Field Demonstration of CO$_2$ Miscible Flooding in the Lansing-Kansas City Formation, Central Kansas

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Lawrence, Kansas

University of Kansas
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Overview

- Demonstration Site
- Objectives
- Working Interest Partners
- Field Demonstration Plan
- Milestones
- Oil Production Response
- Management Plan
- Evaluation of Potential for Commercial Operation
Lansing-Kansas City Production and Project Location

- Hall-Gurney Field
- CO2 Pilot Study Area

Map showing Oil and Gas Fields in Kansas with gas, shallow gas, and oil and gas fields indicated.
Purpose of Demonstration

• Determine the technical and economic feasibility of using CO₂ miscible flooding to recover residual and bypassed oil in LKC shallow shelf carbonates.

• Develop reservoir data for the LKC and Hall-Gurney for other floods

• Develop an understanding of operating costs and operating experience for CO₂ miscible flooding in Lansing-Kansas City reservoirs

• Oil in tank and provide sufficient information to expand to commercial scale
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
DOE Participation

• Phase One – **DOE Contribution 45%**

  – March 2000 to January 2004
  – Perform Reservoir Characterization and Simulation
  – Conduct Field Studies to Determine if CO2 Pilot Implementation Feasible (Included Well Workovers and Water Injection Facilities)
  – Develop Working Interest Partnerships and Other Working Agreements (CO2 Supply, CO2 Transport, and CO2 Injection)
  – Pre-startup Activities (Tank Battery Upgrade and CO2 Injection Equipment Set-up)
  – Trial CO2 Injection
**DOE Participation**

- **Phase Two – ** *DOE Contribution 35%*
  - February 2004 to December 2008
  - Implement, Operate, and Monitor CO2 Pilot

- **Phase Three – ** *DOE Contribution 10%*
  - January 2009 to March 2010
  - Post CO2 Flood Monitoring (Water Injection)
  - Continue Tech Transfer Activities
Milestones

- December 3, 2003 - Begin CO2 Injection
- February 2004 - Initial oil production response in pilot wells ~3 B/D
- June 2005 - Switch to water injection after injection of 16.19 MM lb (138.05 MMCF) of CO2
- May 2006 - Oil production from pilot increased to 5.5-6 B/D
- August 2006 - Discovered increased production from Mar-Lou Lease (NW of Pilot Lease) during April-May 2006
- August 2006 - Colliver A7 opened in C zone - substantial increase in oil production on Colliver A Lease
Production from Surrounding Leases

Graham A
April-May 2006

Colliver A
August 2006

CO2 Project

Deep Wells Only
Carbon Dioxide in Produced Gas - Colliver A7

CO$_2$, mole %

Dates:
- 9/13/2006
- 10/29/2006
- 12/14/2006
- 5/7/2007
- 8/28/2007
- 11/30/2007
- 3/5/2008
- 4/16/2008
- 5/7/2008
- 5/19/2008
- 6/5/2008
- 7/19/2008
- 9/10/2008
- 10/3/2008
- 10/21/2008
Colliver Lease Production

- The increased carbon dioxide concentration in the casing gas in Colliver A7 indicates that oil displaced from the CO2 pilot is being produced from Colliver A7
- Colliver A14 is also producing incremental oil following recompletion in the C zone. Carbon dioxide content of the casing gas is normal for the area.
Colliver A Lease
Monthly Gauged Production
Decline based on 7-year Production
Prior to Opening Colliver A7

- RTP'd LKC in Colliver A 7, 8/28/06
- RTP'd LKC in Colliver A 3, 10/11/06
- RTP'd LKC in Colliver A 14 & acidized shallow zones, 3/13/07
- Ice storm, 12/10/07
- Colliver A 7 rod prt, Feb '08

12,196 Bbl
Table 1: Estimated Incremental Oil from CO2 Injection into LKC C

CO2 Injected-138.05 MMCF

<table>
<thead>
<tr>
<th>Date</th>
<th>CO2 Pilot BBL</th>
<th>Colliver A Lease BBL</th>
<th>Graham A Lease BBL</th>
<th>Total BBL</th>
<th>MCF /BBL</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/30/08</td>
<td>6,836</td>
<td>12,196</td>
<td>920</td>
<td>19,952</td>
<td>6.92</td>
</tr>
</tbody>
</table>
Colliver A Lease
Monthly Gauged Production
10-year Production

100

RTP'd LKC in Colliver A 7, 8/28/06
RTP'd LKC in Colliver A 14 & acidized shallow zones, 3/13/07
Colliver A 7 rod prt, 2/10-17/08
SemCrude mess, -Lease shut in due to lack of storage Jul '08
Dec '07 ice storm
Lightning strike, Aug '08

RTP'd LKC in Colliver A 3, 10/11/06

Jan-05 Jan-06 Jan-07 Jan-08 Jan-09 Jan-10

Avg BOPD

0

10

100

100
Project Management
Budget Period II

• Project is not economic even with DOE cost share
• 95% of the CO2 remains in the LKC C zone reservoir interval
• Maintain pressure in pilot area above MMP(1250 psi)
• Inject water into CO2I-1 to continue mobilization of oil by displacing the carbon dioxide
• Document oil production from Colliver A Lease that can be attributed to CO2 displacement (no economic benefit to some of the WI owners)
• Produce defendable estimates of oil recovery based on oil in the tank
DOE Participation

- **Phase Two – DOE Contribution 35%**
  - February 2004 to December 2008
  - Implement, Operate, and Monitor CO2 Pilot
  - Continuation application to be prepared to extend some Budget Period 2 activities to June 30, 2009

- **Phase Three – DOE Contribution 10%**
  - January 2009 to March 2010
  - Post CO2 Flood Monitoring (Water Injection)
  - Continue Tech Transfer Activities
Summary

- Oil displaced by CO2 injection is being produced from offset leases—primarily Colliver A
- Carbon dioxide concentration in Colliver A7 may have peaked
- Oil production from CO2 pilot lease appears to be stable (3.5-5 B/D-avg~4.5 B/D)
- Estimated incremental oil recovery attributed to CO2 injection from all leases is 6.92 MCF/BBL as of 9/30/08
- Reservoir heterogeneity exceeds initial estimates. Current reservoir model does not represent reservoir heterogeneity correctly
- 10 acre pilot was too small to develop a commercial project
Project Management
Budget Period II-2008

- Operate project until effective displacement ends in pilot and adjacent leases.
- Revise reservoir description to improve capability of reservoir model to match and predict production
- Consider the possibility of expanding the project to commercial scale
Additional Information

Accessible by from web

- http://www.torp.ku.edu/

Website includes data, reports and PPT presentations