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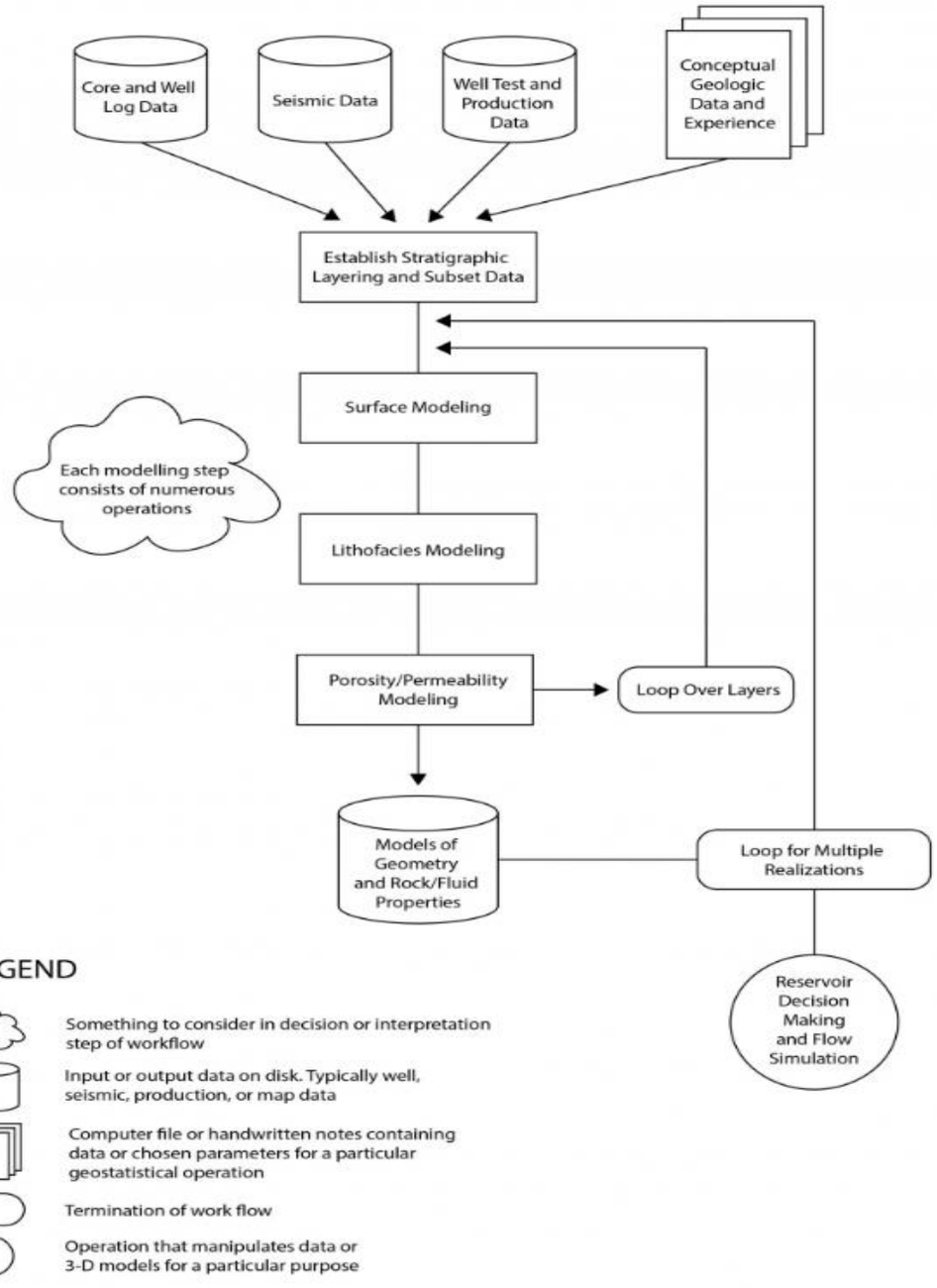
50 years of evolution in Technology, Geoscience and Reservoir Modelling

Agenda

- 1969 Retrospective.
- Reservoir modelling evolution and 2 case studies from the Force archives.
- The good news and the bad news.
- Why it can go wrong / Lessons learned.

Definition

- **Reservoir modelling** is the process of creating a three-dimensional representation of a given reservoir based on its petrophysical, geological and geophysical properties.
  - SEG Wiki



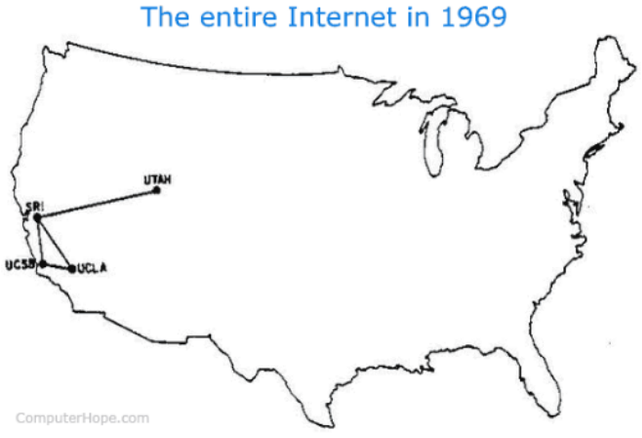
Taken from Pyrcz and Deutsch, 2014. SEG Wiki

Geoscience in 1969

- Walthers Law, Uniformitarianism and the Rule of Superposition all understood and accepted. 
- General acceptance of Plate tectonics.
- First hints that the dinosaurs were related to birds.
- But no Sequence Stratigraphy. 

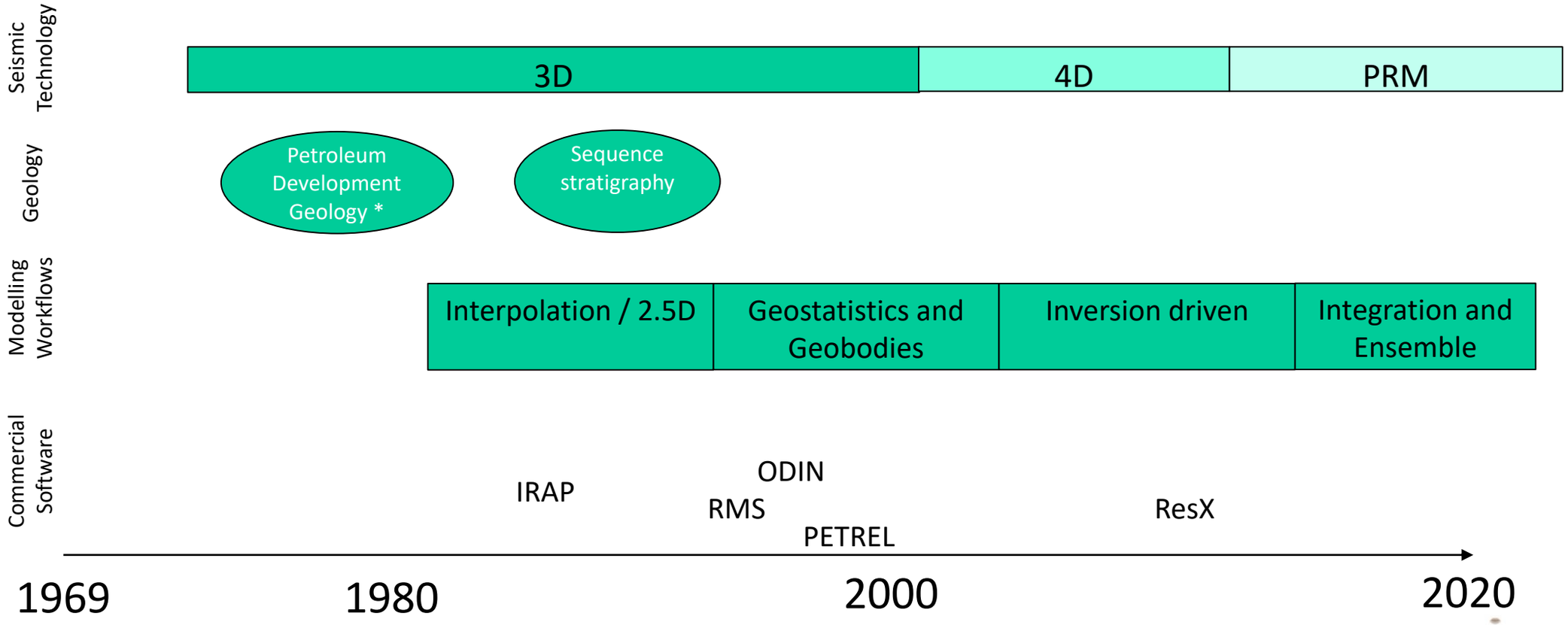
Computer history - 1969

- Intel launches its first commercial memory chip and begins design work on their first microprocessor.
- Xerox invents the laser printer.
- AT&T develop Unix.
- The first message was sent on the ARPANET.



Typical Reservoir study in ‘69

Evolution and industry trends



* 1979 Parke Dicky Tulsa University

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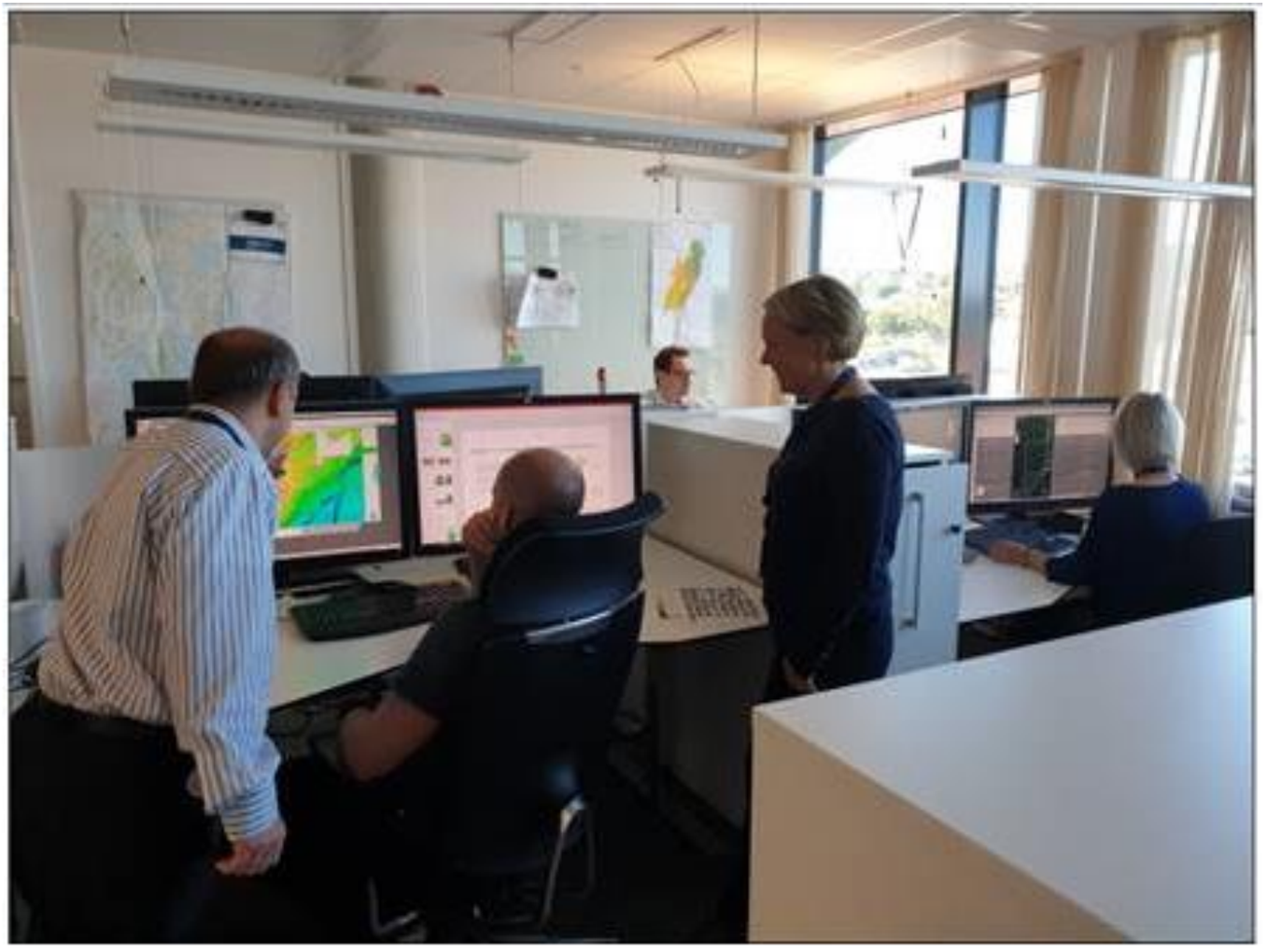
Reservoir studies in 2019



2 case studies from the Force archives

- 2002 :
  - Draugen 2001 4D Repeat Survey - Integrated Multidisciplinary Fasttrack Interpretation.
- 2017
  - Re-thinking the Goliath reservoir models: History matching and identifying infill targets using and ensemble based method.

Draugen 2001 4D Repeat Survey
Integrated Multidisciplinary Fasttrack Interpretation

K. Guderian*, J. Rehling*, Son-Huu Do*, A. White*, A. Onstein#, J. Leiknes+

FORCE Seminar

Stavanger/24.Oct.2002

(* Norske Shell; # Aker Geo;
+ Petoro, formerly Norske Shell)

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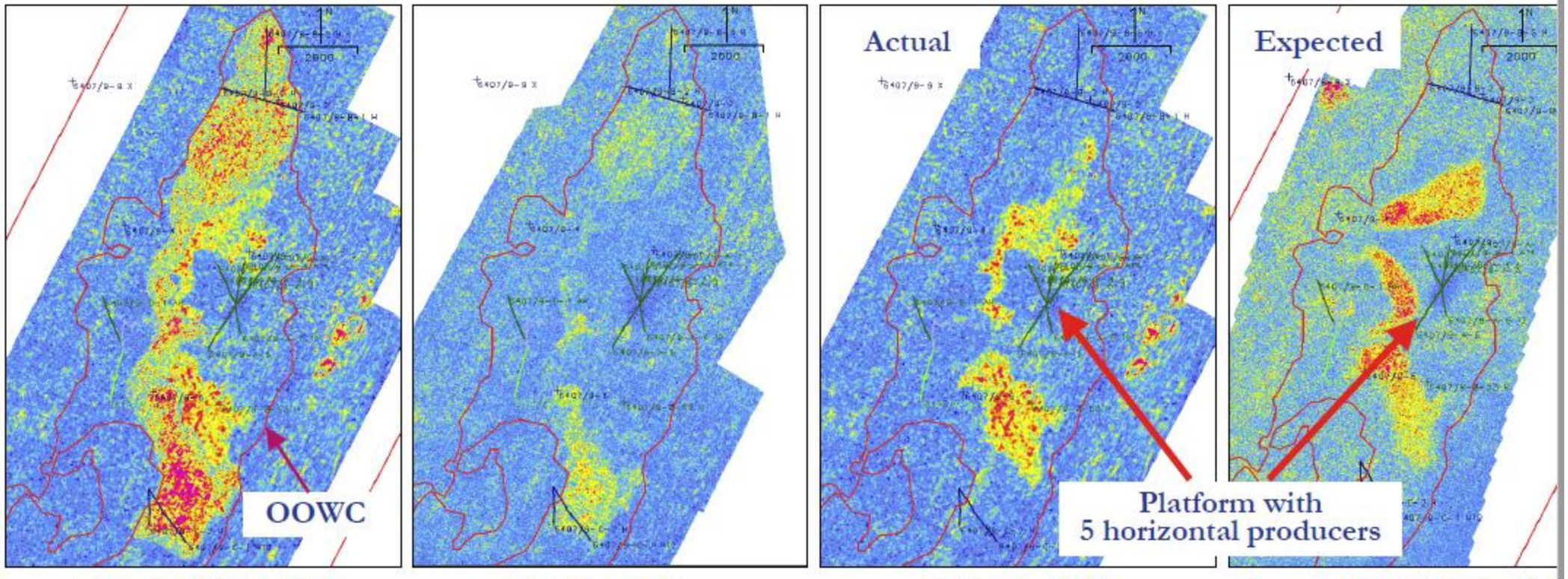
4D Seismic Signal

DRAUGEN

RMS amplitude map 30 ms window around reservoir



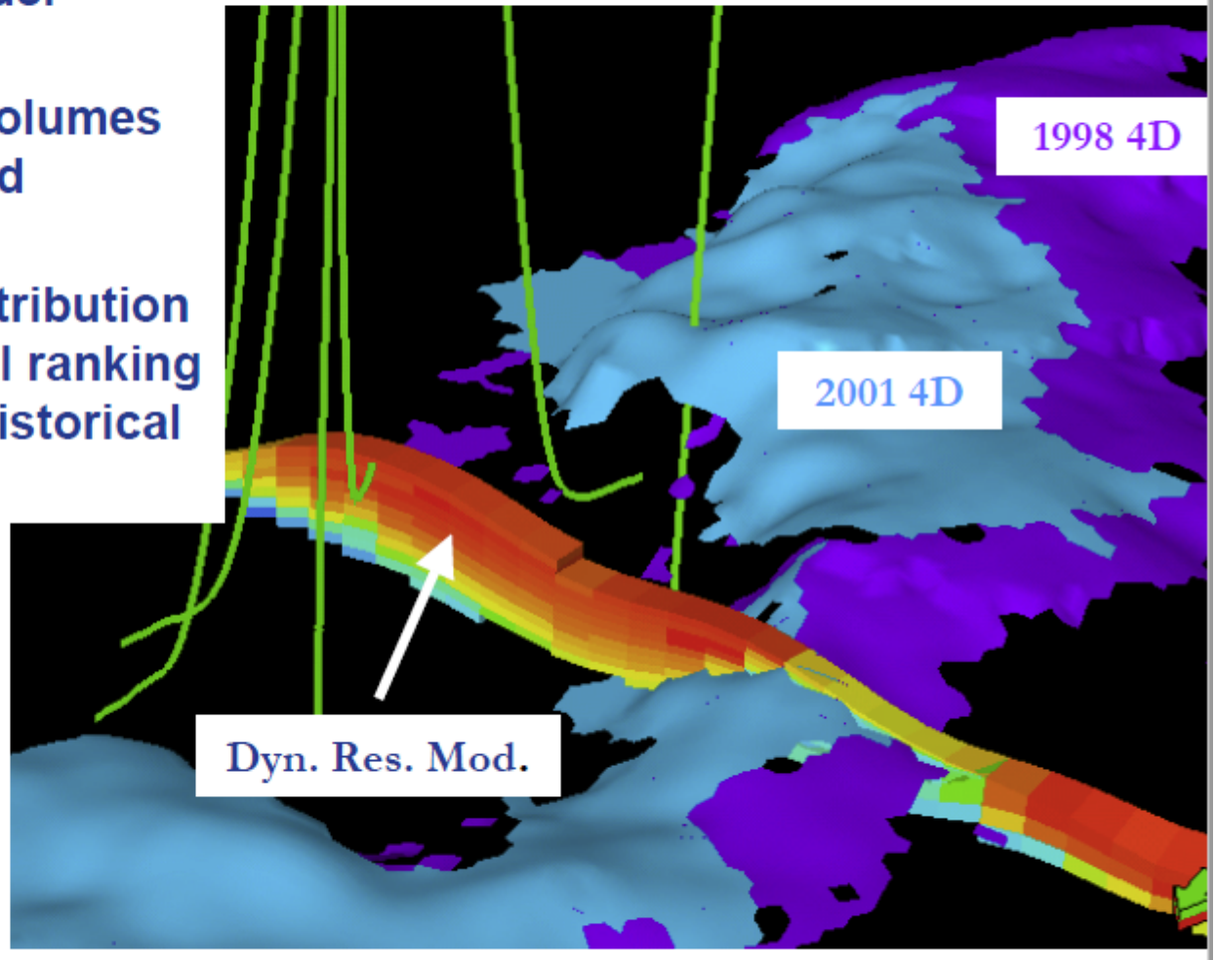
a) Total (1990 – 2001) b) 1990 - 1998 c) 1998 – 2001 d) modelled 1998 – 200

Waterfront is more advanced towards main producing wells;

Earlier water-breakthrough

Model Update

1. Incorporated waterfront map derived from inversion data plus uncertainty range into existing reservoir model realisations.
2. Calculated modelled produced volumes and compared to acutal produced volumes for all realisations.
3. Determined weighted STOIIP distribution from all realisations by statistical ranking based on match to 4D info and historical produced volumes.
4. Created updated dynamic models based on new STOIIP matched to
   - water front position in 1998 and 2001
   - production and pressure history
5. Generated new forecasts



Summary : Draugen 2002

- Deterministic scenario based workflow, ~ 8 realisations
- Separate, “manually” linked software steps.
- Qualitative ranking of several predefined subsurface models / scenarios. Ranking based on the “degree of fit” to water front movement and production + pressure history. -> “manual” (visual) estimate.
- Weighted STOIIP from scenarios used as basis for new, manually history matched “Base Case”

Re-thinking the Goliat reservoir models:

History matching and identifying infill targets using an ensemble based method

Gjertrud Halset, Reservoir geologist
Guro Solberg, Reservoir engineer

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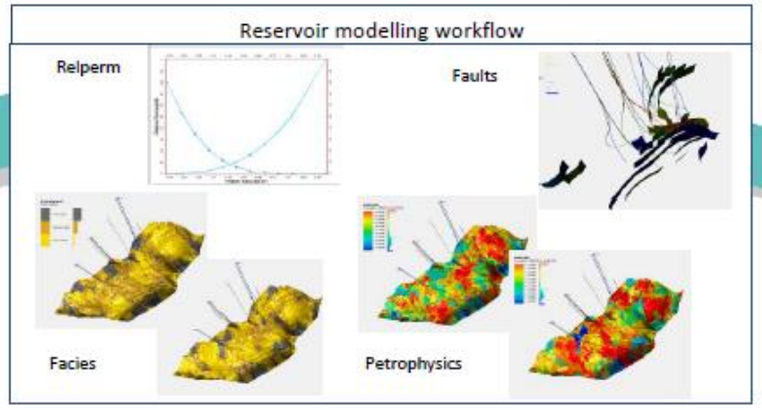
Ensemble-based reservoir modelling

Input

Well logs
Geological concept
Seismic data
Core data

Reservoir modelling workflow

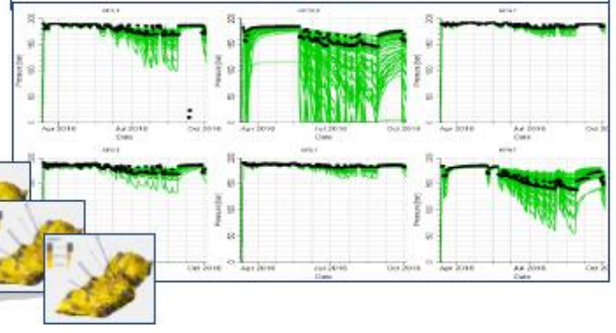


Geological uncertainties included:
- Structural
- Facies
- Petrophysical properties

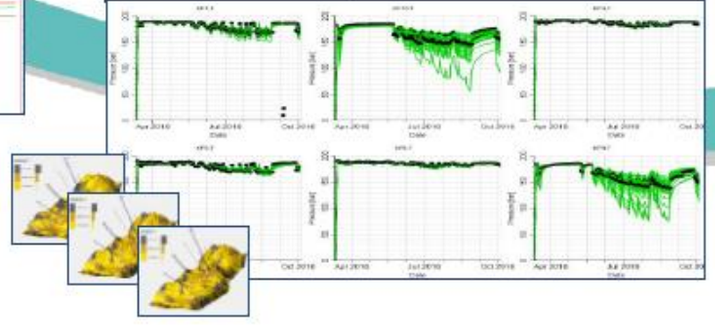
Dynamic uncertainties included:
- Relative permeability
- Fault transmissibility
- OWC and GOC
- Well completion skin / PI multiplier

ResX

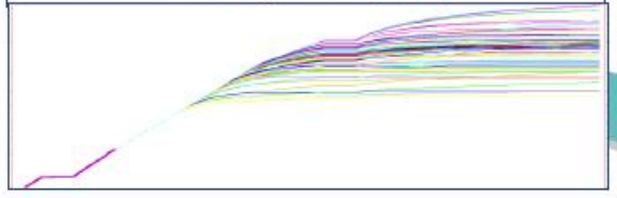
Initial models



History matched models



Forecasting and infill planning



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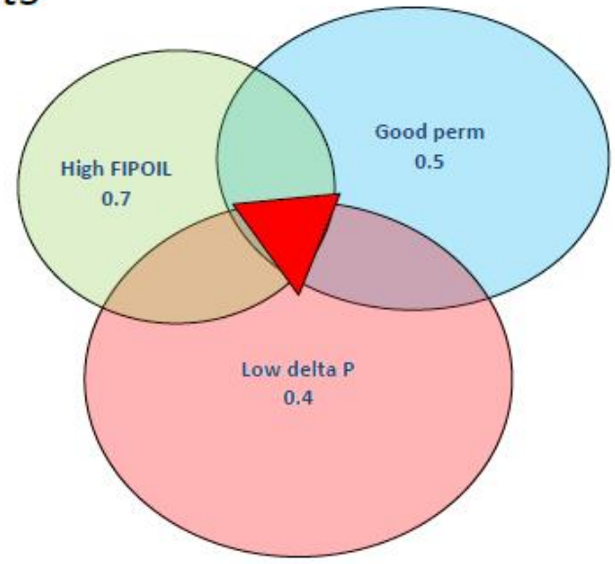
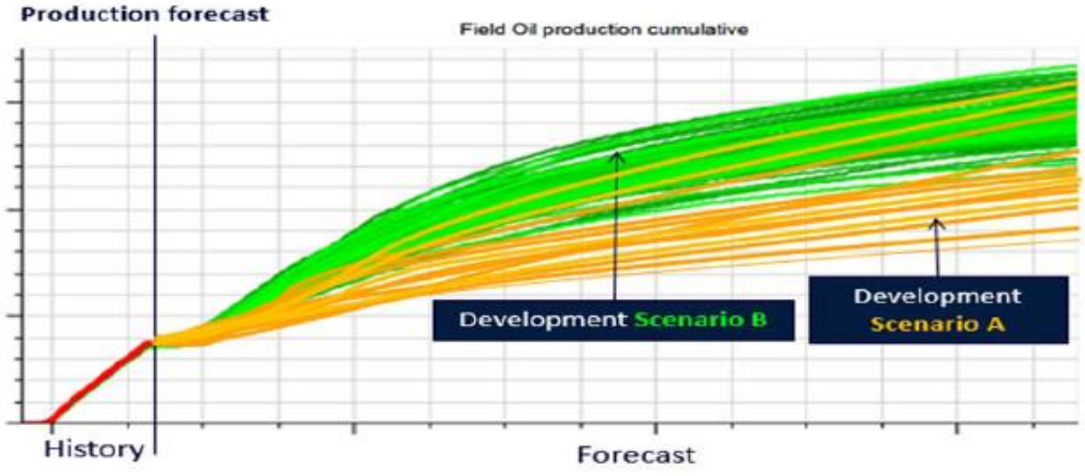
Approach

- *Analyze the ensemble of models to identify robust infill targets*
  - *Identify **connected volumes** combining:*
    - *High probability of good perm sand*
    - *High probability of high in-place volumes*
    - *High probability of small pressure depletion*



- *Evaluate the different development scenarios*



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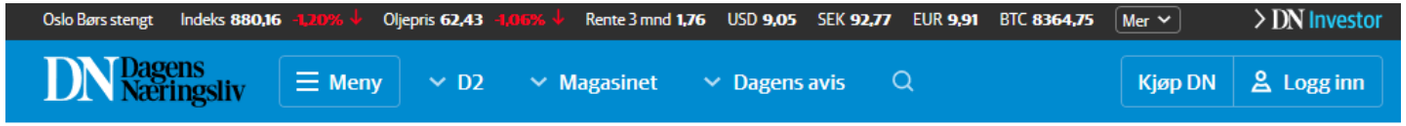
Summary : Goliat 2017

- Automated history matching of the full set of models representing the uncertainty range (ensemble with 50 realisations).
- "Modelling" and "Condition" linked in the workflow and rules based.
- Definition of models workflow based, rather than "output" based.
- One common model for static and dynamic.

Good News

- Many documented examples of business value from reservoir modelling :
  - Better spatial understanding of resource distribution.
  - Identifying and maturing infill targets.
  - Planning extend reach wells.
  - Cross discipline communication.
  - Platform for data integration and validation.

Bad News – in the news



Olje

Feltene gir mindre olje enn tenkt

Tre av fire nye norske oljefelter produserer mindre enn planlagt i

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Bad news - data

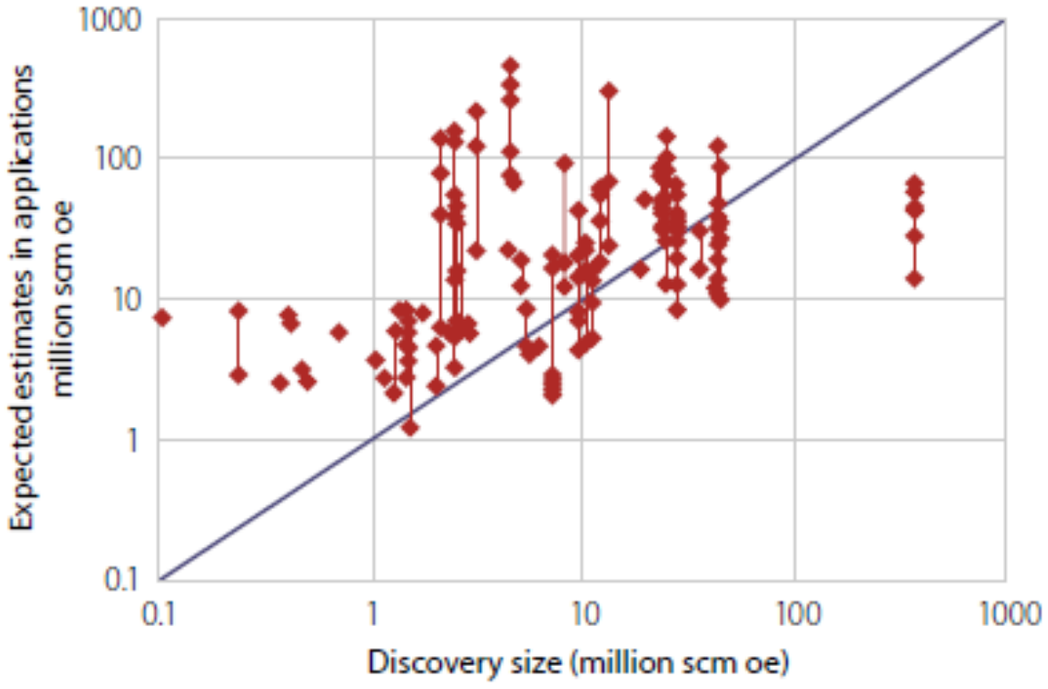

Figure 7.2 *Expected values from companies before award compared with (expected) discovery size (APA rounds 2003-11 and 16th-22nd numbered rounds). Vertical red lines link differences in estimates from various companies for the same discovery. Some finds have an estimate from only one company.*

Source : NPD 2018

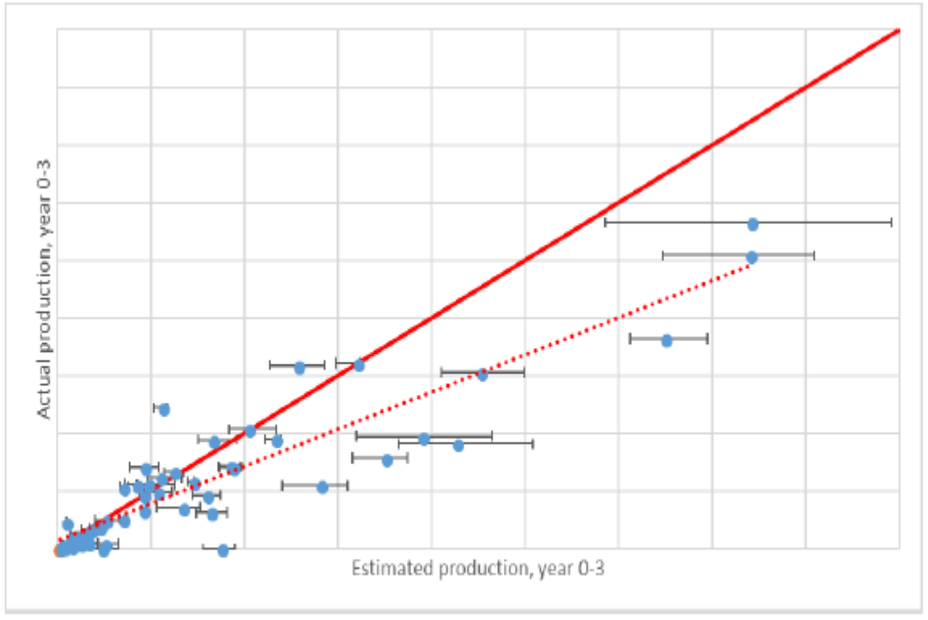

Figure 30: Distribution of results for 56 fields on the NCS, with error bars illustrating the 80 percent confidence interval for each estimate

Source : Erlend Mohus UiS 2018

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What's causing this ?

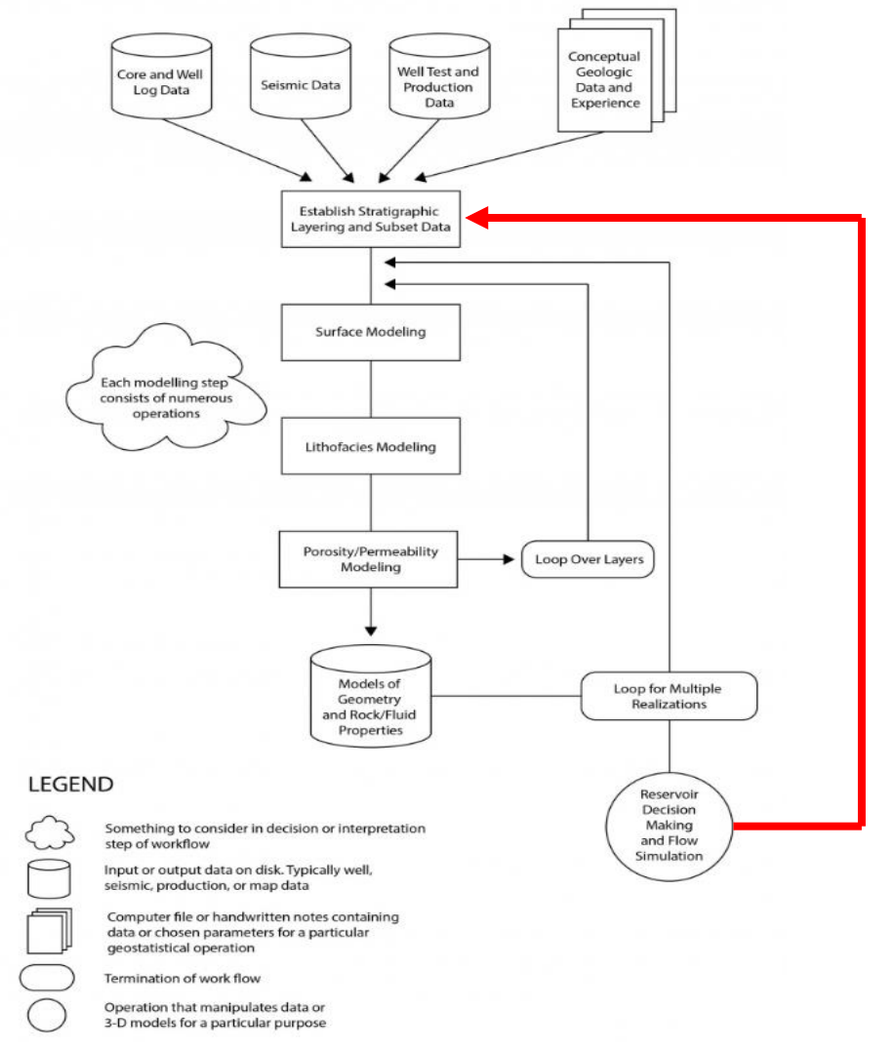
"Oil is first found in the minds of men "- Wallace Pratt
AAPG 1952

Reasons for failure - model space

- Poorly understood (and communicated) subjectivity
  - Well everyone agreed that this was ...
  - It has usually been assumed ....
- Overlooked key uncertainties/failure cases
  - We are still not good at knowing what we don't know .....
- Lack of real discipline integration in the workflow
  - Cookie cutter approach, delivery chains, guidelines as the “bible”
- All of this can lead to anchoring and bias
  - Even in fully probabilistic workflows!

Reasons for failure - organisational

- Lack of a clear understanding of the objectives of the modelling:
  - The first victim of “fast track” project schedules is subsurface uncertainty.
  - We build the “the” model rather than “a model to ...”



Taken from Pyrcz and Deutsch, 2014.
SEG Wiki

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Reasons for failure – organisational 2

- Organisational “fussing”.
- Too many stakeholders and misaligned agendas impacting project decisions and having a “subterranean” influence on technical evaluations:
  - We really need this to be …….
  - Getting this to work is important ……
  - We don’t really have a choice …..

The answer?

- Ensemble based workflows will help, but the team will still be key.
- Success in the oil industry continues to need talent scientists and engineers with:
  - a solid grounding in their technical fields.
  - excellent communication skills.
  - who are also good with computers.....

The future compromise?