# N045: Seismic Inversion and Applications to Stochastic Reservoir Modelling

Instructor(s): Ashley Francis

**Format and Duration**

Classroom - 4 Days
Virtual - 8 Sessions

## Summary

The course covers well-tie and zero-phasing issues, wavelet estimation, Acoustic Impedance Inversion, pitfalls in inversion, upscaling of well logs (Backus upscaling), attribute analysis and stochastic inversion methods. Extensive use is made of examples and exercises.

Business Impact: This practical course explains the principles of inversion from seismic data to rock properties, emphasising the analogies with geostatistics. It demonstrates that seismic inversion must be considered as a stochastic process/exercise and, by extensive use of examples, provides a non-mathematical basis for understanding the concepts.

## Learning Outcomes

Participants will learn to:

1. Assess the quality of the key well-tie process, fundamental to seismic interpretation projects.
2. Perform fluid replacement analysis and Backus upscale modelling on the wavelet in the well-tie process.
3. Design a simple seismic modelling strategy to examine tuning and fluid effects using wedge models.
4. Evaluate how a wavelet may be constructed that most closely resembles the base seismic, and the pitfalls such an estimation may encounter.
5. Appraise the various methods of seismic inversion and their value to interpretation, including model-based methods, structural deconvolution and Relative Acoustic Impedance.
6. Compare inversion methodologies and results with the wider family of seismic attributes.
7. Assess the principles of geostatistics in its role as spatial correlation estimator and relation to simpler averaging and correlation strategies.
8. Compare kriging and best estimation seismic inversion approaches and the role of stochastic simulation in removing bias in best estimate inversion calculations.
9. Evaluate how inversion results can be integrated with well data, using various strategies, such as kriging with external drift and co-kriging.
10. Rate the latest inversion technologies and role of stochastic methods in their development.
11. Assess the potential pitfalls of inversion.

## Training Method

This is a classroom or virtual classroom course, comprising short lectures, discussion, case studies, and practical exercises.

## Who Should Attend

Geophysicists and geologists. An understanding of basic mathematics and physics is required.

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## Course Content

### 1. To Tie a Well

- Phase
- Wavelets
- Checkshot Calibration
- Fluid Replacement Modelling
- Backus Upscaling
- Synthetic Modelling

### 2. Wavelet Estimation

- Determining wavelets directly from seismic
- Strategies for wavelet estimation - Kurtosis, amplitude envelope, cross-correlation
- Phase in VSP datasets will be considered, downgoing wavefield deconvolution (deterministic deconvolution) in zero phasing VSP upgoing wavefields
- Wavelet estimation using well logs - statistical extraction, full extraction, Roy White method
- Practical exercise
- Inversion as zero phase deconvolution, integration (inversion itself) and scaling to absolute values (the model component)

### 3. Acoustic Impedance Inversion

- Inversion methods - model-based methods, structural deconvolution as used in VSP and Relative Acoustic Impedance Inversion (RAI)
- L1 and L2 norms - minimisation strategies.
- Inversion as a well/seismic integration method - similarities to kriging

### 4. Geostatistics Primer

- Importance of the average or mean in estimation
- Expectation or probability weighted outcome.
- Discussion of correlation and correlation coefficient and confidence intervals.
- Spurious correlation Java Applet
- Estimation using spatial correlation - kriging
- Comparison between kriging and best estimation in acoustic impedance inversion
- Bias under best estimate computations - its solution using stochastic simulation
- Kriging with external drift, co-kriging, collocated co-kriging with Markov-Bayes

### 5. Pitfalls in Inversion

- Over-zealous stretch and squeeze in wavelet estimation
- Artefacts in model-based inversion

- Non-uniqueness
- Trace scaling and normalisation
- Skew in cumulative distribution function.
- Estimator shrinkage (the similarity with kriging will be illustrated).

### 6. Inversion Practicals

- Practical investigation using a full sized field data set comprising 2D seismic data and well logs
  - Time picking
  - Model building
  - Wavelet estimation
  - Interpretation of results.
- Examples of 3D seismic inversion

### 7. Stochastic Inversion Methods

- The latest inversion techniques using stochastic methods
- The necessity of developing stochastic approaches
- Link with geostatistics
- The problems associated with stochastic methods - speed, enormous quantities of output data produced
- The future of these methods