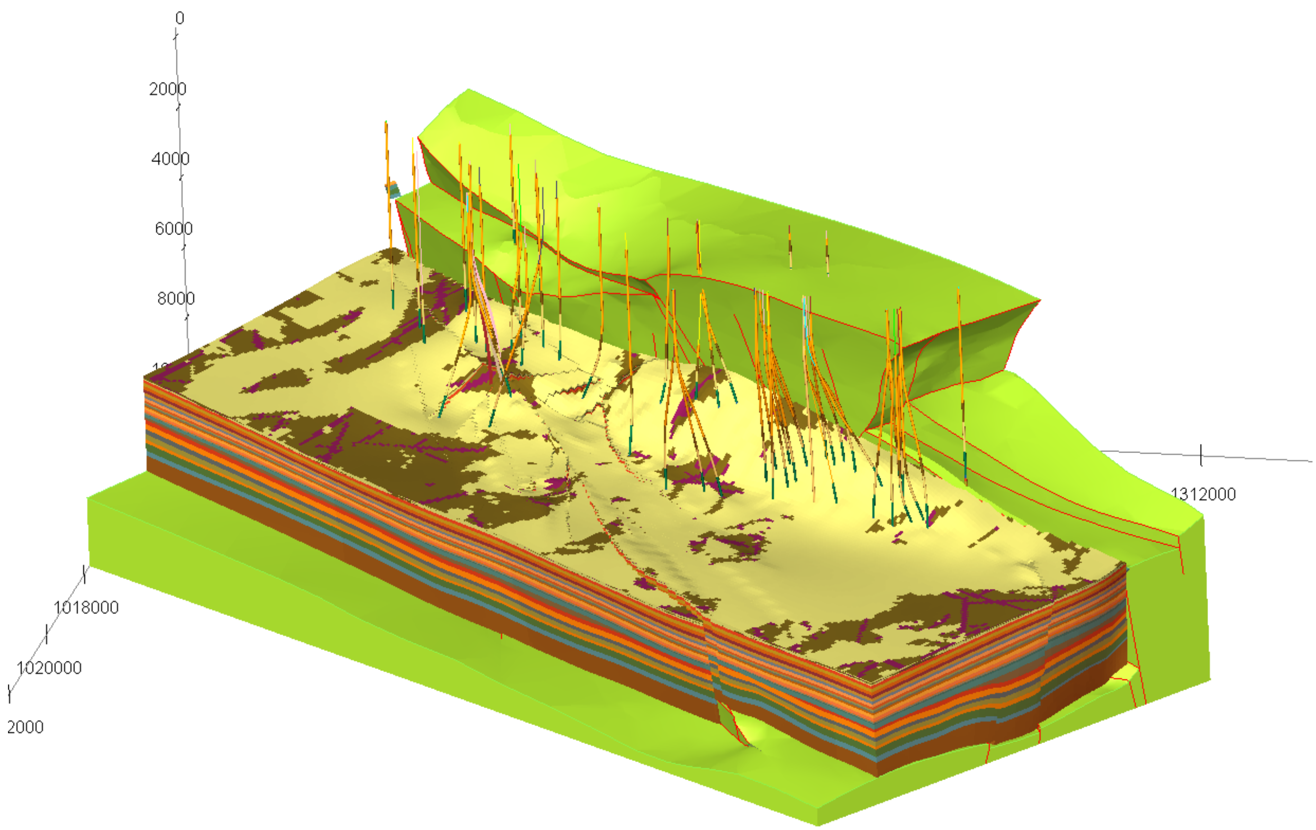
Building an Integrated Static Reservoir Model

5-day Course



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Agenda

Day 1

Morning – Introduction and Overview
Afternoon – Well Data Prep & QC Using Cores - exercises (1, 2)

Day 2

Morning – Core, Pressure and Petrophysical Data Prep and Analysis – exercises (3, 4)
Afternoon – Contact Analysis and Flow Unit Definition – exercises (5, 6)

Day 3

Morning – Preparing Horizon & Fault Data – exercises (7, 8)
Afternoon – Preparing the Structural Framework – exercise (9)

Day 4

Morning – Building the Stratigraphic Framework & Geocellular Gridding - exercise (10)
Afternoon – Facies Modeling – exercise (11)

Day 5

Morning – Petrophysical Modeling – exercise (12)
Afternoon – Selecting Realizations and Upscaling – exercise (13)

Goal

Provide an asset team with static modeling background, data preparation requirements, mentoring, and problem-solving opportunities to guide the team through building geocellular model for use in reservoir simulator

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Topics Covered

Introduction – Static Modeling Course

- Static Modeling Course Objectives
- Model Building Workflow
- Reservoir Modeling and Reservoir Management Plans
    - Field Life Cycle
    - Reservoir Depletion Plans
    - Role of Integration
- 10 Golden Rules for Flow Modeling
- Use and Misuse of Reservoir Modeling
- Cost of Building Reservoir Models
- Benefits of Integrated Model Studies
- Field Case Study Background

✍ Checklist Exercise

Well Data and QC Using Cores

- Types of Well Data and How They are Utilized
- Data Verification and Conditioning
- Geological data
    - Data Prep
    - Assimilation/Interpretation
    - Field Analogs
- Core Description
    - Inventory of available data
    - Digital or manual description
    - How to capture data
    - Value of core description
    - Objectives/focus
    - QC
        - Examples of failed QC (tops, structure, depo environment, wire-line, petro)
    - Observations and documentation
    - Shift to wire-line logs
    - Qualitative data input
    - Importance of scale

✍ Exercise 1 and 2

- Core description and core photos
- Core to wire-line data shift

Core, Pressure and Petrophysical Data Prep and Analysis

- Objective
  - To define an optimized layering scheme
- Data Integration
  - Are all the data available and QC'd?
- Facies and Core Data
  - Core Data Prep
  - Simplify without loss of heterogeneity
  - Examples of Display and Use
  - ✍ Exercise 3 – Teapot dome
    - Plot MDT pressure data
- Input Data Required
  - Core Plug Data
    - Convert analysis to reservoir pressures
- Data Preparation
  - Edit
  - Shift
  - Environmental Corrections
  - Normalization
- Calculation Methods
  - Porosity - f
  - Permeability - k
  - Water Saturation - Sw
- Analysis, QC, and Data Conditioning
  - Core porosity, permeability and Sw
- Facies model considerations
  - Wireline predictability
  - Facies relationship to reservoir quality
  - Vertical and lateral detail
  - Data Revisions
- Cut-offs

✍ Exercise 4 - Modify parameters in Archie's Equation to estimate water saturation (Sw) and chart the sensitivity to input data

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Contact Analysis and Flow Unit Definition

- Contact Analysis
  - Core Data – Oil Stain
  - Open and cased hole logs
  - RFT/MDT
  - Production history – Test Data
  - ✍ Exercise 5 – Teapot dome
    - Pick contact from wire-line cross-section
    - Determine compartments
    - Map influx
- Get the Regional Picture
  - How does the big picture impact my model?
- Reservoir Layering
  - Lithology or sequence based stratigraphy?
  - How much detail?
  - How should facies impact layering?
  - ✍ Exercise 6 – Teapot dome
    - Develop layering scheme based on wire-line/MDT, core, etc.

Preparing Horizon and Fault Data

- Fault Picks in Seismic
  - Procedures
  - Methods
  - Data enhancement
    - Coherency
    - Spectral Decomposition
    - Curvature
  - QC
- Fault Picks in Geology
  - Procedures
  - Methods
  - QC
- Linking seismic and geological faults
- Seismic Horizon Interpretation
  - Methods and areal coverage
- AOI
- Mapping
  - Grid cell size
- External data
  - Dip meter

    - FMI (full-borehole micro imager)
    - UBI (ultrasonic borehole imager)
    - Core
    - DSI (dipole sonic imager)
    - SCAT (statistical curvature analysis technique)
    - Satellite imagery
    - Topographic data
    - Paleontology/Biostratigraphy
- ✍ Exercises 7 and 8
    - ✍ Locate Faults
        - Coordinate all data sets to yield a consistent fault
    - ✍ Overpost seismic outline on field using Google Earth
        - Identify Surface Faulting

Preparing the Structural Framework

- Fault model overview
    - Structural interpretation/style timing
    - Reservoir discontinuities
    - Grid layout and orientation
- Structural styles overview
- Fault framework principles
    - Fit for purpose fault framework
        - Develop only one structural model
    - Model contains all identifiable faults that offset the reservoir interval
        - Stratigraphic limitations treated as faults for simulation model
    - Faults impacting reservoir intervals and fluid flow identified
    - Contacts honored
        - Does the hydrocarbon column seal laterally through a combination of dip/fault/stratigraphic pinchout edges ?
    - Well fault cuts honored
    - Gridding considerations
- Framework construction
    - Working in time and depth domains
    - Workflow
        - Import
        - Build fault planes and QC
        - Feedback loop to structural interpretation
        - Intersection and truncations
        - Edit tipout polygons
- Where things could go wrong
- Structural Uncertainty
- Import Data to modeling package
    - Seismic (sticks, polygons, centerlines, planes)

- Well picks
- QC

- Fault Treatment
  - Vertical vs. Inclined (What are the objectives?)
  - Special Consideration for Reverse Faulting
  - Salt/shale diapirs
- Fault gridding approach
  - Pillar Approach (Petrel/Old RMS)
  - Fault Plane/Block Approach (New RMS/EarthVision)
  - GOCAD/SKUA
  - Fault Model QC
  - Truncations/intersections/well ties/tip-out polygons/unconformities

✍ Exercise 9
  - Determine the truncation order of intersecting faults

<u>Building the Stratigraphic Framework & Geocellular Gridding</u>

- Recap of course topics to date
- Recap of data for field model
- Building Layering into the Static Model
  - Strategy for using mapped horizons and isochores
  - Different scales of Layering
  - Modeler’s controls over layering
  - Feedback of horizon to seismic and geological cross-sections
  - Exercise – using what is known about the reservoir
- Geocellular Gridding
  - Elements and definitions of the geocellular grid
  - Geologic vs. Simulation grid-building workflow & strategy
  - Working within a cell budget
  - ✍ Exercise 10 – estimating cell size, grid size
  - Methods for handling faults in the geocellular grid
  - Keeping scale in mind

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Facies Modeling

- Recap of facies data
- Goal(s) of facies modeling
- Facies Modeling Workflow
  - Blocking
  - Data analysis
  - Define trends vertical and lateral
  - Variograms
  - Deterministic or simulation
- Facies Modeling Options
  - Interpolation
  - Deterministic
  - Object based –
    - Geobody shape, dimension, and orientation
    - Capture vertical and lateral baffles/barriers
  - Indicator
    - Capture baffles
  - Belts or trends
  - Combination
  - Co-simulation, co-located co-simulation

✍ Exercise 11 – propose a facies model at Teapot Dome

Petrophysical Property Modeling

- Recap of course topics to date
- Introduction to property modeling
  - Which properties are modeled?
  - Why properties are modeled at geologic scale
  - Why model each facies and interval separately?
  - ✍ Exercise 12 – properties with and without a facies bias
- Property Modeling Workflow
  - Blocking (upscaling) well logs to geocellular grid
  - Data Analysis of blocked well properties
  - Data preparation
  - Analyzing trends
  - Property correlation
  - Transforming blocked well data
  - Variograms
- Deterministic methods (description, uses)
  - Interpolation
  - Trend modeling

- Geostatistical Methods
    - Kriging (prediction)
    - Stochastic Simulation, co-simulation, co-located co-simulation
- Modeling Water Saturation
    - Sw (prior to production), Swir (irreducible)
    - Using functions (j-function, user-defined, hard wired)
- Scale and history behind geostatistical modeling

Selecting Realizations and Upscaling

- Recap of course topics to date
- Ranking realizations
    - Deterministic vs. stochastic modeling
    - Randomness in facies and property arrays
    - Upscaling as necessary evil – CPU runtime constraint
- Selecting representative realizations
    - Ranking is a fit-for-purpose operation
    - What is held constant? - What is allowed to vary?
    - Ranking criteria
    - Volume (net rock volume, pore volume, HCPV, . .)
    - Connectivity (connected PV, facies, . . .
    - Dynamic (simple streamline breakthrough times)

✍ Exercise 13 – Excel spreadsheet picking the P50

- Upscaling Geomodel Properties for Simulation
    - Upscaling Philosophy and Goals
    - Value of the Downscaled Geocellular grid
    - General upscaling workflow
        - Wireline Logs-to-Blocked Cells
        - Blocked Cells-to-Geocellular Grid
        - Geocellular Grid-to-Simulation Grid
    - Methods for upscaling different properties
        - Discrete (facies)
        - Averaging methods (porosity, k, NTG, Sw)
        - Additional method for upscaling permeability (diagonal tensor)
        - Horizontal vs. layer-based averaging
    - Upscaling Issues & Problems