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Integrated Carbonate Reservoir Development and Management

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Going the Distance - Smart Strategies for Horizontal Well Optimisation for Enhanced Recovery in Carbonate and Clastic Reservoirs

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Outlines

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  - Simulation of horizontal well and optimisation of well leg length
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Introduction

Extending horizontal wellbores is a common method to boost hydrocarbon recovery by increasing reservoir contact, though its effectiveness varies between carbonate and clastic lithologies.

Clastic reservoirs' homogeneity enables predictable productivity with well length, while carbonate reservoirs' heterogeneity and fractures make outcomes less certain.

In both cases, beyond a certain length, frictional losses reduce efficiency, causing up to 40% underperformance if not addressed in well design.

This study uses dynamic reservoir simulation and advanced wellbore modelling to optimise horizontal leg length in a thinly bedded fault block reservoir, evaluating production, pressure, and recovery across multiple scenarios.

Results reveal distinct carbonate and clastic behaviours, highlighting the trade-off between reservoir exposure and wellbore flow efficiency.

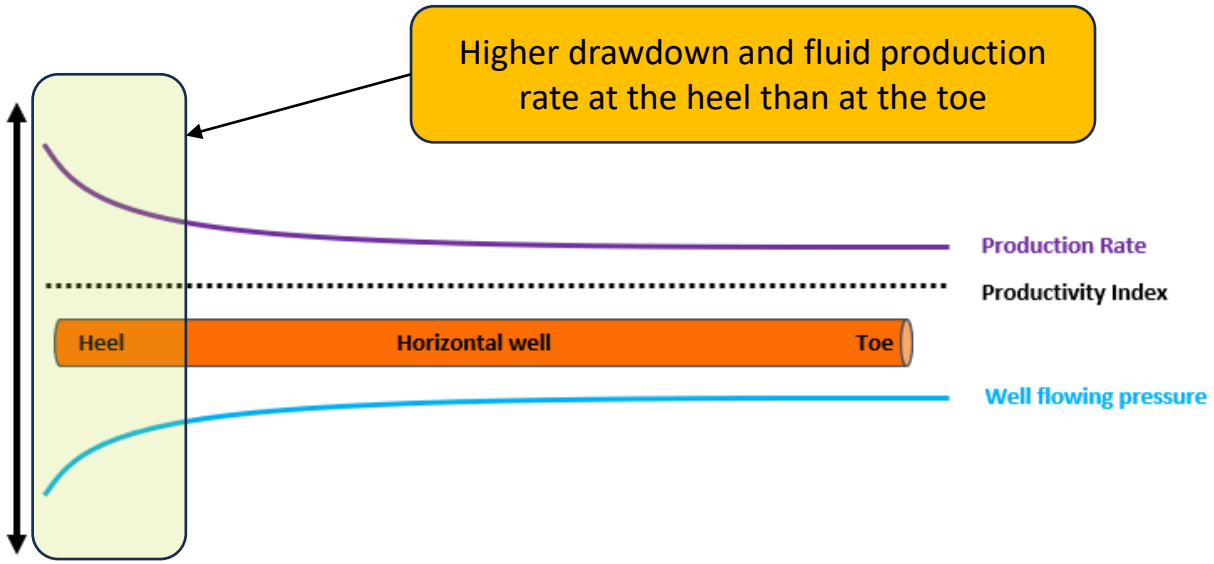
The findings provide practical insights on:

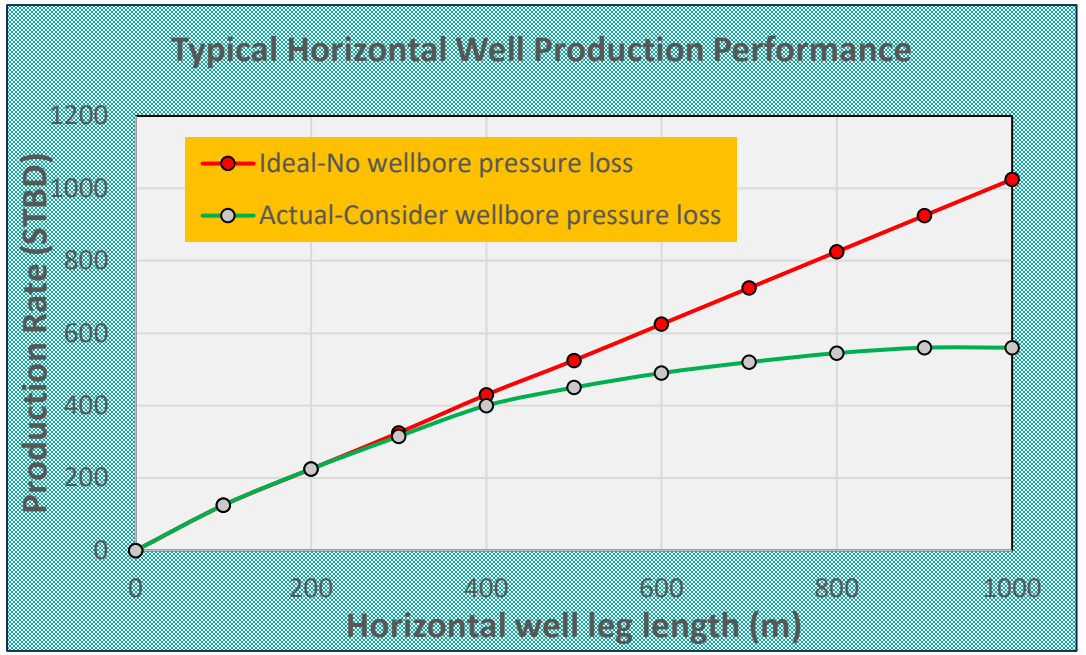
- How lithology-dependent heterogeneity impacts optimal horizontal length.
- Why "longer is not always better" applies equally to carbonates and clastic, though for different reasons.
- How integrated modelling enables field-specific design choices that improve recovery while maintaining economic feasibility.

Methodology – Modelling approach

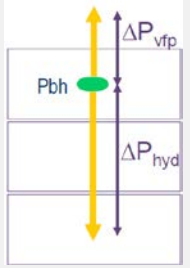
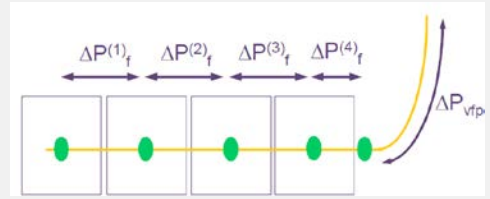
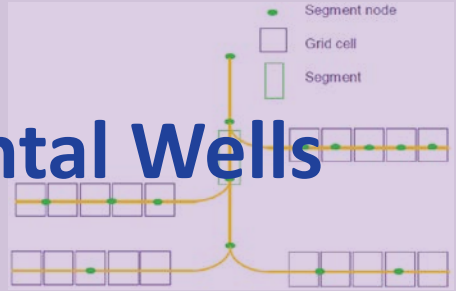
Accurate simulation of horizontal wells in dynamic modelling is crucial, as it requires the representation of unique phenomena that occur exclusively in horizontal wells.

One key aspect is the pressure drop from toe to heel due to friction in the horizontal section, which must be accounted for to ensure realistic modelling outcomes.





Methodology – Available well models

Available well models in dynamic simulation	Assumptions	Suitable for	Schematic
Standard well model	• Wellbore fluid assumed uniform; crossflow may be unrealistic. • Frictional losses between connections and to BHP depth ignored. • VFP tables represent pressure losses from VFP depth to tubing head.	Vertical wells, where frictional pressure drop acting over the relatively short length of the perforated section is generally negligible.	
Friction well model	• Frictional losses in tubing along perforations and between perforations and BHP reference depth are included. • VFP tables represent losses from VFP reference depth to tubing head.	Highly deviated and horizontal wells	
Multisegmented well model	• The wellbore divided into segments • Pressure drop includes friction, hydrostatic head and acceleration • The topology of the well is much better described for complex cases such as multilateral • Crossflow effects are modelled in more detail • VFP tables are used to represent pressure losses between the VFP reference depth and tubing head	Highly deviated, horizontal and multilateral wells	

Most Suitable Modelling Approach for Horizontal Wells

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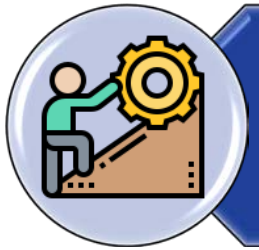
Methodology – History of target reservoir

Study Focus

- Undeveloped compartment in a mature offshore Malaysian oil field (~70 m water depth)
- NW–SE anticline (4.5 × 2.5 km), fault-sealed, isolated from producing blocks
- Discovered in 1980s; 36° API oil, GOR 440 scf/STB, viscosity 0.8 cP

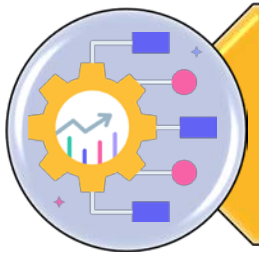
Pressure Test Findings

- Major sands depleted before production
- Likely aquifer communication with nearby field (~4 km away)
- Most depletion in sub-layer E34 → distinct pressure regime



Production Challenge

- E34's unique pressure regime complicates production
- High cross-flow risk in comingled completions
- Requires tailored strategy vs. standard vertical/multi-zone approach



E34 Development Plan

- ~18 MMstb STOIIP; thin bed (7–12 m)
- 21% porosity, 200 mD permeability
- Strategy: maximize recovery with one horizontal well by optimizing leg length
- Leverages horizontal well performance in thin beds & unique pressure regime

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Methodology – Vertical vs Slanted vs Horizontal well performance in target reservoir

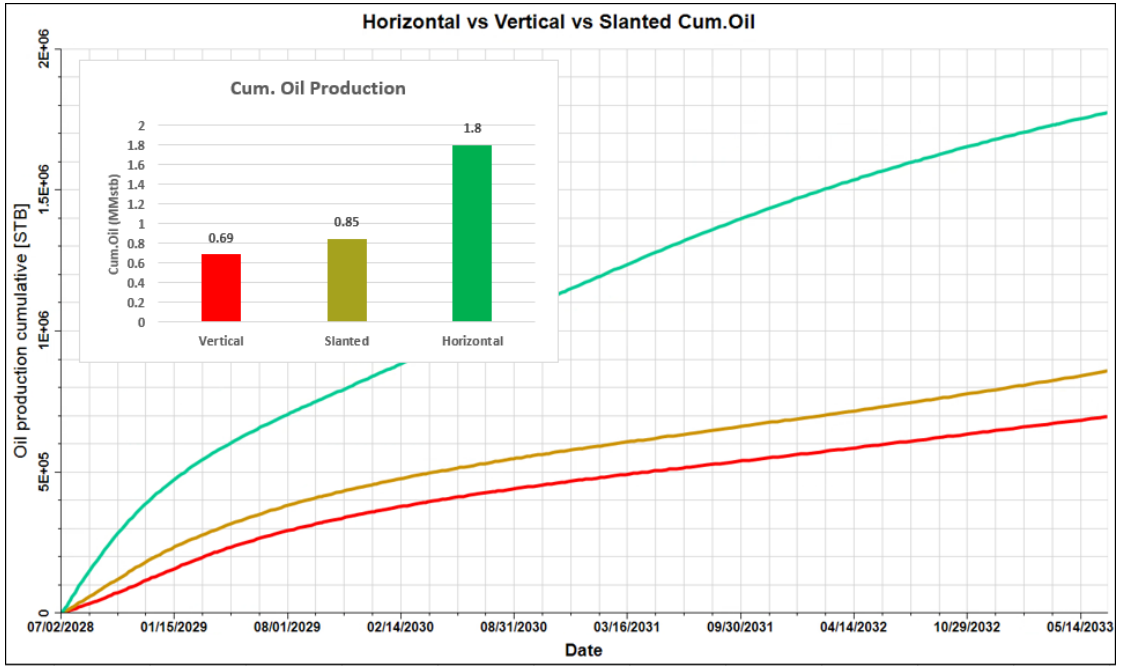
Pre-Optimization Assessment

Sensitivity analysis on target reservoir to compare well performance:

- Vertical well with a maximum inclination of 10 degrees
- Slanted well with a maximum inclination of 70 degrees
- Horizontal well

Key Insight:

Horizontal well provides much higher production gains than vertical or slanted wells due to reservoir thinness.



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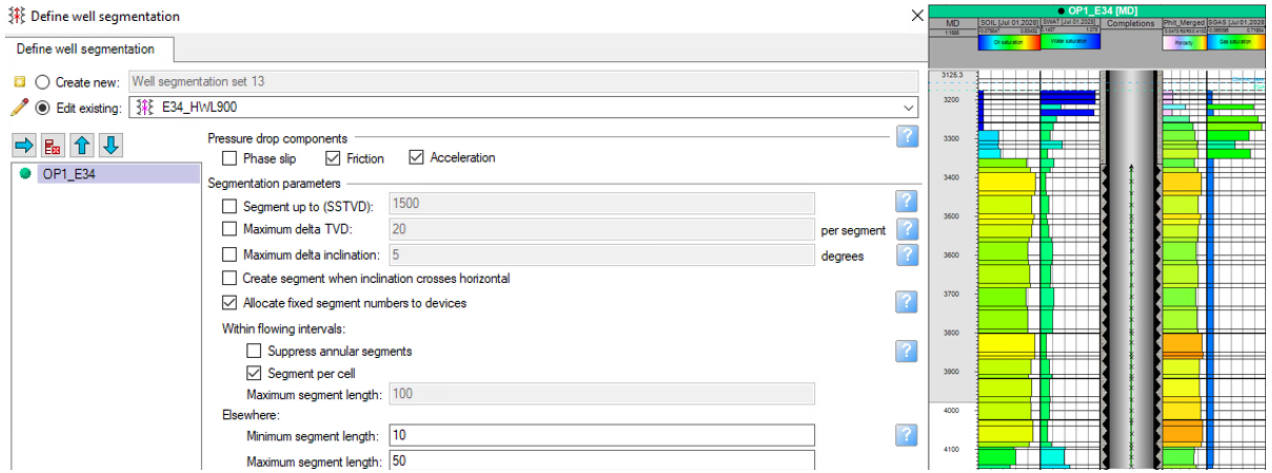
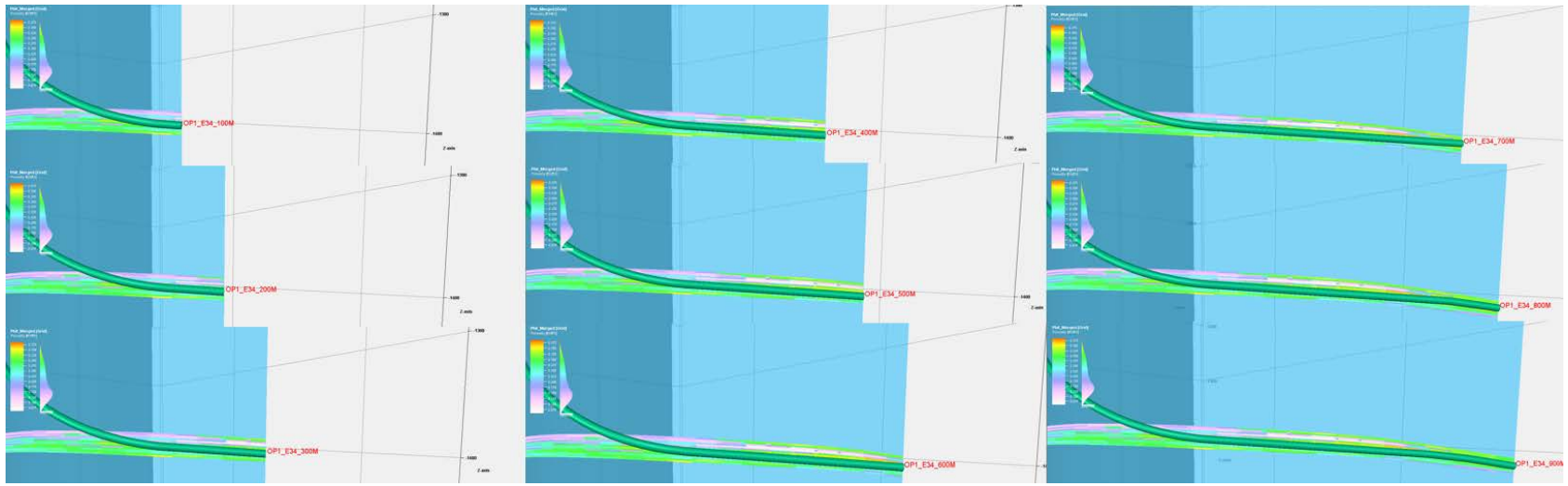
Methodology – Simulation of horizontal well and optimisation of well leg length

Well Modelling Approach

- Multi-segment model with nine trajectories (horizontal legs: 100–900 m)
- Case-hole completion modelled
- Accounts for pressure drops (pipe roughness, fluid acceleration) and hydrostatic pressure





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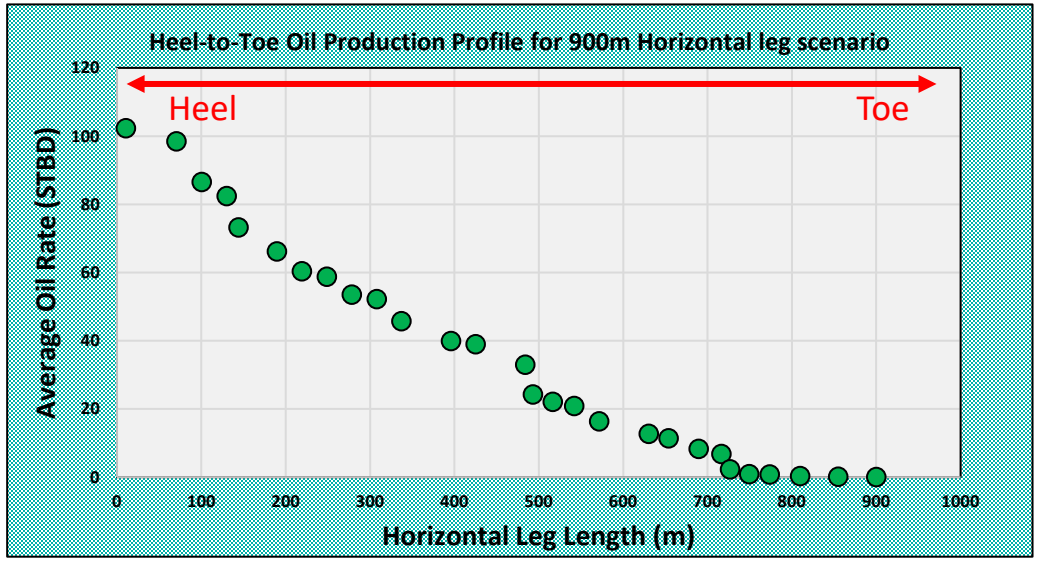
Simulation results

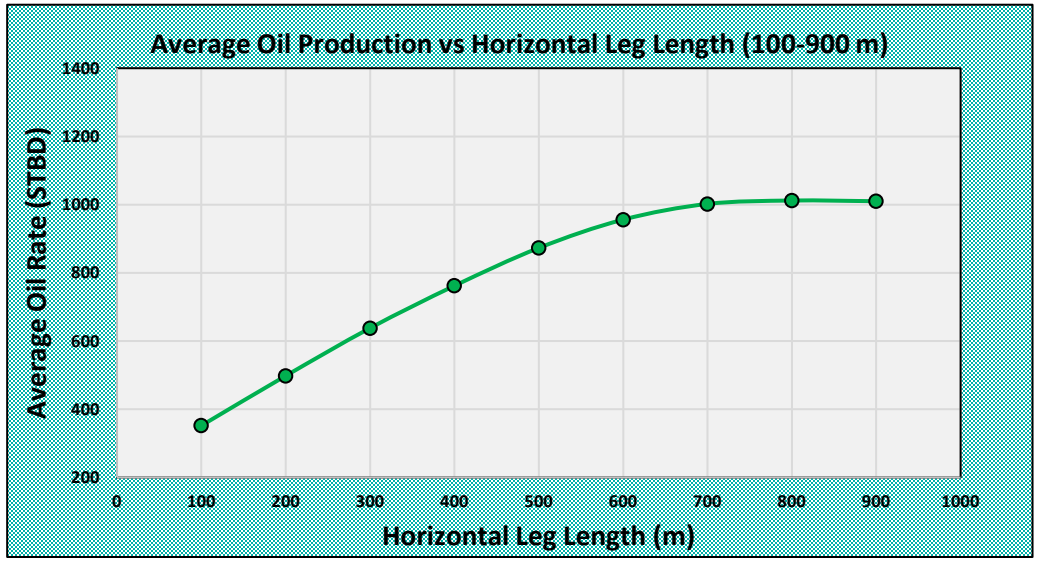
Simulation Insights

- Production contribution varies along the horizontal well (toe to heel)
- Longer horizontal legs do **not** yield proportional production gains

Key Observation

- Each additional meter of horizontal leg adds less production as total length increases (diminishing returns).
- Production gains diminish with longer well legs and plateau beyond a certain length
- Cause: Increased frictional resistance as reservoir contact area grows





Conclusions & Recommendations

- This study presents an **integrated modelling and optimisation workflow for determining the ideal horizontal leg length**, applicable to a wide range of reservoir lithologies and depositional environments.
- The approach effectively supports horizontal well design and performance optimisation in both **carbonate and clastic reservoirs**.
- The **methodology can be seamlessly incorporated into feasibility and development planning to guide well trajectory** design, emphasizing that a uniform horizontal length across wells rarely delivers consistent production outcomes.
- Results from this specific analysis indicate diminishing incremental production beyond a horizontal well leg length of approximately **700 meters**, identifying **600–700 meters** as the optimal range for well OP1.
- Where surface location constraints or drilling and hook-up cost optimisation necessitate longer horizontal sections than optimal lengths, a **segmented well completion strategy** is recommended—initially producing from the **toe section (Phase 1)** followed by the **heel section (Phase 2)**—to maximize overall recovery from the full horizontal interval.