Course Overview

Three-dimensional numerical earth models play an increasingly important role in the E&P industry to improve reservoir management and optimise hydrocarbon recovery. A key challenge for reservoir geophysicists is the quantitative integration of 3-D and 4-D seismic data in static and dynamic earth modelling workflows. Using a combination of theory and illustrations based on a broad range of case studies, the one-day course will review current best practices and future challenges for constraining earth models with seismic information. Emphasis will be placed on seismic data integration in the context of seismic-to-simulator workflows. Topics covered include the construction of stratigraphic grids from interpreted seismic horizons and faults, deterministic and stochastic elastic inversion, cascaded petrophysical inversion, use of seismic geostatistics and rock physics to predict reservoir properties such as lithology and pore fluids, uncertainty propagation techniques, building of geomechanical earth models for seismic Pp prediction, and 4-D earth models generation for seismic monitoring applications.

Summary

The course will address the following questions:

- What seismic inversion techniques should we use to obtain reliable estimates of elastic properties for reservoir modelling applications?
- How do we condition the seismic data prior to inversion?
- When do we use deterministic or stochastic inversion?
- How do we integrate inverted seismic data in a geocellular reservoir model?
- How do we combine seismic rock physics and geostatistics to predict reservoir properties from seismic attributes?
- How do we cascade elastic and petrophysical inversions?
- How do we constrain a fine-scale earth model with band-limited seismic data?
- How do model uncertainty in seismic rock property prediction?
- When do we need to model the overburden, not just the reservoir interval?
- What are the key challenges in building "4-D earth models" for seismic monitoring applications?
- How do we conduct 4-D feasibility studies from flow simulator outputs?
- How do we calculate 3-D and 4-D synthetics from static and dynamic reservoir models?
- How do we handle the grid-to-grid resampling operations required to move data back and forth between seismic cubes, geo-models and flow simulation grids?
Course Organization

The one-day course will be divided into 7 modules of approximately 45 minutes duration each, which will provide an overview of basic concepts and their application to real case study examples from different parts of the world, including both clastic and carbonate reservoirs. The course will also include discussion periods during which the participants will have an opportunity to share their reservoir geophysics experience.

Module 1 – Introduction to Seismic-Based Earth Modelling and Geostatistics
Introduction to 3-D earth modelling
Current workflows for seismic data integration
Construction of stratigraphic grids
Integration of seismic data in earth model framework
Basic geostatistics concepts

Module 2 – Geostatistical Interpolation and Filtering
Introduction to kriging
Seismic-guided, 2-D and 3-D interpolation of reservoir properties
Cokriging and kriging with external drift
Seismic data filtering using factorial kriging and factorial cokriging

Module 3 – Stochastic Simulation with Seismic Constraints
Introduction to stochastic simulation and uncertainty analysis
Sequential Gaussian Simulation (SGS)
SGS with seismic constraints
Stochastic simulation with seismic downscaling
FFT-based simulation
Gradual deformation method

Module 4 – Facies Modelling from Seismic Data
Bayesian classification techniques for seismic lithology and fluid prediction
Sequential indicator simulation with seismic constraints
Truncated Gaussian simulation
Multi-point statistics simulation

Module 5 – Stochastic Inversion
Deterministic versus stochastic inversion
Geostatistical inversion using SGS
Bayesian stochastic inversion
Exploiting geostatistical inversion results
Joint stochastic inversion of elastic and petrophysical properties

Module 6 – Statistical Rock Physics
Monte Carlo simulation of rock physics templates
Combining rock physics and spatial uncertainties
Uncertainty propagation using linearized analysis
Cascaded elastic and petrophysical inversion
Rock physics inversion using Monte Carlo and Bayesian methods
Pseudo-well generation
Direct petrophysical inversion from seismic data

Module 7 – 4-D Earth Modelling & Conclusions
Construction of 4-D earth models
Downscaling of dynamic properties
4-D feasibility studies
Rock physics modelling of pressure and saturation effects
Calculation of 4-D synthetics from flow simulation models
4-D interpretation and 4-D seismic history matching
Future challenges in seismic-constrained earth modelling

Who Should Attend?
The course is aimed at geoscientists and engineers who are involved in the construction of earth models and want to learn about practical techniques for seismic data integration, combined use of seismic rock physics and geostatistics, uncertainty modelling and quantitative 4-D interpretation. The course comes at a time when seismic-based earth modelling has become a key activity for integrated asset teams in the E&P industry. It should therefore be of interest to a broad audience, including technical specialists and managers, who are actively involved or supervise seismic-to-simulator activities.

Biography

Philippe Doyen received a PhD in Geophysics from Stanford University in 1987. He then worked in reservoir geophysics R&D for Western Geophysical in Houston and London until the end of 2001. In 2002, after the merger between Western and Geco-Prakla, he was transferred to Schlumberger and appointed Research Director for Schlumberger Information Solutions. He joined CGG in October 2003 where he is currently Product Manager for Seismic Reservoir Characterization and is based in London. He has also been recently appointed part-time Adjunct Professor at the University of Bergen in Norway. Dr. Doyen has over twenty years R&D experience in reservoir geophysics, geostatistics, earth modelling and rock physics. He has developed a number of geostatistical techniques for seismic-guided rock property prediction, stochastic reservoir modelling and subsurface uncertainty quantification. He has managed the development of several software products for geostatistical earth modelling from seismic data, seismic inversion and data visualization. He has a broad experience in geo-technical consulting and seismic reservoir characterization projects management. He served as EAGE Distinguished Lecturer in 1998.