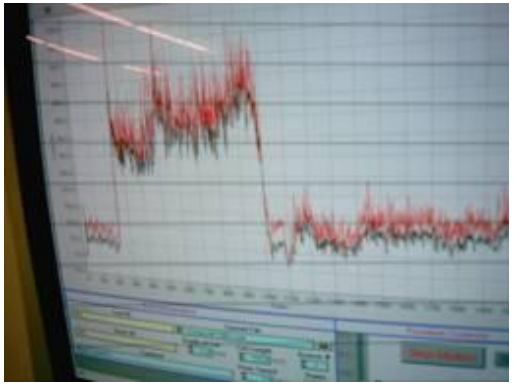
GeoNeurale

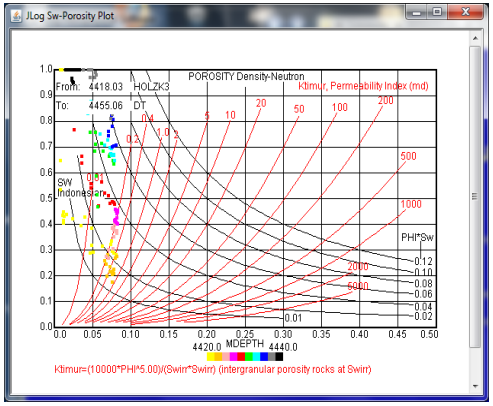
UNIVERSITY OF TRIESTE
Department of Mathematics and Geosciences

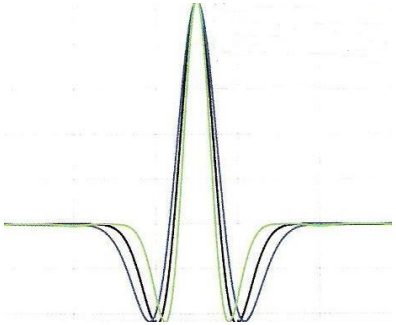
NExt generation DEep GEOthermal resources exploration and exploitation

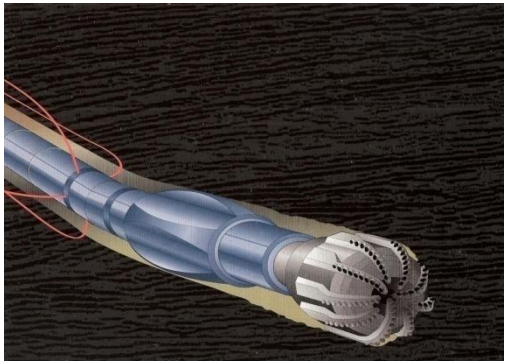
GeoNeurale-Wavefields hosts one of the most advanced research programs on deep geothermal exploration boosting the geothermal systems of the next generation

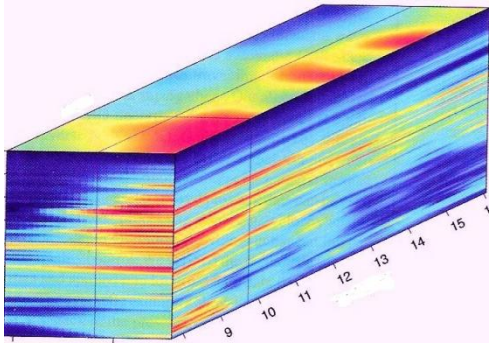
Munich

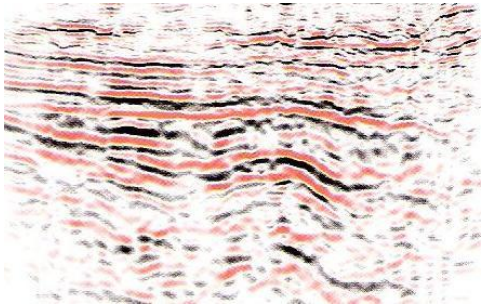












NEDEGEO

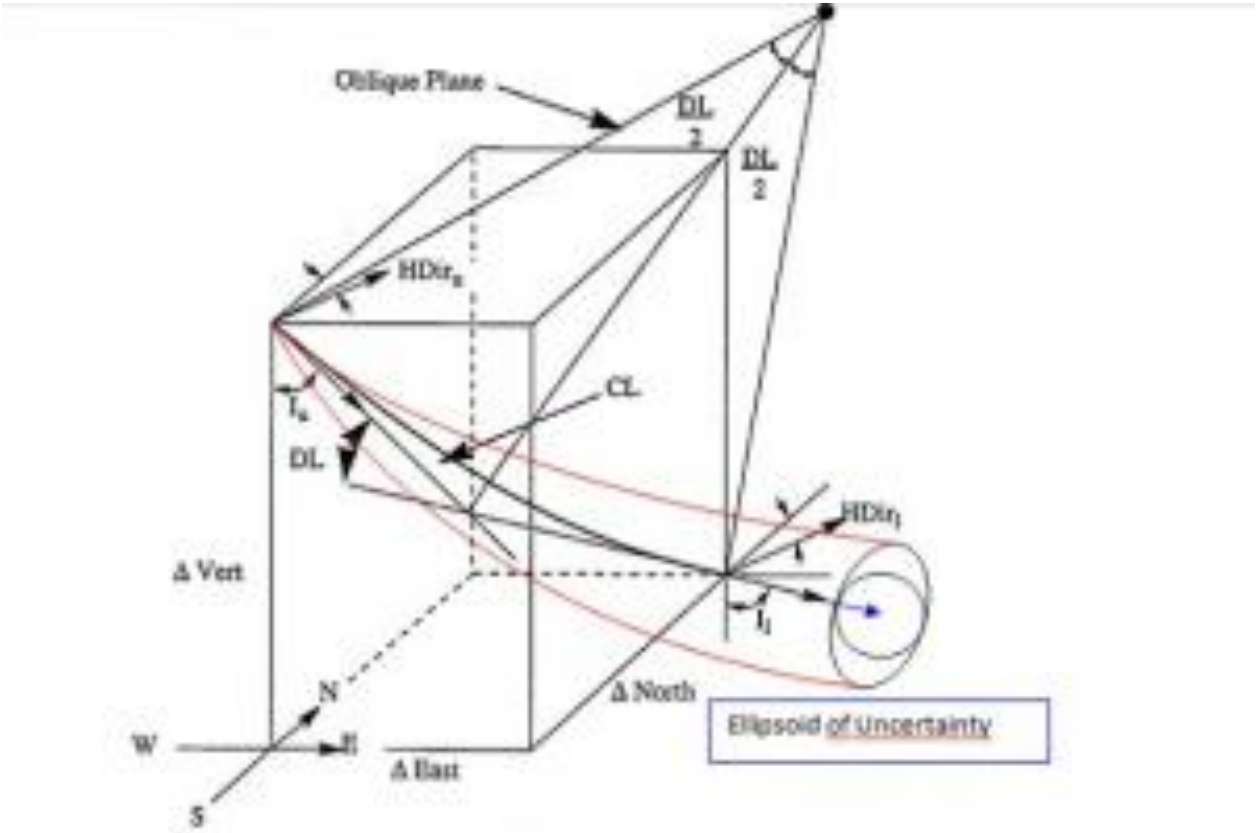
NExt generation DEep GEOthermal resources exploration and exploitation

GeoNeurale-Wavefields hosts one of the most advanced research programs on deep geothermal exploration boosting the geothermal systems of the next generation

Munich 2023

Starting from the ”DEEP DIRECTIVITY SYSTEMS“ theory, integrating exploration geophysics with artificial intelligence, an international research team focuses its work for the preparation of the next geothermal systems marking a breakthrough on the future of the exploration sciences

DEEP DIRECTIVITY SYSTEMS
CHALLENGING THE PROXIMITY UNCERTAINTY



http://deepdirectivity.eu/

30 YEARS EXPERIENCE IN THE OPERATIONS OF THE OIL&GAS EXPLORATION

LINK

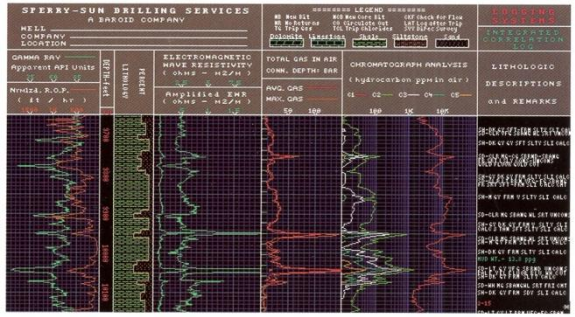
A BRIEF HISTORY OF OUR EXPERIENCE

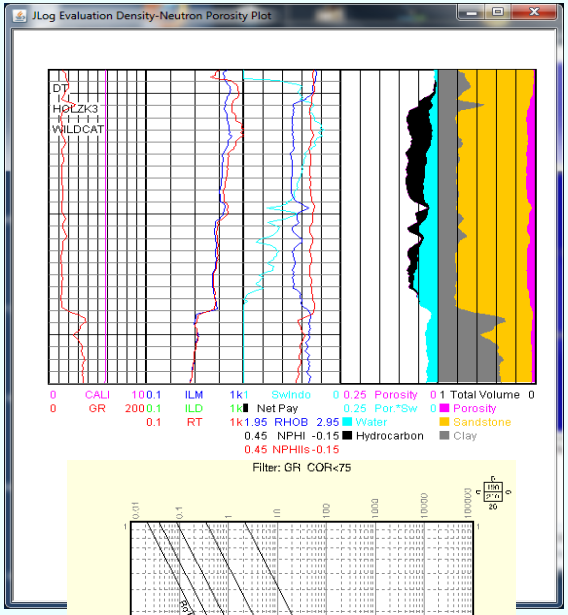
AND

VISITED INSTALLATIONS

http://deepdirectivity.eu/

RESEARCH TOPICS





PLANNING OIL AND GEOTHERMAL EXPLORATION PROJECTS: TECHNOLOGIES OF THE PETROLEUM INDUSTRY

SHORT PROGRAM INDEX

THE STUDIES
THE MACRO-FIELD
REGIONAL STUDIES
GEOPHYSICAL PROSPECTING
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- PROCESSING
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THE PLANNING PHASE
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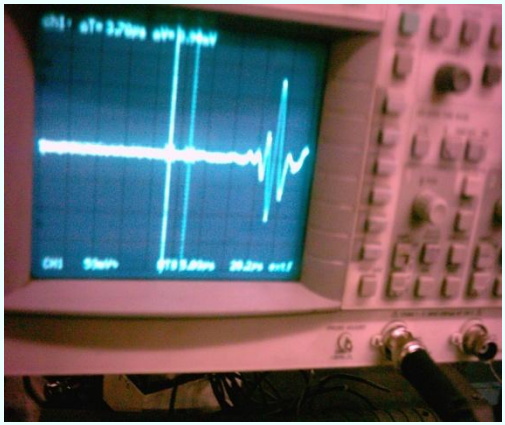
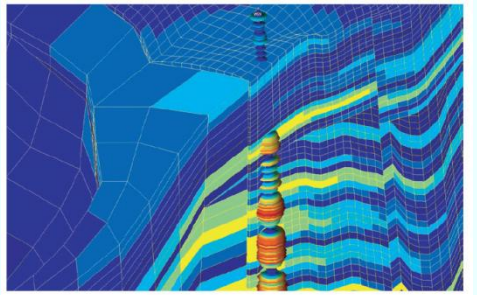
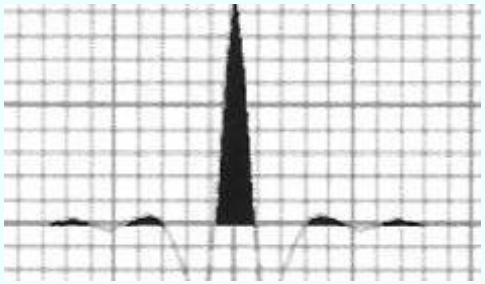
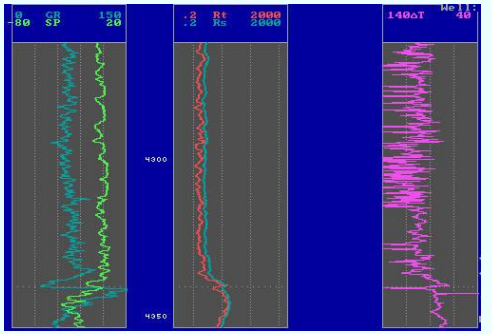
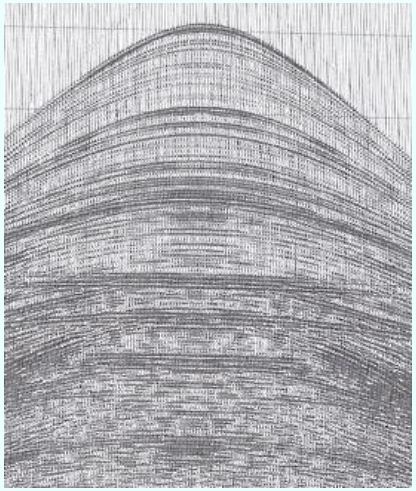
REALTIME RESERVOIR CHARACTERIZATION
TESTING AND PRODUCTION METHODS
STIMULATION: FRAC OPERATIONS, COILED TUBING, ACIDIZING, CO2
WELLTEST

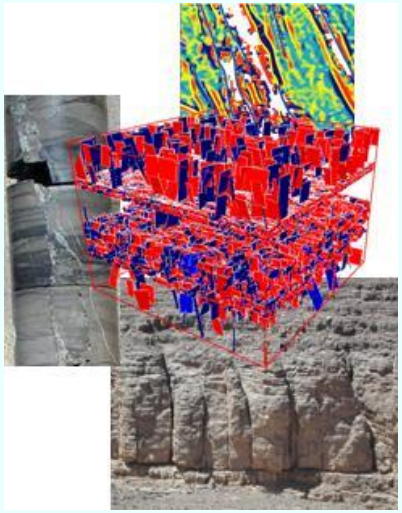












-REGIONAL STUDIES

The reservoir concept: Oil, Gas,Unconventionals, Geothermy
Geology and Plays
Geophysical studies:
Gravitational, Magnetotelluric, Seismic.

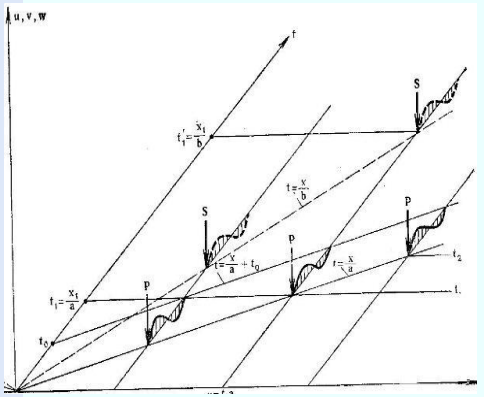
-3D SEISMIC GENERAL CONCEPTS

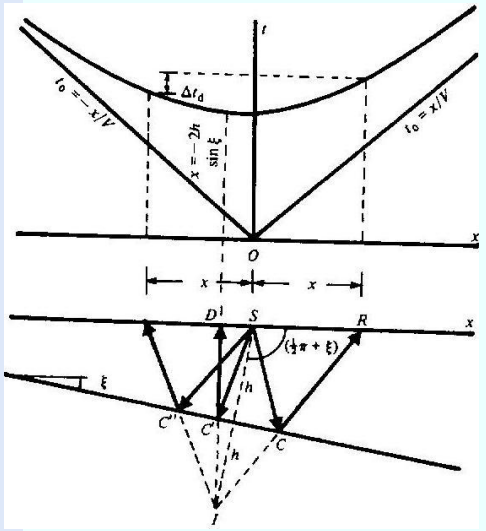
Seismic waves derivation of the wave equation from elasticity theory.
The hooke´s law.
Elastic constants.
The wave equation.
Static versus dynamic elastic parameters.
Geomechanical applications in case studies.

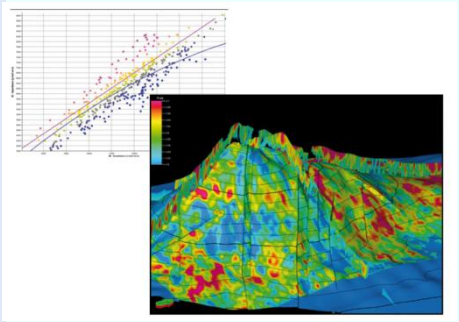
-P-S WAVE PROPAGATION PARAMETERS AND SIGNAL ANALYSIS CONCEPTS

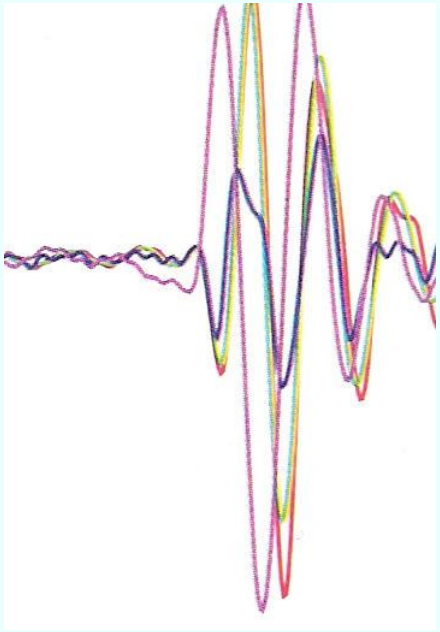
Parameters: amplitude, phase, angular frequency, wavenumber, initial phase,
Frequency,period,wavelength,velocity of propagation.
Monochromatic waves and Fourier series.
The complex notations for wave equations.
Energy of a wave, intensity, spherical divergence.
Group and phase velocity, diffraction, reflectivity and trasmissivity.
The zoeppritz equations (zero offset), acoustic impedance.
Reflection and transmission coefficients.

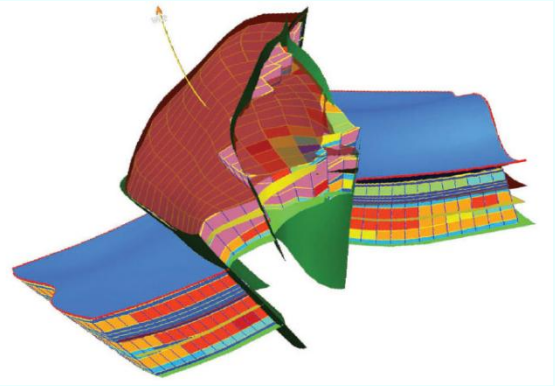
PROCESSING CONCEPTS: AMPLITUDE AND PHASE CONSIDERATIONS
Effects of amplitude, frequency and phase shifts.
Amplitude and phase spectra.
Log simulation through 1-D Fourier transform.
Wave vector representation.
Fourier Transform pairs.
Frequency aliasing.
Seismic reflection models.
Impulse respons models.
Reflection shapes, signatures, spike synthesis.
Time and phase shifts.
Convolution, crosscorrelation, autocorrelations algorithms, schematic of calculation methods.
The "alternative" Fourier transform.
Frequency domain operations, time and frequency domain conversions.
Seismic impedance, reflection/transmission coefficients and seismogram.
Sonic logs and synthetic seismograms.

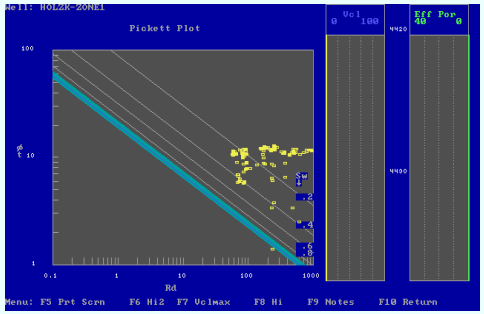












STACKING OF SIGNALS, CDP STACKING
Vector representation of signal and random noise.
The stacking process as a vector sum.
Effect of noise bursts and random noise addition.

APPENDIX
Deconvolution.
Convolutional model in time domain.
Convolutional model in frequency domain.
Inverse filtering.
The source wavelet inverse.
Least square inverse filtering.
Minimum phase wavelet.
Wiener filters.
Spiking deconvolution.
Prewhitening.
Wavelet processing and shaping filters.
Predictive deconvolution.

-SOURCE MODELS

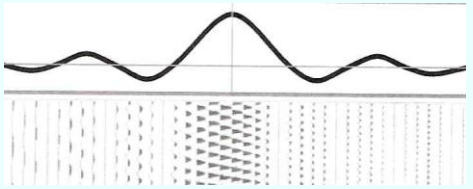
The Dirac Delta function.
Impulse time shift, shifting properties.
Approximations of the Delta function: Rect, Triangular, Gaussian, Cauchy-Lorentz, Cauchy phi, sinc, sinc square.
The Heaviside unit step function.
Time shift. Effects of phase spectrum on wavelet shape.

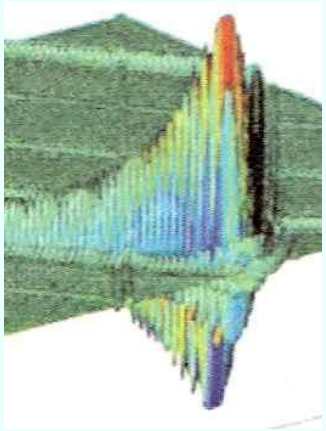
-VIBROSEIS AND SWEEP THEORY

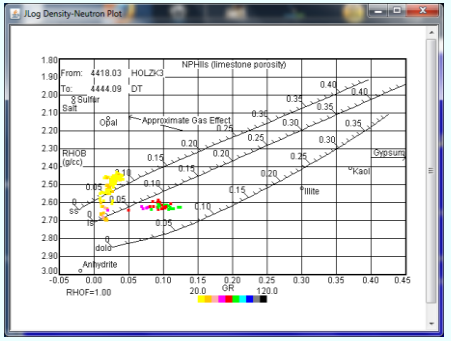
Sweeps crosscorrelation and autocorrelation.
Sweep design.
Bandwidth, frequency and taper.
Side lobes and noise.
Vibrator harmonic ghosts.

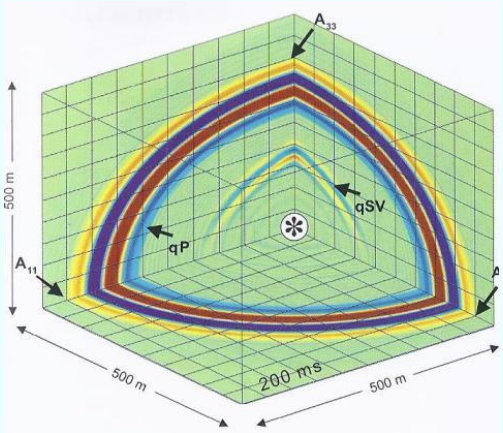
-ARRAY DESIGN

Coherent and incoherent noise.
Synthetic record analysis.
Dominant frequency.
The uniform array, Array linear responses and "alias peaks" as f,k,d and lambda functions.
Shallow and deeper reflectors and frequency content.







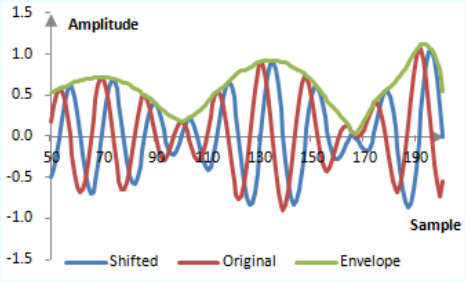


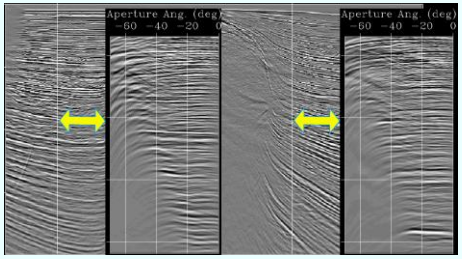
-3D SEISMIC FIELD ACQUISITION PLANNING

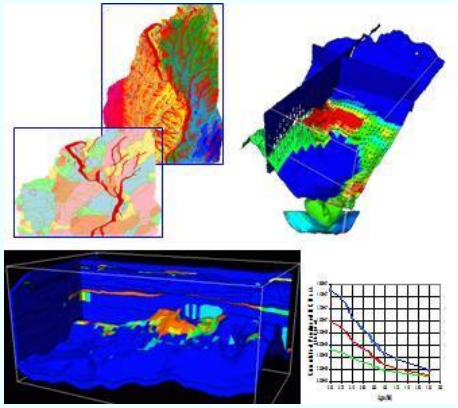
Terminology and definitions in 3D seismic design:
Box, CMP bin, super-bin, inline, crossline, fold, fold taper, mid-point, migration apron, patch, receiver line, source line, scattering angle, S/N ratio, source point density, swath, template, aspect ratio, svy geometry, Xnim, Xmax.
Gather types: orthogonal, common source point, common receiver, common offset, common azimuth, cross-spread, offset vector tile.

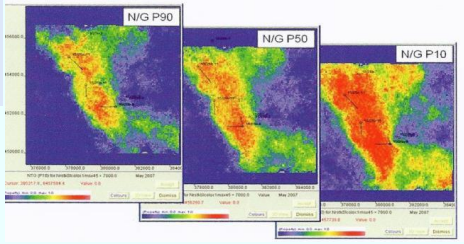
3D SURVEY GEOMETRY PLANNING:
Fold vs S/N ratio, 3D vs 2D fold, inline and xline fold, tot. fold.

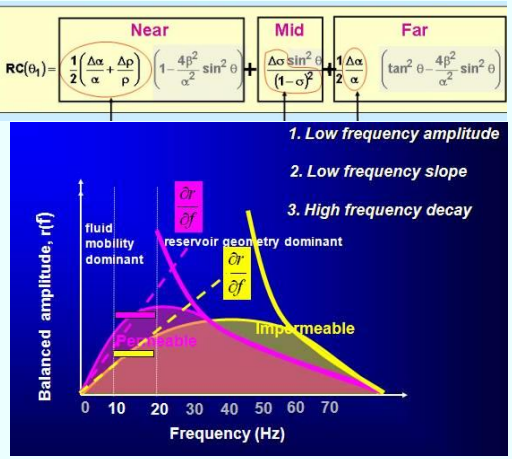
QC: fold taper, S/N ratio and target size.
Unaliased frequency.
Offset and azimuth distribution.
Wide and narrow azimuth.
Fresnel zone.
Migration apron.
Field layouts.
The 5D prestack field.
Main guidelines for 3D seismic field acquisition planning.

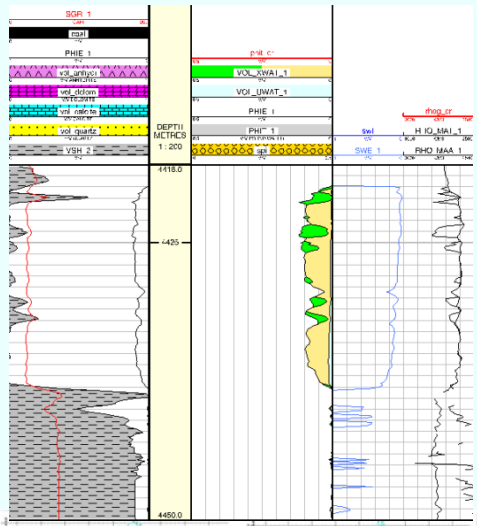












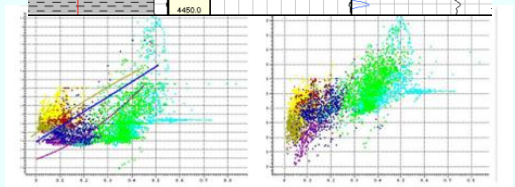


TABLE 4.1—EQUATIONS FOR FRACTURE LENGTH, MAXIMUM FRACTURE WIDTH, AND INJECTION PRESSURE FOR CONSTANT INJECTION RATE

PKN Model

$L(t)$	$w(0,t)$	$p(0,t)-\sigma_H$
$C_1\left[\frac{Gq_0^3}{(1-\nu)\mu h_f^4}\right]^{1/5} t^{4/5}$	$C_2\left[\frac{(1-\nu)q_0^2\mu}{Gh_f}\right]^{1/5} t^{1/5}$	$\frac{C_3}{H_f}\left[\frac{Gq_0^3\mu L}{(1-\nu)^3}\right]^{1/4}$

GdK Model

$C_4\left[\frac{Gq_0^3}{(1-\nu)\mu h_f^3}\right]^{1/6} t^{2/3}$	$C_5\left[\frac{(1-\nu)q_0^3\mu}{Gh_f^3}\right]^{1/6} t^{1/3}$	$\frac{C_6}{2H_f}\left[\frac{Gq_0\mu h_f^3}{(1-\nu)^3 L^2}\right]^{1/4}$

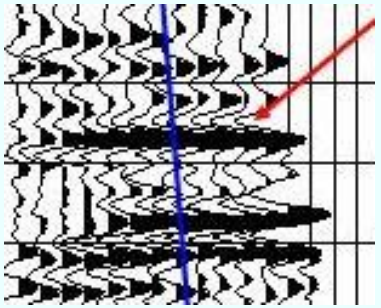
Observe that p_0 increases with fracture length and thus treatment time for PKN models and decreases with fracture length for GdK-type models.

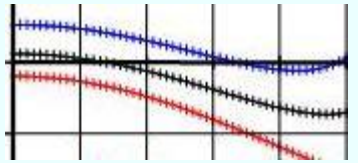
-SEISMIC PROCESSING

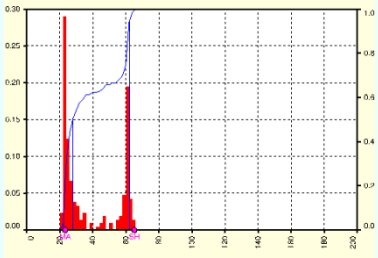
PREPROCESSING:
SEG-Y Format Structure.
Processing sequences overview .

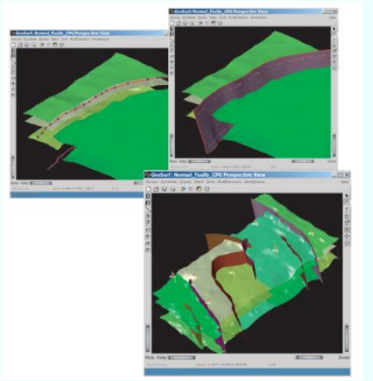
Gain recovery (agc).
Multiplexing and demultiplexing.
Resampling.
Passband filters.
Assign geometry.
Statics and datum correction.
Deconvolution.
Spherical divergence correction.
Trace editing.
NMO stretch.
Display of brute stack.
Velocity analysis.
Surface consistent statics.
Intermediate stacks.
Final velocity analysis.
3D trim statics.
fx-deconvolution.

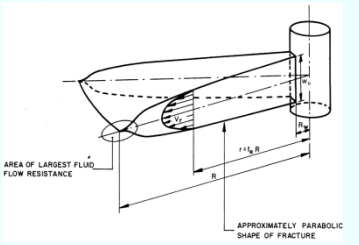
THE 2D-FOURIER TRANSFORM
Spatial aliasing.
Monofrequency signals in the f-k domain.
f-k spectra.
Antialias filters.











-SEISMIC PROCESSING

MIGRATION
Vertical velocity change, ray tracing, diffraction models, DMO migration and dip calculation, zero offset migration of linear reflectors and compass migration, dips before and after migration, offset modeling with variable source/receiver offset, exploding reflectors model, Huygens model, the diffraction model from Huygens to Kirchhoff, downward continuation, post-stack migration methods, Kirchhoff migration, relationship between hyperbola and horizontal reflector , depth and time equations, Kirchhoff migration algorithm, aperture, time interpolation, pre-stack migration, the semi-ellipse as reflection point loci.
Geometry of dip dependent moveout : DD-MO, diffraction modelling of source gathers, scatterpoints and diffractions of constant offset sections, zero offset and constant offset examples, principles of dip-moveout corrections, prestack migration of 3D data volumes, non-zero offset traveltime, DMO, depth migration, kirchhoff depth migration.

APPENDIX
Tau-p transform and gaussian beam.
Reverse time migration.
3D Kirchhoff surfaces.
Kirchhoff summation surfaces Z-O.
Traveltime surface in constant V Z-O.
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VTI, TTI, time migration examples.
Effects of migration aperture.

-SEISMIC PROCESSING: VELOCITIES

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Instantaneous velocity (Vins), Average velocity (Vave), RMS velocity (Vrms), Stacking velocities (Vstk), Interval velocities (Vint).
Errors in interval velocities calculated from stacking velocities.
The RMS applications.
The Eikonal equation: finite grid element traveltime computation.
The wave equation.
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Derivatives of the equation.
Solutions of the full wave equation and finite grid elements solutions.

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Horizontal reflectors series NMO.
Moveout equations of fourth an n order.
NMO stretch.
Dipping reflectors influence on moveout velocity.
Effect of inclination and velocity on NMO for a stratigrafic sequence.
Velocity analysis: traveltime, best-fit and small-spread hyperbolas.
T-X velocity analysis of synthetic gathers.
T-X velocity analysis of CMP gathers.
Velocity spectra.
Coherence Algorithms: stacked amplitude, normalized stacked amplitude NS, time gate normalized and unnormalized xcorrelation sum (N CC), (U CC), energy (E CC), semblance (N E).
Velocity sensitivity to seismic parameters.
V spectra: gate row and contour plots.
Spectra: mute compensation and stacking effects.
Interactive velocity analysis, horizon velocity analysis, coherency attributes stack.

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Wavelet signatures.
The Fourier transform expressions in the seismic theory notations.
The Convolution theorem.
Nyquist frequency: sampling and aliasing operations: Comb, Sync, Boxcar.
Laplace transform and Z-Transform.
Transfer functions.
Applications of correlation and autocorrelation functions to discrete time systems.
Cohrence and semblance functions.

-ROCK PHYSICS AND AMPLITUDE INTERPRETATION

The effective model – from micro to macro-elastic field.
The rev: "representative elementary volume".
Effective medium modeling.
Elementary and effective medium elastic parameters calculations: k, mu, rho.
Effective models: Gassmann, Hertz-Mindlin, Voigt, Reuss, Hill, Hashin-Shtrickman.
Upgrade to the macro-field theory.
The Aki-Richards AVO equations.
Zoeppritz equations linear approximations: Wiggens, Shuey, Borthfeld.
Intercept and gradient parameters.
P-S Velocity, Poisson ratio, density dependency.

Upgrade to the macro-field theory: near, mid and far offset range stack.
Shuey and Hilterman theory.
Rock physics properties influence on angle stacks.
Normal incidence and Poisson reflectivity.
Review of elastic parameters and their effective medium composition in the AVO equations context.
Effective medium averaging equations.
Gamma/Poisson relations.

V and density interpretation.
V-density transforms.
Alternative equations for normal incidence reflection coefficient (NI-RC).
NI-RC: V and Rho sensitivity.
Thin bed analysis.

AVO classifications.
AVO class reconaissance on angle stacks.
Predicting hydrocarbon response in Poisson - RC xplots.

Abnormal pore pressure from seismic data.
Hydrostatic, overburden, effective P.

-AVO ANALYSIS AND SEISMIC INVERSION

Aki-Richards, Wiggins and Fatti forms of Zoeppritz equations linearizations.
The 2 and 3 term Aki-Richards equations.
Significance of intercept, gradient and curvature.
Offset to angle conversions.
AVO seismic attributes and composite attributes and interpretation methods.
Poisson ratio change, shear reflectivity and fluid factor, Rp and Rs.
Castagna mud-rock line.
Rutherford AVO classification.
NI-G xplot and AVO classes.

AVO/AVAZ VTI and HTI weak anisotropy.
Thomsen parameters.
The Aki-Richard equation as a function of Thomsen parameters.
Ruger VTI and HTI equations.
Polarization analysis and anisotropy static modeling.

3D SEISMIC INVERSION
Post-stack and pre-stack seismic inversion.
Elastic inversion.
Acoustic impedance, elastic impedance, extended elastic impedance.
Independent AVO inversion.
Simultaneous AVO inversion.
LMR.

PROCESSING ISSUES
Random and coherent noise attenuation.
Super-gather, parabolic radon transform, RNMO and higher oreder moveout.
Time variant trim statics.

SEISMIC ATTRIBUTES AND 3D VOLUME PROPERTIES DISTRIBUTIONS
Multiattibutes analysis.
Amplitude, complex, time attributes:
Hilbert tansform, real and complex amplitude components.
Amplitude Envelope.
Instantaneous Phase.
Instantaneous Frequency.
Average Frequency.
Dominant Frequency.
Derivative.
Derivative Instantaneous Amplitude.
Second Derivative.
Second Derivative Instantaneous Amplitude.
Amplitude Weighted Cosine Phase.
Amplitude Weighted Frequency.
Amplitude Weighted Phase.
Cosine Instantaneous Phase.
Apparent Polarity.
Integrate.
Integrated Absolute Amplitude.

Predicting target properties in multiattribute space.
Decreasing the prediction error.
Crossvalidation.

Neural networks modeling: from linear to non linear prediction.
Nodes in hidden layers, total iterations.

Stochastic inversion.

-GEOSTATISTICS

From stochastic inversion to geostatistics.

REV (representative elementary volume) and scale variability.
Statistical parameters (univariate distribution).
Sample declustering with elementary statistical parameters.
Moving window statistics.
Bivariate statistics.
Linear regression.
Bivariate statistics for spatial data.
Probability.
Mathematical expectation.
Statistics algebra.
The normal (gaussian) distribution.
Lognormal distribution.
Distribution of static and dynamic reservoir properties.
Stationarity.
The variogram.
Lag tolerance.
Variogram modeling: Nugget, spherical, exponential, gaussian and combination models.
Geometric anisotropy.
Crossvariogram.
Conventional estimation and Kriging: simple and ordinary Kriging.
Cokriging, multigaussian Kriging.
Grid based simulation: sequential gaussian simulation (SGS).
Estimation at the unsampled location.
Comparisons: Kriging and SGS.
Multiple realizations.

-SEISMIC ATTRIBUTES ANALYSIS

Attributes classifications: amplitude attributes, complex attributes, time attributes.
Spectral decomposition.
COMPLEX ATTRIBUTES.
Hilbert transform motivation: the causality condition.
Hilbert transform as convolution operator.
Real and Imaginary components.
Instantaneous phase and frequency.
Envelope and Signal strength.
Zero crossing effect.
Complex attributes interpretation.
Tapered window and Morley wavelets.
SPECTRAL BALANCING AND SPECTRAL DECOMPOSITION.
Colored spectrum.
Spectral decomposition and interpretation´s workflow.
Tuning frequency and sensitivity of spectral components to formation thickness.
Multiattributes interpretation in the frequency domain.
Statistical discrimination on spectral components.
Sensitivity of spectral components to hydrocarbons.
Diffusive Q-model: fluid mobility attributes.
Singularity attributes.
Instantaneous frequency as reflector continuity indicator.
SPICE algorithm and waveform singularities as coherence attributes complement.

-SEISMIC ATTRIBUTES ANALYSIS

GEOMETRIC ATTRIBUTES.
Complex trace analysis: calculation of vector dip and azimuth.
Gradient structure tensor to calculate vector dip.
Discrete search estimate of coherence to calculate vector dip.
Estimate of coherence, dip and azimuth.
Various methods of coherence calculation.
Coherence in the analytic trace and zero crossing issues.
CURVATURE ANALYSIS AND REFLECTOR SHAPE.
Sobel edge detector.
Curvature and structural interpretation.
GLCM textural attributes: energy, entropy, contract, homogeneity.
Visualization of geometric attributes.
Facies analysis.
Multiattributes analysis and color codes visualization.
Multiattributes analysis with overlays and animation.

-GENERAL PETROPHYSICS

The invasion process.
Archie law, formations parameters.
Resisitivity logs.
Resistivity devices:
Focusing electrode logs, microresistivity devices, Induction logs.
Log interpretation.
Formation water resistivity determination.
Determination of saturation.
Rwa as hydrocarbon indicator and overlay solution.
NGS log, porosity logs, density and lithodensity logs, neutron logs.
Lithology and porosity determination.
Formation microscanner and FMI.

-PETROPHYSICS OF CLASTIC FORMATIONS

Formation factor and resistivity index.
Cementation exponent calculation in the Archie equation.
Sw equations and porosity-conductivity partitioning.
Sw calculation in non-Archie formations.
Porosity and saturation partitioning.
Physics of petrophysics parameters measurements.
Equivalent circuits for induction and laterolog tools.
Density and photoelectric cross section measurements.
Pulsed neutron log.
Nuclear magnetic resonance tool theory.
Surface, bulk and diffusion relaxation.
T2 spectrum and cutoffs.
FFI, BWF, BVW typing.
Kozeny-Kenyon and Timur-Coates permeability.
Pc curve and NMR log links.
Dipole-Dipole sonic applications. STC processing.
K and Stoneley waves.
Shear waves anisotropy: fast ans slow S-waves.
V-Phi transforms.
Secondary porosity index.
Gas detection. Xplots DT-Vp/Vs.
Shear waves polarization and splitting: structural and geomechanical interpretation.
Sonic and FMI correlations.

P-S slowness and elastic parameters.
Log tools resolution and ray of investigation.
Log interpretation methodes: Deterministic and stochastik.
Xplots: NPHI-RHOB, DT-RHOB, M-N, Rhoma-Uma, Rwa-Gamma.
Shale typing on xplots, shale and gas corrections.
Pickett plot.
Buckle plot: BVW, Pcap, Swirr, Flow units, Permeability.
BVW and hydrocarbon interpretation.
m-PHI and porosity characterization.

-PETROPHYSICS OF CARBONATE FORMATIONS

The Lucia classification.
Wellbore proximity sectors on carbonate formations.
Vp-Porosity and parameters controlling Vp.
NMR and porosity partitioning.
Pc curves in the context of Lucia carbonate classification.
Winland R35 in the context of Lucia carbonate classification.
Swirr and flow units in the context of Lucia carbonate classification.
Pc curve, NMR, R35, Ka-PHI: reservoir system quality and performance.
Petrofacies and NMR T2 distribution.
Vuggy porosity.
m structural parametrization: VPR and Brie model.
Porosity partitioning in the m dual porosity equation.
The modified Myers model.
m and porosity type.
n exponent, wettability and NMR porosity typing.

PICKETT PLOT INTERPRETATION.
Effects of petrophysical parameters on the Pickett plot:
Sw, m, Rw, n, BVW,Tau, K.
Buckle/Pickett parallel effects: BVW,Sw,K,m.

-STATIC SIMULATION

Between seismic inversion and dynamic simulation.
The 3D SEGY seismic cube.
Operations on the 3D seismic cube.
Positioning petrophysics, drilling dynamics and core data on the 3D cube.
Seismic data visualization: Slices, inlines , crosslines, randomlines, timeslices.
Synthetic seismogram calculation.
Horizon and fault interpretation (autotracking, anttracking), mapping.
Attributes cube generation, attributes map generation.
Volume rendering.
Volume extraction.
Seismic petrophysics attributes.
The Static model.
Logs loading and correlation.
Fault interpretaion and digitization: fault sticks, polygons, digitizing modes.
Pillar gridding: create skeleton grid and horizons building.
Time to depth conversion.
Inter-horizon Zones (isocrones).
Inter-zone Layering (facies / flow units / strata).
Geometrical property modeling.
Upscaling of petrophisical properties.
Facies modeling: sequential indicator simulation.
Object modeling.
Petrophysical modeling: petrophysical properties spatial distribution.
Deterministic workflow (Kriging), stochastic workflow (Sequential Gaussian Simulation).
Volume and STOIIP calculation.
Well trajectory design.

3D SEISMIC MULTICOMPONENT.
FROM PRINCIPLES TO MULTICOMPONENT AND JOINT SEISMIC INVERSION

Section 1 Historical overview, 3D-1C Seismic methods

Section 2 Why use shear waves
- When compressional mode fails .
- When lithological information is required .
- When fluid contend is important.
- When confirmation is needed.
- When shallow to medium depth resolution is required.

Section 3 Theoretical basis
- Elastic wave propagation in homogeneous media.
- Reflection, transmission and conversion of elastic waves.
- Boundary and surface waves.
- Wave attenuation.
- Modelling.

Section 4 Multi-component seismic acquisition
- Shear wave sources.
- Land multi-component receivers.
- Shear wave land acquisition.
- PS mode land acquisition specifics.
- PS mode marine and shallow water acquisition.

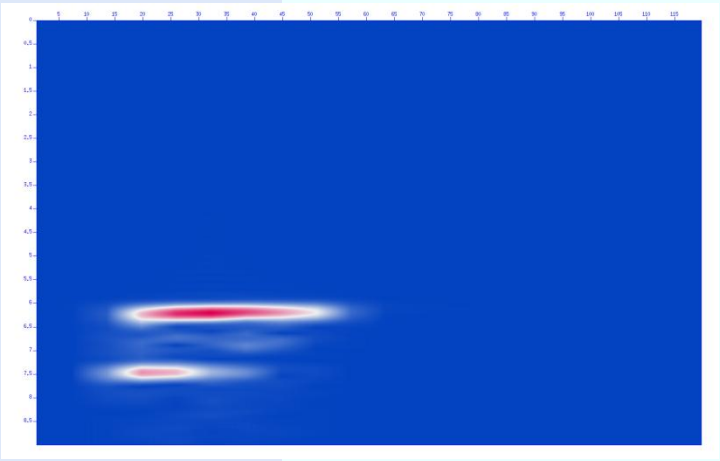
Section 5 Processing of multi-component data
- Generalities about Shear mode processing in VTI environment.
- Static corrections.
- Normal moveout corrections.
- Correlation of P and S data.
- Generalities about PSv mode processing in VTI environment.
- Processing sequence of PSv mode in VTI environment.
- Particulars of marine processing.
- S and PSV mode processing in an orthorhombic environment.
- Inversion and azimuthal analysis.

Section 6 Results of multi-component surveys

Conclusions

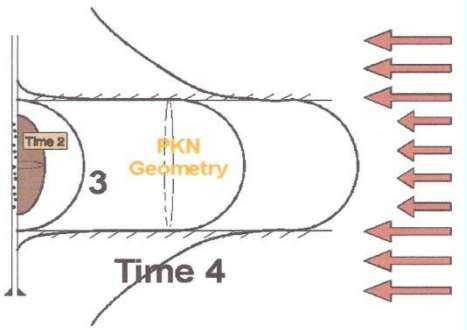
-DRILLING TECHNOLOGY

Main components of a drilling rig.
Data Logging.
Drilling optimization programs.
Drilling methods.
Completions.
Onshore and offshore rigs.



-D&I MEASUREMENTS AND DIRECTIONAL DRILLING

The earth magnetic field.
Magnetic field components: azimuth, dip, declination.
Directional surveys.
Accelerometers, magnetometers, gyroscopes.
Non-magnetic collar calculations.
Declination and grid corrections.
Gravity and magnetic tool/face.
Survey parameters: svy station, inclination, azimuth, departure, course length, hole direction,
TVD, MD, closure, vertical section, closure direction, course deviation, target.
Tangential method calculation for well trajectory.
Minimum curvature method calculation for well trajectory.
Target definition.

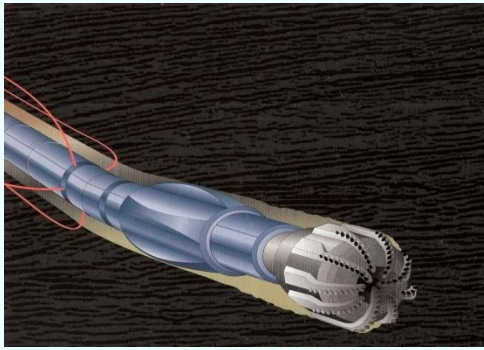


-HYDRAULIC FRACTURING OPERATIONS

In-situ stressfield (closure).
Stress Origin and Magnitude.
Pore Pressure effect.
Elasticity and stress-parameters.
Faulting theory.
Fracture-Azimuth.
Fracture-Geometry.
Hydro-Frac Operations Planning.
Main Variables and Units.
Units Conversions.
Perkins&Kern Model.
Nolte Analysis.
Efficiency.
Tests.

-WELL TEST ANALYSIS

Short overview of modern Well Testing and Curves Interpretation.



PROPEDEUTICAL MATERIAL AVAILABLE AS PDF FILE

-CALCULUS AND LINEAR ALGEBRA
-MATRIX AND TENSORS
-FROM FOURIER TO HILBERT
-STRUCTURAL PLAYS
-INTRODUCTORY ELEMENTS OF PETROPHYSICS
-INTRODUCTORY ELEMENTS OF SEISMOLOGY

DEEP LEARNING

MOTIVATION
Linear and Non-Linear Models
Binary classifiction
Supervised learning methods in Petrophysical Analysis
Unsupervised learning methods in Petrophysical Analysis
Supervised learning Methods in Seismic Analysis
Unsupervised learning Methods in Seismic Analysis
FULLY CONNECTED LAYERS NEURAL NETWORKS
Logistic Regression
Cost Function
Gradient Descent
Forward Propagation
Backwards Propagation
Derivation of Loss and Cost Function
Interlayers Derivatives
Python/numpy vectors
Vectorization
Broadcasting
Shallow Neural Networks
Deep Neural Networks
Dimensioning layers parameters in deep neural networks
Activation Functions: Sigmoid, Tanh, Relu and relative gradients
Vectorized implementations
Iterative optimization processes
Regularization
Batch and mini-batch gradient descent
Gradient descent with momentum
RMSprop
Adam optimization algorithm
Hyperparameter optimization
Batch Norm
Softmax regression
Orthogonalization
Bayes error
Error analysis: bias and variance
Transfer learning
CONVOLUTIONAL NEURAL NETWORKS
Edge detection
Convolutions on RGB images
Multiple filters
Deep convolutional networks
Residual networks
1x1 convolutions
Inception networks
Transfer learning
Localization and detection
Landmark detection
Sliding windows detection
Turning full connected layers into convolutional layers
Convolution implementation of sliding windows
Yolo algorithm
Bounding boxes
Non-max suppression
Anchor boxes
Training the Yolo algorithm

Face / object verification and face recognition
Siamese network
Learning similarity function
Visualization of deep network learning process from shallow to deep layers
Neural style transfer
Content cost function
Style of an image, style matrix
Style cost function
1D, 2D, 3D convolutions

NEURAL NETWORKS SEQUENCE MODELS
Recurrent neural networks (RNN)
Forward and backpropagation
RNN architectures
Vanishing gradients
Gated Recurrent and long short term memory unit
Bidirectional RNN
Attention model

NN / GEOSTATISTICS APPLICATIONS IN 3D SEISMIC AND PETROPHYSICS

High and low resolution measurements
Spatial variability of high and low resolution parameters
Spatial covariance of petrophysical and seismic properties
The variographic function
Kriging property distributions methods
Gaussian property distributions methods
Static models and multiple realizations statistics
Heterogeneity and azimuthal anisotropy of petrophysical and seismic attributes
Spatial upscaling of petrophysical parameters into the seismic cube
Deterministic and stochastic methods in seismic inversion
Amplitude, complex and time seismic attributes
Multiattributes validation
Using multiattributes for property spatial prediction
Distributing petrophysical and seismic properties on the 3D seismic cube
Predicting missing logs

INTERPRETATION WITH PROFESSIONAL SOFTWARE

SEISMIC PROCESSING
Construct velocity model, ray tracing, acquisition on earth model, compare with seismic data, examine shot gathers, sort CDP gathers, velocity analysis, NMO correction, stack, migration

SEISMIC INTERPRETATION
Examples will be with Quantitative interpretation and AVO or Attibutes Analysis.
Seismic Attributes:
Data Loading: SEGY, Creation of a Steering Cube, Horizon Cube etc, Well-Tie, Visualization of Horizons Slices, Inline , Xline, Transverse, Horizontal Sections, Autotracking, Anttracking, Attributes Analysis, Volume Rendering, Spectral Decomposition, Properties Crossplotting, Velocity Analysis, Sequence Stratigraphy

LOG INTERPRETATION
Data loading: LAS, DLIS, ASCII, Format Logs, Merge/Shift, SCAL.
Calculation of PHI,Vsh, PHIeff, Frequency Plots, RHOB-NPHI Xplot, Pickett Xplot,Complex Lithology Xplots, Sw, Shy,K, Pay Volume determination. Single Well and Multi-Well Interpretation

STATIC MODELING SOFTWARE (only theoretical introduction) Fault Modeling, Pillar Gridding, Zonation and Layering, Facies Modeling, Petrophysical Modeling, Upscaling, Well Design

DYNAMIC SIMULATION SOFTWARE (only theoretical introduction)
Overview of the Modeling Process, Conceptual Reservoir Scales, Reservoir Structure, Fluid and Rock-Fluid Interaction, Reservoir Simulation, Reservoir Architecture