Building a Reservoir Model, Pembrokeshire, UK (G055)

Tutor(s)

Mark Bentley: TRACS International Consultancy and Langdale Geoscience.

Overview

This course offers a software-independent view on the process of reservoir model design and simulation model-building, addresses the underlying reasons why some models disappoint and offers solutions that support the building of more efficient, fit-for-purpose models. The thread through the week is a model design for the notional 'Pembroke Field' – a synthetic field constructed from reservoir analogue outcrops in South Pembrokeshire. The Pembroke Field contains three contrasting reservoir types: continental clastics, shallow marine deltaics and naturally fractured carbonates, in both structurally deformed and undeformed settings. Data from producing oil and gas fields has been scaled to the synthetic models to create a realistic hydrocarbon field accumulation, ready for development.

Objectives

You will learn to:

1. Create a fluid-sensitive conceptual model for a heterogeneous reservoir, built from a selection of elements and placed in a realistic architectural framework: the "sketch".
2. Guide the use of geostatistical tools intuitively, balancing deterministic and probabilistic components with awareness of the limits of the tools.
3. Select appropriate methods for modeling of matrix properties, including the handling of net (cut-off's vs total property modeling).
4. Evaluate options for multi-scale modelling and the possible need for multi-scale approaches based on hierarchical understanding of Representative Elementary Volumes (REV).
5. Understand issues surrounding permeability modeling and why this differs from the handling of other properties.
6. Learn a rule of thumb ("Flora's rule") to help assess what level of static model detail matters to flow modeling and forecasting.
7. Review how to use well test analysis to constrain models.
8. Review options for model-based uncertainty handling (base case led, multi-deterministic scenarios, multi-stochastic ensembles), learn how to post-process the results and how to select an appropriate workflow which minimizes impact of behavioral bias.

Exertion Level

This class requires an **EASY** exertion level. Field stops require short walks along coastal paths, beaches and wave cut platforms. The longest walk is <5km (3 miles). Field stops are all at approximately sea level and some are tide dependent. Transport will be by coach.This class requires an EASY exertion level. Field stops require short walks along coastal paths, beaches and wave cut platforms. The longest walk is <5km (3 miles). Field stops are all at approximately sea level and some are tide dependent. Transport will be by coach.

Level and Audience

Intermediate. The course is aimed at geoscientists with knowledge of reservoir modeling software, petrophysicists who provide input to static reservoir models and reservoir engineers involved in simulation work who deal with the static-dynamic interface on a regular basis. The course is also of benefit to team leaders who wish to have a deeper understanding of the principles behind modeling and how to QC models made by others.

Duration and Logistics

7 days; a mix of field work (70%), and classroom exercises (30%).

Course Content

Course Details

The central theme of the course is Reservoir Model Design, on the premise that it is design rather than software knowledge that typically distinguishes “good models” from “bad models”. Considerable time is dedicated to reservoir model and simulation exercises in many companies but the results often disappoint: the time taken to build models is often too long, the models too detailed and cumbersome and the final model is ultimately not fit-for-purpose. This course examines the reasons why and offers remedies to fix these problems.
Modelling and simulation software is not run live on the event – the emphasis is on good design. However, models and simulations of the Pembroke Field have been built at a number of scales and will be shown to quantify the impact of the observed field heterogeneities on fluid flow.
The course is organized around the following five themes, issues within which are often the cause of poor model outcome:

- **Model purpose**
- What is the question we are specifically trying to address? What do we really mean when we say “fit for purpose”?
- **Elements and architecture**
  How much detail should be incorporated into the models? From the rich spectrum of potential lithofacies, electrofacies, biostratigraphic and analogue data inputs, how do we select the “right” number of components (elements) to take forward into the modeling process? Once selected, how do these elements combine into a realistic description of length scales and reservoir architecture? How to capture this in an interpretative sketch that can be used as a cross-discipline communication tool.
- **Probability and determinism**
  Is the balance of probabilistic and deterministic components appropriate given the model purpose? Should heterogeneities be handled implicitly or explicitly in the static and dynamic models and if implicitly, then how should we average their properties? What are our expectations of geostatistics and how do we control the algorithms intuitively to replicate a sketched reservoir concept? This applies both to modeling of the matrix and also fractures, and we explore how we can use well test data to place deterministic constraints on our models.
- **Multi-scale modeling**
  What scale should we be modeling and simulating at, given the fluid type and model purpose? Can everything be modeled at one scale, or are static/dynamic multi-scale models required? We

address the full spectrum of heterogeneity using the concept of Representative Elementary Volumes and conclude that traditional static-dynamic upscaling is only part of the story and not always the main part. Illustrations of fine-scale "Truth" models will be used to illustrate where we sometimes go wrong when we over-simplify a design.

- **Model-based uncertainty-handling**
  How to really go wrong. What are the tools we can use to identify natural bias (heuristics) in the modeling process and select workflows that capture useful ranges in a practical way, minimizing bias in the process. We summarize the current range of stochastically and deterministically led options, including the current trend towards "ensemble" modeling and the use of machine learning and AI. We discuss which techniques are appropriate to use and when, and how to post-process the results and communicate them usefully to colleagues.

Day 1: Arrive in Saundersfoot

Classroom:

- Course introduction and safety briefing

Overnight Saundersfoot.

Day 2: Model purpose, elements and architecture

Fieldwork:

- Amroth, incised valley fill, delta front and delta plain depositional systems

Overnight Saundersfoot.

Day 3: Rock modelling, probability and determinism, practical geostatistics

Fieldwork:

- Swanlake Bay and Manorbier, Lower Old Red Sandstone (Early Devonian) fluvial facies – sandbody types and palaoesols

Overnight Saundersfoot.

Day 4: Property modelling, handling permeability and fractures

Fieldwork:

- Saundersfoot – folding

Overnight Saundersfoot

Day 5: Upscaling and mulit-scale modeling

Fieldwork:

- Stackpole – faulting and fractured carbonates

Overnight Saundersfoot.

Day 6: Model-based uncertainty handling

Fieldwork:

- Tenby – carbonates and structural features

Classroom:

- Completing the Pembroke model design and debriefing with reservoir and simulation models.

Overnight Saundersfoot.

Day 7: Deprature

Departure and travel home.