

# TECHNICAL SPECIFICATIONS



## Interwell

Advanced Seismic Inversion

## Software Presentation

InterWell is Beicip-Franlab's seismic inversion software. Core inversion workflows and algorithms are developed by IFPEN and are enriched by functionalities and attributes from Beicip-Franlab consulting experience. Software environment is based on the INT Viewer platform.

InterWell unified workflow offers the following key stages:

- Seismic data QC and conditioning
- Multi-well and multi-cube wavelet estimation
- Initial impedance modeling for elastic parameters
- Deterministic acoustic/elastic 3D inversion
- VTI deterministic elastic inversion
- Interbed multiple management during inversion process
- Acoustic/elastic geostatistical inversion
- Multi-azimuth inversion and 4D inversion workflows
- Lithology prediction
- Seismic characterization

## Data Management

Benefits from all INTViewer platform capabilities (import/Export, Visualization, QC, calculator).

### DATA IMPORT/EXPORT

- 3D seismic, velocity, and anisotropy data in SEG-Y and binary files format
- 3D seismic gather in SEG-Y format
- Well data in LAS format (3.0)
- Horizons, maps, tables, and pointsets in ASCII format
- Wavelet in ASCII format
- 3D anisotropy parameters and attribute data
- Direct connection with EasyTrace database for transfer of:
  - Input well logs
  - Results extracted at wells
  - EasyTrace tables for Discriminant Analysis training data

### DATA EDITING AND QC

Horizon management

Data extraction and calculators for Wells, Maps and 3D volumes

Automated QC displays on Wells, Maps and sections

## Functionalities & Algorithms

### ELASTIC SEISMIC DATA REGISTRATION

- Residual NMO Misalignment QC and correction between angle stacks using a volumetric analysis and optimization method.
- Generation of cube-to-cube cross-correlation and noise maps

### MULTI-TRACE COHERENCY ANALYSIS

- Estimation of seismic signal, noise and seismic bandwidth

- Seismic signal spectral analysis
- Statistical estimation of wavelet amplitude spectrum for further wavelet estimation

### WELL-TO-SEISMIC CALIBRATION

- Hybrid approach for wavelet estimation (statistical and deterministic)
- Multi-well wavelet extraction and optimization
- Time shift estimation through envelop of intercorrelation
- Wavelet phase and energy determination through multi-trace & multi-well analysis
- Variable phase and amplitude wavelet estimation using a least square optimization method
- Inter-bed multiple management option to detect multiple generator and maximize calibration accuracy
- Flexible editing of calibrated wells location and time-shift
- Energy normalization map from wells using several interpolation methods

### MULTI-CUBE CALIBRATION

- Multi-cube calibration Quality Factor
- Determination of optimal well position taking into account different single-volume calibration sessions

### INITIAL IMPEDANCE MODELING

#### Structural framework definition

Building a geological framework for elastic parameter modeling

- Step by step integration of horizons in a structural model
- Geological macro-units
- Depositional model definition within each macro-unit

#### Model definition

- Creation of an a priori distribution of impedance and density
- Well data interpolation along structural and stratigraphic features
- Modeling of low frequency component using seismic velocity data, whenever relevant

### DETERMINISTIC INVERSION

#### Acoustic and Elastic Bayesian inversion

Inversion products: IP, IS, RHO, Synthetics, Reflection coefficients and Residuals seismic for each angle stack

Additional available elastic parameters: Poisson Ratio, Vp/Vs Ratio, LambdaRho, MuRho, Gradient and Intercept on optimal inversion results  
Taking into account data quality and influence by tuning inversion parameters:

- Bayesian inversion approach
- Parameterization of inversion algorithm through the use of a priori uncertainty assessments
- Volume-dependent tuning of input seismic data volumes
- Optimization through a multi-channel conjugated gradient method
- Monitoring of inversion cost function
- Inversion on full-cube, sub-cube or around a surface

#### Advanced inversion capabilities

- HPC capabilities to minimize computing time
- Inter-Bed Multiple Management (IBMM) technology to attenuate the impact of multiples from a contaminated dataset on the inversion results
- Advanced inversion parameters: IP, IS, Rho min/max and Poisson Ratio constraints
- Laterally variable wavelet energy

- Integration of VTI (Rüger) anisotropy model for enhanced inversion results

## GLOBAL STOCHASTIC INVERSION

Geostatistical inversion, algorithm developed by Cerena (Istituto Superior Tecnico)

- Use of direct stochastic sequential simulations
- Global optimization technique based on the trace-to-trace mismatch between real and synthetic seismic
- Possibility to use deterministic inversion results as secondary variable
- Uncertainty analysis

## AZIMUTHAL INVERSION

Complete sequential multi-azimuth inversion workflow

- Determination of isotropic and anisotropic contributions
- Assessment of horizontal anisotropy parameters through statistical ellipse fitting

## 4D JOINT INVERSION

Complete workflow for Time-lapse inversion

- A priori warping using a multi-channel correlations method
- Physical warping process integrating both P-waves cinematic and impedance variations
- Multi-vintage acoustic and/or elastic post- and/or pre-stack inversion

## Results Analysis

### AUTOMATED DEDICATED QC

#### • Wells

- Sections through wells displaying well paths, logs, markers, seismic horizons along with observed seismic and/or a priori models and/or inversion results
- Automatic display generation for comparisons between initial logs, a priori models, inverted impedance and/or between observed and synthetic traces at wells
- Available for blind wells testing

#### • Wavelets

- Display of the envelop of inter-correlation functions between observed and synthetic traces (time-shift detection)
- Cross-plots and histograms integrating all wells or sub-sets of wells for optimizing the time shift, the phase and the energy
- Mapping of estimated parameters and corresponding correlations of observed vs. synthetic trace, to check the accuracy of the estimated parameters in the vicinity of the wells / intersections
- Correlation coefficient, Phase, Time Shift and Energy maps around wells
- Average calibration attribute maps (multi-cube calibration)
- Wavelet and corresponding phase & amplitude spectrum
- Display of multiple wavelets, comparison of amplitudes spectra, available for multi-cube stability analysis or input versus inversion results QC

#### • Sections

- Automatic combined sections display showing a user-defined selection among inversion results (impedance, synthetic, residuals), input seismic and a priori models for easy comparison

#### • Cross-plots

- Cross-plots available between inverted traces and well logs
- Cross-plots between inverted parameters such as IP vs. IS (or calculated Vp/Vs or PR)

### SEISMIC CHARACTERIZATION TOOLS

Comprehensive set of functionalities and attributes for seismic inversion and reservoir characterization workflows

#### • Filters

- Available for horizons and 3D volumes

#### • Advanced calculator

- Available for single horizon and up to two 3D volumes

#### • Seismic data QC

- Noise maps and energy maps
- Using a constant time window or around an horizon

#### • Inversion QC

- Cross-correlation maps between two 3D volumes
- Energy ratio maps between two 3D volumes
- Noise maps before/after inversion

#### • Frequency analysis on maps

- Minimum, maximum, dominant frequency
- Analysis at -6dB or -10dB

#### • Statistics maps extraction

- Average, minimum, maximum, variance, standard deviation, RMS
- Available around one horizon or in an interval defined by two horizons
- Possible use of threshold to derive proportion maps in an interval

### LITHO SEISMIC CHARACTERIZATION FROM INVERSION RESULTS

Complete workflow for litho-seismic characterization from elastic inversion results

- Dominant lithology prediction using discriminant analysis
- Generation of volumes of dominant lithology and associated probabilities of good assignment

### SEISMIC CONSTRAINTS GENERATION

Trend modeling to estimate key reservoir properties, with the possibility to derive maps from inversion results

## Extensions & Customization

Based on the open Java™-based INT platform (<http://intviewer.net/products/intviewer.html>) allowing a high level of customization and extensions

- Powerful and flexible GUI
- Based on the open source Netbeans Rich Client Platform (RCP) for creating and managing plugin functionality
- Existing plug-ins available among spherical divergence correction, Butterworth filter, binning 4D.
- Interoperability with Python and the Seismic Workbench

## System Requirements

- PC Windows 7
- PC Linux 64 bits RedHat6 or compatible
- RAM: 8 GB or more (minimum: 4 GB)
- CPU: x86 and x86-64 processors
- Graphics board: NVIDIA recommended (or any graphic card compatible with OpenGL)



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