Using Sums not Simulators to Identify the Infill Potential of a Mature Oilfield

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Outline

• Location
• Geology
• Infill Target Roadmap
• Gap Analysis Concept
• Building Reservoir Understanding
• Infill Well Performance Prediction
• Summary
Wytch Farm Field
Location & Reservoir Units

3 Producing Reservoirs

- **Frome**
  - 800m TVD
  - Middle Jurassic

- **Bridport**
  - 925m TVD
  - Lower Jurassic

- **Sherwood**
  - 1585m TVD
  - Triassic

>1 billion bbl STOIIP

- Sherwood
- Bridport
- Frome
Wytch Farm Production History

- **Production highlights**
  - 1st Oil Dec 1987
  - peaked at 105 mbd in 1996
  - currently around 21 mbd

- **Sherwood**
  - high rates, high technology, mature waterflood

- **Bridport / Frome**
  - traditional onshore wells with long lives at low rates

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1st Oil
Wytch Farm Phase 1
Bridport & Sherwood

Nodding Donkeys

1st Oil
Frome

ESP

Horizontal Wells

Vertical & High Angle Wells

ERD Wells

Wytch Farm Phase 2
Onshore Sherwood

Wytch Farm Phase 3
Offshore Sherwood

Infill Drilling
Onshore / Offshore

Waterflood Management

Voidage Replacement
Sherwood is current focus
Remaining Sherwood targets lie in lower quality, more poorly connected upper reservoir
Existing simulation model too coarse to capture detail with remaining targets 1-2 mmstb
Analytical approach developed to assess infill potential
Roadmap for Identification of Infill Targets

**FAQs**
- How much oil was there initially?
- How much has been recovered so far?
- How much will be recovered at CoP?
- How much will be left behind at CoP?

**Needs**
- STOIIP by Region by Zone
- Prod to date by Well / Region by Zone
- Prod to CoP by Well / Region by Zone
- Location of ROS by Region / Zone Incremental vs Acceleration

**Workplan**
- Static Model Rebuild
- Clean up Database Production / Inj
- Surveillance Mapping Zonal allocation
- MBAL Regional Flux
- Graphical Techniques DCA by well
- I.D. Regional Trends WOR vs CUM Oil Cut vs CUM WCUT vs Time Normalise Plots

**Static Targets**
- Fault Shadows
- Flank
- Attic

**Build Reservoir Understanding**

**Production Profiles**
- Rate from rock properties / PI trends
- WCUT, Pressure & Sweep from Surveillance Data & CRE methods
- WCUT increase from DCA trends

**Integrate Understanding Static / Dynamic / Uncertainty**

**GAP Analysis**

Combine analytically to generate recoverable volumes per target
• Need PLT data and a good allocation system for zonal recovery estimation
• Need saturation logs for sweep estimation when drilling new wells
• **So how do you calculate the expected recovery factor?**
Recovery Factor Definition

Max Recovery Factor ($RF_{\text{MAX}}$) = \( \frac{(1-S_{\text{o}} - S_{\text{wi}})}{(1-S_{\text{wi}})} = \frac{A}{B} \)

Expected Recovery = $RF_{\text{MAX}} \times \% \text{ Volumetric Recovery (VR)}$

- So how did we apply this approach to Wytch Farm?
Building Reservoir Understanding #1
Production Data Mining

- Mature fields are their own analogues – make full use of your data

- Generate Classical Reservoir Engineering Plots – Normalise them
GAP Analysis – Sherwood Reservoir

- Static model updated with new top structure and rock property description
- Flux boundaries (hard & soft) identified from static and surveillance data
- STOIIP by Region calculated
- Recovery Factor analysis performed

- GAPs highlighted & targets identified

- **So how do we predict infill well performance?**
Recent infills demonstrate hyperbolic behaviour on start up and level off to exponential decline after 2-3 years.

Rate falls sharply after 1st year due to a combination of transient behaviour and rapid watercut increase.
Building Reservoir Understanding #3
Initial Watercut & Sweep – Various Pointers

#1 Simulation View – *with the usual caveats*
Residual Oil Saturation at YE09 using coarse grid VIP model

#2 Classical Reservoir Engineering
Calculate Reservoir Fractional Flow from Production & Injection data (*Dake p436*)

#3 Field Data
Compare Log Sw from recent wells with initial watercut behaviour

<table>
<thead>
<tr>
<th>Dry vs Wet</th>
<th>Well</th>
<th>Watercut at Start-Up</th>
<th>Log Sw</th>
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<tr>
<td>Wet</td>
<td>A</td>
<td>66%</td>
<td>50-60%</td>
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<tr>
<td></td>
<td>B</td>
<td>75%</td>
<td></td>
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<tr>
<td></td>
<td>C</td>
<td>80%</td>
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</tr>
<tr>
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<td>D</td>
<td>10%</td>
<td>25-30%</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G</td>
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Unswept oil along horizontal well section
**Infill Opportunity Example**

**Identification of Resource Volume & Production Profile Generation**

**GAP Analysis - Identification of Resource Volume**

Integrate Static and Dynamic Understanding

<table>
<thead>
<tr>
<th>Zone</th>
<th>STORP (mmscf)</th>
<th>Polygon Volumetric Recovery at CoP</th>
<th>Expected Polygon Volumetric Recovery</th>
<th>Current RF @ CoP</th>
<th>Expected RF @ CoP</th>
<th>Incremental RF</th>
<th>Incremental Recovery (mmscf)</th>
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<td>Z30</td>
<td>2.2</td>
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<td>75%</td>
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<td></td>
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<td>1.7</td>
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</table>

**Identify Target Polygon**

Well location & desired length

**Calculate Infill Recovery Volume**

Explore uncertainties

**Production Profile Generation**

Material Balance Analytical Model used to match Profile to the Incremental Volume

- Oil Rate vs Time & Cum Oil
- Oilcut vs Cum Oil
- Watercut vs Time

**Rate**

**Cum Recovery**

**Time**

**Cum Recovery**

**Time**
Summary

• As infill targets decrease in size and increase in complexity, understanding of the key risks and uncertainties becomes critical to successful well delivery.

• The benefit of this approach is its simplicity and transparency, which allows infill opportunities to be ranked and enables an understanding of the static and dynamic uncertainties.

• Technique allows rapid opportunity assessment.

• Mature fields are their own analogues – make full use of your data.
Acknowledgements

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Wytch Farm - The Hidden Oilfield

Hidden from view are the gathering station, ten wellsites, Cleaval point pumping station and over 90 miles of infield flowlines.