A Seismic Analysis of a late Albian age Submarine fan, Glenwood Prospect, Jeanne d'Arc Basin, Canada.

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Summary

Prior to this work, amplitude anomalies (bright spots) inferred to be late Albian age submarine fan deposits were mapped on 2D seismic data in the northern Jeanne d'Arc Basin. One of these prospects was acquired in 1999 by a group operated by Norsk Hydro (33.34%), and partners Petro-Canada (33.33%) and Mobil (33.33%) (fig.1). The prospect is a deep marine fan, which is likely to be sand-prone, with good-excellent reservoir potential. Now covered with 3D seismic the Glenwood anomaly has been reinterpreted and mapped. Other methods, including AVO, AVO attributes, amplitude and structure maps and wavelet classification were utilised in order to enhance our understanding of this anomaly. This talk will outline our approach into the characterisation of the anomaly.

Introduction

The Glenwood prospect is positioned on license EL 1047 and is positioned north of White Rose and is situated just off the Outer Ridge in the northern Jeanne d'Arc Basin. (Fig. 1). The Glenwood prospect has a potential STOOIP of 328 mmbbls of oil or 3.1 TCF of gas. The seismic anomaly is interpreted to be a mid-Upper Cretaceous aged, submarine fan deposit. The trap is entirely stratigraphic. The top seal will be a deep-marine shale and with an up dip seal within the main feeder channel. The source rocks are deeply buried and will be gas prone or over mature under the license, but oil in nearby wells suggest the possibility of an oil case.

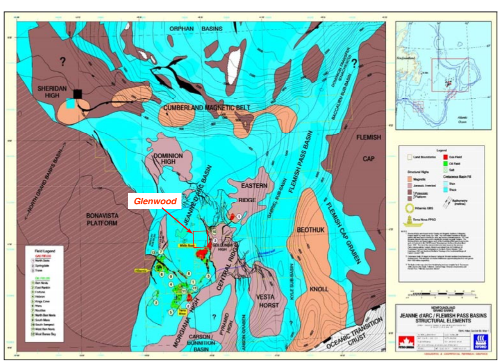

Figure 1: Location map of the Glenwood prospect.

Methodology

The first objective of this study was to review the regional petroleum geology of the Glenwood license using an integrated geological and geophysical approach. There are no wells drilled on the license, but several exist in the vicinity. These wells, plus all available internal and published data, were used in conjunction with the seismic database to formulate the evaluation. Most well data were obtained from the GSC 'Basins' database, available via the Internet.

Reservoir

In order to predict the likely reservoir parameters, potential analogue submarine fans from the North Sea were reviewed. The Glenwood fan is small (3-8kms) in length, and its seismic expression indicates a single package consisting of low-angle reflectors with rare clinoforms and poor internal character. The morphology is lobate, which may be channelised. These characteristics indicate a sand-rich fan (Reading & Richards, 1994). Such fans have high N/G (> 0.7), but are usually fairly thin (<100m). These types of fans may be deposited during highstands, due to shoreface reworking. The amplitude anomalies also suggest a sand model. If so, then Glenwood appears to be a close analogue to the Miller Field of the UK sector; data from Miller and other sources were used as reservoir input parameters for volumetric calculations.

Geophysical Interpretation

Initially the 1998 seismic amplitude anomaly was mapped on 2D data. New 3D seismic data confirmed the presence of this amplitude anomaly and enhanced our understanding of the geology, as a feeder system was evident up-dip of the previously interpreted crestal area.

The seismic anomaly was mapped at a centre of a trough (negative amplitude). The amplitude anomaly should correspond to an acoustic impedance drop, increasing the likelihood for having a porous rather than a calcite cemented sand.

The prospect is defined by a strong seismic amplitude anomaly, which maps out as a set of fan lobes, which occur at slightly different stratigraphic levels, with a maximum length of about 8kms. The top of the prospect, at the up dip seal location, lies at 3710m depth. It has a maximum thickness of about 70m and a combined area of about 130 km^2

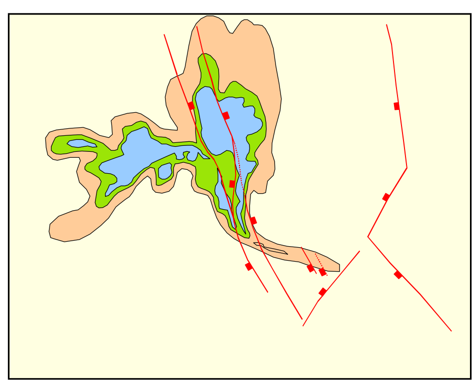

Figure 2: Outline of Glenwood fans.

The prospect is within a stratigraphic sequence not previously penetrated by wells, but seismic correlation strongly suggests the main reservoir lies between the top of the Ben Nevis Fm and the overlying Cenomanian unconformity, which means it is latest Albian to Early Cenomanian in age.

The geological age of the seismic anomaly was detained using regional seismic control. Tie lines from both North Ben Nevis and White Rose clearly indicate that the Glenwood prospect is located between the Ben Nevis Fm and the Cenomanian Unconformity. This suggests a Late Albian age for the submarine fan and confinement within the Nautilus Fm

Stratigraphically, the fan may be equivalent to the Eider Formation as seen in the Whale Basin, which is the first transgressive sand on the Aptian unconformity (McAlpine, 1990),

Inversion
A seismic inversion was done by CGG. The purpose of the seismic inversion was to substantiate the thickness modelling and to confirm an acoustic impedance drop for the Glenwood anomaly. An acoustic impedance drop was confirmed by the inversion. The thickness of the low acoustic impedance interval was determined by measuring the time and depth converted using a velocity of 3600 m/s. An isochore map was then contoured using the measured thickness and the amplitude map

AVO Modelling and Analysis
The main objective of the AVO analysis was to determine the AVO response from a potential reservoir at Glenwood. Both the modelling and AVO analysis where done by Veritas. Models where prepared to determine the theoretical response of a wet, oil and a gas filled reservoir. Based on the modelling results it should be possible to distinguish between a water and hydrocarbon filled reservoir, but to distinguish between gas and oil an absolute calibration point is needed.

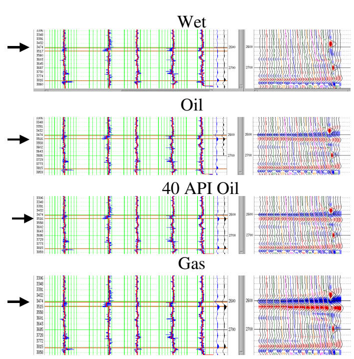

Figure 3: Models showing differences in expected response.

The AVO analysis consisted of two steps. First AVO attributes were determined. Secondly, inversion of two AVO attributes, the expected P-Wave and S-wave reflectivity were extracted. The results of the inversions were used to calculate rock properties. Rock property ($\lambda\rho$ incompressibility and $\mu\rho$ rigidity) and cross-plots were used to assess fluid content and lithology.

Cross-plots suggest low rigidity and incompressibility, which normally would be associated with shale or coal/tuff This is not compatible with the morphology of the low impedance anomaly. Later modeling performed by Veritas suggest that a high porosity sandstone (>12%) and hydrocarbon filled interval could explain the low rigidity/incompressibility and also the low amplitudes observed on the seismic.

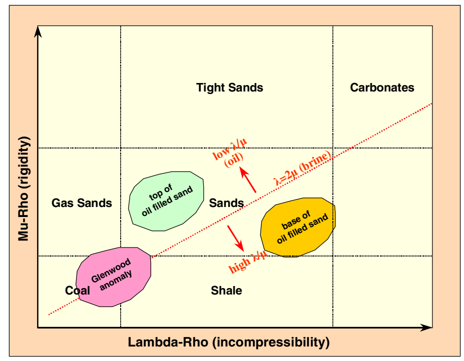

Figure 4: Lambda-Rho Vs Mu-Rho crossplots showing litholog.

From the above observations, there is a positive case for assuming a hydrocarbon filled reservoir in the Glenwood prospect. However, the AVO attributes are closely associated with the outline of the amplitude anomaly and no DHI's are obvious on the seismic data. Leading us to two conclusions, first that the AVO is being influenced more by the porosity that the presence of Hydrocarbon or the reservoir is completely filled.

Depth Conversion
The methodology that was chosen for depth conversion was the application of a linear velocity model down to Base Tertiary and then a second velocity function from Base Tertiary to the character anomaly.

The second velocity model down to the Glenwood anomaly proved to be difficult. Stacking velocities and linear velocity function both gave unrealistic velocities for the interval. A velocity function based on the Base Tertiary to A Marker (or equivalent) interval for all wells in the Jeanne d'Arc Basin was therefore chosen. The resulting interval velocity map shows a slight increase in velocity versus time to the anomaly.

Acknowledgements
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