GEOPHYSICS POSTER 9

FIT FOR PURPOSE SEISMIC RESERVOIR CHARACTERISATION

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Quantitative seismic interpretation utilises seismic amplitude behaviour in conjunction with well log data, petrophysics and rock physics to make quantitative predictions about lithology and fluid away from well locations. Seismic reservoir characterisation in general cannot follow a one-size-fits-all approach – it is critical to consider local geological insight. It is also essential to determine the appropriate quantitative interpretation (QI) workflow based on available seismic and well data, and the desired outcome. Together, this will ensure robust and reliable characterisation of the hydrocarbon reservoir is achieved.

There is an array of QI workflow options for reconnaissance, exploration and reservoir-appraisal applications. Typically reconnaissance workflows must be utilised when no wells are available within the seismic survey area. In this instance, amplitude variation with incident angle (AVA) attributes can be used to identify exploration targets. AVA stack rotations are one powerful attribute to highlight potential anomalies when minimal or no well log data are available within the seismic survey area. AVA stack rotations are equivalent to the well-known extended elastic impedance (EEI) attribute (Whitcombe et al., 2002), and can be thought of as weighted stacks designed to enhance or suppress particular AVA responses. EEI is typically computed in intercept-gradient space, however stack rotations can also be computed using near and far (angle stack) attributes. Near and far AVA attributes have both high signal-to-noise ratio and statistical independence (Herrmann and Cambois, 2001). A simple scan through rotation angles can then be undertaken to quickly highlight interesting anomalies.

When well log data are available, statistical rock physics can be undertaken to quantify the geophysical signatures of all rock and fluid types of interest. Subsequent forward modelling facilitates the understanding of how seismic responses will change as a function of key variables such as depth, fluid content, and reservoir quality. In addition to enabling the prediction of the most likely seismic response, statistical rock physics enables the prediction of the range of possible responses. Capturing this population behaviour results in a more realistic evaluation of any seismic anomalies.

With access to statistical rock physics and forward modelling results, it becomes possible to calibrate variations in AVA stack rotations to known rock and fluid properties, and maximise the discrimination of fluids relative to lithology. More comprehensive exploration and appraisal QI workflows are also possible with access to well log data. Seismic-to-well ties can be made, and relative AVA inversion products can be generated. AVA stack rotations can be applied following simultaneous relative inversion – this largely removes the effect of the seismic wavelet and enhances the interpretability of the data. Note that, it is important to appreciate that stack rotation angles are depth dependent. For example, AVA responses can change with depth as a function of different compaction gradients between sands and shales. It is necessary to take this into consideration when doing exploration work over large time windows.

Where well control is sufficient, it becomes possible to construct low-frequency models and generate absolute rock property derivatives. These inverted rock properties can then be integrated with depth-dependent, stochastic rock physics models using a Bayesian classification scheme to make quantitative predictions about lithology and fluids away from well locations (Lamont, et al., 2008). When multiple wells have penetrated a known reservoir, more focussed reservoir characterisation is possible, and stochastic inversion can be utilised to understand key characteristics and uncertainties in important reservoir parameters such as net sand, porosity, fluid saturation etc. (Glinsky et al., 2005).

Seismic reservoir characterisation must be approached on a case-by-case basis. An integrated workflow that is optimised to take advantage of all available geological and geophysical data is essential. Statistical rock physics is important for understanding seismic responses and their uncertainty, but also for implementing the appropriate workflow and interpretation model. The 'degree' of quantitative interpretation must be a function of the available data and the job at hand.

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