Using Seismic Attributes to Improve G&G Interpretation

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Key Points

- Extract more “even with limited amount of available data”
- More attributes to get an accurate image of the subsurface
- Improve productivity with enhanced technology
- Integrate to reduce risk

Paradigm Attributes Analysis and Visualization solution allows the geoscientist almost to “see” the subsurface.

“What you can see does not need an interpretation”
Agenda

• Introduction
• Seismic Attributes:
  • About Seismic Attributes
  • Challenges
  • What for?
  • Workflow example
• Examples
  • Penobscot, Nova Scotia
  • F3 block, North Sea
• Live presentation
• Q&A
Introduction

• Need for three-dimensional technology to interpret seismic data:
  • Interpretation functionalities as in conventional 2D view window
  • Improve computation time consuming
  • Need of integration of seismic and non-seismic data

• Workflow extension
  − Quantitative Seismic Interpretation
  − Seismic to simulation
  − Geologic Modeling

High energy channel in front with other channels deeper in the scene without rendering artifacts and wrap surface from detection.

Data Courtesy of AWE Limited
A story that starts in 1979
<table>
<thead>
<tr>
<th>Attributes</th>
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<tr>
<td>Post-stack seismic</td>
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<td>Impedances</td>
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<td>Velocities</td>
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<td>CSEM, MT, Gravity, Aeromagnetic</td>
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Technology-driven Industry

O&G industry is driven by advances in Technology

• Improved acquisition technologies
• Exponential increase of available data
• Create and need for new workflows in a multi-domain approach
• Constant and rapid advances in hardware performance
• Need for augment in efficiency in software for analysis and visualization

## Technology Trends

<table>
<thead>
<tr>
<th>Trends</th>
<th>Attribute Calculation and Visualization Opportunity</th>
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<tbody>
<tr>
<td>Volumetric Interpretation</td>
<td>Resolve, recover, and model complex 3-Dimensional features and structures</td>
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<td>Accelerate time to prospect</td>
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<td>Prestack Interpretation</td>
<td>Isolate and visualize DHI Indicators; Observe spatial AVA behavior and changes</td>
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<td>Fast track the quality control of seismic data</td>
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<td>Multiple Seismic Attributes</td>
<td>Understand the interdependencies of different physical and geometric attributes</td>
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<td>Quantitative Seismic Interpretation</td>
<td>Predict and visualize the lithology and fluid content away from the wellbore</td>
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<td>Microseismicity and Passive Seismic</td>
<td>Enhance the geo-reservoir characterization view</td>
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<td>Broadband seismic</td>
<td>High definition visualization/Recover more frequencies from seismic data</td>
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Some Uses of Seismic Attributes
Data Quality Control

Faux furrows in Amplitude Attributes are indication of Clipping
Footprint Suppression

Suppression of acquisition footprint by using Eigenvectors (Coherence) of noise

Images from Chopra & Marfurt, Seismic Attribute Mapping of Structure and Stratigraphy, 2006
Noise Reduction

Before

After

Dip Steered Enhancement Attribute
Visualization and Seismic Interpretation

Seismic Amplitude blended with Signal Envelope

3D view of two volumes (blocks) Signal Envelope blended with Coherence Cube and RGB Blending in Spectral Decomposition
Reservoir Characterization

GPU-based enhanced visualization: karsts from Barnett Shale formation

Seismic facies classification blended with curvature

Brittleness

TOC contents

Different seismic attributes characterizing the Eagle Ford unconventional formation
Generic Workflow

- Data QC
- Imaging Enhancement

Good

Bad

- Investigation and target determination
- Objectives or goals establishment
- Signal Analysis (globally and target level)
- Determination of attributes according with goals
- On the fly benchmark analysis
- Parameters determination and Attributes Calculation
- Interpretation and Visualization
Examples
The Scotian Basin is a passive continental margin that developed after rifting and separation of the North American and African continents beginning in the Middle Triassic.

During the Jurassic Period, a large-scale carbonate bank (Abenaki Formation) and a siliciclastic (Sable) delta coexisted in North America. Conventionally, carbonate systems (in situ) are separated from siliciclastic systems (transported) because of their contrasting origin.

Data source: OpenSeismic Repository
Target: Late Jurassic, Carbonates and Clastic

Objective: Visualization and characterization of two stratigraphic plays: Late Jurassic carbonate reefs and potential sand channels
• Structural Features:
  – Coherence Cube (Semblance, Eigen-based)
• Stratigraphic Features:
  – Spectral Decomposition,
  – Seismic Facies Classification
  – Coherence Cube (Semblance, Eigen-based)
Inline Flattened at Jurassic Mid Baccaro Formation Top level

Deltaic Lobe or Fan

Seismic Expression of Reef, Bubb and Hatledid, 1979
Advanced Attribute Merging Methods

HSV

Hue or color wavelength.

Saturation: How pure or “grey” the color is

Value (also called lightness) or brightness of color.

RGB

Red, Green and Blue

Additive Color
RGB Visualization

Seismic Expression of Reef, Bubb and Hatledid, 1979
HSV Visualization

Coherence

14 Hz

23 Hz

Saturation

Value

B-41

KL-30

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Seismic Facies

Neural Network
Self Organizing Mapping (Kohonen, 1982)

Seismic Facies Map blended with Coherence Cube

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Neural Network
Self Organizing Mapping (Kohonen, 1982)
Inline with Multi-Attribute (Spec Decom, RMS Freq, Coherence and Amp) Seismic Facies Volume blended with seismic amplitude. Potential reefs highlighted, Note the high correlation with GR Log shown.
Multi-attribute seismic facies volume with opacity rendering. Note the reefs highlighted in orange.
F3 Block, Netherland North Sea

- Large-scale sigmoidal bedding
- Deposits of a large fluviodeltaic system that drained large parts of the Baltic Sea region (Sorensen, 1997; Overeem et al., 2001)
- Basin dominated by rifting during most of the Mesozoic with a Cenozoic post rift sag phase
- During most of the post-rift phase the basin accumulated thick sedimentary mega-sequence
- Pliocene-Pleistocene times, coastlines shifted back and forth (Sha, 1991) leading to a variety of sedimentary environments and grain sizes.

Data source: OpenSeismic Repository
Target: Late Jurassic, Clastic and Carbonates

Amplitude extraction along time slice 1000 ms
Objectives
Visualization, interpretation and characterization of structural (faulting and fracturing) and stratigraphic features (channels, progradations and northern reef)
• **Structural Features:**
  - User Defined (Structural Enhancement)
  - Coherence
  - Fault Likelihood
  - Fault Enhancement
  - Curvature (Most Positive, Most Negative)

• **Stratigraphic Features:**
  - RMS Frequency,
  - Spectral Decomposition,
  - Seismic Facies Classification
  - Principal Component Analysis
Principal Component Analysis

- The correlation matrix of the input data volumes is decomposed into a summation of Eigen vectors and values.
- The variance as a function of the covariance matrix and projection weights is greatest along the maximum elongation trend of each component.
- By imposing a standardization constraint, maximization of variance is achieved by orthogonal rotation of the principal axes.
- **Redundant data which do not contribute to the maximum spread of the data clouds are eliminated by this method.**
Attributes for Direct Hydrocarbon Indicators (DHI)

Shallow geological features (548 ms) with anomalies highlighted by Signal Envelope Attribute. Could indicate gas migrated and accumulated
Attributes for DHI

Gas Anomalies detected with Spectral Decomposition and isolated with opacity
Summary

- Visualization techniques like advanced blend methods to extract more
- “On the fly” calculation, visualization and interpretation
- Contribution to a multi-disciplinary approach
- Fast rewards for improved creativity
- HD interpretation within reduced cycle time
- Manage better decision-making process by derisking
Thank You