Uncertainty in Unconventional Resource Assessment

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TD Newcrest’s 2010 Calgary Unconventional Oil & Gas Forum
July 13-15, 2010
Key Issues

“How the shift to the evaluation of Unconventional Resources changes the evaluation workflow”

• Some key issues:
  • Limited data availability in emerging regions
  • Understanding the geology
    • OGIP or OOIP? Cutoffs and effective OGIP/OOIP?
  • Production data? Type curves?
  • Recovery factors?
  • Optimal level of development?
Limited Data Availability

- Limited data availability suggests limited certainty
- Assigned volumes will reflect this certainty
  - Portions of the reservoir remain ‘undiscovered’
  - Portions of the reservoir booked as Contingent Resources
  - Large distribution of results from low estimate to high estimate
- Additional data acquisition helps to remove this uncertainty
• This was a much more simple definition with conventional plays.
• To be discovered, must be “known accumulation” i.e. individual body of petroleum in a reservoir, penetrated by a well.
• Furthermore, to be “known” a well must have demonstrated the existence of hydrocarbons by testing (however, log and/or core an nearby analogy may suffice).
Discovered vs. Undiscovered

- How far away from confirmed productivity does the “known” accumulation extend?
- What about log control only (remember low phi)? Or seismic control only?
- At what point are we back into “moose pasture”?
By their very nature, tight and unconventional reservoirs make standard log and core analysis more complex:

- Parameters such as net thickness, porosity, $S_w$ not unique
- Free gas-in-place and adjustment for adsorbed gas in shales
- What is the OGIP?
- What is the sensitivity to cutoffs and the resulting effective OGIP?
### Volumetric Uncertainties

<table>
<thead>
<tr>
<th>CUTOFF LEVEL #1</th>
<th>CUTOFF LEVEL #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h_1 = 35$ m</td>
<td>$h_2 = 75$ m</td>
</tr>
<tr>
<td>$\Phi_1 = 5.6%$</td>
<td>$\Phi_2 = 4.5%$</td>
</tr>
<tr>
<td>$Sw = 28%$</td>
<td>$Sw = 35%$</td>
</tr>
<tr>
<td>HCPV = 1.41 m</td>
<td>HCPV = 2.19 m (+55%)</td>
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</tbody>
</table>

- In theory both of these are accurate ...however,
- Further testing and long-term production will demonstrate which is more correct
- A pilot region which is fully developed, or even “over developed” may prove contribution from the lower quality (phi, k) rock
Volumetric Uncertainties

This requirement for data is compounded with Shale gas analysis:

- Specialized Core Analysis
- Gas Content (Desorption analysis and Adsorption Isotherm)
- Gas Composition
- Vitrinite Reflectance
- Rock-Evaluation Pyrolysis
- Mineralogical Analyses
Production and Test Data

- Uncertainty in production analysis:
  - Working with early time, or test data only
  - Lack of long-term decline trends (very little data > 2-5 yrs)
- Very long transient flow periods
  - This is dictated by low permeability and large gas accumulations
  - Helps establish IP stats and trends
  - Dictates use of type-curves to help quantify uncertainty
- Does not yet define EUR (but options are limited)
Production and Test Data

- Example well with nearly two years history:
- Three decline trends shown to match the historical data:
  - All three trends accurately match early time data
- EUR ranges from 2.9 to 3.9 BCF EUR
Production and Test Data

Example well with nearly two years history:

- EUR ranges from 2.9 to 3.9 BCF EUR
- RF ranges from 35 to 50 percent (est. 8 BCF OGIP)
- Infill opportunity?
- Is OGIP correct?
- Is DCA reliable yet?
- Uncertainty on all parameters at this stage!
Example provided:

- Multiple hz wells have been drilled
- Production (2+yrs) has created pressure drop in regions
- Monitoring of pressure (at existing, new or observation wells) will let you better define if the OGIP/OOIP in your geological model is too high or too low.
- Sensitivity to cutoffs employed?
Of course, all of the analysis described here is not static!

As technology changes the way the resources are developed, the analysis and the results are required to change also.

This dictates the need for an experienced G&G and Engg team to stay on top of it.
In Review

- Study Area Defined
- OGIP/ OOIP estimates prepared
- Sensitivity to cutoffs examined
- Production data is analyzed
- Regional RF estimated
- Type Curves
Thank You

- Questions?
- Comments?

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