Paradigm®

Quantitative Seismic Interpretation

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Integrate QSI Workflows Early in the G&G Cycle to Reduce Uncertainty

The integration of early Quantitative Seismic Interpretation (QSI) into the seismic interpretation process is one of the most effective methods for reducing uncertainty in the long term. Adding QSI to daily interpretation work can help companies thrive, even in challenging economic conditions.

Paradigm® Quantitative Seismic Interpretation modules are directly integrated into the interpretation platform. They benefit from a high-definition viewer, and direct access to data stored in Paradigm Epos®-based data repositories.

Paradigm QSI quantifies the relevant parameters of the subsurface for each rock unit within the geometrical interpretation framework. Our technology provides answers to questions about rock type, lithology, reservoir properties, fluid fill, elastic properties, and geomechanical properties, helping you to better evaluate your probability of drilling success.

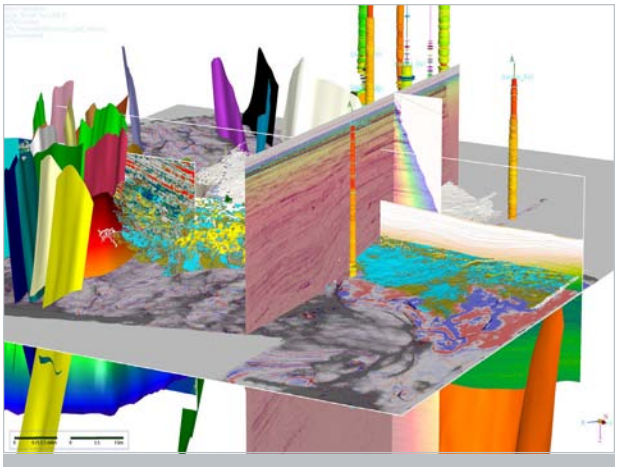
The workflow traditionally begins with prestack migrated data organized in offset/angle gathers or angle stack volumes. The user reviews and conditions the data in Paradigm's 2D Canvas for detailed work, or 3D Canvas for more integrated interpretation. Both windows provide attractive functionalities for this, including a comprehensive set of dedicated algorithms for pre-conditioning the data, an interactive framework for running the process, and an advanced platform for visualizing and analyzing the results.

AVO/AVAz Inversion and Analysis

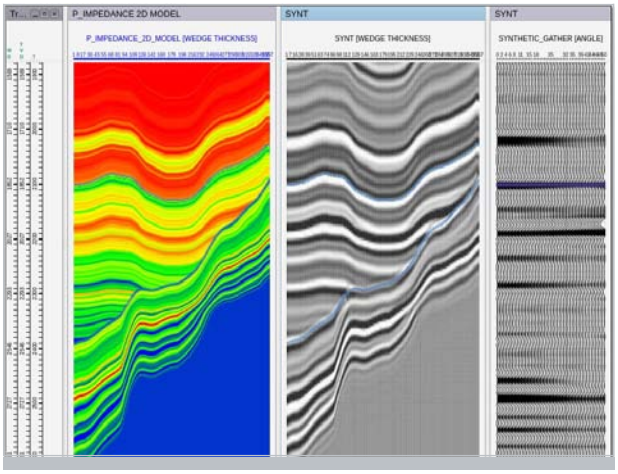
A central component of QSI is AVO inversion and analysis, which is the leading seismic amplitude analysis technology for direct hydrocarbon detection. Integrating AVO into the interpretation workflow adds information about rock and fluid properties to the knowledge acquired in seismic surveys, enhancing understanding of the reservoir and lowering exploration risk. Paradigm QSI offers the level of integration, qualification and analysis needed by geoscientists to confidently use seismic amplitudes to identify quality prospects, clearly delineate reservoirs, and characterize reservoir properties.

Seismic Amplitude Inversions

The Paradigm QSI system integrates seismic, well and geological data to produce a comprehensive description of reservoir properties, including impedances, porosities, saturations and lithology. A full set of traditional and innovative inversion techniques enables the user to select the right technology for each project. The system is specifically designed to support the interpretation of multiple attributes simultaneously, for enhanced efficiency and ease of use.



▲ Use QSI to improve drilling success through early characterization of reservoir properties.



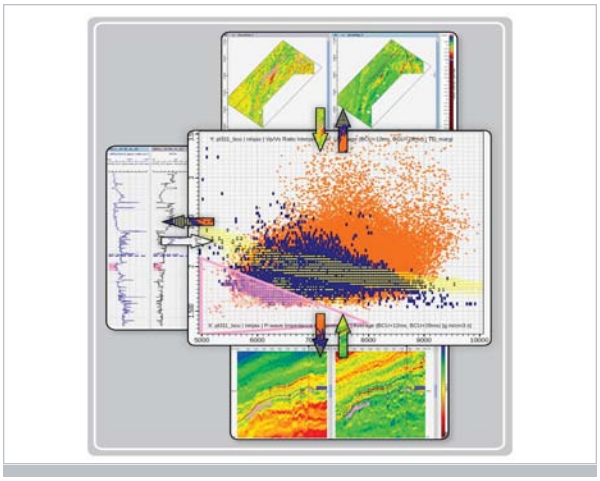
▲ 2D modeling provides a deeper understanding of the link between seismic wave shape and rock properties at the well.

QSI Features

- On-the-fly and batch prestack pre-conditioning
- Wavelet and stretching
- Automatic residual moveout corrections (isotropic and anisotropic)
- Prestack amplitude calibration
- Advanced QC feasibility analysis tools, enabling a thorough investigation into the effects of acquisition geometry, structure and pre-processing on AVO analysis
- Direct links to interpretation and well log data stores
- Intuitive, easy-to-use log window
- Advanced synthetics utility for calibrating multiple wells with seismic data in a multi-attribute interpretation environment, for extracting wavelets, and for rock physics modeling
- Wedge/2D forward modeling, giving users the option to play the "what if" game (structure, fluid and porosity), and accurately assess their prospect
- Crossplotting, designed to analyze multi-attribute seismic data and multi-attribute rock properties, and to integrate well log and seismic data in crossplot space

Features of AVO/AVAz Inversions

- Model-based AVO inversion in both time and depth domains, 2- and 3-term inversions using a variety of algorithms, and 2- and 3-term multi-azimuth inversions
- On-the-fly angle gather reconstruction from multiple angle stacks; and on-the-fly, multi-azimuth gather reconstruction from multi-azimuth sectors
- Complete workflow for multi-azimuth AVO analysis for anisotropy and fracture detection
- Unique, 3D model-based AVO modeling away from the well bore



▲ Share crossplot data from different sources (logs, maps, volumes) in one integrated window.

Features of Seismic Inversions

- Seismic attribute technology: Includes complex trace attributes, geometric attributes, multi-attribute analysis and interpretation tools, and multi-attribute, statistical analysis tools
- Geostatistical model building: Detailed high-resolution models that integrate well log data with interpretation, velocity and seismic data in a complex geological framework
- Colored inversion: Fast track inversion using seismic data and well data frequency spectrum to invert data and output relative acoustic impedance
- Poststack amplitude inversion: Various methods for inverting poststack seismic data in order to create impedance volumes
- Simultaneous elastic impedance inversion: Using a variety of techniques, seismic and AVO data are inverted to produce a broad set of attributes, including P and S impedances, Elastic Impedance, $\lambda*\rho$ and $\mu*\rho$, Poisson's Ratio, and density
- 4D cross-equalization of a multi-vintage dataset in 4D exploration using Neural Network technology
- Full-functionality depth workflow for colored inversion and Prestack Maximum Likelihood Inversion (PMLI), including well log calibration
- Simultaneous multi-attribute neural network inversion to convert seismic data directly into rock properties
- Crossplot lithoseismic classification: Defines multi-variate lithofacies probability from well data and applies it to prestack inversion results, to deliver probability volumes of predicted lithofacies and/or fluid properties

Flexible QSI Packaging

Paradigm QSI packages have been configured specifically for different data characterization goals. For the interpreter, the **QSI-RFP (Rock and Fluid Properties)** package is aimed at providing deeper insight into the subsurface, to enhance understanding of the impact of lithology and fluid on seismic data.

Major features of the QSI-RFP package include:

- Colored Inversion
- AVO analysis
- Multi-disciplinary crossplot
- Gather conditioning
- Synthetic utility
- Wedge modeling

For those who wish to go beyond interpretation, a **QSI-RFP for Reservoir Geophysics** package enables users to dig deeper into their data using techniques such as AVO, elastic inversion and automatic residual moveout analysis and correction.

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The ***QSI-RFP for Reservoir Geophysics*** package includes all of the features in the QSI-RFP package, plus:

- Velocity analysis with Paradigm FastVel®
- Seismic attributes
- Machine learning to correlate logs and seismic data
- Poststack amplitude inversion
- Simultaneous inversions using prestack data (full collection of gathers)
- Crossplot-based lithoseismic classification
- Stochastic refinement - Uses SKUA-GOCAD™ simulation technology to produce multiple, equally probable,high-resolution impedance volumes

For specialists who need to characterize unconventional and other fractured reservoirs, Paradigm offers the **QSI-AzFP (Azimuthal Analysis of Fracture Properties)** package.

QSI-AzFP is a comprehensive system for performing azimuthal analysis of fracture properties, providing accurate information about the orientation, intensity and density of fracture/tectonic stress systems.

Major features in QSI-AzFP include:

- Azimuthal-dependent residual moveout analysis (FastVel/VVAZ) and amplitude variation (AVAZ) analysis for automated extraction of azimuthally dependent attributes
- Support for both full-azimuth OVT (sectored) and EarthStudy 360® gathers for analysis and display
- Customizable vector map displays
- Includes FastVel and full-azimuth AVA analysis, and gather conditioning

The **QSI-PPP** package is available for specialists who need to characterize pore pressure from seismic data. The seismic pore pressure attribute is a workflow-guided application for calculating pressure volumes from seismic interval velocities. Outputs include density, normal compaction trend, hydrostatic pressure, overburden pressure, pore pressure, vertical effective stress, and fracture pressure.

Major features in QSI-PPP include:

- Geolog-PPP for 1D pore pressure prediction analysis based on well data
- A comprehensive set of tools for obtaining high-resolution seismic velocities (FastVel and CVI)
- Geostatistical volume creation to generate 3D volumes from 1D logs

The Advantages of Paradigm QSI

- Full integration into SeisEarth makes QSI easily accessible to the interpreter, with all data readily available throughout the workflow.
- Efficient use of azimuthal data leads to effective fracture detection.
- QSI workflows provide more information from available seismic data, enabling enhanced reservoir model quality.
- AVO and amplitude inversion directly from prestack data with interactive, on-the-fly preconditioning results in fast, high-quality, detailed understanding of the seismic AVO response.
- A high level of interactivity reduces decision-making time and improves prediction accuracy.
- An extensive QC toolbox delivers better quality results.
- A depth workflow provides fast and precise characterization of depth migrated seismic data.
- Inversion algorithms can run on Linux clusters, for high productivity.

Interoperability

All Epos®-based applications enable interoperability with third-party data stores, including:

- OpenWorks® R5000
- GeoFrame® 2012

System specifications

- 64-bit Red Hat® Enterprise Linux® 6.5 and subsequent minor releases, and 7.0 and subsequent minor releases
- Microsoft® Windows® 7, 8.1, 10

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