Geological Expression from Seismic Data in Unconventional Shale reservoirs
Gaynor Paton1, Tom Woollorton2, Luis Gomez3

1- RAAberdeen, Northpoint (Suite e3), Exploration Drive, Aberdeen Science and Energy Park, Aberdeen, AB25 1HZ
2- RA Houston, 850 Town and Country Blvd, Suite 500, Houston, TX 77024
3- RALondon, Premier House, 10 Gray’s Place, London, SW1P 1SB

*Contact: LGomez@fia-geosciences.com

Data conditioning

The application of structurally oriented and edge preserving filters has been extremely effective in improving signal-to-noise ratios in seismic datasets from all play styles, and this is particularly true in shale data. Often onshore datasets used in the interpretation of shales are of older vintage, lower fold, constrained by acquisition practicalities, and subject to greater challenges such as processing statics. An equally important workflow is Spectral Enhancement, which allows the interpreter to whiten the frequency spectrum in a targeted fashion and reveal high frequency information in the seismic, which is usually masked by lower frequency ranges. This can be critical in enhancing interpretability of thin events, and increase the likelihood of successful well landings in thin formations (Figure 2).

Fracture analysis

Predicting the presence of natural fractures is a challenge critical to good well performance, but due to scale cannot be achieved directly from seismic data. One method is to use macro-scale structural trends such as faults, flexures or dip planes, which are commonly extracted from seismic data, and measure their relative abundance throughout the data (Figure 4).

Multi-attribute visualisation

One volume, or even one technique rarely gives the whole story, and we have found that analysing multiple seismic attributes and combining them together with sophisticated colour blending techniques is an effective way of improving the understanding of shale play (Figure 5).

Structural and Stratigraphic Expression

The stratigraphic variations in shale or gross shale packages can be related to thickness, lithology and kerogen content, and are often expressed in the form of frequency variations in seismic data. Being able to rapidly measure, extract and interpret frequency content from seismic data is vital for accurate analysis of shale reservoirs and has been achieved using Frequency Decomposition and RGB blending. Prospective shale plays are often a product of the tectonic setting and history in which they developed. As the seismic expression of structure can be highly variable, multi attribute visualisation techniques such as CMY blending (cyan, magenta and yellow) are important for interpreting the information contained in multiple volumes simultaneously (Figure 3).

Conclusions

• Data conditioning increased the signal-to-noise ratio, enhanced interpretability of thin events, and increased the likelihood of successful well landings in thin formations.
• Structural and Stratigraphic expression techniques analysed the seismic expression of structural and stratigraphic features, enabling a better understanding of the shale play.
• Fracture analysis highlighted areas of higher likelihood of fracture presence, enabling the generation of a probability map of prospective sweet spots.

References


Analysis Objective

Geometrical

Data Conditioning Noise removal; increased vertical resolution
Edge Detection Identify major faults
Curvature (maximum, minimum, most positive, most negative, mean & Gaussian) Fault and fracture identification
Dissolution of Curvature and Edge detection attributes Isolation of high stress zones
Frequency decomposition Illumination of depositional and structural heterogeneity

Geomechanical

Elastic anisotropy to generate P & S impedance volumes; density, Lmbda-Rho, Mu-rho and Vp/Vs; Poisson’s ratio & Young’s Modulus etc
Identification of brittle and ductile zones
HTI, AVA(Z; and RMO(Z); processing for azimuthal and angle dependent behaviour of velocity
Stress intensity and orientation

Combining Attributes

Cross plotting geometrical vs geomechanical attributes
Seismic characterisation of the shale
Co-visualisation of geometrical and geomechanical attributes
Indicators for sweet-spot identification

Fig 1. A typical suite of seismic volumes and their use in shale interpretation.

What the industry requires is a robust, comprehensive and user-friendly tool that can be used to analyse the results of this enormous financial investment in new data in order to quickly and accurately characterise unconventional shale reservoirs to assist in maximizing the impact of overall development strategies as well as the completion strategy of an individual well. GeoTeric employs a Geological Expression approach which is an innovative data-driven, interpreter-guided approach and has been shown to significantly improve interpretation productivity in shale environments.

Geological Expression workflows have added value in shale interpretation through:
• Improving the signal to noise ratio and vertical resolution of seismic reflectivity data;
• Delineating regional and small scale faulting;
• Detecting drilling hazards;
• Differentiating prospective areas on the basis of subtle variations in seismic character and frequency content that can indicate variations in reservoir thickness, lithology, and kerogen content;
• Predicting zones of increased tectonic deformation;
• Determining dominant stress directions and the orientation of natural fracturing through azimuthally sectored datasets and anisotropy analysis.

presentation}

Structural and Stratigraphic Expression

The stratigraphic variations in shale...