Application of AVO and Spectral Decomposition for Derisking Paleogene Hydrocarbon Traps in the UK North Sea

Nick Loizou[1]

[1]Oil and Gas Authority

Abstract

Since 2000, 30 exploration wells located in the UK Northern North Sea and the Outer Moray Firth have targeted Paleogene prospects. All 30 wells encountered high-quality reservoir of between 24% and 34% porosity with only seven encountering hydrocarbons. The target reservoirs were all at depths between 1600 and 2500 metres sub-sea where AVO analysis should be feasible. A post-mortem AVO analysis and spectral decomposition was undertaken on eight of the 30 wells, which included three that encountered hydrocarbons and five dry holes. All of the seismic data were pre-processed to zero phase prior to AVO analysis. Pre-stack amplitude analysis was performed on selected CDP gathers from each dataset in the vicinity of the well location. For the AVO processing, the angle gathers analysed ranged up to 17m; for the 'nears' and up to 37m; for the 'fars'. The cable length of the 3D seismic data was at least 3 km providing data suitable for AVO analysis down to approximately 2.1 km sub-sea for a straight ray path. A conventional stack technique was used, with all the data NMO-corrected. Stack data of near, middle and far offsets were generated to analyse the relative seismic amplitudes in each offset range. AVO attribute analysis was carried out using standard attributes, with AVO intercept and gradient being computed. The effects of dispersion and attenuation on AVO effects are also analysed. Variation of P-wave reflection coefficients with saturation and frequency modelled for typical Classes 1 and 3 AVO, respectively. Spectral decomposition was used in conjunction with AVO analysis for direct hydrocarbon detection. Comparisons were made of the spectral data from selected CDP gathers in and outside the target reservoir zones. Iso-frequency sections were generated from the stacked data for each of the wells. From these it is apparent that some of the wells exhibit frequency anomalies that are associated with a Class 3 AVO response. In conclusion, the AVO analyses confirms a Class 3 AVO anomaly for the wells with hydrocarbons whilst the 5 dry holes categorically show a Class I AVO anomaly which imply that many of the dry holes could have been avoided by the application of AVO and spectral decomposition. Both tools are beneficial for predicting the presence or non-presence of hydrocarbons in undrilled Paleogene hydrocarbon traps in the North Sea. However, the effectiveness and confidence in the validity of the results requires the availability of good quality seismic data.