PENGUIN A FIELD

A simple approach to simulation in a complex reservoir

Ceri Griffith-Swain, Carlos Annia, Sami Al Nofli
Penguins Subsurface Team
Reserves: Our use of the term “reserves” in this presentation means SEC proved oil and gas reserves.

Resources: Our use of the term “resources” in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

Organic: Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

Resources plays: our use of the term ‘resources plays’ refers to tight, shale and coal bed methane oil and gas acreage.

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- 50% Shell, 50% Esso Exploration & Production Ltd
- Developed 2001-2007
- 1st oil/gas in Jan 2003
- 9 well subsea development
- Fluids commingled and sent via 65 km subsea tieback to Brent Charlie processing facilities
- A group of highly faulted and structurally complex fields
Kimmeridge Mass Flow – Upper Jurassic Magnus Sandstone Member

Western collapsed terrace of the Penguins Horst Block

3 exploration/appraisal wells

2 wells: A01 (2003), A02 (2005)

Structural/stratigraphic compartmentalisation

N/G 30-70 %, Porosity 15-18 %, Permeability 10-30 mD
Modelling Rationale

Limited ability to capture full range of uncertainty.

2nd Order Uncertainties
- PVT
- Communication A1 – A2
- Extent of depletion by A1
- Drillability – Depletion
Simplified Modelling Workflow

Stage 1: Experimental modelling
- 3x2 km sector cut from the box model

Stage 2: Interim check
- Static model
- 3x2 km sector cut from the static model

Stage 3: Forecast modelling
- 24 realisations created from the box model
- Full Field MBAL Model

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A simple full field model with no structure was created using the Top Magnus well tops.

The box model was populated using a simple workflow to represent the following uncertainties:
- Layer density of the Petrel model
- Shale percentage
- Sand body size and orientation

To ensure a fast run time for the dynamic analysis a 3x2 km sector was cut from the generic box model.

The sector encompassed the A1 horizontal well which has the highest confidence performance data.
Experimental Results: Impact of Shale Thickness

- Models run with the same NtG but varying the layer density

- Increasing the layer density (thinner layering) gives a better match with the early build up pressure

- Varying the number of thin shale beds does not match the performance from the well, the simulated pressure is much higher than the observed pressure

- The facies distribution and stacking pattern of these lobe complexes control the STOIIP, and also have an impact on the near well-bore pressure behaviour, but are not enough to enable a full history match
Experimental Results: Impact of Faults

- a) Faults fully sealing
- b) Faults partially sealing
- c) Small window of communication to the West
- d) Small window of communication to the West and North

- Test faults with varied transmissibility introduced
- Faults require ‘low transmissibility’ windows of communication
- The complex faulting patterns influence the lateral connectivity of the system
The same 3x2 km sector was cut from the static model.

A history match was achieved using the same parameters as the sector from the box model.

Applicability of box modelling approach confirmed.
Realisation Results

- Smaller lobes & higher shale % = low recovery factor
- Larger lobes & smaller shale % = higher recovery factor

24 realisations, generated from varying the static uncertainties were run from the Box Model.

More confidence in the model – it does what you expect.
The faults are believed to demonstrate low transmissibility behaviour, and provide a means of controlling the oil influx from the surrounding compartments into the horizontal well block.
A full field material balance model in MoReS was used to generate the proposed new well forecasts. Consists of the three grid cell representations for each of the fault blocks, these correspond to the three (near, mid and far) tanks in the existing history matched material balance MoReS model. Each fault block has a range of uncertainty based on:

- In place volumes
- Transmissibilities between near, mid and far volumes
- Transmissibilities into the neighbouring fault blocks

Forecast Methodology

Full Field MBAL Model (MoReS)

A1 and A2 successful history match

243 Realisations run
Conclusions

- Simple model: easy to run and fit for purpose to capture a range of Penguin A uncertainties whilst honouring the well data and the geological model

- Increasing the shale layer density impacts the near well-bore pressure behaviour

- The faults are thought to demonstrate low transmissibility behaviour, and provide a means of controlling the oil influx from the surrounding compartments into the horizontal well block

- The static uncertainties (shale density) along with STOIP, fault transmissibility and well productivity were used to create a realistic range of forecasts

- The learnings from this work were then implemented into a full field material balance model in MoReS and achieved a history match over the whole field
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