DEFINING NET PAY

• What is “net pay”?  
• Several definitions; sometimes confusing  
• How we determine reserves depends on objectives and data available  
  – Static: resource and reserve calculations; what is there and estimated recoverable?  
  – Dynamic: what will flow?  

• Data used  
  – Logs  
  – Core  
  – Well tests  
  – Production  
  – Seismic
NET SAND / PAY, RESOURCE AND RESERVE DETERMINATIONS

Methods

• **Volumetric (Static)**

• **Dynamic**

• Production History

• Analogy
DETERMINING HYDROCARBONS IN-PLACE

• Static Definition
  \[ \text{OOIP} = 7758 \text{ Ah} \ \phi(1 - S_w)/B_{oi} \]

• Assumes net properties

• Evaluating net
  – Identify any area without HC’s
  – Logs: apply series of criteria
    • \((S_w > \text{cutoff}) \ \text{AND} \ (V_{sh} > \text{cutoff}) \ \text{AND} \ (\phi < \text{cutoff}) \ \text{etc…}\)
    • Compare with core, if available
    • Calibrate to seismic?
Fluid Distribution

<table>
<thead>
<tr>
<th>VCL</th>
<th>ILDC</th>
<th>RHOCN</th>
<th>GAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 dec</td>
<td>0.2</td>
<td>1.65</td>
<td>1 us/f</td>
</tr>
<tr>
<td></td>
<td>ohmm</td>
<td>2.65</td>
<td></td>
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<table>
<thead>
<tr>
<th>CNLSS</th>
<th>BVW</th>
<th>OIL</th>
<th>BVWG</th>
<th>SW</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>1 dec</td>
<td>0</td>
<td>1</td>
<td>-1</td>
</tr>
</tbody>
</table>

Graph showing fluid distribution with various readings and measurements.
## INPUTS TO VOLUMETRIC RESERVES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRC</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>SPC</td>
<td>-160 MV</td>
<td>40</td>
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<td>ACAL</td>
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<td>16</td>
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<tr>
<td>ILDC</td>
<td>0.2</td>
<td>200</td>
</tr>
<tr>
<td>RHOC</td>
<td>1.95</td>
<td>2.95</td>
</tr>
<tr>
<td>DC</td>
<td>150 us/f</td>
<td>50</td>
</tr>
<tr>
<td>ILDC</td>
<td>0.2</td>
<td>200</td>
</tr>
<tr>
<td>SNC</td>
<td>0.45</td>
<td>-0.15</td>
</tr>
<tr>
<td>MLLCF</td>
<td>0.2</td>
<td>200</td>
</tr>
</tbody>
</table>

Calculate $\overline{\phi}$, $\overline{Sw}$

- Vshale
- Thickness
- Porosity

Modfoed from NExT, 1999
SOME TERMINOLOGY

**Explanation**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFE</td>
<td>Derrick Floor Elevation</td>
</tr>
<tr>
<td>MD</td>
<td>Measured Depth</td>
</tr>
<tr>
<td>TVD</td>
<td>True Vertical Depth</td>
</tr>
<tr>
<td>TVDSS</td>
<td>True Vertical Depth SubSea</td>
</tr>
</tbody>
</table>

(modified from Jahn and others, 1998)
MORE TERMINOLOGY

Isochore = Isopach (Horizontal Surface)

Also, called True Stratigraphic Thickness (TST)

Isopach is measured perpendicular to surface (true thickness)

Isochore is the vertical thickness of an interval

Isochore thickness is greater than isopach thickness for dipping strata

Mapping software determines isochore
CORRELATION TECHNIQUES

DATUM

Marker beds

Log patterns
WELL-LOG CORRELATION

Stratigraphic Cross Section

(modified from Jahn and others, 1998)
STRUCTURAL CROSS SECTION

(modified from Jahn and others, 1998)
RESERVOIR DETERMINATION

<table>
<thead>
<tr>
<th>API Units</th>
<th>Depth</th>
<th>Interpretation</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>Non Reservoir</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>Reservoir</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>Non Reservoir</td>
</tr>
<tr>
<td>GR 100</td>
<td></td>
<td>Reservoir</td>
</tr>
<tr>
<td>Gamma Ray Curve</td>
<td></td>
<td>Non Reservoir</td>
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</table>

- Sand Line (0% Shale)
- Shale Line (0% Sand)
- Net Sand Cut-Off Line (50% Shale)
Common alternatives for net pay definition

- Use static criteria
  - $(Sw > \text{cutoff}) \text{ AND } (Vsh > \text{cutoff}) \text{ AND } (\phi < \text{cutoff})$ etc…

- Try to correlate $k$ with log measurements
  - Use core data
DEFINING NET PAY

Core data & logs for net pay determination

- Define \( k \) cutoff e.g., 1\( \text{mD} \)
- Define \( \phi \) value e.g. \( \phi = 10\% \)
- Apply net pay using log \( \phi \) value \( \phi > 10\% \)
- Note errors arise
  - \( k > 1 \) AND \( \phi < 10\% \)
    - 11 of 86
    - \( \text{Prob}(k > 1 \text{ AND } \phi < 10) = 13\% \)
  - \( k < 1 \) AND \( \phi > 10\% \)
    - 2 of 86
    - \( \text{Prob}(k < 1 \text{ AND } \phi > 10) = 2\% \)
  - \( \text{Prob}(k > 1 \mid \phi < 10\%) = 24\% \)
Deciding on predictor log(s)
- What controls perm?
- Carbonates
  - Grain size and sorting less effect
  - Diagenesis more important
  - Critical thresholds often seen
    - Below $\phi = 10$, $k$ variable
    - Above $\phi = 10$, $k$ systematic
## RESERVOIR DETERMINATION

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- **Sand Line (0% Shale)**
- **Shale Line (0% Sand)**
- **Net Sand Cut-Off Line (50% Shale)**
- **Gamma Ray Curve**
Net-to-Gross Determination

Net/Gross (N/G) = 15/20 = 0.75

(modified from Jahn and others, 1998)
Defining Gross Thickness, Net Sand, and Net Pay

Measure thickness (MT) of Well 1 < MT of Well 2

(modified from Jahn and others, 1998)
Combination Trap:
Faulted Anticline and Stratigraphic Pinch-Out
Structure Map and Cross Section

(modified from Jahn and others, 1998)
Summary

- **OOIP** = 7758 Ah $\phi(1 - S_w)/B_{oi}$
- Oil reserves = OOIP x R.F.
- **OGIP** = 43,560 Ah $\phi(1 - S_w)/B_{gi}$
- Gas reserves = OGIP x R.F.
- Remaining reserves = Reserves at original conditions - cumulative production

Modified from NExT, 1999