Brage Statfjord Revitalization
Subsurface Workflow during an Infill Well Project

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Statfjord Revitalization

Agenda

- Introduction to Brage Statfjord
- Basis for new wells
- Static model
- Case Study: uncertainty handling during the lifetime of the project
  - Identify phase
  - Select phase
- Conclusion
On production since September 1993, Statfjord has contributed over 50% of the total Brage production (3 other reservoirs)

Concept: **Sand-Box** → connected reservoir

- Dead oil with common initial FWL and limited bottom aquifer: 60m oil column in South, less in North
- STOIIP ~ 53 MSm³ / RF >= 55%
- 13 historical producers: mostly long horizontal, near reservoir top (now 5 active in South)
- 2 main historical injectors: slanted perforated around and below the initial FWL (now 1 active in South)
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**Basis for a Well Project in South**

- Natural production decline: need for infill targets

Based on STOIIP estimates and historical production:
  - RF: 65% N vs 55% S → Potential in South
  - Backed-up by 4D seismic signal

- Explanations:
  - ratio of (injected water) / (pore volume)
  - well density

- Contingency for South injector failure

2014 - 1992

4D map: change in AI

hardening
softening
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Static Model (Pre Well Project)

**Properties**
- High sand proportion
- No well-well shale correlation
- Calcite nodules 2-4% of GRV

**Grid**
- High marker control
- Depth conversion (top surf.)
  - Error map
  - U: +/-3% in GRV (200 real.)
- Bounding faults U: +/-3% in GRV

**Observations / Starting Point**
- Logs from previous model

**Chosen Option**
- Keep all except new Sw logs (n,m - Archie)
- \( \rightarrow \) 3 J-functions for initialization
- \( \rightarrow \) 1 kept after early HM
- Facies: Sand / Shale (SIS) with VSP
- K/Phi: Gaussian sim. (shale inactive)
- NTG

Use most likely top surface
- Isochore down
- 50*50*1 m³ / no upscaling

**Single Static Realisation: Base Case**
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Identify Phase – Prove Feasibility

Manual HM (focus: South and oil prod.)
- sensible parameters: Kv/Kh, Rel perm
- need to include vertical baffle

Well Concept
- volume balance in South tank
- avoid closing current producers

Well Locations
- same strategy as hist. wells: 2D prob.
- limited number of tested configurations
- use 2D maps for producer

Drilling & Well Dept.

control from SCAL data
also seen in 4D seismic

result: 2 acceptable HMs

Well-Pair: 1 producer 1 injector

Simulation maps
Seismic attic oil map (4D map also)
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Identify Phase – Prove Feasibility

- Reserves estimate: field delta oil production - 6 cases
  - 2 HMs
  - Different prediction settings in the “Do Nothing” case (reservoir pressure)

Well-Pair

- Injector close to old producer, convenient slot (well cost)

Project approved
Select Phase – Optimize

Part 1: still using the base case static model and the 2 HMs

- Compare Well-Pair with other **concepts** (>10)
  - [1-2] new wells
  - use active wells for injection or short sidetracked prod.
  - economic screening

Well-Pair ranks best
Producer before injector

Injector location
- tested every 250 m

Move injector
~ 500 m South

cHECKED ON 4 REALISATIONS (2HMS, 1/0 BAFFLE)

Simulation baffle tested against synthetic 4D seismic

Baffle “confirmed” and mapped with 3D seismic

A subsidiary of BASF – We create chemistry
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Select Phase – Uncertainty

Part 2: more static realisations

Petrophysical update (unpredicted)
- core data is now stress corrected
- K/Phi correlation clarified

Workflow – “discrete” variables
- 25 static realizations: a: [1-25]
- 3 “dynamic sets”: b: [1-3]
  1 ➔ HMBC16 / 2 ➔ intermediate / 3 ➔ HMBC16_2
- 3 fault scenarios: c: [1-3]
  case name: XXX_a_b_c (all combinations)

Reserves Estimate
- cases assumed a priori equiprobable
- for each case - HM mark (criteria, OF)
- screening or “weighting”

From previous phase:
Kv/Kh
Rel. perm

225 “HMs”

4D baffle geometries

Fault Scenario
MULTFLT

SS_1_S
SS_1_N
1
0
0.05
0
1
0.05

2
3
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Select Phase – Posterior Analysis

Maps: posterior justification for the WP location

Impact of input variables

Project approved: wells to be drilled in 2017
Conclusion

- How is the uncertainty on the well-pair evaluation evolving during the project?
  - confidence is building up after each milestone (decision)
  - complexity and number of parameters is increasing

- The exercise of looking back at the full project workflow is performed too rarely
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Questions?