ANALYSIS OF MARMATON AND CHEROKEE GROUP CUTTINGS SAMPLES FOR GAS CONTENT -- DART CHEROKEE BASIN OPERATING COMPANY #D1-3 B. NEILL, ET AL.; SW SE SW SW 3-T.30S.-R.14E.; WILSON COUNTY, KANSAS

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SUMMARY

Nine cuttings samples from the Pennsylvanian Marmaton Group and Cherokee Group were collected from the Dart Cherokee Basin #D1-3 B. Neill et al., well; SW SE SW SW sec. 3-T.30S.-R.14E.; Wilson County, KS. The samples calculate as having the following gas contents:

- Tulsa "coal" at 638' to 642' depth[1] (25 scf/ton)
- Mulberry coal at 810' to 812' depth[2] (109 scf/ton)
- Little Osage Shale at 884' to 886' depth[1] (5 scf/ton)
- Mulky coal at 902'-903' depth[2, 3, 4] (2617 scf/ton)
- Croweburg coal at 972'-973' depth[2, 3, 4] (1249 scf/ton)
- Mineral coal at 1012'-1013' depth[2] (113 scf/ton)
- "upper Tebo" coal at 1035' to 1036' depth[2] (46 scf/ton)
- Rowe coal at 1162' to 1164' depth[2] (82 scf/ton)
- Riverton coal at 1203' to 1204' depth[5] (---- scf/ton)

[1]no coal in sample
[2]assuming accompanying dark shales in sample desorb 3 scf/ton
[3]coal gas content difficult to assess due to gas-rich shales admixed with the coal
[4]reliability of result is unclear due to small amount of coal in the sample
[5]a leak was detected in the canister after desorption finished, no valid gas content measure is possible

BACKGROUND

The Dart Cherokee Basin Dart Cherokee Basin #D1-3 B. Neill et al., well; SW SE SW SW sec. 3-T.30S.-R.14E. in 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 March 31 and April 1, 2004, by Tom O'Neill of Dart Cherokee Basin L.L.C., and turned over to LeaAnn Davidson of the Kansas Geological Survey on April 1, 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 obtained by Tom O'Neill 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 particular 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.

Eleven cuttings samples from the Pennsylvanian Marmaton and Cherokee Groups were collected:

- Tulsa "coal" at 638' to 642' depth (99 grams dry wt.)
- Mulberry coal at 810' to 812' depth (538 grams dry wt.)
- Little Osage Shale at 884' to 886' depth (573 grams dry wt.)
- Mulky coal at 902'-903' depth (900 grams dry wt.)
- Croweburg coal at 972'-973' depth (524 grams dry wt.)
- Mineral coal at 1012'-1013' depth (162 grams dry wt.)
- "upper Tebo" coal at 1035' to 1036' depth (129 grams dry wt.)
- Rowe coal at 1162' to 1164' depth (245 grams dry wt.)
- Riverton coal at 1203' to 1204' depth (sample not saved)

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 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) 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)
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 0.6 (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 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 by 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 4-11)

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:

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

A unique solution for gas $\text{content}_{\text{coal}}$ 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 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 12)

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 13)

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 (Tulsa "coal" at 638' to 642' depth; Little Osage Shale at 884' to 886' depth) contained no coal. The gas analyses associated with these samples is therefore a gas content for shale.

The Mulky coal (902'-903' depth) and Croweburg coal (972'-973' depth) samples registered exceptionally high gas contents (respectively 2617 scf/ton and 1249 scf/ton; assuming accompanying black shales desorbed 3 scf/ton). These samples were dominated by a very dark to black shales (N1, N2) that display a high-gamma ray values on wireline logs. These shales likely have a high gas content, perhaps close to that of the average gas content for the entire sample (i.e., 35 to 40 scf/ton).

The best constrained data are that associated with the Mulberry sample (810'-812'), which contained 18% coal. This sample is followed closely by the Rowe coal (1162' to 1164' depth) and "upper Tebo" coal 1035' to 1036' depth), which respectively have 13% and 8% coal. The Mineral coal (1012'-1013' depth), with 3% coal, also has acceptably constrained data, but the calculated gas content for the coal in this sample varies more with whatever value is assumed for the accompanying black shales. The subsidiary amount of coal in this sample imparts some uncertainty to the desorption measurements, but an approximation of its gas content is nevertheless obtained. An estimate for gas content for the coal in this samples can be made, assuming the admixed dark shale in the sample desorb 3 scf/ton.

A leak was detected in the canister containing the Riverton "coal" at 1203'-1204' depth, thus any data collected for this sample are considered invalid. No material was retained from this canister for any further analyses.

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

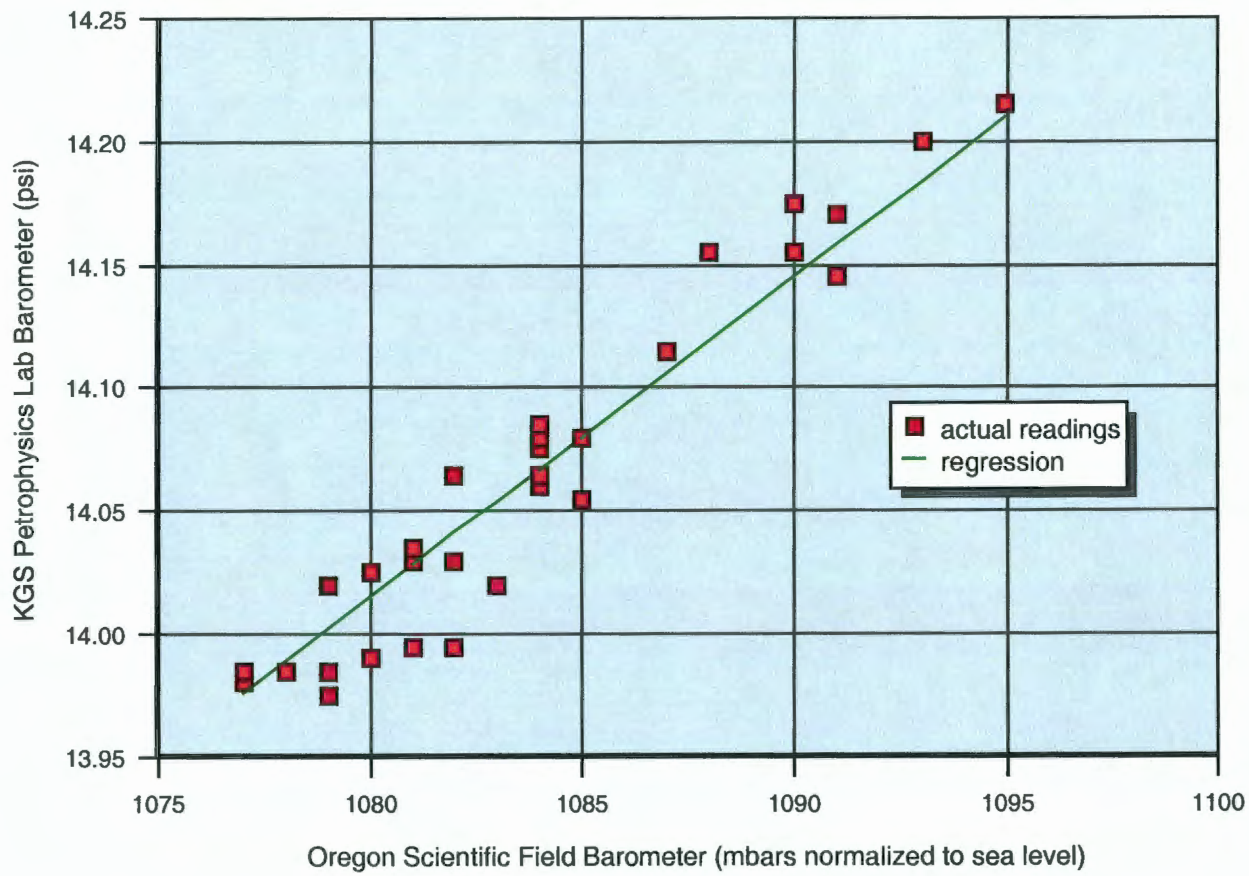


FIGURE 1.

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-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

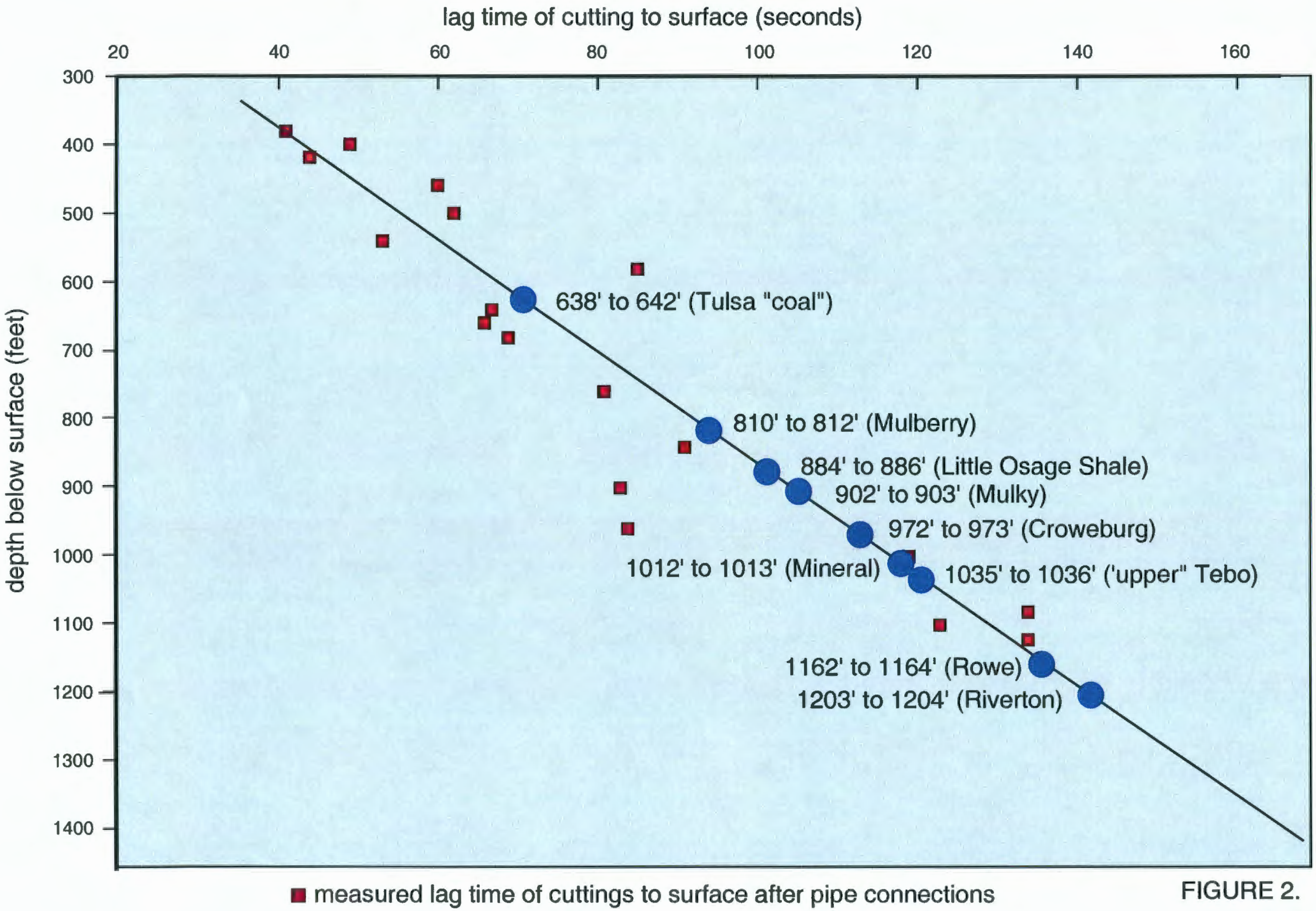


FIGURE 2.

TABLE 1 -- Desorption data for DART CHEROKEE BASIN B. NEILL ET AL. #D1-3; SW SE SW SW 3-T.30S.-R.14E.

SAMPLE: 638' to 642' (Tulsa "coal") cuttings in SSD canister K

	lbs.	grams
dry sample weight:	0.1914	86.84

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

est. lost gas (cc) =	TIME OF: off bottom	at surface	in canister	elapsed time (off bottom to canistering)
13	3/31/04 12:26	3/31/04 12:27	3/31/04 12:30	3.5 minutes
				0.058 hours
				0.241522946 SQRT (hrs)

RIG/LAB MEASUREMENTS measured cc	measured T (F)	measured P	CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi) cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	CUMULATIVE VOLUMES cubic ft (@STP)	cc (@STP)	SCF/TON without lost gas	SCF/TON with lost gas	TIME OF MEASURE	TIME SINCE off bottom	in canister	SQRT hrs. (since off bottom)
41	65	1089	0.0014	525	14.135	0.001378973	39.05	0.001378973	39.05	14.41	19.20	4/2/04 12:22	47:55:05	47:51:35	6.922286873
7	66	1088	0.0002	526	14.122	0.000234771	6.65	0.001613744	45.70	16.86	21.65	4/3/04 17:29	77:02:05	76:58:35	8.776942647
0	65	1087	0	525	14.109	0	0.00	0.001613744	45.70	16.86	21.65	4/4/04 15:39	99:12:05	99:08:35	9.959989402
3	65	1082	0.0001	525	14.044	0.000100252	2.84	0.001713995	48.53	17.91	22.70	4/5/04 21:29	129:02:05	128:58:35	11.35934515
3	67	1080	0.0001	527	14.018	9.96868E-05	2.82	0.001813682	51.36	18.95	23.74	4/6/04 14:32	146:05:05	146:01:35	12.0865513
3	68	1076	0.0001	528	13.966	9.91295E-05	2.81	0.001912812	54.16	19.98	24.78	4/7/04 14:08	169:41:05	169:37:35	13.02630885
-2	67	1082	-7E-05	527	14.044	-6.65809E-05	-1.89	0.001846231	52.28	19.29	24.08	4/6/04 14:18	193:49:05	193:45:35	13.92185532
-2	66	1081	-7E-05	526	14.031	-6.66459E-05	-1.89	0.001779585	50.39	18.59	23.39	4/9/04 16:50	220:23:05	220:19:35	14.84536029

DESORPTION TERMINATED 4/9/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 25 days

SAMPLE: 810' to 812' (Mulberry coal) cuttings in SSD canister 8

	lbs.	grams
dry sample weight:	0.2716	123.19

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

est. lost gas (cc) =	TIME OF: off bottom	at surface	in canister	elapsed time (off bottom to canistering)
20	3/31/04 14:11	3/31/04 14:12	3/31/04 14:14	3.2 minutes
				0.053 hours
				0.230337916 SQRT (hrs)

RIG/LAB MEASUREMENTS measured cc	measured T (F)	measured P	CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi) cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	CUMULATIVE VOLUMES cubic ft (@STP)	cc (@STP)	SCF/TON without lost gas	SCF/TON with lost gas	TIME OF MEASURE	TIME SINCE off bottom	in canister	SQRT hrs. (since off bottom)
141	65	1089	0.005	525	14.135	0.00474232	134.29	0.00474232	134.29	34.92	40.13	4/2/04 12:25	46:13:49	46:10:38	6.799285093
40	66	1088	0.0014	526	14.122	0.001341546	37.99	0.006083869	172.28	44.80	50.01	4/3/04 17:29	75:17:49	75:14:38	8.677381197
17	65	1087	0.0006	525	14.109	0.000570719	16.16	0.006654588	188.44	49.01	54.21	4/4/04 15:40	97:28:49	97:25:38	9.873210105
18	65	1082	0.0006	525	14.044	0.000601511	17.03	0.007256099	205.47	53.44	58.64	4/5/04 21:30	127:18:49	127:15:38	11.28333333
10	67	1080	0.0004	527	14.018	0.000332289	9.41	0.007588388	214.88	55.88	81.09	4/6/04 14:33	144:21:49	144:18:38	12.01514091
13	68	1076	0.0005	528	13.968	0.000429561	12.16	0.008017949	227.04	59.05	64.25	4/7/04 14:08	167:56:49	167:53:38	12.95943457
7	67	1082	0.0002	527	14.044	0.000233033	6.60	0.008250983	233.64	60.76	65.97	4/8/04 14:16	192:04:49	192:01:38	13.85930293
8	66	1081	0.0003	528	14.031	0.000266583	7.55	0.008517568	241.19	62.73	67.93	4/9/04 16:51	218:39:49	218:36:38	14.78727869
3	63	1084	0.0001	523	14.070	0.000100821	2.85	0.008618387	244.04	83.47	88.67	4/11/04 22:49	272:37:49	272:34:38	16.51151955
2	62	1086	7E-05	522	14.096	6.74672E-05	1.91	0.008685854	245.96	63.97	69.17	4/12/04 14:49	288:37:49	288:34:38	16.98912234
1	61	1088	4E-05	521	14.122	3.36606E-05	0.96	0.008719715	246.91	64.22	69.42	4/13/04 14:10	311:58:49	311:55:38	17.66296345
4	62	1085	0.0001	522	14.083	0.00013481	3.82	0.008654525	250.73	65.21	70.41	4/14/04 14:10	335:58:49	335:55:38	18.3297648
8	64	1076	0.0003	524	13.966	0.000266383	7.54	0.009120888	258.27	67.17	72.37	4/15/04 14:28	360:16:49	360:13:38	18.98105049
6	68	1078	0.0002	528	13.992	0.000198827	5.62	0.009319516	263.90	68.63	73.83	4/16/04 13:54	383:42:49	383:39:38	19.5860922
6	71	1081	0.0002	531	14.031	0.000198055	5.61	0.009517571	269.51	70.09	75.29	4/17/04 19:32	413:20:49	413:17:38	20.33093565
6	71	1079	0.0002	531	14.005	0.000197688	5.60	0.009715259	275.10	71.55	76.75	4/18/04 16:02	433:50:49	433:47:38	20.82899288
1	68	1088	4E-05	528	14.122	3.34117E-05	0.95	0.009748671	276.05	71.79	76.99	4/19/04 14:03	455:51:49	455:48:38	21.35096277
10	71	1071	0.0004	531	13.901	0.000327038	9.26	0.010075709	285.31	74.20	79.40	4/20/04 12:58	478:46:49	478:43:38	21.88104837
3	68	1075	0.0001	528	13.953	9.90373E-05	2.80	0.010174746	288.12	74.93	80.13	4/21/04 13:15	503:03:49	503:00:38	22.42907959
2	68	1080	7E-05	528	14.018	6.6332E-05	1.88	0.010241076	289.99	75.42	80.62	4/22/04 18:16	530:04:49	530:01:38	23.02347232
-1	66	1088	-4E-05	526	14.122	-3.35387E-05	-0.95	0.010207539	289.04	75.17	80.37	4/23/04 14:22	552:10:49	552:07:38	23.4985165
6	69	1078	0.0002	529	13.992	0.000198252	5.81	0.010405791	294.66	76.63	81.83	4/24/04 12:11	573:59:49	573:56:38	23.95823333
-1	66	1090	-4E-05	526	14.148	-3.38004E-05	-0.95	0.010372191	293.71	76.39	81.59	4/26/04 11:18	621:06:49	621:03:38	24.92215101
3	65	1087	0.0001	525	14.109	0.000100715	2.85	0.010472906	296.56	77.13	82.33	4/27/04 12:33	646:21:49	646:18:38	25.42368209
7	68	1072	0.0002	528	13.914	0.000230442	6.53	0.010703348	303.08	78.82	84.03	4/28/04 15:29	673:17:49	673:14:38	25.94796609
0	68	1079	0	528	14.005	0	0.00	0.010703348	303.08	78.82	84.03	4/29/04 14:28	696:16:49	696:13:38	26.38712333
-2	66	1086	-7E-05	526	14.096	-6.69541E-05	-1.90	0.010636394	301.19	78.33	83.53	5/1/04 17:44	747:32:49	747:29:38	27.34130473
-2	64	1084	-7E-05	524	14.070	-6.70859E-05	-1.90	0.010589308	299.29	77.84	83.04	5/3/04 18:41	796:29:49	796:26:38	28.22227745

DESORPTION TERMINATED 5/3/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 26 days

SAMPLE: 884' to 886' (Little Osage Shale) cuttings in Dart SSD canister

	lbs.	grams
dry sample weight:	0.9578	434.46

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

est. lost gas (cc) =	TIME OF: off bottom	at surface	in canister	elapsed time (off bottom to canistering)
13	3/31/04 15:29	3/31/04 15:30	3/31/04 15:33	3.6 minutes
				0.059 hours
				0.243812314 SQRT (hrs)

RIG/LAB MEASUREMENTS measured cc	measured T (F)	measured P	CONVERSION OF RIG/LAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi) cubic ft	absolute T (R)	psia	cubic ft (@STP)	cc (@STP)	CUMULATIVE VOLUMES cubic ft (@STP)	cc (@STP)	SCF/TON without lost gas	SCF/TON with lost gas	TIME OF MEASURE	TIME SINCE off bottom	in canister	SQRT hrs. (since off bottom)
49	65	1089	0.0017	525	14.135	0.00164804	46.67	0.00164804	46.67	3.44	4.40	4/2/04 12:30	45:00:34	44:57:00	6.708907843
2	66	1088	7E-05	526	14.122	6.70774E-05	1.90	0.001715118	48.57	3.58	4.54	4/3/04 17:30	74:00:34	73:57:00	8.602874197

-1	65	1087	-4E-05	525	14.109	-3.35717E-05	-0.95	0.001681546	47.82	3.51	4.47	4/4/04	15:41	96:11:34	96:08:00	9.807791687
-1	65	1082	-4E-05	525	14.044	-3.34173E-05	-0.95	0.001648129	46.67	3.44	4.40	4/5/04	21:23	125:53:34	125:50:00	11.22019509
1	67	1080	4E-05	527	14.018	3.32289E-05	0.94	0.001681358	47.61	3.51	4.47	4/6/04	14:33	143:03:34	143:00:00	11.98074598
2	66	1076	7E-05	528	13.966	6.60863E-05	1.87	0.001747444	49.48	3.65	4.61	4/7/04	14:09	166:39:34	166:36:00	12.90966477
-3	67	1082	-0.0001	527	14.044	-9.98714E-05	-2.83	0.001847573	46.65	3.44	4.40	4/8/04	14:16	190:46:34	190:43:00	13.81217257

DESORPTION TERMINATED 4/8/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 18 days

SAMPLE: 902' to 903' (Mulky coal) cuttings in Dart SSD canister

	lbs.	grams
dry sample weight:	1.7721	803.82

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)
47	off bottom	at surface	in canister	3.8 minutes
	3/31/04 15:54	3/31/04 15:55	3/31/04 15:58	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)
620	65	1089	0.0219	525	14.135	0.020852757	590.48	0.020852757	590.48	23.53	25.41	4/2/04	12:32	44:37:50	44:34:00	6.680610418
164	66	1088	0.0058	526	14.122	0.005500348	155.75	0.026353105	748.23	29.74	31.62	4/3/04	17:31	73:36:50	73:33:00	8.579853664
70	65	1087	0.0025	525	14.109	0.00235002	66.54	0.028703125	812.78	32.39	34.27	4/4/04	15:41	95:46:50	95:43:00	9.786754087
56	65	1082	0.002	525	14.044	0.001871368	52.99	0.030574493	865.77	34.51	36.38	4/5/04	21:23	125:28:50	125:25:00	11.20181037
30	67	1080	0.0011	527	14.018	0.000996866	28.23	0.03157136	894.00	35.63	37.50	4/6/04	14:33	142:38:50	142:35:00	11.94350125
31	68	1076	0.0011	528	13.966	0.001024338	29.01	0.032595898	923.00	36.79	38.66	4/7/04	14:09	166:14:50	166:11:00	12.89368924
22	67	1082	0.0008	527	14.044	0.00073239	20.74	0.033328089	943.74	37.61	39.49	4/8/04	14:17	190:22:50	190:19:00	13.79784605
20	66	1081	0.0007	526	14.031	0.000666459	18.87	0.033994547	962.61	38.37	40.24	4/9/04	18:51	216:56:50	216:53:00	14.72912836
5	82	1087	0.0002	522	14.109	0.000168823	4.78	0.03416337	967.40	38.56	40.43	4/10/04	16:30	240:35:50	240:32:00	15.51119667
3	63	1084	0.0001	523	14.070	0.000100821	2.85	0.034264192	970.25	36.67	40.54	4/11/04	22:49	270:54:50	270:51:00	16.45946199
0	62	1086	0	522	14.096	0	0.00	0.034264192	970.25	38.67	40.54	4/12/04	14:49	286:54:50	286:51:00	16.93853267
12	61	1088	0.0004	521	14.122	0.000406327	11.51	0.034870519	981.76	39.13	41.00	4/13/04	14:11	310:16:50	310:13:00	17.6147823
9	62	1065	0.0003	522	14.083	0.000303323	8.59	0.034973841	990.35	39.47	41.34	4/14/04	14:10	334:15:50	334:12:00	18.28288514
12	64	1076	0.0004	524	13.986	0.000399545	11.31	0.035373388	1001.86	39.92	41.80	4/15/04	14:28	358:33:50	358:30:00	18.93578329
10	68	1078	0.0004	528	13.992	0.000331048	9.37	0.035704432	1011.03	40.30	42.17	4/18/04	13:54	381:59:50	381:56:00	19.54474922
10	71	1081	0.0004	531	14.031	0.000330092	9.35	0.036034523	1020.36	40.67	42.54	4/17/04	19:32	411:37:50	411:34:00	20.28868048
8	71	1079	0.0003	531	14.005	0.000263585	7.46	0.036298108	1027.64	40.97	42.84	4/16/04	16:02	432:07:50	432:04:00	20.78775013
3	68	1088	0.0001	528	14.122	0.000100235	2.84	0.036398343	1030.68	41.08	42.95	4/19/04	14:04	454:09:50	454:06:00	21.31112125
11	71	1071	0.0004	531	13.901	0.000359742	10.19	0.038758085	1040.87	41.48	43.36	4/20/04	12:59	477:04:50	477:01:00	21.84217378
5	68	1075	0.0002	528	13.953	0.000165082	4.67	0.038923147	1045.54	41.67	43.54	4/21/04	13:15	501:20:50	501:17:00	22.39078431
3	68	1080	0.0001	528	14.018	9.9498E-05	2.82	0.037022645	1046.38	41.78	43.66	4/22/04	16:16	528:21:50	528:18:00	22.98816734
-1	66	1086	-4E-05	526	14.122	-3.35387E-05	-0.95	0.036989106	1047.41	41.75	43.62	4/23/04	14:22	550:27:50	550:24:00	23.46196686
6	69	1078	0.0002	529	13.992	0.000198252	5.81	0.037187358	1053.02	41.97	43.84	4/24/04	12:11	572:16:50	572:13:00	23.92238608
1	66	1090	4E-05	526	14.148	3.36004E-05	0.95	0.037220959	1053.98	42.01	43.88	4/26/04	11:18	619:23:50	619:20:00	24.88769218
3	65	1087	0.0001	525	14.109	0.000100715	2.85	0.037321674	1056.83	42.12	43.99	4/27/04	12:33	644:38:50	644:35:00	25.38990394
8	68	1072	0.0003	528	13.914	0.000263363	7.46	0.037585038	1064.29	42.42	44.29	4/28/04	15:29	671:34:50	671:31:00	25.91487132
3	68	1079	0.0001	528	14.005	9.94059E-05	2.81	0.037684442	1087.10	42.53	44.40	4/29/04	14:29	694:34:50	694:31:00	26.35489623
1	66	1086	4E-05	526	14.096	3.34771E-05	0.95	0.037717919	1088.05	42.57	44.44	5/1/04	17:45	745:50:50	745:47:00	27.31020363
0	64	1084	0	524	14.070	0	0.00	0.037717919	1068.05	42.57	44.44	5/3/04	18:43	794:48:50	794:45:00	28.19244383
4	66	1081	0.0001	526	14.031	0.000133292	3.77	0.037851211	1071.62	42.72	44.59	5/5/04	9:36	833:41:50	833:38:00	28.87381551
5	69	1079	0.0002	529	14.005	0.000165363	4.68	0.038016574	1078.51	42.91	44.78	5/6/04	10:53	858:58:50	658:55:00	29.30837006
4	71	1084	0.0001	531	14.070	0.000132403	3.75	0.038148977	1080.25	43.05	44.93	5/7/04	13:28	885:33:50	885:30:00	29.75842551
5	70	1080	0.0002	530	14.018	0.000165204	4.88	0.038314181	1084.93	43.24	45.11	5/8/04	14:26	910:31:50	910:28:00	30.17499885
5	71	1079	0.0002	531	14.005	0.00016474	4.66	0.038478922	1089.60	43.43	45.30	5/9/04	19:47	939:52:50	939:49:00	30.65747145
2	71	1081	7E-05	531	14.031	6.60183E-05	1.87	0.03854494	1091.47	43.50	45.37	5/10/04	13:50	957:55:50	957:52:00	30.95045324
4	71	1077	0.0001	531	13.979	0.000131548	3.73	0.038678488	1095.19	43.65	45.52	5/11/04	14:11	982:16:50	982:13:00	31.34135536
4	72	1076	0.0001	532	13.966	0.000131179	3.71	0.038807887	1098.91	43.80	45.67	5/12/04	10:35	1002:40:50	1002:37:00	31.66513154
1	72	1061	4E-05	532	14.031	3.29471E-05	0.93	0.038840614	1099.84	43.64	45.71	5/13/04	14:20	1030:25:50	1030:22:00	32.10032018
-8	65	1068	-0.0003	525	14.122	-0.000268821	-7.61	0.038571793	1092.23	43.53	45.41	5/15/04	23:21	1087:26:50	1087:23:00	32.97646467
0	68	1062	0	528	14.044	0	0.00	0.038571793	1092.23	43.53	45.41	5/17/04	9:35	1121:40:50	1121:37:00	33.49149975
1	70	1083	4E-05	530	14.057	3.31326E-05	0.94	0.038604926	1093.17	43.57	45.44	5/18/04	14:29	1150:34:50	1150:31:00	33.92020866
4	72	1081	0.0001	532	14.031	0.000131788	3.73	0.038736715	1096.90	43.72	45.59	5/20/04	13:50	1197:55:50	1197:52:00	34.6111334

DESORPTION TERMINATED 5/20/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 10 days

SAMPLE: 972' to 973' (Croweburg coal) cuttings in Dart SSD canister

	lbs.	grams
dry sample weight:	0.8610	390.55

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)
24	off bottom	at surface	in canister	4.0 minutes
	4/1/04 11:03	4/1/04 11:05	4/1/04 11:08	0.067 hours
				0.259807621 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)
242	65	1088	0.0085	525	14.122	0.008131828	230.27	0.008131828	230.27	18.89	20.86	4/2/04 12:48	25:44:03	25:40:00	5.072885438
63	66	1088	0.0022	526	14.122	0.002112939	59.83	0.010244766	290.10	23.80	25.77	4/3/04 17:33	54:29:03	54:25:00	7.381339084
22	65	1087	0.0008	525	14.109	0.000738578	20.91	0.010983344	311.01	25.51	27.48	4/4/04 15:42	76:38:03	76:34:00	8.75409428
20	65	1082	0.0007	525	14.044	0.000668346	18.93	0.01165169	329.94	27.07	29.03	4/5/04 21:32	106:28:03	106:24:00	10.31830897
10	67	1080	0.0004	527	14.018	0.000332289	9.41	0.011983979	339.35	27.84	29.81	4/6/04 14:34	123:30:03	123:26:00	11.11309288
11	68	1076	0.0004	528	13.966	0.000363475	10.29	0.012347454	349.64	28.68	30.65	4/7/04 14:09	147:05:03	147:01:00	12.12782613
6	67	1082	0.0002	527	14.044	0.000199743	5.66	0.012547197	355.30	29.15	31.11	4/8/04 14:17	171:13:03	171:09:00	13.08501051
5	66	1081	0.0002	526	14.031	0.000166615	4.72	0.012713811	360.01	29.53	31.50	4/9/04 16:52	197:48:03	197:44:00	14.06416842
0	63	1084	0	523	14.070	0	0.00	0.012713811	360.01	29.53	31.50	4/11/04 22:50	251:46:03	251:42:00	15.86718311
0	62	1086	0	522	14.096	0	0.00	0.012713811	360.01	29.53	31.50	4/12/04 14:50	267:46:03	267:42:00	16.3636029
0	61	1088	0	521	14.122	0	0.00	0.012713811	360.01	29.53	31.50	4/13/04 14:14	291:10:03	291:06:00	17.06363091

DESORPTION TERMINATED 4/13/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 12 days

SAMPLE: 1012' to 1013' (Mineral coal) cuttings in Dart SSD canister

dry sample weight: 0.2320 lbs. 105.22 grams

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

est. lost gas (cc) = 15

TIME OF: off bottom 4/1/04 10:26; at surface 4/1/04 10:28; in canister 4/1/04 10:31

elapsed time (off bottom to canistering): 5.2 minutes; 0.086 hours; 0.293446948 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)
13	65	1088	0.0005	525	14.122	0.000436834	12.37	0.000436834	12.37	3.77	8.33	4/2/04 11:54	25:27:25	25:22:15	5.045487533
0	66	1088	0	526	14.122	0	0.00	0.000436834	12.37	3.77	8.33	4/3/04 17:34	55:07:25	55:02:15	7.424527669
-1	65	1087	-4E-05	525	14.109	-3.35717E-05	-0.95	0.000403262	11.42	3.48	8.04	4/4/04 15:43	77:16:25	77:11:15	8.790541002
0	65	1080	0	525	14.018	0	0.00	0.000403262	11.42	3.48	8.04	4/5/04 21:32	107:05:25	107:00:15	10.34844325

SAMPLE DECANISTERED 4/5/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 21 days

SAMPLE: 1035' to 1036' ("upper" Tebo coal) cuttings in Dart SSD canister

dry sample weight: 0.2373 lbs. 107.63 grams

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

est. lost gas (cc) = 12

TIME OF: off bottom 4/1/04 11:43; at surface 4/1/04 11:44; in canister 4/1/04 11:46

elapsed time (off bottom to canistering): 3.7 minutes; 0.062 hours; 0.248327741 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)
12	65	1088	0.0004	525	14.122	0.000403231	11.42	0.000403231	11.42	3.40	6.97	4/2/04 12:58	25:14:57	25:11:15	5.02485489
0	66	1088	0	526	14.122	0	0.00	0.000403231	11.42	3.40	6.97	4/3/04 17:35	53:51:57	53:48:15	7.339334666
0	65	1087	0	525	14.109	0	0.00	0.000403231	11.42	3.40	6.97	4/4/04 15:43	75:59:57	75:56:15	8.717750092
-1	65	1082	-4E-05	525	14.044	-3.34173E-05	-0.95	0.000369814	10.47	3.12	6.69	4/5/04 21:34	105:50:57	105:47:15	10.28830242
1	67	1080	4E-05	527	14.018	3.32269E-05	0.94	0.000403043	11.41	3.40	6.97	4/6/04 14:34	122:50:57	122:47:15	11.08373433
1	68	1076	4E-05	526	13.966	3.30432E-05	0.94	0.000436086	12.35	3.68	7.25	4/7/04 14:10	146:26:57	146:23:15	12.10161835
-3	67	1082	-0.0001	527	14.044	-9.98714E-05	-2.83	0.000336215	9.52	2.83	6.41	4/8/04 14:17	170:33:57	170:30:15	13.0600855

SAMPLE DECANISTERED 4/8/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 16 days

SAMPLE: 1162' to 1164' (Rowe coal) cuttings in Dart SSD canister

dry sample weight: 0.4734 lbs. 214.73 grams

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

est. lost gas (cc) = 20

TIME OF: off bottom 4/1/04 12:43; at surface 4/1/04 12:45; in canister 4/1/04 12:50

elapsed time (off bottom to canistering): 7.4 minutes; 0.123 hours; 0.351188458 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)
45	65	1088	0.0016	525	14.122	0.001512117	42.82	0.001512117	42.82	6.39	9.37	4/2/04 12:59	24:15:39	24:08:15	4.925528736
12	66	1088	0.0004	526	14.122	0.000402465	11.40	0.001914581	54.21	8.09	11.07	4/3/04 17:35	52:51:39	52:44:15	7.270545601
5	65	1087	0.0002	525	14.109	0.000167859	4.75	0.00208244	58.97	8.80	11.76	4/4/04 15:44	75:00:39	74:53:15	8.660879478
6	65	1082	0.0002	525	14.044	0.000200504	5.68	0.002282943	64.65	9.64	12.63	4/5/04 21:34	104:50:39	104:43:15	10.23934405
5	67	1080	0.0002	527	14.018	0.000166145	4.70	0.002449088	69.35	10.35	13.33	4/6/04 14:34	121:50:39	121:43:15	11.03830452
5	68	1076	0.0002	526	13.966	0.000165216	4.68	0.002614304	74.03	11.04	14.03	4/7/04 14:10	145:26:39	145:19:15	12.06002349
1	67	1082	4E-05	527	14.044	3.32905E-05	0.94	0.002647594	74.97	11.19	14.17	4/8/04 14:18	169:34:39	169:27:15	13.0221926
2	66	1081	7E-05	526	14.031	6.66459E-05	1.89	0.00271424	76.86	11.47	14.45	4/9/04 16:53	196:09:39	196:02:15	14.00574287
0	63	1084	0	523	14.070	0	0.00	0.00271424	76.86	11.47	14.45	4/11/04 22:51	250:07:39	250:00:15	15.81541969
0	62	1086	0	522	14.096	0	0.00	0.00271424	76.86	11.47	14.45	4/12/04 14:51	266:07:39	266:00:15	16.31341473
0	61	1088	0	521	14.122	0	0.00	0.00271424	76.86	11.47	14.45	4/13/04 14:15	289:31:39	289:24:15	17.01550763

SAMPLE DECANISTERED 3/30/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 26 days

SAMPLE: 1203' to 1204' (Riverton coal) cuttings in Dart SSD canister

	lbs.	grams
dry sample weight:	0.0000	0

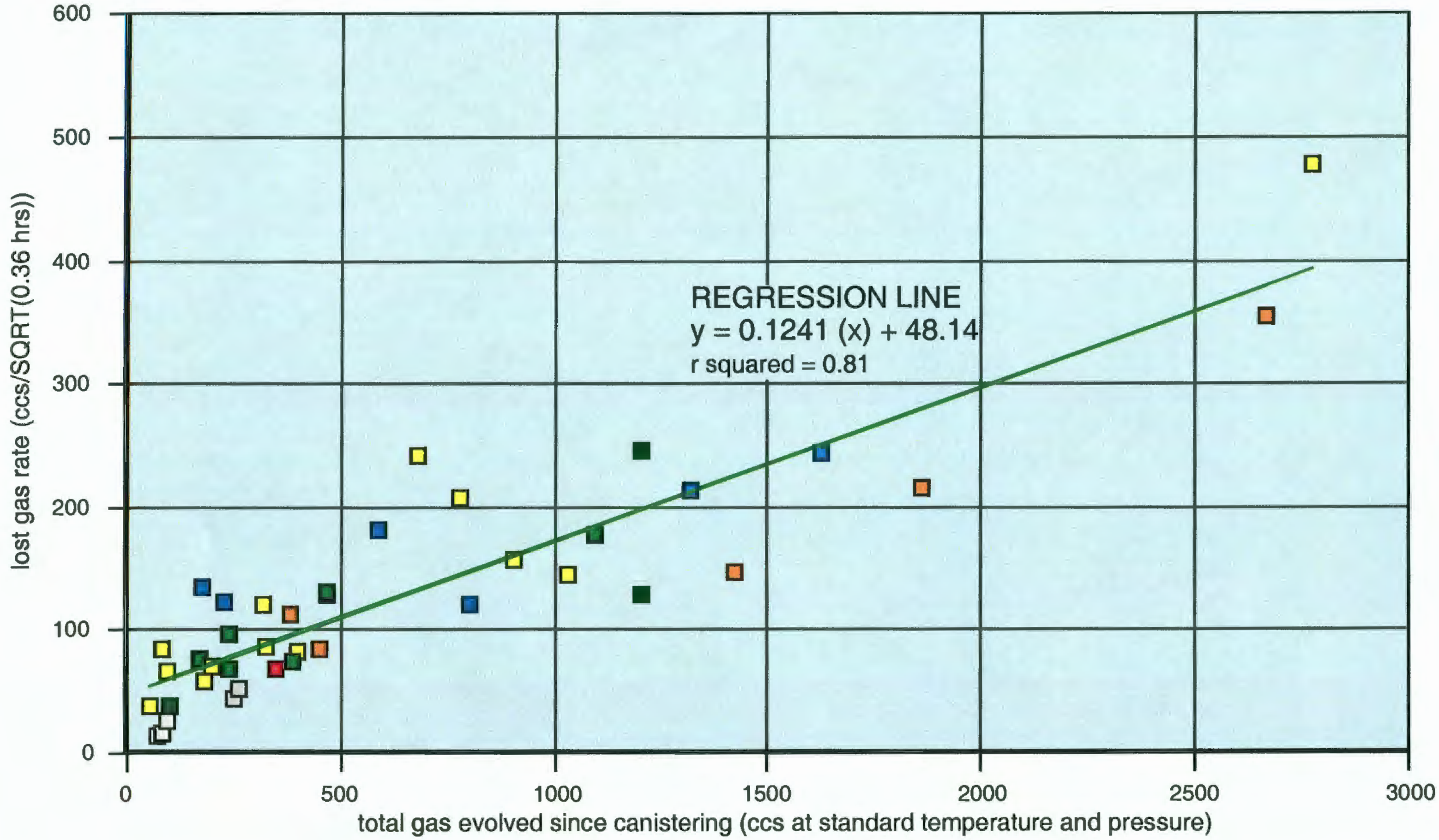
NOTE: los gas is estimated by time interval between at surface and canister times, and total gas evolved

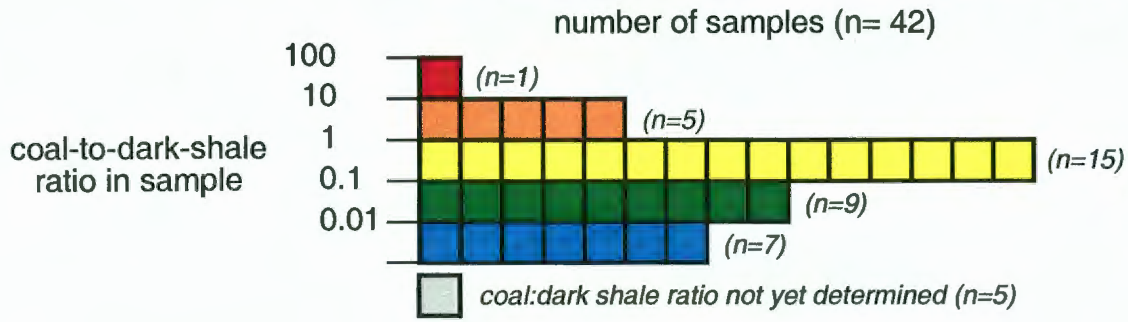
est. lost gas (cc) =	TIME OF:			elapsed time (off bottom to canistering)
0	off bottom	at surface	in canister	7.5 minutes
	4/1/04 13:14	4/1/04 13:16	4/1/04 13:21	0.126 hours
				0.354729944 SQRT (hrs)

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)
3	65	1088	0.0001	525	14.122	0.000100808	2.85	0.000100808	2.85	#DIV/0!	#DIV/0!	4/2/04 13:02	23:47:38	23:40:05	4.877897999
4	66	1088	0.0001	526	14.122	0.000134155	3.80	0.000234963	6.65	#DIV/0!	#DIV/0!	4/3/04 17:36	52:21:38	52:14:05	7.236059394
0	65	1087	0	525	14.109	0	0.00	0.000234963	6.65	#DIV/0!	#DIV/0!	4/4/04 15:45	74:30:38	74:23:05	8.631949696

SAMPLE DECANISTERED 4/6/2004 DUE TO NO MORE GAS BEING EVOLVED (LEAKY CANISTER!); sample air dried for 20 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

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

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 #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

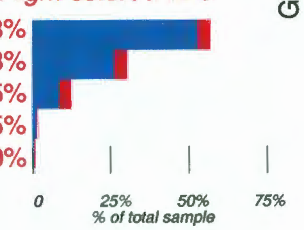
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of Tulsa "coal" from 638' to 642

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

total gas desorbed
(including estimated lost gas) = 67.2 ccs

TOTAL DRY WEIGHT OF SAMPLE = 99.10 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 12.28 grams (12.4%)
$\text{weight}_{dark\ shale}$ = 86.82 grams (87.6%)
weight_{coal} = 0.00 grams (0.0%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	55.58	0.00% / 92.92% / 7.08%
>0.0661"	29.76	0.00% / 86.32% / 13.68%
>0.0460"	12.02	0.00% / 68.95% / 31.05%
>0.0331"	1.26	0.00% / 73.85% / 26.15%
<0.0331"	0.49	0.00% / 60.00% / 40.00%
	99.10 TOTAL	



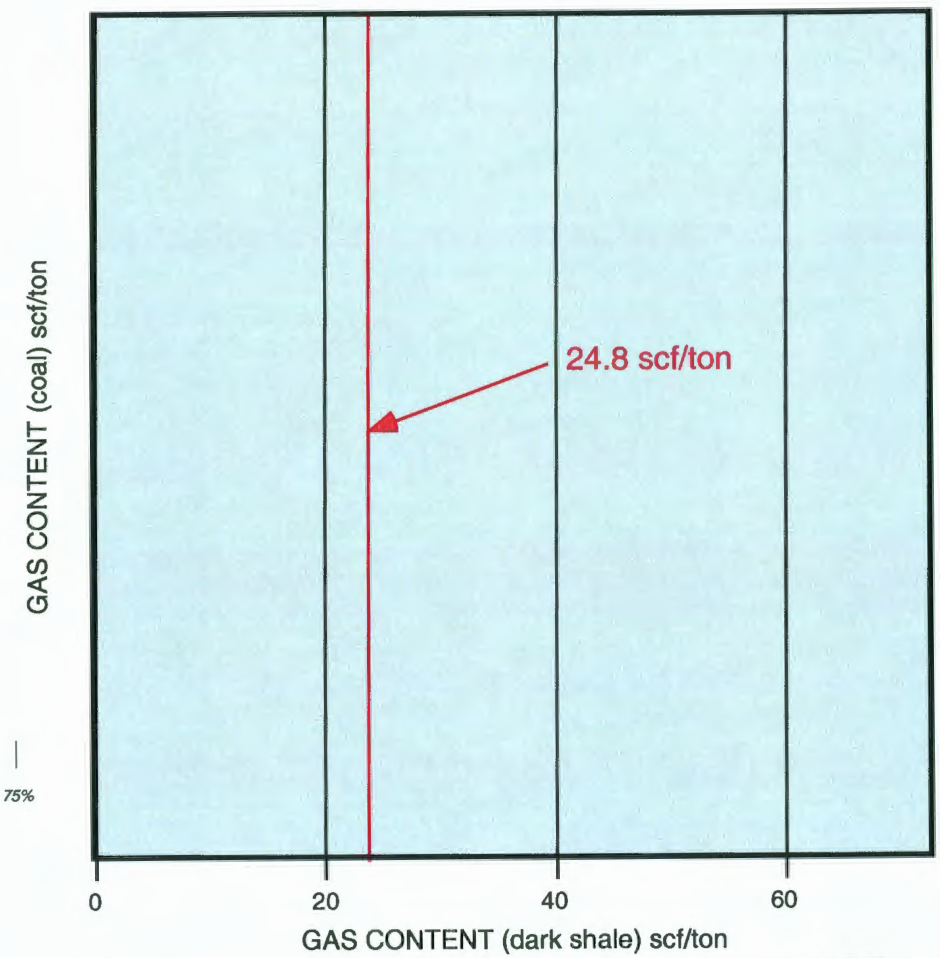


FIGURE 4.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

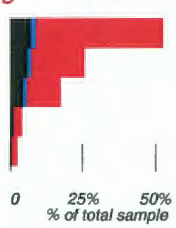
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Mulberry coal from 810' to 812'

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

total gas desorbed
(including estimated lost gas) = 323.1 ccs

TOTAL DRY WEIGHT OF SAMPLE = 538.13 grams
$\text{weight}_{\text{light-colored lithologies}}$ = 414.95 grams (77.1%)
$\text{weight}_{\text{dark shale}}$ = 28.72 grams (5.3%)
weight_{coal} = 94.47 grams (17.6%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	277.60	12.97% / 3.86% / 83.17%
>0.0661"	135.62	21.64% / 6.38% / 71.98%
>0.0460"	92.02	24.72% / 7.87% / 67.42%
>0.0331"	21.10	21.82% / 7.27% / 70.91%
<0.0331"	11.79	15.00% / 5.00% / 80.00%
	538.13 TOTAL	



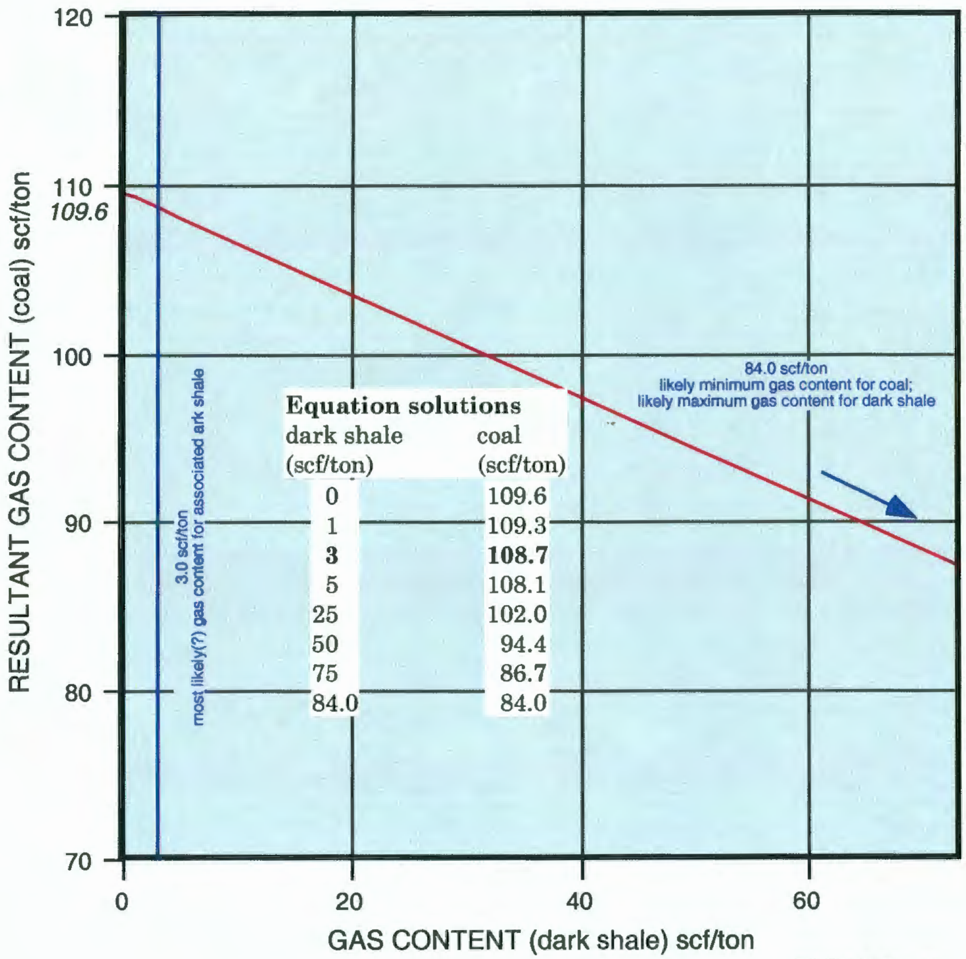


FIGURE 5.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

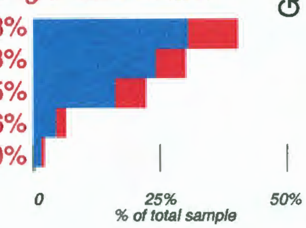
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of Little Osage Shale from 884' to 886'

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

total gas desorbed
(including estimated lost gas) = 62.5 ccs

TOTAL DRY WEIGHT OF SAMPLE = 572.67 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 138.21 grams (24.1%)
$\text{weight}_{dark\ shale}$ = 434.46 grams (75.9%)
weight_{coal} = 0.00 grams (0.0%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	228.80	0.00% / 75.72% / 24.28%
>0.0661"	170.89	0.00% / 80.17% / 19.83%
>0.0460"	125.70	0.00% / 72.65% / 27.35%
>0.0331"	35.61	0.00% / 69.44% / 30.56%
<0.0331"	11.67	0.00% / 70.00% / 30.00%
	572.67 TOTAL	



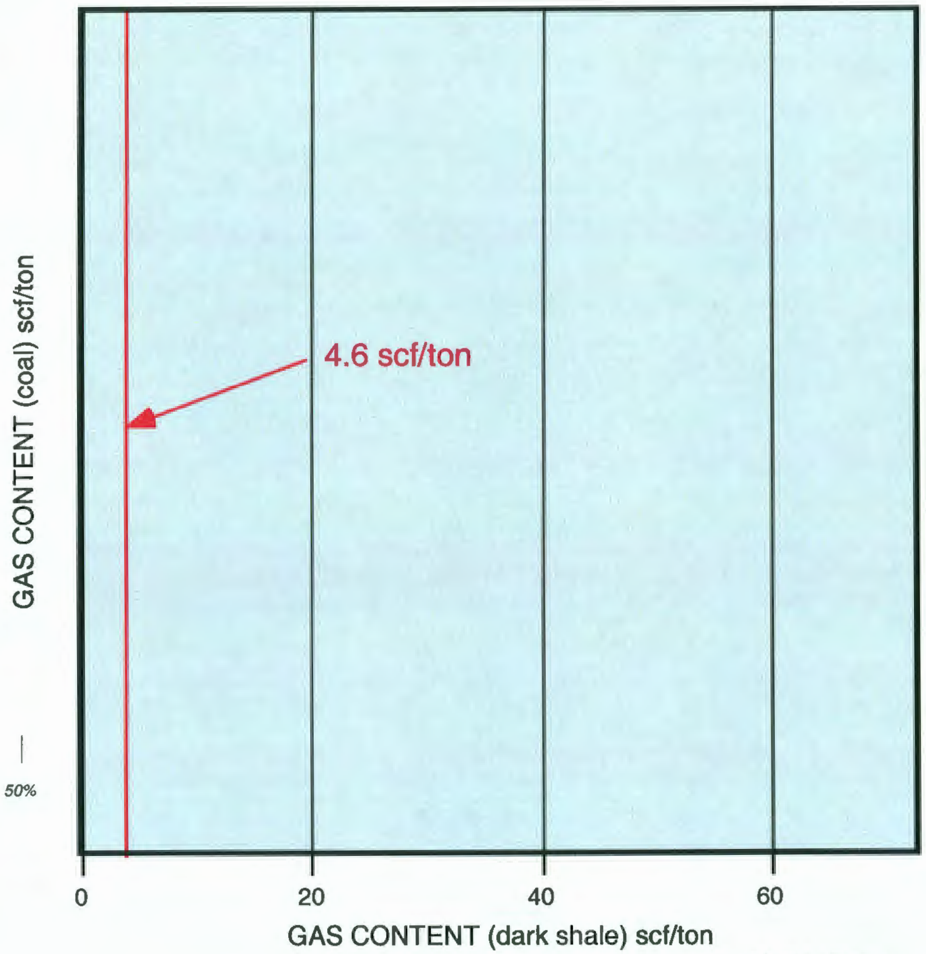


FIGURE 6.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

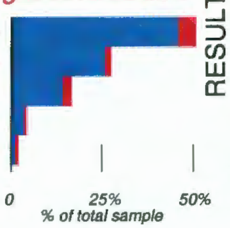
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Mulky coal from 902' to 903'

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

total gas desorbed
(including estimated lost gas) = 1146.8 ccs

TOTAL DRY WEIGHT OF SAMPLE = 900.22 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 96.40 grams (10.7%)
$\text{weight}_{dark\ shale}$ = 790.69 grams (87.8%)
weight_{coal} = 13.13 grams (1.5%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	453.56	0.93% / 89.37% / 9.69%
>0.0661"	244.99	1.98% / 91.67% / 6.35%
>0.0460"	147.21	2.12% / 83.05% / 14.83%
>0.0331"	37.51	1.98% / 78.22% / 19.80%
<0.0331"	16.95	1.00% / 54.00% / 45.00%
	900.22 TOTAL	



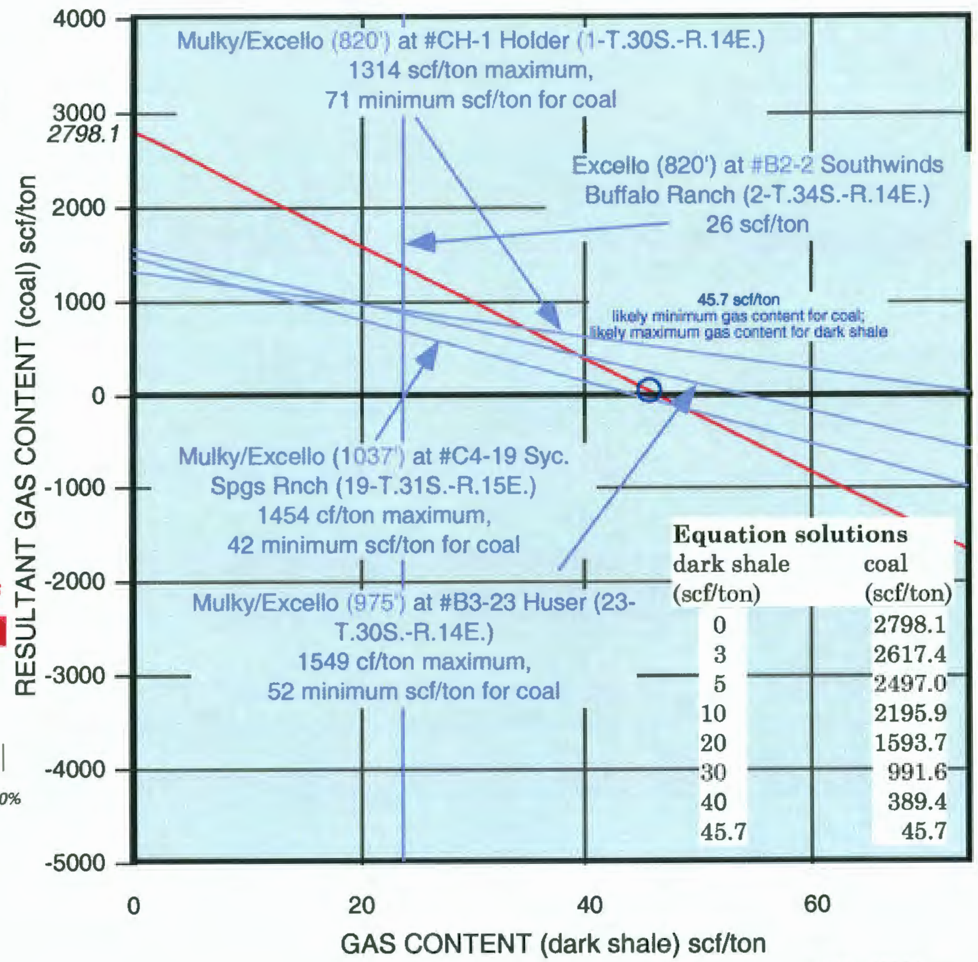


FIGURE 7.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

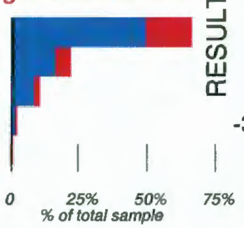
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Croweburg coal from 972' to 973'

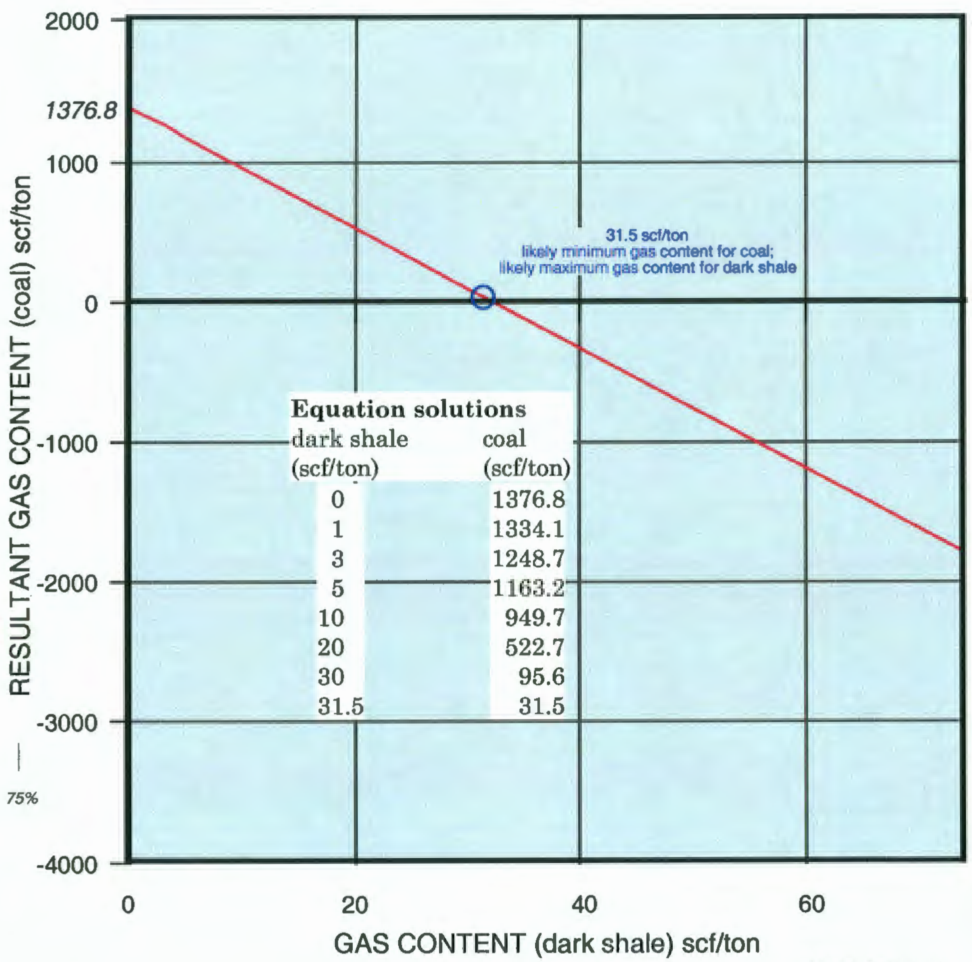
$$\text{GAS CONTENT}_{coal} = \frac{\text{total gas desorbed} - ((\text{gas content}_{dark\ shale}) * (\text{weight}_{dark\ shale}))}{\text{weight}_{coal}}$$

total gas desorbed
(including estimated lost gas) = 384.0 ccs

TOTAL DRY WEIGHT OF SAMPLE = 523.5 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 132.94 grams (25.4%)
$\text{weight}_{dark\ shale}$ = 381.61 grams (72.9%)
weight_{coal} = 8.94 grams (1.7%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	342.70	0.96% / 73.61% / 25.43%
>0.0661"	114.29	3.22% / 70.71% / 26.07%
>0.0460"	54.76	2.85% / 75.09% / 22.06%
>0.0331"	9.70	3.17% / 65.08% / 31.75%
<0.0331"	2.03	5.00% / 55.00% / 40.00%
	523.48 TOTAL	





Equation solutions

dark shale (scf/ton)	coal (scf/ton)
0	1376.8
1	1334.1
3	1248.7
5	1163.2
10	949.7
20	522.7
30	95.6
31.5	31.5

FIGURE 8.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

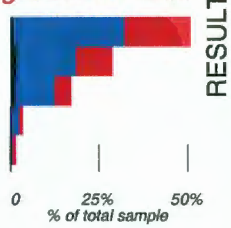
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Mineral coal from 1012' to 1013'

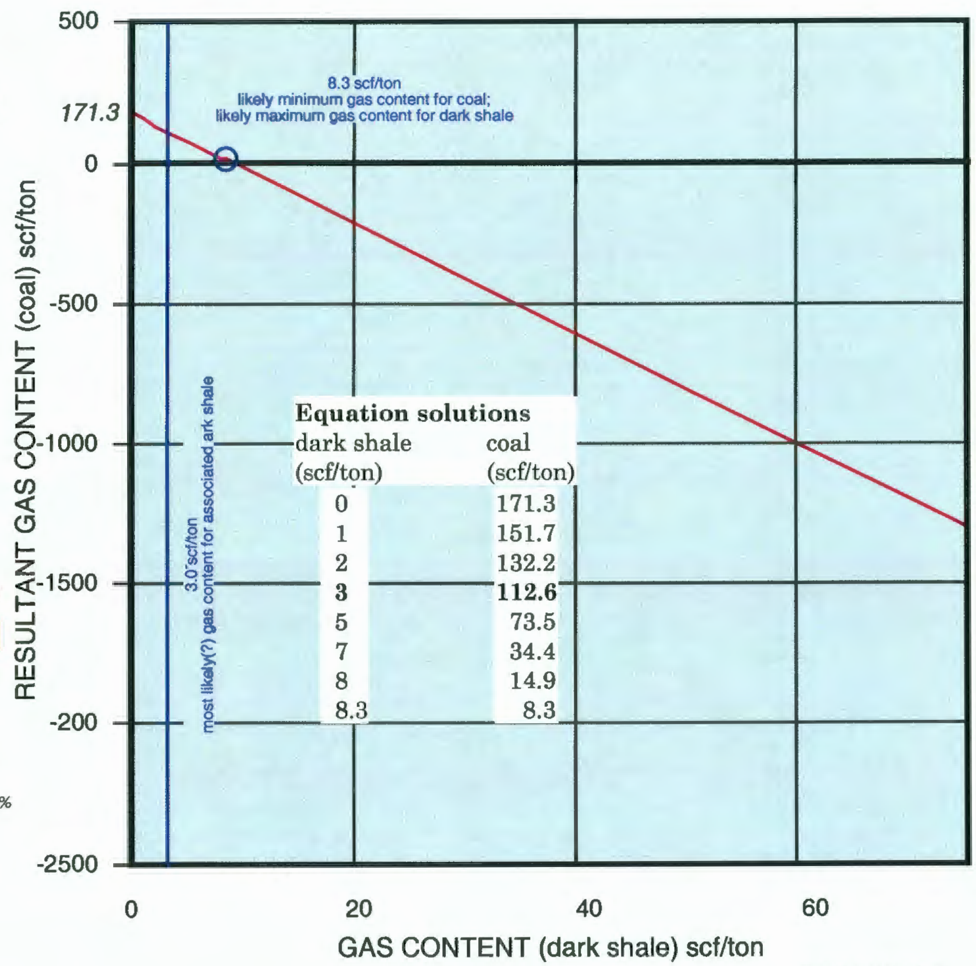
$$\text{GAS CONTENT}_{coal} = \frac{\text{total gas desorbed} - ((\text{gas content}_{dark\ shale}) * (\text{weight}_{dark\ shale}))}{\text{weight}_{coal}}$$

total gas desorbed
(including estimated lost gas) = 27.3 ccs

TOTAL DRY WEIGHT OF SAMPLE = 161.58 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 56.36 grams (34.9%)
$\text{weight}_{dark\ shale}$ = 100.10 grams (62.0%)
weight_{coal} = 5.12 grams (3.2%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	80.85	1.10% / 63.20% / 35.71%
>0.0661"	45.78	4.61% / 59.52% / 35.87%
>0.0460"	27.30	6.13% / 65.13% / 28.74%
>0.0331"	5.45	6.25% / 60.94% / 32.81%
<0.0331"	2.20	5.00% / 30.00% / 65.00%
	161.58 TOTAL	





Equation solutions

dark shale (scf/ton)	coal (scf/ton)
0	171.3
1	151.7
2	132.2
3	**112.6**
5	73.5
7	34.4
8	14.9
8.3	8.3

FIGURE 9.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

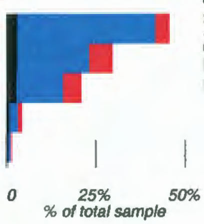
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of "upper" Tebo coal from 1035' to 1036'

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

total gas desorbed
(including estimated lost gas) = 24.4 ccs

TOTAL DRY WEIGHT OF SAMPLE = 129.00 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 21.37 grams (16.6%)
$\text{weight}_{dark\ shale}$ = 96.90 grams (75.1%)
weight_{coal} = 10.73 grams (8.3%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	58.01	5.83% / 85.64% / 8.54%
>0.0661"	37.60	9.24% / 68.48% / 22.27%
>0.0460"	26.43	11.71% / 63.51% / 24.77%
>0.0331"	5.47	11.59% / 65.22% / 23.19%
<0.0331"	1.49	10.00% / 75.00% / 15.00%
	129.00 TOTAL	



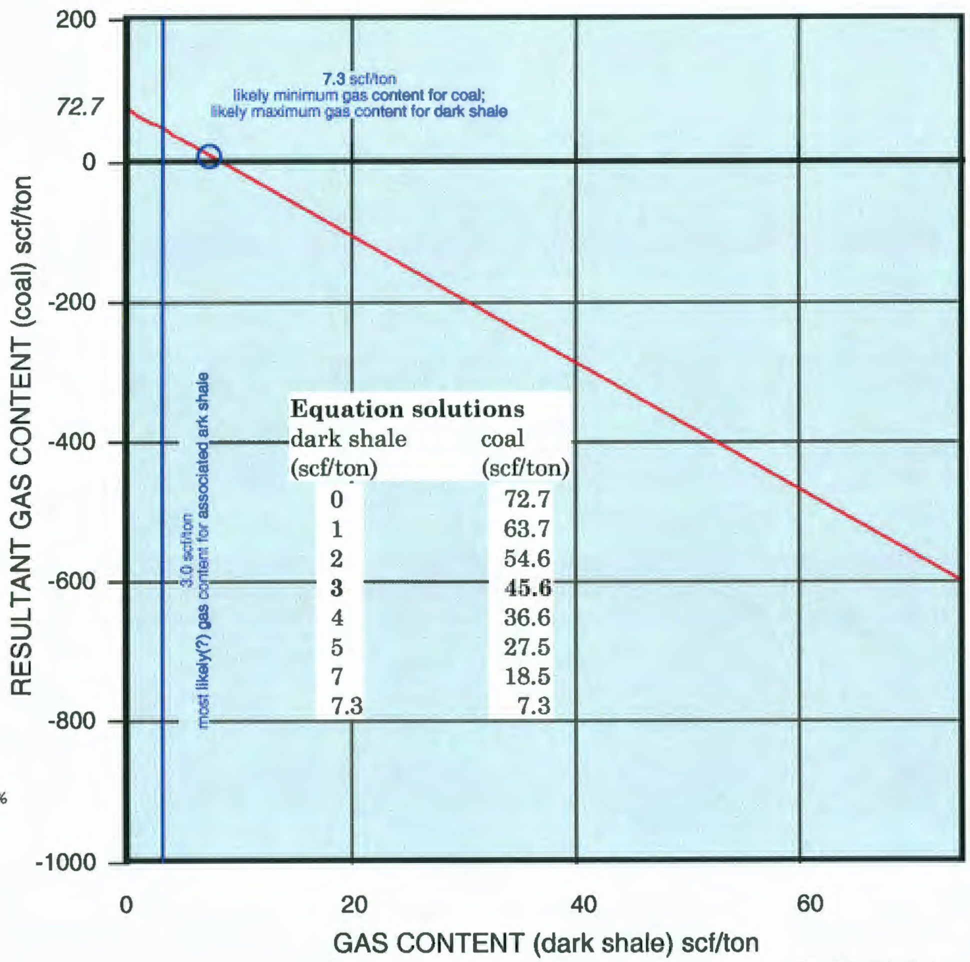


FIGURE 10.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

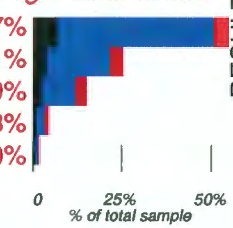
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Rowe coal from 1162' to 1164'

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

total gas desorbed
(including estimated lost gas) = 98.9 ccs

TOTAL DRY WEIGHT OF SAMPLE = 245.25 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 30.52 grams (12.4%)
$\text{weight}_{dark\ shale}$ = 183.74 grams (74.9%)
weight_{coal} = 30.99 grams (12.6%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	132.61	11.62% / 80.81% / 7.57%
>0.0661"	61.33	13.92% / 71.37% / 14.71%
>0.0460"	36.61	14.22% / 65.09% / 20.69%
>0.0331"	10.42	13.51% / 59.46% / 27.03%
<0.0331"	4.28	10.00% / 65.00% / 25.00%
	245.25 TOTAL	



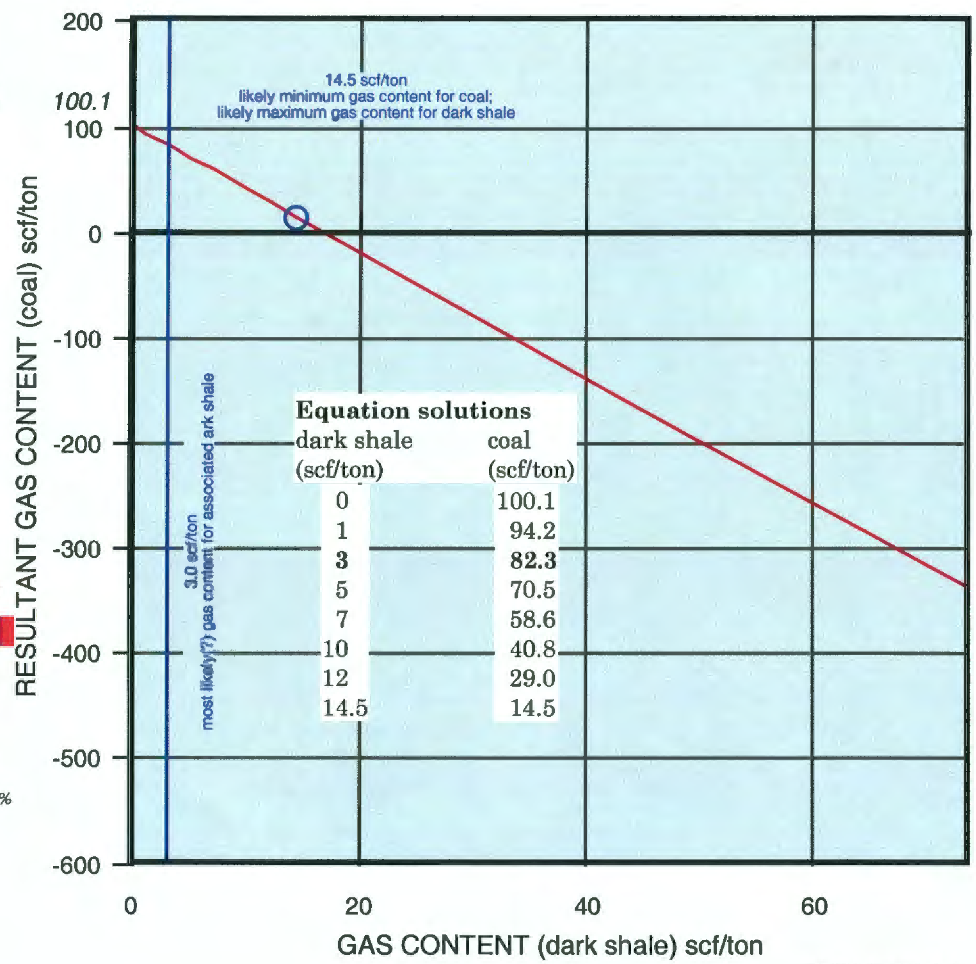


FIGURE 11.

Desorption Characteristics of Cuttings Samples

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

surface
100'
200'
300'
400'
500'
600'
O 638'-642' Tulsa "coal"
700'
800'
O 810'-812' Mulberry
O 884'-886' Little Osage Shale
O 902'-903' Mulky
O 972'-973' Croweburg
1000'
O 1012'-1013' Mineral
O 1035'-1036' "upper" Tebo
1100'
O 1162'-1164' Rowe
1200'
O 1203'-1204' Riverton
1300'

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for all samples

UNIT	coal in sample	scf/ton w/ shale @ 3 scf/ton	maximum scf/ton	minimum scf/ton
Tulsa "coal"	0%	----	----	24.8
Mulberry	18%	108.7	109.6	84.0
Little Osage Shale	0%	----	----	4.6
Mulky	2%	2617.4	2798.1	45.7
Croweburg	2%	1248.7	1376.8	31.5
Mineral	3%	112.6	171.3	8.3
"upper" Tebo	8%	45.6	72.7	7.3
Rowe	13%	82.3	100.1	14.5
Riverton		*no valid data*		

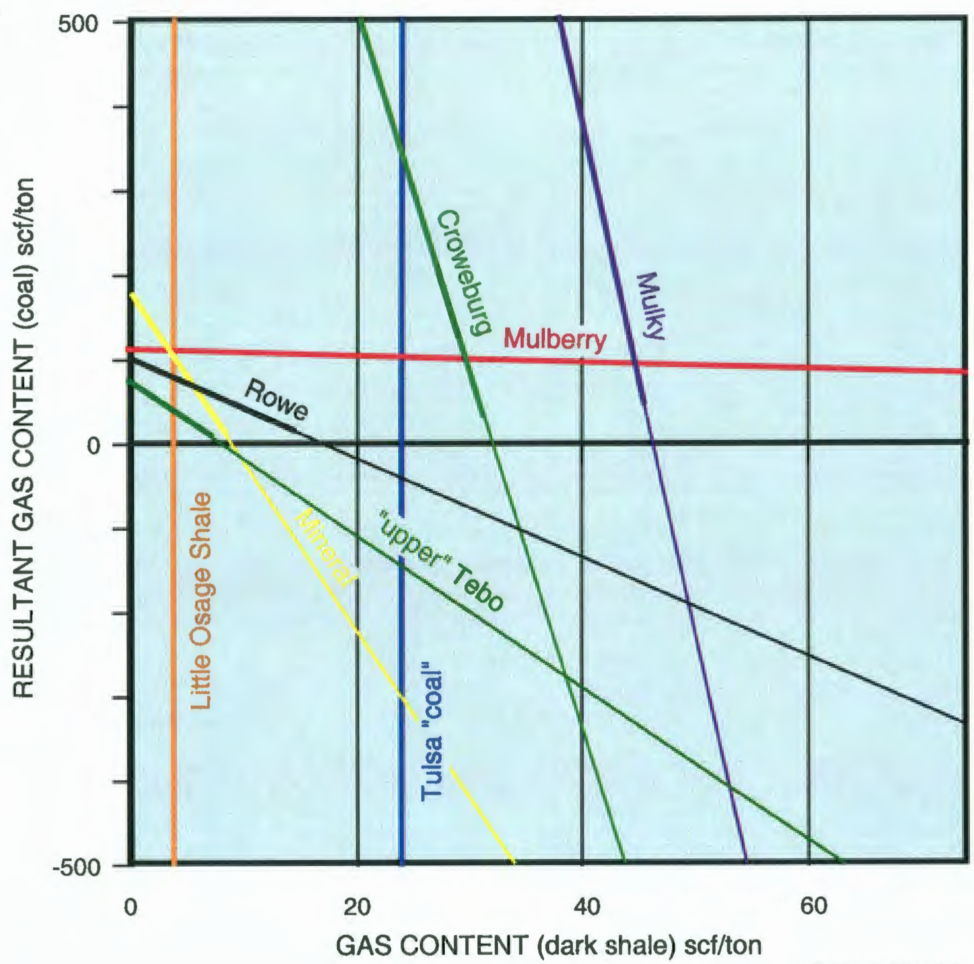


FIGURE 12.

Desorption Characteristics of Cuttings Samples

based on total weight of gas-generating lithologies (i.e., coal and dark shale) in sample

Dart Cherokee Basin #D1-3 B. Neill et al., SW SE SW SW 3-T.30S.-R.14E., Wilson County, KS

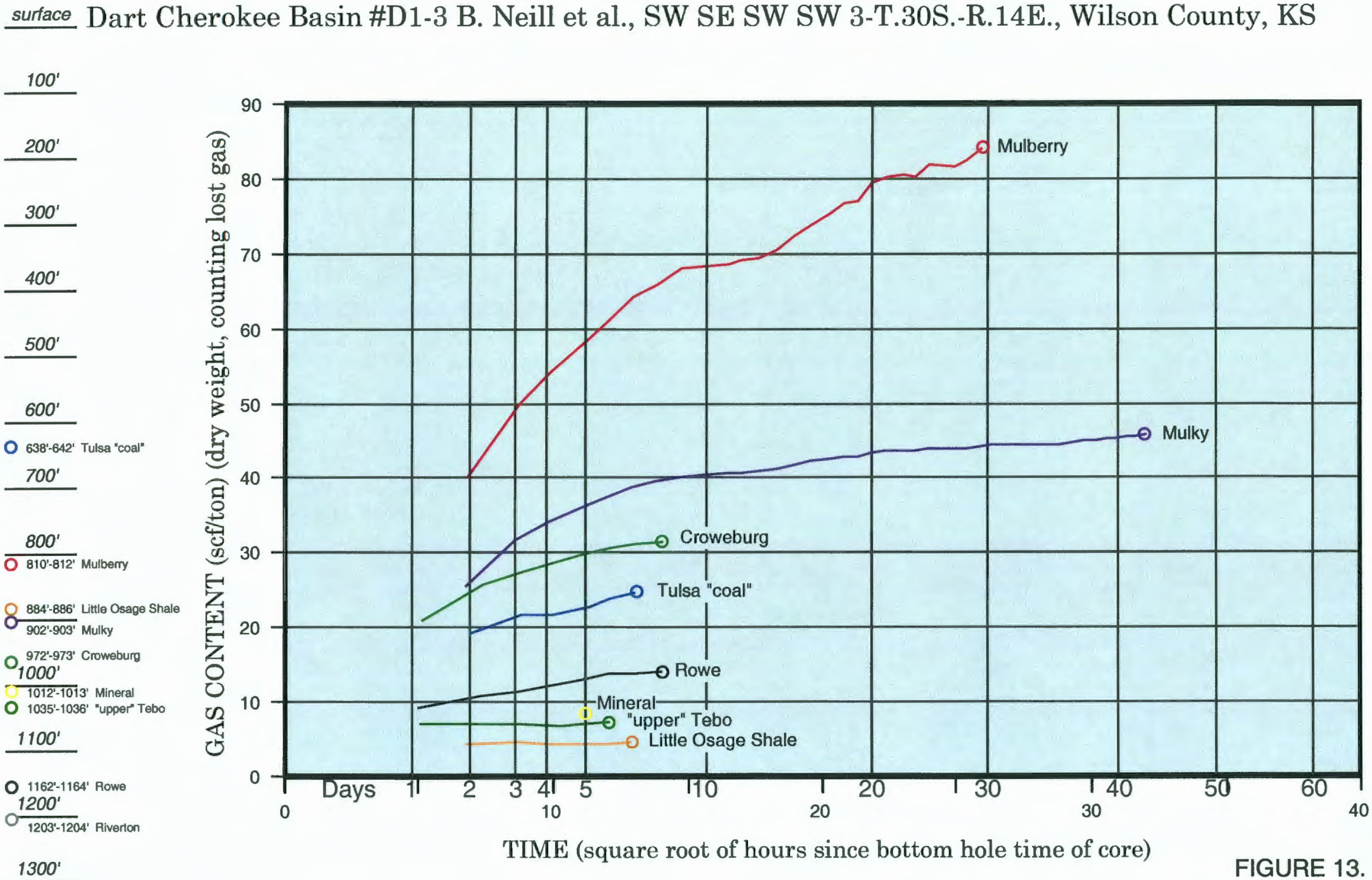


FIGURE 13.