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AVO Analysis to Improve Hydrocarbon Prediction in the Gulf of Thailand

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Abstract

To improve hydrocarbon prediction, geophysicists use rock physics to understand the seismic responses according to reservoir-seal rock properties and effects of fluid fill in the reservoir. This study describes the results of rock physics and amplitude versus offset (AVO) analysis and determines a modified chance of geological success using the available database from an oil field in the Gulf of Thailand. The method begins with a rock physics analysis of key wells. A depth trend plot is performed to observe rock physics properties of sandstone and shale together with their compaction trends. Fluid replacement modeling (FRM) is then performed across many wells to generate a predicted seismic response for different pore fluids (gas, oil, and water). The predicted AVO response is then calibrated against the actual AVO response from the seismic data at well locations. A total of four hundred and fifty drilled data points from sixty-nine wells from the Nong Yao oil field were utilized as a database in the analysis. The FRM results show obvious separation between hydrocarbon- and water-bearing reservoirs at shallow depths down to around 3800 ft TVDSS, shown on a cross-plot of acoustic impedance (AI) vs Vp/Vs ratio. This suggests that seismic amplitude variations from near to far offsets are expected to be identified in both AVO modeling and the actual seismic data. The results of AVO modeling and well calibration indicate that most reservoirs in the oil field are Class III AVO at this shallow depth range. A seismic AVO response database (intercept and gradient) from a 3D seismic dataset at the top of sandstone units is recorded and compared to their actual fluid types from well results. A background water line is defined with the clear observation that increasing distance from the background water line correlates with an increasing chance of hydrocarbon fill. After that, data points are categorized into weak, moderate, and strong AVO responses based upon their distance from the background water line, and this is used to modify the chance of geological success of near-field exploration drilling targets utilizing Bayes' theorem. The database suggests an increased chance of geological success of up to 20% in a strong AVO supported target and around 10% in a moderate AVO supported target. Targets are then quantitatively ranked and graded in a near-field exploration portfolio.

Keywords: seismic amplitude, AVO, rock physics, hydrocarbon prediction, Gulf of Thailand