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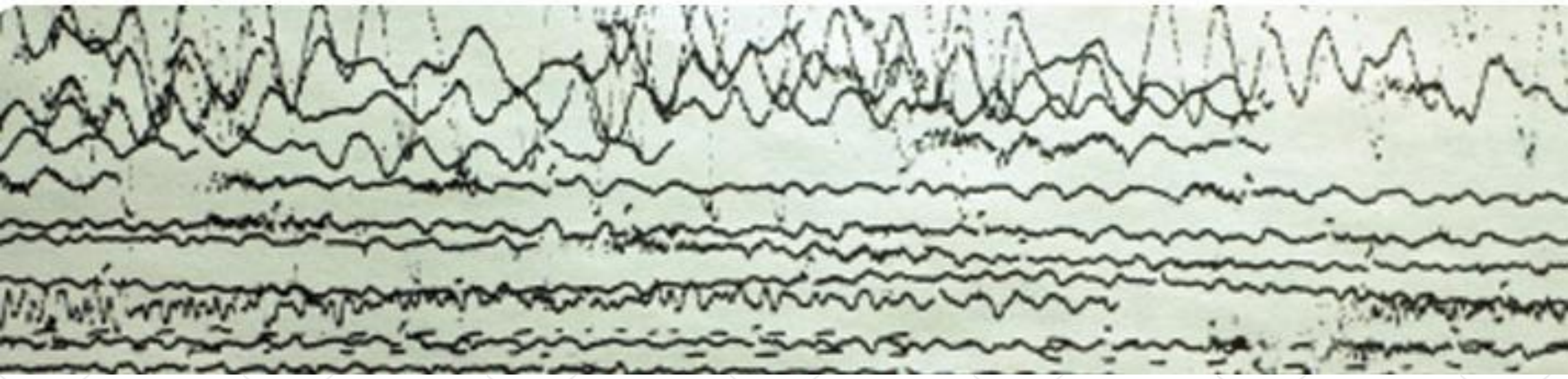
ADVANCED SEISMIC DATA PROCESSING

27 February – 2 March 2012, Kuala Lumpur, Malaysia



Your Expert Trainer: Piet Gerritsma

Piet joined Shell in 1969 as a research geophysicist in Rijswijk (The Netherlands) and Houston (USA). He acquired operational experience as processing and special studies geophysicist in Brunei and in Canada. He was Shell's representative in international research consortia: SEP (Stanford), DELPHI (Delft University of Technology) and IFP (Institut Francais du Petrole); he also served as associate editor of Geophysical Prospecting on Migration, Modelling and Inversion. During his Shell career he has always lectured at both basic as well as advanced level covering a broad range of topics. He left Shell in 1999 after 30 years of service.

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Course Description
With the presence of new data acquisition techniques, new processing methods have to be developed. Existing and new data sets will be exploited for optimal information retrieval; in addition to the conventional P-waves also the S-waves will be investigated together with kinematic properties and dynamic properties for lithology and/or direct hydrocarbon indication will be investigated. Anisotropy, where present, should be taken into account and can be exploited for a.o. fracture orientation and density and time-to-depth conversion. The availability of other types of data like geological data and well data, in a production environment, should be properly integrated in inversion studies to initialize and constrain the results.

This course deals with advanced processing methods that are often carried out as part of a special study and may involve the integration of data acquisition, processing and interpretation as well as petrophysics, production geology and reservoir engineering. The topics that will be discussed cover a wide spectrum and are representative for what has become feasible nowadays.

Course Objectives
At the end of this course the participants will have a working knowledge of the full range of representative special processing methods, which he may carry out himself and/or supervise. He or she is fully capable to account for the geophysical input in multi-disciplinary teams.

The following topics will be discussed:
1. Stress-strain relationships
2. The wave equation
3. Wavefield extrapolation
4. Anisotropy
5. Migration, time migration, depth migration and true-amplitude migration: theory and algorithms
6. DMO (dip moveout) and PSI (pre-stack imaging): theory and algorithms
7. Velocity model building and updating: theory and algorithms
8. VSP and hole-to-hole seismic: acquisition and processing
9. Multi-component seismic, shear seismic and anisotropy: acquisition and processing
10. OBC (ocean bottom cable) and OBS (ocean bottom system): acquisition and processing
11. Design and assessment of different acquisition geometries
12. AVO (amplitude versus offset) and AVA (amplitude versus angle): theory and processing
13. Inversion: overview of different methods
14. 4D or time-lapse seismic: feasibility and requirements and processing

Learning, methods and tools:
This course includes theory and exercises; a handout that covers all course material will be made available.

Your Expert Trainer: Piet Gerritsma

Piet Gerritsma graduated in physics at the University of Groningen. He joined Shell in 1969 as a research geophysicist in Rijswijk (The Netherlands) and Houston (USA). He was actively involved in the development of programs for statics, velocity analysis, synthetic seismograms and raytracing, deconvolution, multi-component seismic, shear waves and anisotropy, AVO and migration. He acquired operational experience as processing and special studies geophysicist in Brunei and in Canada. He was Shell's representative in international research consortia: SEP (Stanford), DELPHI (Delft University of Technology) and IFP (Institut Francais du Petrole); he also served as associate editor of Geophysical Prospecting on Migration, Modelling and Inversion. During his Shell career he has always lectured at both basic as well as advanced level covering a broad range of topics. He left Shell in 1999 after 30 years of service. Since that time he is a lecturer at CTG (Center for Technical Geoscience) at the Delft University of Technology. He teaches regularly courses for national and international oil companies and service companies both as an independent teacher as well as on behalf of geoscience training alliances.

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5 Day Course Outline

1. Stress-strain relationships
- Deformation and the strain tensor
- Traction and the stress tensor
- Stress-strain relations: Hooke's law
- The equation of motion
- Symmetry properties of the stress tensor, strain tensor and stress-strain tensor
- Definitions of elastic constants
- Relationships between elastic constants

2. The wave equation
- The acoustic wave equation:
  - The acoustic wave equation
  - The reciprocity theorem
  - The integral representation of the acoustic wavefield
- The elastic wave equation:
  - The general case
  - The inhomogeneous isotropic case
  - The homogeneous case
  - From elastic to acoustic
  - P-waves and S-waves
  - Reciprocity theorems
  - Green's function and the Representation Theorems
- The boundary conditions
- Plane wave solutions
- Lamé's Theorem
- One-way elastic wave equations for P- and S-waves
- Raytracing; the eiconal equation and transport equation
- Phase, group and energy velocities

3. Wavefield extrapolation
- Temporal and spatial Fourier transforms
- The acoustic wave equation in the different domains
- Wavefield extrapolation in the different domains
- Wavefield extrapolation and migration in the spatial Fourier domain
- Wavefield extrapolation in the tau,p-domain
- Forward and backward wavefield extrapolation with the Kirchhoff integral
- Design of wavefield extrapolators

4. Anisotropy
- Introduction and definition of anisotropy
- The stress tensor, the Voigt form and symmetries
- Plane wave solutions and Christoffel equations
- Phase velocity and Group velocity
- Relationships between Wave surface and Slowness surface
- Measurement of group velocity and phase velocity
- Raytracing, eiconal equation and transport equation
- Shear wave splitting
- Definitions pertaining to anisotropy
- Transverse isotropy (TI):
  - Angle dependence of velocities in VTI media
  - Thomsen's notation for weakly anisotropic media
  - Elastic constants in finely layered media
  - Angle dependency of reflection and transmission coefficients
  - HTI media and azimuthal anisotropy
- Anisotropy from seismic measurements - processing
- Crack and fracture properties

5. Migration: principles and algorithms
- Imaging conditions; wavefield extrapolation
- The Kirchhoff integral; the Rayleigh integral; one-way versions of the Rayleigh
- integral; Kirchhoff (=summation - = diffraction stack -) migration
- Migration algorithms:
  - k,f-migration
  - phase-shift migration, phase-shift plus interpolation, split step Fourier
  - phase screen migration
  - finite difference migration
  - summation migration
  - migration in terms of double focusing
  - reverse time migration
  - Gaussian beam migration

- Aliasing; migration impulse responses
- Diffraction tomography; the point-spread function and resolution
- True amplitude migration
- Migration and Inversion

6. DMO (dip moveout) and PSI (pre-stack imaging): theory and algorithms

- Definition, effects, objective
- The DMO impulse response
- DMO coverage; regularization; DMO and inverse DMO
- PSI (pre-stack imaging) and EOM (equivalent offset migration)
- Algorithms
- Generalized data mapping
- Common-reflection-surface (=CRS) stack

7. Velocity model building and updating: theory and algorithms

- Minimal datasets and common image gathers (CIG's)
- Iterative velocity model building with CIG's
- The migration conditions
- Migration and traveltime inversion
- Migration and demigration
- Normal incidence wavefront curvature and stacking velocity
- Velocity model parameterisation

- Velocity model building methods:
  - coherency inversion or model based stack
  - map migration
  - dynamic map migration (DMM) or curvature inversion
  - stereotomography
  - traveltime inversion (TTI) and traveltime tomography
  - traveltime inversion in the migrated domain (TTIMD)
  - depth focusing analysis (DFA)
  - common focus panel (CFP) analysis
  - differential semblance optimisation (DSO)
  - velocity scanning

8. VSP and hole-to-hole seismic: acquisition and processing

- VSP
  - Acquisition geometries; multi-component datasets
  - Wavefield separation: P-waves and S-waves; Upgoing and Downgoing waves
  - Deconvolution
  - Migration of VSP data
  - VSP and seismic-to-well matching
- Hole-to-hole
  - Data acquisition
  - Cross-well wavefield separation
  - The projection slice theorem and image reconstruction
  - Traveltime tomography: ART, SIRT and Radon transform
  - Diffraction tomography, k-space illumination, resolution and imaging
  - Migration

9. Multi-component seismic, shear seismic and anisotropy: acquisition and processing

- The data matrix
- Polarization analysis of three component seismic
- Polarization filtering
- Rotation of sources and receivers
- Characteristics of P-, SV- and SH waves
- P-SV converted waves: generation and processing
- Displacement components of free surface geophones
- The wavefield generated by a vertical vibrator
- P/S-wavefield separation:
  - VSP data
  - Surface seismic data
- Elastic wavefield decomposition
- Elastic migration and redatuming

10. OBC (ocean bottom cable) and OBS (ocean bottom system): acquisition and processing

- OBS and OBC: 4C features and P-SV characteristics
- Acquisition
  - acquisition geometries
  - receiver location determination
  - calibration of various receivers

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- Processing
  - hydrophone and vertical geophone
  - hydrophone and vertical and radial geophone
  - vertical and radial geophone
  - hydrophone and three-component geophone
  - source signal estimation from dual conjugate field measurements
- Case studies

12. AVO (Amplitude Versus Offset) and AVA (Amplitude Versus Angle) : theory and processing

- Factors affecting amplitudes
- The boundary conditions
- Example of normal incidence reflection and transmission
- Reflection and transmission for isotropic elastic media – the Zoeppritz equations
- Approximate expressions for reflection coefficients
- Rock properties; fluid substitution algorithms and Vp-Vs relationships
- Processing for AVO and true-amplitude migration
- Estimation of AVO parameters and AVO inversion
- AVO attributes, cross plotting of AVO attributes and AVO classification
- Reflectivity from logs and AVO modeling
- Angle stacks and elastic impedance

13. Inversion : overview of different methods

- Linear least-squares estimation
- Weighted linear least-squares estimation
- Iterative linearized least-squares estimation; Gauss-Newton method
- Damped least-squares estimation with the Marquardt and Levenberg method
- The gradient or Steepest Descent (SD) method
- Singular Value Decomposition (SVD)
- Resolution matrix and covariance matrix
- Resolution and reliability
- Bayesian estimation, use of a priori knowledge
  - Summary of over determined but under constrained problems
- The Conjugate Gradient (CG) method
- Search methods: Flexible Polyhedron Search
- Simulated annealing
- Entropy methods
- Neural Nets
- Genetic algorithms
- Classification and discrimination methods
  - The self organizing map (SOM)
  - Cluster analysis
  - Principal component analysis
  - Gaussian classification
  - Discriminant analysis
  - Factor analysis

14. 4D or time-lapse seismic: feasibility and requirements and processing

- Objectives and feasibility analysis
- Rock physics
- Fluid substitution with the Gassmann equation
- Measurements of traveltime differences and amplitude differences
- Quantization of repeatability of acquisition and processing
- Time lapse data acquisition and time lapse data processing
- Methods to compare different datasets
- Methods for cross-equalization of two datasets
- 4D modeling

About petroEDGE

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REGISTRATION FORM

Kuala Lumpur, Malaysia 27 February – 2 March 2012	**Early Bird Price**	√	**Normal Price**	√
5 day – Advanced Seismic Data Processing	**SGD 3599**		**S$ 3799**	

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