KGS OFR 2008-34

Kansas Low-BTU Gas
Compositions and Production Potential at
Elmdale field, Chase County, Kansas

Saibal Bhattacharya
Lynn Watney
Dave Newell
Fifty-four gas analyses were collected from published and private sources from the region of the Elmdale Gas Field in Kansas to survey the likely range of compositions of natural gas in this region and to determine what strata may contain low-BTU gas resources. Several pay zones, ranging in age from Permian to Mississippian, produce gas in the region.
In general, the shallower pay zones contain low-BTU gas (i.e. <950 BTU/scf)
Hydrocarbon wetness, the ratio of heavier molecular-weight hydrocarbons to that of methane plus the heavier molecular-weight hydrocarbons, increases with increasing age and depth of the producing formation.
The presence of these heavier-molecular-weight hydrocarbons increase the heating value (BTU content) when natural gases contain them, and this partly account for the better BTU content of the deeper gases, in addition to the greater percentages on nitrogen in the shallower gases.
Nitrogen-to-helium ratios for all the gases essentially remains the same regardless of the age of the pay zone, suggesting a common source for these component gases. The greater percentages of nitrogen and helium in the shallower, low-BTU zones indicates that these zones will have better economics if helium is attempted to be recovered from the rejected noncombustible gases in the upgrading process.
### Compositional ranges of hydrocarbon and nonhydrocarbon gases – Part 1. The deeper formations have a greater range in composition, but this may be due to more samples being available.
PERCENTAGE RANGES in COMPONENT-GAS COMPOSITIONS
Gas fields on Nemaha Uplift
Morris and Chase Counties, KS

nonhydrocarbon gases

Compositional ranges of hydrocarbon and nonhydrocarbon gases – Part 2. The deeper formations have a greater range in composition, but this may be due to more samples being available.
Wireline logs from 26 wells in and around Elmdale field were analyzed for resource evaluation.

Initial analysis at Frankhauser Trust E1 well – Tecumseh interval (704 to 714 ft):
- Produced water free
- Gas effect visible on neutron porosity
- Separation between porosity and BVW (bulk-volume-water)
  - Implies water-free or production with minimal water
- Low GR (gamma) values

Above log analysis was used to define:
- Archie parameters – $m = 1.8$, $a = 1$, and $R_w = 0.079$
  - Used universally in analysis of other wells in the study
- Petrophysical cut-offs
  - Porosity $> 0.19$, $S_w < 0.60$, $V_{shale} < 85\%$, and $BVW < 0.15$
RESOURCE EVALUATION - II
LOW-BTU GAS – ELMDALE FIELD, CHASE COUNTY, KS

- Most wells in study area produce pipeline quality gas from LKC (Lansing-Kansas City)
- Shallower sands that were analyzed at all wells for low-BTU potential include
  - Ireland, Douglas, Tecumseh, Calhoun, Severy, and White Clouds
- Porosity correction
  - Density and neutron porosity logs run on limestone matrix (2.71 g/cc) were corrected to sandstone matrix (2.65 g/cc)
- Gas Effect – neutron cross-over
  - Neutron Porosity < Density Porosity
    - Deeper invasion into low porosity zones often mask gas effects
    - Gas effects easily visible in high porosity zones with shallow invasion
  - Presence of Gas Effect – strong indicator of presence of gas
  - Absence of Gas Effect – does not necessarily mean that the zone is bereft of producible gas
- Zonal production potential prediction was based on respective log signatures
Fankhauser Tr. E-1 - Tecumseh (704-714 ft)

- Neutron gas effect, relatively low GR, and separation between density phi and BVW, Sw < 60%
- BVW clustering at low value (0.12) indicating larger pores, and no or limited water production
- Gas zone – flowed water-free gas

Log analysis of Tecumseh zone in Frankhauser Trust E1 well.
## Summary of Resource Analysis

<table>
<thead>
<tr>
<th>Well</th>
<th>API</th>
<th>Operator</th>
<th>Sec</th>
<th>Twn - S</th>
<th>Rng - E</th>
<th>调查</th>
<th>约翰逊</th>
<th>特查胡姆斯</th>
<th>卡伦</th>
<th>西耶</th>
<th>白云</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmer</td>
<td>15-017-20845</td>
<td>Range Oil Co</td>
<td>9</td>
<td>20</td>
<td>7</td>
<td>7</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
</tr>
<tr>
<td>Donahue A1</td>
<td>15-017-20846</td>
<td>AEC</td>
<td>18</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
</tr>
<tr>
<td>Stevens A1</td>
<td>15-017-20861</td>
<td>AEC</td>
<td>18</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
</tr>
<tr>
<td>Giger D1</td>
<td>15-017-20844</td>
<td>AEC</td>
<td>20</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>wet</td>
<td>trans</td>
<td>Trans</td>
<td>wet</td>
<td>wet</td>
</tr>
<tr>
<td>Kohr A1</td>
<td>15-017-20842</td>
<td>AEC</td>
<td>21</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>wet</td>
<td>wet</td>
<td>Trans</td>
<td>wet</td>
<td>wet</td>
</tr>
<tr>
<td>Ward Ranch A1</td>
<td>15-017-20816</td>
<td>AEC</td>
<td>21</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>wet</td>
<td>wet-coal</td>
<td>wet</td>
<td>wet-coal</td>
<td>wet</td>
</tr>
<tr>
<td>Mushrush B1</td>
<td>15-017-20810</td>
<td>AEC</td>
<td>23</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>no Rt</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
<td>wet</td>
</tr>
<tr>
<td>Mushrush 26-1</td>
<td>15-017-20497-0001</td>
<td>Tejas Energy</td>
<td>26</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>wet</td>
<td>wet</td>
<td>Trans</td>
<td>&amp; coal</td>
<td>wet</td>
</tr>
<tr>
<td>Mushrush 26-2</td>
<td>15-017-20790</td>
<td>AEC</td>
<td>26</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>wet</td>
<td>Trans-fine</td>
<td>Trans &amp; Coal</td>
<td>wet</td>
<td></td>
</tr>
<tr>
<td>Noble A1</td>
<td>15-017-20868</td>
<td>AEC</td>
<td>27</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>wet</td>
<td>Trans-fine</td>
<td>wet</td>
<td></td>
</tr>
<tr>
<td>McCallum A1</td>
<td>15-017-20822</td>
<td>AEC</td>
<td>27</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>no Rt</td>
<td>wet</td>
<td>Trans-fine</td>
<td>wet</td>
<td></td>
</tr>
<tr>
<td>Thurston 1-27</td>
<td>15-017-20092-0001</td>
<td>AEC</td>
<td>27</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>wet</td>
<td>Trans-fine</td>
<td>wet</td>
<td></td>
</tr>
<tr>
<td>Giger A1</td>
<td>15-017-20823</td>
<td>AEC</td>
<td>28</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Trans-fine</td>
<td>Trans-fine</td>
<td>Trans &amp; Coal</td>
<td>wet</td>
</tr>
<tr>
<td>Prezter A1</td>
<td>15-017-20817</td>
<td>AEC</td>
<td>28</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Trans-fine</td>
<td>Trans-fine</td>
<td>Trans &amp; Coal</td>
<td>wet</td>
</tr>
<tr>
<td>Marshall A1</td>
<td>15-017-20811</td>
<td>AEC</td>
<td>28</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>wet</td>
<td>Trans-fine</td>
<td>Trans &amp; Coal</td>
<td>wet</td>
</tr>
<tr>
<td>Davis/Giger B1 Gas Unit</td>
<td>15-017-20860</td>
<td>AEC</td>
<td>29</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>wet</td>
<td>Wet</td>
<td>Gas + transition</td>
<td>Wet + 2 ft coal</td>
</tr>
<tr>
<td>Giger B1</td>
<td>15-017-20824</td>
<td>AEC</td>
<td>29</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>wet</td>
<td>Shaly</td>
<td>Gas</td>
<td>Wet</td>
</tr>
<tr>
<td>Kissel 1-29</td>
<td>15-017-20081-0001</td>
<td>AEC</td>
<td>29</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Gas</td>
<td>Gas</td>
<td>Shaly</td>
<td>Gas</td>
</tr>
<tr>
<td>Fankhauser Trust E1</td>
<td>15-017-20843</td>
<td>AEC</td>
<td>32</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Gas</td>
<td>Gas</td>
<td>Shaly</td>
<td>Gas</td>
</tr>
<tr>
<td>Fankhauser Trust D1</td>
<td>15-017-20841</td>
<td>AEC</td>
<td>33</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Wet</td>
<td>Wet</td>
<td>Shaly</td>
<td>Wet</td>
</tr>
<tr>
<td>Wood A1</td>
<td>15-017-20828</td>
<td>AEC</td>
<td>33</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Fankhauser 1-33</td>
<td>15-017-20091-0001</td>
<td>AEC</td>
<td>33</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>no Rt</td>
<td>Wet</td>
<td>Trans-fine</td>
<td>Shaly</td>
<td>Wet</td>
</tr>
<tr>
<td>Starkey A1</td>
<td>15-017-20800</td>
<td>AEC</td>
<td>34</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>McCaulum-Simmons G</td>
<td>15-017-20858</td>
<td>AEC</td>
<td>34</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Wet</td>
<td>Trans</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Stauffer 1A-34</td>
<td>15-017-20786</td>
<td>Yellow Rose Energy</td>
<td>34</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>na</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Stauffer 3-34</td>
<td>15-017-20372</td>
<td>D&amp;Pet</td>
<td>34</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>na</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Stauffer 2-35</td>
<td>15-017-20090</td>
<td>Viking Intl Pet</td>
<td>35</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Stauffer 8-35</td>
<td>15-017-20789</td>
<td>AEC</td>
<td>35</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Stauffer 5-35</td>
<td>15-017-20373-0001</td>
<td>Viking Intl Pet</td>
<td>35</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>not logged</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Spinden A1</td>
<td>15-017-20801</td>
<td>AEC</td>
<td>36</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Trans</td>
<td>Wet</td>
<td>Wet</td>
<td>Trans</td>
</tr>
<tr>
<td>Stauffer 3</td>
<td>15-017-20126</td>
<td>Jackman &amp; Jackman</td>
<td>35</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steerman A1</td>
<td>15-017-20830</td>
<td>AEC</td>
<td>1</td>
<td>20</td>
<td>7</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reehling Trust B1</td>
<td>15-017-20809</td>
<td>AEC</td>
<td>1</td>
<td>20</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Reehling Trust B3</td>
<td>15-017-20826</td>
<td>AEC</td>
<td>1</td>
<td>20</td>
<td>7</td>
<td>7</td>
<td>yes</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
<td>Wet</td>
</tr>
</tbody>
</table>

Summary of log analyses for wells in and around the Elmdale field, Chase County, Kansas.
RESOURCE EVALUATION - Example
PALMER 1 – ELMDALE FIELD, CHASE COUNTY, KS

- Analyzed zones marked in RED
- Ireland sand (1014 to 1030 ft) – Strong gas production potential
  - High porosity, low GR values, BVW cluster around 0.14
  - Gas effect on neutron log over lower part of the interval
  - Produces water-free low-BTU gas
- Tecumseh sand (744 to 754 ft) – Good indications of gas
  - Low BVW (< 0.1) and GR, gas effect on neutron
  - Tested significant volumes of low-BTU gas
- Calhoun sand (654 to 657 ft) – Some gas potential
  - Low BVW (< 0.14) and GR, minor gas effect on neutron, separation between porosity and BVW
  - No gas shows recorded during drilling
- Severy sand (570 to 578 ft) – Gas bearing potential
  - Gas effect on neutron, moderate GR, separation between density porosity and BVW
  - Transition zone visible
  - Tested significant volumes of low-BTU gas
Palmer #1

Ireland (1014-1030 ft)
- **Strong gas indications** with high porosity, low BVW including clustering around 0.12, and lower GR
- Neutron gas effect on cleaner sandstone
- Sw < 60%
- Produces water-free low-BTU gas
Palmer #1

**Tecumseh (744-754 ft)**

- Good indications of gas pay
  - relatively low GR, BVW cluster ~0.08, high porosity, gas effect on neutron log, Sw < 50%
- Tecumseh identified as pay using cut-offs defined at Frankhauser Trust E1 well

Log analysis of Tecumseh sand in Palmer 1 well.
Palmer #1 – Tecumseh Sandstone

- **Gamma ray** does not recognize the fine-grained, well sorted, porous sand, probably due to K-rich mica content
- **Vsh** from **Neutron-density** overcorrect due to probable gas effect on neutron

Comparison of Vshale calculated from gamma with that calculated from neutron-density porosities in Tecumseh sand in Palmer 1.
Palmer #1
Calhoun (654-657 ft)

- Indications of gas pay with low BVW (~0.13), possible gas effect on neutron log, Sw < 60%, separation between density porosity and BVW
- However, no shows observed during drilling through zone

Log analysis of Calhoun sand in Palmer 1 well.
Palmer 1
Severy (570-578 ft)

- Gas effect on neutron, separation between density porosity and BVW, GR ~100 API, Sw < 60%
- Parts of the sand has BVW < 0.14
- Possibly gas bearing

Log analysis of Severy sand in Palmer 1 well.
**Reehling B-1**

**Douglas (1044-1049 ft)**

- High porosity and separation between density porosity and BVW
- However, GR is > 100 API
- Zone appears to be shaly. Need to test to validate GR cut-off.
- **Poor prospect for gas - shaly**

Log analysis of Douglas sand in Reehling B1 well.
Reehling B-1
Severy (643-666 ft)

- High GR
- BVW and density porosity overlap
- Sw > 80%
- Expected to be wet

Log analysis of Severy sand in Reehling B1 well.
Reehling B-1

White Cloud (590-604 ft)
- High GR (~100 API), little separation between density porosity and BVW
- Sw > 80%
- Expected to be wet

Log analysis of White Cloud sand in Reehling B1 well.
Reehling B-3  
Tecumseh (872-880 ft)

- Washout at shale accounting for high porosity on top of sand
- High GR (~100 API), and overlap of BVW and density porosity
- Expected to be wet

Density log reading high (~50%) at washout across shale see caliper log

Log analysis of Tecumseh sand in Reehling B3 well.
Reehling B-3
Severy (692-702 ft)

- Overlying coal (690-692 ft) possibly - high porosity combines with slightly lower GR
- Sand - overlap between BVW and density porosity
- Expected to be wet

Log analysis of Severy sand in Reehling B3 well.
Reehling B-3

- Coal overlying Severy sand

Log showing location of coal bed atop the Severy sand in Reehling B3 well.
Spinden A-1
Ireland (1080-1086 ft)

- Separation between density porosity and BVW
- GR < 100, Sw~80%, BVW high
- Poor prospect – some gas in transition

Log analysis of Ireland sand in Spinden A1 well.
Spinden A-1
Douglas (1035-40)

- High GR (> 100 API), separation between density porosity and BVW
- Increasing Sw at the base indicate possible transition
- Probably some gas where Sw < 60%.
- GR cut-off needs to be tested.
Spinden A-1

Tecumseh (822-30 ft)

- Capping shale on top of sand.
- Density porosity and BVW overlap in sand, and high GR (> 100 API)
- **Sand expected to be wet**

Capping shale – not a wash out effect

Log analysis of Tecumseh sand in Spinden A1 well.
Spinden A-1

Shale caps Tecumseh sand. The high porosity marking the shale is not due to hole washout.

Log showing the location of the shale bed capping the Tecumseh sand in Spinden A1 well.
Spinden A-1
Severy (655-61 ft)

- Cleaner sand (low GR) with high BVW (>0.16) indicating finer pores
- Separation between density porosity and BVW
- Intermediate Sw (between 60 and 70%) suggests
- Gas in transition

Log analysis of Severy sand in Spinden A1 well.
Stauffer 2-35
Douglas (1034-42 ft)

- Gas confirmed during drilling
- GR < 100 API, separation between density porosity and BVW
- Sw > 70% and increases with depth
- Probably some gas in transitional
- Recommend further testing

Log analysis of Douglas sand in Stauffer 2-35 well.
Stauffer 2-35

Tecumseh (839-45 ft)

- Little separation between density porosity and BVW
- Sw increases with depth and exceeds 80%
- Sand expected to be wet

Log analysis of Tecumseh sand in Stauffer 2-35 well.
Stauffer 2-35
Shale bed overlies the Tecumseh sand

Log showing location of shale bed overlying Tecumseh sand in Stauffer 2-35 well.
Stauffer 2-35
Severy (672-679 ft)

- Overlap of BVW and density porosity
- Sw > 80%)
- Slight cleaning of sand upward
- Sand expected to be wet

Log analysis of Severy sand in Stauffer 2-35 well.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>SW 20%</th>
<th>SW 40%</th>
<th>SW 60%</th>
<th>SW 80%</th>
<th>SW 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>675</td>
<td>0.010</td>
<td>0.100</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>675</td>
<td>0.010</td>
<td>0.100</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>675</td>
<td>0.010</td>
<td>0.100</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>675</td>
<td>0.010</td>
<td>0.100</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

RESISTIVITY Ohm-m

Porosity:
- Wet (red) zones above higher phi, but shaly (high GR)

Depth:
- 679 - 700
- 672 - 679
- 658 - 672
- 644 - 658
- 630 - 644

Severy Depth: 635 - 700
X: Y: a: 1 m: 1.8 n: 2 RW: 0.079
Stauffer 8-35
Douglas (965-967 ft)

- Shale washout on top of sand (962-964 ft)
- Sand below shale - BVW cluster around 0.15, separation between density porosity and BVW
- Sw < 80%
- Thin zone with some transitional gas.
- Zone needs to be tested to see if water is mobile.

Log analysis of Douglas sand in Stauffer 8-35 well.
Stauffer 8-35 Douglas

- Washout at top in overlying shale

Log showing shale that was washed out. Shale overlies the Severy sand in Stauffer 2-35 well.
Stauffer 8-35
Tecumseh (755-759 ft)

- Small clustering at moderate BVW (0.15) – test to check for mobile water
- Decrease in GR upwards may be indicative of coarsening
- Top of sand - Separation between density porosity and BVW
- Sw > 80%
- Bottom of sand - Sw increases downwards
- Poor prospect - gas in transition zone

Log analysis of Tecumseh sand in Stauffer 8-35 well.
Stauffer 8-35

Calhoun (658-65 ft)

- Top of sand – low GR and separation between density porosity and BVW, BVW around 0.14
- Base of sand - Sw increases with depth – indicative of transition
- Probably gas in transition

Log analysis of Calhoun sand in Stauffer 8-35 well.
Stauffer 8-35
Severy (577-588 ft)

- Clustered BVW ~0.14
- Coal on top of sand (high porosity, moderate GR)
- GR indicates cleaning upward in sand. No gas effect visible. Porosity low.
- Slight separation between density porosity and BVW, Sw < 80%
- Probable gas
Mccallum Simmons GU #1
Douglas (895-897 ft)

- Washout above sand in shale bed (891-895 ft)
- BVW < 0.14 in sand with separation between density porosity and BVW
- Sw < 80% in sand
- Probably gas in transition

Log analysis of Douglas sand in McCallum Simmons GU 1 well.
Starkey A-1

Douglas (871-874 ft)

- Gas effect on neutron porosity, separation between density porosity and BVW. No washout.
- But high BVW (>0.18) suggesting fine pores and probable lower perm
- Coarsening upward package indicated by decreasing BVW. GR < 100 API.
- May produce gas.

Log analysis of Douglas sand in Starkey A1 well.
Starkey A-1

Calhoun (583-86 ft)

- Slight gas effect on neutron porosity
- High BVW (>0.2) suggest fine pores
- High Sw (+ 80%) suggests transition. Also Sw increases with depth.
- Gas in transition

Log analysis of Calhoun sand in Starkey A1 well.
Starkey A-1

Severy (500-506 ft)

- Slight gas effect on neutron porosity
- Low BVW (~0.12) suggest larger pores. Sw increases with depth. Much of sand at Sw < 60%.
- A (3 ft) coal bed is suspected to overly the sand.
- GAS zone

Log analysis of Severy sand in Starkey A1 well.
Wood A-1

Douglas (940-943 ft)

- No gas effect on neutron porosity. Separation between density porosity and BVW.
- Quite shaly (GR> 100 API), but BVW less than 0.155
- Sw < 80% and increases with depth
- Possible gas in transition

Wood A-1

Tecumseh (732-736 ft)

- Slight gas effect on neutron log.
- GR < 100 API with moderate porosity and BVW cluster around 0.0135
- Sw < 80%. No transition visible
- Possibly gas
KISSEL #1-29

Ireland (1020-1037 ft)

- Gas effect visible on neutron porosity log, separation between density porosity and BVW
- Low GR (< 100 API) and BVW cluster around 0.14
- 60% > Sw > 80%
- Possibly Gas

Log analysis of Ireland sand in Kissel 1-29 well.
Kissel 1-29

Tecumseh (766-771 ft)

- Gas effect on neutron porosity, separation between density porosity and BVW
- BVW < 0.16 with some clustering around 0.14. Sw close to 60%
- Possible mudcake build up over this interval indicating higher permeability
- Possibly gas

Log analysis of Tecumseh sand in Kissel 1-29 well.
Kissel 1-29

- Mudcake buildup 762-772 ft.

Log showing mud cake buildup over the Tecumseh sand in Kissel 1-29 well.
Giger B-1

Tecumseh (750-755 ft)

- Gas effect on neutron porosity, separation between density porosity and BVW
- BVW clusters around 0.15, moderately high density porosity (28%), Sw ~ 60% or less
- GR high
- Possibly gas bearing. No show during drilling.

Log analysis of Tecumseh sand in Giger B1 well.
Giger B-1

- Samples indicate fine grain porous sandstone in spite of high gamma ray;
- No gas show during drilling.

Log showing high GR over sand interval while geo report indicates fine grained sand from the same interval.
Giger B-1
Severy (580-585 ft)

- Gas effect on neutron porosity, slight separation between density porosity and BVW
- Increasing BVW and Sw with depth
- Moderate porosity, and relatively low GR (< 100 API), Sw + 70%
- Possible coal bed (2 ft) above sand
- Possible gas zone in transition

Log analysis of Severy sand in Giger B1 well.
Log showing presence of possible coal bed in Giger B1 well.
Davis/Giger GU B-1
Tecumseh (752-756 ft)

- No gas effect, separation between density porosity and BVW

- Increasing Sw and BVW with depth. Upper sand Sw < 80% and BVW < 0.16.

- Some chance of gas in transition. No show during drilling.

Log analysis of Tecumseh sand in Davis-Giger GU B1 well.
Davis/Giger GU B-1

- Georeport indicate sand without gas show

Geo report indicates no gas shows during drilling of Tecumseh in Davis/Giger GU B1 well.
Suspect coal bed

Davis/Giger GU B-1
Severy (579-586 ft)
- Suspect coal to overly the sand
- Little separation between density porosity and BVW
- Sw +90%
- Wet sand

Log analysis of Severy sand in Davis-Giger GU B1 well.
Log analysis of Ireland sand in Marshall A1 well.

**Marshall A1**

**Ireland (1007-1026 ft)**

- Minor separation between density porosity and BVW
- High GR (+100 API) due to micaceous sand (georeport)
- Some gas show (bubbles) observed (georeport)
- Sw + 90%
- Wet Sand
Geo report showing mention of micaceous sand and gas bubbles during drilling of Ireland in Marshall A1 well.
Giger A-1

Calhoun (608-611 ft)

- Gas effect on neutron porosity, separation between density porosity and BVW
- Sw~80% and BVW +0.18
- GR~75 API
- Probable gas in transition

Log analysis of Calhoun sand in Giger A1 well.
Noble #1
Calhoun (593-598 ft)

- Gas effect on neutron porosity, some separation between density porosity and BVW
- High Sw +80% and increasing with depth. BVW +0.14 and increases with depth. Slight gas bubbles on drilling
- Gas in transition

Log analysis of Calhoun sand in Noble 1 well.
Geo report showing observation of gas bubbles during drilling of Calhoun sand in Noble 1 well.
Mushrush 2-26
Calhoun (671-675 ft)

- Appearance of gas effect on neutron log, slight separation between density log and BVW
- Sw +80%, BVW >0.16
- Poor prospect - gas in transition

Log analysis of Calhoun sand in Mushrush 2-26 well.
Mushrush 2-26
Severy (596-599 ft)

- Thin gas sand, BVW cluster ~014, Sw 70%
- Appearance of a gas effect on the neutron log, separation between density log and BVW
- Gas in transition
- Thin coal on top

Log analysis of Severy sand in Mushrush 2-26 well.
Ward Ranch A-1

Tecumseh (808-816 ft)

- Washout 802-806 ft – so shale (and not coal) overlies the sand
- BVW > density porosity
- Wet sand

Log analysis of Tecumseh sand in Ward Ranch A1 well.
Ward Ranch A-1

- Wash out coincides with high porosity – suggestive of shale bed rather than coal.

Log showing washout coincident with porosity high implying presence of shale overlying the Tecumseh sand in Ward Ranch A1 well.
Kohr A-1

Severy (582-86 ft)
- Coal overlying sand
- Gas effect on neutron porosity, separation between density porosity and BVW
- Sw < 80% and increases with depth like BVW (> 0.145)
- Probably gas in transition

Log analysis of Severy sand in Kohr A1 well.
Log analysis of Tecumseh sand in Giger D1 well.

Giger D-1
Tecumseh (722-727 ft)

- BVW and Sw increase with depth
- Separation between density porosity and BVW
- Poor prospect - gas in transition
Giger D-1

Calhoun (658-661 ft)

- Gas effect on neutron density, some separation between density porosity and BVW
- Sw > 80% and increases with depth. BVW + 0.16
- Poor prospect - Gas in transition,

Log analysis of Calhoun sand in Giger D1 well.
CONCLUSIONS

• Wireline logs from 26 wells in and around the Elmdale field were analyzed to determine the gas production potential of several sand bodies such as Ireland, Douglas, Tecumseh, Calhoun, Severy, and White Cloud. Gas production potential was identified in these sands at several wells.
  – Current log analysis indicates that each of the sand bodies show gas production potential at a limited number of wells, and that none of the sands have a pervasive gas production potential over the study area.
  – Additional production testing needs to be carried out at select wells to validate and refine the log analysis.

• Regional analyses of low-BTU data was initiated using 54 gas samples and the following trends observed:
  – In general, the shallower zones tend to produce low-BTU gas.
  – Hydrocarbon-wetness increases with age and depth of the producing zone.
  – Nitrogen-to-helium ratios are unaffected by the age of the pay zone.
  – Given the limited data set available, the deeper formations appear to display a greater compositional range hydrocarbon and non-hydrocarbon gases.