Discussion – SPEE Monograph 3
“Guidelines For The Practical Evaluation of Undeveloped Reserves in Resource Plays”

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Houston
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Genesis of the Resource Play Committee

In 2008, the Society of Petroleum Evaluation Engineers recognized few, if any, guidelines existed to assist evaluators with determining reserves and resources for “Resource Play” hydrocarbon reservoirs. Consequently, the SPEE Board formed a committee to prepare such guidelines. Starting in 2009, our Resource Play Committee began a dialogue on issues associated with these types of oil and gas reservoirs.
Resource Plays Committee Participants

Robin Bertram – Calgary
Gary Gonzenbach – Austin
Jim Gouveia – Calgary
Brent Hale – Dallas
Russell Hall – Midland
Paul Lupardus – OKC
Paul McDonald – Dallas
Nathan Meehan – Houston
Bill Vail – Houston
Marshall Watson - Midland
Monograph 3 – “Guidelines For The Practical Evaluation of Undeveloped Reserves in Resource Plays”

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Chapter 2 – Statistics – A Brief Lesson
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Chapter 1 – What is a Resource Play?

Typical Resource Play Reservoirs

- Shale Gas
- Coalbed Methane
- Tight Gas Reservoirs
- Basin Centered Gas Systems
- Certain Tight Oil Reservoirs
Exhibits a **repeatable** statistical distribution of EURs

Offset well performance is not a reliable indicator of PUD performance

Contains continuous hydrocarbon systems that are regional in extent

Hydrocarbons are not held in place by hydrodynamics
Resource Play - Tier 2 Criteria

- Requires Extensive Stimulation to Produce
- Produces Little In-situ Water
- Does Not Exhibit an Obvious Seal or Trap
- Low Matrix Permeability (< 0.1 mD)
ALL VIRGINIA WELLS --- CBM WELLS HIGHLIGHTED IN GREEN

<table>
<thead>
<tr>
<th></th>
<th>Oil &amp; Gas Wells</th>
<th>CBM Wells</th>
</tr>
</thead>
</table>

Buck Knob

Nora

Oakwood

Buck Knob

DICKENSON

WISE

RUSSELL

NORA

LEE

SCOTT

WASHINGTON

SMYTH

GRAYSON

TAZEWELL

WYTHE
Distribution of EUR results

Well Count: 1121
Mean: 476 MMcf
Median: 394 MMcf
Chapter 2 - Statistics

Chapter Highlights

– Importance & Relevance of Lognormal Distributions
– Use of P10/P90 ratios as a measure of uncertainty for Lognormal Distributions
– Recommendations for Minimum Sample Size
– Aggregation
Use of P10/P90 ratios

Plotting EURs using a probit scale
Minimum Sample Size

Confidence in Achieving (Mean less 10%) or More vs. Sample Size

Confidence of Meeting or Exceeding

Sample Size

P10/P90 = 5  P10/P90 = 10
Aggregation

Figure 2 - Impact of Aggregation on a Lognormal Distribution With a P10/P90 Ratio of 10
More Wells leads to tighter spread between P10 and P90
Chapter 3 – What Constitutes a Proved Location in a Resource Play?

How many offset locations can be classified as proved?

Monograph 3 makes the case that statistical methods can be applied as “reliable technology” for quantifying future development drilling.
Chapter 3 – Analogous Wells

Analogous Wells Have Similar:
- Geology
- Completion Procedure
- Lateral Length
- Spacing
- Interference
- Wellbore Orientation
### Making the Transition to a Statistical Analysis

**Well Counts for Various Stages of Development**

<table>
<thead>
<tr>
<th>RATIO OF ANALOGOUS PRODUCING WELLS TO RECOMMENDED SAMPLE SIZE</th>
<th>PHASE OF RESOURCE PLAY DEVELOPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early</td>
</tr>
<tr>
<td>P&lt;sub&gt;10&lt;/sub&gt; /P&lt;sub&gt;90&lt;/sub&gt; &lt; 4, APPROXIMATE WELL COUNT</td>
<td>&lt; 50</td>
</tr>
<tr>
<td>P&lt;sub&gt;10&lt;/sub&gt; /P&lt;sub&gt;90&lt;/sub&gt; 4 TO 10, APPROXIMATE WELL COUNT</td>
<td>&lt; 50-200</td>
</tr>
<tr>
<td>P&lt;sub&gt;10&lt;/sub&gt; /P&lt;sub&gt;90&lt;/sub&gt; 10 TO 30, APPROXIMATE WELL COUNT</td>
<td>&lt; 200-700</td>
</tr>
</tbody>
</table>
How Many Locations Can Be Identified as Proved?

PUD counts at Various Stages

<table>
<thead>
<tr>
<th>PHASE OF RESOURCE PLAY DEVELOPMENT</th>
<th>Early</th>
<th>Intermediate</th>
<th>Statistical</th>
<th>Mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECOMMENDED NUMBER OF PUD OFFSETS PER PRODUCING WELL (VERTICAL WELLS)</td>
<td>4</td>
<td>8</td>
<td>Statistical</td>
<td>Statistical</td>
</tr>
<tr>
<td>RECOMMENDED NUMBER OF PUD OFFSETS PER PRODUCING WELL (HORIZONTAL WELLS)</td>
<td>2-4</td>
<td>4-8</td>
<td>Statistical</td>
<td>Statistical</td>
</tr>
</tbody>
</table>
Monograph 3 recommends using the **Expanding Concentric Radii** method.

This method compares ever increasing areas of potential reservoir around **Anchor** wells to the EUR distribution of the **Anchors**.

If the EUR statistical distribution for each area is comparable, then each area is an extension of the resource play, and areas bound by the concentric circles should be **Proved** reserves.
Expanding Concentric Radii Method

First, create a statistical distribution for wells located in the center of the concentric circles, the “Anchor” wells.

Anchor Well Located In First Circle (Closest Area)
Expanding Concentric Radii Method

The second step creates subsequent statistical distributions for wells located in each concentric circle.

- **Test Set 1**
  - Inside 0.5 mile

- **Test Set 2**
  - Inside 1 mile

- **Test Set 3**
  - Inside 2 miles
Expanding Concentric Radii Method

- **Step 1** – Create one statistical distribution for “Anchor” wells
- **Step 2** – Create a subsequent statistical distribution for wells positioned in Expanding Concentric Radii (Test Sets)
- **Step 3** – Compare each statistical distribution from the test sets to the “Anchor” wells
Expanding Concentric Radii Method

Legend

- Anchor Well
- Producing Well (Non-Anchor)

Test Set 1
Test Set 2

0.5 Mile Radius Distribution
1 Mile Radius Distribution
Expanding Concentric Radii Method

- Distribution
- Data Points - 54
  - P99 = 17025.0
  - P90 = 31201.0
  - P50 = 65594.2
  - Mean = 75996.1
  - P10 = 137899.4
  - P1 = 252722.6

EUR (barrels)
Determining “Proved” Area From Well Control

Legend
- Anchor Set 1
- Analogue Wells
- Geologic Subset 1
- Project 1
- Non Contiguous Drilling Area
- LKH
- Resource Play

Clipped Polygons within Expanding Concentric Circles
Chapter 4 - Estimating Reserves for Undrilled Locations in a Resource Play

- Identify Analogous Wells
- Create a Statistical Distribution for Analogous Wells
- Determine the Number of Drilling Opportunities
- Prepare a Monte Carlo Simulation
- Estimate Reserves using PRMS Definitions
Alternatives for Running Monte Carlo Simulations

- Method #1: Use $P^\wedge$ to approximate $P_{90}$ value
- Method #2: Apply aggregation factor provided in Monograph
Method #1 - What Is $P^\wedge$?

- $P^\wedge$ (P-hat) is the Average of $P_{\text{mean}}$ and P50 for the single well EUR distribution
- $P^\wedge$ is Often Close to the P90 Value for an Aggregation of Wells
- Consequently, it is a useful measurement when evaluating a large group of wells
- Recommended for use when comparing various EUR distributions in our Concentric Radii Method
Method #2 - Proved Aggregation Factor

![Graph showing the relationship between well count and proved aggregation factor with different P10/P90 values.](image)
Concepts that deviate from past procedures

- Expanding beyond the one-offset constraint
- Proved areas or enclosures as defined by this method are not deterministic
- Aggregation results and P90 will vary as a function of the well count or remaining locations
Final Comments on Evaluating Resource Plays

- Our Resource Play Committee can not over-emphasize the **necessity** of exercising good judgment in evaluating resource plays.
- Maintain perspective
- Rely on experience
- We see Monograph 3 as a starting point, not the final say on these issues.
Current Status – Monograph 3

- The Resource Play Committee has submitted a Final Draft to the SPEE Board.
- This draft is currently undergoing a final round of peer review.
- When approved, we anticipate that an electronic version will be made available to the public.
Disclaimer

Please note that all of the views and opinions expressed within this presentation are opinions held solely by the author and by members of SPEE’s Resource Play Committee; they represent neither the opinions of *DeGolyer and MacNaughton* (Texas Registered Engineering Firm F-716) nor of its management.
I’d like to express my sincere appreciation to all the companies that participated in this work:

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