SIGMA^3 Integrated Reservoir Solutions

Reservoir GEOPHYSICS

Navigate around obstacles and drill with confidence.

The Driller's GPS Guide to the Reservoir

A road trip used to be filled with unknowns along the way. We would plan our route on a map and then venture out not knowing if there were construction or other delays. We also didn't know the locations of the sweet spots, that is, the best refueling and eating stops. Modern cars are now equipped with GPS units that are programed with the "sweet spots" and, in addition, receive up-to-date information regarding traffic congestion, road construction and other obstacles that might impede your progress to your destination. This allows you take remedial steps to take the most efficient route.

As oil companies accelerate capital investment in their exploration and development efforts, and with drilling operations and oil field services costs continuing to climb, a wrong turn, no matter how small, has a serious impact on the bottom line.

Reservoir geophysics today gives drilling engineers more thorough "road maps" of the subsurface to develop and carry out the best well planning with the lowest risk. In addition, the logging while drilling tools give an updated the earth model, just as the auto's GPS unit gives the driver an updated picture of his surroundings.

SIGMA^3 Integrated Reservoir Solutions™ incorporates a workflow that uses proprietary technologies to develop an industry-leading interpretation of 3D seismic data to give you an unparalleled reservoir description so you can drill with confidence.

The process starts with a thorough analysis of the geological framework by incorporating a complete petrophysical analysis of available well control into an earth model. This analysis includes a proprietary fluid substitution method that estimates the seismic response from different fluids in the reservoir as gas, oil and brine in reservoir pore space has been demonstrated to show different acoustic responses. The different fluid scenarios are modeled for their spectral decomposition and

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AVO response. Acoustic Impedance is used to discriminate different lithologies from the log response. This petrophysical analysis and modeling process develops calibration criteria for evaluating seismic attributes that are derived from the SIGMA^3 tool kit, such as spectral decomposition, spectral inversion, AVO, multi-attribute inversion and neural network inversion.

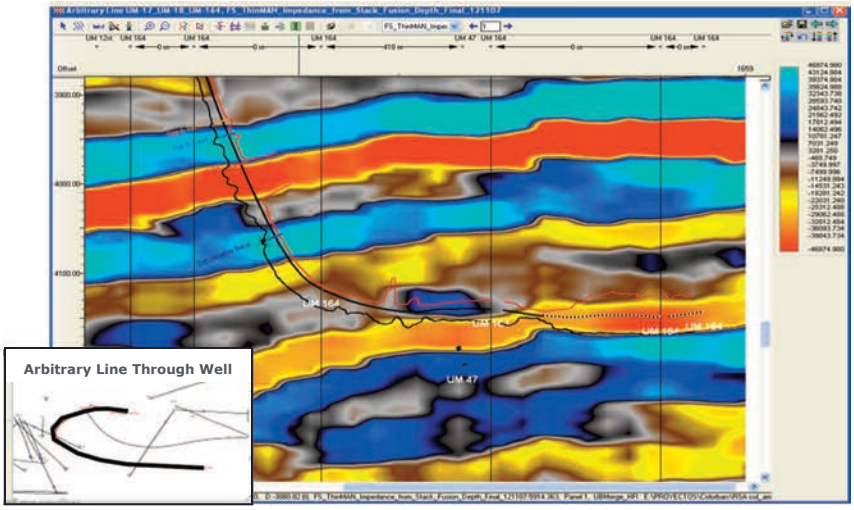
The seismic data are conditioned with more SIGMA^3 proprietary tools, including amplitude-friendly Radon noise suppression and AVO attribute based residual velocity programs. The resulting improved data quality gives better subsurface predictions of potential net-sand and net-pay, plus a better description of the path to the reservoir. Spectral decomposition and pseudo density from multi-attribute inversions are calibrated with well logs to give lithological and hydrocarbon predictions.

Pseudo impedance and reflectivity derived from SIGMA^3 high-resolution spectral inversion, ThinMAN™, are used to provide a better structural and stratigraphic subsurface description. The high-resolution velocity analysis coupled with geo-statistical technologies incorporating well ties to seismic interpretations develop more accurate time-to-depth conversions that provide a robust framework for a more accurate forecast of the reservoir penetration points. These more accurate depth converted volumes have proved to show more detailed features than were previously observed in typical time volumes.

Proven in the Field

SIGMA^3 interpreters worked with the drilling engineers during the drilling phase of the project as described in a 2009 SEG Annual Meeting Paper*. The drillers went into the drilling program with a better understanding of what to expect and maintained continuous contact with the interpreters.

The illustration shows the complex well path and the path taken by the drill bit. As the drilling progressed, the drillers on the well became concerned when they encountered a shale zone as they thought they should be approaching the targeted reservoir. The MWD data



Real-time analysis with ThinMAN impedance.

were updated as the drilling progressed and the location of this shale zone is shown in blue. From this updated information the SIGMA^3 interpreters assured the drillers that they were on track to get to the interpreted "sweet spot." They had the confidence to proceed to their target, which proved to be their "sweet spot".

Navigate to Success

Advances in technology have improved mobility by changing the way we navigate around the obstacles in our path. SIGMA^3 has the tools you need to create your own updated earth model in your next drilling program. You'll achieve more thorough well planning, calculate reserves with unprecedented accuracy, and get to your destination.

*The Use of Seismic Attributes and Spectral Decomposition to Support the Drilling Plan of the Uracoa-Bombal Fields

SIGMA^3

Integrate Geoscience, Engineering & Real-Time Microseismic Monitoring

Through a truly integrated, reservoir-centric portfolio of technology, expertise and services, SIGMA^3 Integrated Reservoir Solutions delivers an unprecedented level of integration that spans reservoir understanding to production optimization. Oil & gas companies will accelerate their return on investment by making more confident decisions that are the catalyst for long-term success.

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