HYDROCARBON SOURCE-ROCK ANALYSES,
AMOCO PRODUCTION COMPANY NO. 1 BAKER WELL,
QUAY COUNTY, NEW MEXICO

By GeoChem Laboratories, Inc.
and Chevron U.S.A., Inc.
Mr. Steve Jacobson  
CHEVRON, USA, INC.  
700 S. Colorado Blvd., Box 599  
Denver, CO 80201  

Dear Mr. Jacobson:

Please find enclosed the results of the geochemical screening analysis on the four (4) samples as you requested.

Your reference numbers and well name for these samples are listed below with the corresponding GeoChem job and sample numbers:

GeoChem Job No. D1123-001  P4420-5  6400'-6500'  Amoco Production Baker #1
-002  -6  7100'-7200'  29-N-3QF
-003  -7  7700'-7800'  Quay Co., NM
-004  -8  8050'-8100'

If you should have any questions concerning this analysis, please do not hesitate to call us.

Sincerely,

Randy W. Perlis  
Technical Manager

RWP:pkn
Enclosure
## RESULTS OF TOTAL ORGANIC CARBON

<table>
<thead>
<tr>
<th>GEOCHEM SAMPLE NUMBER</th>
<th>CLIENT IDENTIFICATION NUMBER</th>
<th>TOTAL ORGANIC CARBON (% of Rock)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1123-001</td>
<td>Depth 6400'-6500'</td>
<td>0.84 Abo</td>
</tr>
<tr>
<td>D1123-002</td>
<td>Depth 7100'-7200'</td>
<td>1.21 Canyon</td>
</tr>
<tr>
<td>D1123-003</td>
<td>Depth 7700'-7800'</td>
<td>1.67 Strawn</td>
</tr>
<tr>
<td>D1123-004</td>
<td>Depth 8050'-8100'</td>
<td>6.56/6.59 Strawn</td>
</tr>
</tbody>
</table>
RESULTS OF ROCK-EVAL PYROLYSIS

<table>
<thead>
<tr>
<th>GeoChem Sample No.</th>
<th>Client Identification Number</th>
<th>Tmax (°C)</th>
<th>S1 (mg/g)</th>
<th>S2 (mg/g)</th>
<th>S3 (mg/g)</th>
<th>PI</th>
<th>S2/S3</th>
<th>T.O.C. (wt. %)</th>
<th>Hydrogen Index</th>
<th>Oxygen Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1123-001</td>
<td>Depth 6400'-6500'</td>
<td>337</td>
<td>0.26</td>
<td>0.55</td>
<td>0.56</td>
<td>0.29</td>
<td>1.17</td>
<td>0.84</td>
<td>77.5</td>
<td>66.1</td>
</tr>
<tr>
<td>D1123-002</td>
<td>Depth 7100'-7200'</td>
<td>440</td>
<td>0.20</td>
<td>0.80</td>
<td>0.40</td>
<td>0.20</td>
<td>1.97</td>
<td>1.21</td>
<td>66.0</td>
<td>33.5</td>
</tr>
<tr>
<td>D1123-003</td>
<td>Depth 7700'-7800'</td>
<td>445</td>
<td>0.26</td>
<td>1.63</td>
<td>0.42</td>
<td>0.14</td>
<td>3.90</td>
<td>1.67</td>
<td>97.5</td>
<td>25.0</td>
</tr>
<tr>
<td>D1123-004</td>
<td>Depth 8050'-8100'</td>
<td>442</td>
<td>0.74</td>
<td>8.78</td>
<td>0.33</td>
<td>0.08</td>
<td>26.22</td>
<td>6.58</td>
<td>133.4</td>
<td>5.1</td>
</tr>
</tbody>
</table>
JAN 18, 1984
TIME = 1442
ID = 23001
FID ATTENUATION = 4
TCD ATTENUATION = 32

0% 50% 90%
100 350 550

332°
425°
509°

TOC = 0.84
WT = 99.4
TMAX = 332 DEGREES C
S1 = +2.632E-01 SUM = +1.302E+03
S2 = +6.511E-01 SUM = +4.704E+03
S3 = +5.555E-01 SUM = +7.391E+03
UNKNOWN
JAN 13, 1984
TIME= 1511
ID= 23002
FID ATTENUATION= 8
TCD ATTENUATION= 32

TOC = 1.21
WT = 99.4
TMAX = 440 DEGREES C
S1= +2.014E-01 SUM= +1.455E+03
S2= +7.991E-01 SUM= +5.773E+03
S3= +4.049E-01 SUM= +5.683E+03
UNKNOWN
GEOCOM ROCK EVAL II

JAN 18, 1984
TIME= 1548
ID= 23003
FID ATTENUATION= 16
TCO ATTENUATION= 32

0%  50%  90%
100  350  550

311°

44°

ROE = 1.67
NT = 99.6
TMAX = 445 DEGREES C
S1= +2.563E-01 SUM= +1.356E+03
S2= +1.628E+00 SUM= +1.119E+04
S3= +4.181E-01 SUM= +5.843E+03
UNKNOWN
GEOCOM ROCK EVAL II

JAN 18, 1984
TIME= 1608
ID= 23004
FID ATTENUATION= 128
TCD ATTENUATION= 32

TOC = 6.58
WT = 99.4
T MAX = 442 DEGREES C
S1= +7.393E-01 SUM= +5.341E+03
S2= +8.780E+00 SUM= +6.343E+04
S3= +3.349E-01 SUM= +4.889E+03
UNKNOWN
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<tr>
<th>Depth</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>Tmax</th>
<th>PI</th>
<th>S2/S3</th>
<th>TOC</th>
<th>HI</th>
<th>OI</th>
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<tr>
<td>001</td>
<td>0.26</td>
<td>0.65</td>
<td>0.56</td>
<td>332</td>
<td>0.29</td>
<td>0.17</td>
<td>0.94</td>
<td>077.5</td>
<td>066.1</td>
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<tr>
<td>002</td>
<td>0.20</td>
<td>0.80</td>
<td>0.40</td>
<td>440</td>
<td>0.20</td>
<td>0.97</td>
<td>01.21</td>
<td>066.0</td>
<td>033.5</td>
</tr>
<tr>
<td>003</td>
<td>0.26</td>
<td>0.63</td>
<td>0.42</td>
<td>445</td>
<td>0.14</td>
<td>03.90</td>
<td>01.67</td>
<td>097.5</td>
<td>025.0</td>
</tr>
<tr>
<td>004</td>
<td>0.74</td>
<td>0.73</td>
<td>0.33</td>
<td>442</td>
<td>0.08</td>
<td>26.22</td>
<td>06.58</td>
<td>133.4</td>
<td>065.1</td>
</tr>
</tbody>
</table>

**Legend**
- = NEGATIVE DATA
* = SIGNAL > A/D LIMIT
+ = DATA > COLUMN LIMIT
# = INVALID DATA/RESULTS
BIOSTRATIGRAPHIC STUDY #1303 (ADDENDUM)

LOCATION: Amoco Baker #1 (P4420)
Sec. 29, T29N, R30E
Quay County, New Mexico

PROBLEM: MOA, TAI and RoV analyses of four Pennsylvanian age well cuttings samples for J. T. Jonas.

RESULTS:

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Depth</th>
<th>MOA Kerogen Type %</th>
<th>Organic Yield</th>
<th>TAI</th>
<th>RoV</th>
<th>Age/J.T. Jonas</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4420-1</td>
<td>6300 - 400'</td>
<td>0 20 40 40</td>
<td>Trace</td>
<td>2.7</td>
<td>No plug.</td>
<td>Wolfcamp? - Penn.</td>
</tr>
<tr>
<td>2</td>
<td>6600 - 700'</td>
<td>0 15 45 40</td>
<td>Trace</td>
<td>2.7</td>
<td>No plug.</td>
<td>&quot;</td>
</tr>
<tr>
<td>3</td>
<td>7500 - 600'</td>
<td>0 20 50 30</td>
<td>Trace</td>
<td>2.8-2.9</td>
<td>No plug.</td>
<td>&quot;</td>
</tr>
<tr>
<td>4</td>
<td>7800 - 900'</td>
<td>0 20 40 40</td>
<td>Trace</td>
<td>2.7</td>
<td>No plug.</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

DISCUSSION:

MOA analysis of these samples by S. C. Teerman - COFRC (re memo to S. R. Jacobson, 3/25/85) and J. D. Saxton indicate the organic matter in these samples to be dominantly Type III vitrinitic "gas prone" kerogen. This determination is somewhat corroborated by pyrolysis results of four other samples within the same over-all well interval, in which HI values range from 66.0 to 133.4 indicating gas proneness (i.e., 0-150).

This degree of corroboration became necessary because of the presence of a great deal of amorphous Type III amorphous material which resembles Type II "oil prone" kerogen.

M. W. THOMPSON/J. D. SAXTON
S. C. TEERMAN (COFRC)

MWT: mm
MEMORANDUM
Box 446
La Habra, CA  90631
March 25, 1985

MOA ANALYSIS AMOCO BAKER #1, NM AND IDENTIFICATION OF AMORPHOUS VITRINITE

MR. S. R. JACOBSON
Chevron-Central

Dear Steve:

Much of the amorphous fraction in the four Amoco Baker #1 samples (P-4420) consists of vitrinitic organic matter (OM). However, some oil-prone amorphous OM and degraded cutinite also occur in these samples (approximately 5-20%). This observation is based on microscopic analysis of sieved transmitted light slides only. Geochemical data are necessary to confirm the microscopic classification of amorphous organic matter.

Identification of Amorphous Vitrinite

The following are some general comments and microscopic properties that can be used to help identify amorphous vitrinite:

1. Descending gradation of identifiable vitrinitic particles to amorphous-like OM. Often, amorphous vitrinitic material will display a transition between amorphous and structured OM (Plates 1 and 2). Vitrinitic particles that display amorphous edges or "coatings" are often a good clue that the amorphous OM may be humic in origin. Remnants of vegetal or woody structure (incompletely altered humic remains) in amorphous-looking particles also suggest a humic origin of the OM (Plate 2).

2. Appearance in reflected light. Amorphous vitrinite with a maturity less than about 0.8% vitrinite reflectance will generally have higher "visual reflectivity" than oil-prone amorphous OM. However, with increasing maturity, the hydrogen content of oil-prone amorphous OM decreases; therefore, their reflectivity or "gray level" increases and they develop a more consolidated texture resulting in an appearance similar to vitrinitic OM. Vitrinitic remnants in amorphous clumps or particles are easier to recognize in reflected light. As shown in Plates 1 and 2, using a transmitted light slide and alternating between transmitted and reflected light can be very useful to help recognize vitrinite remnants.
3. Color of amorphous OM in transmitted light. In general, humic amorphous OM will be a darker color (reddish brown or dark brown) compared to oil-prone OM. This color difference is especially evident at the edges of amorphous particles. However, this is a subjective and maturation dependent property. The color of amorphous OM is somewhat dependent upon the Eh potential of the depositional environment, (Masran and Pockock, 1981). With increasing maturity, the color differences between different types of amorphous kerogens become less distinctive.

4. Fluorescence of amorphous OM. Although the fluorescence of oil-prone kerogens is often extremely weak, it can sometimes be used to help distinguish oil-prone and vitrinitic (non-fluorescent) amorphous OM. Immature oil-prone amorphous kerogens have a positive fading effect (increase in fluorescent intensity with time of excitation), which can be used to help identify the oil-prone amorphous kerogen. However, fluorescence is subjective and also maturation dependent and can not be used alone to distinguish different types of amorphous kerogens.

5. Texture. Oil-prone amorphous kerogen will sometimes display a more crystalline or "grainy" texture in contrast to amorphous vitrinite.

6. Other characteristics useful in detecting amorphous vitrinite include: (a) evidence of fungal breakdown such as woody remains permeated with fungal hyphae, (b) partial degradation, pitting, or patterned thinning of exinitic material, and (c) diagnostic microfossils, which provide information on the depositional environment.

As stated above, most of these microscopic properties that can be used to identify amorphous vitrinite are subjective and often difficult to detect. No single microscopic property will provide a conclusive answer. The problem is compounded with mature and post-mature samples. However, by piecing together as much information as possible by using the above criteria a decision can often be made on the type of amorphous OM. This decision needs to be confirmed with geochemical analyses. I hope in the near future to write a more complete description (with photomicrographs) of the microscopic properties and identification of amorphous humic material.

S. C. TEERMAN
COFRC

SCT:ez

Attach: Plates 1-2
cc w/attach:
   L. C. Bonham
   R. W. Jones

File-4+4
REFERENCES


PLATE 1

Figure 1. Amorphous vitrinitic particles in transmitted light (arrows). Note gradation of identifiable vitrinitic particles to amorphous-like organic matter. 750X

Figure 2. Amorphous vitrinitic particle in reflected light. Using transmitted light. Note the more vitrinitic appearance of particles in reflected light. Same field of view as Figure 1. 750X

PLATE 2

Figure 1. Amorphous vitrinitic particle in transmitted light. Note reddish-brown color of particle (arrow), which is transition between vitrinite and amorphous. 750X

Figure 2. Amorphous vitrinitic particle in reflected light. Note vitrinite relic in particle (arrow). Same field of view as Figure 1. 750X
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Identification Number</th>
<th>Tmax (°C)</th>
<th>S1 (mg/g)</th>
<th>S2 (mg/g)</th>
<th>S3 (mg/g)</th>
<th>S1/S1 + S2</th>
<th>PI</th>
<th>S2/S3</th>
<th>T.O.C.</th>
<th>Hydrogen Index</th>
<th>Oxygen Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>123-001</td>
<td>Depth 6400'-6500'</td>
<td>332</td>
<td>0.26</td>
<td>0.65</td>
<td>0.56</td>
<td>0.29</td>
<td>1.17</td>
<td>0.84</td>
<td>&lt;1%</td>
<td>77.5</td>
<td>-</td>
</tr>
<tr>
<td>123-002</td>
<td>Depth 7100'-7200'</td>
<td>440</td>
<td>0.20</td>
<td>0.80</td>
<td>0.40</td>
<td>0.20</td>
<td>1.97</td>
<td>1.21</td>
<td>66.0</td>
<td>33.5</td>
<td>-</td>
</tr>
<tr>
<td>123-003</td>
<td>Depth 7700'-7800'</td>
<td>445</td>
<td>0.26</td>
<td>1.63</td>
<td>0.42</td>
<td>0.14</td>
<td>3.90</td>
<td>1.67</td>
<td>97.5</td>
<td>25.0</td>
<td>-</td>
</tr>
<tr>
<td>123-004</td>
<td>Depth 8050'-8100'</td>
<td>442</td>
<td>0.74</td>
<td>8.78</td>
<td>0.33</td>
<td>0.08</td>
<td>26.22</td>
<td>5.1</td>
<td>133.4</td>
<td>5.1</td>
<td>-</td>
</tr>
</tbody>
</table>

- S1 = Free hydrocarbons, mg HC/g of rock
- S2 = Residual hydrocarbon potential (mg HC/g of rock)
- S3 = CO2 produced from kerogen pyrolysis (mg CO2/g of rock)
- Hydrogen Index = mg HC/g organic carbon
- Oxygen Index = mg CO2/g organic carbon
- PI = S1/S1 + S2
- Tmax = Temperature Index, degrees C.
TABLE 1

GEOCHEMICAL PARAMETERS
DESCRIBING SOURCE ROCK
GENERATIVE POTENTIAL AND
LEVEL OF THERMAL MATURATION

<table>
<thead>
<tr>
<th>Quantity</th>
<th>TOC (wt.%)</th>
<th>S2 (mg HC/g rock)</th>
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</thead>
<tbody>
<tr>
<td>Poor</td>
<td>0-0.5</td>
<td>0-3</td>
</tr>
<tr>
<td>Fair</td>
<td>0.5-1</td>
<td>3-5</td>
</tr>
<tr>
<td>Good</td>
<td>1-2</td>
<td>5-10</td>
</tr>
<tr>
<td>Very Good</td>
<td>&gt;2</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quality</th>
<th>HI* (mg HC/g C&lt;sub&gt;org&lt;/sub&gt;)</th>
<th>S2/S3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>0-150</td>
<td>0-3</td>
</tr>
<tr>
<td>Gas and oil</td>
<td>150-300</td>
<td>3-5</td>
</tr>
<tr>
<td>Oil</td>
<td>&gt;300</td>
<td>&gt;5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maturation</th>
<th>PI [S1/(S1+S2)]</th>
<th>T&lt;sub&gt;max&lt;/sub&gt; (°C)</th>
<th>R&lt;sub&gt;o&lt;/sub&gt; (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil &quot;birthline&quot;</td>
<td>-0.1</td>
<td>-435</td>
<td>~0.6</td>
</tr>
<tr>
<td>Oil &quot;deadline&quot;</td>
<td>-0.4</td>
<td>-460</td>
<td>~1.2</td>
</tr>
</tbody>
</table>

*Hydrogen Index, assuming a level of thermal maturation for the organic matter equivalent to R<sub>o</sub> = 0.6%.
FIGURE 1

FIGURE 2