ANALYSIS OF CHEROKEE GROUP CUTTINGS SAMPLES FOR GAS CONTENT -- EVERGREEN OPERATING CORP. EVERGREEN GRABLE #12-27; SW SW SW 27-T.3S.-R.21E., DONIPHAN COUNTY, KANSAS

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SUMMARY

Four cuttings samples from the Pennsylvanian Cherokee Group were collected from the Evergreen Operating Corp. Grable #12-27; SW SW SW 27-T.3S.-R.21E., Doniphan County, KS. The samples calculate as having the following gas contents:

- Tebo coal at 1220.0' to 1221.0' depth[1] (8 scf/ton)
- Dry Wood coal at 1408.4' to 1410.0' depth[1] (17 scf/ton)
- Rowe "D" coal at 1455.4' to 1558.0' depth[1] (21 scf/ton)
- Warner "A" coal at 1554.6' to 1555.4' depth[1] (26 scf/ton)

[1]assuming accompanying dark shale in sample desorbs 3 scf/ton

BACKGROUND

The Evergreen Operating Corp. Grable #12-27; SW SW SW 27-T.3S.-R.21E., Doniphan 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 February 29 and March 1, 2004 by K. David Newell and Galen A. Worthington of the Kansas Geological Survey, with assistance from Richard Robba (consultant to Evergreen). Samples were obtained during coring of the well, with no cessation of drilling before zones of interest (i.e., coals and dark shales in the Cherokee Group) were penetrated. The well was drilled using a mud system, with a rig owned by Layne-Christensen, Canada, Ltd.

Lag times for samples to reach the surface (important for assessing lost gas) were determined with a rule-of-thumb rate of circulation of 100 feet per minute. A mud-logging trailer with a gas detector trailer was on site.

Four cuttings samples from the Pennsylvanian Cherokee Group were collected:

- Tebo coal at 1220.0' to 1221.0' depth (349 grams dry wt.)
- Dry Wood coal at 1408.4' to 1410.0' depth (282 grams dry wt.)
- Rowe "D" coal at 1455.4' to 1558.0' depth (305 grams dry wt.)
- Warner "A" coal at 1554.6' to 1555.4' depth (261 grams dry wt.)

The cuttings were caught in kitchen strainers as they exited the shale shaker 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 biocide was poured into the canisters before the canisters were sealed.

Temperature baths for the desorption canisters were on site, with temperature kept at approximately 70 ˚F. The canistered samples at the end of the day were transported to the laboratory at the Kansas Geological Survey in Lawrence, KS and desorption measurements were continued at the same temperature. 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.

Most desorption canisters were made in-house at the Kansas Geological Survey. The "ST" canisters enclosed a volume of 38 cubic inches (620 cm^3). The "DN" canisters enclosed a volume of 44 cubic inches (720 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 linear regression 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. The regression equation was entered into the desorption spreadsheet and was used to automatically convert the millibar measurement to barometric pressure in pounds per square inch (psi).

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

$$n = PV/RT$$

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

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

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

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

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

The conversion calculations in the spreadsheet were carried out in the English metric system, 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 (i.e., the gas lost from the sample from the time it was drilled, brought to the surface, to the time it was canistered) was 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. Characteristically, the cumulative gas evolved from the sample, when plotted against the square root of time, is linear for a short time period after the sample reaches ambient surface pressure conditions, therefore lost gas is determined by a line projected back to time zero. The period of linearity generally is about an hour for cuttings samples.

LITHOLOGIC ANALYSIS

Upon removal from the canisters, the cuttings were washed of drilling mud, and either air-dried for several days, or 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) data tables for the desorption analyses, 2) lost-gas graphs, 3) "lithologic component sensitivity analyses" showing the interdependence of gas evolved from dark shale versus coal in each sample, 4) a summary component analysis for all samples showing relative reliability of the data from all the samples, and 5) a desorption graph for all the samples.

Data Tables of the Desorption Analyses (Table 1)
These are the basic data used for lost-gas analysis and determination of total gas desorbed from the cuttings samples. Basic temperature, volume, and barometric measurements are listed at left. Farther to the right, these are converted to standard temperature, pressure and volumes. The volumes are cumulatively summed, and converted to scf/ton based on the total weight of coal *and* dark shale in the sample. At the right of the table, the time of the measurements are listed and converted to hours (and square root of hours) since the sample was drilled.

Lost-Gas Graphs (Figures 1-4)
Gas lost prior to the canistering of the sample was estimated by extrapolation of the first few data points after the sample was canistered. The linear characteristic of the initial desorption measurements is usually lost within the first hour after the cuttings leave the bottom of the hole, thus data are presented in the lost-gas graphs for only up to one hour after cuttings are off bottom. Lost-gas volumes derived from this analysis are incorporated in the data tables described above.

"Lithologic Component Sensitivity Analyses" (Figures 5-8)
Collection of pure lithologies using drill cuttings 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:

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

A unique solution for *gas content*$_{coal}$ in this equation is not possible because *gas content*$_{dark\ shale}$ is not known exactly. An answer can only be expressed as a linear solution to the above equation. The richer in gas the dark shales are, the poorer in gas the admixed coal has to be, and 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 with normal gamma-ray readings in Kansas 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. For example, the Mulky coal is a coal associated with a "hot shale" (Excello Shale).

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*$_{dark\ shale}$.

Desorption Graph (Figure 10)

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

All of the other samples contain adequate coal for reasonable determination of gas content of the coal. No sample had less than 28% coal. According to the summary diagram for the sensitivity analyses (Figure 9), the best constrained results (in which the resultant coal gas content varies the least with shale gas content) is for the Rowe "D" coal (1455.4' to 1558.0'). The least constrained results are for the Tebo coal (1220.0' - 1221.0').

REFERENCES

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

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

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

FIGURES and TABLES

FIGURE 10. Desorption graph for all samples.

TABLE 1 – Desorption data for EVERGREEN GRABLE #12-27; SW SW SW 27-T.3S.-R.21E., Doniphan County, KS

SAMPLE: 1220.0' to 1221.0' (Tebo coal) cuttings in canister DN2

dry sample weight: 0.5308 lbs. 240.76 grams

est. lost gas (cc) = 12

TIME OF: off bottom 2/29/04 16:08; at surface 2/29/04 16:22; in canister 2/29/04 16:38

elapsed time (off bottom to canistering): 29.6 minutes; 0.493 hours; 0.702179148 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	TIME SINCE in canister	SQRT hrs. (since off bottom)
2	72	1062	7E-05	532	13.784	6.4736E-05	1.83	6.4736E-05	1.83	0.24	1.84	2/29/04 16:51	0:42:35	0:13:00	0.84245013
2	72	1062	7E-05	532	13.784	6.4736E-05	1.83	0.000129472	3.67	0.49	2.08	2/29/04 16:56	0:49:35	0:20:00	0.909059343
2	72	1062	7E-05	532	13.784	6.4736E-05	1.83	0.000194208	5.50	0.73	2.33	2/29/04 17:17	1:08:35	0:39:00	1.069137763
2	70	1063	7E-05	530	13.797	6.50415E-05	1.84	0.00025925	7.34	0.96	2.57	2/29/04 17:39	1:30:35	1:01:00	1.228707541
2	72	1063	7E-05	532	13.797	6.4797E-05	1.83	0.000324047	9.18	1.22	2.82	2/29/04 17:50	1:41:50	1:12:15	1.302774816
13 5	70	1059	0.0005	530	13.745	0.000437378	12.39	0.000761425	21.56	2.87	4.47	3/1/04 2:05	9:56:20	9:26:45	3.152600338
1	67	1061	4E-05	527	13.771	3.26443E-05	0.92	0.000794069	22.49	2.99	4.59	3/1/04 12:23	20:14:20	19:44:45	4.498765263
0	71	1091	0	531	14.161	0	0.00	0.000794069	22.49	2.99	4.59	3/2/04 10:35	42:26:20	41:56:45	6.514513711
1	72	1089	4E-05	532	14.135	3.31909E-05	0.94	0.00082726	23.43	3.12	4.71	3/3/04 9:32	65:23:20	64:53:45	8.086339647
4	71	1073	0.0001	531	13.927	0.000131059	3.71	0.000958319	27.14	3.61	5.21	3/4/04 12:20	92:11:20	91:41:45	9.601504512
1	73	1075	4E-05	533	13.953	3.27028E-05	0.93	0.000991022	28.06	3.73	5.33	3/5/04 9:22	113:13:20	112:43:45	10.64059313
-3	72	1081	-0.0001	532	14.031	-9.88413E-05	-2.80	0.000892181	25.26	3.36	4.96	3/6/04 11:24	139:15:20	138:45:45	11.80065912
-4	71	1091	-0.0001	531	14.161	-0.000133258	-3.77	0.000758923	21.49	2.86	4.46	3/7/04 13:13	165:04:20	164:34:45	12.84804352
0	71	1088	0	531	14.122	0	0.00	0.000758923	21.49	2.86	4.46	3/8/04 9:51	185:42:20	185:12:45	13.62738256

DESORPTION TERMINATED 3/8/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 12 days

SAMPLE: 1408.4' to 1410.0' (Dry Wood coal) in canister ST6

dry sample weight: 0.2297 lbs. 104.21 grams

est. lost gas (cc) = 10

TIME OF: off bottom 3/1/04 1:38; at surface 3/1/04 1:43; in canister 3/1/04 2:00

elapsed time (off bottom to canistering): 22.5 minutes; 0.375 hours; 0.612372436 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	TIME SINCE in canister	SQRT hrs. (since off bottom)
2	70	1059	7E-05	530	13.745	6.47968E-05	1.83	6.47968E-05	1.63	0.56	3.64	3/1/04 2:10	0:32:00	0:09:30	0.730296743
1	70	1059	4E-05	530	13.745	3.23984E-05	0.92	9.71951E-05	2.75	0.85	3.92	3/1/04 2:15	0:37:00	0:14:30	0.785281266
1	70	1059	4E-05	530	13.745	3.23984E-05	0.92	0.000129594	3.67	1.13	4.20	3/1/04 2:20	0:42:00	0:19:30	0.836660026
1	70	1059	4E-05	530	13.745	3.23984E-05	0.92	0.000161992	4.59	1.41	4.48	3/1/04 2:29	0:51:00	0:28:30	0.921954446
1	70	1059	4E-05	530	13.745	3.23984E-05	0.92	0.00019439	5.50	1.69	4.77	3/1/04 2:55	1:17:30	0:55:00	1.136515141
1	69	1058	4E-05	529	13.732	3.2429E-05	0.92	0.000226819	6.42	1.97	5.05	3/1/04 3:13	1:35:00	1:12:30	1.258305739
1	69	1058	4E-05	529	13.732	3.2429E-05	0.92	0.000259248	7.34	2.26	5.33	3/1/04 3:27	1:49:00	1:26:30	1.347837775
1	69	1058	4E-05	529	13.732	3.2429E-05	0.92	0.000291677	8.26	2.54	5.61	3/1/04 3:56	2:18:00	1:55:30	1.516575089
1	69	1058	4E-05	529	13.732	3.2429E-05	0.92	0.000324106	9.18	2.82	5.90	3/1/04 4:15	2:37:00	2:14:30	1.617611408
1	69	1057	4E-05	529	13.719	3.23983E-05	0.92	0.000356504	10.10	3.10	8.18	3/1/04 4:20	2:42:30	2:20:00	1.845701471
1	69	1057	4E-05	529	13.719	3.23983E-05	0.92	0.000388903	11.01	3.39	6.46	3/1/04 4:40	3:02:30	2:40:00	1.744037461
1	68	1057	4E-05	528	13.719	3.24597E-05	0.92	0.000421363	11.93	3.67	6.74	3/1/04 5:01	3:23:00	3:00:30	1.839383955
1	68	1057	4E-05	528	13.719	3.24597E-05	0.92	0.000453822	12.85	3.95	7.03	3/1/04 5:18	3:40:00	3:17:30	1.914854215
1	68	1057	4E-05	528	13.719	3.24597E-05	0.92	0.000486282	13.77	4.23	7.31	3/1/04 5:34	3:56:45	3:34:15	1.986412176
1	68	1057	4E-05	528	13.719	3.24597E-05	0.92	0.000518742	14.69	4.52	7.59	3/1/04 6:10	4:32:30	4:10:00	2.131118642
0.5	67	1061	2E-05	527	13.771	1.63222E-05	0.48	0.000535064	15.15	4.66	7.73	3/1/04 12:23	10:45:00	10:22:30	3.278719262
6	71	1091	0.0002	531	14.161	0.000199887	5.66	0.000734951	20.81	6.40	9.47	3/2/04 10:34	32:56:00	32:33:30	5.738757124
5	72	1089	0.0002	532	14.135	0.000165955	4.70	0.000900905	25.51	7.84	10.92	3/3/04 9:32	55:54:00	55:31:30	7.476630257
5	71	1073	0.0002	531	13.927	0.000163824	4.64	0.00106473	30.15	9.27	12.34	3/4/04 12:21	82:43:00	82:20:30	9.094870349
3	73	1075	0.0001	533	13.953	9.81083E-05	2.78	0.001162838	32.93	10.12	13.20	3/5/04 9:23	103:45:00	103:22:30	10.18577439
-2	72	1081	-7E-05	532	14.031	-6.58942E-05	-1.87	0.001096944	31.06	9.55	12.62	3/6/04 11:25	129:47:00	129:24:30	11.39224883
-3	71	1091	-0.0001	531	14.161	-9.99435E-05	-2.83	0.000997	28.23	8.66	11.75	3/7/04 13:14	155:36:00	155:13:30	12.4739729
1	71	1088	4E-05	531	14.122	3.32229E-05	0.94	0.001030223	29.17	8.97	12.04	3/8/04 9:53	176:15:00	175:52:30	13.27591805
-0.5	72	1089	-2E-05	532	14.135	-1.65955E-05	-0.47	0.001013628	28.70	8.82	11.90	3/10/04 20:53	235:15:00	234:52:30	15.33786165

DESORPTION TERMINATED 3/10/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 6 days

SAMPLE: 1455.4' to 1458.0' (Rowe "D" coal) in canister DN3

dry sample weight: 0.5482 lbs. 248.84 grams

est. lost gas (cc) = 19

TIME OF: off bottom 3/1/04 6:00; at surface 3/1/04 6:15; in canister 3/1/04 6:28

elapsed time (off bottom to canistering): 28.3 minutes; 0.471 hours; 0.686172962 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	TIME SINCE in canister	SQRT hrs. (since off bottom)
2	68	1057	7E-05	528	13.719	6.49194E-05	1.84	6.49194E-05	1.84	0.24	2.69	3/1/04 6:37	0:36:30	0:08:15	0.779957264
3	68	1057	0.0001	528	13.719	9.7379E-05	2.76	0.000162298	4.60	0.59	3.04	3/1/04 6:44	0:43:30	0:15:15	0.851469318

2	68	1057	7E-05	528	13.719	6.49194E-05	1.84	0.000227218	8.43	0.83	3.28	3/1/04	6:53	0:53:00	0:24:45	0.939858145
3	69	1058	0.0001	529	13.732	9.72869E-05	2.75	0.000324505	9.19	1.18	3.63	3/1/04	7:03	1:02:30	0:34:15	1.020620726
3	69	1058	0.0001	529	13.732	9.72869E-05	2.75	0.000421792	11.94	1.54	3.99	3/1/04	7:12	1:11:30	0:43:15	1.09163486
2	69	1058	7E-05	529	13.732	6.48579E-05	1.84	0.00048665	13.78	1.78	4.22	3/1/04	7:19	1:18:45	0:50:30	1.145643924
2	69	1058	7E-05	529	13.732	6.48579E-05	1.84	0.000551508	15.62	2.01	4.46	3/1/04	7:27	1:26:30	0:58:15	1.200694244
2	69	1058	7E-05	529	13.732	6.48579E-05	1.84	0.000616365	17.45	2.25	4.70	3/1/04	7:35	1:34:30	1:06:15	1.25499004
2	68	1058	7E-05	528	13.732	6.49808E-05	1.84	0.000681346	19.29	2.49	4.93	3/1/04	7:43	1:42:30	1:14:15	1.307032262
2	68	1058	7E-05	528	13.732	6.49808E-05	1.84	0.000746327	21.13	2.72	5.17	3/1/04	7:50	1:49:30	1:21:15	1.350925609
3	68	1058	0.0001	528	13.732	9.74712E-05	2.76	0.000843798	23.89	3.08	5.53	3/1/04	8:00	1:59:30	1:31:15	1.411264209
1	68	1058	4E-05	528	13.732	3.24904E-05	0.92	0.000876289	24.81	3.20	5.65	3/1/04	8:10	2:09:30	1:41:15	1.469126725
2	68	1058	7E-05	528	13.732	6.49808E-05	1.84	0.000941269	26.65	3.43	5.88	3/1/04	8:20	2:19:30	1:51:15	1.524795068
2	68	1058	7E-05	528	13.732	6.49808E-05	1.84	0.00100625	28.49	3.67	6.12	3/1/04	8:29	2:29:00	2:00:45	1.575859554
2	68	1058	7E-05	528	13.732	6.49808E-05	1.84	0.001071231	30.33	3.91	6.36	3/1/04	8:40	2:40:00	2:11:45	1.632993162
2	68	1058	7E-05	528	13.732	6.49808E-05	1.84	0.001136212	32.17	4.15	6.59	3/1/04	8:57	2:56:30	2:28:15	1.715128761
2	68	1058	7E-05	528	13.732	6.49808E-05	1.84	0.001201193	34.01	4.38	6.83	3/1/04	9:10	3:09:30	2:41:15	1.777170035
4	68	1059	0.0001	528	13.745	0.000130084	3.68	0.001331277	37.70	4.86	7.31	3/1/04	9:54	3:53:30	3:25:15	1.972730764
11	68	1060	0.0004	528	13.758	0.00035807	10.14	0.001689347	47.84	6.16	8.61	3/1/04	11:08	5:07:30	4:39:15	2.263846285
2	67	1060	7E-05	527	13.758	6.52272E-05	1.85	0.001754574	49.68	6.40	8.85	3/1/04	11:27	5:26:45	4:58:30	2.333630933
1	67	1061	4E-05	527	13.771	3.26443E-05	0.92	0.001787218	50.61	6.52	8.97	3/1/04	11:58	5:58:15	5:30:00	2.443528869
-3	67	1061	-0.0001	527	13.771	-9.7933E-05	-2.77	0.001689285	47.84	6.16	8.61	3/1/04	12:22	6:22:00	5:53:45	2.523225449
32	71	1091	0.0011	531	14.181	0.001066064	30.19	0.00275535	78.02	10.05	12.50	3/2/04	10:35	28:34:30	28:06:15	5.345558904
18	72	1089	0.0006	532	14.135	0.000597437	16.92	0.003352786	94.94	12.23	14.68	3/3/04	9:32	51:31:30	51:03:15	7.178091668
15	71	1073	0.0005	531	13.927	0.000491473	13.92	0.003844259	108.86	14.03	18.47	3/4/04	12:23	78:22:30	77:54:15	8.852965605
8	73	1075	0.0003	533	13.953	0.000261622	7.41	0.004105882	116.27	14.98	17.43	3/5/04	9:24	99:23:30	98:55:15	9.969536933
1	72	1081	4E-05	532	14.031	3.29471E-05	0.93	0.004138829	117.20	15.10	17.55	3/6/04	11:25	125:24:30	124:56:15	11.19858622
-2	71	1091	-7E-05	531	14.161	-6.6629E-05	-1.89	0.0040722	115.31	14.86	17.31	3/7/04	13:15	151:14:30	150:48:15	12.29803507
2	71	1088	7E-05	531	14.122	6.64458E-05	1.88	0.004138645	117.19	15.10	17.55	3/8/04	9:53	171:52:30	171:24:15	13.1101106
2	72	1089	7E-05	532	14.135	6.63819E-05	1.88	0.004205027	119.07	15.34	17.79	3/10/04	20:54	230:53:30	230:25:15	15.19511983
-2	71	1099	-7E-05	531	14.265	-6.71176E-05	-1.90	0.00413791	117.17	15.10	17.55	3/12/04	9:18	287:17:30	266:49:15	16.34905706
6	71	1082	0.0002	531	14.044	0.000198238	5.61	0.004336148	122.79	15.82	18.27	3/15/04	11:19	341:18:30	340:50:15	18.47453202
2	70	1086	7E-05	530	14.096	6.64488E-05	1.88	0.004402597	124.67	16.06	18.51	3/16/04	10:10	364:09:30	383:41:15	19.08293304
3	72	1078	0.0001	532	13.992	9.8567E-05	2.79	0.004501164	127.46	16.42	18.87	3/17/04	10:15	388:14:30	367:48:15	19.70384903
0	72	1087	0	532	14.109	0	0.00	0.004501164	127.46	16.42	18.87	3/18/04	15:16	417:15:30	418:47:15	20.4269022
1	73	1087	4E-05	533	14.109	3.30678E-05	0.94	0.004534231	128.39	16.54	18.99	3/19/04	10:02	438:01:30	435:33:15	20.88121185
-1	75	1094	-4E-05	535	14.200	-3.31564E-05	-0.94	0.004501075	127.46	16.42	18.87	3/20/04	12:57	462:56:30	462:28:15	21.51607926
-4	73	1102	-0.0001	533	14.303	-0.000134097	-3.80	0.004366979	123.66	15.93	18.38	3/21/04	13:22	487:21:30	486:53:15	22.07619381
0	72	1097	0	532	14.239	0	0.00	0.004366979	123.66	15.93	18.38	3/22/04	9:44	507:43:30	507:15:15	22.53275394
4	72	1084	0.0001	532	14.070	0.000132154	3.74	0.004499133	127.40	16.42	18.86	3/23/04	9:10	531:09:30	530:41:15	23.04687253
2	72	1081	7E-05	532	14.031	6.58942E-05	1.87	0.004565027	129.27	16.66	19.10	3/24/04	13:32	559:31:30	559:03:15	23.6542808
3	73	1082	0.0001	533	14.044	9.87471E-05	2.80	0.004663774	132.06	17.02	19.46	3/25/04	11:30	581:29:30	581:01:15	24.11413831
3	75	1084	0.0001	535	14.070	9.85598E-05	2.79	0.004762334	134.85	17.38	19.82	3/26/04	14:27	608:26:30	607:58:15	24.66661036
3	76	1076	0.0001	536	13.966	9.76499E-05	2.77	0.004859984	137.62	17.73	20.18	3/27/04	16:17	634:16:30	633:48:15	25.18481685
-2	74	1084	-7E-05	534	14.070	-6.58296E-05	-1.86	0.004794154	135.75	17.49	19.94	3/28/04	12:03	654:02:30	653:34:15	25.57423834
-4	74	1086	-0.0001	534	14.096	-0.000131902	-3.74	0.004662252	132.02	17.01	19.46	3/29/04	16:42	882:41:30	682:13:15	26.128369

DESORPTION TERMINATED 3/29/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 6 days

SAMPLE: 1554.6' to 1555.4' (Warner "A" coal) in canister ST4

	lbs.	grams
dry sample weight:	0.2887	130.96

est. lost gas (cc) = 35

TIME OF:	off bottom	at surface	in canister
	3/1/04 13:17	3/1/04 13:33	3/1/04 13:51

elapsed time (off bottom to canistering)
33.5 minutes
0.558 hours
0.747217059 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)
5	66	1062	0.0002	526	13.784	0.000163686	4.64	0.000163686	4.64	1.13	9.70	3/1/04	13:58	0:41:00	0:07:30	0.826639784
1	66	1062	4E-05	526	13.784	3.27372E-05	0.93	0.000196423	5.56	1.38	9.92	3/1/04	14:03	0:45:45	0:12:15	0.87321246
2	66	1063	7E-05	526	13.797	6.55361E-05	1.86	0.00026196	7.42	1.81	10.38	3/1/04	14:10	0:52:30	0:19:00	0.935414347
1	66	1063	4E-05	526	13.797	3.27681E-05	0.93	0.000294728	8.35	2.04	10.60	3/1/04	14:19	1:02:00	0:28:30	1.016530045
1	66	1064	4E-05	526	13.810	3.27989E-05	0.93	0.000327526	9.27	2.27	10.83	3/1/04	14:46	1:28:30	0:55:00	1.21449578
19	71	1091	0.0007	531	14.161	0.000632976	17.92	0.000960502	27.20	6.65	15.22	3/2/04	10:37	21:19:30	20:48:00	4.617899956
10	72	1089	0.0004	532	14.135	0.000331909	9.40	0.001292411	38.60	8.95	17.52	3/3/04	9:33	44:15:30	43:42:00	6.65269369
9	71	1073	0.0003	531	13.927	0.000294884	8.35	0.001587295	44.95	11.00	19.56	3/4/04	12:24	71:06:30	70:33:00	8.432575724
4	73	1075	0.0001	533	13.953	0.000130811	3.70	0.001718106	48.65	11.90	20.46	3/5/04	9:24	92:06:30	91:33:00	9.597308651
-1	72	1081	-4E-05	532	14.031	-3.29471E-05	-0.93	0.001685159	47.72	11.67	20.24	3/6/04	11:26	118:08:30	117:35:00	10.86929927
-3	71	1091	-0.0001	531	14.181	-9.99435E-05	-2.83	0.001585216	44.89	10.98	19.54	3/7/04	13:15	143:57:30	143:24:00	11.99826376
1	71	1088	4E-05	531	14.122	3.32229E-05	0.94	0.001818439	45.83	11.21	19.77	3/8/04	9:54	164:36:30	164:03:00	12.82997792

-1	72	1089	-4E-05	532	14.135	-3.31909E-05	-0.94	0.001585248	44.89	10.98	19.54	3/10/04	20:54	223:36:30	223:03:00	14.95353916

DESORPTION TERMINATED 3/10/2004 DUE TO NO MORE GAS BEING EVOLVED; sample air dried for 8 days

1220' to 1222' (Tebo coal) cuttings in canister DN2

Evergreen #12-37 Grable #12-37; SW SW NW 27-T.35S.-R.21E., Doniphan County, KS

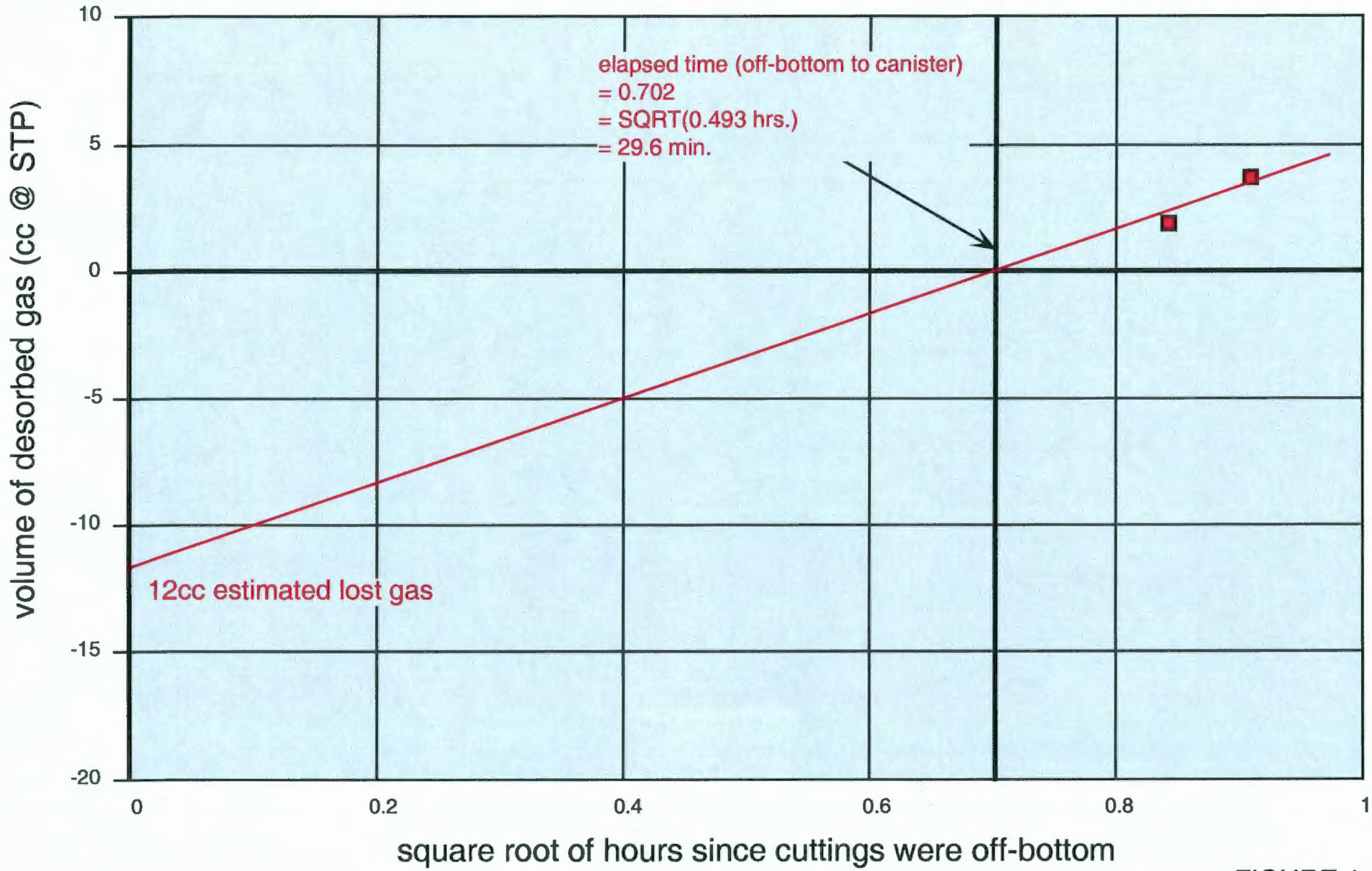


FIGURE 1.

1408' to 1410' (Drywood coal) in canister ST6

Evergreen #12-37 Grable #12-37; SW SW NW 27-T.35S.-R.21E., Doniphan County, KS

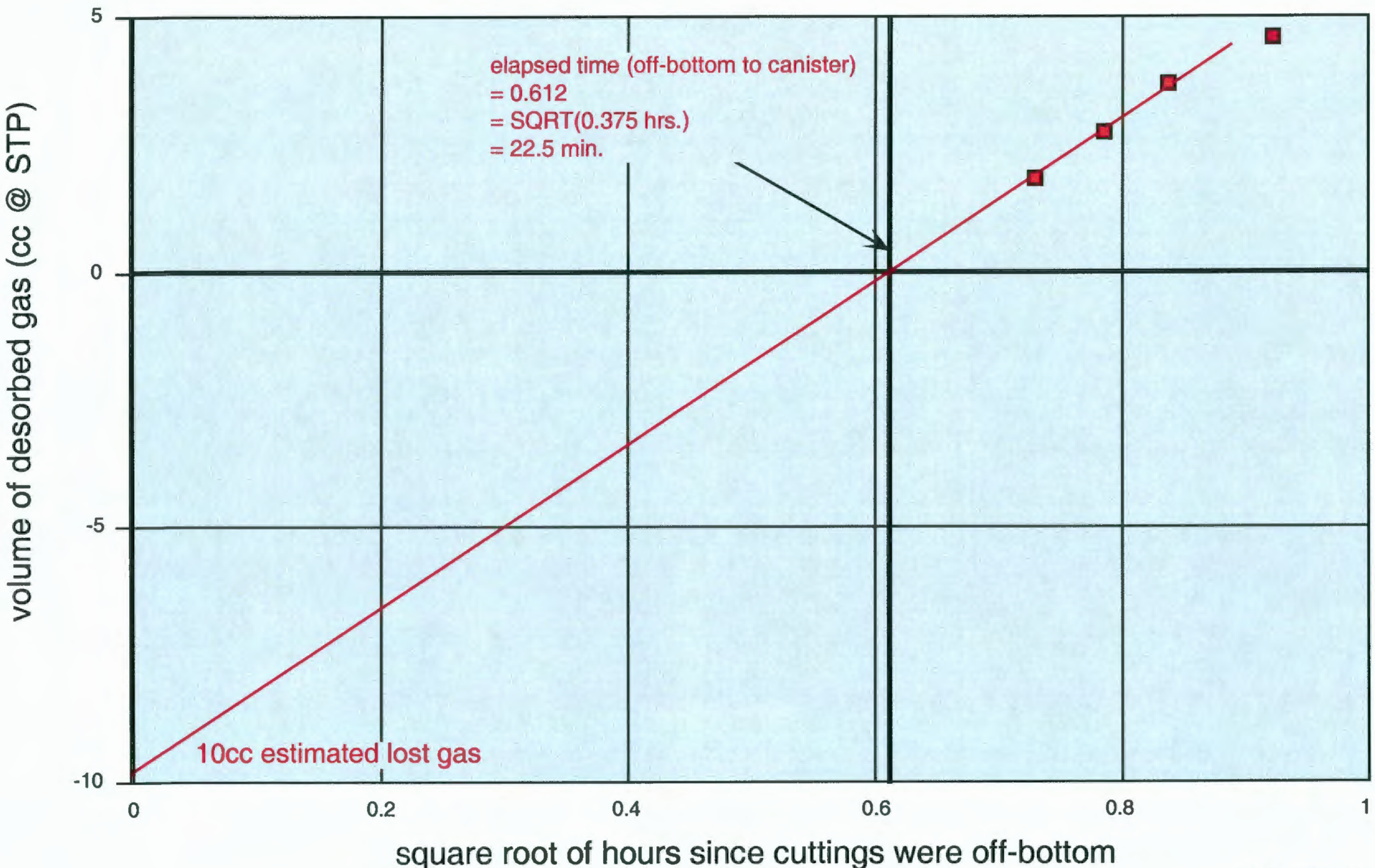
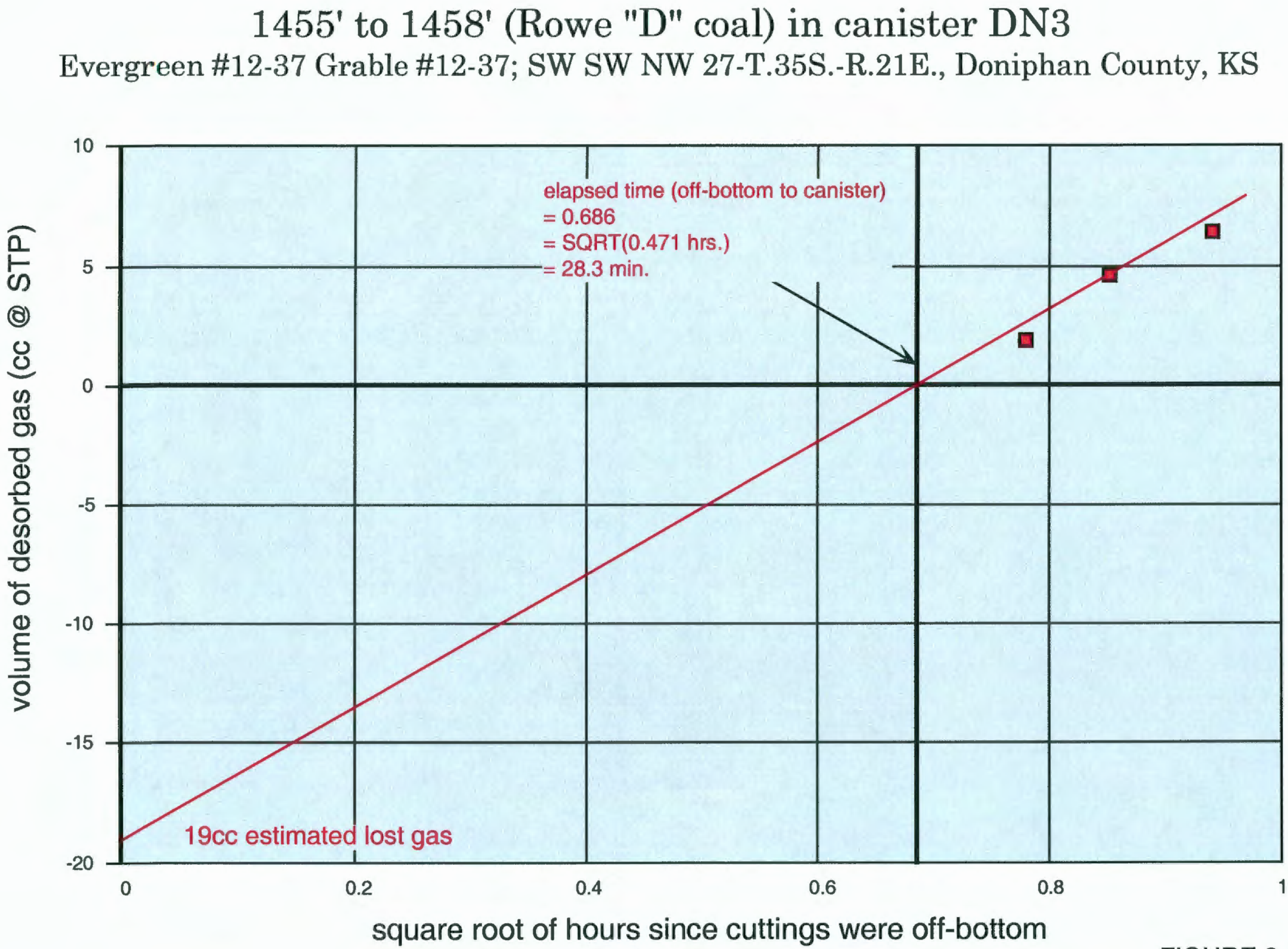


FIGURE 2.



1455' to 1458' (Rowe "D" coal) in canister DN3
Evergreen #12-37 Grable #12-37; SW SW NW 27-T.35S.-R.21E., Doniphan County, KS
elapsed time (off-bottom to canister)
= 0.686
= SQRT(0.471 hrs.)
= 28.3 min.
19cc estimated lost gas
volume of desorbed gas (cc @ STP)
square root of hours since cuttings were off-bottom
10
5
0
-5
-10
-15
-20
0
0.2
0.4
0.6
0.8
1

FIGURE 3.

1554' to 1555' (Warner "A" coal) in canister ST4

Evergreen #12-37 Grable #12-37; SW SW NW 27-T.35S.-R.21E., Doniphan County, KS

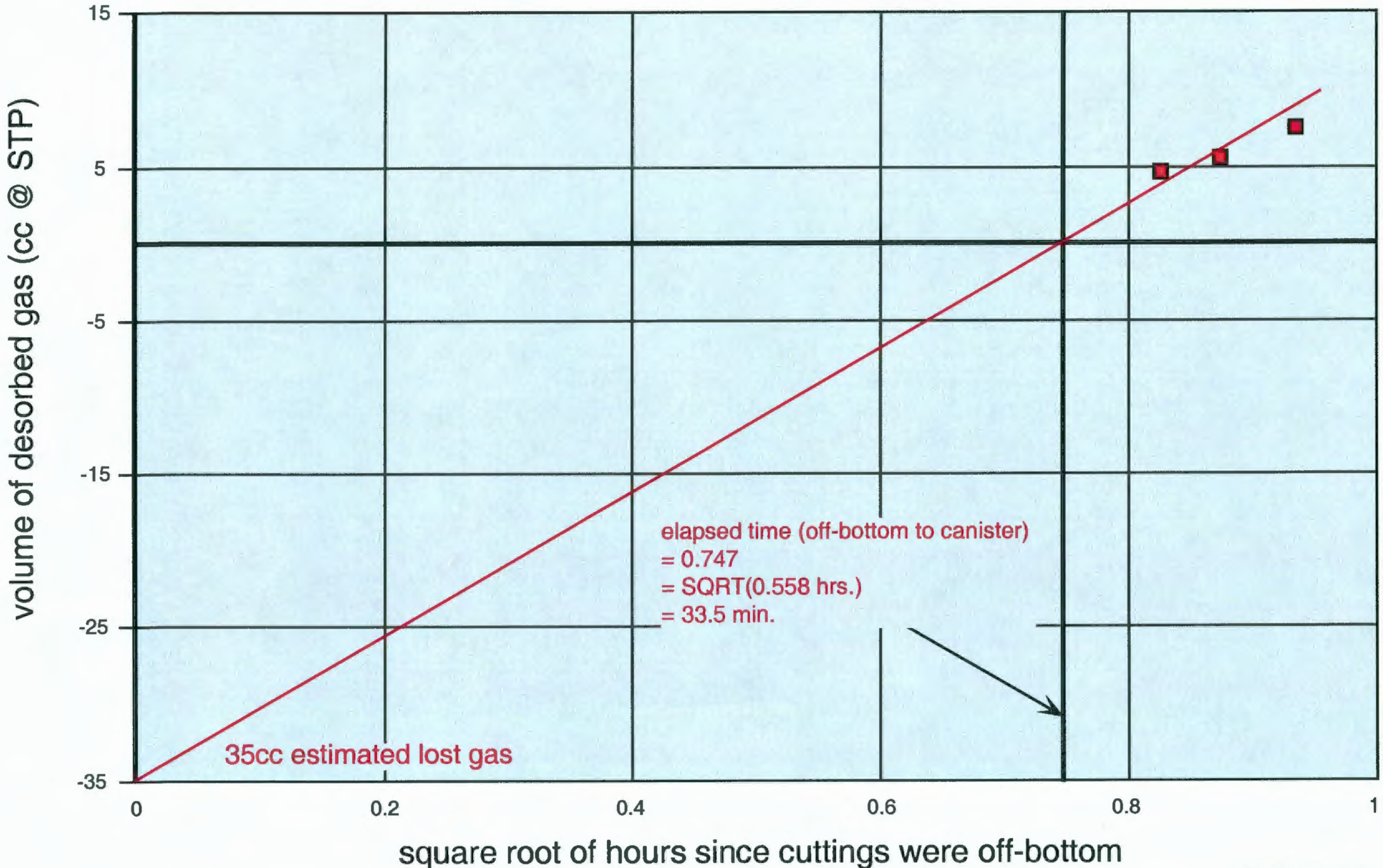


FIGURE 4.

Desorption Characteristics of Cuttings Samples

Evergreen Grable #12-27; 27-T.3S.-R.21E., Doniphan County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Tebo coal from 1220.0'-1221.0'

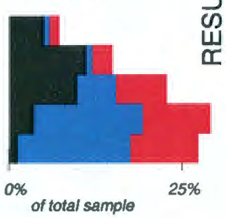
$$\text{GAS CONTENT}_{coal} = \frac{\text{total gas desorbed} - ((\text{gas content}_{dark\ shale}) * (\text{weight}_{dark\ shale}))}{\text{weight}_{coal}}$$

total gas desorbed = 40.1 ccs

TOTAL DRY WEIGHT OF SAMPLE = 348.99 grams

$\text{weight}_{light\text{-}colored\ lithologies}$ =	108.23 grams (31.0%)
$\text{weight}_{dark\ shale}$ =	136.81 grams (39.2%)
weight_{coal} =	103.95 grams (29.8%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	24.79	68.47% / 12.31% / 19.22%
>0.0661"	51.32	74.06% / 6.14% / 19.80%
>0.0460"	78.39	42.54% / 25.00% / 32.46%
>0.0331"	100.36	11.81% / 54.33% / 33.86%
<0.0331"	94.13	4.00% / 60.00% / 36.00%
	348.99 TOTAL	



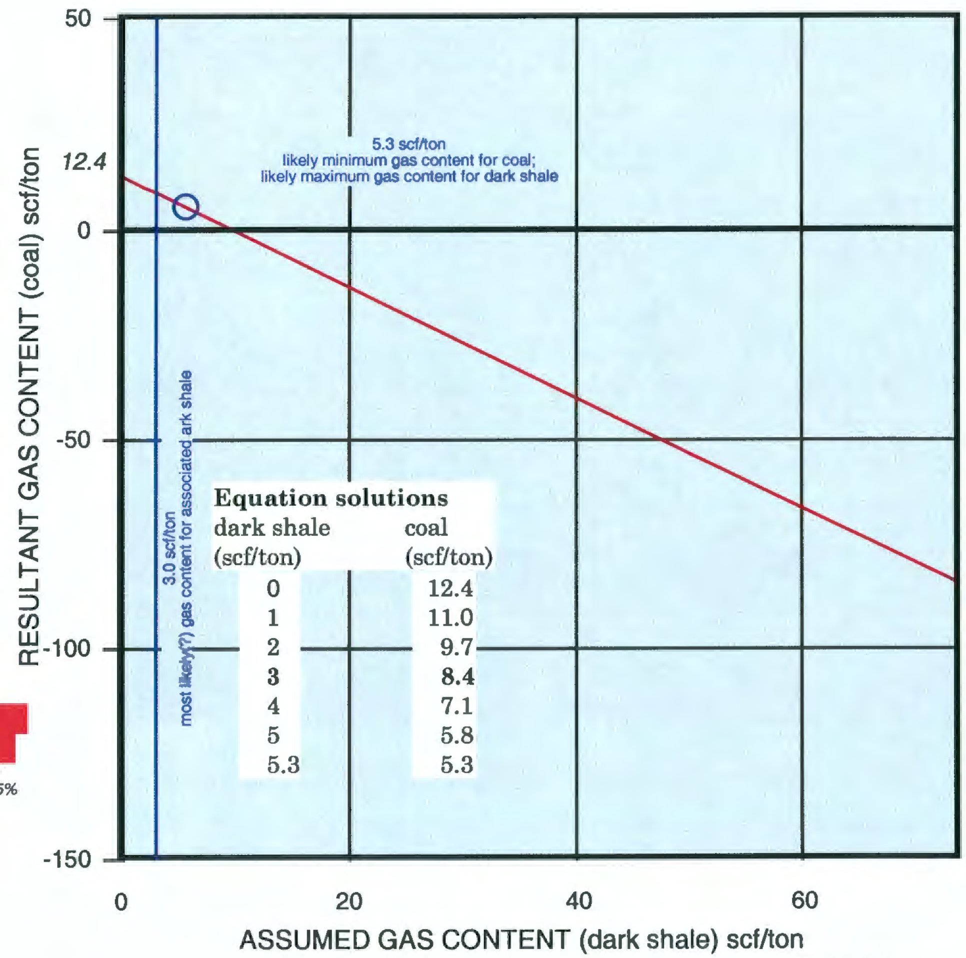


FIGURE 5.

Desorption Characteristics of Cuttings Samples

Evergreen Grable #12-27; 27-T.3S.-R.21E., Doniphan County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Dry Wood coal from 1408.4'-1410.0'

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

total gas desorbed = 42.9 ccs

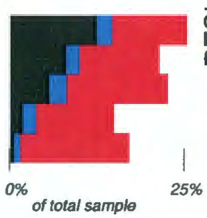
TOTAL DRY WEIGHT OF SAMPLE = 281.60 grams

$\text{weight}_{light\text{-}colored\ lithologies}$ = 177.39 grams (63.0%)

$\text{weight}_{dark\ shale}$ = 26.28 grams (9.3%)

weight_{coal} = 77.93 grams (27.7%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	70.68	48.62% / 9.06% / 42.32%
>0.0661"	59.37	37.40% / 8.65% / 53.94%
>0.0460"	62.69	24.31% / 11.46% / 64.24%
>0.0331"	41.52	11.31% / 12.50% / 76.19%
<0.0331"	47.34	3.00% / 5.00% / 92.00%
	281.60 TOTAL	



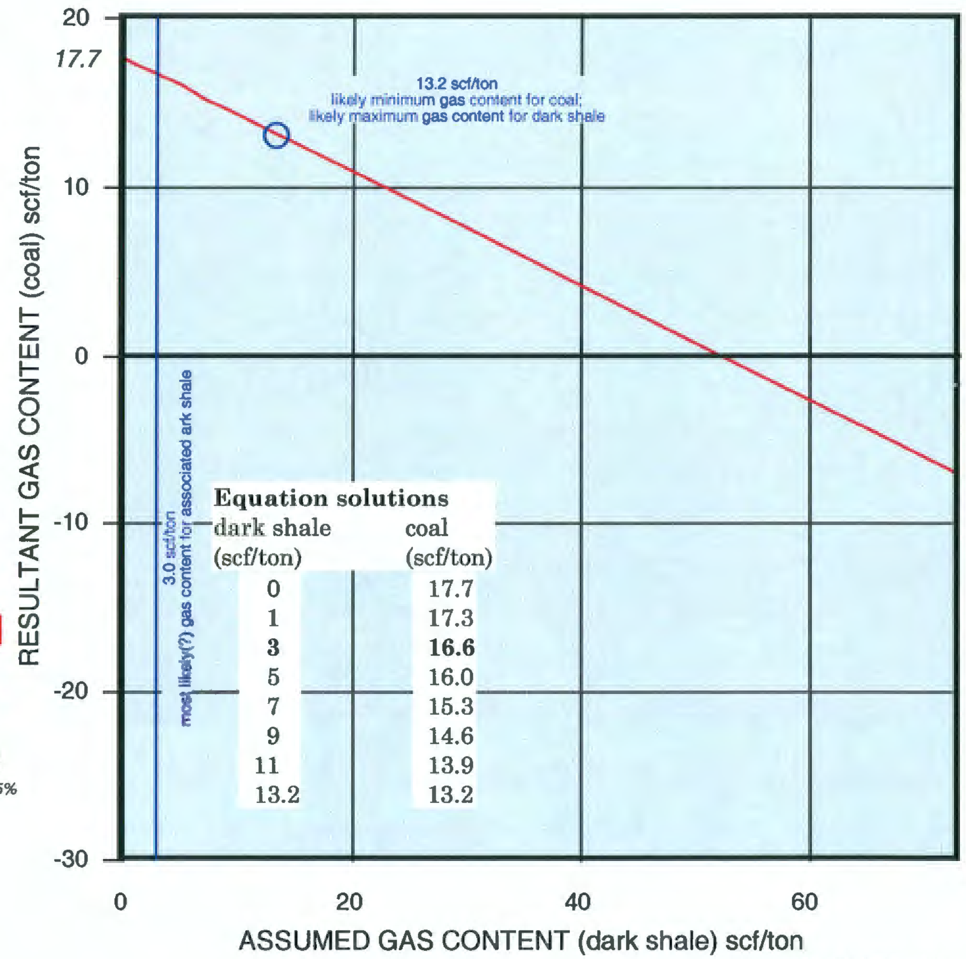


FIGURE 6.

Desorption Characteristics of Cuttings Samples

Evergreen Grable #12-27; 27-T.3S.-R.21E., Doniphan County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Rowe "D" coal from 1455.4'-1458.0'

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

total gas desorbed = 156.6 ccs

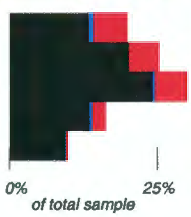
TOTAL DRY WEIGHT OF SAMPLE = 305.46 grams

$\text{weight}_{light\text{-}colored\ lithologies}$ = 56.82 grams (18.6%)

$\text{weight}_{dark\ shale}$ = 5.80 grams (1.9%)

weight_{coal} = 242.84 grams (79.5%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	60.20	66.99% / 4.16% / 28.85%
>0.0661"	76.22	79.66% / 0.17% / 20.17%
>0.0460"	90.60	80.49% / 1.22% / 18.29%
>0.0331"	48.93	83.46% / 3.01% / 13.53%
<0.0331"	29.51	95.00% / 2.00% / 3.00%
	305.46 TOTAL	



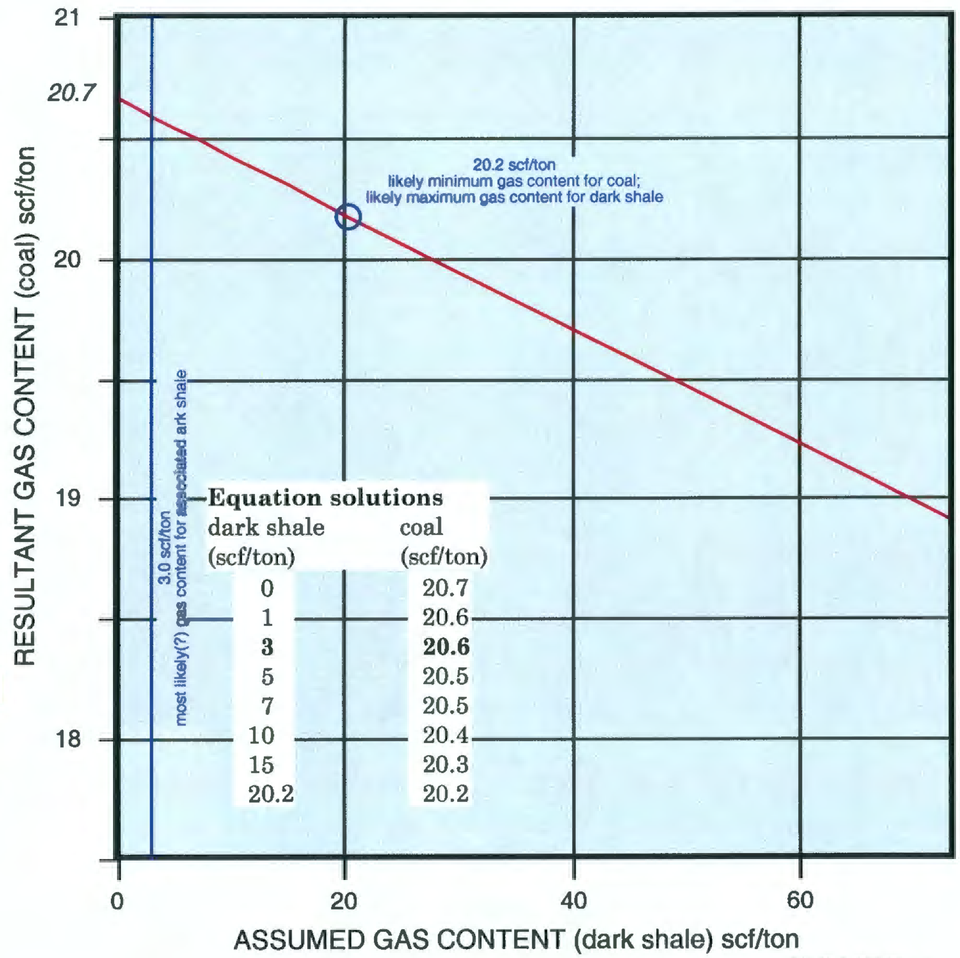


FIGURE 7.

Desorption Characteristics of Cuttings Samples

Evergreen Grable #12-27; 27-T.3S.-R.21E., Doniphan County, KS

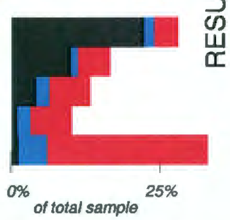
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Warner "A" coal from 1554.6'-1555.0'

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

total gas desorbed = 83.7 ccs

TOTAL DRY WEIGHT OF SAMPLE = 261.48 grams
$\text{weight}_{light\text{-}colored\ lithologies}$ = 130.52 grams (49.9%)
$\text{weight}_{dark\ shale}$ = 32.52 grams (12.4%)
weight_{coal} = 98.44 grams (37.7%)

sieve size	*grams*	*% coal / % dark shale / % light-colored liths*
>0.0930"	72.52	79.15% / 6.47% / 14.38%
>0.0661"	42.96	60.23% / 7.20% / 32.56%
>0.0460"	34.29	30.29% / 17.52% / 52.19%
>0.0331"	26.14	8.45% / 22.54% / 69.01%
<0.0331"	85.57	3.00% / 15.00% / 82.00%
	261.48 TOTAL	



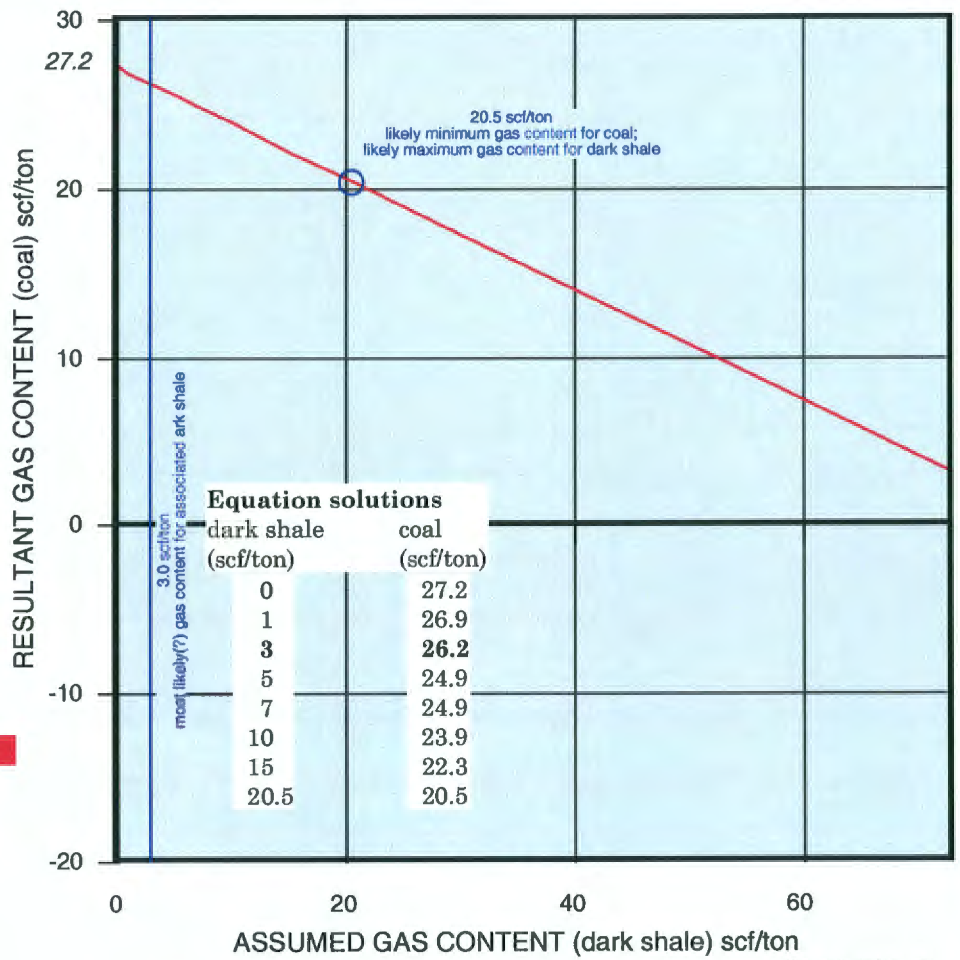


FIGURE 8.

Desorption Characteristics of Cuttings Samples

Evergreen #12-37 Grable #12-37; SW SW NW 27-T.35S.-R.21E., Doniphan County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for all samples

UNIT	coal in sample	scf/ton w/ shale @ 3 scf/ton	maximum scf/ton	minimum scf/ton
Tebo	30%	8.4	12.4	5.3
Dry Wood	28%	16.6	17.7	13.2
Rowe "D"	80%	20.6	20.7	20.2
Warner "A"	38%	26.2	27.2	20.5

500'
600'
700'
800'
900'
1000'
1100'
1200'
O 1220'-1221' Tebo
1300'
1400'
O 1408'-1410' Dry Wood
O 1455'-1458' Rowe "D"
1500'
O 1554'-1555' Warner "A"
1600'

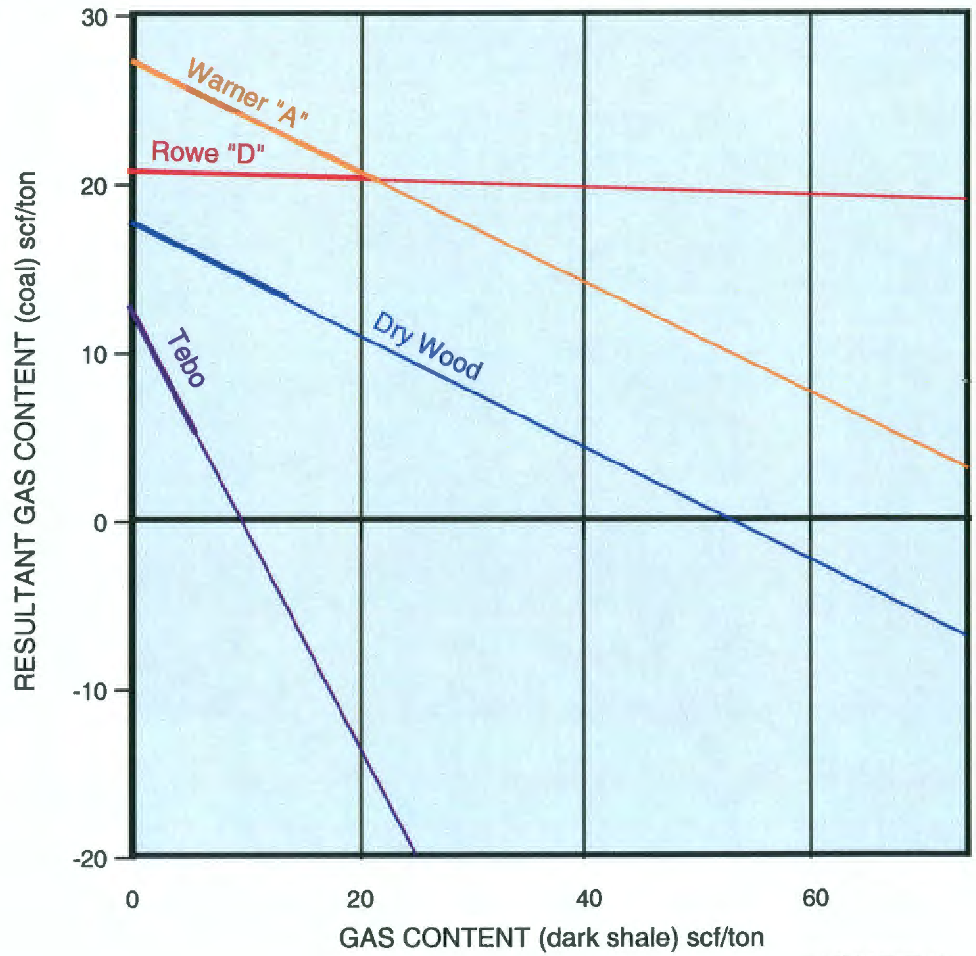


FIGURE 9.

Desorption Characteristics of Cuttings Samples

based on total weight of gas-generating lithologies (i.e., coal and dark shale) in sample
Evergreen #12-37 Grable #12-37; SW SW NW 27-T.35S.-R.21E., Doniphan County, KS

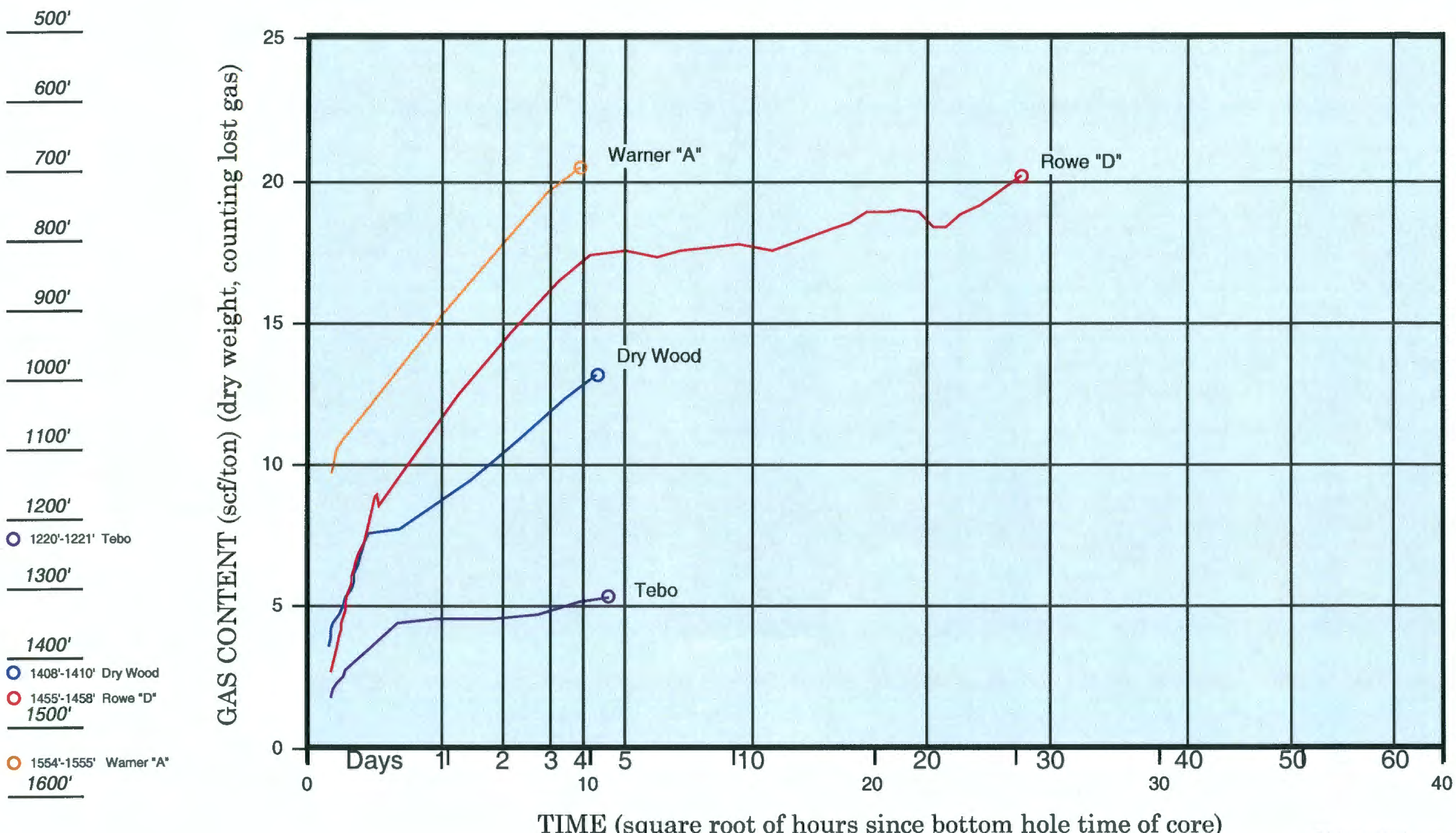


FIGURE 10.