Paper 2

Predicting reservoir quality from seismic data — lessons from the Cakerawala Field development, Malaysia-Thailand Joint Development Area (MTJDA), Block A18

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The use of acoustic impedance for predicting reservoir quality is well established in the oil and gas industry. Variations in the rock velocity and density can be related to variations in porosity and pore fluid content. These relationships together with estimates of acoustic impedance derived from seismic data can be used to make pre-drill predictions of net pay sand. Two key uncertainties need to addressed when using seismically derived acoustic impedance in this manner. First, due to limitations in the resolution of typical seismic data, the fine detail of the reservoir cannot be uniquely determined. Second, the relationship between acoustic impedance and porosity is statistical in nature and is better described as a probability function rather a simple regression. In this paper we show how these uncertainties have been approached in predrill reservoir prediction in the Cakerawala Field. In addition to describing the methodology we provide a detailed comparison of the pre- versus post-drill net pay estimates and a discussion of where the approach has been both successful and unsuccessful.

The Cakerawala Field is located in the Malaysia-Thailand Joint Development Area (MTJDA), Block A18 approximately 150 km off the east coast of Narathiwat in Southern Thailand and Kota Bharu in Northern Peninsular Malaysia. As with most shallow reservoirs in the Malay Basin seismic amplitude anomalies provide a very effective means of finding hydrocarbons in Block A18. Typically, the reservoir rocks are of relatively high porosity and presence of gas produces prominent bright spots and flat spots in seismic data. While direct hydrocarbon indicators are quite useful in the exploration phase a more quantitative approach is called for to guide well targeting for field development. Specifically the goal is to provide predrill estimates of net pay to optimize development well locations and also to refine reserves estimates. The approach used in Cakerawala Field was the stochastic inversion technique developed by Jason Geosystems. Using existing well control, probability density functions were defined to characterize the range of variation expected in the fine detail of the reservoir and the uncertainty in the relationship between impedance and both lithology and porosity. These PDF's were then used to guide a series of inversions or different realizations of the reservoir. Although multiple reservoir realizations can be used in various ways (including running each realization through reservoir simulation) the approach taken here was to average the net pay from all realizations to yield a "most likely" net pay map over two relatively thick reservoir sequences. These maps were then used to target all development wells and generate the pre-drill net pay predictions.

When comparing predicted versus actual pay in we found a very good relationship in Sequence II where reservoirs are relatively thick and laterally continuous. The predictions were significantly better than could be achieved by using existing well control only, and provide a very reliable method for future well targeting.

In Sequence I however several factors combined to generate errors. Although there is a reasonably good linear relationship between predicted and actual pay there are some significant outliers. Analysis of the outliers showed one case of significant over-prediction of pay (i.e. predicted greater than actual) when the well penetrated a high quality sand channel. Since none of the calibration wells encountered such a channel this error could possibly be controlled by rerunning the stochastic inversion with better calibration. The second, set of outliers indicated a tendency to under-predict pay in areas where the seismic data were obscured by the presence of shallow gas. This error is difficult to address directly within the inversion methodology but can be approximately corrected by applying scalars based on shallow gas maps. Both under-prediction and over-prediction errors are more likely in Sequence I because, compared with Sequence II, the individual subsequences are thinner and spatially more variable due to differences in the depositional environment. Although both sequences were deposited in a tidally influenced estuary/marine to delta front setting, the gas bearing Sequence II reservoirs are generally mouth bar sediments while Sequence I reservoirs are more estuarine.

In conclusion, estimates of acoustic impedance based on seismic data have been found to be very useful for predrill prediction of net pay in the Cakerawala field. Several sources of error remain, with error due to the presence of shallow gas being the most significant. A scaling approach based on shallow gas mapping has been developed to correct this error. Ongoing work is focused on integrating net pay prediction maps with reserves estimation methodology.