Thin Oil Rim Development in Carbonate Field: Concept & Challenges

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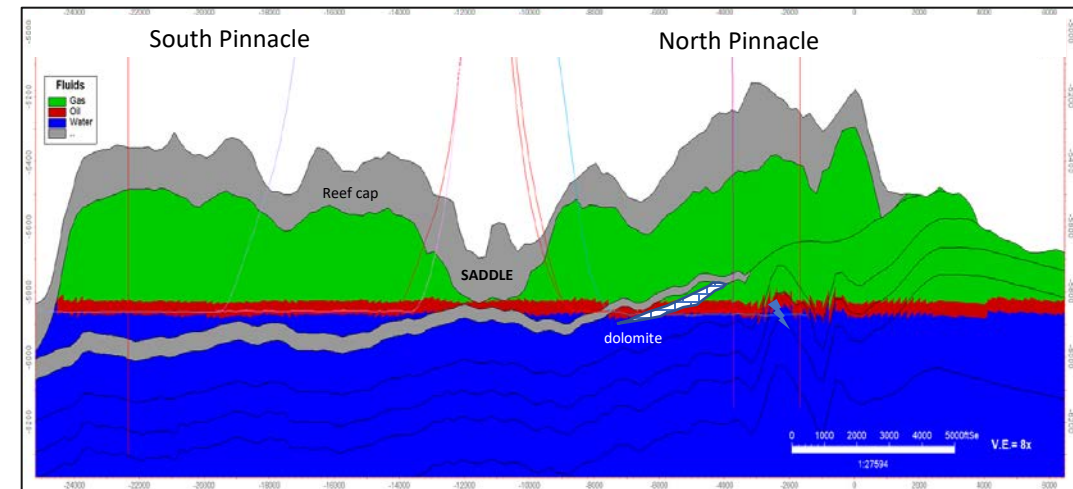
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Objective

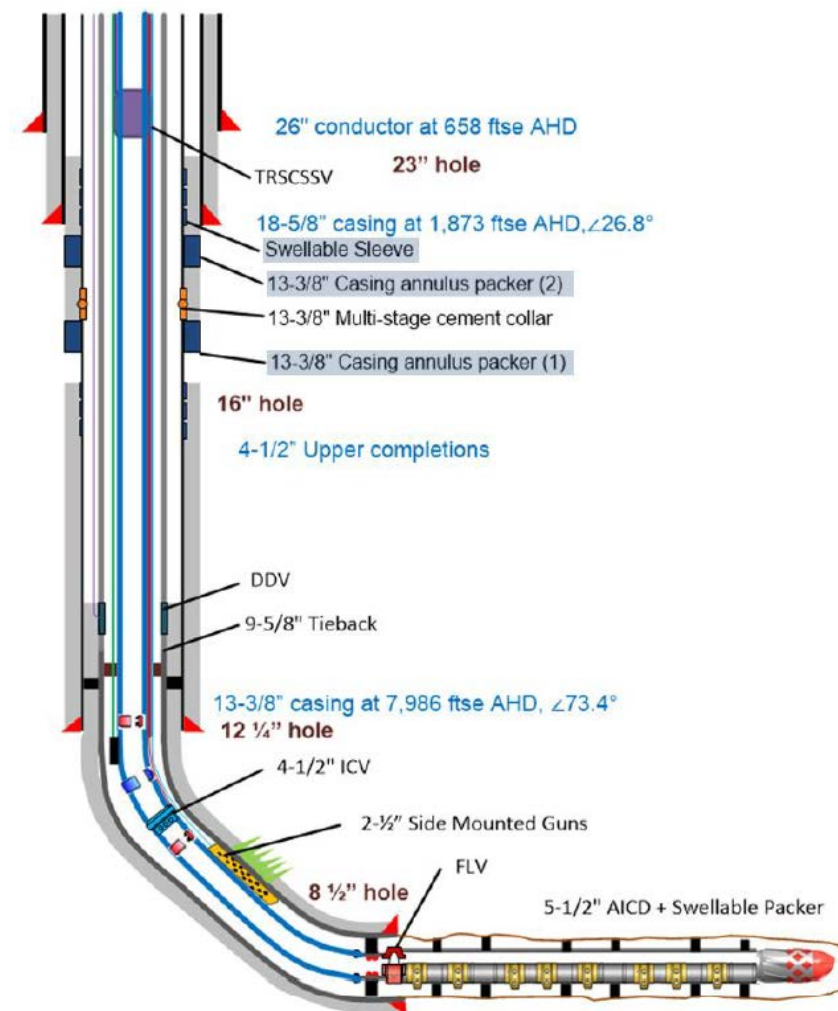To share Field A's field development concept, challenges and lessons learnt.

Field Background

- Field A is Pinnacle-type carbonate oil and gas field located offshore Malaysia.

- Field A is separated into 2 substructure (Northern & Southern pinnacle), with thin oil rim feature - 50ft of oil rim & 600 ft of gas column.

- Field development challenges:

  - Heterogeneous & moderate permeability carbonate formation, with thin oil rim between gas cap & aquifer.

  - Oil recovery is limited to narrow region around well completion, thus requiring maximum footage coverage across oil rim reservoir – horizontal well concept.

  - Early gas breakthrough will risk oil recovery due to reservoir pressure losses from excessive gas production.
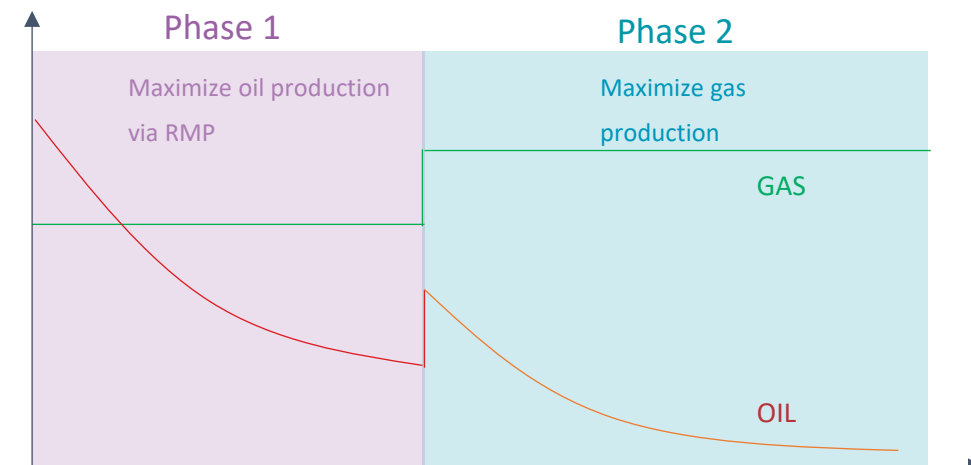
Development Concept & Well Design

- Field development is separated into 2 phase: Phased development allows for Phase 2 well design and placement optimization, with the data analysis from Phase 1 development.

- Development well design:
  - Long horizontal well of ~6000ft to maximize oil reservoir coverage and minimize drawdown during production.
  - Lower completion is fitted with AICD (Autonomous Inflow Control Device), with the purpose of controlling gas intake. Horizontal section is compartmentalized into 10-12 sections with swellable packer.
  - Upper completion is equipped with ICV (Inflow Control Valve), which function as in-situ gas lift for well kick off, and gas entry during Gas Cap Blow Down Phase.
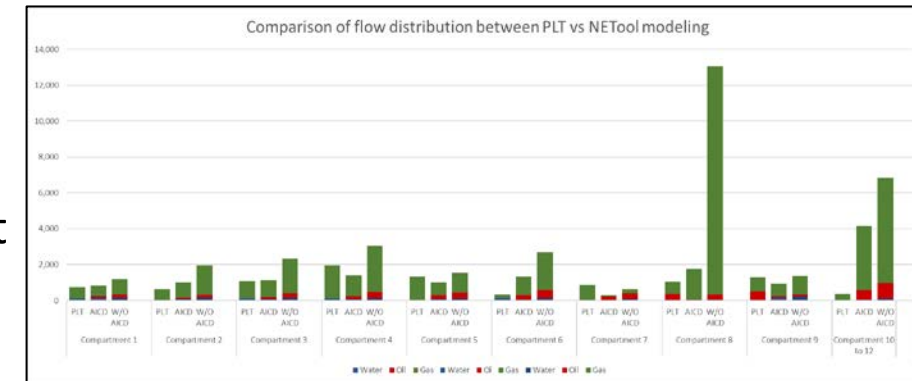
Field A Reservoir Management Plan & WRFM Optimization

- Field A's life is divided into 2 phase:
    - Phase 1: maximize oil recovery by limiting field gas offtake, with the objective of controlling reservoir pressure depletion.
    - Phase 2: maximize oil and gas recovery with production from gas zone (Gas Cap Blowdown), which is achieved by producing from ICV.

- Frequent individual well testing is required for production optimization. Critical monitoring parameter are Gas Oil Ratio (GOR) and watercut (WC) %.

- Real time data, coupled with in-house smart well test, allows for active field production monitoring and quick intervention.

Phase 1 — Maximize oil production via RMP

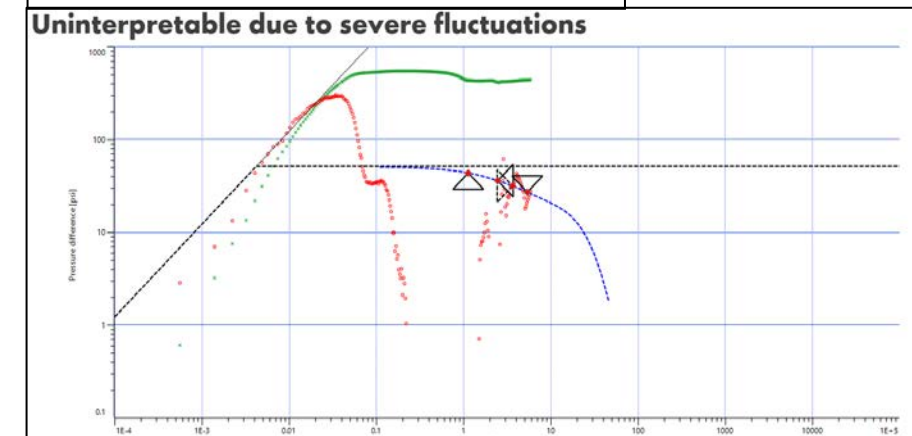Phase 2 — Maximize gas production

GAS

OIL

Challenges & Key Learnings

- Uncertainties on AICD effectiveness:
  - Cannot be physically ascertained, only through model comparison
  - Possible AICD sectional failure/damages from Day 1 cannot be identified and likely to be taken as baseline.

- AICD possible degradation/damage with time can be detected but will require baseline PLT from Day 1 and periodic logging thereafter which may be very costly and operationally risky.

- Challenging PLT execution:
  - Long horizontal section (~6000 ft), covering whole interval is risky.
  - Risk of creating fish (1 well has fish downhole while executing PLT).

- Challenging PLT and PTA interpretation:
  - Complex phase distribution affecting PLT and noisy pressure response for PTA

- AICD is 1-way valve, limited production enhancement activities can be conducted (no well stimulation, only plug as water/gas shut-off).

Comparison of flow distribution between PLT vs NETool modeling

Well A2 PTA

Uninterpretable due to severe fluctuations

Summary

- Field A's phased development allows the team to apply Phase 1 learnings into Phase 2 development, which covers well location optimization & well construction and completion.

- Controlling gas offtake improves oil recovery through preservation of gas cap energy.

- AICD application coupled with well segmentation via swellable packers allows for autonomous choke back of high GOR section and even contribution on horizontal wells.
    - Effectiveness of AICD remains an uncertainty given the challenges in data acquisition.

- Robust reservoir management plan enables monetization of both oil and gas from marginal thin oil rim.

Acknowledgement

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Q&A