**Prospect Evaluation**

**Definitions**

- **A Play**: An exploration concept that includes a specific source, reservoir, and trap type.
- **A Lead**: An possible trap, data is not sufficient to fully map it.
- **A Prospect**: A specific trap that has been identified and mapped but has not been drilled yet.
- **Wildcat Well**: A well far from previous drilling.
- **Reserves**: Oil and gas that have been drilled and can be produced economically.

**Exploration Strategy**

1. Global Basin Analysis
   - Complete Basin Studies
   - Acquire New Exploration Licenses
2. Develop Play Concepts
3. Define Exploration Play Areas
4. Evaluate Prospects
5. Identify Drillable Prospects
6. Drill Exploration Wells
7. Develop New Field

**CRITICAL DECISIONS?**

- Which Play to Enter
- Which Prospects to Drill

**Play and Prospect Decisions Require Methodical Analysis**

- Technical Risk Evaluation
- Economic Evaluation
**Basin/Play Evaluation**

1. Basin Scale Assessment
2. Estimation of undiscovered potential within each Play
3. Volumetric Calculations (Reserve estimates)
4. Assessment of Prospect-Specific Risk
5. Economic Analysis
   - Infrastructure
   - Market
   - Price
   - Taxes and Royalties
   - Political Risks

**Probability of Success**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Risk (0-1.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability hydrocarbon charge</td>
<td>0.80</td>
</tr>
<tr>
<td>Probability of good reservoir</td>
<td>0.80</td>
</tr>
<tr>
<td>Probability of a trap</td>
<td>0.70</td>
</tr>
<tr>
<td>(Multiply all the factors)</td>
<td>Chance of Success 0.44</td>
</tr>
</tbody>
</table>

**To drill or not to drill?**

- Basin-scale **Conventional** Play Assessment:
  1) Identify areas of a basin where there are: source rocks, reservoirs and traps
  2) Identify prospects in those areas
  3) Rank the prospects by risk
  4) Drill the best one, then re-evaluate the others

**Drilling Success Rates**

[Graph showing success rates in the U.S.A. with different categories: Development wells, Exploratory Wells, Seismic Stacking, 3D Seismic, True Wildcat wells.]
Drilling of Exploration Wells in US

Dry Exploration Wells Drilled

More Detailed Risk Factors
- Hydrocarbon charge
  - Source Rock Quality (TOC, Kerogen type)
  - Maturity of Source Rock
  - Migration Pathways
- Reservoir
  - Porosity
  - Permeability
- Trap
  - Closure (Trap volume)
  - Top Seal, Fault Seal (Trapping efficiency)
  - Timing

Drilling of Development Wells in US

Dry Development Wells

Basin-wide Play Map
**Probability of Play Success**

A. Everything is cool (100%)
B. No structural traps (20%)
C. Long migration required (50%)
D. Long migration and bad reservoir (30%)
E. Poor source (50%)

**Prospects Evaluation, Barents Sea**

Jurassic

- Gertrude Prospects
- Polonius Prospect
- Claudius Lead

**Hamlet**

- Geology: 138 billion scm (gas)
- RESERVOIR POTENTIAL:
  - Pay Aerial Extent = 500 km²
  - Pay Thickness = 750 m
  - Porosity = 14%
  - Saturation = 60%
  - 431 Billion scm

- Risk Elements:
  - Source Presence = 1
  - Source Maturity = 1
  - Reservoir Quality = 0.6
  - Trap Quality = 0.6
  - Migration/Trap Timing = 0.8

**RISK ELEMENTS:**

<table>
<thead>
<tr>
<th>Risk Element</th>
<th>P50</th>
<th>P10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pay Aerial Extent</td>
<td>200km²</td>
<td>340km²</td>
</tr>
<tr>
<td>Pay Thickness</td>
<td>750m</td>
<td>1050m</td>
</tr>
<tr>
<td>Porosity</td>
<td>7%</td>
<td>14%</td>
</tr>
<tr>
<td>Saturation</td>
<td>40%</td>
<td>60%</td>
</tr>
</tbody>
</table>
**Probability Distribution**

Every risk element of a prospect is imperfectly known before drilling.

\[ P_{90} = \text{"I am 90% sure that it will be bigger than this"} \]

**Volumetric calculation**

- Reserves = Area of trap × Net reservoir thickness × Porosity × Hydrocarbon saturation × Recovery factor × Formation volume factor

**Cumulative Probability**

- P95 = Min
- P90 = Most likely
- P10 = Max

**Area Risk**

- Fault-dependent closure
- Independent closure
**Volumetric Example**

Thickness: 48 ft
Net/Gross: 0.40
Net Thickness = 19 ft

**Net Reservoir – Set Porosity Cut off**

Only include the high porosity reservoir

**Recovery Factor**

- Oil in place vs. Reserves
- Most of the oil stays stuck in the reservoir
- Reserves “can be produced economically”
- Varies widely depending on permeability, oil viscosity, reservoir pressure, etc.
- 30% average?

**Formation Volume Factor**

- Change in volume from reservoir to surface conditions
- Depends on Reservoir Temp, Pressure and gas-oil ratio
- 1 to 3.0
- High shrinkage oil $B_{oil} = 1.4$
- Low Shrinkage oil $B_{oil} = 1.2$
**Alaska North Slope Formation**

**Volume Factor (FVF)**

- Lighter Oil
- Heavier Oil

**GERTRUDE Prospect**

**RISK ELEMENTS:**
- Source Presence = .8
- Source Maturity = .6
- Reservoir Quality = .7
- Trap Quality = .7
- Migration/Trap Timing = .6

**GEOMETRY:**
- **RESERVOIR POTENTIAL:**
  - Pay Areal Extent = 25 km² - 27 km²
  - Pay Thickness = 140 m - 150 m
  - Porosity = 8% - 11%
  - Saturation = 70% - 80%

**ESTIMATED RESERVES:**
- Risk Elements x Res. Potential
  - P_{50} = 0.80 billion scm
  - P_{10} = 6.84 Billion scm

**How to compare two prospects?**

- **Small size, Low Risk**
  - Reserves = 6.8 billion
  - Chance of success = 30%
  - Risked volume = 6.8 * 0.30 = 2 billion scm

- **Big size, High Risk**
  - Reserves = 14 billion
  - Chance of success = 12%
  - Risked volume = 14 * 0.12 = 1.68 billion scm

“Risked Reserves”
**Take Home Ideas**

- Exploration is about reducing risk by collecting the right data
- Risk comes from uncertainty (incomplete knowledge)
- Reserves calculations require quantitative evaluation of all components of the Petroleum System