

ANALYSIS OF CHEROKEE GROUP CUTTINGS SAMPLES FOR GAS CONTENT  
-- EVERGREEN OPERATING CORP. LIGGATT #42-35; 35-T.5S.-R.16E.;  
JACKSON COUNTY, KANSAS

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## SUMMARY

Seven cuttings samples from the Pennsylvanian Cherokee Group were collected from the Evergreen Operating Corp. Liggatt #42-35 well, 35-T.5S.-R.16E.; Jackson County, KS.

The samples calculate as having the following gas contents:

- Weir "B" coal at 1648' to 1650' depth<sup>1</sup> (61.8 scf/ton)
- Weir "D" at 1694' to 1695' depth<sup>1,2</sup> (29.9 scf/ton)
- Dry Wood coal at 1828' to 1830' depth<sup>1</sup> (144.9 scf/ton)
- Neutral "A" coal at 1934' to 1936' depth<sup>1</sup> (108.8 scf/ton)
- Neutral "C" coal at 1957' to 1959' depth<sup>1</sup> (117.8 scf/ton)
- Neutral "D" coal at 1969' to 1970' depth<sup>1</sup> (121.1 scf/ton)
- Neutral "E" coal at 1983' to 1985' depth<sup>1</sup> (112.2 scf/ton)

<sup>1</sup>assuming accompanying dark shales in sample desorb 3 scf/ton

<sup>2</sup>reliability of result is unclear due to small amount of coal in the sample

## BACKGROUND

The Evergreen Operating Corp. Liggatt #42-35 well, 35-T.5S.-R.16E.; Jackson County, KS was selected for cuttings desorption tests in association with an on-going coalbed gas research project at the Kansas Geological Survey. The samples were gathered January 9, 2004 by K. David Newell and W. Matthew Brown of the Kansas Geological Survey, with assistance from Richard Robba (consultant to Evergreen). Samples were obtained during normal drilling of the well, with no cessation of drilling before zones of interest (i.e., coals and dark shales in the Cherokee Group) were penetrated. The 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 periodically by carbide tests. A mud-logging trailer with a gas detector trailer was on site.

Seven cuttings samples from the Pennsylvanian Cherokee Group were collected:

- Weir "B" coal at 1648' to 1650' depth (422 grams dry wt.)
- Weir "D" at 1694' to 1695' depth (455 grams dry wt.)
- Dry Wood coal at 1828' to 1830' depth (330 grams dry wt.)
- Neutral "A" coal at 1934' to 1936' depth (433 grams dry wt.)
- Neutral "C" coal at 1957' to 1959' depth (445 grams dry wt.)
- Neutral "D" coal at 1969' to 1970' depth (540 grams dry wt.)
- Neutral "E" coal at 1983' to 1985' depth (1397 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 80 °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<sup>3</sup>). The "DN" canisters enclosed a volume of 44 cubic inches (720 cm<sup>3</sup>), and the one "Brady" canister used enclosed a volume of 106 cubic inches (1740 cm<sup>3</sup>).

The desorbed gas that collected in the desorption canisters was periodically released into the volumetric displacement apparatus and measured as a function of time, temperature, and atmospheric pressure.

The time and atmospheric pressure were measured in the field using a portable weather station (model BA928) marketed by Oregon Scientific (Tualatin, OR). The atmospheric pressure was displayed in millibars on this instrument, however, this measurement was not the actual barometric pressure, but rather an altitude-compensated barometric pressure automatically converted to a sea-level-equivalent pressure. 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:

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

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

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

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

The conversion calculations in the spreadsheet were carried out in the English metric system, as this is the customary measure system used in American coal and oil industry.  $V$  is therefore converted to cubic feet;  $P$  is psia;  $T$  is °R.

The desorbed gas was summed over the time period for which the coal samples evolved all of their gas. In the case of well cuttings from Evergreen Operating Corp. Liggatt #42-35 well, the maximum time of desorption was 38 days.

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 1-7)*

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 8-14)*

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:

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

A unique solution for  $\text{gas content}_{\text{coal}}$  in this equation is not possible because  $\text{gas content}_{\text{dark shale}}$  is not known exactly. An answer can only be expressed as a linear solution to the above equation. The richer in gas the dark shales are, the poorer in gas the admixed coal has to be, and visa versa. If there is little dark shale in a sample, a relatively well constrained answer for  $\text{gas content}_{\text{coal}}$  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 bivariate 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 than 10 scf/ton before the associated coal starts to have a gas content less than that of the dark shale. In all the lithologic-component-sensitivity-analysis diagrams, a "break-even" point is therefore noted where the gas content of the coal is equal to that of the dark shale. This "break-

even" point corresponds to the minimum gas content assignable to the coal and maximum gas content assignable to the dark shale. It can also be thought of the scf/ton gas content of the cuttings sample minus the weight of any of the lighter-colored lithologies, which are assumed to have no inherent gas content. Conversely 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 15)*

This diagram is a summary of the individual "lithologic component sensitivity analyses" for each sample, all set at a common scale. The steeper the angle of the line for a sample, the more uncertainty is attached to the results (i.e., *gas content<sub>coal</sub>*) for that sample. If the coal content is miniscule (i.e., < approximately 5%), the results are a better reflection of the *gas content<sub>dark shale</sub>*.

#### *Desorption Graph (Figure 16)*

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

The Weir "D" sample did not contain significant coal -- only 1%. The low gas content of the sample and the low percentage of coal, in combination with the high content of dark shale makes the gas content of the coal change drastically with only slight changes in the assumed gas content of the dark shale. The coal may be cavings from other zones, but it also may be remnants of very thin stringers within a dark shale. In any event, the results for the gas content of the coal for this sample are unclear.

All of the other samples contain adequate coal for reasonable determination of gas content of the coal. According to the summary diagram for the sensitivity analyses (Figure 16), the best constrained results (in which the resultant coal gas content varies the least with shale gas content) is for the Neutral "E" coal (1983' - 1985'). The least constrained results are for the Weir "D" coal.

## 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

TABLE 1. Desorption measurements for samples.

FIGURE 1. Lost-gas graph for Weir "B" coal at 1648' to 1650' depth.

FIGURE 2. Lost-gas graph for Weir "D" coal at 1694' to 1695' depth.

FIGURE 3. Lost-gas graph for Dry Wood coal at 1828' to 1830' depth.

FIGURE 4. Lost-gas graph for Neutral "A" coal at 1934' to 1936' depth.

FIGURE 5. Lost-gas graph for Neutral "C" coal at 1957' to 1959' depth.

FIGURE 6. Lost-gas graph for Neutral "D" coal at 1969' to 1970' depth.

FIGURE 7. Lost-gas graph for Neutral "E" coal at 1983' to 1985' depth.

FIGURE 8. Sensitivity analysis for Weir "B" coal at 1648' to 1650' depth.

FIGURE 9. Sensitivity analysis for Weir "D" coal at 1694' to 1695' depth.

FIGURE 10. Sensitivity analysis for Dry Wood coal at 1828' to 1830' depth.

FIGURE 11. Sensitivity analysis for Neutral "A" coal at 1934' to 1936' depth.

FIGURE 12. Sensitivity analysis for Neutral "C" coal at 1957' to 1959' depth.

FIGURE 13. Sensitivity analysis for Neutral "D" coal at 1969' to 1970' depth.

FIGURE 14. Sensitivity analysis for Neutral "E" coal at 1983' to 1985' depth.

FIGURE 15. Lithologic component sensitivity analyses for all samples.

FIGURE 16. Desorption graph for all samples.





dry sample weight: 0.6229 lbs. 282.54 grams

est. lost gas (cc) = TIME OF: 81 off bottom 2/9/04 2:47 at surface 2/9/04 3:01 in canister 2/9/04 3:04 elapsed time (off bottom to canistering) 17.2 minutes 0.287 hours

Table with columns for RIGLAB MEASUREMENTS, CONVERSION OF RIGLAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi), CUMULATIVE VOLUMES, SCF/TON, SCF/TON, TIME OF MEASURE, TIME SINCE, and SORT hrs. Includes a row for 'DESORPTION TERMINATED 2/22/2004 DUE TO NO MORE GAS BEING EVOLVED; sampled air dried for 6 days'.

SAMPLE: 1934 to 1936 (Neutral "A" coal) In canister DN1

dry sample weight: 0.8876 lbs. 402.81 grams

est. lost gas (cc) = TIME OF: 180 off bottom 2/9/04 4:04 at surface 2/9/04 4:17 in canister 2/9/04 4:28 elapsed time (off bottom to canistering) 22.5 minutes 0.375 hours

Table with columns for RIGLAB MEASUREMENTS, CONVERSION OF RIGLAB MEASUREMENTS TO STP (@60 deg F; 14.7 psi), CUMULATIVE VOLUMES, SCF/TON, SCF/TON, TIME OF MEASURE, TIME SINCE, and SORT hrs.





1648' to 1650' (Weir "B" coal) in canister ST7  
Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

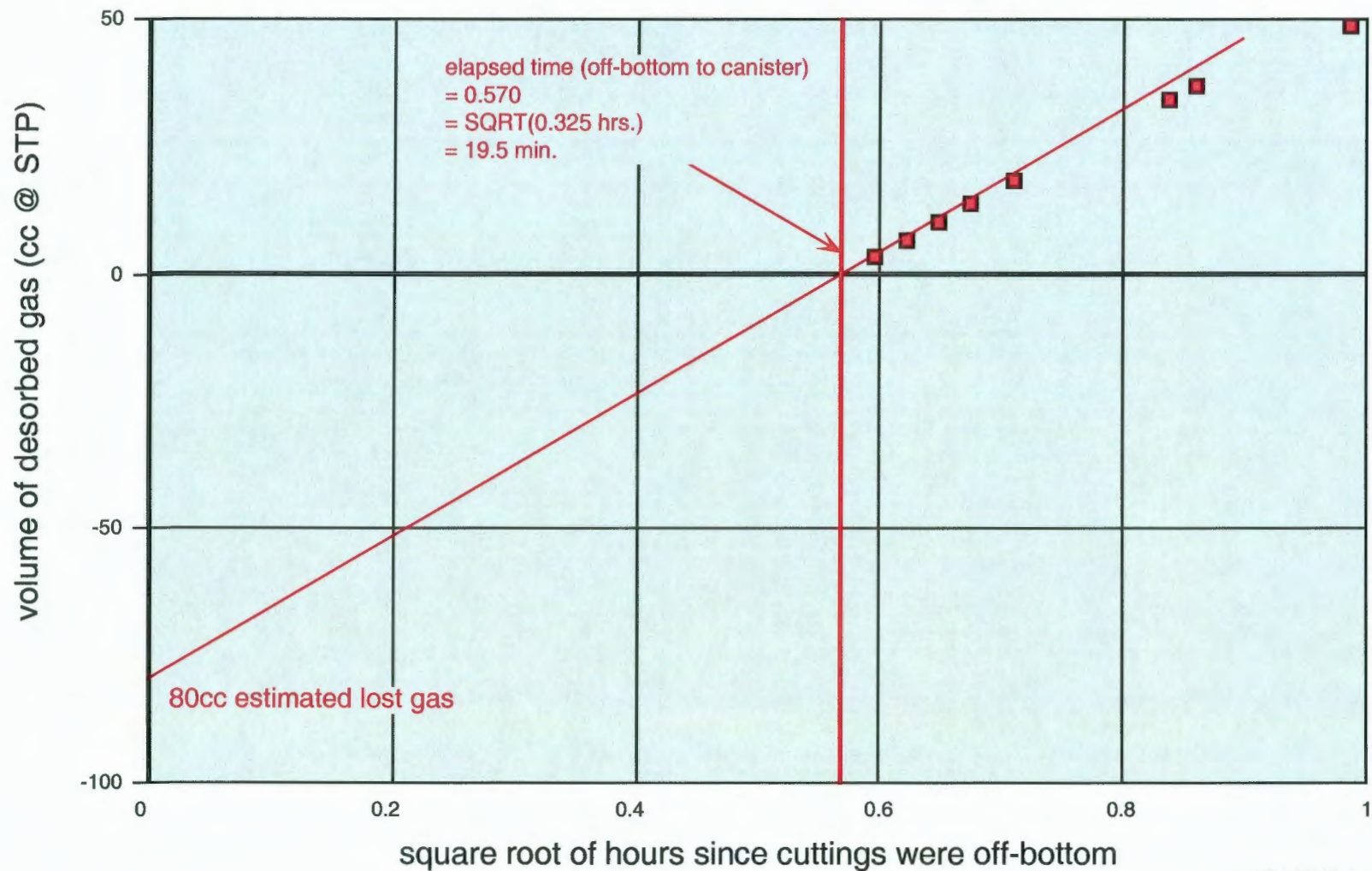


FIGURE 1.

1694' to 1695' (Weir "D" "coal") in canister ST4  
Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

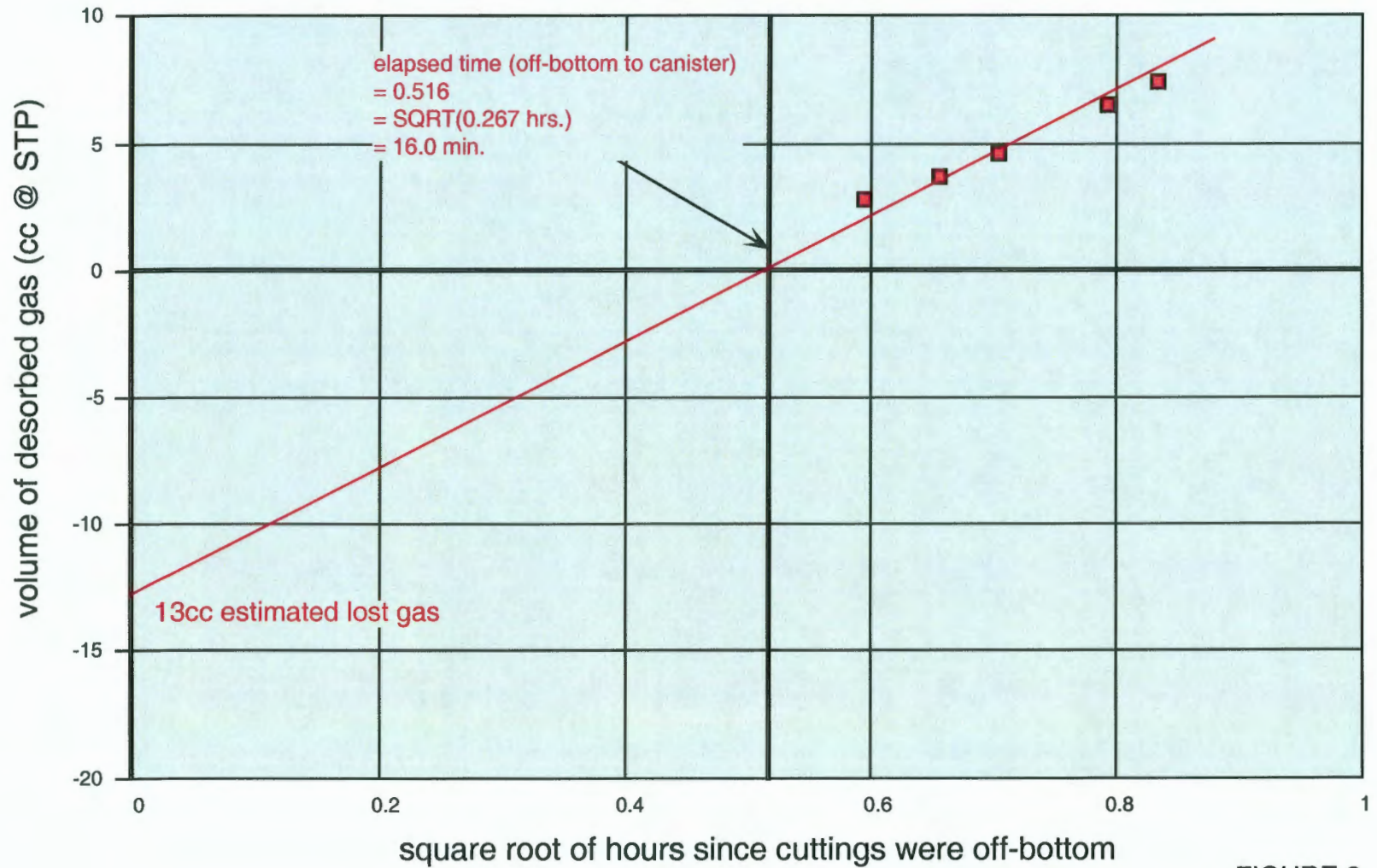


FIGURE 2.

1828' to 1830' (Drywood coal) in canister ST6  
Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

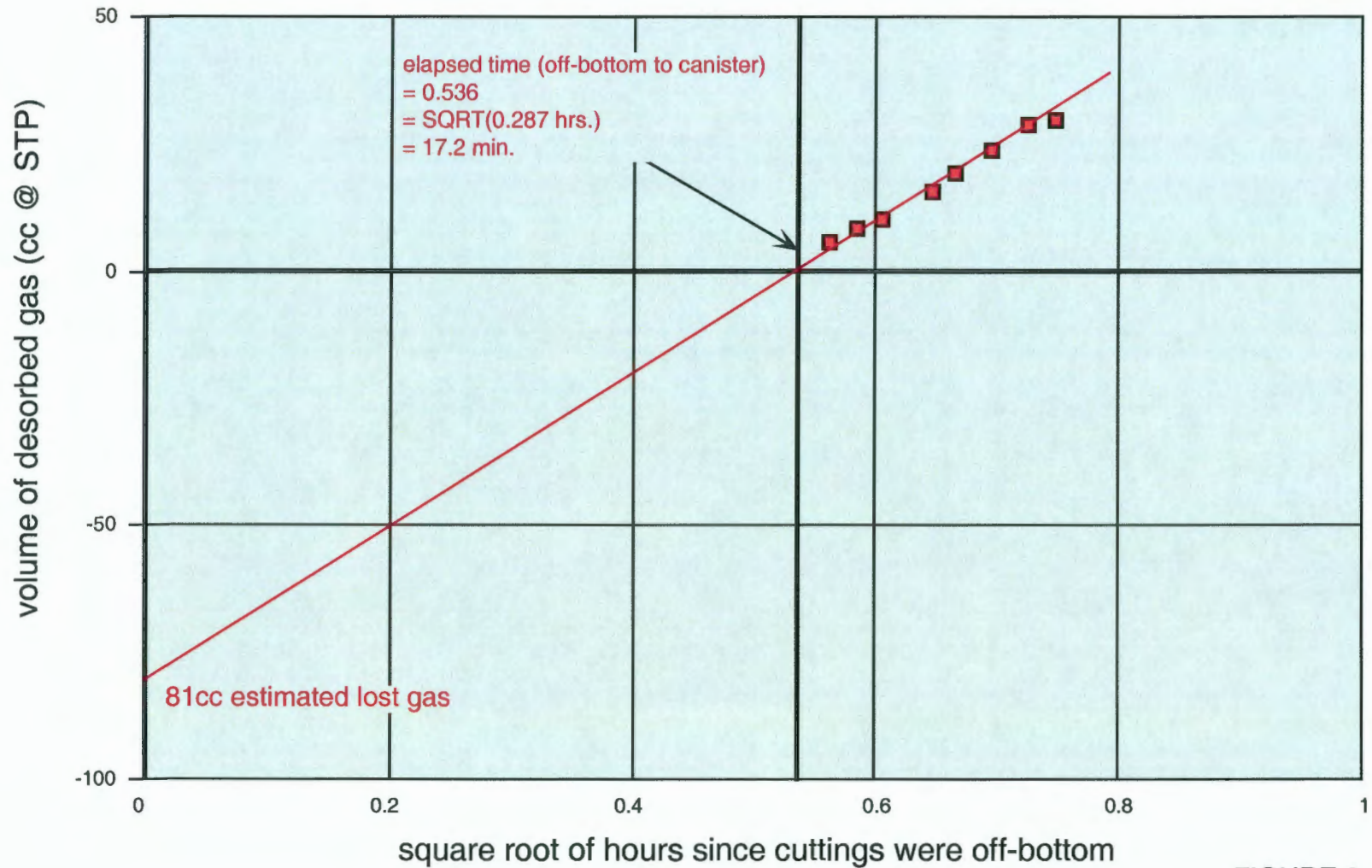


FIGURE 3.

1934' to 1936' (Neutral "A" coal) in canister DN1  
Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

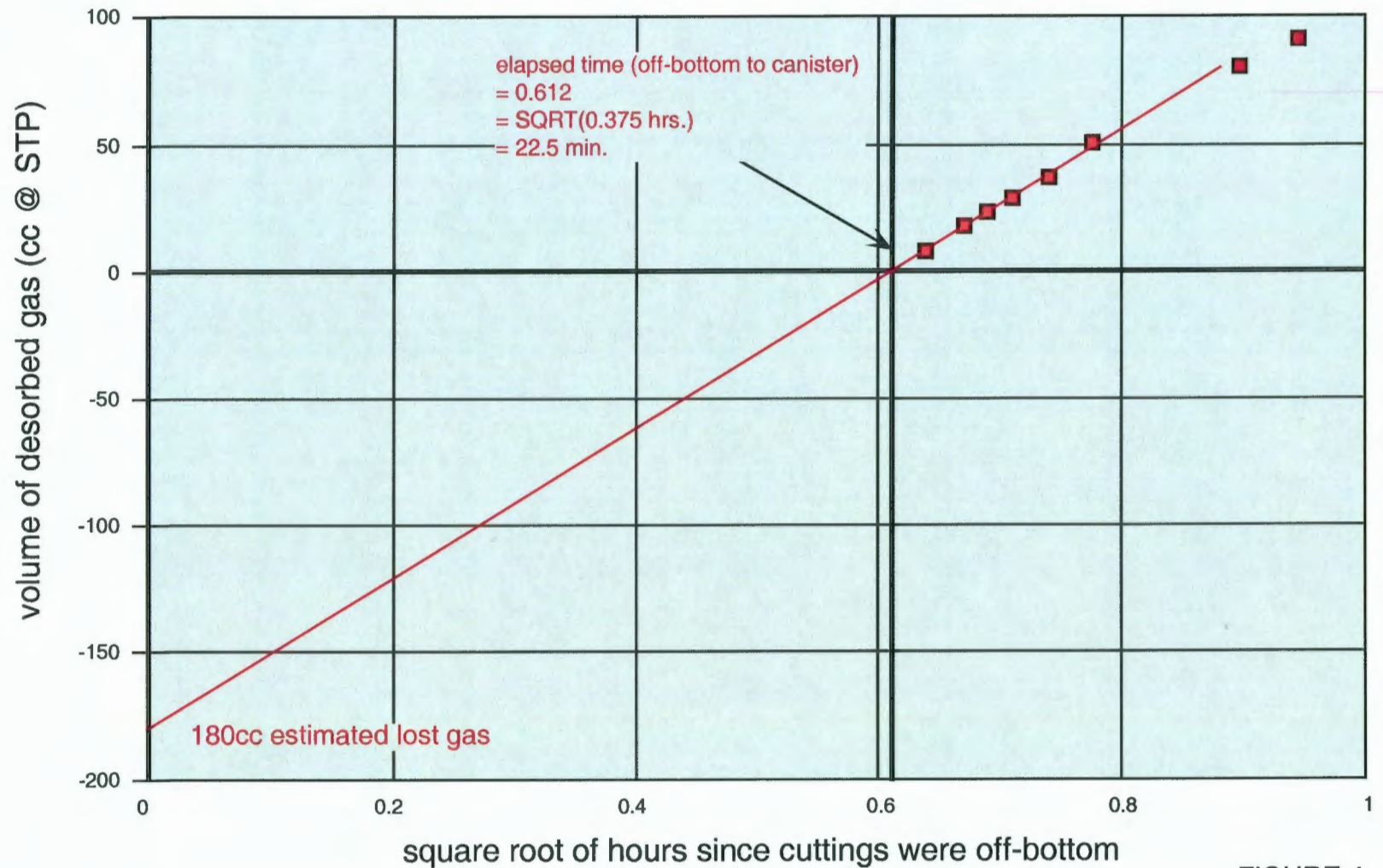


FIGURE 4.



1957' to 1959' (Neutral "C" coal) in canister ST5  
Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

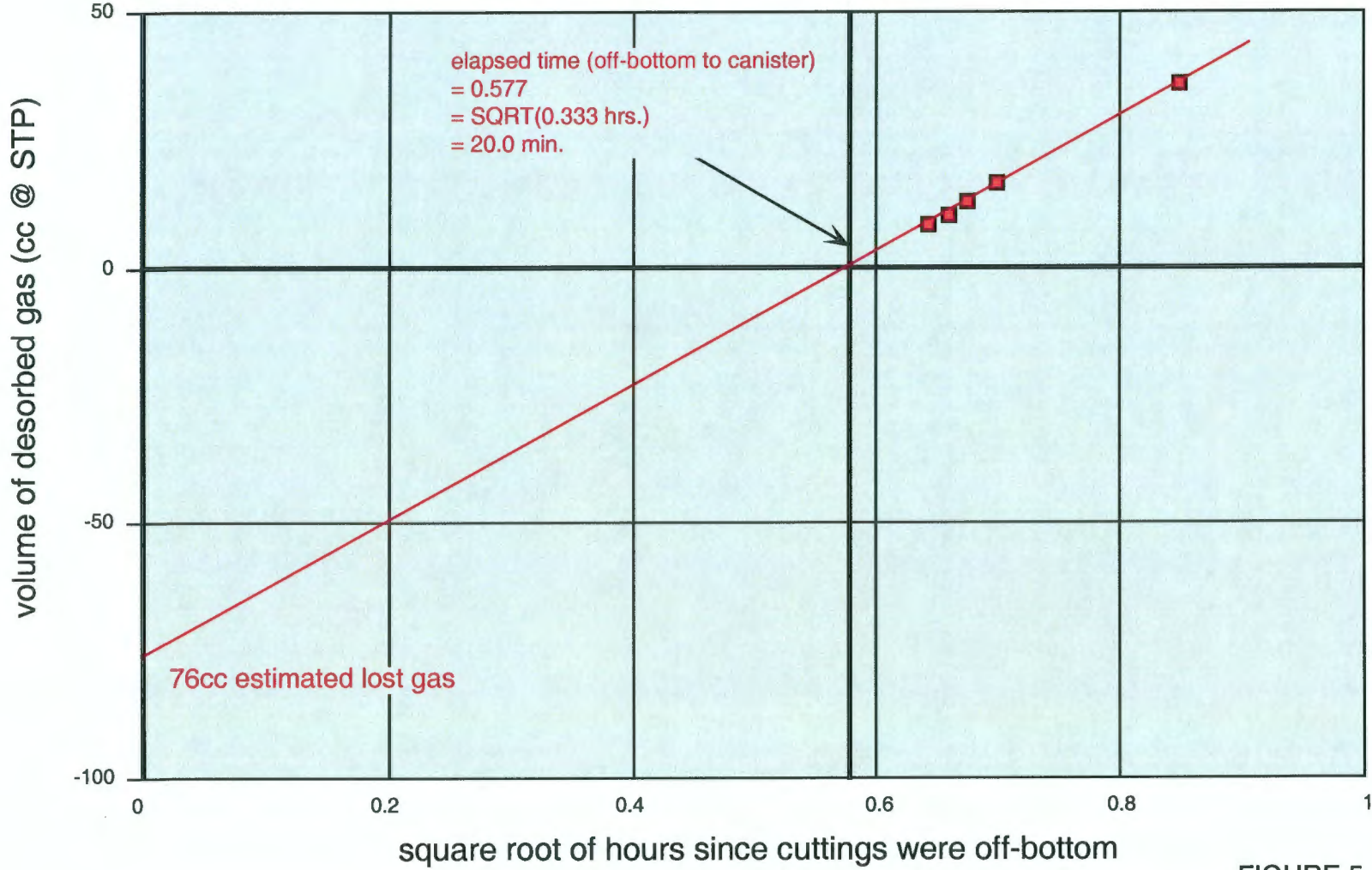


FIGURE 5.

1969' to 1970' (Neutral "D" coal) in canister DN2  
Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

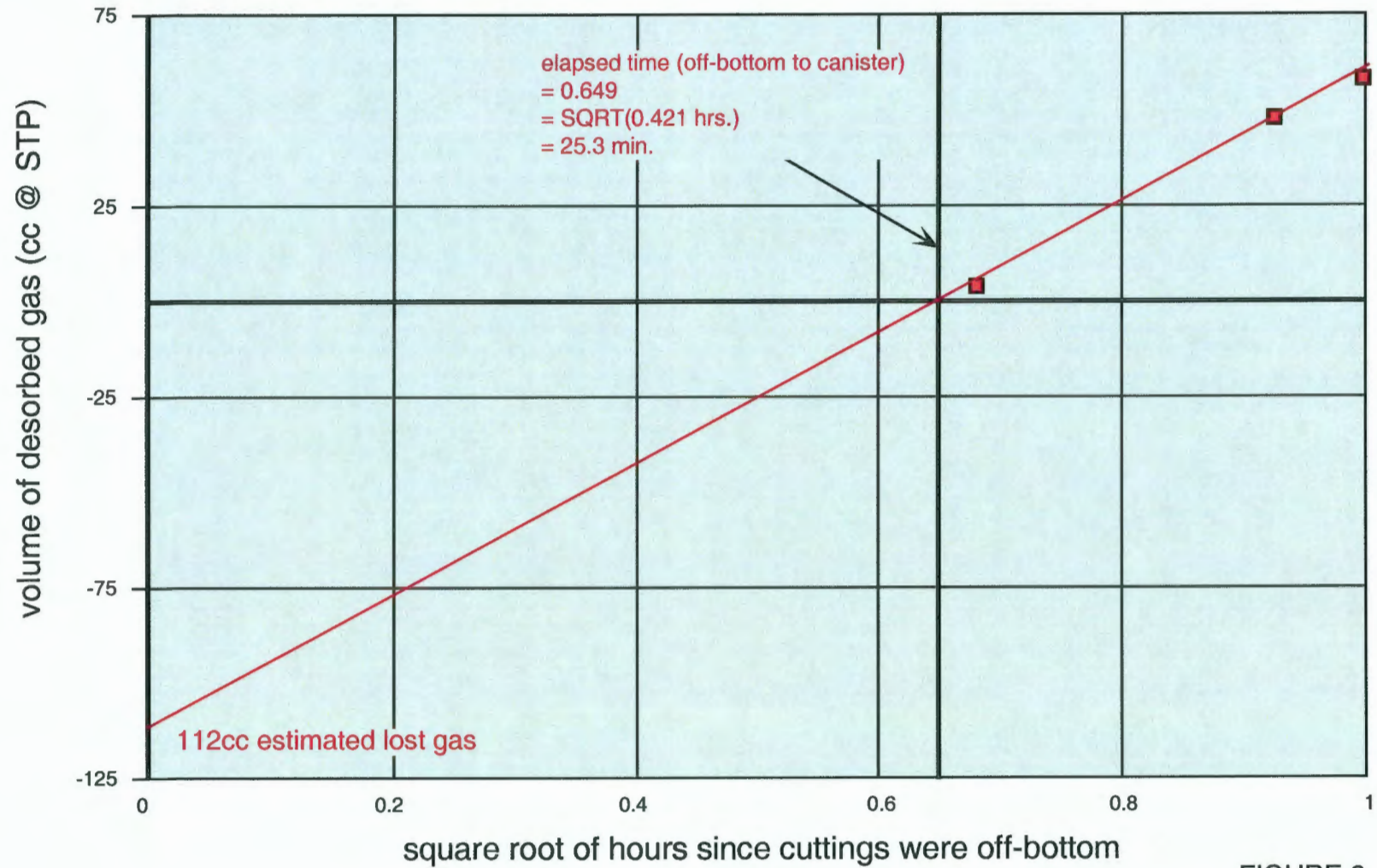


FIGURE 6.

1983' to 1985' (Neutral "D" coal) in canister Brady 27  
Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

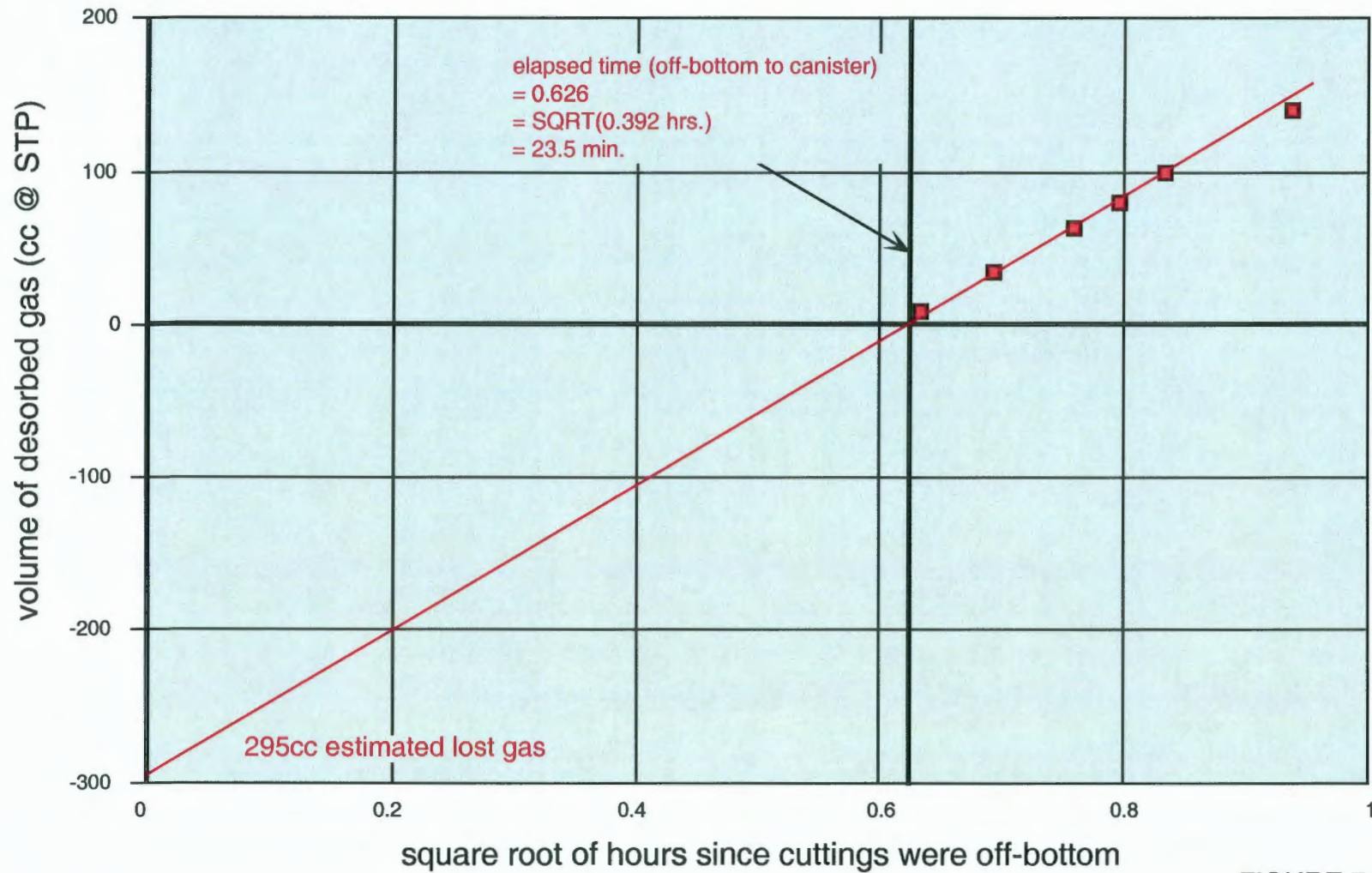


FIGURE 7.

# Desorption Characteristics of Cuttings Samples

## Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Weir "B" coal from 1648-1650'

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

total gas desorbed = 264.1 ccs

TOTAL DRY WEIGHT OF SAMPLE = 421.95 grams

weight<sub>light-colored lithologies</sub> = 97.57 grams (23.1%)

weight<sub>dark shale</sub> = 197.05 grams (46.7%)

weight<sub>coal</sub> = 127.33 grams (30.2%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	43.98	22.48% / 46.55% / 30.97%
>0.0661"	58.20	24.23% / 35.67% / 40.11%
>0.0460"	89.44	26.17% / 40.64% / 33.19%
>0.0331"	78.87	31.52% / 46.74% / 21.74%
<0.0331"	151.45	36.36% / 54.55% / 9.09%
<b>421.95 TOTAL</b>		

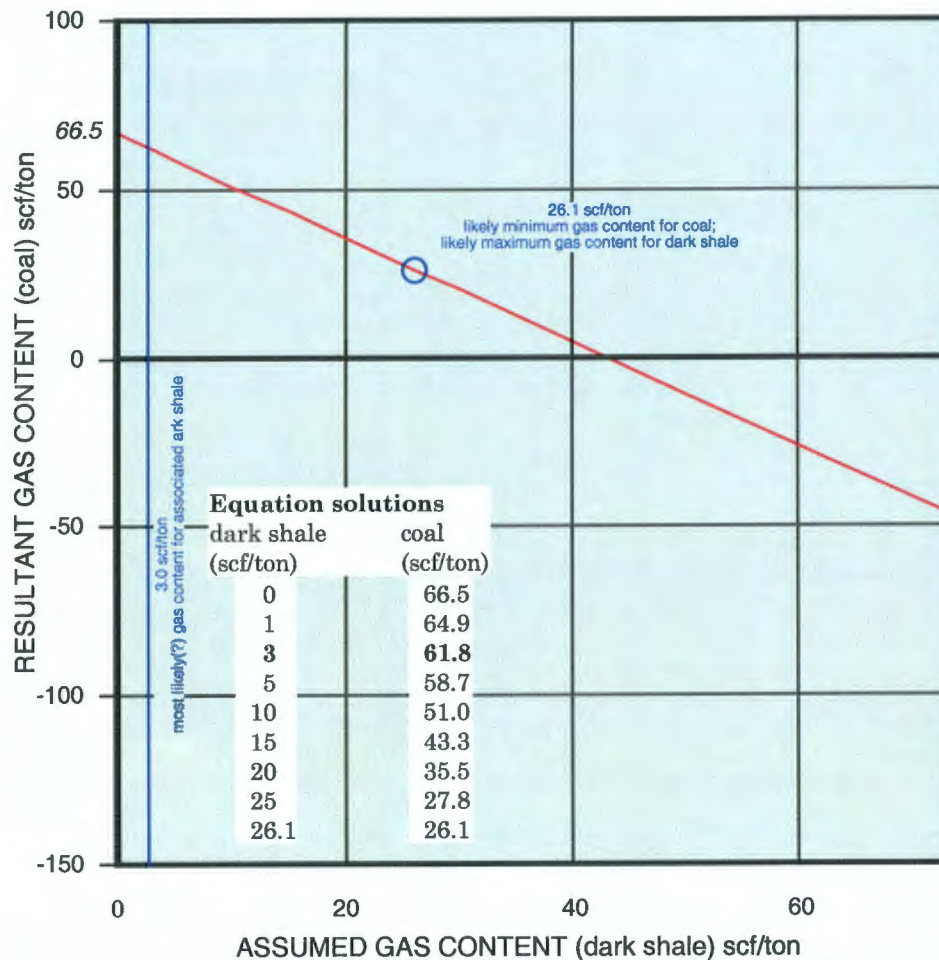
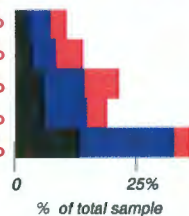


FIGURE 8.

# Desorption Characteristics of Cuttings Samples

## Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Weir "D" coal from 1694-1695'

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

total gas desorbed = 43.3 ccs

TOTAL DRY WEIGHT OF SAMPLE = 455.44 grams

weight<sub>light-colored lithologies</sub> = 38.13 grams (8.4%)

weight<sub>dark shale</sub> = 412.25 grams (90.5%)

weight<sub>coal</sub> = 5.06 grams (1.1%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	76.29	0.30% / 81.69% / 18.01%
>0.0661"	99.48	1.00% / 88.57% / 10.42%
>0.0460"	111.39	1.22% / 92.46% / 6.31%
>0.0331"	76.91	1.48% / 93.47% / 5.04%
<0.0331"	91.37	1.46% / 95.15% / 3.40%

**455.44 TOTAL**

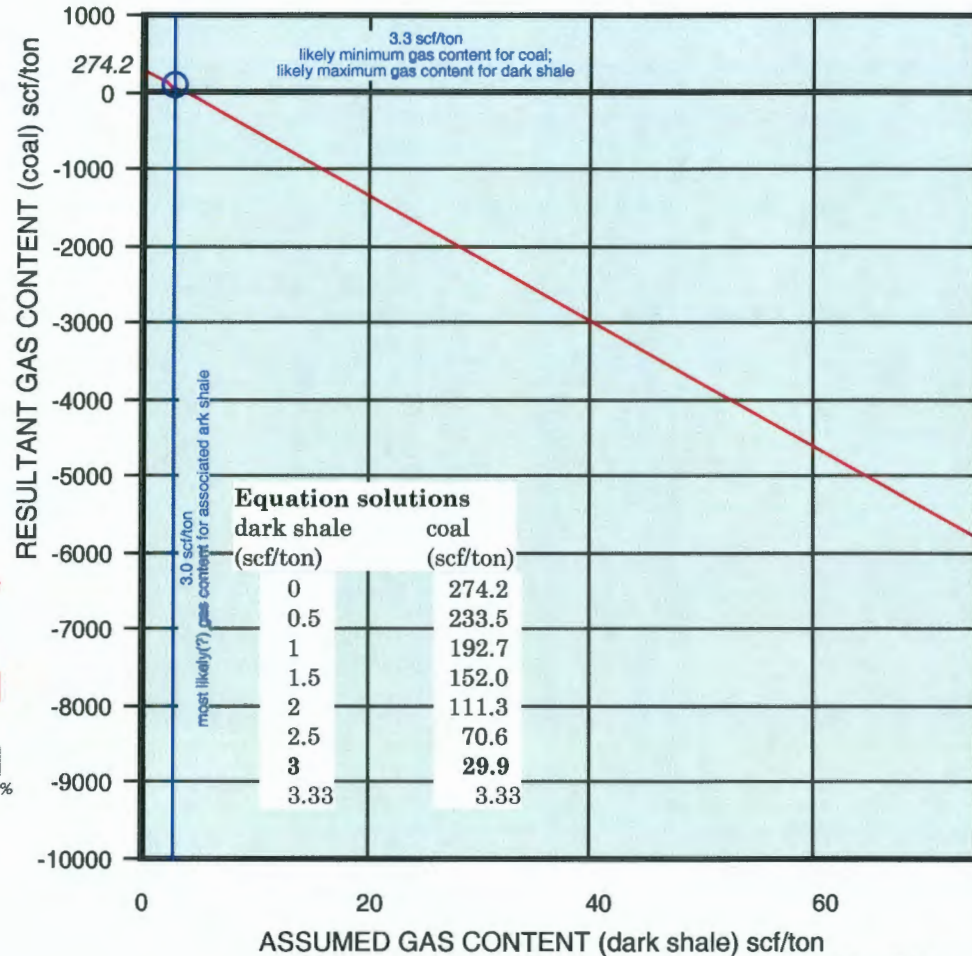
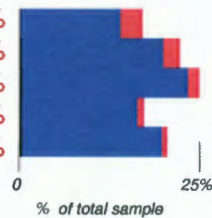


FIGURE 9.

# Desorption Characteristics of Cuttings Samples

## Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Dry Wood coal from 1828-1830'

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

total gas desorbed = 326.5 ccs

TOTAL DRY WEIGHT OF SAMPLE = 330.16 grams

weight<sub>light-colored lithologies</sub> = 47.62 grams (14.4%)

weight<sub>dark shale</sub> = 214.79 grams (65.1%)

weight<sub>coal</sub> = 67.74 grams (20.5%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	26.20	11.78% / 71.90% / 16.31%
>0.0661"	39.66	14.43% / 67.98% / 17.59%
>0.0460"	62.63	16.07% / 60.66% / 23.27%
>0.0331"	64.29	17.74% / 58.06% / 24.19%
<0.0331"	137.38	27.27% / 68.18% / 4.55%

**330.16 TOTAL**

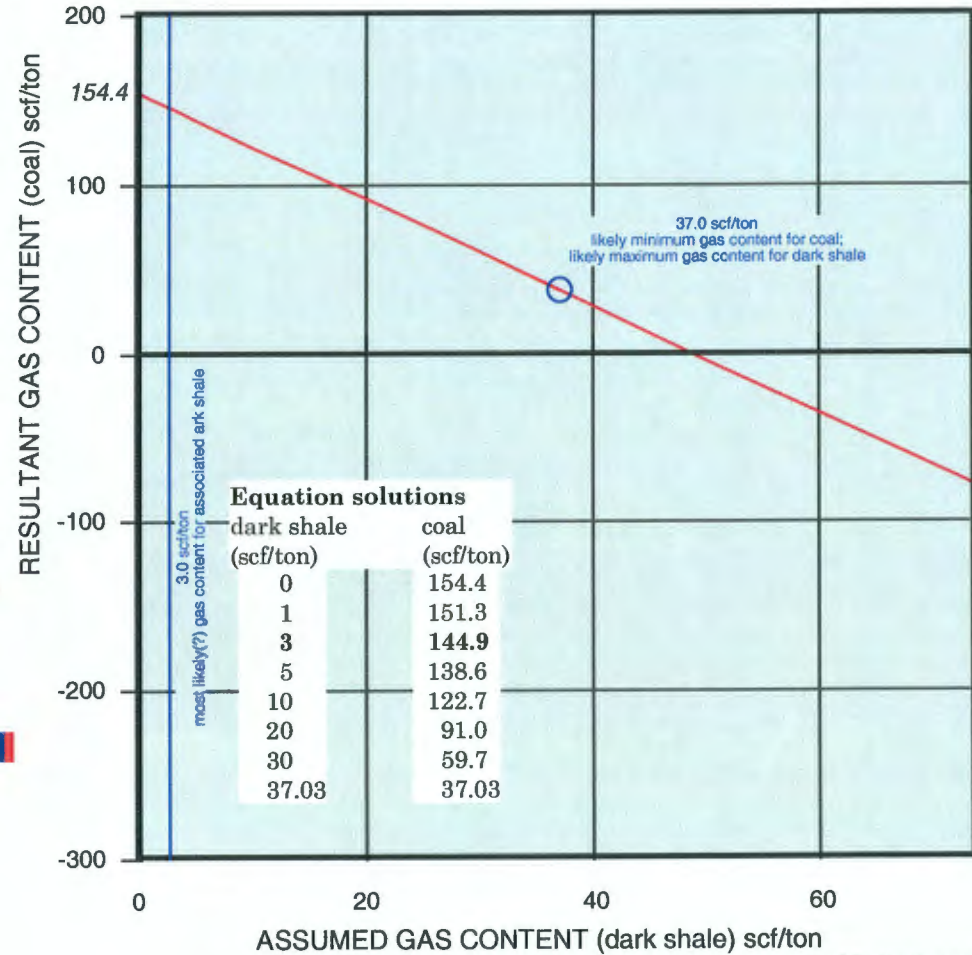
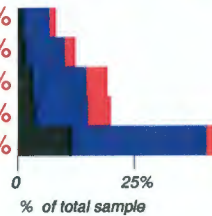


FIGURE 10.

# Desorption Characteristics of Cuttings Samples

## Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Neutral "A" coal from 1934-1936'

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

total gas desorbed = 617.5 ccs

TOTAL DRY WEIGHT OF SAMPLE = 432.99 grams

weight<sub>light-colored lithologies</sub> = 30.38 grams (7.0%)

weight<sub>dark shale</sub> = 227.04 grams (52.4%)

weight<sub>coal</sub> = 175.57 grams (40.6%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	51.63	40.71% / 46.39% / 12.90%
>0.0661"	77.96	34.85% / 57.85% / 7.29%
>0.0460"	103.42	30.24% / 61.54% / 8.22%
>0.0331"	83.66	37.63% / 54.84% / 7.53%
<0.0331"	116.31	55.56% / 41.67% / 2.78%
<b>432.99 TOTAL</b>		

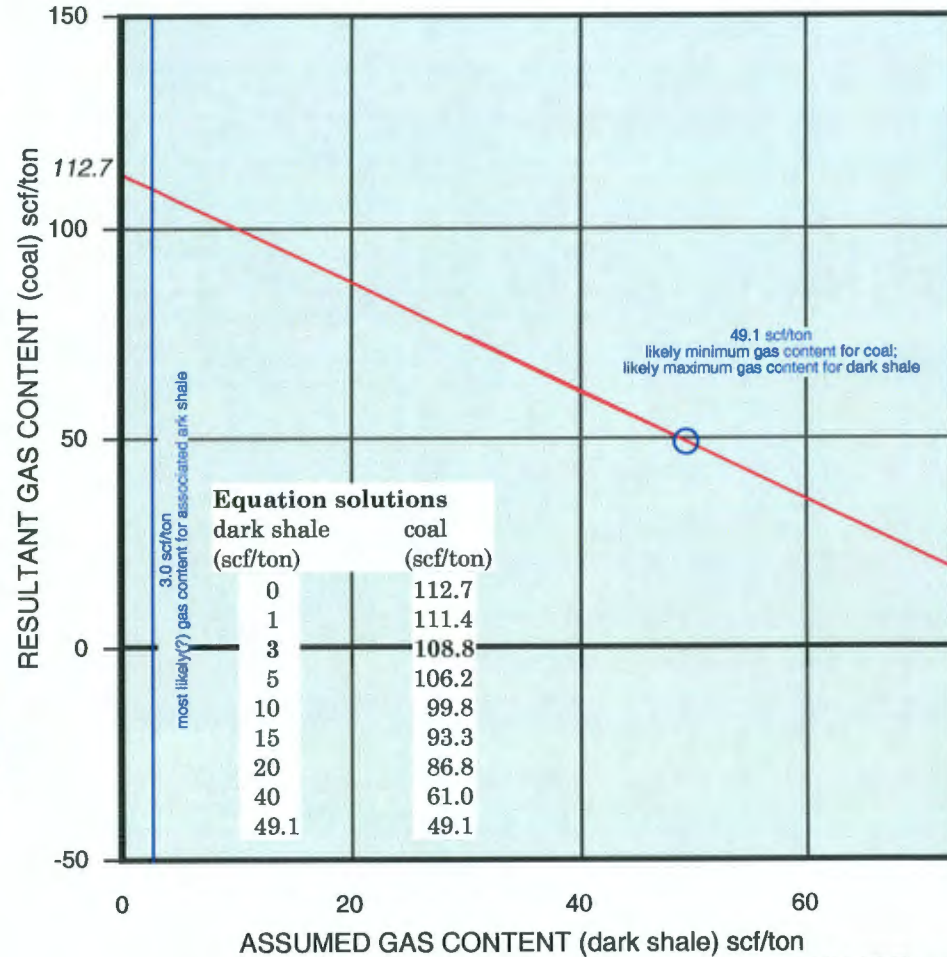
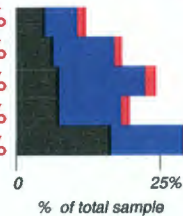


FIGURE 11.

# Desorption Characteristics of Cuttings Samples

## Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Neutral "C" coal from 1957-1959'

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

total gas desorbed = 339.8 ccs

TOTAL DRY WEIGHT OF SAMPLE = 445.36 grams

weight<sub>light-colored lithologies</sub> = 99.59 grams (22.4%)

weight<sub>dark shale</sub> = 260.00 grams (58.4%)

weight<sub>coal</sub> = 85.77 grams (19.3%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	85.19	28.14% / 61.33% / 10.53%
>0.0661"	74.48	17.73% / 68.29% / 13.98%
>0.0460"	90.85	20.62% / 56.40% / 22.99%
>0.0331"	74.55	13.16% / 61.05% / 25.79%
<0.0331"	120.28	16.67% / 50.00% / 33.33%
<b>445.36 TOTAL</b>		

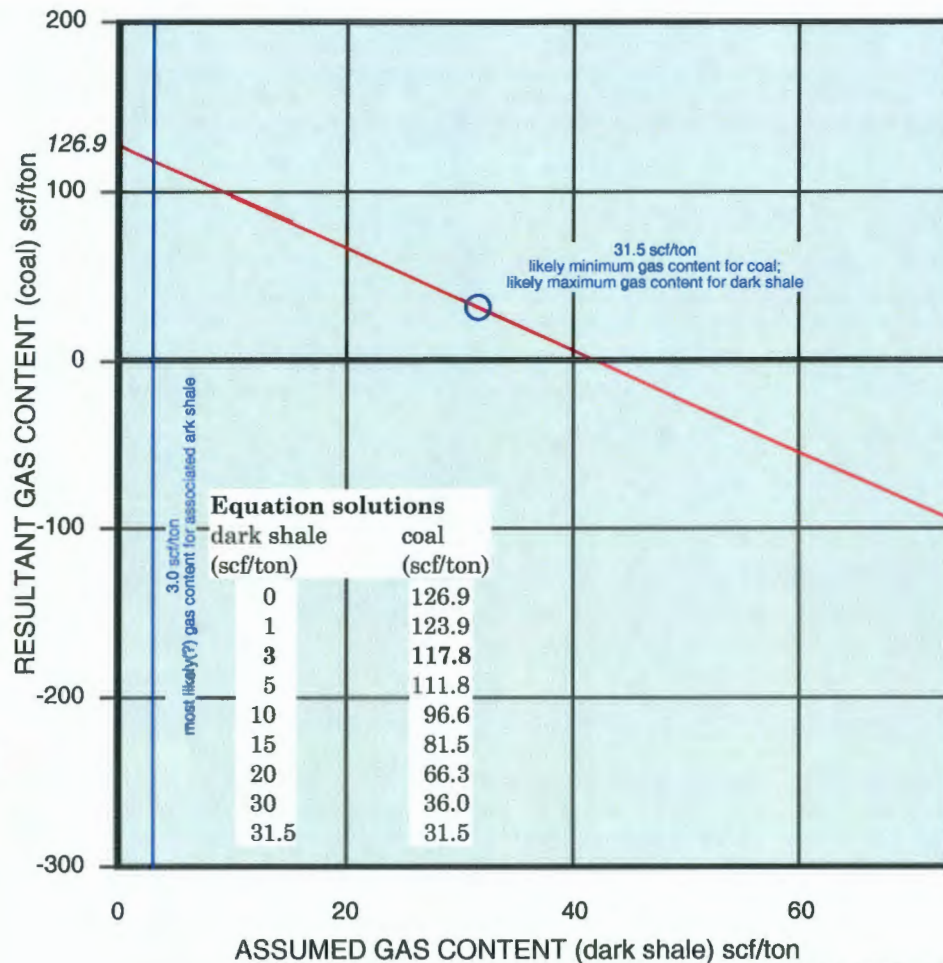
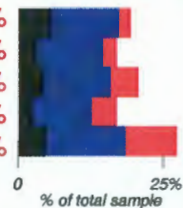


FIGURE 12.



# Desorption Characteristics of Cuttings Samples

## Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Neutral "D" coal from 1969-1970'

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

total gas desorbed = 495.0 ccs

TOTAL DRY WEIGHT OF SAMPLE = 540.18 grams

weight<sub>light-colored lithologies</sub> = 156.00 grams (28.8%)

weight<sub>dark shale</sub> = 259.67 grams (48.1%)

weight<sub>coal</sub> = 124.51 grams (23.1%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	93.91	23.09% / 28.41% / 48.50%
>0.0661"	89.47	23.78% / 38.81% / 37.41%
>0.0460"	123.63	25.38% / 46.17% / 28.45%
>0.0331"	91.34	20.42% / 59.69% / 19.90%
<0.0331"	141.83	22.22% / 61.11% / 16.67%

**540.18 TOTAL**

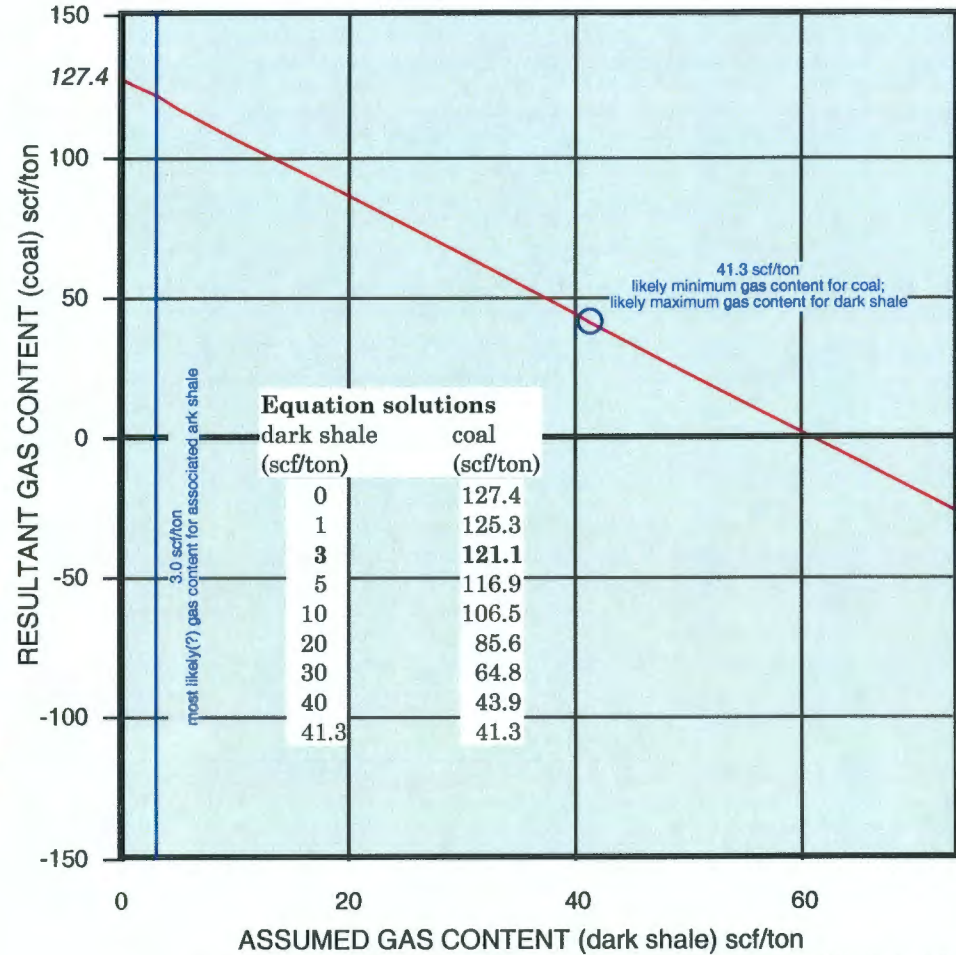
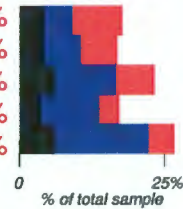


FIGURE 13.

# Desorption Characteristics of Cuttings Samples

## Evergreen #42-35 Liggatt, 35-T.5S.-R.16E., Jackson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Neutral "E" coal from 1983' to 1985'

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

total gas desorbed = 1396.7 ccs

TOTAL DRY WEIGHT OF SAMPLE = 890.37 grams

weight<sub>light-colored lithologies</sub> = 392.30 grams (44.1%)

weight<sub>dark shale</sub> = 214.79 grams (24.1%)

weight<sub>coal</sub> = 283.28 grams (31.8%)

sieve size	grams	% coal / % dark shale / % light-colored liths
>0.0930"	201.42	36.95% / 22.03% / 41.02%
>0.0661"	174.52	34.15% / 19.72% / 46.14%
>0.0460"	184.13	29.97% / 29.16% / 40.87%
>0.0331"	130.65	40.83% / 35.00% / 24.17%
<0.0331"	199.66	75.00% / 18.33% / 6.67%

**890.37 TOTAL**

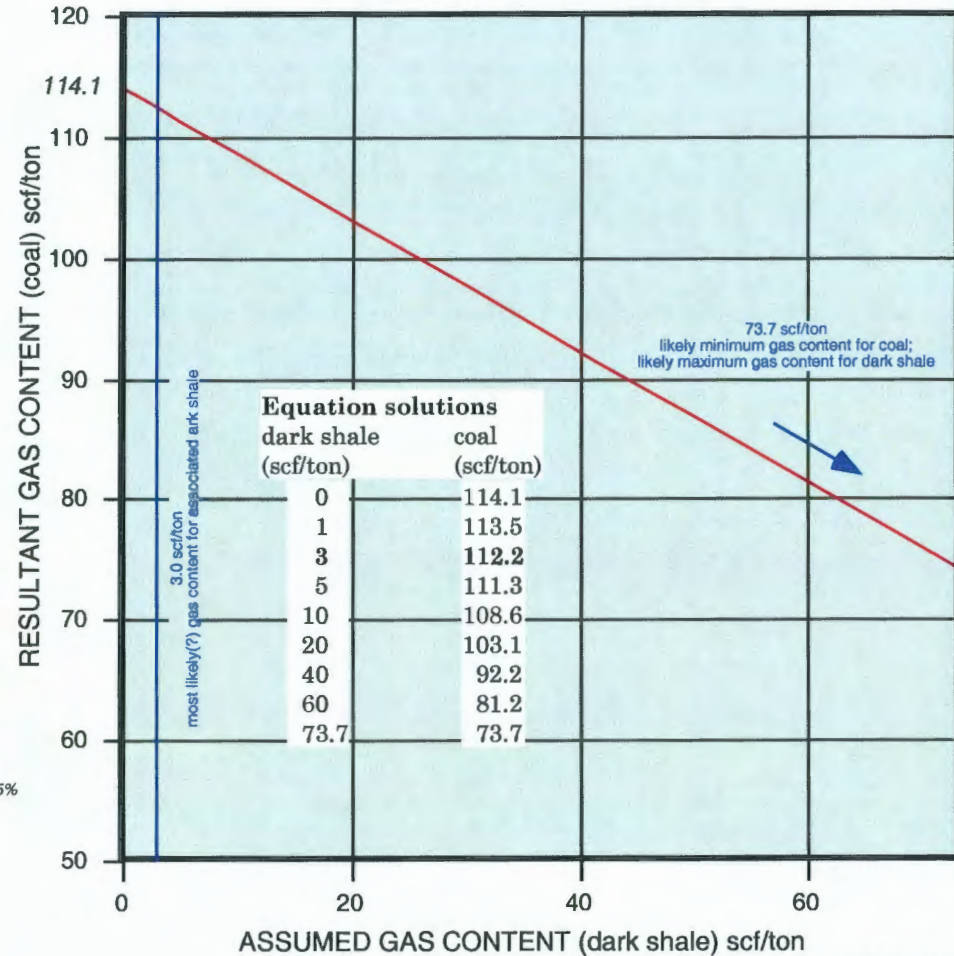
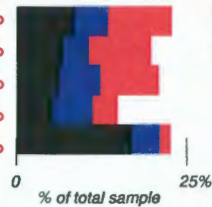


FIGURE 14.

# Desorption Characteristics of Cuttings Samples

## Evergreen Liggatt #42-35; 35-T.5S.-R.16E.; Jackson County, KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for all samples

	UNIT	coal in sample	maximum scf/ton	scf/ton w/ shale @ 3 scf/ton	minimum scf/ton
1500'	Weir "B"	30%	66.5	61.8	26.1
	Weir "D"	1%	274.2	29.9	3.3
	Dry Wood	21%	154.4	144.9	37.0
	Neutral "A"	41%	112.7	108.8	49.1
1600'	Neutral "C"	19%	126.9	117.8	31.5
	Neutral "D"	23%	127.4	121.1	41.3
	Neutral "E"	32%	114.1	112.2	73.7

- 1648'-1650' Weir "B"
- 1694'-1695' Weir "D"
- 1828'-1830' Dry Wood
- 1934'-1936' Neutral "A"
- 1957'-1959' Neutral "C"
- 1969'-1970' Neutral "D"
- 1983'-1985' Neutral "E"

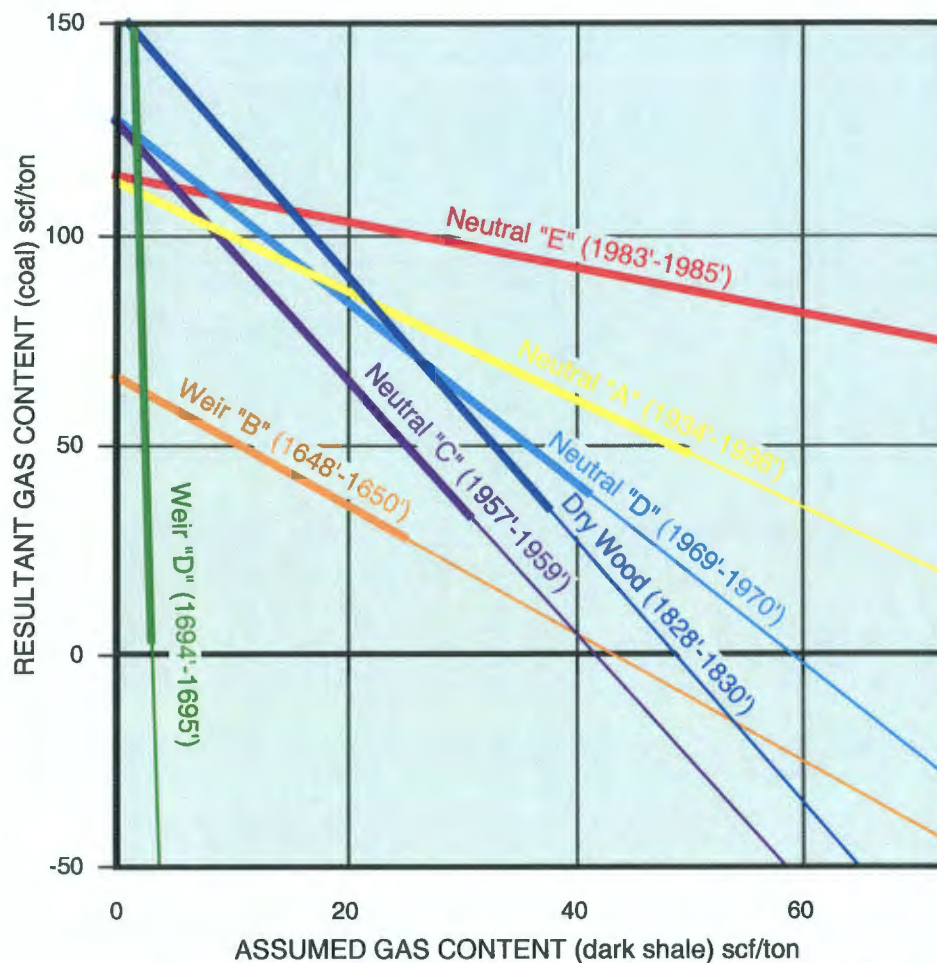


FIGURE 15.

# Desorption Characteristics of Cuttings Samples

based on total weight of gas-generating lithologies (i.e., coal and dark shale) in sample  
 Evergreen Liggatt #42-35;  
 35-T.5S.-R.16E.; Jackson County, KS

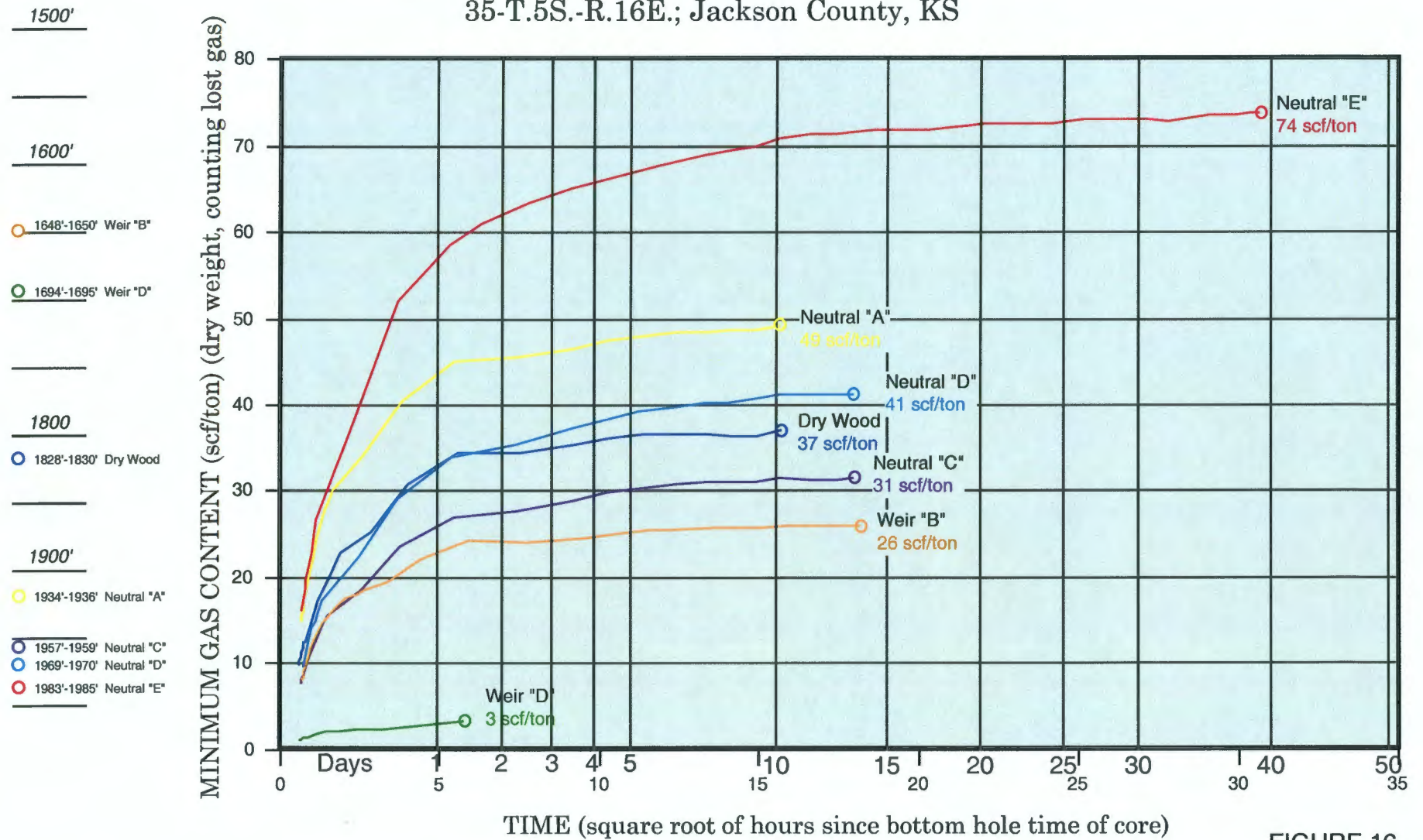


FIGURE 16.