Using the Full Seismic Wavefield

Workflow integration drives optimized well placements.

When determining where to place horizontal wells in reservoirs of high structural and stratigraphic complexity or for developing unconventional hydrocarbon resources, a number of criteria have to be considered, including petrophysical, geological, and geophysical factors. Water saturation, hydrocarbon content, rock properties, in-situ stress fields, karsting, faulting, and fracturing, all need to be evaluated and integrated into a single model for use in the decision-making process. Both wireline log data and new seismic acquisition techniques such as rich-azimuth 3D surveys bring a partial answer and need to be correlated in an integrated interpretation workflow. In particular for shale gas reservoirs, determination of the mineralogy and fluid content is a mandatory step in a full petrophysical process, considering that intervals with higher quartz content are generally more adapted for fracture simulation than zones with a higher limestone and clay content.

Another characteristic of shale gas reservoirs is the presence or absence of open fractures, which can have a major impact on well completions and productivity, as they can connect two formations with distinct fluid content and could thus impact drilling plans. A well-known example is the US Barnett Shale formation, which overlaps the water-bearing Ellenberger carbonate formation. In order to achieve optimal production, these types of reservoir need to be stimulated through a hydraulic fracture process, the propagation of which can be heavily influenced by open or healed fractures. Understanding in-situ stress regimes and reservoir pressure conditions near the well is mandatory for the success of any hydraulic fracturing program.

3D seismic data represents the main source of useful information for structural and stratigraphic interpretation workflows. Recently, the industry has integrated the use of wide and rich azimuth seismic data, mainly to improve the illumination of reservoirs beneath highly complex structures or for providing high-quality subsurface images that more clearly qualify reservoir compartmentalization or permeability. Paradigm’s EarthStudy 360 is based on a new concept for generating continuous azimuth, angle-dependent data, using the full wavefield. The company says that this helps to extract high-resolution data and information related to subsurface angle-related reflectivity. The method optimizes perfectly the continuity or discontinuity of subsurface features like faults and small scale fractures from the seismic data, as the angle gathers carry both full azimuth reflection (amplitude) and directional (dip and azimuth) information.

Paradigm says that interpreting high-quality seismic data through enhanced visualization techniques guides the geoscientist directly to a more precise characterization of the reservoir, enhancing predictions of the spatial and temporal conditions of trapping systems, the distribution of subsurface lithology and reservoir properties, calibrated to the in-situ conditions observed at the wells.

Controlling drilling risk is a high priority and 3D visualization helps to identify and mitigate potential threats that drilling engineers may encounter by integrating all the information in a unique 3D canvas.

The challenge of producing hydrocarbons economically from increasingly complex unconventional reservoirs drives the need for well path and engineering design optimization at every stage of the planning and drilling process. Designing wells within a 3D structural model, which integrates all relevant features, can shorten well planning cycle times, improve well placement and reduce drilling risk. To learn more, visit Paradigm at booth 1445.