Optimizing Pre-stack Seismic Processing and AVO Inversion Workflows to Unlock Permian Gharif Reservoir, Sultanate of Oman

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Abstract

In recent years, Petroleum Development Oman (PDO) has embarked in exploration and development of the Permian Gharif reservoir. The reservoir is in the form of sand channels surrounded by continuous shale units deposited during terrestrial, fluvial and marginal marine environments. Historically, it has been challenging to map Gharif sand channels due to their complexity, size and acoustic signature overlap with surrounding shale. Rock physics analysis indicates that pre-stack elastic inversion is required to separate sand from shale. Thus, PDO has adapted new AVO friendly processing workflow to preserve the true variation of amplitude with offset. Over the past 5 years, several AVO inversion trials have been conducted to map Gharif sand in central and north Oman. Overall, the results show miss match with the well data and the achieved vertical resolution was not adequate to delineate Gharif individual sand bodies. In a recent attempt we further optimized the processing and inversion workflows to improve vertical resolution and match with well data.

Output seismic from older AVO friendly processing workflow have been characterized by limited frequency bandwidth (7-45 Hz), with which it was difficult to map Gharif thin sand layers. Recently, we started a new Gharif project in North Oman. In this area, the drillers are interested on mapping a specific thin sand layer in the upper part of Gharif. The sand layer thickness varies from 5 to 15 m. We conducted synthetic forward modelling to understand the required frequencies to adequately map this relatively thin layer. The modelling indicated that the frequency bandwidth had to be boosted to be able to resolve the targeted sand layer. The revised processing workflow focused on broadening the frequency bandwidth and at the same time minimize the impact of multiples and improve the AVO amplitude match between seismic and wells. The processing efforts resulted in widening the frequency bandwidth to 5-70 Hz, providing us with better chance to image the targeted sand layer. Simultaneously, we revised the inversion workflow. Older AVO studies have been yielding moderate to poor Vp/Vs match with well data. Testing have shown that the AVO results are very sensitive to the input wavelet. This time, we tested utilizing wavelets with different wavelength and vertical extraction windows (including and excluding overburden). We came up with new guidelines on how to extract the wavelets for Gharif inversion.

Furthermore, we observed that it is recommended not to invert for large areas but rather split it to smaller segments to account for variability in amplitudes which might be driven by variation in geology and seismic quality. The new AVO inversion results show significantly improved match between inverted and well Vp/Vs. The new learnings have been implemented in this case study. The results are giving better understanding of Gharif channel system in alignment with the well data and geological understanding of the area. The results are being utilized to pick additional wells in the area. Once having the results from the newly drilled wells, we will cross check them with the inversion prediction to build confidence on the inversion products. Furthermore, the new AVO practices are being implemented in the ongoing AVO friendly processing projects across Oman.