Discriminating Between Commercial and Residual Hydrocarbon Saturation Integrating Pre-Stack Seismic and CSEM Data

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ABSTRACT

The integration of pre-stack seismic inversion attributes with controlled source electromagnetic (CSEM) attributes using a rock physics framework constitutes one of the most modern and complete methodologies to carry out geophysical reservoir characterisation. We present an example from the Hoop area of the Barents Sea showing the approach described above to discriminate between commercial and non-commercial (residual) hydrocarbon saturations. The analysis of seismic data provides the structural framework, and from AVO information, the possibility to derive P- and S-wave impedance volumes. These two valuable independent measurements can be linked to porosity and lithology, however, the seismic data cannot distinguish between low- and high-saturated hydrocarbon volumes due to their similar AVO responses. In contrast, CSEM data provide a lower resolution measure of resistivity, which, when constrained within the structural framework and integrated with the seismically derived volumes of porosity and lithology, can be linked to fluid saturation allowing the separation between commercial and non-commercial hydrocarbon accumulations. This identification of hydrocarbon bearing reservoirs and separation of commercial and non-commercial volumes would not be possible to achieve if only CSEM or seismic reservoir characterisation approaches were applied seperately. A dataset consisting of 2D GeoStreamer® seismic and towed streamer electromagnetic data that were acquired concurrently in 2015 by PGS provide the surface geophysical measurements used in this study. Two wells in the area: Wisting Central (7324/8-1) and Wisting Alternative (7324/7-1S) provided calibration for the rock physics modelling and the quantitative integrated analysis. In the first stage of the analysis, we inverted pre-stack seismic and CSEM data separately for impedance and anisotropic resistivity respectively. We then applied the multi-attribute rotation scheme (MARS) to estimate rock properties from seismic data. This analysis verified that the seismic data alone could not distinguish between commercial and non-commercial hydrocarbon saturations. Therefore, in the final stage of the analysis we inverted the seismic and CSEM derived properties within a rock physics framework. The inclusion of the CSEM-derived resistivity information within the inversion approach allowed for the separation of these two possible scenarios. Results showed excellent correlation with known well outcomes.