Center for Energy Economics
20th Annual Meeting
December 9-10, 2015

Technology White Space
&
The Effect of Oil Price Decline on Innovation

Robert Kleinberg
Schlumberger
Brilliant New Technology, Or Something Else?
Recovery Methods
Conventional Oil

Primary Recovery
- Lithostatic Pressure
- Solution Gas Drive
  - Artificial Lift

Secondary Recovery
- Pressure Maintenance
  - Water Drive
  - Gas Drive

Tertiary Recovery
- Carbon Dioxide
- Steam
- Miscible Solvent
- Surfactant
Recovery Methods
Tight Oil

Primary Recovery

Lithostatic Pressure

Solution Gas Drive

Artificial Lift

EIA Conference, July 2014
Today

Same Techniques, Even More Brute Force

- No more derisking
  - Retreat to sweet spots

- Superfracks
  - Longer laterals
  - More water
  - More proppant

- Back to slickwater
  - Replacing technically superior gel fracks
  - Propane fracks have died

- Focus on OPEX breakeven
Does a Low Price Environment Encourage Innovation?

No

Familiar prospects developed in familiar ways

Operators: An end to “science experiments”

Service companies: Major cuts in resources, including R&D

Scaling back or withdrawal from university collaborations

Hiring freeze cuts off major source of new ideas
Case Study: Service Company A

Massive layoffs: ~ −25% yoy

   Easy-to-replace personnel first, but Company A quickly reached bone

Clearing out of senior staff

   No costly retirement incentives, but old-timers know the party is over (again) and is unlikely to resume soon.

R&D budget reduced

   No new hires
   No CAPEX
   No interns
   No travel budget
   No pay increases
   No Christmas Party

E. Scrooge, CEO
Company A
Schlumberger Gave Back 24% of Its Revenue
40% of Its Net Income

(1) Annual rate, excluding fourth quarter
(2) Includes charge against earnings
Schlumberger Research & Engineering

2004-2014: Laissez les bon temps roulez
2015: Short Sharp Shock

Great Recession

-16%
Refrac

Realization that there are many ways to do it wrong
  Remediation of heel but not toe
  Screen outs

Incremental technology improvements

Service company marketing push
  Fiscal incentives, some with Wall Street involvement
In-Fill Drilling

No longer controversial, now part of the business plan
Cross-well interference is usually temporary

Multi-well pads: 5 wells destined to increase to 30

Maintains roughly-even flows in gas gathering systems
As do DUCs (drilled uncompleted wells)

Especially attractive in stacked plays
Marcellus-Utica
Middle Bakken-Three Forks
Permian Basin: Wolfberry et al.
Tight Oil EOR?
Huff & Puff is the Most Promising Method

<table>
<thead>
<tr>
<th>System</th>
<th>Carbon Dioxide</th>
<th>Miscible Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported by</td>
<td>Government</td>
<td>Industry</td>
</tr>
<tr>
<td>Ancillary Problem Addressed</td>
<td>Climate Change</td>
<td>Flaring</td>
</tr>
<tr>
<td>Barriers</td>
<td>see below</td>
<td>Gas processing</td>
</tr>
<tr>
<td>Activity</td>
<td>Many academic papers; some lab tests</td>
<td>A few SPE papers</td>
</tr>
</tbody>
</table>

Petroleum industry lives in a CO$_2$ constrained world

- Limited supply, in the absence of carbon capture regime
- Carbon capture is expensive
  -> greater than the social cost of carbon
- Pipeline infrastructure limited
End