The Russell Kansas CO2 Pilot
– The Strangest Thing

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Murfin Drilling Company

TORP Oil Recovery Conference
Wichita, Kansas
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Overview

- Background
- Dead in the Water
- Resurgence
- Recent Activity
- Discussion
Location of Ethanol Plant & CO2 Pilot Site

Kansas Geological Survey

Koudelle and Dubois, 1999
Many Variations Came & Went

Potential CO2 Flood Patterns
MV Energy
Colliver-Carter Leases
14S-13W
Russell County Kansas

Legend:
- Oil Producer
- CO2 Injector
- Water Injector (Containment)
- Alternate Oil Producer
- Alternate or Repl. Water Injector (Containment)
Preferred Choice Before Funding Issues

60-acre Pattern

14S-13W
Russell County
Kansas

- Oil Producer
- CO2 Injector
- Water Injector (Containment)
- Alternate Oil Producer
- Alternate or Repl. Water Injector (Containment)
Geologic Overview

Type Log CO2#18

L-KC “C” divided into 6 Layers-three flooding cycles

• General Properties*
  – C1: 8 md, 18.8%
  – C2: 150 md, 25.8%
  – C3: 40 md, 22.0%
  – C4: 6 md, 19.4%
  – C5: 2 md, 14.7%
  – C6: 0.3 md, 12.0%

• *- CO2#18 exhibits better properties than average for site
Work Timeline

• Phase One – *DOE Contribution 45%*
  
  – March 2000 to January 2004
  
  – Perform Reservoir Characterization and Simulation
  
  – Develop Working Interest Partnerships and Other Working Agreements (CO2 Supply, CO2 Transport, and CO2 Injection – Summer, Fall, Winter 2002)
  
  – Conduct Field Studies to Determine if CO2 Pilot Implementation Feasible (Included Well Workovers and Water Injection Facilities – Winter, Spring 2003)
  
  – Pre-startup Activities (Tank Battery Upgrade and CO2 Injection Equipment Set-up – Fall 2003)
  
  – CO2 Injection Commences December 1, 2003
Work Timeline

• Phase Two – *DOE Contribution 35%*
  – February 2004 to December 2008
  – Implement, Operate, and Monitor CO2 Pilot - present
  – CO2 Injection Terminated June 17, 2005
  – Water Injection Commences June 21, 2005

• Phase Three – *DOE Contribution 10%*
  – January 2009 to March 2010
  – Post Flood Monitoring
  – Continue Tech Transfer Activities
## Summary of Implementation Costs

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workover CO2 #18</td>
<td>$58 M</td>
</tr>
<tr>
<td>Drill &amp; Complete CO2 I-1</td>
<td>$284 M</td>
</tr>
<tr>
<td>Run Liner in CO2 #12</td>
<td>$50 M</td>
</tr>
<tr>
<td>Workover CO2 #10</td>
<td>$93 M</td>
</tr>
<tr>
<td>Drill Deeper CO2 #16</td>
<td>$122 M</td>
</tr>
<tr>
<td>Construct Freshwater Plant</td>
<td>$71 M</td>
</tr>
<tr>
<td>Run Liner in CO2 #13</td>
<td>$50 M</td>
</tr>
<tr>
<td>Set-up CO2 Skid &amp; Tank</td>
<td>$11 M</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>$11 M</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$750 M</strong></td>
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</tbody>
</table>

Murfin & WI Partners (55 %) $412.5 M
DOE (45 %) $337.5 M
## Summary of Operating Costs

<table>
<thead>
<tr>
<th>Year</th>
<th>WI Income</th>
<th>WI Oper Cost</th>
<th>Profit/Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>$0</td>
<td>$10,160</td>
<td>($10,160)</td>
</tr>
<tr>
<td>2003</td>
<td>$8,641</td>
<td>$175,718</td>
<td>($167,077)</td>
</tr>
<tr>
<td>2004</td>
<td>$28,621</td>
<td>$105,446</td>
<td>($76,825)</td>
</tr>
<tr>
<td>2005</td>
<td>$53,755</td>
<td>$71,171</td>
<td>($17,416)</td>
</tr>
<tr>
<td>2006</td>
<td>$98,370</td>
<td>$119,439</td>
<td>($21,069)</td>
</tr>
<tr>
<td>Total</td>
<td>$189,387</td>
<td>$481,934</td>
<td>($292,547)</td>
</tr>
</tbody>
</table>
Russell CO2 Pilot
Total Daily Production & Injection

Dead in the Water?
March 2006 – Pilot On Last Legs?

- Still no oil kick
- Pilot Area loosing +/- $6,000 per month
- Everyone (but one) thought Project done

Guess who?
(It wasn’t me.)
Resurgence

Fast Forward to August 2006

– KIOGA Annual meeting Wichita, KS

– Marlin Robinson of Mar-Lou Oil approaches KU Booths

– “Not sure I want to tell you this, but …”
Where Did the CO2 Go?

Kansas Geologic Survey

Deep Wells Only
Russell CO2 Pilot
Total Daily Production & Injection

Resurgence?
It Only Makes Sense To:

– Release the packer in Colliver 7 & produce from LKC (August 28, 2006)

– Knock-out CIBP in Colliver 3 & RTP well in LKC (October 11, 2006)
Colliver A Lease Oil Production

As of mid-November 2006

- Colliver A 7 packer released, 8/28/06
- Colliver A 3 RTP'd, 10/11/06
- Colliver A 7 SPM from 11.3 to 12.5, 9/28/06
- Colliver A 3 RTP'd, 10/17/06
- 5 wells producing, #1, #5, #6, #7, & #14
- Long stroked Colliver A 3, 10/17/06

bopd

12/14/05 2/2/06 3/24/06 5/13/06 7/2/06 8/21/06 10/10/06 11/29/06 1/18/07

Colliver A Lease Oil Production
As of March 2007:

- Continue to maximize pilot production (pump-off #12, pump #16 more often, maintain pressure bubble)

- RTP Carter 2 in LKC (March 7, 2007)

- Knock-out CIBP in Colliver 14 & RTP in LKC (March 13, 2007)
Colliver A Lease Oil Production

Colliver A 7 packer released, 8/28/06
Colliver A 7 SPM from 11.3 to 12.5, 9/28/06
Colliver A 3 RTP’d, 10/11/06
Long stroked Colliver A 3, 10/17/06

5 wells producing, #1, #5, #6, #7, &

Colliver Lease as of April 2, 2007
Russell CO2 Pilot
Total Daily Production & Injection

Resurgence?
Graham A Lease
Monthly Oil Production

bpm

Colliver A Lease
Monthly Gauged Production
7-year Production

Colliver lease since 2000
General Comments

Should More Be Done?

• Should commercial project be attempted?
• Would commercial project be economic?
• Would operators pool their resources?
• Is there sequestration angle?
Geologic Overview

Higher Permeability
100’s md

Moderate Permeability
10’s md

Low k contact

Moderate Permeability
10’s md

Higher Permeability
100’s md

Gonzalez & Eberli (1997)
**Costs to Date**

**Workover CO2 #18 to isolate LKC C**

- May & June 2000
- Cement squeeze several zones, reperf LKC C
- Total Cost = $58,000

**Drill and Complete CO2 I-1 into LKC C**

- September & October 2000
- Total Cost = $284,000
Costs to Date

Run liner in CO2 #12 to isolate LKC C
- February & March 2003
- Plug back LKC G w/ cement
- Cmt 4-1/2” liner in 6”, left LKC C openhole
- Total Cost = $50,000

Workover CO2 #10 to isolate LKC C
- March 2003
- Cement LKC C & G openhole
- Redrill LKC C and perforate
- Run tandem packer across shallow zones
- Total Cost = $93,000
**Costs to Date**

**Drill Deeper CO2 #16 into LKC C**

- March & April 2003
- Remove existing shallow liner (Jan ’03)
- Drill deeper into LKC C & G, cmt 4-1/2” csg to surface, perforate LKC C, acidize
- Total Cost = $122,000

Running KGS VSP Cable into 16

Fishing KGS VSP Cable from 16
Construct Freshwater Injection Plant

- April 2003
- Drill freshwater supply well
- Lay lines, construct shed, set pump & tanks
- Total Cost = $71,000
**Costs to Date**

**Run liner in CO2 #13 to isolate LKC C**

- May 2003
- Cmt 4-1/2” liner (to surface in 6”) across LKC C & G
- Perforate & acidize LKC C
- Total Cost = $50,000

**Tank Battery**

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Perforating CO2 #13

Acidizing CO2 #13
**Costs to Date**

**Set-up CO2 Skid and Upgrade TB**

- November 2003
- Set-up CO2 injection skid & storage tank
- Install gas separator, FWKO, and water disposal tank at tank battery
- Total Cost = $11,000 (install CO2 skid only)
Operational Issues

– CO2 Injection Pump too Big
  • Excessive CO2 recycle and venting
  • Pump requires overhaul July 2004; Smaller plungers inserted
  • Venting problem eliminated
Operational Issues

– Metering Inaccuracies

• CO2 rate measurement at skid inaccurate
• Pump pulsation creates backflow through turbine meter
• CO2 rate, temperature, and pressure measurement relocated to CO2 I-1 June 2004
• Metering accuracy improves significantly
Russell CO2 Pilot
Cumulative Production and Injection

CO2 injection commenced December 1, 2003
Current Operations

Monthly Costs

– Lease Operating Expense (LOE)
  • Average $11,900/month without DOE cost-share
  • Average $ 8,900/month with DOE 35% cost-share

– Economic Limit at Current LOE (w/ DOE cost-share)
  • 8.4 bopd @ $40/bbl oil price
  • 7.4 bopd @ $45/bbl oil price

– Emphasize Cost-Sharing