New Insights into the Petroleum Potential of the onshore Otway Basin, Victoria Australia

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SUMMARY

A seismic attribute study was conducted over a subset of data located in the onshore area of the Otway Basin, Victoria. Attributes were developed from the original legacy processed seismic data including energy and frequency attributes. With investigation and analysis it was possible to identify an amplitude anomaly with multiple stacked attribute anomalies directly related to reservoir levels with observed hydrocarbon shows from legacy well data close to the structure. This study combined with a new independent evaluation of the exploration potential revealing thickening and extension of an excellent reservoir and indications of trapped hydrocarbons that have previously gone unnoticed on data acquired in the 1980's.

Evaluation of the well data identified a thick sequence of stacked sandstones representing a facies change of the lower Eumeralla Fm. Identification of anomalous energy and frequency and combined with a neural network chimney model that demonstrates a gas cloud overlying the reservoir interval; presents a clear target for further evaluation.

Seismic mapping identified potential closure from a coarse 2D seismic grid. The nearby Greenslopes-1 well, located in a highly structured zone, represents high risk leak potential from migrated hydrocarbons and was drilled in a zone of low seal potential. This well however, provides an excellent test of the good quality reservoir potential at the level of the interpreted anomalous energy and frequency attributes.

Deterministic volumetrics of the prospect assuming a 70% recovery factor estimate recoverable gas volumes of 108 BCF. If a 10 barrel/MMCF ratio is assumed for condensate then the estimated recoverable condensate volume is estimated at 1.08 MMBBL. The overlying gas cloud potentially indicates significant liquids enrichment and it is likely the reservoir contains a fully saturated hydrocarbon charge.

Due to the current moratorium for onshore oil and gas drilling in Victoria the target will undergo further evaluation to assess the oil potential.

Key words: Otway, Petroleum, Interpretation, Seismic, Attributes

INTRODUCTION

Interpretation of seismic anomalies visible on legacy 2D data in a subset of data located in the onshore Otway Basin demonstrated many interesting anomalies. It is believed that observed frequency attenuation and brightening events on the seismic are likely caused by hydrocarbons. Attribute, spectral decomposition and neural network studies were conducted to evaluate the seismic to determine if any visually observed anomalies could be assigned to low velocity frequency anomalies and gas chimneys to predict charge, seal and leak potential.

The study is focused on the Central Portland Trough area of the Otway Basin. The focus area was in close proximity to the Windermere oil discovery. Numerous oil and gas shows have been documented in wells including Greenslopes-1, Kilara-1, Moyne Falls-1 and Hawkesdale-1 within and surrounding the study area. To the south, Port Fairy-1 (2002) analysis observed a 15m column of light 52deg API oil and associated gas in the production tubing by gradient survey (Crowe, 2003). The current study was devised to evaluate amplitude anomalies observable on the seismic that have not previously been assessed following these methods and a study of this type. This study looks to evaluate the petroleum prospectivity of an area that has been downgraded by poor results from past exploration. The current study comprised of a review of the seismic lines in the area and the locations of ten interpreted disturbances were mapped followed by a review of the seismic data to evaluate for possible causes. The work included analysis of attributes, spectral decomposition, neural network gas chimney modelling and interpretation of horizons and structure to develop potential prospects and leads for further evaluation.

The Greenslopes seismic survey was acquired in 1984 and interpretation of this data shows a structured anticline with draping of lower Cretaceous sediments including the primary reservoir target the Pretty Hill Sandstone overlain by interpreted siltstone and shale dominated Eumeralla Fm (Mitchell, 1986). The 3 way dip closure was drilled in 1986 by Phoenix Oil and Gas targeting the Pretty Hill Sandstone (Figure 1) with an interpreted Eumeralla Fm seal. The drilling result however revealed significant facies changes and the interpreted siltstone-shale sealing unit of the lower Eumeralla Fm is a good quality sequence of sandstones with the

Windermere Sandstone member overlying the Pretty Hill Sandstone providing a thick sandstone dominated sequence over 1000m. The Pretty Hills Sandstone lacked vertical seal at Greenslopes-1 and the top of the Windermere Sandstone overlying the Pretty Hills Sandstone appears structurally complex in this location and likely breached by faulting.

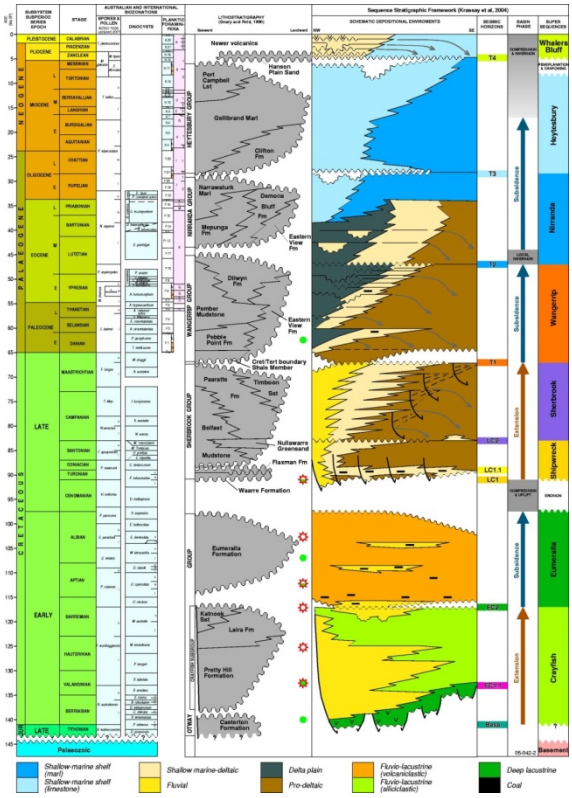

Figure 1 Generalised stratigraphic table of the Otway Basin with the highlighted (red outline) Windermere Sandstone overlying possible Katnook Sandstone and Pretty Hill Sandstone. In the study location Laira Fm is absent. Source: Geoscience Australia

METHODOLOGY

Initial evaluation involved extraction of many attributes from the processed seismic data mainly comprising of variations of energy, frequency, similarity and dip attributes. These attributes were used to identify potential anomalous areas by highlighting high energy anomalies related to structural closures difficult to visualise on the legacy processed seismic data. These anomalies were correlated to nearby wells to evaluate the potential reservoir and assess evidence of hydrocarbons. Investigations resulted in further evaluation including spectral decomposition to assess low velocity high energy anomalies that could indicate trapped hydrocarbons. Following encouraging results, a neural network chimney study was also conducted. Gas chimneys are interpreted in seismic data as vertical zones of chaotic, often low amplitude, reflectivity (Connolly et al., 2014). Processing of gas chimneys is a method of evaluation used to highlight these features in processed seismic data (Connolly, et al., 2014; Meldahl, et al., 2001; Aminzadeh & de Groot, 2006). An interpreter selects a set of picks to identify and guide a supervised Neural Network with examples of known gas chimneys and examples of non-gas chimneys. The neural network analysis evaluates the picks against a selection of directional attributes to guide creation of the gas chimney model and find similar features (Connolly, et al., 2014). By imaging the gas chimneys we can predict the depth where the source of the hydrocarbons occurs on the seismic and tie this level to geology (Ligtenberg & Thomsen, 2003; Connolly, et al., 2014). It has been demonstrated in previous studies that it is possible to evaluate and predict charge, seal and leak potential （Heggland 2013).

RESULTS

The Otway Basin attribute study was successful in identifying one particular high energy anomaly observable on two adjacent seismic lines and one perpendicular line. Subsequent spectral decomposition analysis revealed a strong low frequency anomaly in the same location further strengthening the target as a potential hydrocarbon induced anomaly. In addition interpretation of a gas cloud overlying the anomaly was further supported by the neural network chimney study however this study requires further refinement and potentially reprocessing of the 2D data to improve the quality. Testing of the oil prone target identified is yet to occur due to the drilling moratorium in Victoria, Australia.

An example of the initial attribute study and interpretation is presented in Figure 2. Opx84b-24 is one of 3 lines that image the anomalies and shows RMS Amplitude and Frequency Washout Ratio (RMS low frequency/RMS high frequency) overlayed on the seismic data. The blue interpreted horizon is top Windermere Sandstone; correlated to the nearby Greenslopes-1 well which has

fluorescence and log interpreted residual hydrocarbons in the sandstone units. Greenslopes-1 provides good indications of charge into this reservoir and interpretation of this structure suggests Greenslopes-1 was drilled on a breached anticline with high risk of leakage. A review of the stratigraphy and hydrocarbon indications observed in Greenslopes-1 suggests a thick reservoir interval exists in stacked channel sands of the Windermere Sandstone overlying a possible Katnook Sandstone interval and the Pretty Hills Sandstone outside structural closure.

Log analysis of the Greenslopes-1 well confirmed excellent reservoir potential in this area and indicated residual hydrocarbons and observed fluorescence in cuttings suggesting residual leaked hydrocarbons. A valid nearby closure correlated to a thick sequence of sands with up to 30% porosity and 250mD permeability could potentially trap migrated oil and gas. Work by Macintyre (2011) demonstrated the Windermere Sandstone member has the highest reservoir potential of the Eumeralla Formation sandstone groups based on current data. Additionally, to the north and east of the target location, legacy wells have intersected Pretty Hill Sandstone with 28-32% porosity and 2-5 Darcies permeability. Two of three wells failed to test valid structural closures and the valid structural test does not have associated potential hydrocarbon anomalies.

Further analysis of Opx84b-24 with spectral decomposition (Figure 3) showed a strong low frequency anomaly in the same location as the RMS amplitude anomaly. Low frequency amplitude anomalies are often diagnostic of hydrocarbons on seismic data. A similar low frequency anomaly is also visible on the adjacent seismic line opx84b-22, interpreted to be an extension of the hydrocarbon bearing closure.

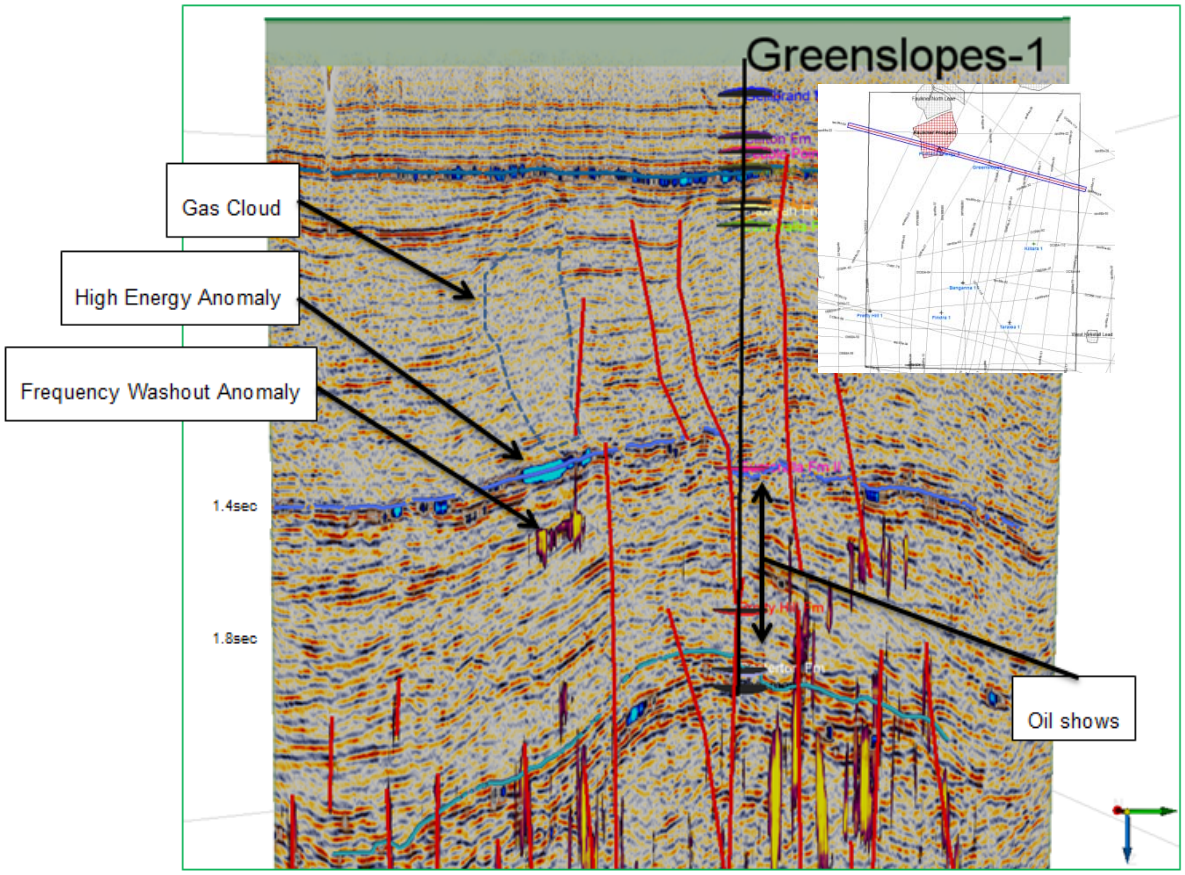

Figure 2 Initial Seismic attribute study anomaly observations with horizon interpretation, structure and nearby Greenslopes-1 well on seismic line opx84b-24

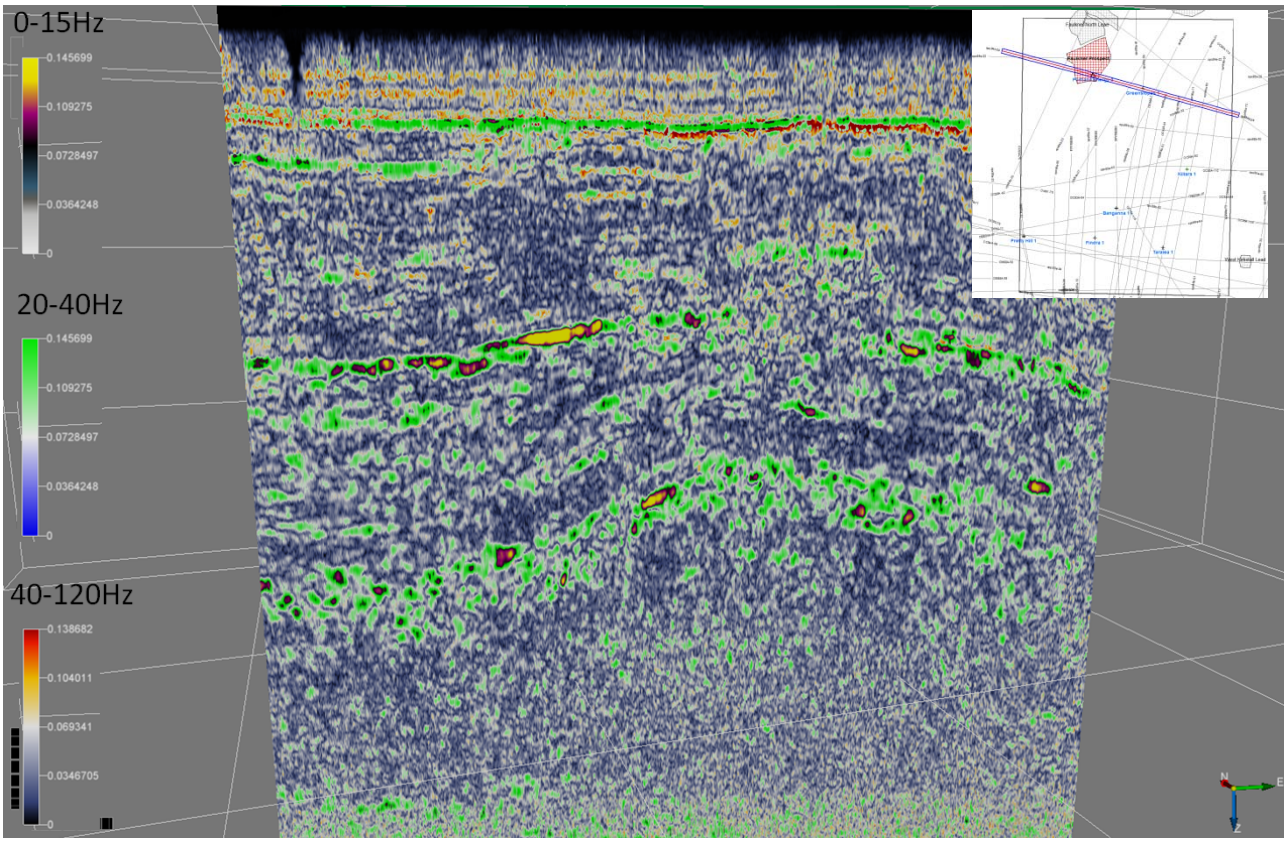

Figure 3 Overlain spectral decomposition with two semitransparent layers over the high frequency background 40-120Hz spectral decomposition on seismic line opx84b-24

Opx84b-24 provides a good example of the chimney model (Figure 4). Due to the relatively low quality of the 80's 2D processing there is considerable noise throughout the data that may have affected the neural network, however there are good indications that gas chimneys have been imaged. If the trap displayed a chimney extending vertically along a fault trace as shown in Figure 5 (Fault Leak Trap MIT-LIT) then we would likely have a breached trap with higher risk failure (Heggland, 2013). That however is not the case, instead we see a clear gas cloud anomaly overlying a frequency anomaly and has been demonstrated by Heggland(2013) to indicate leakage of lighter hydrocarbon components (gas) and likely indicates a fully oil saturated reservoir. With the oil discovery to the south in the Windermere wells, and the Port Fairy-1 oil and gas shows the likelyhood of trapped hydrocarons is high.

Additional to the gas cloud we observe extensive chimneys in the Casterton Formation shales that are a known source for oil and gas. These gas chimneys are lateraly extensive and may indicate a zone of expulsion and charge for the overlying trap via vertical migration.

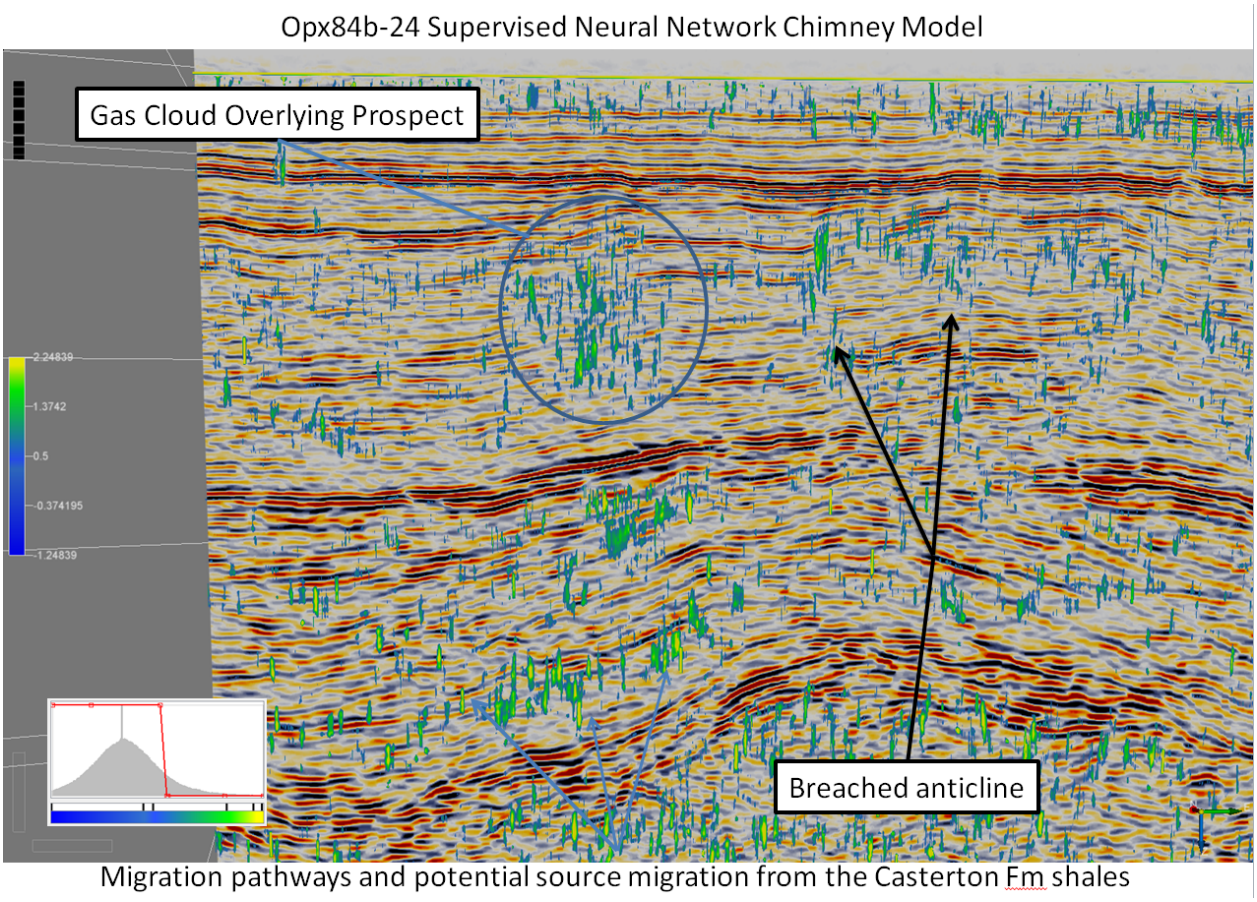

Figure 4 Neural network chimney study overlying opx84b-24 seismic line.

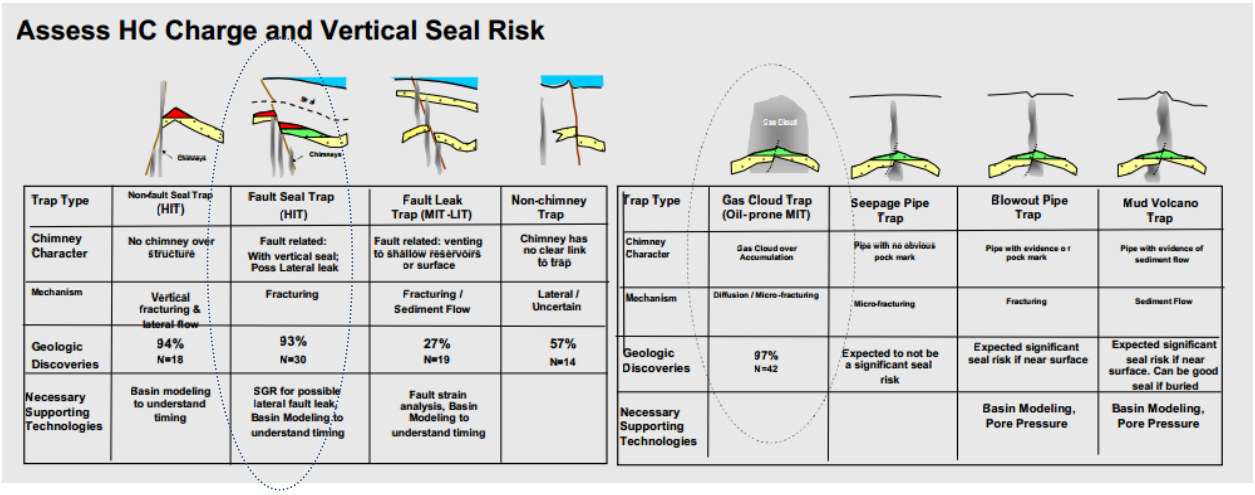

Figure 5 Hydrocarbon charge and seal risking methods (Heggland 2013)

CONCLUSIONS

In conclusion, the attribute analysis, spectral decomposition and neural network chimney modelling have enhanced the understanding of the target, charge risk, leakage risk, seal effectiveness and source potential. Further seismic and a surface geochemical assessment could add value to understanding the prospect however the current charge, reservoir, and trap risks appear to be low.

Attribute analysis revealed a seismic anomaly over three seismic lines in the Windermere Sandstone. Re-evaluation of the nearby Greenslopes-1 well indicated a facies change and up to 1000m of dominantly reservoir quality sandstone with sporadic intra-formational seal and indications of hydrocarbon charge at a location outside of mapped structural closure. Spectral decomposition analysis of three lines show a low velocity anomaly in the location of the amplitude anomaly further supporting a hydrocarbon

charged reservoir. Neural Network chimney analysis demonstrated a charged closure with an overlying gas cloud potentially indicating a fully saturated reservoir with lighter hydrocarbon components leaking. In combination all these observations suggest the reservoir may be oil prone and fully saturated. Additional 3D seismic data will improve understanding of the size and extent of the closure while the drilling moratorium is in place.

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