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The Approach, the Benefit, the Value of Closing the Gap between Geology, Geophysics and Engineering - A Case Study in the Powder River Basin, Wyoming

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ABSTRACT

Two complementary but expensive technologies - hydraulic fracking and horizontal drilling have led to a huge upswing in oil production. The only drawback is that oil prices must remain high enough to justify the costs of extraction. In the Rocky Mountains, there has been a marked drop in rig counts due to the decline in oil prices since 2015. Overall efficiency can be improved if wellbores target rock packages with favorable reservoir and geomechanical properties. A predictable subsurface model utilizing geology, geophysics, and engineering, allows for more effective well placement and low completion cost. This paper presents an integrated method of building a subsurface model to predict reservoir properties using core, well and seismic data of the tight Wall Creek/Shannon sandstones in the Powder River Basin, Wyoming. Traditional geomodeling methods construct a detailed model at well resolution, where the main issue is the predictability away from the wells. Yet the ability of prediction and risk management are paramount for an effective well placement. Currently, 3D seismic has dawned a veritable new era of geoscience, and yet seismic data is still generally used for structural interpretation, amplitude attribute analysis, and deterministic inversion. None of these results could exceed the limitation of seismic resolution, which is far removed from well resolution. A seismically constrained subsurface model, is a combination of traditional geomodeling and seismic inversion. It allows for quantitative integration of all data types from different scales of measurement in an unbiased manner, at a scale that approaches that of well logs. This study includes a total of 18 distinct core facies, identified by mineralogic, petrographic, physical and biogenic sedimentary features observed in core. The initial core facies were subsequently upscaled and tied to 9 unique log facies. These resulting log facies were then upscaled to seismic facies via a rock physics model, bridging the scale gap between core, log, and 3D seismic data. A simultaneous, geostatistical seismic inversion was conducted on a 3D seismic volume. One of the primary benefits of seismic data is the lateral resolution away from the wells. Rock physics plays an indispensable role here, as it forms the link between seismic elastic parameters and reservoir /geomechanical properties of the rock. Interpreting the change of seismic signatures of rock types, porosity and fluid is achievable via rock physics. Rock physics has been embedded in the modeling and inversion processes of the geostatistical inversion, which makes the result more robust and predictable. A series of highly detailed lithofacies and elastic rock property models were created. The final stage involves a cross-validation and refinement of geologic understanding. A geological stratigraphic interpretation was used to validate the 3D geostatistical model, which highlights details beyond the wells, as long as it honors the geological interpretation. Geological interpretation can be refined based on the subsurface model. The subsurface model accurately characterizes 3D reservoir heterogeneity, helps an advanced geological understanding, provides Phi-H maps, and measures uncertainty. A subsequent reservoir model can be used to identify sweet spots. It has been demonstrated that the subsurface model correlates with gas show and fracking pressure, thereby mitigating inherent risks in drilling and enhancing well economics.