Advancements in LWD Sonic Technology Sets New Benchmark on Reservoir Characterizations

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Summary

The Ravva Field is located in the KG Basin, Eastern offshore, India. The Ravva main producing reservoir comprises very good porosity and multi-darcy permeability with high hydrocarbon saturation. Mud filtrate invasion is very common in these unconsolidated sandstone reservoirs due to which post drilling wireline sonic logs are affected. This affects seismic to well ties and rock physics models. Generally, LWD data is less affected by mud filtrate invasion, hence compressional data should be closer to true formation P-wave velocity leading to better well ties and improved modeling results. Sonic while drilling data was acquired in one of the wells in order to measure more accurate p-wave velocity for the purpose of well ties, rock physics modeling and AVO modeling. P-wave velocity has been used successfully in updating rock physics and AVO modeling studies. Seismic-based reservoir characterization at flow unit levels, facies mapping, detailed rock and fluid characterization and identification of optimal completion technologies have helped to determine effective reservoir management strategy to maximize hydrocarbon recovery.

The main objective of this study is to measure more accurate p-wave velocity for the purpose of well ties, rock physics modeling and AVO modeling.

Keywords: AVO Modeling, Real Time Seismic Well Tie, Advance LWD Sonic Measurements

Introduction

The Ravva field was discovered in 1987 and has been on production for more than 20 years from Middle Miocene reservoirs and has recovered substantial amount of hydrocarbon till date. The Middle Miocene reservoirs have been deposited in shallow marine conditions and are thought to be shoreface and distributary channels in an overall wave dominated setting.

Well A is a near-vertical development well located in RAD Block of Ravva field, KG basin (Figure 1).

Figure 1: Location Map of Ravva field.
Mud filtrate invasion effects on sonic logs

Mud filtrate invasion is very common in these unconsolidated sandstone reservoirs due to which wireline sonic logs are affected. This effect is more severe particularly in water base mud compared to oil base mud drilling fluids. Figure-2 is an example of mismatch between the seismic and synthetic seismogram. These logs were acquired in wireline mode and are severely affected by the invasion. Hence, sonic log is recorded faster than actual. The computed Acoustic Impedance (AI) log shows increase in impedance at the top of reservoir and the synthetic seismogram is represented as blue peak. But the near angle stack data shows strong negative trough at the top of the reservoir. The resultant synthetic seismogram is not matching with the actual seismic. The recorded faster sonic also affects rock physics models and prediction of AVO responses.

LWD Sonic Technology

The latest generation multipole sonic (Monopole and Quadrupole) LWD technology in a 6” slim hole section has been deployed for the first time in India to obtain real time compressional and slow formation shear data. Generally, the LWD data is less affected by mud filtrate invasion, hence compressional data represents more accurate formation P-wave velocity leading to better well ties and improved modeling results. Figure-3 shows LWD SonicScope recorded mode processing result for monopole high and Quadrupole shear. Track-8 shows quadrupole shear, which is continuous and of good quality, even the high frequency monopole compressional data is superior in quality. Using advance LWD sonic tool, shear slowness of up to 300us/ft was obtained successfully using quadrupole data processing.

Real Time Seismic Well Tie

While drilling, seismic to well ties and nearby well correlation in the shallow seismic events have significantly reduced the depth uncertainty at the reservoir section and more confidently selected the casing shoe depth prior to drill the target section. Seismic is a measurement in time and the implicit uncertainty in the measured seismic velocities causes a depth uncertainty of up to 5%. Using density, sonic velocities and seismic wavelet, a seismic to well tie was created. Several workflows and tools were tested and it showed that this can be achieved in real-time. Note that a seismic look-ahead clearly remains the domain of seismicVSION and Wireline VSPs. A fit-for purpose well-seismic tie helped us to more accurately put the bit onto the seismic section.

AVO Modelling

LWD SonicScope logs were used to generate AVO curves to understand the hydrocarbon response of the reservoir. Figure-4 shows AVO modeling for the variation of reflectivity with angle. Blue curve shows Class I AVO anomaly for brine sands. HC bearing sands display Class II (oil) and Class III (gas) AVO anomaly. Average Vp, Vs and RHOB are computed for oil, brine and gas sands along with shale. The AVO responses predicted from SonicScope logs are consistent with seismic data. Hence monopole compressional and quadrupole shear data represents truer formation P-wave and S-wave velocity to further carry out AVO modeling studies. This data was also calibrated by the 4D simultaneous AVO inversion.

Results

The well was completed with open hole sandscreen with swell packer. LWD advance sonic data helped in generating better offset synthetic seismograms, building robust rock physics model and also predicted correct AVO and 4D responses that were observed in the latest timelapse seismic. This data is used for calibration of 4D simultaneous AVO inversion results that increased confidence in planning additional wells in Ravva field.
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Figure 2: Well to seismic tie panel

Figure 3: LWD SonicScope Well A recorded mode processing result for monopole high and Quadrupole shear. Track-8 shows quadrupole shear, which is continuous and of good quality, even the high frequency monopole compressional data is superior in quality.