**Field Development**

**Stages of the Search for Oil**
- Regional Assessment
- Exploration
  - Discovery
  - Field Delineation
- Infrastructure Development
- Field Development
- Abandonment

**Field Delineation**

**Development objectives**
- An oil well is a financial investment
- Maximize Rate of Return ($/year or oil barrels/year)
- Maximize Ultimate Recovery (Total $ or total oil production)

**Key Questions:**
- Is it economically viable?
  - Total reserves? → Volumetric Assessment
  - Production Rate? → Reservoir Model/Analogs
  - Well Life? → Reservoir Model/Analogs
  - Costs?
    - Leasing, Drilling, Completion, Infrastructure, Production
  - Price of oil or gas?

**Reservoir Modeling**

Want to know:
- Production rate for oil, gas and water
- Evolution of Pressure
- Life of each well
- Optimal Well density
- Production strategy:
  - Pumping?
  - Gas injection?
  - Water Injection
  - Frac’ing?
Data Needed

- Field Geometry → Seismic and Wells
- Reservoir thickness and distribution
- Barriers (Faults, pinch outs, etc)
- Reservoir Properties:
  - Porosity distribution
  - Permeability (matrix perm, fracture perm)
- Fluid Properties
  - Oil saturation
  - Gas/Oil ratios
  - OWC, GOC

Building a reservoir model

1. Define facies in core
2. Relate facies to log
3. Predict facies in wells without core, but with good logs
4. Fill the gaps between wells

28 cores
1600 wells
108 Million Cells

3D Reservoir Model

Reservoir Modeling
Grid of Reservoir Properties

Fractures in Reservoir Simulations

- Matrix Permeability
- Fracture Permeability

Distributed Fracture Network

Model Production History for Each Grid Cell

- Oil Rate
- Water Cut
- After 1 year of history
**History Matching – Test of the Model**

Diamonds are measured, lines are model production

LP Sand, Eugene Island Field, Offshore Louisiana

Guerin, Gilles 2000

**Field Life**

Pressure Regimes- Primary Gas

Exsolation Drive

- Initially gas is dissolved in the oil
- Continuous pressure decline
- Gas peak after oil peak
- Low water production
- Low recovery factor

Recovery factor= 5-30%

Gluyas & Swarbrick, 2003
**Dissolved Gas vs Gas Cap**

- Gas cap expands
- Gas helps push the oil down
- Low water production
- Perf the wells in the oil zone
- Re-inject the gas

Recovery factor= 20-50%

Gluyas & Swarbrick, 2003

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**Water Drive**

- Oil displaces water
- OWC moves up
- Pressure remains steady
- High recovery factor
- Very high water production
- Fractures can flood the wells

Recovery factor= 30-70%

Gluyas & Swarbrick, 2003

**Pressure Regimes- Water Drive**

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Gluyas & Swarbrick, 2003

**Injection Wells –Enhanced Oil Recovery (EOR)**

- Sustain pressure
- Inject Gas, water or CO2 to displace oil
- Line Drive – tilted reservoir

Gluyas & Swarbrick, 2003

**Pattern Drives**

Gluyas & Swarbrick, 2003
**Water follows the highest perm channels**

Injection Well

Production Well

**Water flood issues**

Injection Well

Production Well

In this case water front is even, effective flood

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**Enhanced Oil Recovery - CO₂ Injection**

- CO₂ dissolves in oil at high P
- Works like a solvent
- Oil viscosity decreases
- Alternate CO₂ and water injection
- Water pushes oil towards the production wells

- CO₂ Sequestration

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**Criteria for Screening Reservoirs for CO₂ EOR Suitability**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth, ft</td>
<td>&lt; 8,800 and &gt; 2,000</td>
</tr>
<tr>
<td>Temperature, °F</td>
<td>&lt; 250, but not critical</td>
</tr>
<tr>
<td>Pressure, psia</td>
<td>&gt; 1,200 to 1,500</td>
</tr>
<tr>
<td>Permeability, md</td>
<td>&gt; 1 to 5</td>
</tr>
<tr>
<td>Oil gravity, API</td>
<td>&gt; 27 to 30</td>
</tr>
<tr>
<td>Viscosity, cp</td>
<td>≤ 10 to 12</td>
</tr>
<tr>
<td>Residual oil saturation after waterflood, fraction of pore space</td>
<td>&gt; 0.25 to 0.30</td>
</tr>
</tbody>
</table>

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**Wasson Field CO₂ EOR, West Texas**

120 Mbbls extra