I HATE SALES. CAN YOU CROSS-TRAIN ME TO BE AN ENGINEER?

ABSOLUTELY. ALL YOU NEED IS A TIME MACHINE AND A BRAIN WITH TWICE AS MANY FOLDS AS YOUR CURRENT MODEL.

MAYBE I COULD TRY RESERVES.

THAT'S JUST LIQUOR AND GUESSING.
SPEE Monograph 4 -- Committee Members

Jim Erdle (CMG)

Creties Jenkins (Rose & Associates)

John Lee (SPEE, Univ of Houston)

Casey O’Shea (IHS/Fekete)

John Ritter (SPEE, Occidental Petroleum)

John Seidle (SPEE, MHA Petroleum Consultants)

Darla-Jean Weatherford (TextRight, technical editor)

Scott Wilson (SPEE, Ryder Scott)
SPEE Monograph 4 -- Outline

1. Definition of Unconventional Reservoirs (UCR)
2. Reservoir Characterization Aspects of Estimating Developed Reserves in UCR’s
3. Drilling, Completions, and Operational Aspects of Estimating Developed Reserves in UCR’s
4. Classical Arps’ Decline Curve Analysis (DCA)
5. Fluid Flow Theory & Alternative Decline Curve Methods
6. Analytical Models
7. Modern Performance Analysis
8. Discretized Models
9. Probabilistic Methods and Uncertainty in Forecasts and Estimated Ultimate Recovery
10. Summary of Current Technology and Expected Future Trends
SPEE Monograph 4 -- Timeline

- 1 Dec - Revised chapter drafts to editors
- 1 Jan 2014 – Manuscript draft to authors
- 1 Feb – Revised manuscript to SPEE Executive Committee & RDC
- 1 Apr – Comments back from SPEE Ex Comm & RDC
- 1 May? 1 Jun? – Manuscript released to sister societies
- Release + 2 mons – Comments back from sister societies
- Release + 4 mons – Respond to sister societies, final to SPEE Ex Comm
- Monograph in print 4Q 2014?
US unconventional oil production forecast to be a major source for next 30+ years

EIA AEO 2013, Reference Case
US unconventional gas forecast to be increasing fraction of domestic production over next 30 yrs

Figure 91. Natural gas production by source, 1990-2040 (trillion cubic feet)

US Natural Gas Production by Source, EIA
Annual Energy Outlook 2013
SPEE Monograph 4 – Concerned with 3 unconventional reservoirs

1. Shales
2. Tight sands and carbonates
3. Coals
Permeabilities of unconventional reservoirs

Ref: Schlumberger “Oilfield Review”
Geology is important – Haynesville deposition

Ref: Martin & Ewing, 2009
Geology is important – Eagle Ford geochem

Ref: US EIA
Workflow 1a – Validate data – Bakken well
Workflow 1b – Validate data – DJ Niobrara well
Workflow 2a – DJ Niobrara well - construct diagnostic plot(s)
Workflow 2b – Diagnostic plot variables

Normalized rate = \( q_o/(\pi - p_{wf}) \)

Material balance time = \( N_p/q_o \)
Workflow 2c – DJ Niobrara well - identify flow regimes

½ slope line

6.1 years

Unit slope line
Workflow 3 – Fit data to selected models

Hyperbolic

Stretched Exponential

Duong

Weibull

Ref: Mishra, 2012, SPE 161092
Workflow 4a – Forecasts with selected models

Figure 27 Example 2, comparison of 30-year forecasts for $q$

Figure 28 Example 2, comparison of 30-year forecasts for $G_p$

Ref: Mishra, 2012, SPE 161092
## Workflow 4b – Forecast summary

<table>
<thead>
<tr>
<th>model</th>
<th>30 yr EUR, mmcf</th>
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<tbody>
<tr>
<td>Arps</td>
<td>407</td>
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<tr>
<td>SEDM</td>
<td>346</td>
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<tr>
<td>Duong</td>
<td>392</td>
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<tr>
<td>Weibull</td>
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<table>
<thead>
<tr>
<th>level</th>
<th>30 yr EUR, mmcf</th>
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</thead>
<tbody>
<tr>
<td>P90</td>
<td>324</td>
</tr>
<tr>
<td>P50</td>
<td>369</td>
</tr>
<tr>
<td>P10</td>
<td>403</td>
</tr>
</tbody>
</table>
Workflow 5a – Eagle Ford well - Simulation grid

Ref: Erdle, SPEE mono 4
Workflow 5b – Model history matches

Ref: Erdle, SPEE mono 4
Workflow 5c – Simulation forecasts

Ref: Erdle, SPEE mono 4
Workflow 5d – Eagle Ford well - Simulated EUR’s

<table>
<thead>
<tr>
<th>Run #</th>
<th>HM Error (%)</th>
<th>Oil EUR (stb)</th>
<th>Gas EUR (MMscf)</th>
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<td>651,310</td>
<td>915</td>
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<tr>
<td>373</td>
<td>5.7327</td>
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<td>976</td>
</tr>
</tbody>
</table>

Oil EUR’s, stb
P90 - 597,239
P50 - 649,306
P10 - 713,591

Gas EUR’s, mmcf
P90 - 863
P50 - 917
P10 - 976
Interesting but…

What do we do when we have to evaluate 800 wells in a week?
Real life 1 – Bakken data
Real life 3 – Bakken 50 yr forecast
EUR = 1,117 mmbo
Real life 4 – Bakken 50 yr forecast w/ 8% min decline
EUR = 740 mbo
What do you do when you have to evaluate 800 wells in a week?

1. Decline curve analysis with minimum decline?

2. DCA w/ min decline + add’l analysis of high value wells?

3. Other?
SPEE Monograph 4 – Summary 1

• UCR’s important US oil and gas source for next 30+ yrs

• Geology is important UCR control

• UCR developed reserves workflow—Ideal case
  1. Assess data quality
  2. Construct diagnostic plots
  3. Fit simple models
  4. Forecast simple models
  5. Simulation
SPEE Monograph 4 – Summary 2

- UCR developed reserves workflow—Common case
  1. DCA with minimum decline

- Monograph 4 in print 4Q 2014?
Thank you!

Monograph 4 committee is interested in your comments--

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