Rock Physics-Based Workflows for Lithology and Fluid Property Prediction in Frontier Basins

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Quantitative seismic interpretation techniques have been applied with consistent success to predicting lithology and fluids in areas with high-quality local-well control. By contrast, the application of the same techniques is problematic in frontier basins where the nearest well control is some distance away. When rock property models are extrapolated outside the range of calibration, seismic responses can not be always reliably predicted.

Here we introduce an integrated methodology for frontier exploration that combines rock physics modeling and seismic-based evaluation techniques, allowing the interpreter to reliably extrapolate, predict, and quantify seismic responses for several geologic scenarios. This method includes examination of geological processes, to understand the predominant effects on the seismic properties and their variations from distant well control to prospect locations. Seismic amplitudes are interpreted in terms of pore pressure, lithology, rock texture, fluid content, and porosity, focusing on establishing a rock properties-based seismic interpretation framework and derisking the exploration opportunities. The overall goal of this methodology is to generate a catalog of seismic responses of potential exploration success and failure scenarios.

This methodology uses state-of-the-art rock physics models that are integrated effectively with existing thermal, burial, and reservoir quality prediction models based on regional basin modeling and petrographic data. These techniques link the rock elastic properties to their bulk properties (porosity, lithology), physical conditions (pressure, temperature, and pore fluid properties) and geological characteristics (texture and composition). The interpretation framework comprises the following tasks: (1) Log and seismic quality control and conditioning. (2) Analysis of check-shot velocity surveys. (3) Calibration of well and seismic velocities. (4) Rock typing and upscaling of log data. (5) Rock property trend analysis, rock-physics diagnostic, and model formulation. (6) Generation of synthetic seismograms. (7) Model extrapolation through velocity-based vertical effective stress and reservoir porosity predictions. Seismic velocities are used to estimate the fluid pressure and to constrain the modeling of mudrock properties. (8) Scenario-based AVO forward modeling. (9) Pre-stack interpretation and volume-based multi-attribute seismic scanning. Examples from frontier basins will be presented.