



“Bridging Domains - Solution Workflows for Marginal Field Challenges”

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Improved Recovery & EOR

Focus on Improving Recovery in a (very) Mature Field

- Look at History
- As Is Case (Look-Back)
- Model-Centric FDP
- Update

Set the stage for the future,....

All fields, including Giants, become marginal eventually.

But when?

Time, fiscal & political regimes, incentives, reserves, oil price, entrepreneurial-ship, cost, logistics, etc. all drive the moment when an operator deems a field to be 'uneconomic'; and another operator may jump on the same moment & opportunity as a great investment, given their experience, culture, and knowledge of advanced technology.

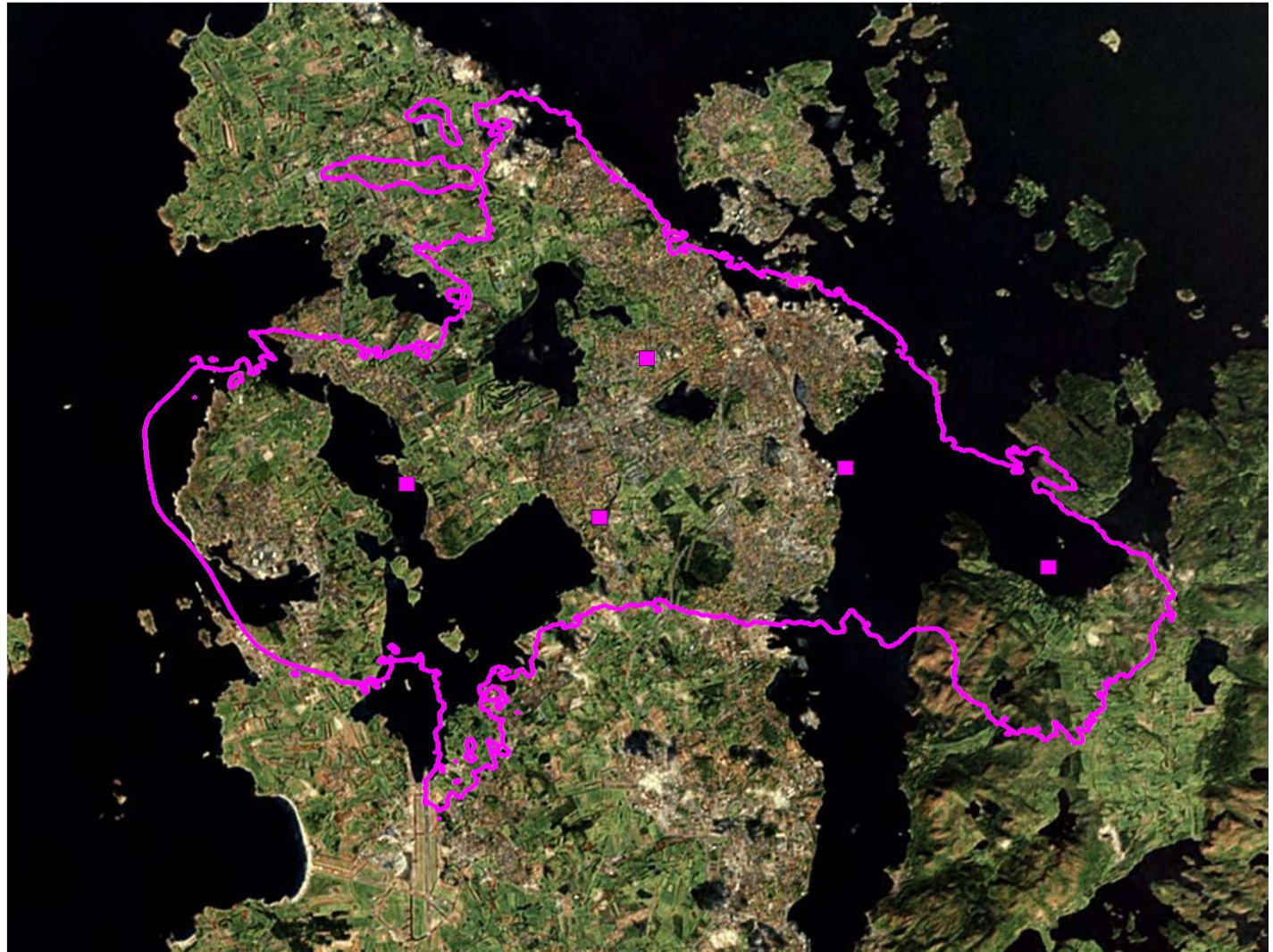
A case in Point: the UKCS Forties Field example.

Forties Overview

- Apache acquired Forties from BP in 2003
- Annualized average production was 41,000 bopd and declining, unlike the early 1980s when the field was producing between 500,000 and 400,000 bopd
- No new wells had been drilled since 2001 when the previous BP drilling campaign had been cancelled.
- By 2003 the field had produced a cumulative 2.5 billion barrels of oil out of an in place volume between 4.2 and 5 billion barrels and the field was sold with 144 mmbo remaining reserves
- Apache has tested over 100 drilling targets, made over 80 production completions and 4 injection completions
- With Apache drilling campaign the annualized average production rate held close to 60,000 bopd since 2005
- Apache has produced over 150 mmbo from the field of which 75 mmbo has been produced from Apache drilled wells
- Currently producing between 50,000 and 70,000 bopd
- New 18 slot Forties Alpha Satellite platform to be commissioned for installation in 2012
- Charlie 4-3 well commenced production at a rate of 12,567 barrels of oil per day (b/d). This well's initial production (IP) rate is the highest in the Forties since 1990 and follows the previously disclosed Charlie 2-2, which was completed in March with an IP rate of 11,876 b/d.

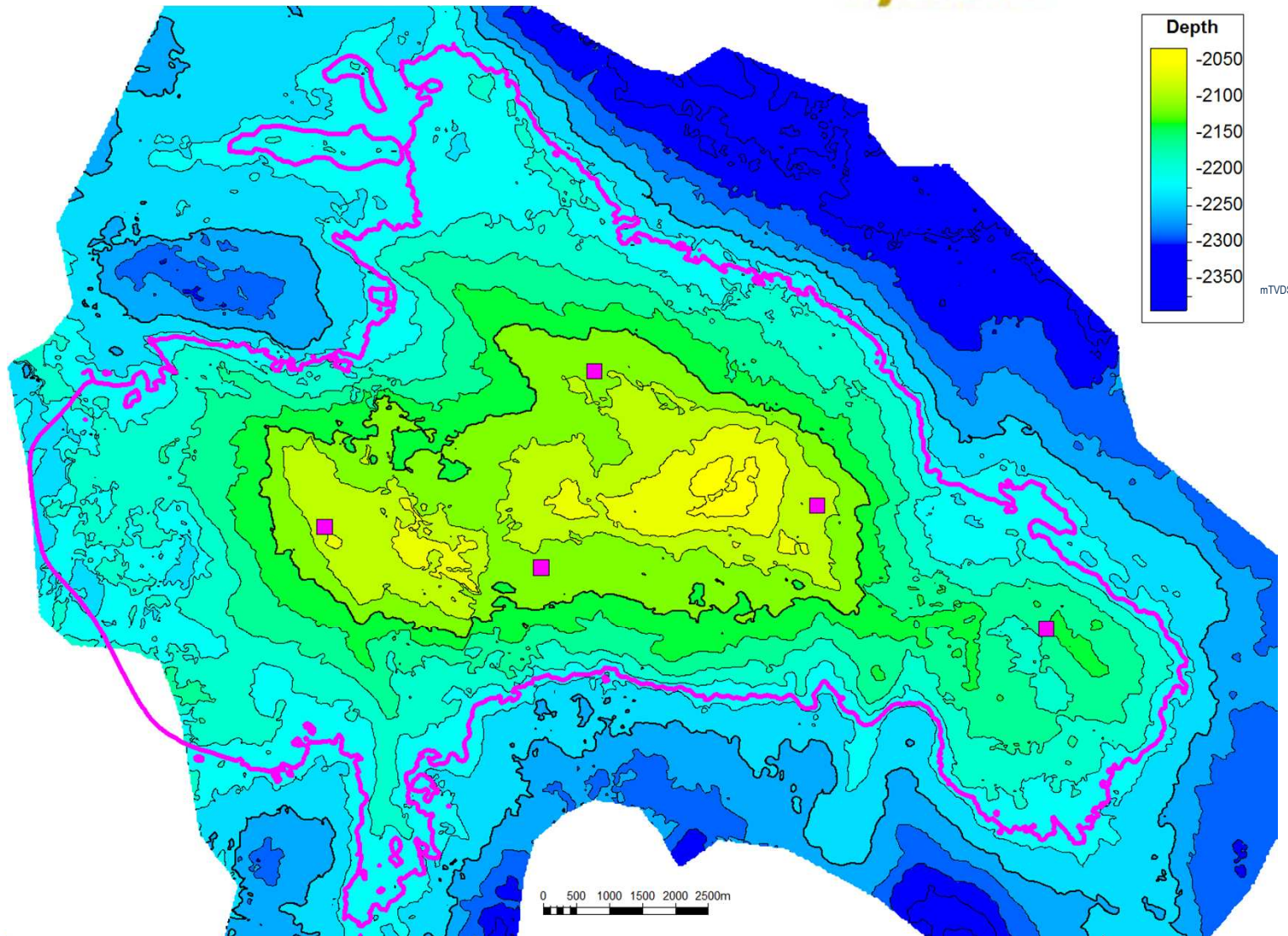
Forties Field Outline, for Scale

Max dimension 16 km E-W
and 13 km N-S
Max original oil column ~180m

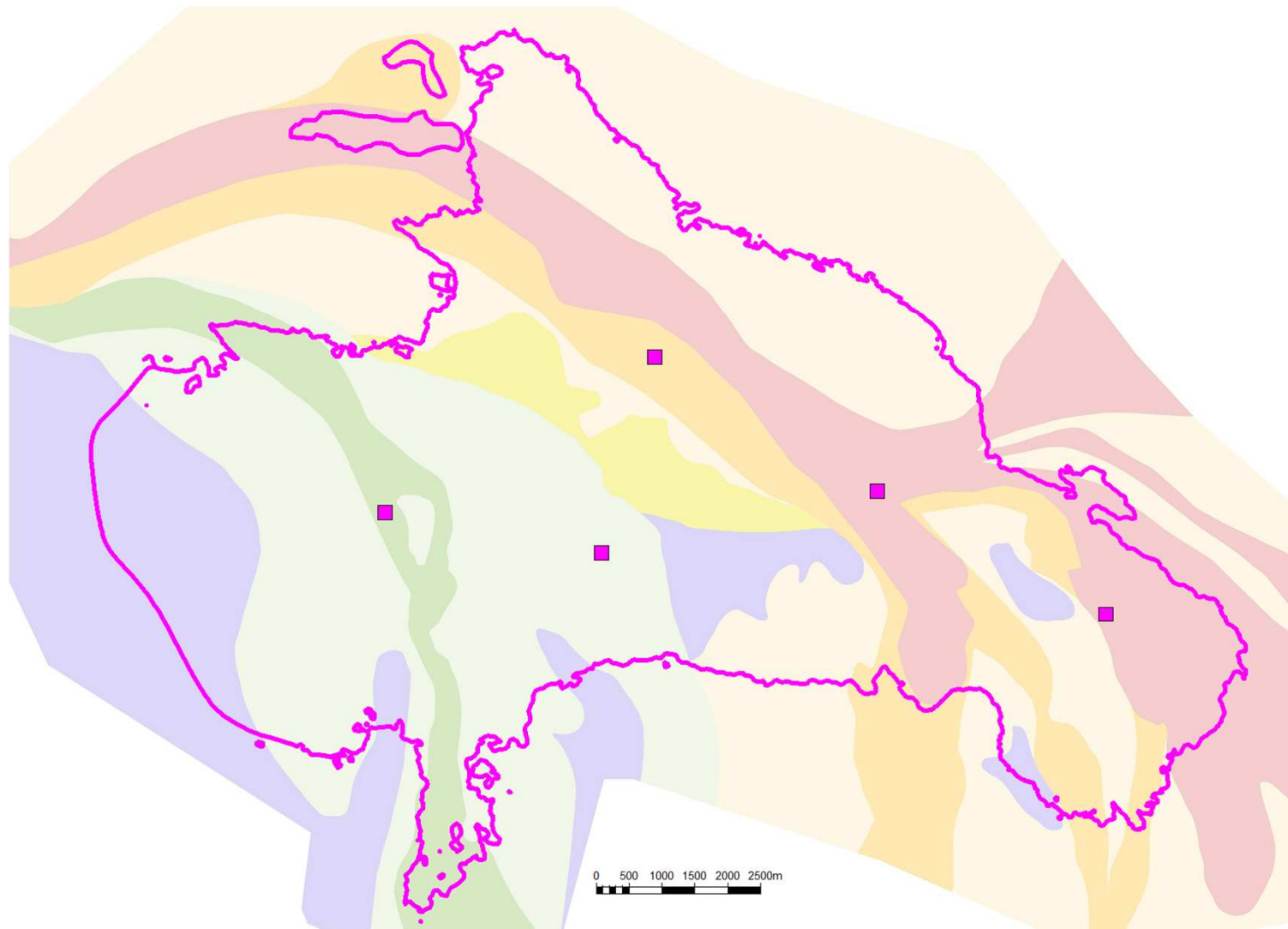


Forties structure

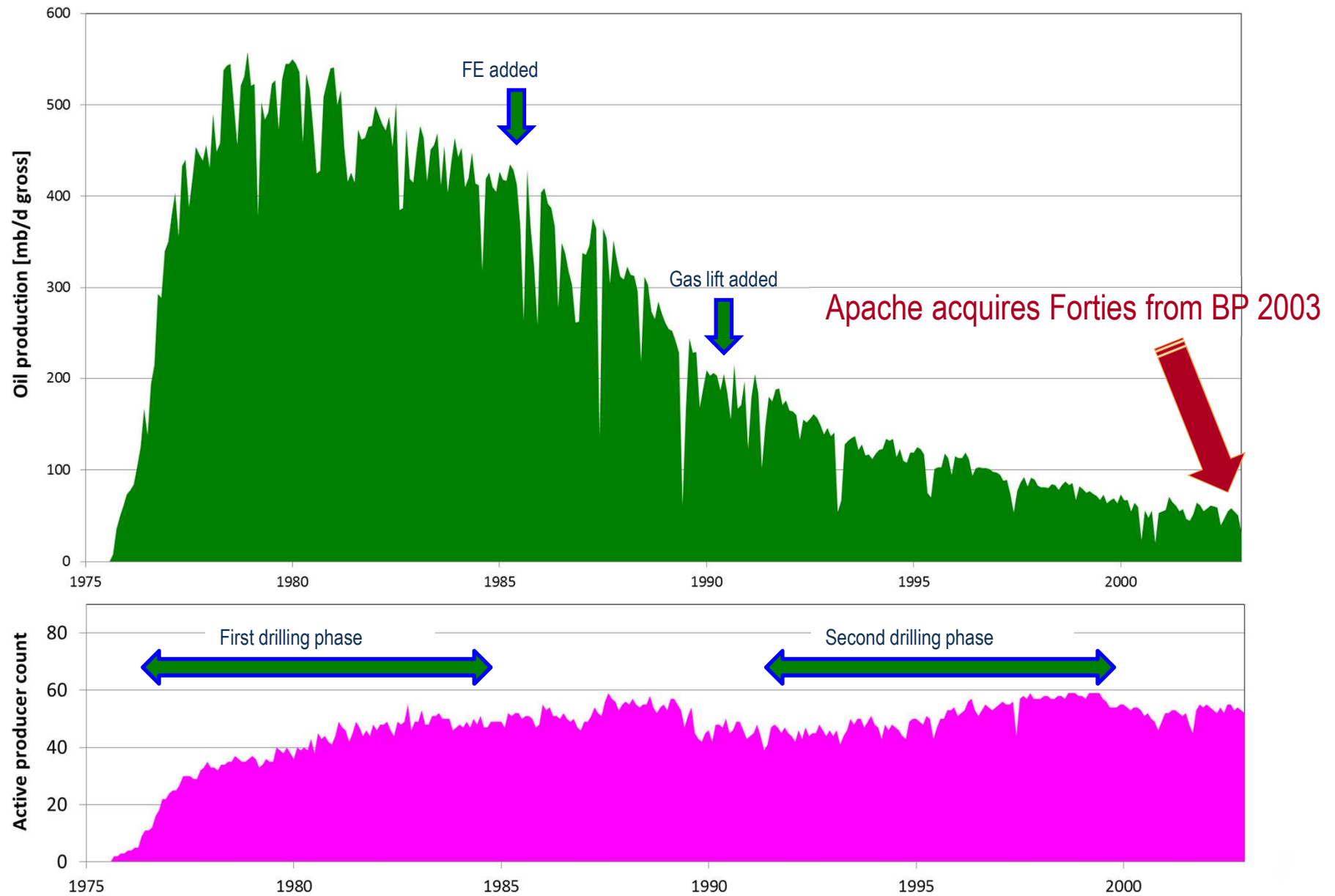
Apache



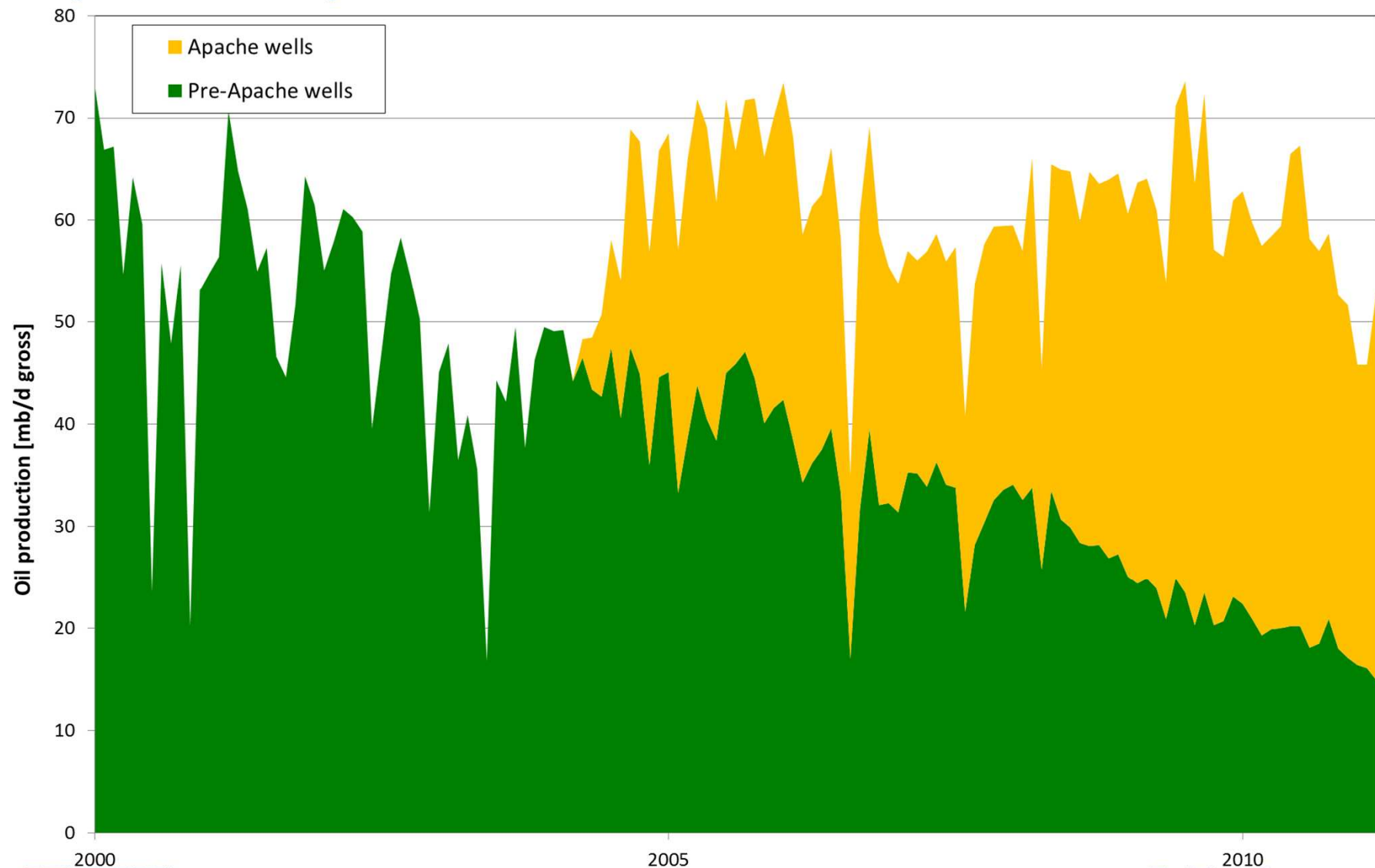
Forties reservoir architecture



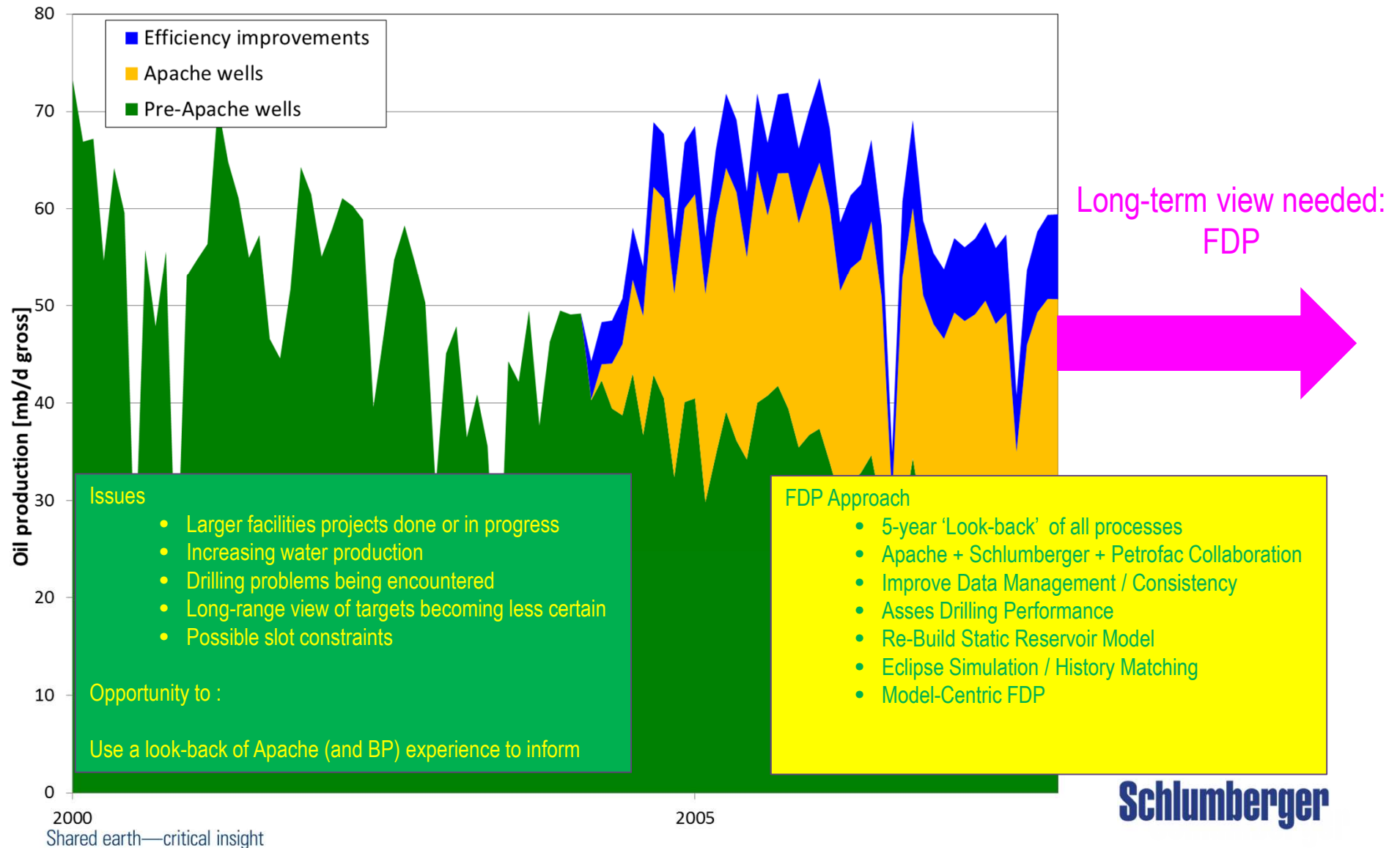
Forties: Pre-Apache history



Apache story



Field Development Plan – time out



Model-Centric Look-Back

Call to build an FDP (CEO)

- Look-back at all aspects of 5 year Apache Forties History
 - Facilities
 - Drilling Records - Construction
 - Production
 - G&G Success
 - Static & Dynamic Model(s)
 - Interpretation & Correlations
 - Target Inventory

FDP recipe

Apache

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Petrofac



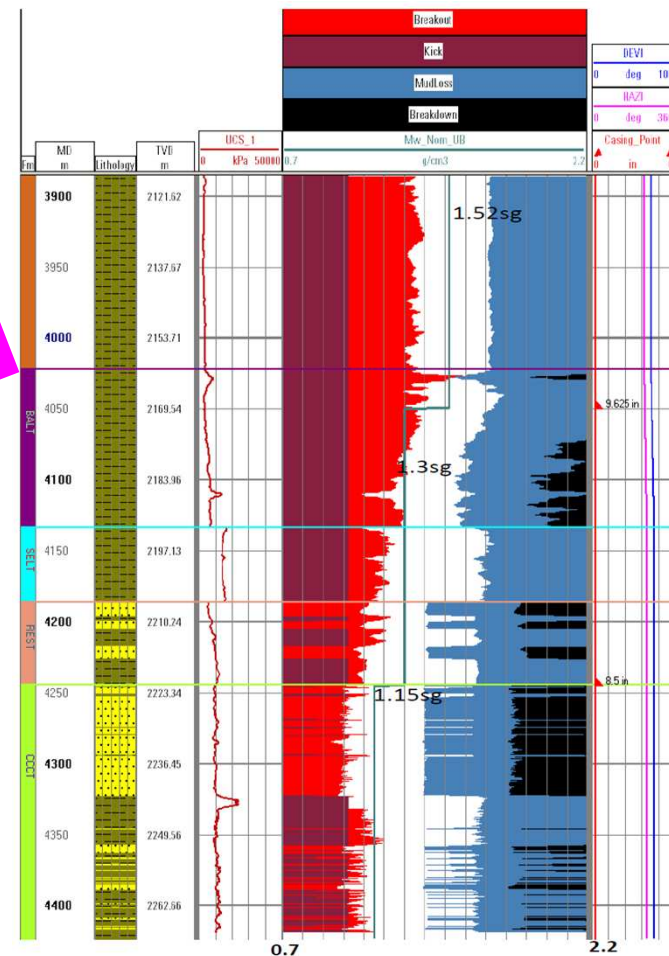
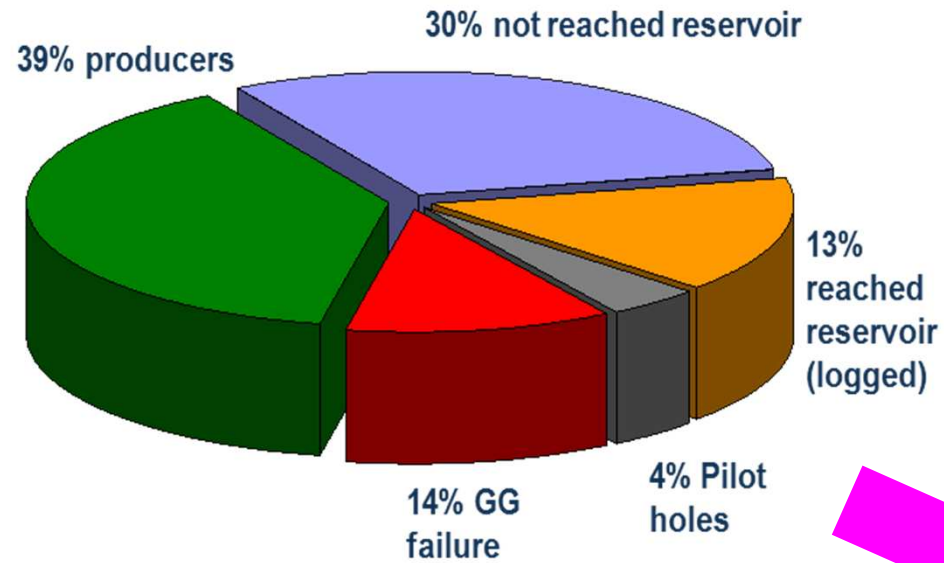
Data management
Geomechanics
Completion practices
Target book
Static Model
Simulation model
Facilities enhancements
Maintenance list

2 steps

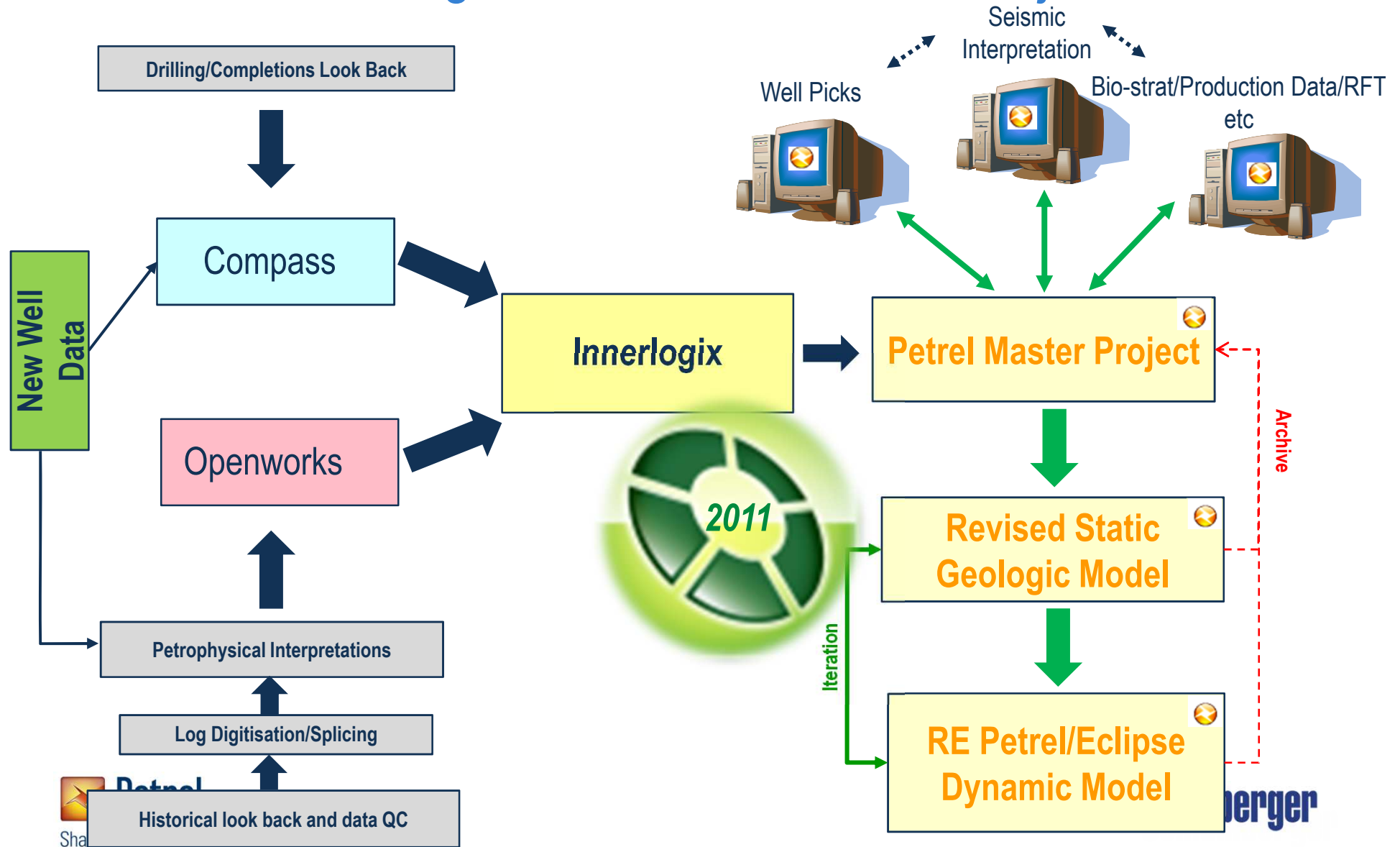
- Take stock of where we were
- Identify scenarios for continuing development and progress one to full economics

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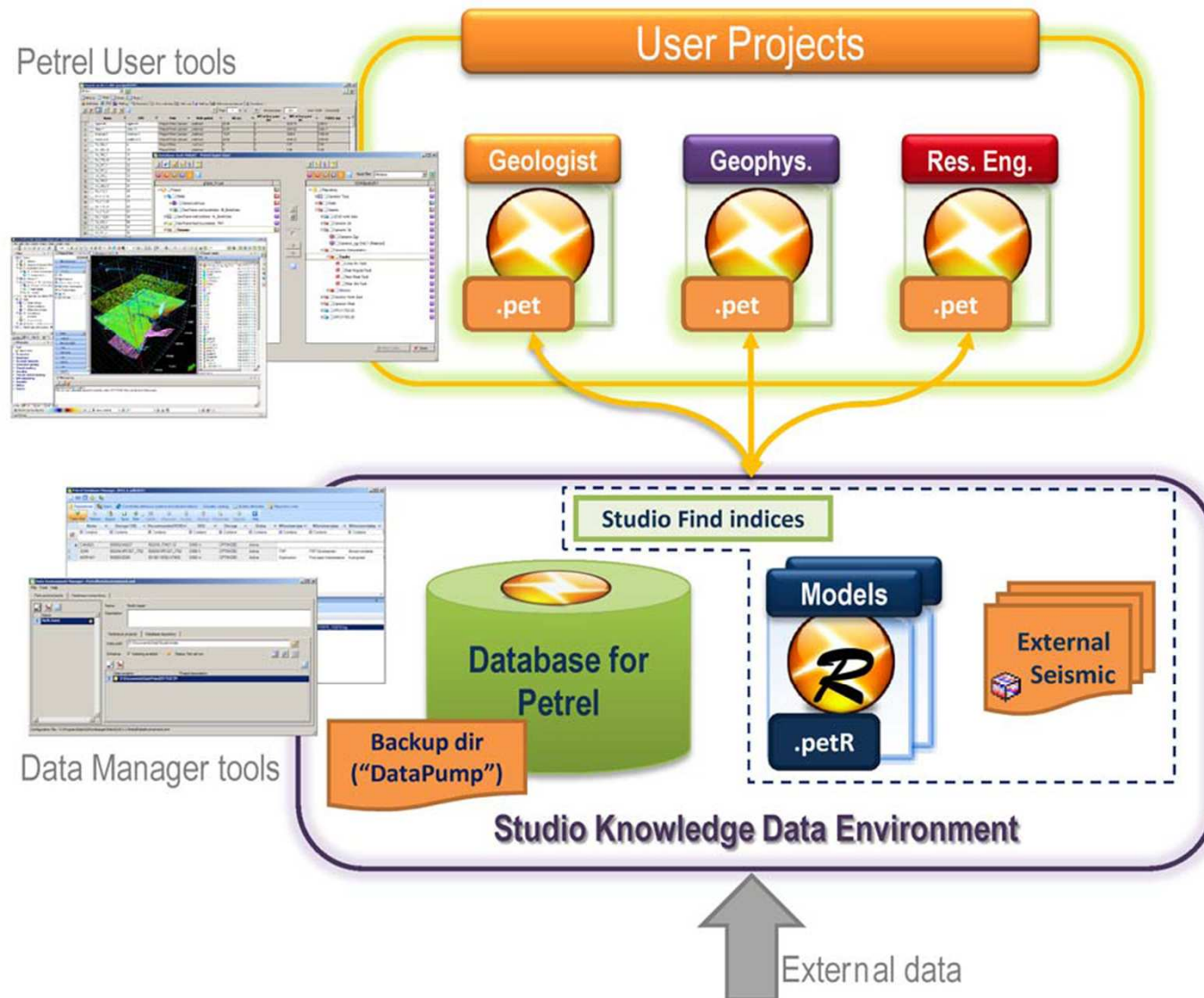
Look-Back - Geomechanics



Phase I (look-back) to Phase III (FDP): InnerLogix & Petrel Reference Project

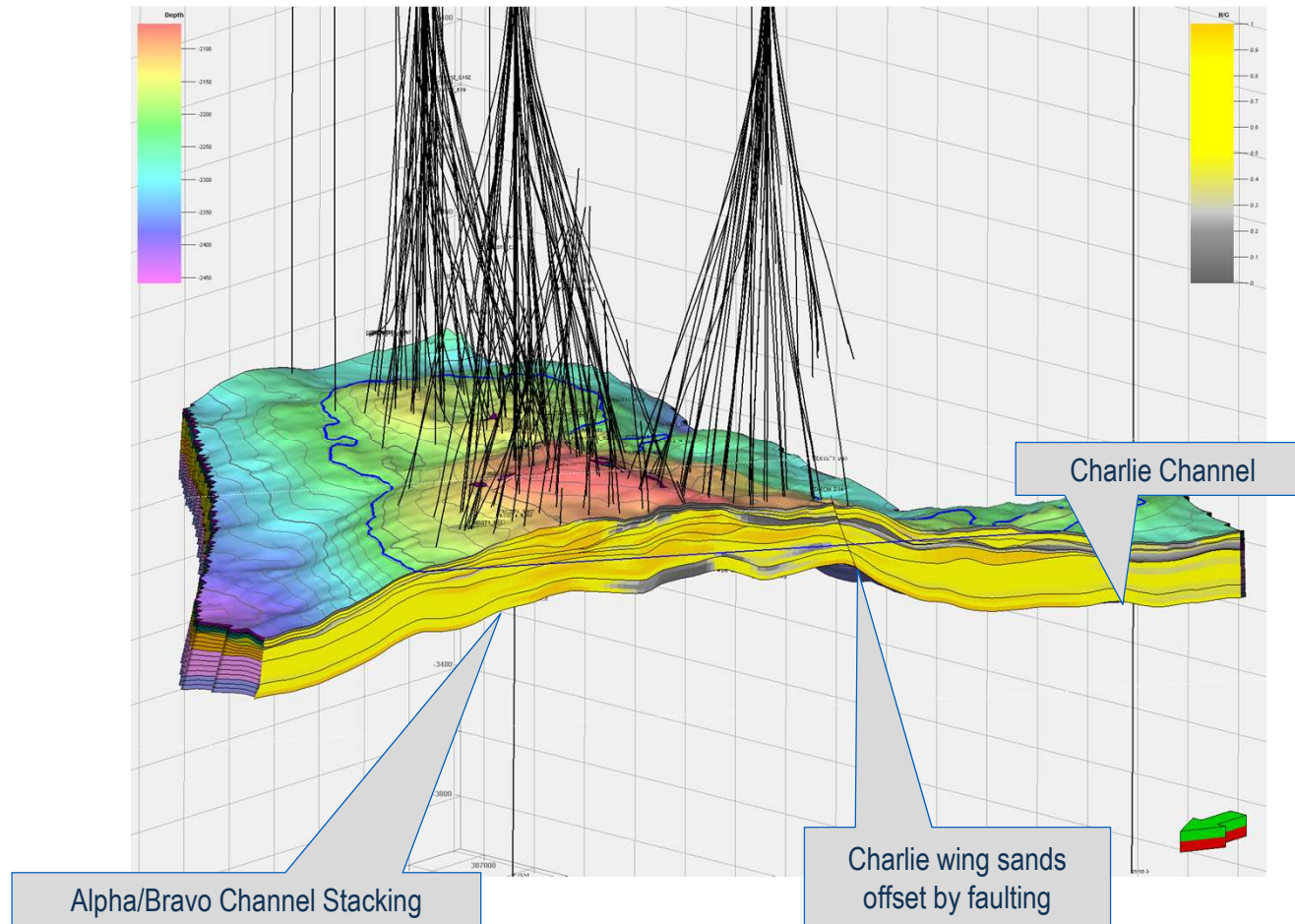


Updates: Petrel 2011 - Knowledge Data Environment

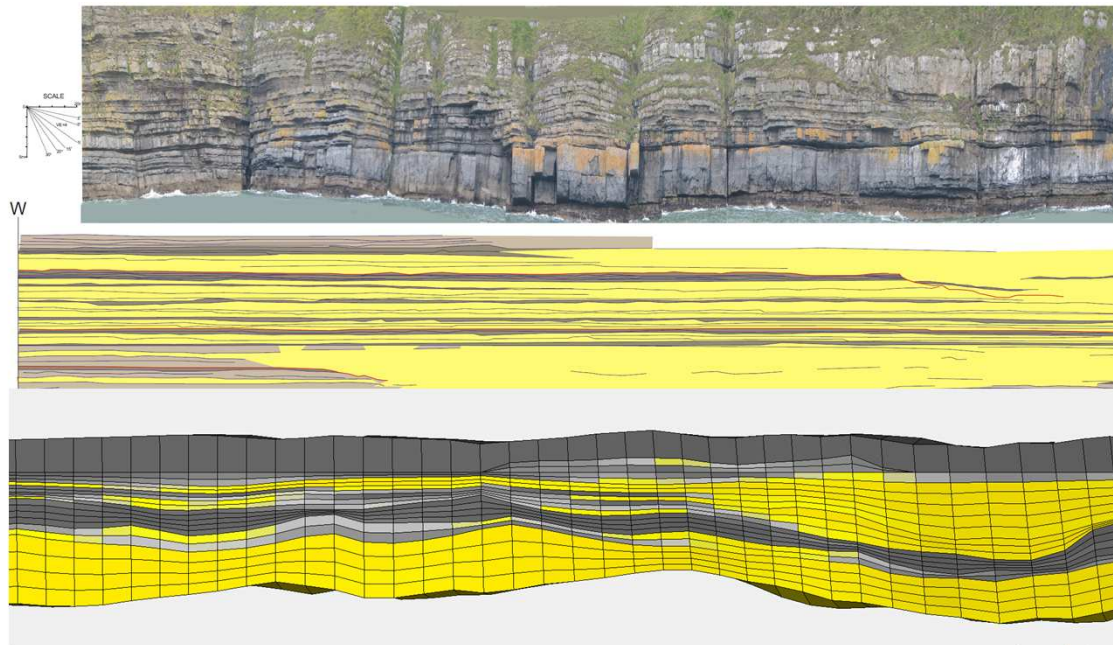


New 'Living' Static Model Honouring the Conceptual Models & Data

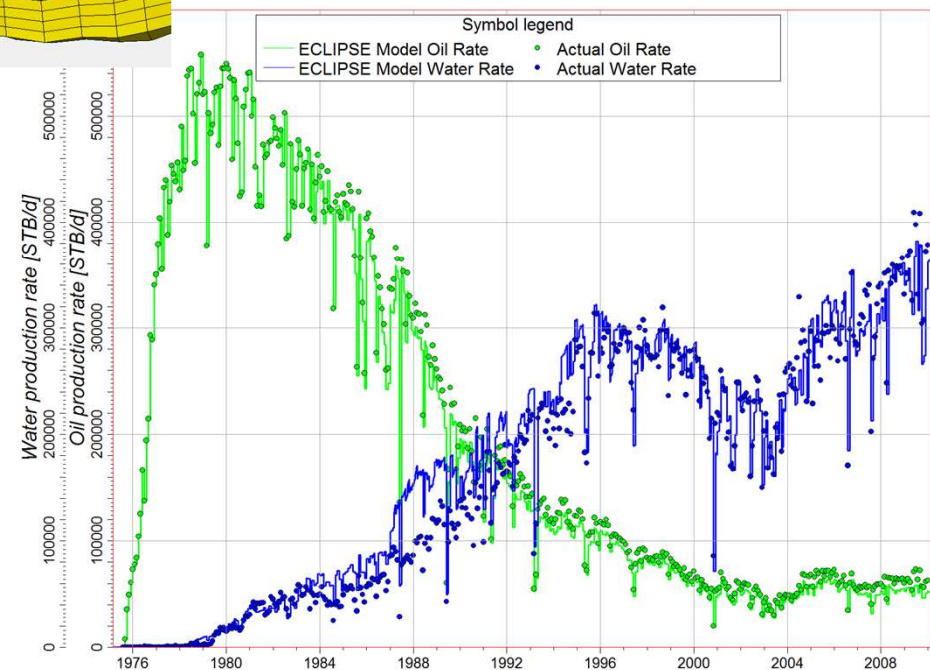
Echo Alpha Bravo Delta



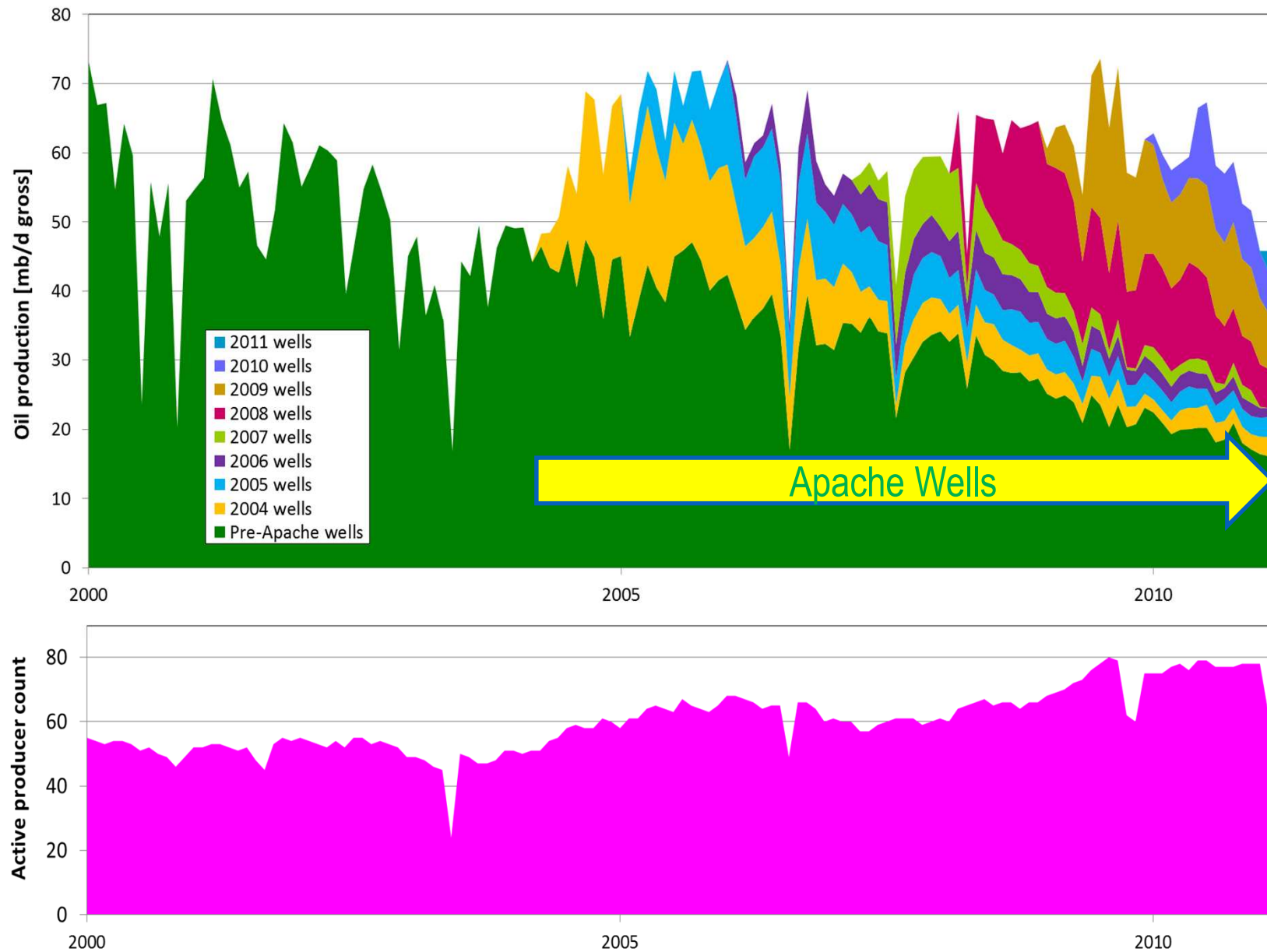
Reservoir modelling



Forties Oil and Water Production

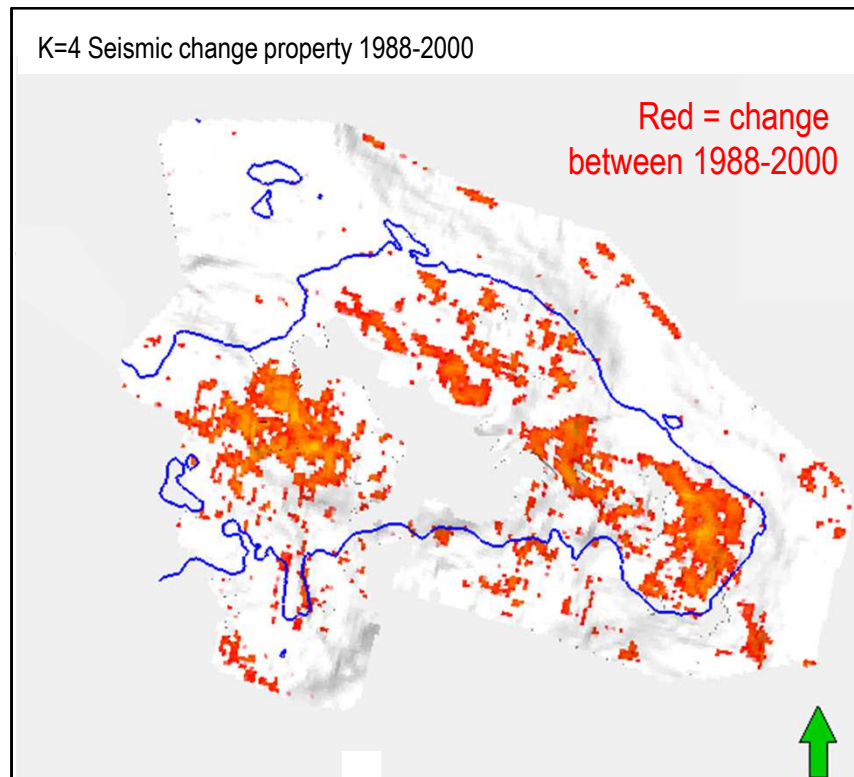


Forties drilling history – Apache Drilling Campaigns

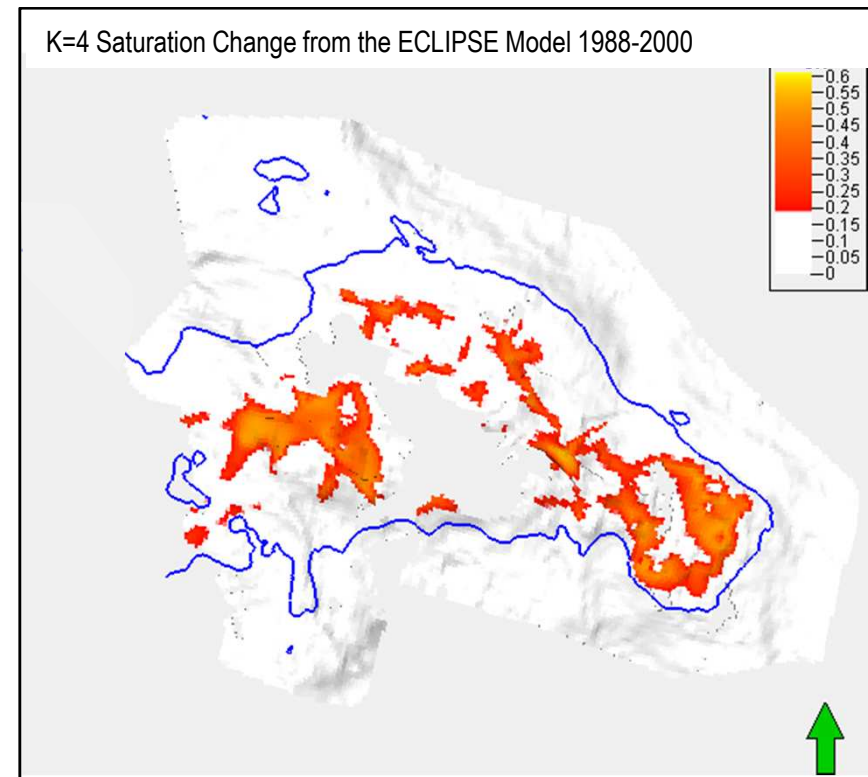


4D Seismic – Model comparison

SEISMIC

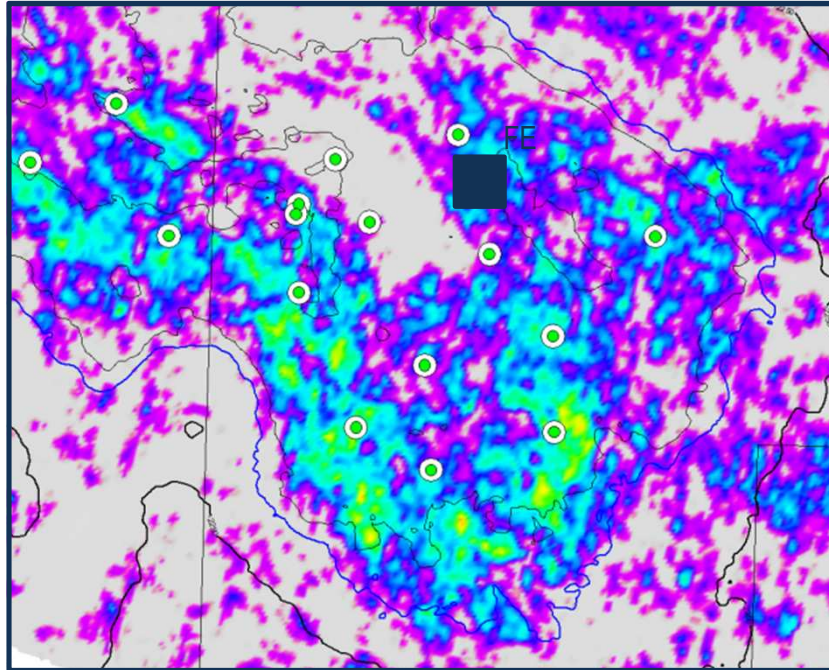


SIMULATION MODEL

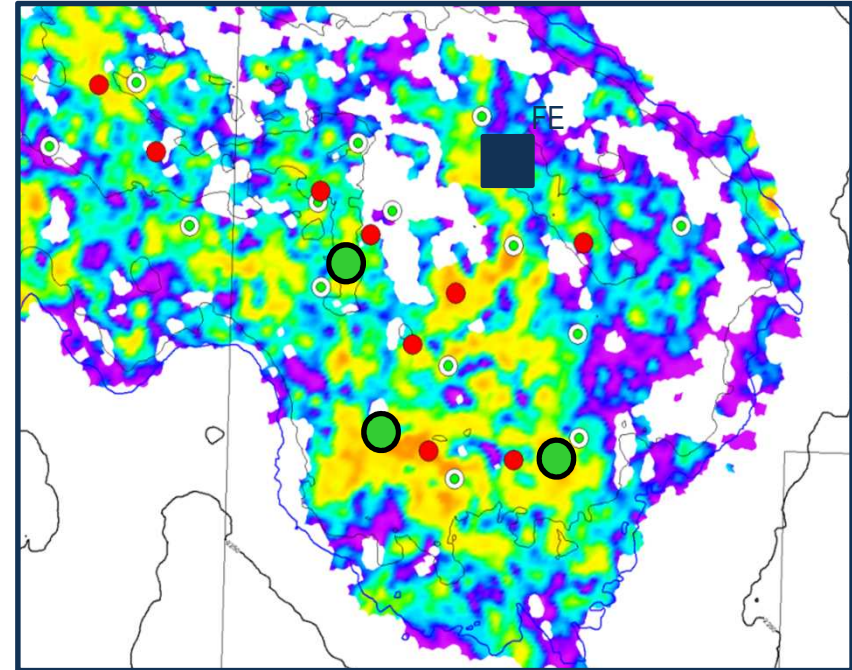


2010 4D seismic - Echo area targets

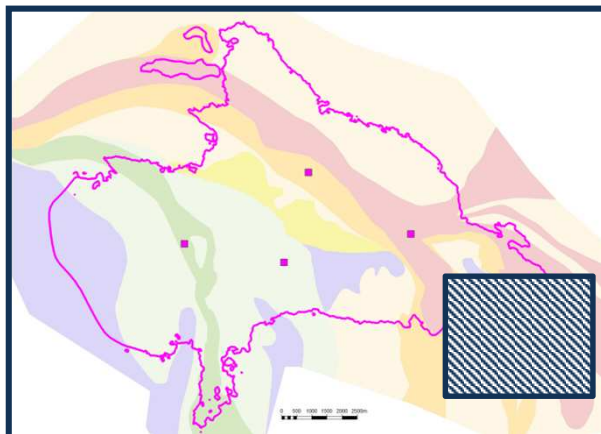
2004



2010



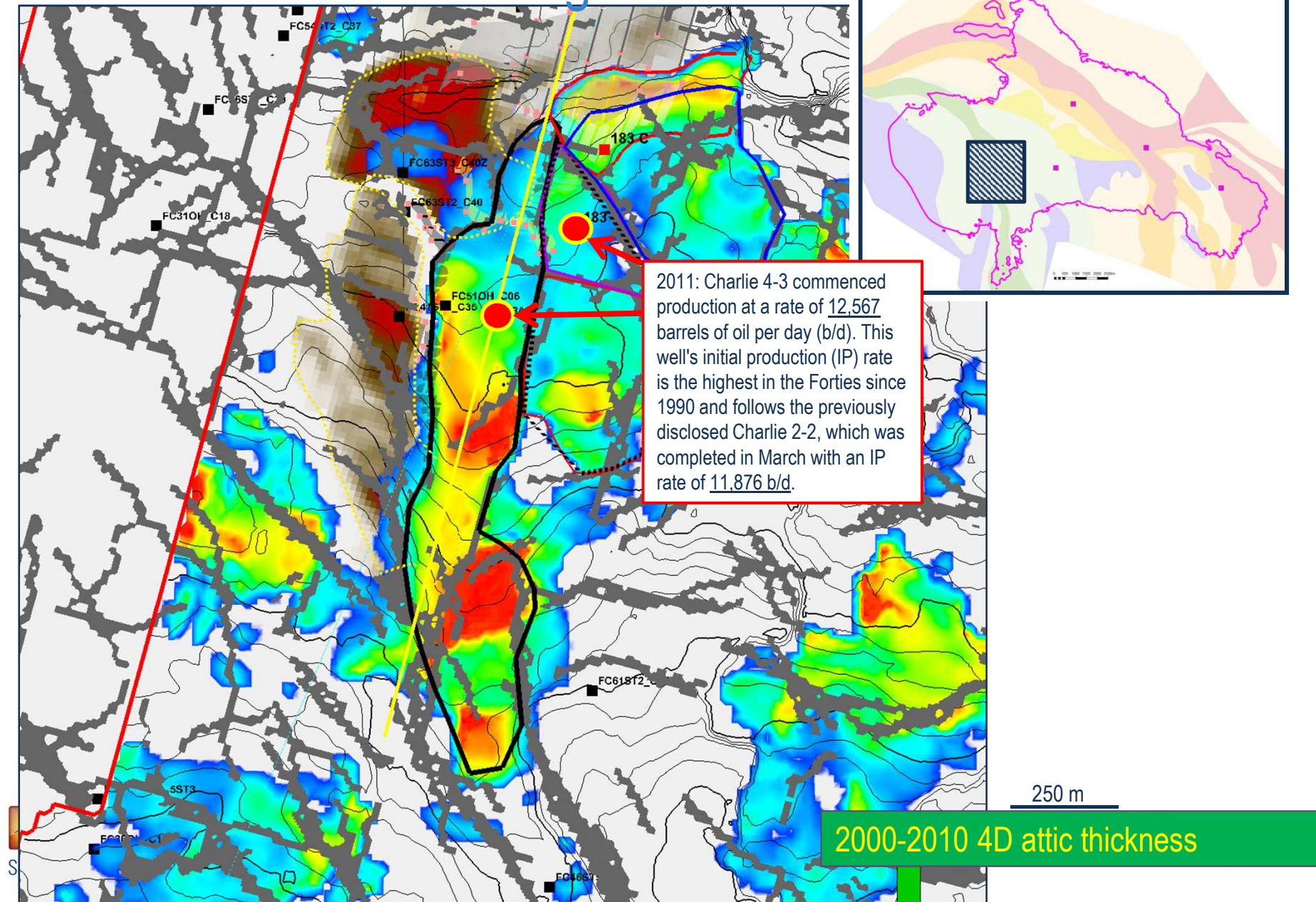
1 km



LHS = 2000 oil attribute with 2004-2005 wells
RHS = 2010 oil attribute, green 2011 wells, red remaining targets

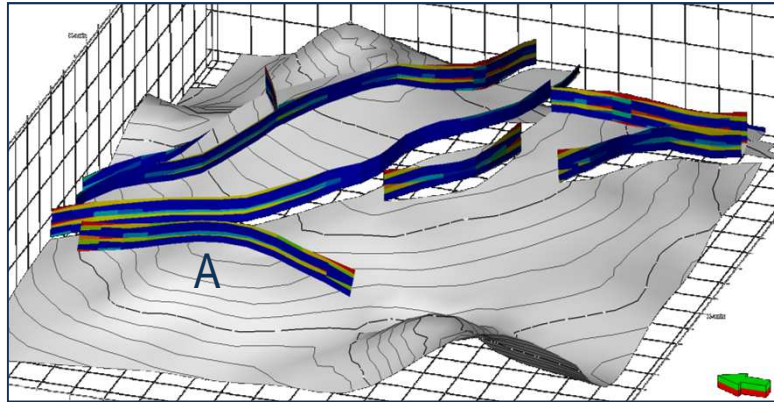
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Post FDP 2011 4D drilling successes



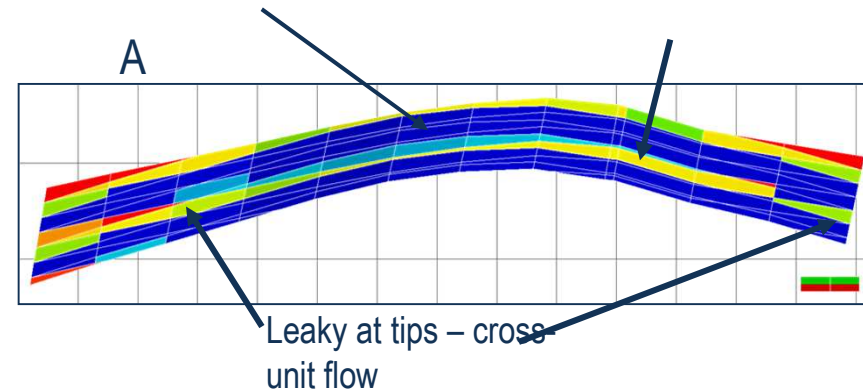
New Technology - Impact of modelling 'closed' faults (TM = 0) vs highly sealing faults

Fault transmissibility – highly sealing case

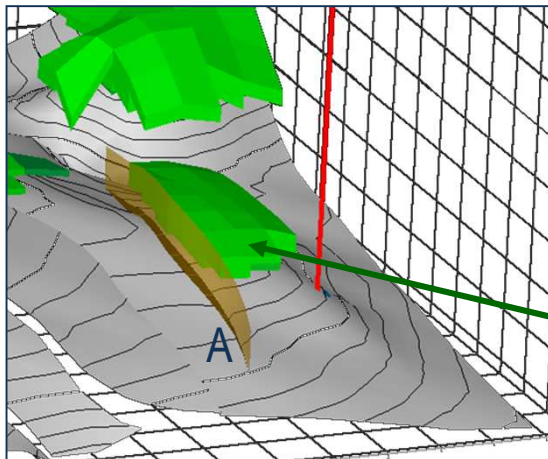


80% fault sealed case

Local flowing windows

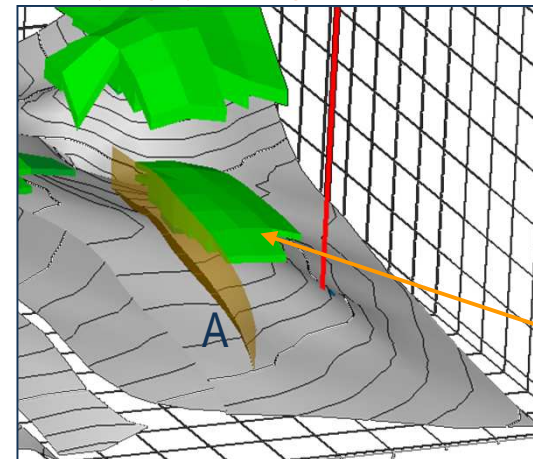


TM=0



Oil remaining

Very highly sealing case

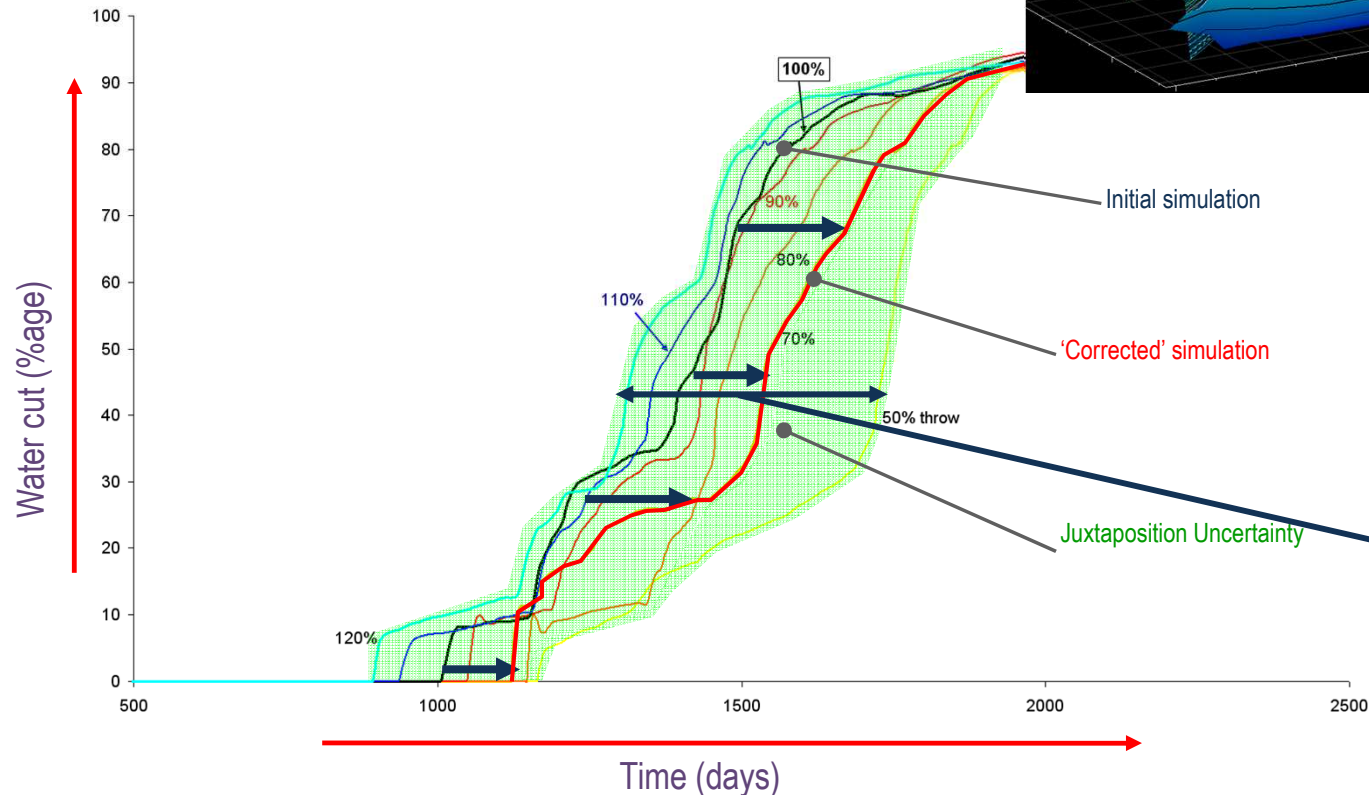
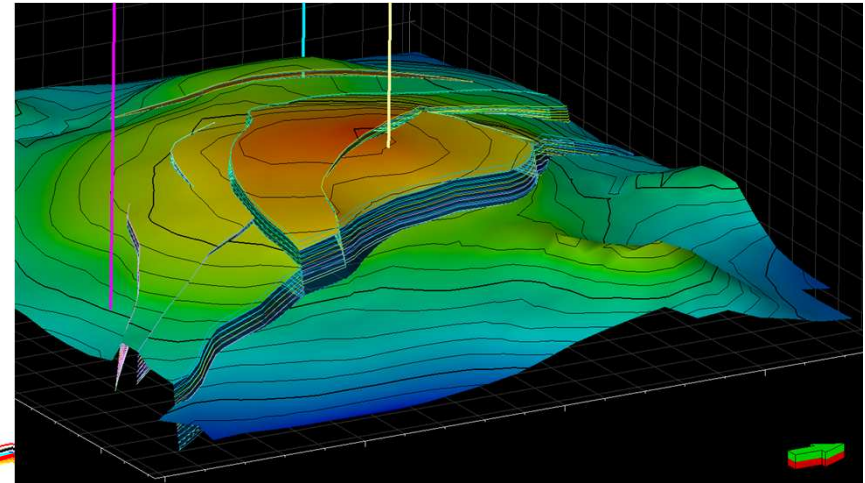


~ half volume

- Impact on predicted flow and residuals – EXPLO to EOR targeting

New Technology

Impact of throw modification in the simulator (not Forties case)



- 15-40% variation in breakthrough times

- Impact on modelled profitability

~\$70 million on a \$240 million asset

Closing Conclusive Comments

Keys to Success: 'Marginal Field' Evaluation (Big or Small)

- Look-Back to Look Forward
- Data Cleanliness and Data Management
- Integration across Domains (1D → 4D)
- Detailed Reservoir Characterization + 4D + Simulation
- Data & Interpretation QC and Uncertainty Modelling
- Common Data and Interpretation Platforms (Petrel)
- Staying Abreast with New Technology

Acknowledgements & Thank You's

Finding Petroleum for the invitation to present!

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Various SPE and industry presentation references available upon request.