Maximizing Recoverable Reserves in Tight Reservoirs Using Geostatistical Inversion from 3D Seismic Data: A Powder River Basin Case Study

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ABSTRACT

The application of horizontal drilling and multi-stage hydraulic fracturing has boosted economic recoveries from unconventional reservoirs. Applying this new technology requires proper placement of horizontal wells combined with hydraulic stimulation to create fractures extending from the horizontal wellbore. The economics of unconventional plays can be improved if horizontal wellbores target facies with favorable reservoir and geomechanical properties. Seismic inversion is a robust method to effectively characterize a reservoir into discreet facies and properties exhibiting either optimum or poor production capacity thereby allowing for more effective well placement. This study focuses on utilizing geostatistical inversion to predict facies and reservoir/geomechanical properties of a tight, unconventional Upper Cretaceous sandstone in the Powder River Basin, Wyoming. A three-phased approach was developed for this project: The first phase required petrophysics and rock physics modeling of the wireline log data which had been calibrated to core data to determine if facies discrimination can be achieved. Modeling of the tight sandstone from well log data yielded five unique lithology types discriminated by the elastic response. This well data was upscaled to seismic resolution and still provided discrimination of the five lithotypes. The second phase involved accurate reinterpretation of the horizons performed on layer based simultaneous inversion data, which has wavelet and tuning effects removed from the seismic. By using this approach, an accurate stratigraphic earth model was developed for the geostatistical inversion. The third phase incorporated data from various disciplines including the seismic inversion of the 3D dataset to provide highly detailed subsurface facies models together with absolute reservoir rock and geomechanical properties together with associated measurements of uncertainty. A series of highly detailed lithologic and elastic rockproperty 3D volumes were created through a Markov Chain Monte Carlo and Bayesianinference method for systematically incorporating various sources of prior information together in an unbiased, rigorous and consistent manner. The final datasets accuratelycharacterized the 3D reservoir distribution as tested against blind wells, provided porosity-height maps, gave measurements of uncertainty for any facies or property and allowed the identification of sweet spots for reservoir development and well placement.