Technology and Solutions

Quantitative Seismic Interpretation is Key to Improving Drilling Productivity

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In the face of today’s difficult economic situation, both operators and software & service providers in the oil and gas industry are challenged to expand their traditional working methods in order to adapt to new circumstances. Among other steps that must be taken, is to continue developing technologies that can enhance result accuracy, reduce risk and increase drilling efficiency. Companies that are successful in doing this will be better equipped to “weather the storm” and even thrive in the current economy.

One of the most effective methods for reducing uncertainty is the integration of early Quantitative Seismic Interpretation (QSI) into the seismic interpretation process. The uncertainty which needs to be taken into account when drilling decisions are made is a cumulative result of approximations, decisions and knowledge accumulated in the past, using QSI in daily interpretation work can help validate and improve the information available to geoscientists seeking to reduce risk.

What is Quantitative Seismic Interpretation?
QSI is exactly what is says it is: the process of interpreting seismic data in a quantitative manner. Conventional interpretation is mostly about structure and stratigraphy; it is designed to understand the geology and build the geometric framework (horizons and faults) of the subsurface. It is mostly qualitative and low resolution. QSI, on the other hand, quantifies the relevant parameters of the subsurface for each rock unit within the geometrical interpretation framework.

Performing QSI requires the integration of poststack and prestack seismic data with well data and with rock physics concepts. From a technology perspective, QSI involves many components: prestack interpretation, AVO/AVA/AVAZ inversions, rock physics, synthetic seismograms from well logs, wedge modeling, statistical reservoir characterization, facies classification, and more. QSI can also be used to produce prestack attributes, a process which is not easily performed in classic Processing and Imaging applications, due to the integrated workflows required to generate such attributes.

Why Does QSI Matter?
QSI offers a wide range of benefits, which can enhance productivity and make the development cycle faster and more efficient. Below are some of the capabilities available to geoscientists using QSI in different stages of the E&P cycle:

- During the exploration phase
  - Gain earlier and better understanding of rock properties, for more efficient prospect ranking
  - Obtain more knowledge from sparse well information and relate seismic to existing wells and models

- During the development phase
  - Understand reservoir behavior and integrate reservoir heterogeneity
  - Optimize target placement through a deeper understanding of the reservoir’s architecture, a result of combining well information with state-of-the-art seismic inversion and attributes

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- Improve field development efficiency, by characterizing fractures using OVT and full-azimuth gathers (AVAZ) to extract maximum information from seismic data and gain insight into fracture and stress properties.

- In any geological context
  - Assess the quality of prestack seismic data with residual velocity move-out analysis at high resolution
  - Validate AVA/AVO relevance as hydrocarbon indicators
  - Build a trusted relation between seismic, wells, rock physics models and geological models to ensure a consistent match with production

Making QSI Available to Interpreters

Unfortunately, some QSI techniques are still perceived as being appropriate for specialists only. In order to make them available to the wider interpretation user base, the industry has made significant efforts to simplify the tools while retaining the high science that supports them. Techniques like Colored Inversion (a simple and fast method for creating impedance volumes to identify and map geo bodies and lithology units), AVO inversion and neural networks are creating new opportunities to turn QSI workflows into “bread and butter” techniques for the interpreter.

One of the challenges in optimizing hydrocarbon production or infill development in laterally heterogeneous reservoirs is to combine geological information about lithology and geophysical data acquired through reflection seismic data. As the source of information can vary (lithology logs, cuttings, and for seismic, post and prestack attributes) and can arrive in different resolutions, in traditional workflows, the integration of all the available data had to be done manually. This signaled tedious work for the analyst, and was sometimes ruled out altogether due to time limits. The ability to provide interpreters with all the relevant tools in an integrated environment is now opening new fields of possibility. A rough estimate of lithology and fluid content can be performed in the early discovery stages to provide a reasonable estimate of the economic viability of a prospect, and to rank it among others. This estimation can then be iteratively refined over time in order to reduce uncertainty.

Scale the Tools to the Need

For maximum effectiveness, the various QSI methodologies need to be adapted to different types of users. For example, QSI for rock & fluid properties, which is well suited to interpreters, should be slightly different from configurations designed for reservoir geophysicists. The first needs to provide a way to estimate gross lithology, and discriminate false hydrocarbon indicators from true ones. Colored Inversion, AVO inversion, and AVO modeling are already used for that purpose by many interpreters. Other tools that are useful to interpreters include multi-disciplinary cross plot, interactive Synthetics for calibrating single or multiple wells in both time and depth, and fluid substitution to consider “what if” scenarios and accurately analyze the effects of fluid on seismic data.

The second configuration, aimed at Reservoir Geophysicists, should have tools for analyzing elastic properties and preparing better inputs for reservoir modeling. Such a package can include velocity analysis, machine learning to correlate logs and seismic data, and simultaneous inversions using a full collection of gathers (prestack data). All of the steps are interdependent and each one, if well controlled, limits uncertainty for the next. The impact of early characterization on appraisal wells has a strong influence on exploration and later development investments.

Finally, when fluid flow is impacted by natural fracture systems, or when fracking is involved in unconventional plays, integrating QSI into the workflow can provide accurate information about the orientation, intensity, and density of fracture/tectonic-stress systems. The ability to integrate fracture interpretation from borehole images with the latest full-azimuth data, provides a unique way to control the impact of fracture sets on well production.

The system that enables the azimuthal analysis of Fracture Properties may also include azimuthal-dependent residual moveout analysis and amplitude variation analysis for automated extraction of azimuthally dependent attributes, support for both sectored and full-azimuth gathers for analysis and display, and customizable vector map displays.

Since it is obvious that the impact of rock, fluid and fractures is critical to the financial return on any prospect, progressively integrating characterization through the use of embedded QSI tools provides a way to drastically reduce drilling risk. At each step of the prospect’s life cycle, it ensures the cohesion of the interpretation scheme, and provides a consistent way to move between interpretation and modeling.