ANALYSIS OF KANSAS CITY, MARMATON, AND CHEROKEE GROUP CUTTINGS SAMPLES FOR GAS CONTENT
-- PETROL OIL & GAS #24-1 RAHMEIER; S2 NW NW SW sec. 24-T.20S.-R.16E., COFFEY COUNTY, KANSAS

By
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SUMMARY

Seven cuttings samples from the Pennsylvanian Kansas City, Marmaton, and Cherokee Groups were collected from the Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-T.20S.-R.16E., in Coffey Co., KS. The samples calculate as having the following gas contents:

- Stark Shale at 804.0' to 807.5' depth (20 scf/ton)
- Hushpuckney Shale at 835.0' to 838.0' depth (20 scf/ton)
- Anna Shale at 1101.0' to 1102.5' depth (11 scf/ton)
- Little Osage Shale at 1158.0' to 1161.0' depth (5 scf/ton)
- Mulky coal at 1182.0' to 1184.0' depth (28 scf/ton)
- Bevier coal at 1250.0' to 1252.0' depth (24 scf/ton)
- Croweburg coal at 1262.0' to 1264.0' depth (16 scf/ton)

Attempts at obtaining cores of the Tebo coal at 1344' depth and the Riverton coal at 1521' depth were not successful because the coal was apparently milled to fine-grained material and washed from the core barrel during the coring process, thus no samples of these coals were recovered. Sampling of Tebo coal was attempted when the hole was being reamed after the coring, but no adequate amount of coal was obtained:

- Tebo coal at 1344.0' to 1345.5' depth (-- scf/ton)

Fragments of carbonaceous underclay and coal were obtained from the Riverton core, but no significant amount of gas was desorbed from this material:

- Riverton coal fragments/underclay at 1521.0 to 1522.5' depth (9 scf/ton)

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

2no results due to negligible amount of coal in sample

BACKGROUND

The Petrol Oil & Gas #24-1 Rahmeier well, S2 NW NW SW, 24-20S-16E in Coffey Co., 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 18, 19, and 20, 2004, by K.D. Newell and W.M. Brown of the Kansas Geological Survey. Cuttings samples were obtained during normal drilling of the well, with brief cessation of drilling before zones of interest (i.e., coals and dark shales in the Pennsylvanian Kansas City, Marmaton, and Cherokee Groups) were penetrated. The well was drilled using a mud rotary rig ("Rig #9") owned by Coconut Drilling.

Lag times for samples to reach the surface (important for assessing lost gas) were determined by periodic carbide tests.

Eight cuttings samples were collected:

- Stark Shale at 804.0' to 807.5' depth (101 grams dry wt.)
- Hushpuckney Shale at 835.0' to 838.0' depth (205 grams dry wt.)
• Anna Shale at 1101.0' to 1102.5' depth (432 grams dry wt.)
• Little Osage Shale at 1158.0' to 1161.0' depth (1275 grams dry wt.)
• Mulky coal at 1182.0' to 1184.0' depth (319 grams dry wt.)
• Bevier coal at 1250.0' to 1252.0' depth (335 grams dry wt.)
• Croweburg coal at 1262.0' to 1264.0' depth (678 grams dry wt.)
• Tebo coal at 1344.0' to 1345.5' depth (797 grams dry wt.)

One core-fragment sample from the was also collected:
• Riverton coal fragments/underclay at 1521.0' to 1522.5' depth (493 grams dry wt.)

The cuttings were placed in kitchen strainers after they were shoveled from a settling box in the mud stream situated immediately before the mud emptied into the mud pit. After catching the cuttings samples, the samples were then washed in water while in the kitchen strainers to rid them of as much drilling mud as possible. The cuttings were then placed in desorption canisters.

The Tebo coal cuttings sample was also obtained from this settling box, but its sampling took place during the reaming of the hole after coring. The coring for this coal was unsuccessful because the coal was likely milled into fine-grained material that washed out of the core barrel during coring. Similarly, most of the Riverton coal was also likely milled and lost during coring. Some small core chunks of coaly material were placed in a canister in an attempt to salvage some information about the Riverton interval, but upon examination after decanistering, much of this material was considered underclay.

Five cuttings samples (Stark Shale, Hushpuckney Shale, Anna Shale, Mulky coal, Bevier coal) were placed in "Stoeckinger" desorption canisters, which average 38 cubic inches internal volume (620 cm$^3$). The Little Osage Shale sample was placed in a canister having 106 cubic inches internal volume (1740 cm$^3$) (i.e., "Brady" canister). The Croweburg and Tebo samples were placed in canisters having 182 cubic inches internal volume (2985 cm$^3$) (i.e., "Maggy" canisters). The Riverton coal sample was placed in a canister having 153 cubic inches internal volume (2985 cm$^3$). With this latter sample, a concrete plug was also placed in the desorption canister to decrease the volume of free space within the canister. The volume of this plug was 77 cubic inches (1262 cm$^3$).

The"Stoeckinger" desorption canisters were obtained from Bill Stoeckinger, consulting geologist to Petrol Oil and Gas. The "Maggy" and "Brady" canisters were made in-house at the Kansas Geological Survey. The canister used for the Riverton sample was obtained from SSD, Inc., in Grand Junction, CO.

Temperature baths for the desorption canisters were on site, with temperature kept at approximately 75 °F for the Croweburg and shallower samples. The Tebo and Riverton samples were placed in an 80 °F temperature bath. The canistered samples were transported to the laboratory at the Kansas Geological Survey in Lawrence, KS, on January 20, 2004, and desorption measurements were continued at approximately 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.

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

The time and atmospheric pressure were measured in the field using a portable weather station (model BA928) marketed by Oregon Scientific (Tualatin, OR). The atmospheric pressure was displayed in millibars on this instrument, however, this measurement was not the actual barometric pressure, but rather an altitude-compensated barometric pressure automatically converted to a sea-level-equivalent pressure. To translate this measurement to actual atmospheric pressure, a regression correlation was determined over several weeks by comparing readings from the Oregon Scientific instrument to that from a pressure transducer in the Petrophysics Laboratory in the Kansas Geological Survey in Lawrence, KS (Figure 1). The regression equation shown graphically in Figure 1 was entered into a spreadsheet and was used to automatically convert the millibar measurement to barometric pressure in pounds per square inch (psi).

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

\[ n = \frac{PV}{RT} \]

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 ($^\circ R = 460 + ^\circ F$). $P_{rig}$, $V_{rig}$, 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:

$$V_{stp} = \frac{T_{stp}}{T_{rig}} \left( \frac{P_{rig}}{P_{stp}} \right) V_{rig}$$

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 (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 dried in air for several 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 run 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 cuttings 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 2-10)
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 for cuttings are presented in the lost-gas graphs for only up
to one hour after cuttings were off bottom. Lost-gas for the Riverton coal
fragments/underclay was posted for a 9-hour period after the core was pulled off bottom.
The lost-gas volumes derived from these graphs are incorporated in the data tables
described above.

“Lithologic Component Sensitivity Analyses” (Figures 11-18)
Collection of pure lithologies from relatively thin-bedded strata is rather difficult using
cuttings. 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 vice 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 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 wells in southeastern Kansas. 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 displaying 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, the assumed 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 Cuttings Samples (Figure 19)**

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., \text{gas content}_{\text{coal}}) for that sample. If the coal content is miniscule (i.e., < approximately 5%), the results are a better reflection of the \text{gas content}_{\text{dark shale}}.
Desorption Graph (Figure 20)
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.

ASHING and DENSITY EXPERIMENTS

Simple ashing of the samples was carried out in a muffle furnace at the Kansas Geological Survey in which the samples were first weighed and then subjected to 110 °C until their weight stabilized. This first firing approximates moisture content. A second firing at 750 °C for three to four days essentially ashed the sample. Two crucibles of sample were utilized for both the 110 °C and 750 °C firings. Each crucible was filled with approximately 1.5 grams of pulverized coal (i.e., < 0.0460" sieve size). Results were accepted if the difference in weight loss for each sample was less than 2%.

<table>
<thead>
<tr>
<th>unit</th>
<th>depth</th>
<th>moisture</th>
<th>ash</th>
<th>moisture-free ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stark Shale</td>
<td>804'</td>
<td>1.17%</td>
<td>77.75%</td>
<td>78.66%</td>
</tr>
<tr>
<td>Hushpuckney Shale</td>
<td>835'</td>
<td>0.72%</td>
<td>73.93%</td>
<td>74.46%</td>
</tr>
<tr>
<td>Anna Shale</td>
<td>1101'</td>
<td>3.42%</td>
<td>70.22%</td>
<td>72.70%</td>
</tr>
<tr>
<td>Little Osage Shale</td>
<td>1158'</td>
<td>0.93%</td>
<td>72.51%</td>
<td>73.19%</td>
</tr>
<tr>
<td>Excello Shale</td>
<td>1182'</td>
<td>1.82%</td>
<td>66.94%</td>
<td>68.18%</td>
</tr>
<tr>
<td>Mulky coal</td>
<td>1182'</td>
<td>0.78%</td>
<td>7.84%</td>
<td>7.90%</td>
</tr>
<tr>
<td>Bevier coal</td>
<td>1250'</td>
<td>0.79%</td>
<td>9.77%</td>
<td>9.84%</td>
</tr>
<tr>
<td>Croweburg coal</td>
<td>1162'</td>
<td>0.72%</td>
<td>7.83%</td>
<td>7.89%</td>
</tr>
<tr>
<td>Riverton underclay</td>
<td>1521'</td>
<td>1.17%</td>
<td>14.40%</td>
<td>14.57%</td>
</tr>
</tbody>
</table>

Using the equation from McLennan and others (1995):

\[ G_c = G_{pc} (1-a_d) \]

where:
- \( G_c \) = gas content, scf/ton
- \( G_{pc} \) = "pure coal", gas content, scf/ton
- \( a_d \) = dry ash content, weight fraction

the gas content of the samples converts to:

<table>
<thead>
<tr>
<th>unit</th>
<th>depth</th>
<th>moisture-free ash</th>
<th>( G_c )</th>
<th>( G_{pc} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stark Shale</td>
<td>804'</td>
<td>78.66%</td>
<td>20.1 scf/ton</td>
<td>94.2 scf/ton</td>
</tr>
<tr>
<td>Hushpuckney Shale</td>
<td>835'</td>
<td>74.46%</td>
<td>20.4 scf/ton</td>
<td>79.9 scf/ton</td>
</tr>
<tr>
<td>Anna Shale</td>
<td>1101'</td>
<td>72.70%</td>
<td>10.8 scf/ton</td>
<td>39.6 scf/ton</td>
</tr>
<tr>
<td>Little Osage Shale</td>
<td>1158'</td>
<td>73.19%</td>
<td>4.6 scf/ton</td>
<td>17.2 scf/ton</td>
</tr>
<tr>
<td>Excello Shale</td>
<td>1182'</td>
<td>68.18%</td>
<td>3 (?) scf/ton</td>
<td>9.4 (?) scf/ton</td>
</tr>
<tr>
<td>Mulky coal</td>
<td>1182'</td>
<td>7.90%</td>
<td>27.6 scf/ton</td>
<td>30.0 scf/ton</td>
</tr>
</tbody>
</table>
Coal samples were also tested for their density. Cuttings samples (4 to 5 grams) were weighed and then placed in water in a 10-cc graduated cylinder to determine the volume of the sample. The Riverton coal/underclay samples were weighed and immersed in water in a beaker filled to its brim. The displaced water was spilled from the beaker and subsequently weighed. The volume of the sample is thus easily converted to volume using 1 gram/cc for the density of the water. The following density measurements were calculated:

<table>
<thead>
<tr>
<th>unit</th>
<th>depth</th>
<th>density and uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stark Shale</td>
<td>804'</td>
<td>2.08 g/cc ± 0.07</td>
</tr>
<tr>
<td>Hushpuckney Shale</td>
<td>835'</td>
<td>2.11 g/cc ± 0.07</td>
</tr>
<tr>
<td>Anna Shale</td>
<td>1101'</td>
<td>2.11 g/cc ± 0.07</td>
</tr>
<tr>
<td>Little Osage Shale</td>
<td>1158'</td>
<td>2.12 g/cc ± 0.07</td>
</tr>
<tr>
<td>Excello Shale</td>
<td>1182'</td>
<td>2.01 g/cc ± 0.07</td>
</tr>
<tr>
<td>Mulky coal</td>
<td>1182'</td>
<td>1.68 g/cc ± 0.07</td>
</tr>
<tr>
<td>Bevier coal</td>
<td>1250'</td>
<td>1.29 g/cc ± 0.07</td>
</tr>
<tr>
<td>Croweburg coal</td>
<td>1162'</td>
<td>1.31 g/cc ± 0.07</td>
</tr>
<tr>
<td>Riverton underclay</td>
<td>1521'</td>
<td>1.69 g/cc ± 0.05</td>
</tr>
</tbody>
</table>

RESULTS and DISCUSSION

According to the summary diagram for the sensitivity analyses (Figure 19), the Mulky, Bevier, and Croweburg coals all have nearly identically constrained (in which the resultant coal gas content varies almost identically with shale gas content). The rest of the samples are shales, and thus there is no variation the gas content of coal vs. shale in these samples.

Estimates for gas content for the three coal samples, assuming the admixed dark shale in the samples desorb 3 scf/ton, are presented on their sensitivity diagrams. Air rigs typically produce cuttings samples having only about 10% coal, or less, but more coal in the sample (60% - 75%) is obtainable with a mud rig.

The Riverton sample registered a poor gas content due to its poor sample quality. True Riverton coal was not recovered from the core, thus this zone was not adequately tested for its gas content.

REFERENCES


FIGURES and TABLES

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

TABLE 1. Desorption measurements for samples.

FIGURE 2. Lost-gas graph for Stark Shale at 804.0' to 807.5' depth.
FIGURE 3. Lost-gas graph for Hushpuckney Shale at 835.0' to 838.0' depth.
FIGURE 4. Lost-gas graph for Anna Shale at 1101.0' to 1102.5' depth.
FIGURE 5. Lost-gas graph for Little Osage Shale at 1158.0' to 1161.0' depth.
FIGURE 6. Lost-gas graph for Mulky coal at 1182.0' to 1184.0' depth.
FIGURE 7. Lost-gas graph for Bevier coal at 1250.0' to 1252.0' depth.
FIGURE 8. Lost-gas graph for Croweburg coal at 1262.0' to 1264.0' depth.
FIGURE 9. Lost-gas graph for Tebo coal at 1344.0' to 1345.5' depth.
FIGURE 10. Lost-gas graph for Riverton coal fragments/underclay at 1521.0 to 1522.5' depth.

FIGURE 11. Sensitivity analysis for Stark Shale at 804.0' to 807.5' depth.
FIGURE 12. Sensitivity analysis for Hushpuckney Shale at 835.0' to 838.0' depth.
FIGURE 13. Sensitivity analysis for Anna Shale at 1101.0' to 1102.5' depth.
FIGURE 14. Sensitivity analysis for Little Osage Shale at 1158.0' to 1161.0' depth.
FIGURE 15. Sensitivity analysis for Mulky coal at 1182.0' to 1184.0' depth.
FIGURE 16. Sensitivity analysis for Bevier coal at 1250.0' to 1252.0' depth.
FIGURE 17. Sensitivity analysis for Croweburg coal at 1262.0' to 1264.0' depth.
FIGURE 18. Sensitivity analysis for Tebo coal at 1344.0' to 1345.5' depth.

FIGURE 19. Lithologic component sensitivity analyses for all samples.

FIGURE 20. Desorption graph for all samples.
Correlation of Field Barometer to KGS Petrophysics Lab Barometer

FIGURE 1.
<table>
<thead>
<tr>
<th>TIME OF</th>
<th>off bottom</th>
<th>at surface</th>
<th>in canister</th>
<th>elapsed time (off bottom to cementing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/18/04 12:59</td>
<td>0.43789252</td>
<td>0.40824902</td>
<td>0.40292498</td>
<td>10.12 hours</td>
</tr>
<tr>
<td>1/18/04 12:44</td>
<td>0.00147573</td>
<td>0.00136775</td>
<td>0.00133496</td>
<td>9.32 hours</td>
</tr>
<tr>
<td>1/18/04 12:39</td>
<td>0.00139705</td>
<td>0.00127149</td>
<td>0.00124080</td>
<td>9.27 hours</td>
</tr>
<tr>
<td>1/18/04 12:34</td>
<td>0.00136572</td>
<td>0.00123596</td>
<td>0.00120398</td>
<td>9.22 hours</td>
</tr>
<tr>
<td>1/18/04 12:29</td>
<td>0.00133579</td>
<td>0.00119724</td>
<td>0.00115775</td>
<td>9.18 hours</td>
</tr>
<tr>
<td>1/18/04 12:24</td>
<td>0.00130710</td>
<td>0.00115974</td>
<td>0.00111846</td>
<td>9.14 hours</td>
</tr>
<tr>
<td>1/18/04 12:19</td>
<td>0.00127849</td>
<td>0.00112812</td>
<td>0.00108574</td>
<td>9.10 hours</td>
</tr>
<tr>
<td>1/18/04 12:14</td>
<td>0.00124841</td>
<td>0.00109574</td>
<td>0.00105259</td>
<td>9.06 hours</td>
</tr>
<tr>
<td>1/18/04 12:09</td>
<td>0.00121740</td>
<td>0.00106197</td>
<td>0.00101697</td>
<td>9.02 hours</td>
</tr>
<tr>
<td>1/18/04 12:04</td>
<td>0.00118363</td>
<td>0.00103860</td>
<td>0.00099148</td>
<td>8.98 hours</td>
</tr>
<tr>
<td>1/18/04 11:59</td>
<td>0.00114760</td>
<td>0.00097944</td>
<td>0.00093708</td>
<td>8.94 hours</td>
</tr>
<tr>
<td>1/18/04 11:54</td>
<td>0.00110952</td>
<td>0.00093018</td>
<td>0.00088478</td>
<td>8.90 hours</td>
</tr>
<tr>
<td>1/18/04 11:49</td>
<td>0.00106744</td>
<td>0.00077635</td>
<td>0.00072656</td>
<td>8.86 hours</td>
</tr>
<tr>
<td>1/18/04 11:44</td>
<td>0.00102203</td>
<td>0.00063768</td>
<td>0.00058747</td>
<td>8.82 hours</td>
</tr>
<tr>
<td>1/18/04 11:39</td>
<td>0.00097232</td>
<td>0.00049798</td>
<td>0.00044734</td>
<td>8.78 hours</td>
</tr>
<tr>
<td>1/18/04 11:34</td>
<td>0.00092034</td>
<td>0.00035650</td>
<td>0.00030595</td>
<td>8.74 hours</td>
</tr>
<tr>
<td>1/18/04 11:29</td>
<td>0.00086462</td>
<td>0.00021395</td>
<td>0.00016333</td>
<td>8.70 hours</td>
</tr>
<tr>
<td>1/18/04 11:24</td>
<td>0.00080697</td>
<td>0.00006934</td>
<td>0.00001872</td>
<td>8.66 hours</td>
</tr>
<tr>
<td>1/18/04 11:19</td>
<td>0.00074592</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.62 hours</td>
</tr>
<tr>
<td>1/18/04 11:14</td>
<td>0.00068286</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.58 hours</td>
</tr>
<tr>
<td>1/18/04 11:09</td>
<td>0.00062098</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.54 hours</td>
</tr>
<tr>
<td>1/18/04 11:04</td>
<td>0.00055911</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.50 hours</td>
</tr>
<tr>
<td>1/18/04 11:00</td>
<td>0.00049853</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.46 hours</td>
</tr>
<tr>
<td>1/18/04 10:55</td>
<td>0.00043813</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.42 hours</td>
</tr>
<tr>
<td>1/18/04 10:50</td>
<td>0.00037800</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.38 hours</td>
</tr>
<tr>
<td>1/18/04 10:45</td>
<td>0.00031792</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.34 hours</td>
</tr>
<tr>
<td>1/18/04 10:40</td>
<td>0.00025784</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.30 hours</td>
</tr>
<tr>
<td>1/18/04 10:35</td>
<td>0.00019776</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.26 hours</td>
</tr>
<tr>
<td>1/18/04 10:30</td>
<td>0.00013768</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.22 hours</td>
</tr>
<tr>
<td>1/18/04 10:25</td>
<td>0.00007760</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.18 hours</td>
</tr>
<tr>
<td>1/18/04 10:20</td>
<td>0.00001752</td>
<td>0.00001633</td>
<td>0.00000000</td>
<td>8.14 hours</td>
</tr>
</tbody>
</table>

**Notes:**
- The table provides conversion measurements for Diesel Oil & Gas 820-1 Rheemr, 52 NN NW SW 24-205-10E, Coffey City, KS.
- The data includes measurements of in-canister dry salt, elapsed time (off bottom to cementing), and cementing data.
- The table also contains conversion of diesel oil and gas measurements to STP (100 deg F).
<table>
<thead>
<tr>
<th>Date</th>
<th>Temp (°C)</th>
<th>Lat (°N)</th>
<th>Lon (°W)</th>
<th>Sample Weight (g)</th>
<th>Lost Gas (cc)</th>
<th>Cumulative Volume (STP ft³)</th>
<th>Conversion to STP</th>
<th>Time (hrs)</th>
<th>Elapsed Time (off bottom to canistering)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/19/04</td>
<td>12.3</td>
<td>37.05</td>
<td>118.21</td>
<td>0.126</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>11/18/04</td>
<td>14.7</td>
<td>37.05</td>
<td>118.21</td>
<td>0.126</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>11/19/04</td>
<td>15.0</td>
<td>37.05</td>
<td>118.21</td>
<td>0.126</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>11/20/04</td>
<td>15.3</td>
<td>37.05</td>
<td>118.21</td>
<td>0.126</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>11/21/04</td>
<td>15.6</td>
<td>37.05</td>
<td>118.21</td>
<td>0.126</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>11/22/04</td>
<td>15.9</td>
<td>37.05</td>
<td>118.21</td>
<td>0.126</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Conversion of Rig Lab Measurements to STP:**

- **Cumulative Volume (STP ft³):**
  - 10/19/04: 0.00
  - 11/18/04: 0.00
  - 11/19/04: 0.00
  - 11/20/04: 0.00
  - 11/21/04: 0.00
  - 11/22/04: 0.00

- **Time since off bottom:**
  - 10/19/04: 1.00
  - 11/18/04: 1.00
  - 11/19/04: 1.00
  - 11/20/04: 1.00
  - 11/21/04: 1.00
  - 11/22/04: 1.00

- **Elapsed time (off bottom to canistering):**
  - 10/19/04: 0.00
  - 11/18/04: 0.00
  - 11/19/04: 0.00
  - 11/20/04: 0.00
  - 11/21/04: 0.00
  - 11/22/04: 0.00
<table>
<thead>
<tr>
<th>Sample</th>
<th>Date</th>
<th>Time</th>
<th>Temperature</th>
<th>Pressure</th>
<th>Humidity</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>08/12</td>
<td>14:30</td>
<td>25°C</td>
<td>760 mmHg</td>
<td>50%</td>
<td>10.2 g</td>
</tr>
</tbody>
</table>

### Dry Sample Weight

- **Sample:** E1
- **Date:** 08/12
- **Time:** 14:30
- **Temperature:** 25°C
- **Pressure:** 760 mmHg
- **Humidity:** 50%
- **Weight:** 10.2 g
<table>
<thead>
<tr>
<th>Temperature</th>
<th>Relative Humidity</th>
<th>Relative Humidity Difference</th>
<th>Sample Weight</th>
<th>Date</th>
<th>Time</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Difference</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>80</td>
<td>0.0006</td>
<td>67.80</td>
<td>4.8g</td>
<td>8/3</td>
<td>1/27/04</td>
<td>10:01</td>
<td>154.57</td>
<td>163.31</td>
<td>152.17</td>
</tr>
<tr>
<td>-28</td>
<td>62</td>
<td>-0.001</td>
<td>61.15</td>
<td>2.72</td>
<td>8/3</td>
<td>2/2/04</td>
<td>10:55</td>
<td>314.51</td>
<td>313.25</td>
<td>312.00</td>
</tr>
<tr>
<td>-40</td>
<td>44</td>
<td>-0.0014</td>
<td>53.03</td>
<td>0.33</td>
<td>8/3</td>
<td>2/9/04</td>
<td>10:47</td>
<td>477.42</td>
<td>476.17</td>
<td>475.00</td>
</tr>
</tbody>
</table>

DECANISTREID 2/10/2004, sample dried for 11 days in air
804.0'-807.5' (Stark Shale) cuttings in canister Stoeckinger 6
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

![Graph showing desorption of gas over time](image)

- Elapsed time (off-bottom to canister) = 0.408
  - $\sqrt{0.167}$ hrs.
  - 10.0 min.

- 11cc estimated lost gas

**FIGURE 2.**

square root of hours since cuttings were off-bottom
835.0'-838.0' (Hushpuckney Shale) cuttings in canister Stoeckinger 7
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

elapsed time (off-bottom to canister)
= 0.438
= SQRT(0.192 hrs.)
= 11.5 min.

delay in gas desorption due to sample being subjected to outside temperatures of 10 °F?

42cc(?) estimated lost gas

square root of hours since cuttings were off-bottom

FIGURE 3.
1101.0'-1102.5' (Anna Shale) cuttings in canister Stoeckinger 4
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

elapsed time (off-bottom to canister)
= 0.658
= SQRT(0.433 hrs.)
= 26.0 min.

delay in gas desorption due to sample being subjected to outside temperatures of 10 F?

9cc(?) estimated lost gas

square root of hours since cuttings were off-bottom

FIGURE 4.
1158.0'-1161.0' (Little Osage Shale) cuttings in canister Brady 27
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

Elapsed time (off-bottom to canister) = 0.772
= SQRT(0.590 hrs.) = 35.8 min.

39cc estimated lost gas

FIGURE 5.
1182.0'-1184.0' (Mulky coal) cuttings in canister Stoeckinger 1
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

Elapsed time (off-bottom to canister)
= 0.548
= SQRT(0.300 hrs.)
= 18.0 min.

40cc estimated lost gas

FIGURE 6.
1250.0'-1152.0' (Bevier coal) cuttings in canister Stoeckinger 5
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

![Graph](image)

**FIGURE 7.**

- Elapsed time (off-bottom to canister) = 0.612
- = $\sqrt{0.375 \text{ hrs.}}$
- = 225 min.

- 38 cc estimated lost gas
1262.0'-1164.0' (Croweburg coal) cuttings in canister Maggy 3
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

Elapsed time (off-bottom to canister)
= 0.674
= SQRT(0.454 hrs.)
= 27.2 min.

58cc estimated lost gas

FIGURE 8.
1344.0'-1345.5' (Tebo coal) cuttings in canister Maggy 4
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

elapsed time (off-bottom to canister)
= 0.791
= SQRT(0.625 hrs.)
= 37.5 min.

24cc estimated lost gas

square root of hours since cuttings were off-bottom

FIGURE 9.
1521.0'-1522.5' (Riverton coal underclay) core chips in canister I
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

Elapsed time (off-bottom to canister)
= 1.63
= SQRT(2.667 hrs.)
= 160.0 min.

56cc estimated lost gas

Square root of hours since cuttings were off-bottom

FIGURE 10.
Desorption Characteristics of Cuttings Samples
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Stark Shale from 804.0'-807.5'

GAS CONTENT \(_{\text{coal}}\) =
\[
\text{total gas desorbed} - \left( (\text{gas content}_{\text{dark shale}}) \times (\text{weight}_{\text{dark shale}}) \right) / \text{weight}_{\text{coal}}
\]

\[
\begin{align*}
\text{total gas desorbed} &= 56.2 \text{ ccs} \\
\text{TOTAL DRY WEIGHT OF SAMPLE} &= 101.55 \text{ grams} \\
\text{weight}_{\text{light-colored lithologies}} &= 12.06 \text{ grams (12.1\%)} \\
\text{weight}_{\text{dark shale}} &= 89.49 \text{ grams (88.1\%)} \\
\text{weight}_{\text{coal}} &= 0.00 \text{ grams (0.0\%)}
\end{align*}
\]

\[
\begin{array}{c|c|c|c}
\text{sieve size} & \text{grams} & \% \text{ coal} / \% \text{ dark shale} / \% \text{ light-colored liths} \\
\hline
>0.0930" & 28.83 & 0.00\% / 93.00\% / 7.00\% \\
>0.0661" & 30.79 & 0.00\% / 88.87\% / 11.13\% \\
>0.0460" & 23.46 & 0.00\% / 86.20\% / 13.80\% \\
>0.0331" & 10.74 & 0.00\% / 82.86\% / 17.14\% \\
<0.0331" & 7.57 & 0.00\% / 80.00\% / 20.00\%
\end{array}
\]

101.55 TOTAL

20.1 scf/ton

FIGURE 11.
Desorption Characteristics of Cuttings Samples
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Hushpuckney Shale from 835.0'-838.0'

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

\text{total gas desorbed} = 205.3 \text{ ccs}

\text{TOTAL DRY WEIGHT OF SAMPLE} = 517.77 \text{ grams}

\text{weight}_{\text{light-colored lithologies}} = 193.67 \text{ grams (37.4%)}
\text{weight}_{\text{dark shale}} = 324.10 \text{ grams (62.6%)}
\text{weight}_{\text{coal}} = 0.00 \text{ grams (0.0%)}

\begin{array}{c|c|c|c|c|c}
\text{sieve size} & \text{grams} & \% \text{coal} & \% \text{dark shale} & \% \text{light-colored liths} \\
\hline
>0.0930*' & 37.12 & 0.00\% & 91.31\% & 8.69\% \\
>0.0661*' & 55.05 & 0.00\% & 78.35\% & 21.65\% \\
>0.0460*' & 91.16 & 0.00\% & 70.97\% & 29.03\% \\
>0.0331*' & 114.07 & 0.00\% & 64.45\% & 35.55\% \\
<0.0331*' & 220.37 & 0.00\% & 49.40\% & 50.60\%
\end{array}

\text{517.77 TOTAL}

\text{FIGURE 12.}
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Anna Shale from 1101.5'-1102.5'

GAS CONTENT_{coal} =
\[
\frac{\text{total gas desorbed} - ((\text{gas content}_{dark\ shale}) \times (\text{weight}_{dark\ shale}))}{\text{weight}_{coal}}
\]

total gas desorbed = 19.2 ccs

TOTAL DRY WEIGHT OF SAMPLE = 432.29 grams

\begin{align*}
\text{weight}_{light-colored\ lithologies} &= 375.16\ \text{grams (86.8\%)} \\
\text{weight}_{dark\ shale} &= 57.13\ \text{grams (13.2\%)} \\
\text{weight}_{coal} &= 0.00\ \text{grams (0.0\%)}
\end{align*}

\begin{table}
\begin{tabular}{|c|c|c|c|c|}
\hline
\text{sieve size} & \text{grams} & \%\ coal & \%\ dark\ shale & \%\ light-colored\ liths \\
\hline
>0.0930'' & 38.22 & 0.00\% & 10.73\% & 89.27\% \\
>0.0661'' & 50.40 & 0.00\% & 13.34\% & 86.66\% \\
>0.0460'' & 70.12 & 0.00\% & 15.33\% & 84.67\% \\
>0.0331'' & 76.29 & 0.00\% & 13.60\% & 86.40\% \\
<0.0331'' & 197.27 & 0.00\% & 12.77\% & 87.23\% \\
\hline
\text{432.29 TOTAL} & & & & \\
\hline
\end{tabular}
\end{table}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure13.jpg}
\caption{ASSUMED GAS CONTENT (dark shale) scf/ton}
\end{figure}

FIGURE 13.
LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Little Osage Shale from 1158.0'-1161.0'

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

\[
\text{total gas desorbed} = 105.6 \text{ ccs}
\]

TOTAL DRY WEIGHT OF SAMPLE = 1275.48 grams

- weight\text{light-colored lithologies} = 538.39 grams (42.2%)
- weight\text{dark shale} = 737.09 grams (57.8%)
- weight\text{coal} = 0.00 grams (0.0%)

<table>
<thead>
<tr>
<th>sieve size</th>
<th>grams</th>
<th>% coal</th>
<th>% dark shale</th>
<th>% light-colored liths</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.0930&quot;</td>
<td>99.26</td>
<td>0.00%</td>
<td>81.07%</td>
<td>18.33%</td>
</tr>
<tr>
<td>&gt;0.0661&quot;</td>
<td>130.13</td>
<td>0.00%</td>
<td>71.25%</td>
<td>28.75%</td>
</tr>
<tr>
<td>&gt;0.0480&quot;</td>
<td>217.99</td>
<td>0.00%</td>
<td>67.11%</td>
<td>32.89%</td>
</tr>
<tr>
<td>&gt;0.0331&quot;</td>
<td>273.24</td>
<td>0.00%</td>
<td>58.33%</td>
<td>41.67%</td>
</tr>
<tr>
<td>&lt;0.0331&quot;</td>
<td>554.87</td>
<td>0.00%</td>
<td>46.43%</td>
<td>53.57%</td>
</tr>
</tbody>
</table>

1275.48 TOTAL

\[
\text{RESULTANT GAS CONTENT (coal)} \text{ scf/ton}
\]

\[
\text{ASSUMED GAS CONTENT (dark shale)} \text{ scf/ton}
\]

4.6 scf/ton

FIGURE 14.
Desorption Characteristics of Cuttings Samples
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Mulky coal from 1182.0'-1184.0'

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

\[
\text{total gas desorbed} = 207.7 \text{ ccs}
\]

TOTAL DRY WEIGHT OF SAMPLE = 319.09 grams

weight_{\text{light-colored lithologies}} = 18.38 grams (5.8%)
weight_{\text{dark shale}} = 66.85 grams (21.0%)
weight_{\text{coal}} = 233.86 grams (73.3%)

<table>
<thead>
<tr>
<th>sieve size</th>
<th>grams</th>
<th>% coal / % dark shale / % light-colored litihes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.0930*</td>
<td>93.68</td>
<td>86.59% / 12.22% / 1.19%</td>
</tr>
<tr>
<td>&gt;0.0661*</td>
<td>59.27</td>
<td>83.65% / 12.60% / 3.75%</td>
</tr>
<tr>
<td>&gt;0.0460*</td>
<td>61.50</td>
<td>79.77% / 14.89% / 5.34%</td>
</tr>
<tr>
<td>&gt;0.0331*</td>
<td>45.05</td>
<td>67.20% / 24.34% / 8.47%</td>
</tr>
<tr>
<td>&lt;0.0331*</td>
<td>59.59</td>
<td>40.00% / 46.67% / 13.33%</td>
</tr>
</tbody>
</table>

**319.09 TOTAL**

\[
\begin{align*}
\text{Equation solutions} \\
\text{dark shale} & \quad \text{coal} \\
0 & \quad 28.5 \ (\text{scf/ton}) \\
1 & \quad 28.2 \ (\text{scf/ton}) \\
3 & \quad 27.6 \ (\text{scf/ton}) \\
5 & \quad 27.1 \ (\text{scf/ton}) \\
10 & \quad 25.6 \ (\text{scf/ton}) \\
15 & \quad 24.2 \ (\text{scf/ton}) \\
20 & \quad 22.7 \ (\text{scf/ton}) \\
22.1 & \quad 22.1 \ (\text{scf/ton}) \\
\end{align*}
\]

**FIGURE 15.**
Desorption Characteristics of Cuttings Samples
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Bevier coal from 1250.0'-1252.0'

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

total gas desorbed = 182.5 ccs

TOTAL DRY WEIGHT OF SAMPLE = 334.95 grams

weight_{light-colored lithologies} = 30.91 grams (9.2%)
weight_{dark shale} = 66.57 grams (19.9%)
weight_{coal} = 237.47 grams (70.9%)

<table>
<thead>
<tr>
<th>sieve size</th>
<th>grams</th>
<th>% coal / % dark shale / % light-colored liths</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.0930&quot;</td>
<td>46.70</td>
<td>89.58% / 6.60% / 3.82%</td>
</tr>
<tr>
<td>&gt;0.0661&quot;</td>
<td>64.29</td>
<td>83.00% / 12.09% / 4.91%</td>
</tr>
<tr>
<td>&gt;0.0460&quot;</td>
<td>81.41</td>
<td>77.01% / 16.05% / 6.94%</td>
</tr>
<tr>
<td>&gt;0.0331&quot;</td>
<td>63.58</td>
<td>63.06% / 25.68% / 11.26%</td>
</tr>
<tr>
<td>&lt;0.0331&quot;</td>
<td>78.96</td>
<td>50.00% / 33.33% / 16.67%</td>
</tr>
</tbody>
</table>

334.95 TOTAL

0.0930" 0.0661" 0.0460" 0.0331"

FIGURE 16.
Desorption Characteristics of Cuttings Samples
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Croweburg coal from 1262.0'-1264.0'

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

Total gas desorbed = 253.1 ccs

TOTAL DRY WEIGHT OF SAMPLE = 678.48 grams
- weight_{light-colored lithologies} = 66.17 grams (9.8%)
- weight_{dark shale} = 144.09 grams (21.1%)
- weight_{coal} = 468.22 grams (69.0%)

<table>
<thead>
<tr>
<th>sieve size</th>
<th>grams</th>
<th>% coal / % dark shale / % light-colored liths</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.0930&quot;</td>
<td>169.70</td>
<td>85.64% / 12.27% / 2.09%</td>
</tr>
<tr>
<td>&gt;0.0661&quot;</td>
<td>138.62</td>
<td>76.60% / 15.45% / 7.95%</td>
</tr>
<tr>
<td>&gt;0.0460&quot;</td>
<td>152.50</td>
<td>67.18% / 21.23% / 11.60%</td>
</tr>
<tr>
<td>&gt;0.0331&quot;</td>
<td>106.49</td>
<td>53.30% / 29.25% / 17.45%</td>
</tr>
<tr>
<td>&lt;0.0331&quot;</td>
<td>111.17</td>
<td>51.72% / 34.48% / 13.79%</td>
</tr>
</tbody>
</table>

678.48 TOTAL

FIGURE 17.
Desorption Characteristics of Cuttings Samples
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for calculation of gas content of Tebo coal from 1344.0'-1345.5'

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

\[
\text{total gas desorbed} = 38.7 \text{ ccs}
\]

TOTAL DRY WEIGHT OF SAMPLE = 797.12 grams
weight_{light-colored lithologies} = 304.18 grams (38.2%)
weight_{dark shale} = 485.33 grams (60.9%)
weight_{coal} = 7.60 grams (1.0%)

Equation solutions NO MEANINGFUL RESULTS due to negligible amount of coal in sample

FIGURE 18.
Desorption Characteristics of Cuttings Samples
Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

LITHOLOGIC COMPONENT SENSITIVITY ANALYSIS for all cuttings samples

**FIGURE 19.**
Desorption Characteristics of Cuttings Samples

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

Petrol Oil & Gas #24-1 Rahmeier, S2 NW NW SW 24-20S-16E, Coffey Co., KS

FIGURE 20.