Potential of improved reservoir management

HOW DO WE UNLOCK ADDITIONAL 1 TRILLION BARRELS OF OIL EQUIVALENTS?
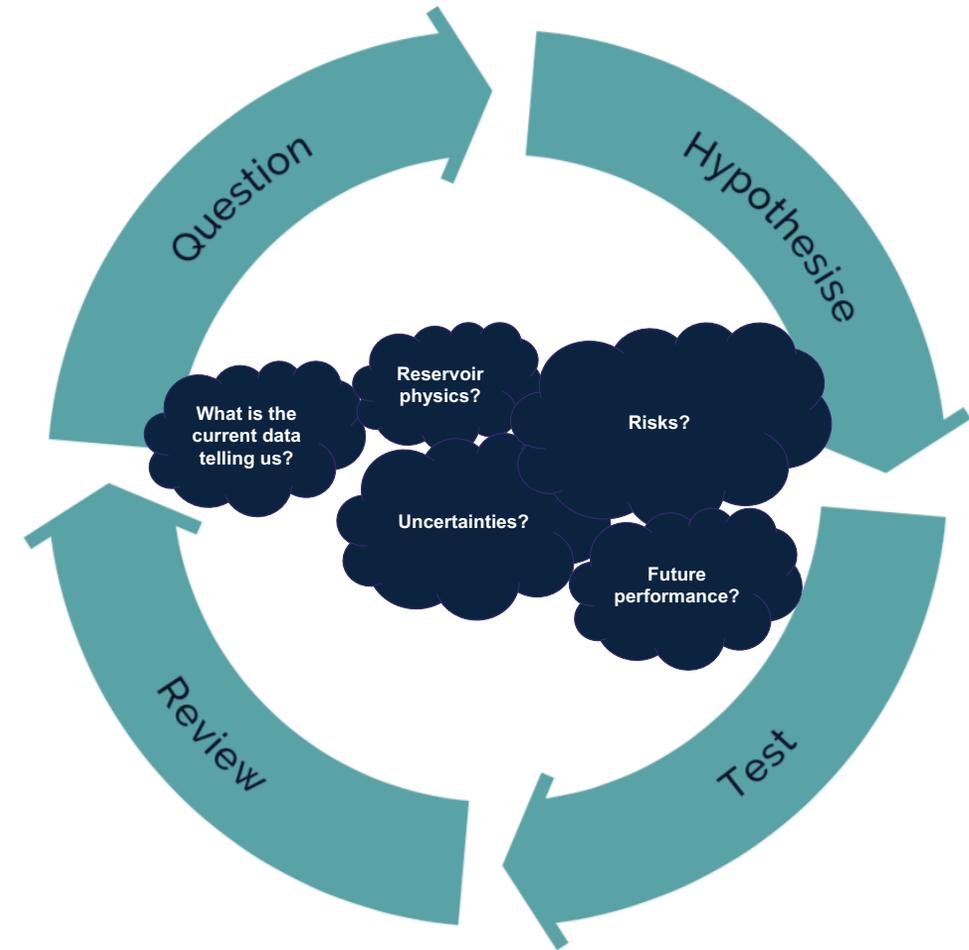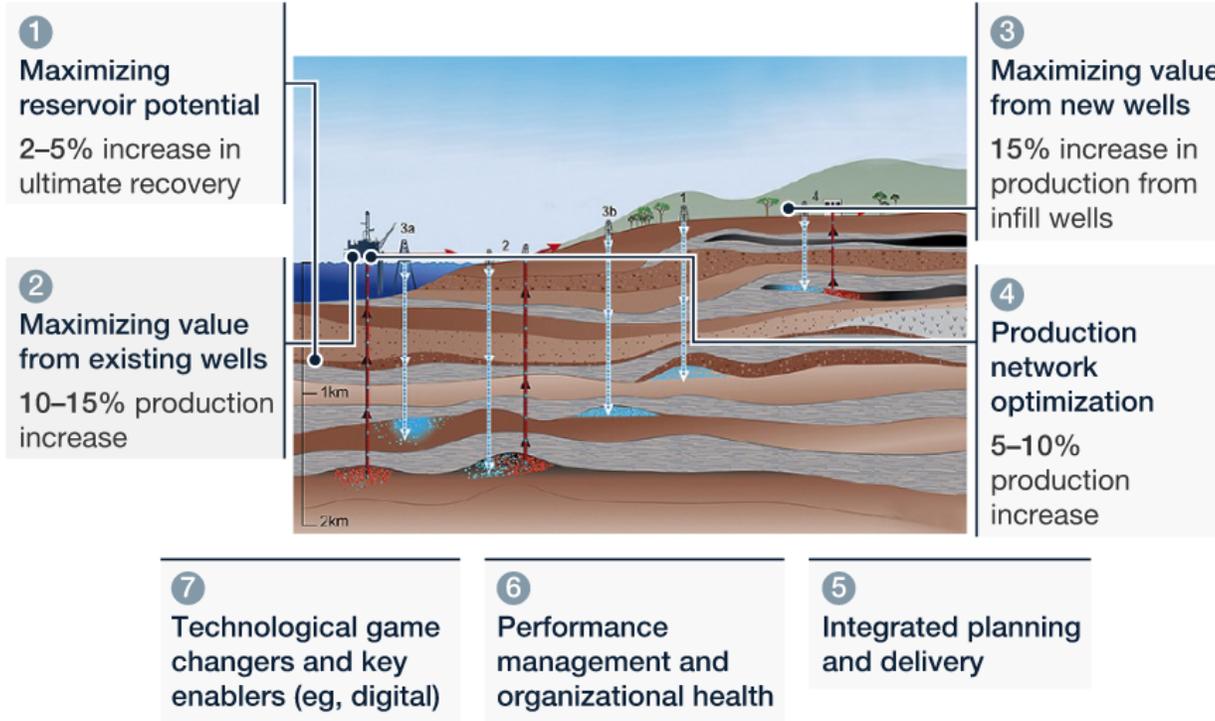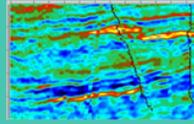
1 Maximizing reservoir potential — 2–5% increase in ultimate recovery

2 Maximizing value from existing wells — 10–15% production increase

3 Maximizing value from new wells — 15% increase in production from infill wells

4 Production network optimization — 5–10% production increase

5 Integrated planning and delivery

6 Performance management and organizational health

7 Technological game changers and key enablers (eg, digital)

McKinsey&Company

Question — Hypothesise — Test — Review

What is the current data telling us? — Reservoir physics? — Risks? — Uncertainties? — Future performance?

# Reservoir modelling

Static data

Seismic surveys	Well cores	Well logs	Geological analogues
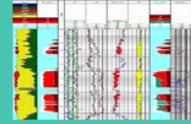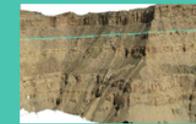
Millions of unknowns
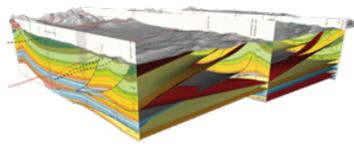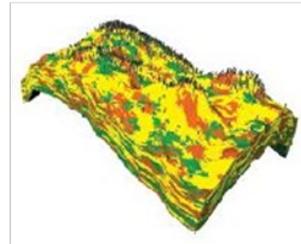
Structure   Facies   Petrophysics   Water saturation   Rel.perm   PVT
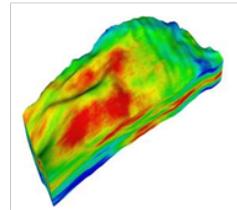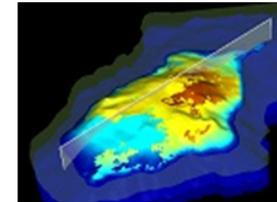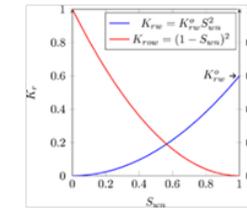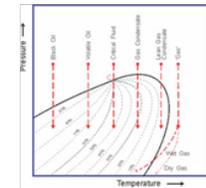
Dynamic data
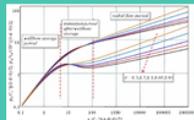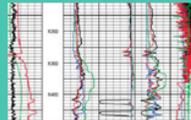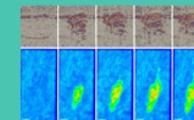
DST	RFT/PLT	Production data	4D Seismic

# Reservoir modelling = inverse problem!

**Static data**
- Seismic surveys
- Well cores
- Well logs
- Geological analogues

Millions of unknowns
- Structure
- Facies
- Petrophysics
- Water saturation
- Rel.perm
- PVT

Dynamic data
- DST
- RFT/PLT
- Production data
- 4D Seismic
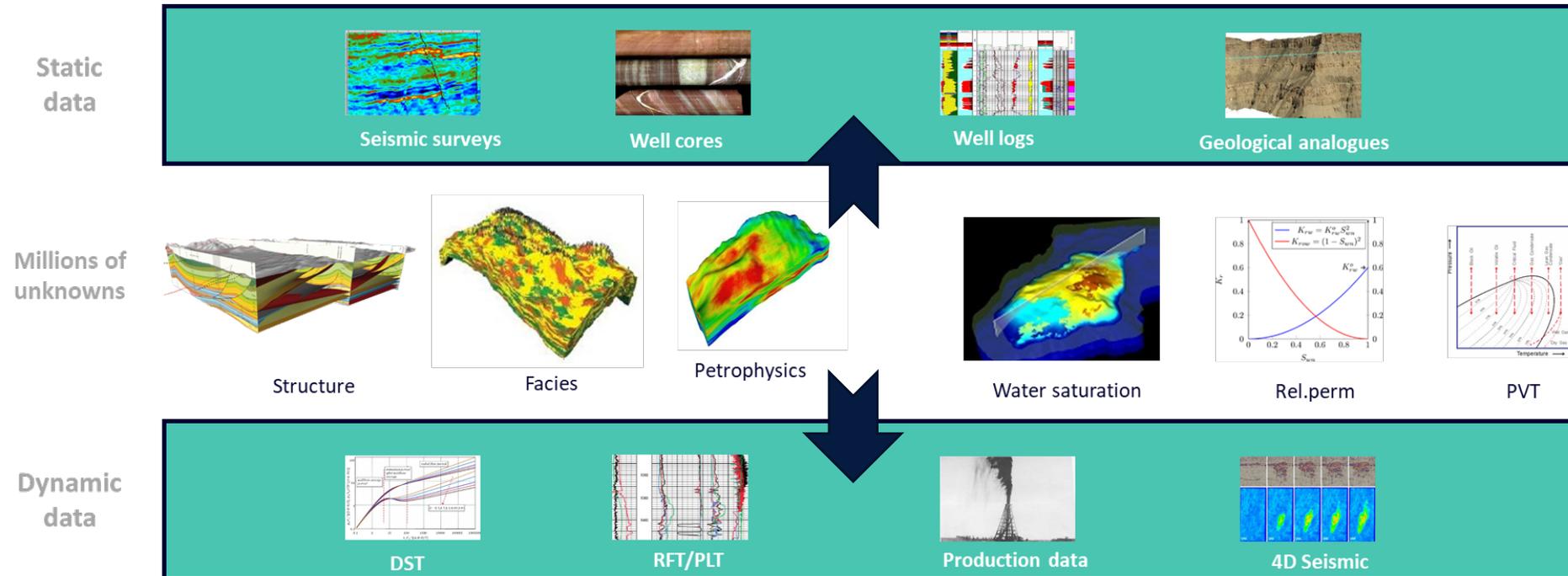
We should not create reservoir models and hope they eventually fit the data (i.e. solve a "forward problem")…

Reservoir modelling = inverse problem!

Static data
- Seismic surveys
- Well cores
- Well logs
- Geological analogues

Millions of unknowns
- Structure
- Facies
- Petrophysics
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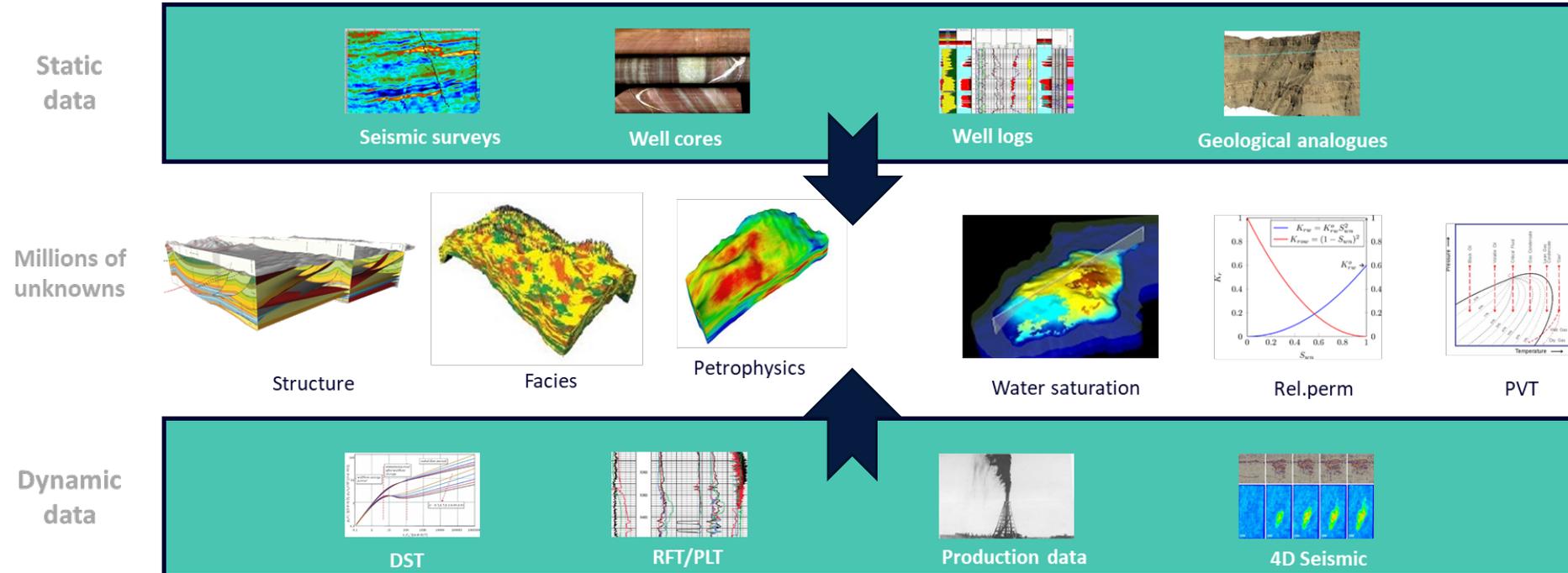
…instead data should be used to gain a better understanding of the unknown reservoir properties (i.e. solve the "inverse problem")

The 7 Wastes of Reservoir Modelling Projects

CONSEQUENCE OF THE "FORWARD PROBLEM" APPROACH

Non-utilized Talent
Underutilizing people`s talents, skills and knowledge

Defects
Rework, repetition, scrap and incorrect information

Handoffs and Delays
Working in silos and wasted time waiting for the next step in the process

THE 7 WASTES
of reservoir modelling projects

Loss of Information
Communication failures and overlooked data

Relearning and Task Switching
Loss of time, productivity and quality due to frequent task switching and continual relearning

Overspecialization
Overspecializing in a particular skill at the cost of competence in complementary skills and holistic experience

Non-Value Adding Features
Spending time and energy in features and activities that add no significant value and are not wirh the investment

Resoptima's technology solution

A FAST, INTEGRATED AND ITERATIVE APPROACH

Resoptima

Seismic

Well logs

Production data

4D seismic

ResX
Uncertainty-centric modelling
Data conditioning

Assimilate all data

Curate Data

Define Boundaries

Refine concepts

Ensemble of models

Pivot or persist?

Explore opportunities

IRMA
Ensemble Analytics
Decision support
Risk mitigation

Improve understanding

Measure predictability

Field development Opportunities

IOR Prospects

Predictive analytics

Portfolio Insights

Reservoir modelling using ResX:

TRAINING A MULTI-LEVEL GRAPH NETWORK*

- Reservoir physics defines graph relationships
  - Model parameters are easy to interpret
    (no black box!)

- **ResX**: Training the graph network

  - Fit for purpose machine learning algorithms:
    - Principal Component Analysis
    - Gaussian Process Learning (Kriging++)
    - Metric Learning
    - Stochastic Programming
    - Sparse Regression
    - ++++

*See e.g. Google's DeepMind project (Battaglia et al. 2018: *Relational inductive biases, deep learning, and graph networks*)
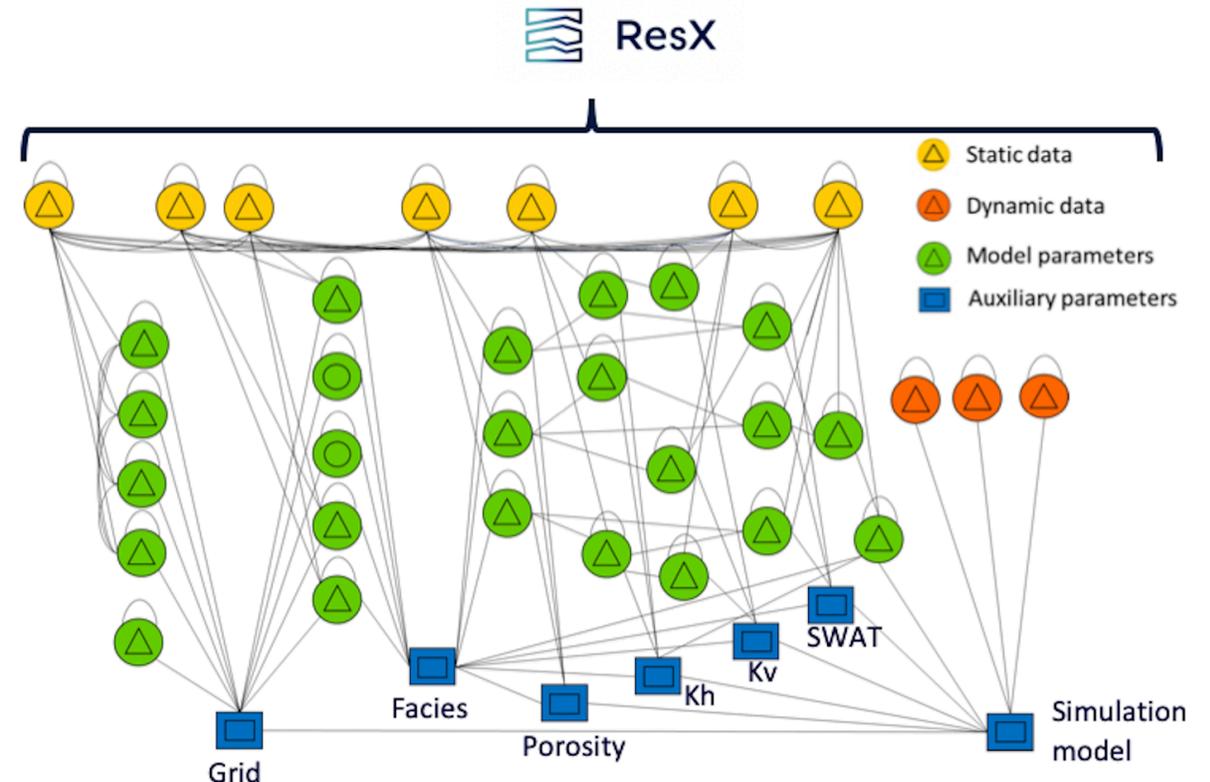
Technology in Action

DATA TO DECISION INPUT WITHIN 24 HOURS

Technology in Action

Challenge:

- North sea field, complex geology

- Client had indications that their models and recoverable volume estimates (PDO) were too optimistic (decline analysis)

Solution:

- First results in **less than 24 hours**:
  - Complete re-modelling (including grid)
  - **Minimum Viable Workflow**

- Final results in **one week**:
  - **Explore** multiple modelling scenarios (grid, etc.)
 - Future predictions

Results:

- Significantly improved history match (all ensemble members)

- Increased confidence (volume estimates)

Ensemble
Observed

Technology in action

Prior
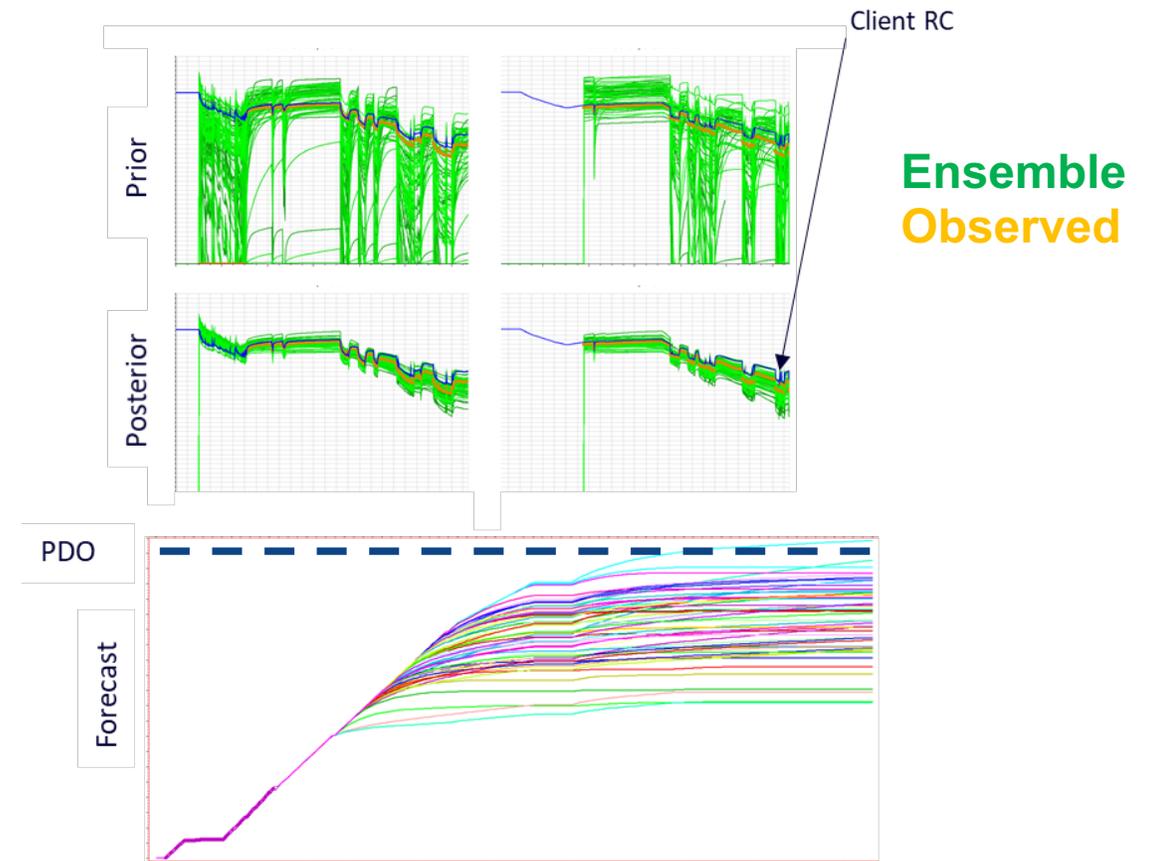
Technology in action

OBSERVATIONS

Posterior
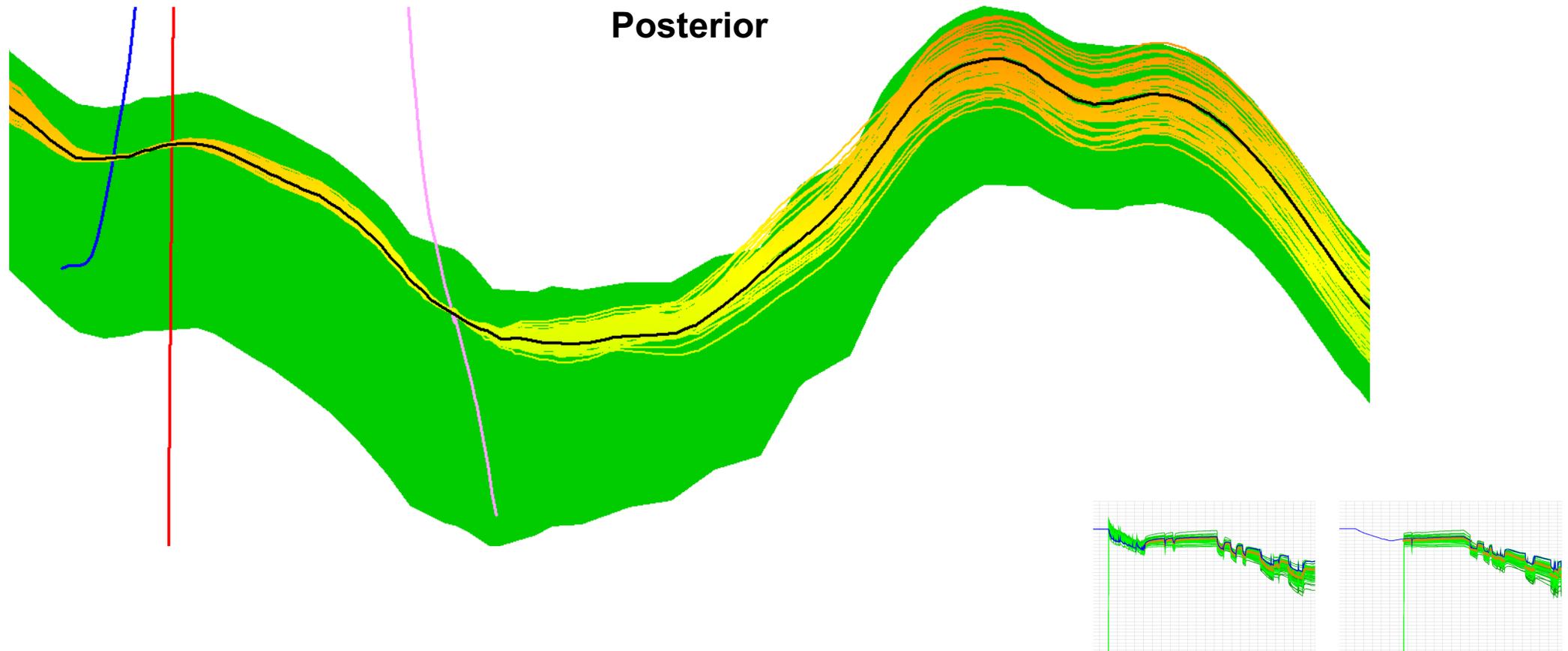
Concluding remarks

INCREASE SUBSURFACE UNDERSTANDING = KEY TO INCREASED RESERVES

Requires a continuous discovery process!

Seismic

Well logs

Production data

4D seismic

ResX
Uncertainty-centric modelling
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