42:00	31.44439537	

SAMPLE: 997', Mineral coal, in canister #23

	lbs.	grams
dry sample weight:	0.0137	6.20

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		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
27	67	1085	0.001	527	14.083	0.000901335	25.52	0.000901335	25.52	131.96
5	67	1081	0.0002	527	14.031	0.000166296	4.71	0.001067633	30.23	156.31
- 2	67	1080	-7E-05	527	14.018	-6.6456E-05	-1.88	0.001001175	28.35	146.58
- 7	67	1091	-2E-04	527	14.161	-0.00023497	-6.65	0.000766204	21.70	112.18
- 3	67	1088	-1E-04	527	14.122	-0.00010043	-2.84	0.000665779	18.85	97.47

Sample air dried for approximately one week

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

est. lost gas (cc) =	TIME 0F:						elapsed time (off bottom to canistering)
12	off bottom		at surface		in canister		3.0 minutes
	1/25/06	11:46	1/25/06	11:50	1/25/06	11:51	0.050 hours

SCF/TON		TIME SINCE			0.223606798 SQRT (hrs)
with lost gas	TIME OF MEASURE	off bottom	in canister	SQRT hrs. (since off bottom)	
194.00	1/27/06 17:29	53:41:00	53:38:00	7.32689111	
216.35	1/30/06 15:40	123:52:00	123:49:00	11.12954027	
208.62	2/3/06 16:23	220:35:00	220:32:00	14.85204612	
174.22	2/7/06 16:18	316:30:00	316:27:00	17.79044887	
159.52	2/10/06 12:51	385:03:00	385:00:00	19.62269095	

SAMPLE: 1020', Tebo coal, in canister #25

	lbs.	grams
dry sample weight:	0.0436	19.89

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		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
32	67	1085	0.0011	527	14.063	0.001068249	30.25	0.001068249	30.25	46.72
8	67	1081	0.0003	527	14.031	0.000266078	7.53	0.001334326	37.78	60.86
0	67	1080	0	527	14.018	0	0.00	0.001334326	37.78	60.86
- 6	67	1091	-2E-04	527	14.161	-0.0002014	-5.70	0.001132922	32.08	51.67
- 3	67	1088	-1E-04	527	14.122	-0.00010043	-2.84	0.001032497	29.24	47.09

Sample air dried for approximately one week

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

est. lost gas (cc) =	TIME 0F:						elapsed time (off bottom to canistering)
15	off bottom		at surface		in canister		5.0 minutes
	1/25/06	11:59	1/25/06	12:03	1/25/06	12:04	0.083 hours

SCF/TON		TIME SINCE			0.288675135 SQRT (hrs)
with lost gas	TIME OF MEASURE	off bottom	in canister	SQRT hrs. (since off bottom)	
72.89	1/27/06 17:29	53:30:00	53:25:00	7.314369419	
65.02	1/30/06 15:40	123:41:00	123:36:00	11.12130088	
65.02	2/3/06 16:23	220:24:00	220:19:00	14.84567465	
75.84	2/7/06 16:18	316:19:00	316:14:00	17.76529355	
71.26	2/10/06 12:51	384:52:00	384:47:00	19.61801693	

SAMPLE: 1054', Weir-Pittsburg coal, in canister DCB C

	lbs.	grams
dry sample weight:	0.0140	6.37

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		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
13	67	1085	0.0005	527	14.063	0.000433976	12.29	0.000433976	12.29	61.65
6	67	1081	0.0002	527	14.031	0.000199558	5.65	0.000633534	17.94	90.29
3	67	1080	0.0001	527	14.018	9.98866E-05	2.82	0.000733221	20.76	104.50
- 3	67	1091	-1E-04	527	14.161	-0.0001007	-2.85	0.000632519	17.91	90.15
- 2	67	1088	-7E-05	527	14.122	-6.695E-05	-1.90	0.000565569	16.02	80.61

Sample air dried for approximately one week

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

est. lost gas (cc) =	TIME 0F:						elapsed time (off bottom to canistering)
11	off bottom		at surface		in canister		3.0 minutes
	1/25/06	12:59	1/25/06	13:01	1/25/06	13:02	0.050 hours

SCF/TON		TIME SINCE			0.223606798 SQRT (hrs)
with lost gas	TIME OF MEASURE	off bottom	in canister	SQRT hrs. (since off bottom)	
117.22	1/27/06 17:29	52:30:00	52:27:00	7.245686373	
145.66	1/30/06 15:40	122:41:00	122:38:00	11.07625087	
159.67	2/3/06 16:23	219:24:00	219:21:00	14.81215717	
145.52	2/7/06 16:18	315:19:00	315:16:00	17.75715618	
135.97	2/10/06 12:51	383:52:00	383:49:00	19.59251558	

SAMPLE: 1195', Rowe coal, in canister DCB F

	lbs.	grams
dry sample weight:	0.9804	444.70

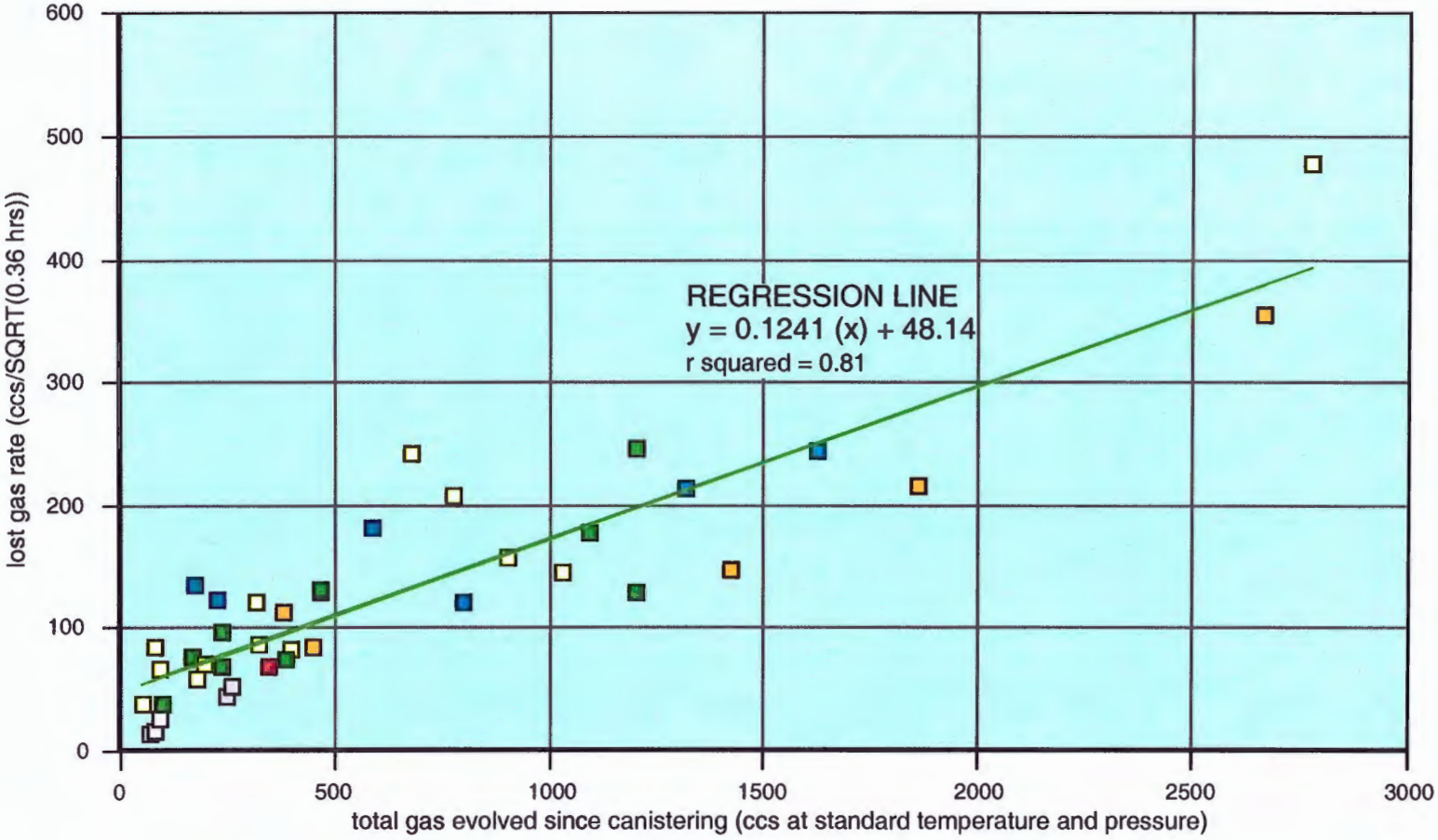
NOTE: lost gas is estimated by time interval between at surface and canister times, and total gas evolved

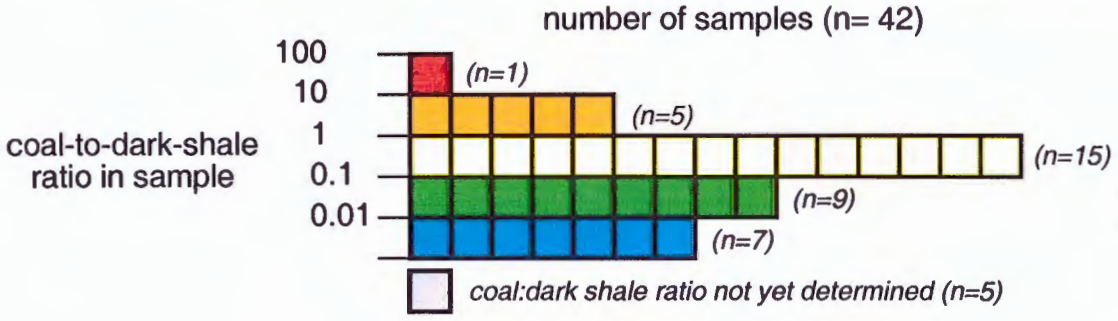
est. lost gas (cc) =	TIME 0F:						elapsed time (off bottom to canistering)
27	off bottom		at surface		in canister		4.0 minutes

RIG/LAB MEASUREMENTS			CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi)					CUMULATIVE VOLUMES		SCF/TON	SCF/TON	1/25/06 12:11	1/25/06 12:14	1/25/06 12:15	0.067 hours
													TIME SINCE		0.258198889 SQRT (hrs)
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)
279	67	1085	0.0099	527	14.083	0.009313792	263.74	0.009313792	263.74	19.00	20.95	1/27/06 17:30	53:19:00	53:15:00	7.301826256
100	67	1081	0.0035	527	14.031	0.00332597	94.18	0.012639762	357.92	25.79	27.73	1/30/06 15:41	123:30:00	123:26:00	11.11305539
44	67	1080	0.0016	527	14.018	0.001462073	41.40	0.014101835	399.32	28.77	30.71	2/3/06 16:25	220:14:00	220:10:00	14.84026055
16	67	1091	0.0006	527	14.161	0.000537078	15.21	0.014638912	414.53	29.86	31.81	2/7/06 16:19	316:08:00	316:04:00	17.78013873
8	67	1088	0.0003	527	14.122	0.000267801	7.58	0.014906713	422.11	30.41	32.35	2/10/06 12:56	384:45:00	384:41:00	19.61504525
13	66	1074	0.0005	526	13.940	0.000430393	12.19	0.015337106	434.30	31.29	33.23	2/14/06 15:11	483:00:00	482:56:00	21.97726098
-3	68	1095	-1E-04	528	14.213	-0.00010088	-2.86	0.015236226	431.44	31.08	33.03	2/19/06 14:04	601:53:00	601:49:00	24.53331069
8	66	1082	0.0003	526	14.044	0.00026683	7.56	0.015503056	439.00	31.63	33.57	2/24/06 14:44	722:33:00	722:29:00	26.88029018
6	66	1075	0.0002	526	13.953	0.000198828	5.63	0.015701884	444.63	32.03	33.98	2/27/06 17:24	797:13:00	797:09:00	28.23502553
-3	67	1094	-1E-04	527	14.200	-0.00010098	-2.86	0.015600905	441.77	31.83	33.77	3/3/06 16:59	892:48:00	892:44:00	29.87975904
8	67	1074	0.0003	527	13.940	0.000264355	7.49	0.015865259	449.25	32.37	34.31	3/7/06 16:17	988:06:00	988:02:00	31.43405796
-2	67	1089	-7E-05	527	14.135	-6.7012E-05	-1.90	0.015798248	447.35	32.23	34.17	3/14/06 15:28	1155:17:00	1155:13:00	33.98945915
7	66	1068	0.0002	526	13.862	0.000230455	6.53	0.016028703	453.88	32.70	34.64	3/30/06 15:38	1539:27:00	1539:23:00	39.23562547
-1	66	1074	-4E-05	526	13.940	-3.3107E-05	-0.94	0.015995596	452.94	32.83	34.58	4/5/06 14:43	1682:32:00	1682:28:00	41.01669492
0	66	1071	0	526	13.901	0	0.00	0.015995596	452.94	32.63	34.58	4/14/06 16:19	1900:08:00	1900:04:00	43.59051885

Sample air dried for approximately one week

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 2.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #C3-34 Edens, NE SE 34-T.29S.-R.14E., Wilson County, KS

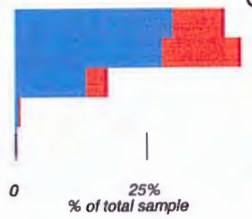
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of shale at 819', associated with Mulberry coal

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

total gas desorbed
(including estimated lost gas) = 175.3 ccs

TOTAL DRY WEIGHT OF SAMPLE = 215.48 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 62.52 grams (29.0%)
$\text{weight}_{dark\ shale}$ = 152.96 grams (71.0%)
weight_{coal} = 0.00 grams (0.0%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	84.79	0.00% / 75.24% / 24.76%
>0.0661"	91.49	0.00% / 65.03% / 34.97%
>0.0460"	37.15	0.00% / 76.11% / 23.89%
>0.0331"	1.67	0.00% / 67.44% / 32.56%
<0.0331"	0.39	0.00% / 70.00% / 30.00%
	215.48 TOTAL	



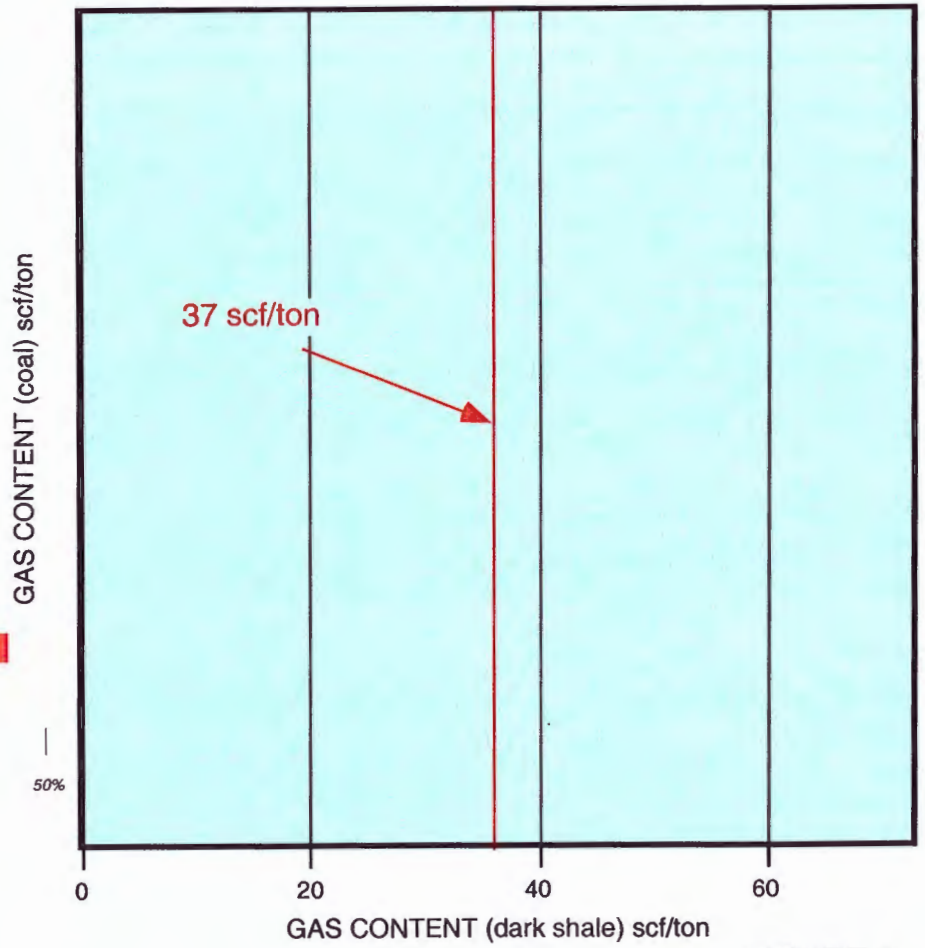


FIGURE 3.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #C3-34 Edens, NE SE 34-T.29S.-R.14E., Wilson County, KS

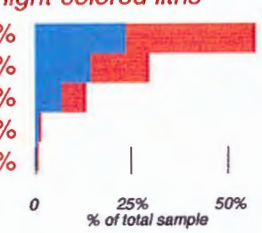
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of Little Osage Shale at 878'

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

total gas desorbed
(including estimated lost gas) = 268.4 ccs

TOTAL DRY WEIGHT OF SAMPLE = 493.92 grams
$\text{weight}_{\text{light-colored lithologies}}$ = 272.92 grams (55.3%)
$\text{weight}_{\text{dark shale}}$ = 221.02 grams (44.8%)
weight_{coal} = 0.00 grams (0.0%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	278.67	0.00% / 41.05% / 58.95%
>0.0661"	143.40	0.00% / 48.52% / 51.48%
>0.0460"	63.26	0.00% / 51.22% / 48.78%
>0.0331"	6.25	0.00% / 53.85% / 46.15%
<0.0331"	2.34	0.00% / 55.00% / 45.00%
	493.92 TOTAL	



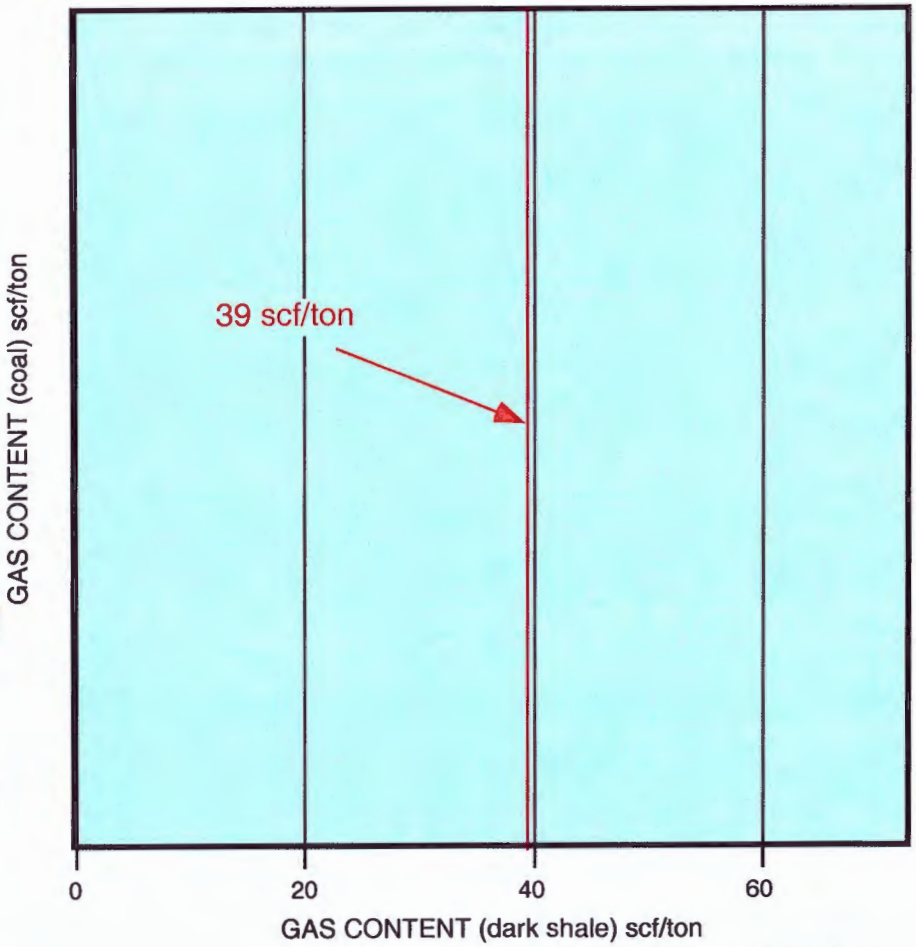


FIGURE 4.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #C3-34 Edens, NE SE 34-T.29S.-R.14E., Wilson County, KS

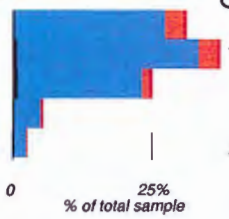
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of Mulky coal/Excello Shale at 891'

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

total gas desorbed
(including estimated lost gas) = 614.4 ccs

TOTAL DRY WEIGHT OF SAMPLE = 389.16 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 38.33 grams (9.9%)
$\text{weight}_{dark\ shale}$ = 344.72 grams (88.6%)
weight_{coal} = 6.11 grams (1.6%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	119.94	0.58% / 87.00% / 12.42%
>0.0661"	142.90	1.51% / 89.15% / 9.34%
>0.0460"	96.27	2.73% / 89.70% / 7.58%
>0.0331"	20.55	2.13% / 88.65% / 9.22%
<0.0331"	9.70	2.00% / 88.50% / 9.50%
	389.16 TOTAL	



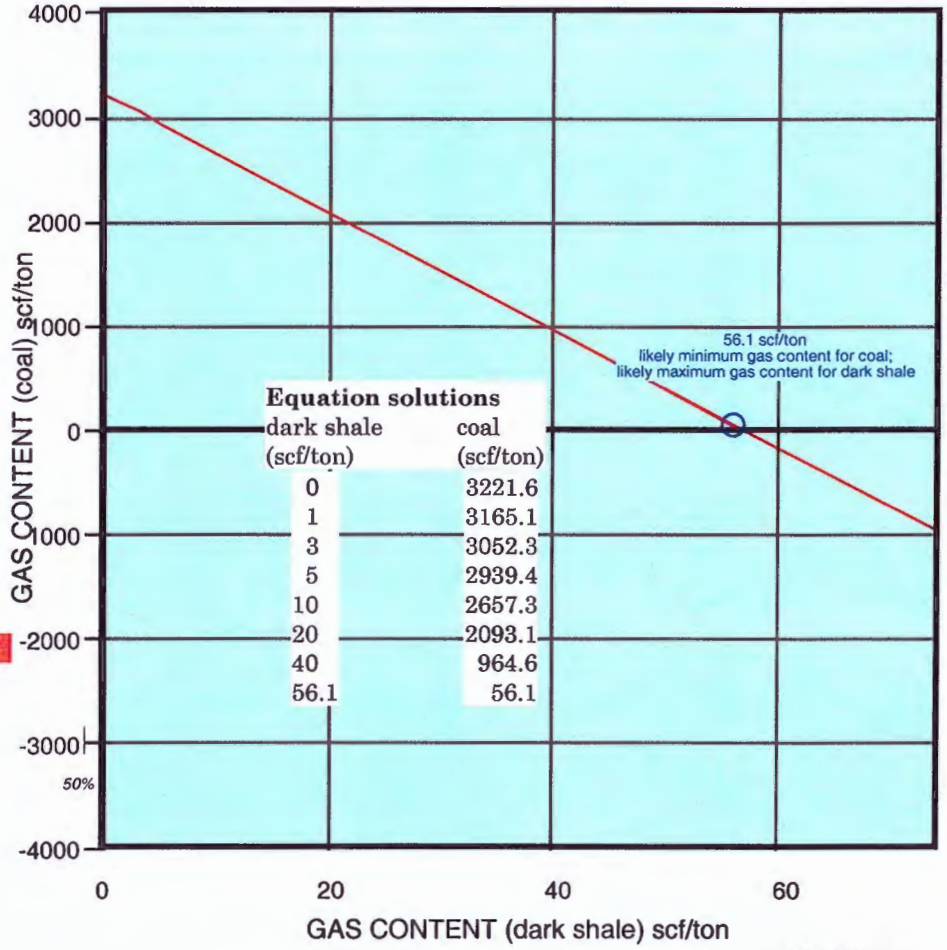


FIGURE 5.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #C3-34 Edens, NE SE 34-T.29S.-R.14E., Wilson County, KS

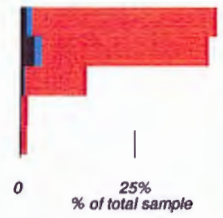
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of unidentified coal at 958'

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

total gas desorbed
(including estimated lost gas) = 106.5 ccs

TOTAL DRY WEIGHT OF SAMPLE = 513.83 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 471.42 grams (91.9%)
$\text{weight}_{dark\ shale}$ = 18.95 grams (3.7%)
weight_{coal} = 22.66 grams (4.4%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	217.57	2.47% / 3.42% / 94.11%
>0.0661"	208.09	6.84% / 4.40% / 88.76%
>0.0460"	72.84	3.85% / 2.88% / 93.27%
>0.0331"	7.90	2.00% / 2.00% / 96.00%
<0.0331"	6.64	1.50% / 1.50% / 97.00%
	513.03 TOTAL	



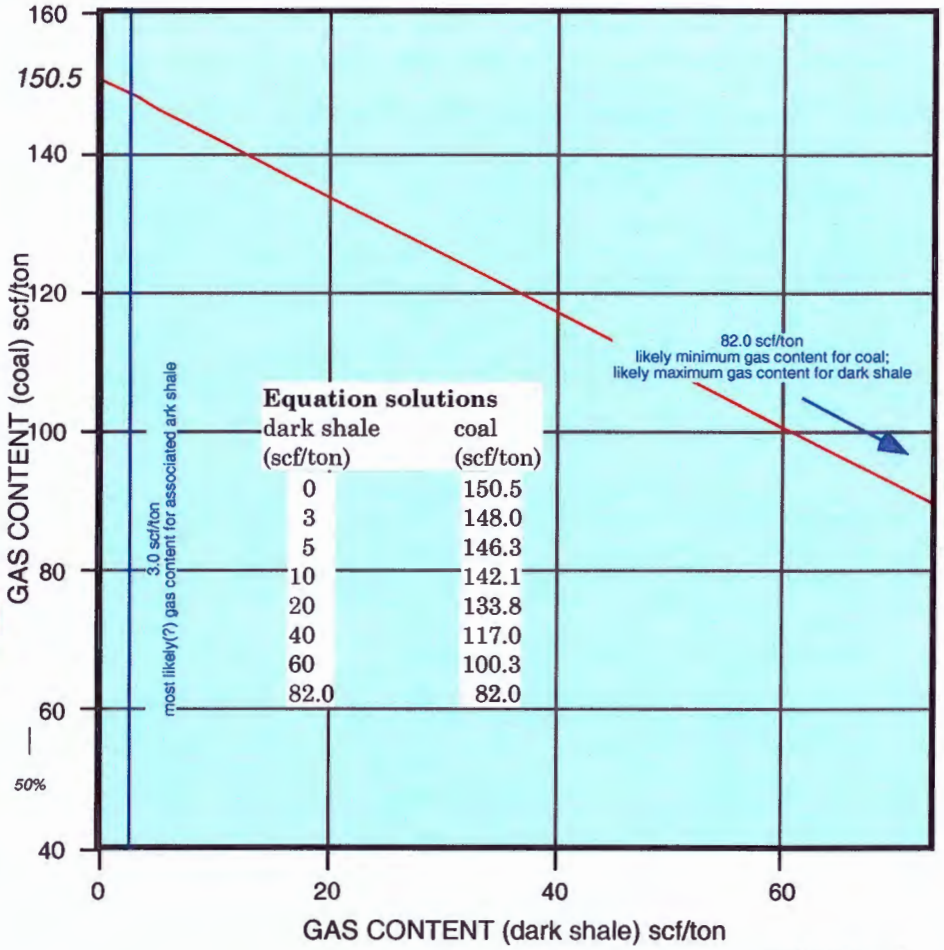


FIGURE 6.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #C3-34 Edens, NE SE 34-T.29S.-R.14E., Wilson County, KS

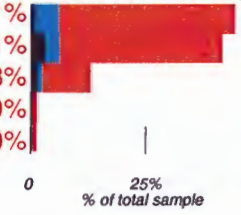
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of Tebo coal at 1020'

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

total gas desorbed
(including estimated lost gas) = 52.8 ccs

TOTAL DRY WEIGHT OF SAMPLE = 132.79 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 112.90 grams (85.0%)
$\text{weight}_{dark\ shale}$ = 13.44 grams (10.1%)
weight_{coal} = 6.44 grams (4.9%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	58.51	1.57% / 12.02% / 86.41%
>0.0661"	54.85	6.90% / 8.09% / 85.01%
>0.0460"	17.08	8.91% / 9.72% / 81.38%
>0.0331"	1.27	9.09% / 12.12% / 78.79%
<0.0331"	1.08	10.00% / 15.00% / 75.00%
	132.79 TOTAL	



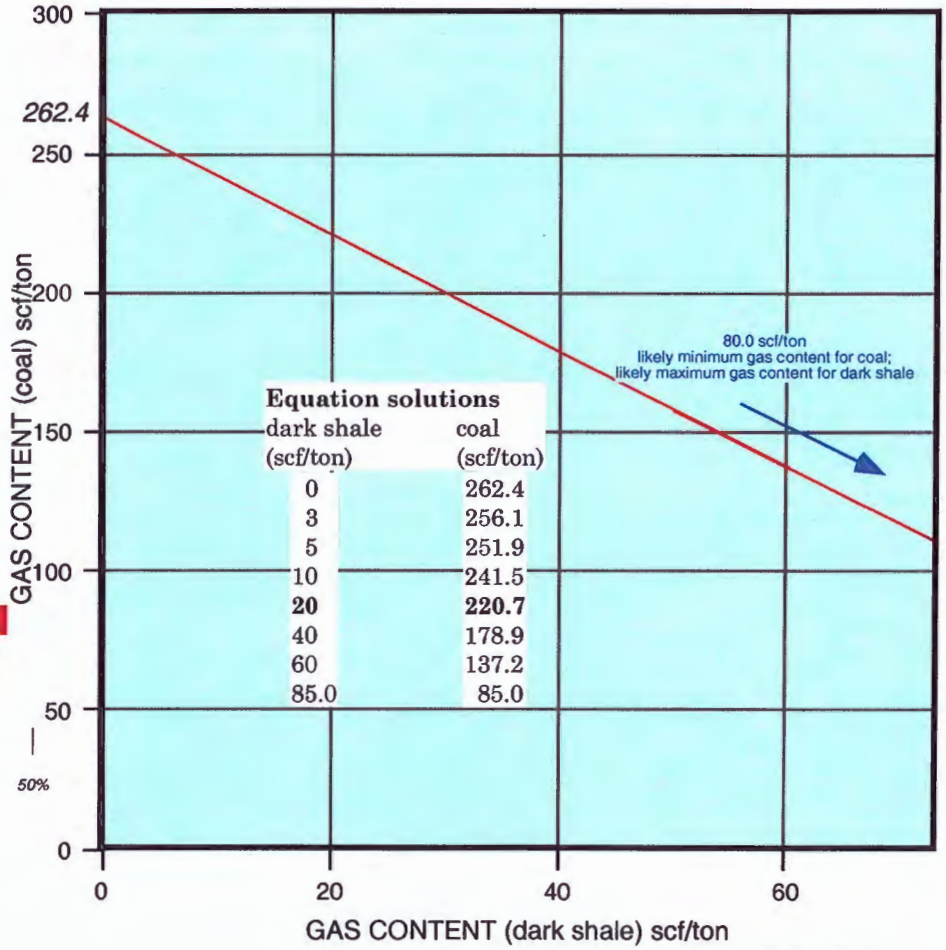


FIGURE 7.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #C3-34 Edens, NE SE 34-T.29S.-R.14E., Wilson County, KS

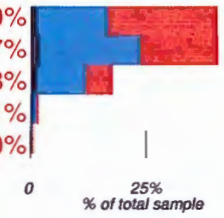
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of Rowe coal at 1195'

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

total gas desorbed
(including estimated lost gas) = 480.9 ccs

TOTAL DRY WEIGHT OF SAMPLE = 838.98 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 394.28 grams (47.0%)
$\text{weight}_{dark\ shale}$ = 415.60 grams (49.5%)
weight_{coal} = 29.10 grams (3.5%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	336.90	2.50% / 38.21% / 59.30%
>0.0661"	338.46	3.61% / 54.42% / 41.97%
>0.0460"	146.30	5.24% / 61.17% / 32.58%
>0.0331"	13.10	4.65% / 67.44% / 27.91%
<0.0331"	4.21	4.00% / 69.00% / 27.00%
	838.98 TOTAL	



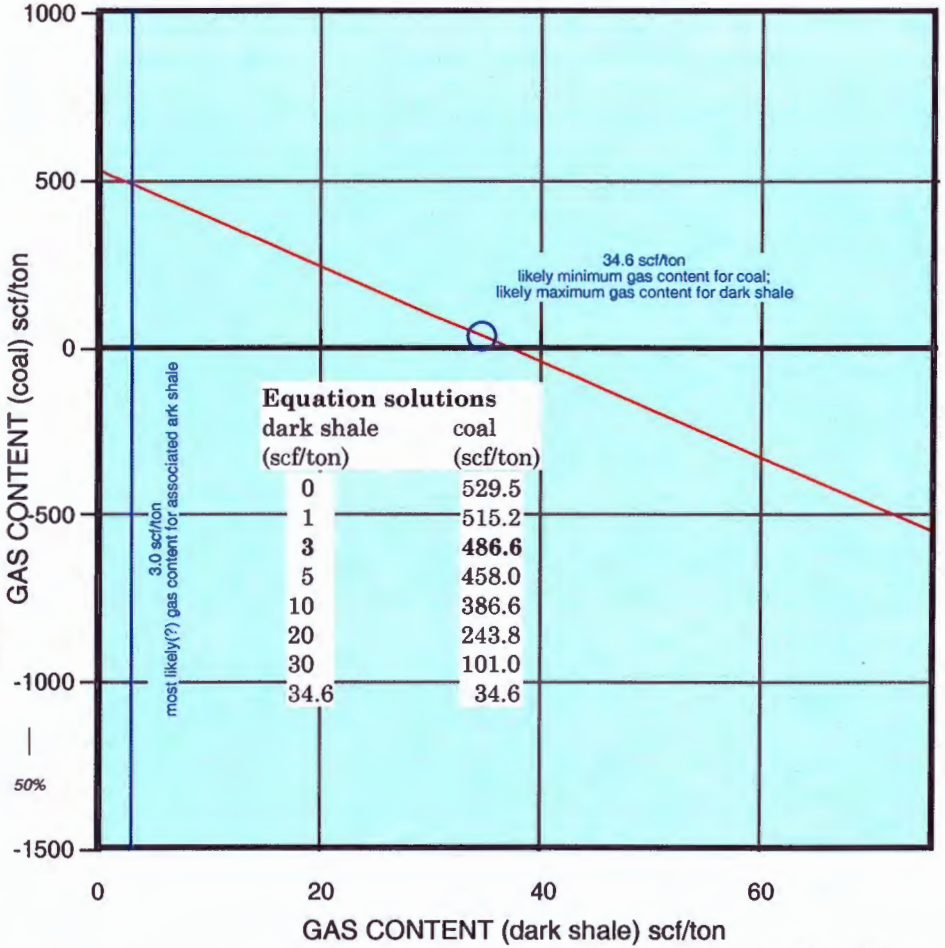


FIGURE 8.

Desorption Characteristics of Cuttings Samples

Daart Cherokee Basin #C3-34 Edens, NE SE 34-T.29S.-R.14E., Wilson County, KS

surface

100'

200'

300'

400'

500'

600'

800'

1100'

819' sh w/ Mulberry

878' Little Osage Sh.
891' Mulky/Excello Sh.

939' Bevier
958' unknown coal

997' Mineral

1020' Tebo
1054' Weir-Pittsburg

1195' Rowe

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for all samples

UNIT	coal in sample	dk sh in sample	scf/ton w/ shale @ 3 scf/ton	maximum scf/ton	minimum scf/ton
819' sh. sh w/Mul.	----	71%	----	----	36.7
878' L.O.S.	----	45%	----	----	38.9
891' Mulky/Excello	2%	89%		*no valid data*	56.1
939' Bevier	<1%	<5%		*no valid data*	
958' unknown	4%	4%	148.0	150.5	82.0
997' Mineral	<1%	<5%		*no valid data*	
1020' Tebo	2%	31%	220.7	262.4	85.0
1054' Weir-Pitt	10%	15%		*no valid data*	
1195' Rowe	<1%	<5%	486.6	529.5	34.6

scf/ton w/ shale @ 20 scf/ton

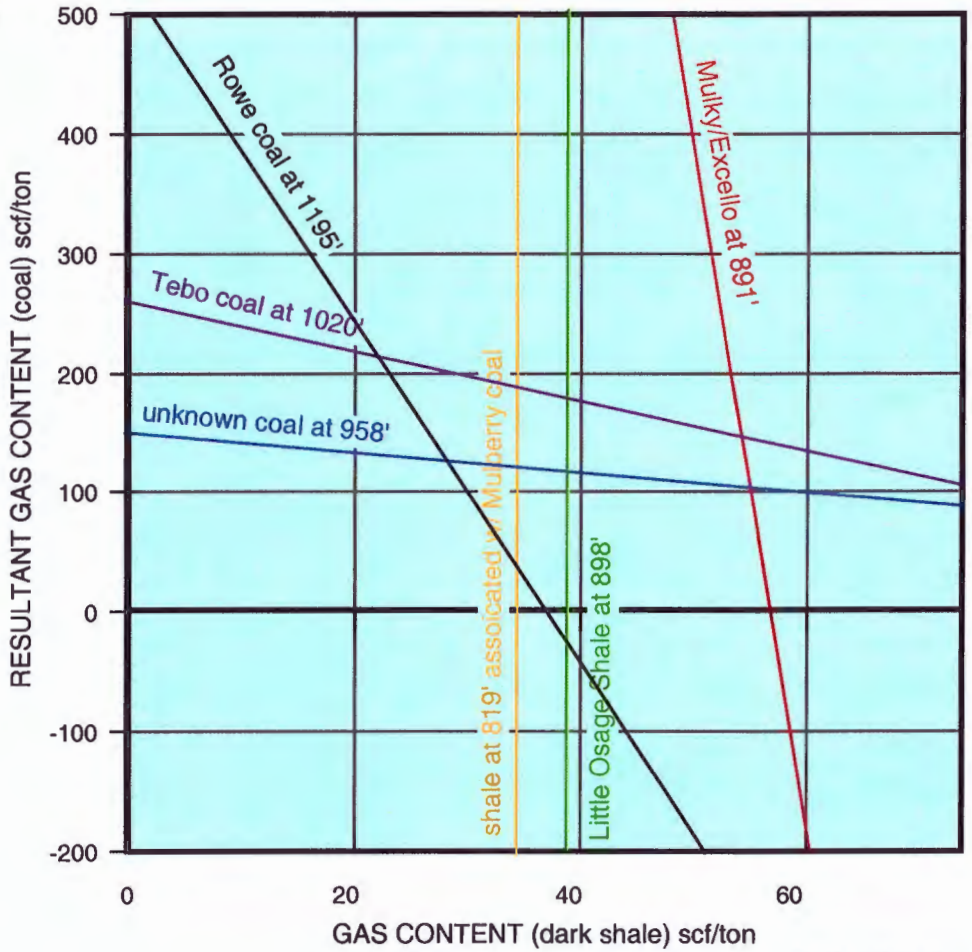


FIGURE 9.