FUGRO SEISMIC IMAGING PTY LTD

AVO ANALYSIS REPORT
FOR
GREAT SOUTH LAND MINERALS

Location : Tasmania
Permit : SEL 13/98
Surveys : 2001 and 2006 Tasmanian Seismic Surveys

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Fugro Seismic Imaging Pty Ltd
69 Outram Street
West Perth WA 6005

Tel: +61 (0)8 9322 2490
Fax: +61 (0)8 9481 6721
E-mail: info@fugro-fsi.com.au

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1 INTRODUCTION

Fugro Seismic Imaging was requested to undertake AVO analysis of three lines from the Tasmania Basin area. Two of the lines were from the 2001 survey, whilst a third was from the 2006 survey. The 2001 lines were reprocessed from field tape uisng the same parameters as previously. The 2006 line was taken directly from DMO CDP gathers.

Line	CDP Range
TB02-BA	2300-3000
TB01-PB	5650-6350
TB01-TD	1-600

Personnel

Fugro Seismic Imaging Pty Ltd
Mark Brailey Land Processing Manager

GSLM
Diego Gonzalez Geologist

2 BACKGROUND

It is known that reflection coefficient at an interface varies with angle of incidence. The Poisson's Ratio of the strata either side of the interface affects the way in which the reflection coefficient varies. A low Poisson's Ratio sand will result in an increase in reflection coefficient or amplitude with angle of incidence.

Fugro Seismic Imaging (F.S.I.) AVO analysis is applied using the Shuey Approximation. A velocity function is used to calculate the angle of incidence at each layer boundary and then interpolated to produce the angle of incidence at each time sample and offset. A robust linear regression is used to calculate the intercept and gradient of the amplitudes at each time sample (Walden, 1991). Four types of attributes are routinely produced from this analysis; Intercept, Gradient, Product (Intercept times Gradient) and Delta Rp (based on cross-plotting intercept and gradient), but many others are possible.

Delta Rp

This method is based on the concept of cross plotting AVO measurements. Data input to the cross plot are Rp (or Intercept) and the Gradient measurement from the seismic gathers. The F.S.I. algorithm calculates a lithological trend from the Rp and Gradient data. This trend represents the average response of brine-filled rocks in the analysis window. Unusual rocks, like gas-filled sands are displaced from this wet trend. The Delta Rp calculation is the reflectivity separation between a data point with anomalous reflectivity and the trend. The top of a class III hydrocarbon saturated sand unit is displayed as a trough, whereas the base is a peak. All anomalous points to the left of the lithological trend in the cross-plot are negative numbers (trough) while all anomalous points to the right of the lithological trend are positive (peak).

Intercept , Gradient and Product

I represents intercept, which is the zero offset reflection coefficient and G represents gradient, which is essentially the change in amplitude with offset at any particular time sample within a CDP gather. The product of these two attributes tends to give the largest anomalies at the top and base of gas sands with low acoustic impedance (class III). This normally serves to highlight events in the CDP gather with either high intercepts, high gradients, or both. The calculation uses the sign of both the intercept and gradient as the sign of the product is used in the interpretation of the results.

3 PROCESSING SEQUENCE DIAGRAM

FROM DMO GATHERS
|
DESPIKE
|
NMO CORRECTION
|
MUTE
|
F-K FILTER
|
OSTRANDER MIX
|
SCALING
|
FLOATING DATUM TO FINAL DATUM
|
AVO ANALYSIS

4 PROCESSING SEQUENCE

This sequence details the additional processing required to condition the gathers prior to AVO analysis. While the 2001 lines were processed from field tape only post-DMO processes are mentioned below.

4.1 DESPIKE

Automatic trace editing was used to down-weight spiking data based on peak-to-median ratios and standard deviations within user specified windows.

4.2 NMO CORRECTION

Dix fourth order NMO correction was performed using the final velocity functions.

4.3 MUTE

A post NMO outer trace mute was applied to remove any coherent noise on the outer traces and to reduce contamination from the effect of NMO stretch on the far offsets.

4.4 F-K FILTER

An F-K filter was applied to the CDP gathers to remove dipping noise using a 5 ms/trace cut.

4.5 OSTRANDER MIX

A 1-2-1 mix of the data was applied in the offset and CDP domains.

4.6 SCALING

A 1000 ms AGC was applied to the gather traces to compensate for amplitude irregularities.

4.7 STATICS

Floating datum to final seismic reference component of the statics was applied prior to stack. This corrects the data from floating datum to a final datum at sea level. New time origin: -500 ms (TB02-BA) and -700 ms (TB01-PB and TB01-TD)

4.8 AVO ANALYSIS

Four AVO attributes were produced; intercept, gradient, product and Delta Rp stacks. The analysis was conducted over 0 to 30 degrees. A typical angle of incidence distribution from line TB01-TD can be seen below (where every division equates to 5 degrees).

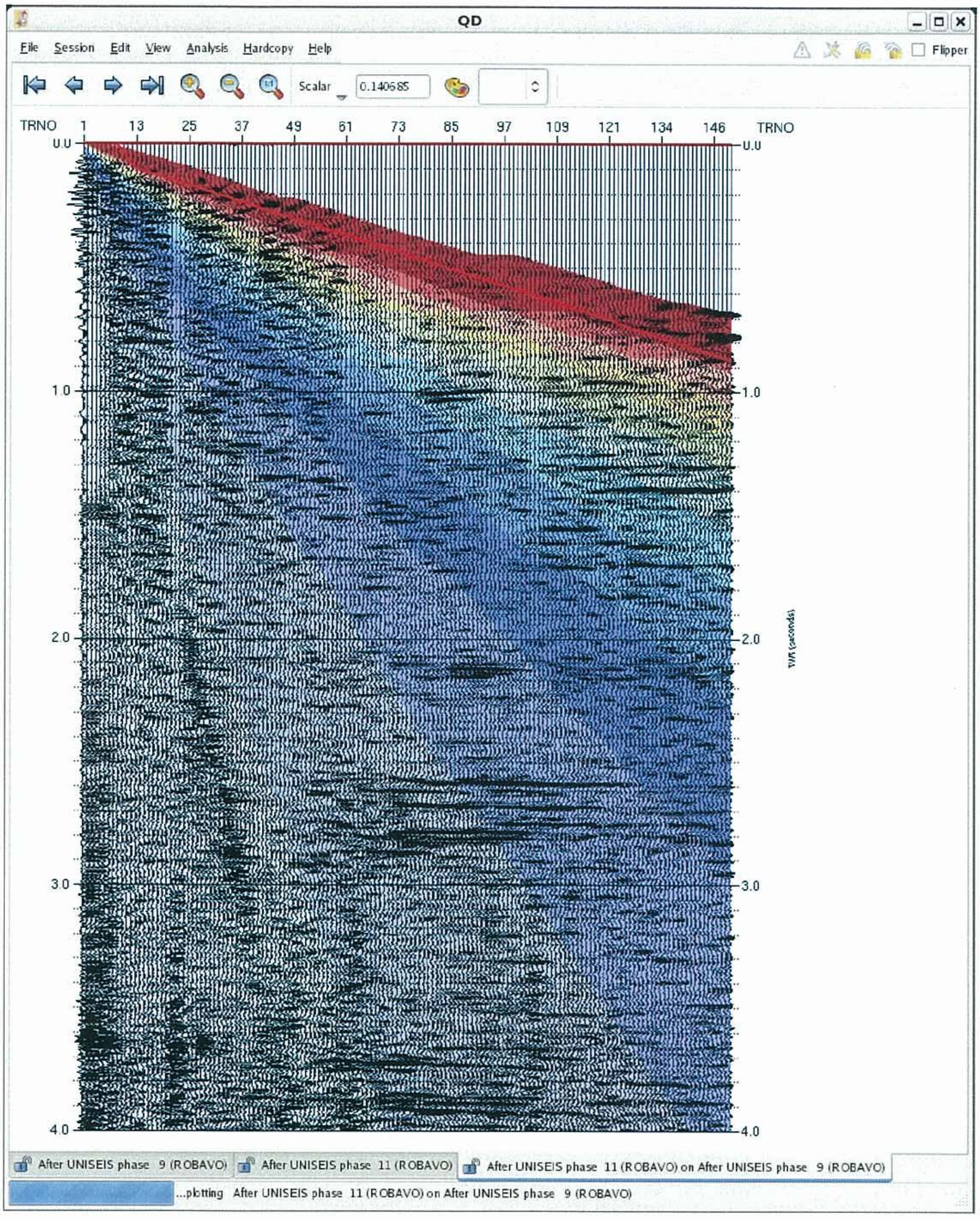


Figure 1 : Line TB01-TD typical angle of incidence overlaying CDP gather.

5 OBSERVATIONS

Line TB01-PB:

On this line various flat spots were visible on the final migration. The gradient stack highlights much of the region exhibiting these flat spots, so much that it is difficult to identify the truly anomalous areas.. However, some of the stronger gradient responses also coincide with a strong intercept, Delta Rp and product stack anomaly. eg CDP 5960 at 1800 ms. The Delta Rp response of the upper anomalies (around 1700-1900 ms) are stonger than those below (2100-2400 ms). The product stack contains anomlies but not of the expected polarity for a typical low inpedance gas sand, which would be distinguished by a strong red (positive value) at both the top and base of the sand. On the CDP gather at 5960 the reason for the anomalous behaviour at 1800 ms is clear. But the manner of amplitude change with offset is not consistent.

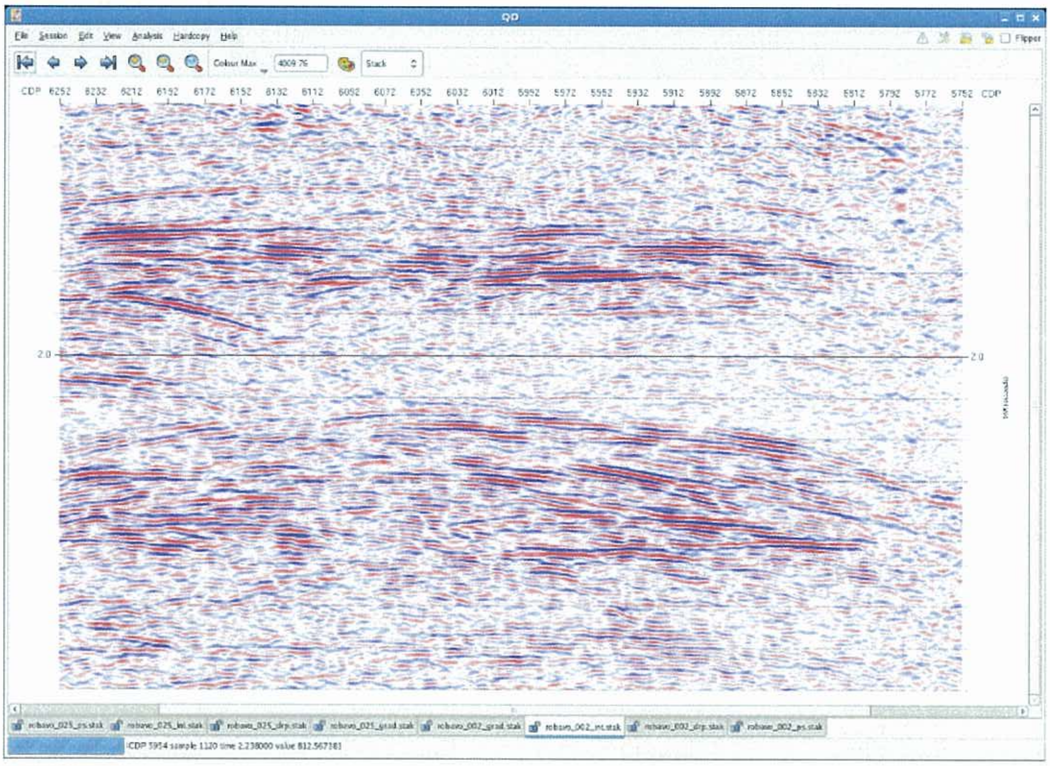


Figure 2 : Line TB01-PB Intercept stack.

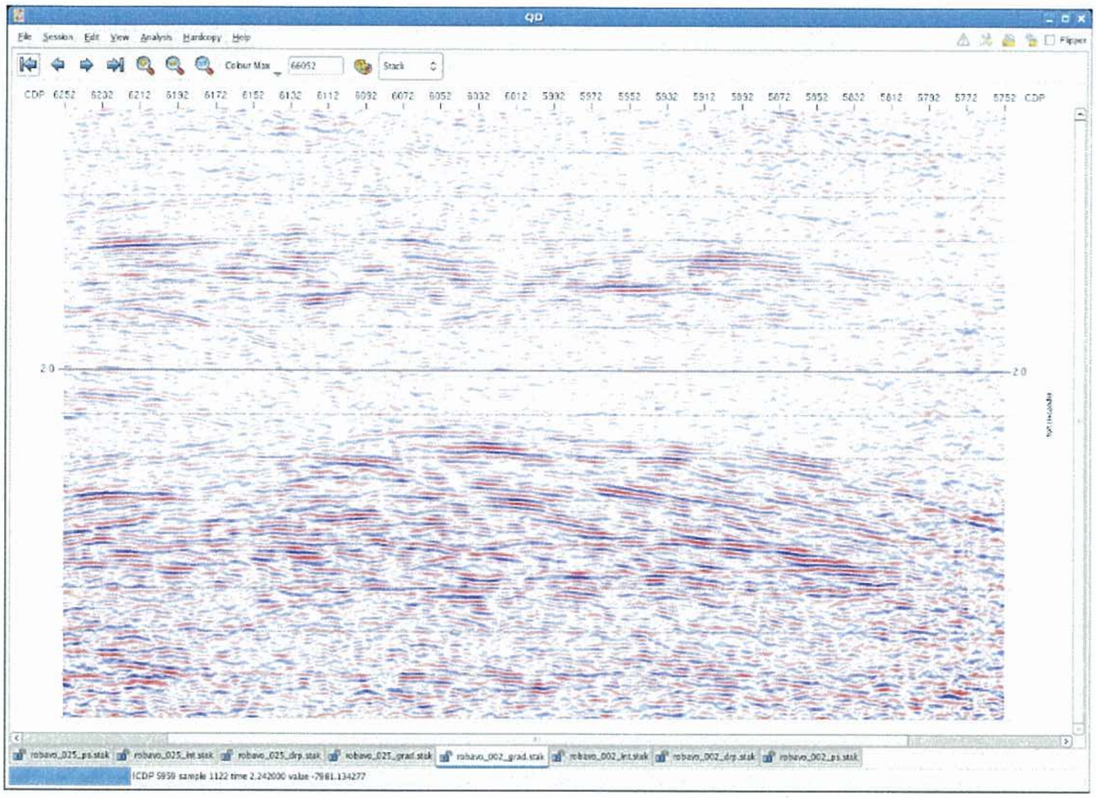


Figure 3 : Line TB01-PB Gradient stack.

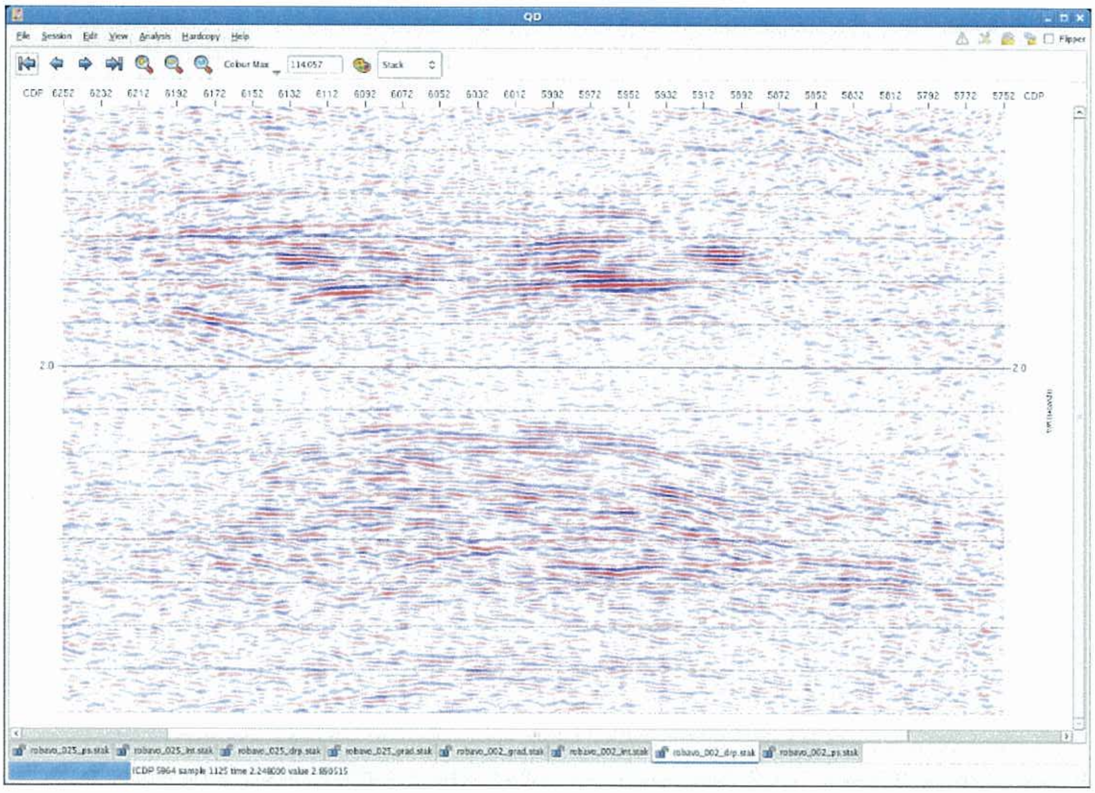


Figure 4 : Line TB01-PB Delta Rp stack.

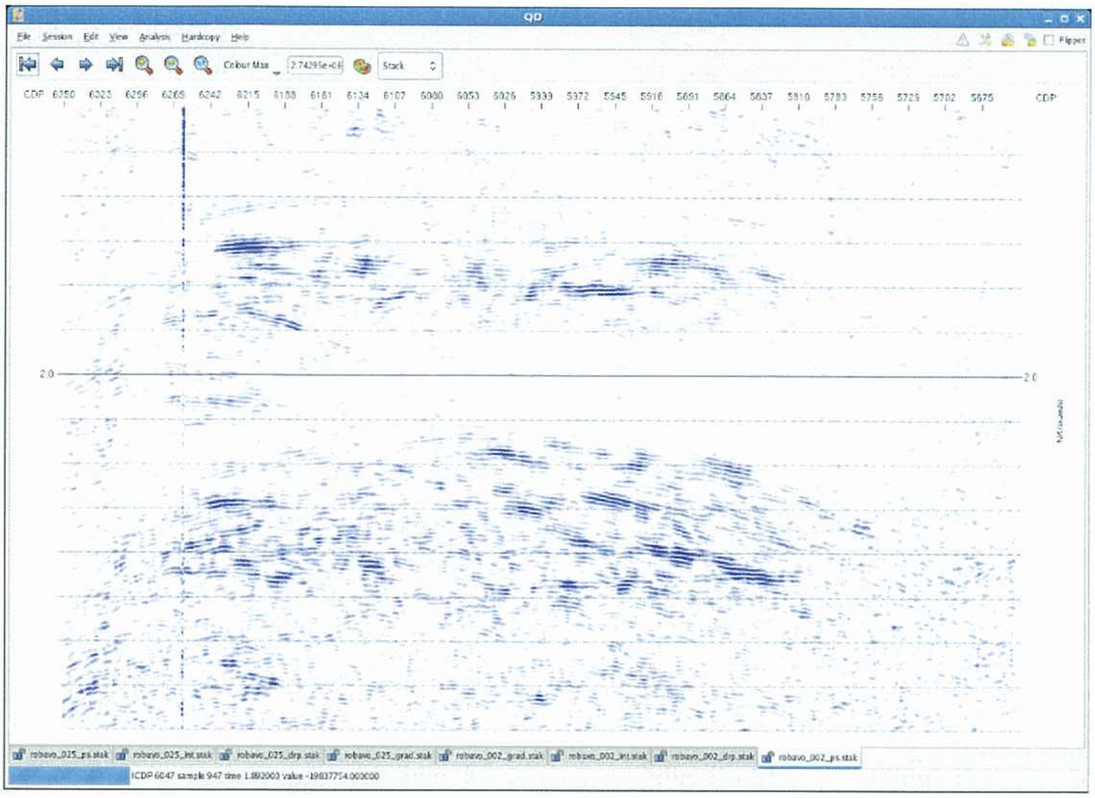


Figure 5 : Line TB01-PB Product stack.

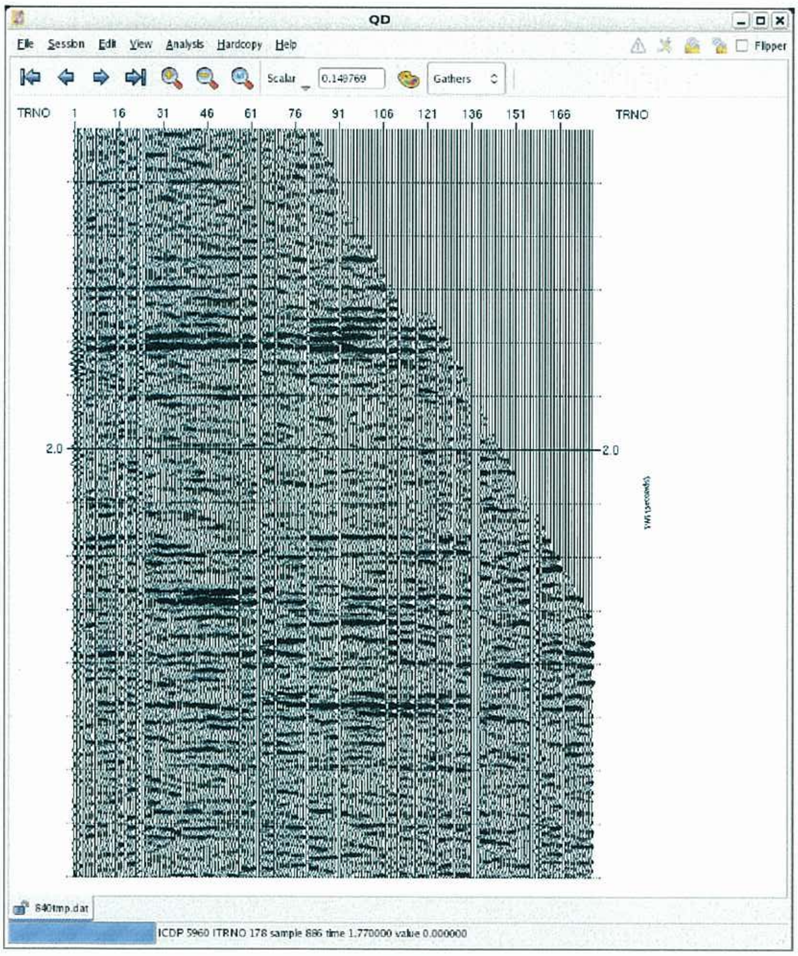


Figure 6 : Line TB01-PB CDP gather 5960.

Line TB01-TD:

Note that only CDP 100-600 have been included due to the noise introduced as the fold drops towards the end of the line. Even at CDP 100 some higher ampltiudes are visible which are associated with this noise. The noisy vertical bands are also caused by CDPs with lower fold. The gradient stack shows a strongly anomalous zone at about 2900-3000 ms. This corresponds to the strong blue events on the product stack. The Delta Rp stack doesn't really corroborate the gradient anomaly except at the very highest part of the anomaly (approx CDP 200). If anything the Delta Rp suggests that further up-dip of this event is more anomalous. There is also a strong Delta Rp response at 2400 ms. But the CDP gather (CDP 135) at this time is not convincing. On other CDP gathers (100 and 185) the reason for the high gradient response is event with high amplitudes coming out at the far offsets.

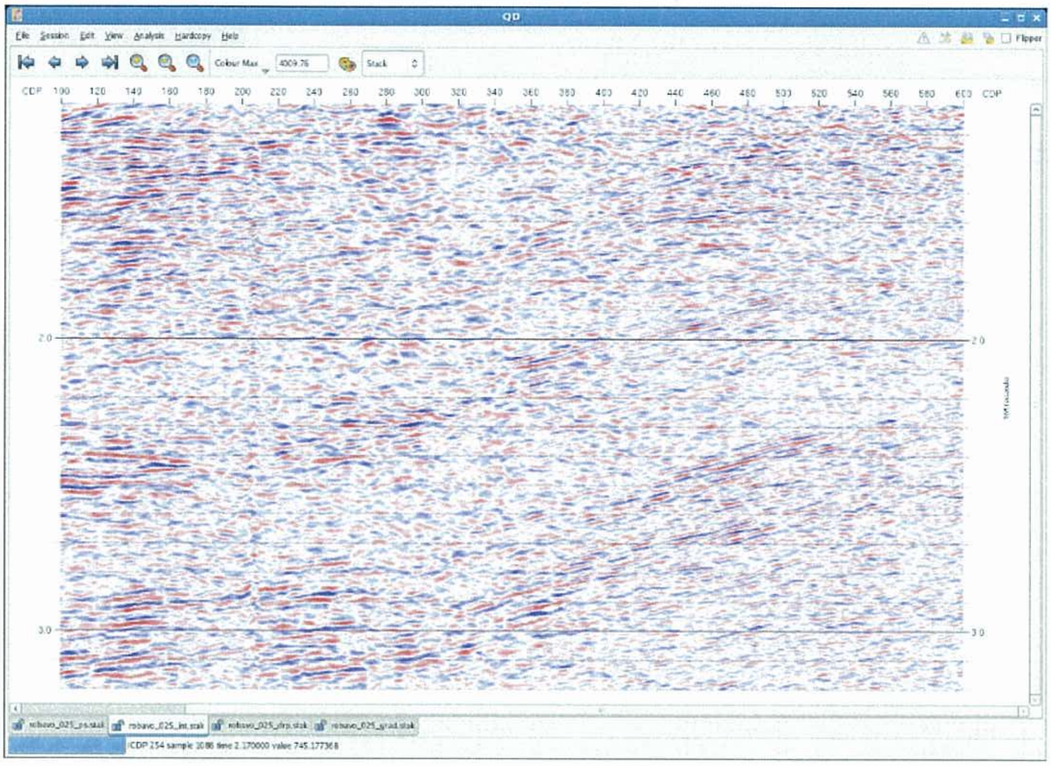


Figure 7 : Line TB01-TD Intercept Stack

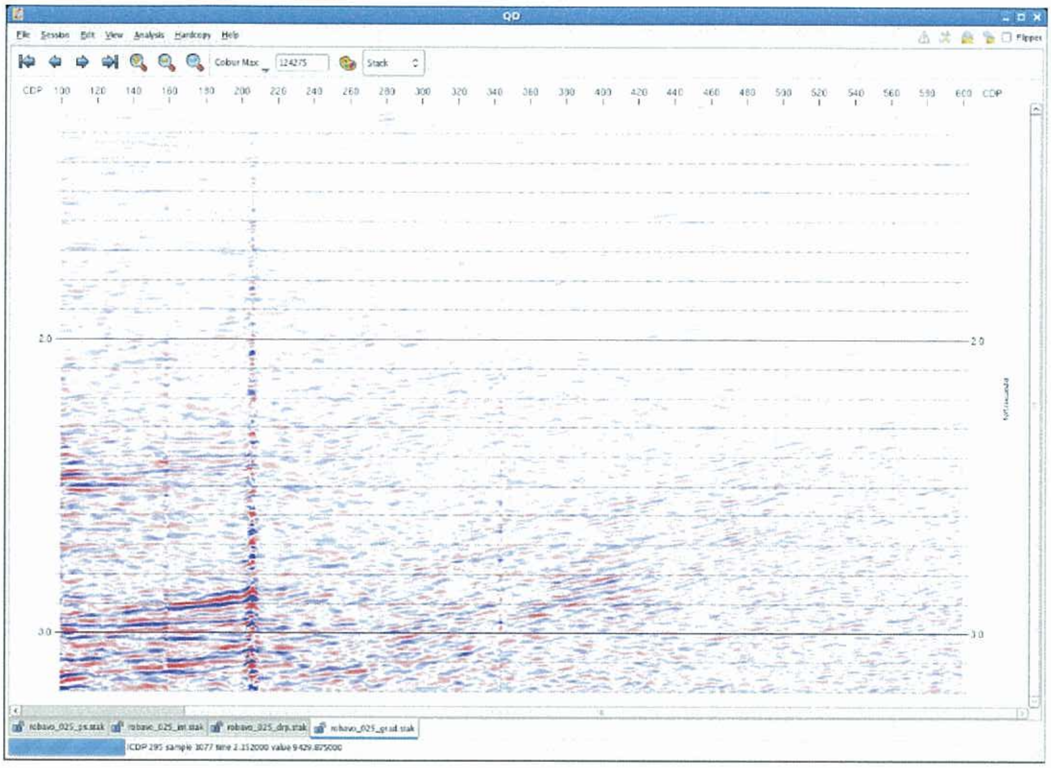


Figure 8 : Line TB01-TD Gradient stack.

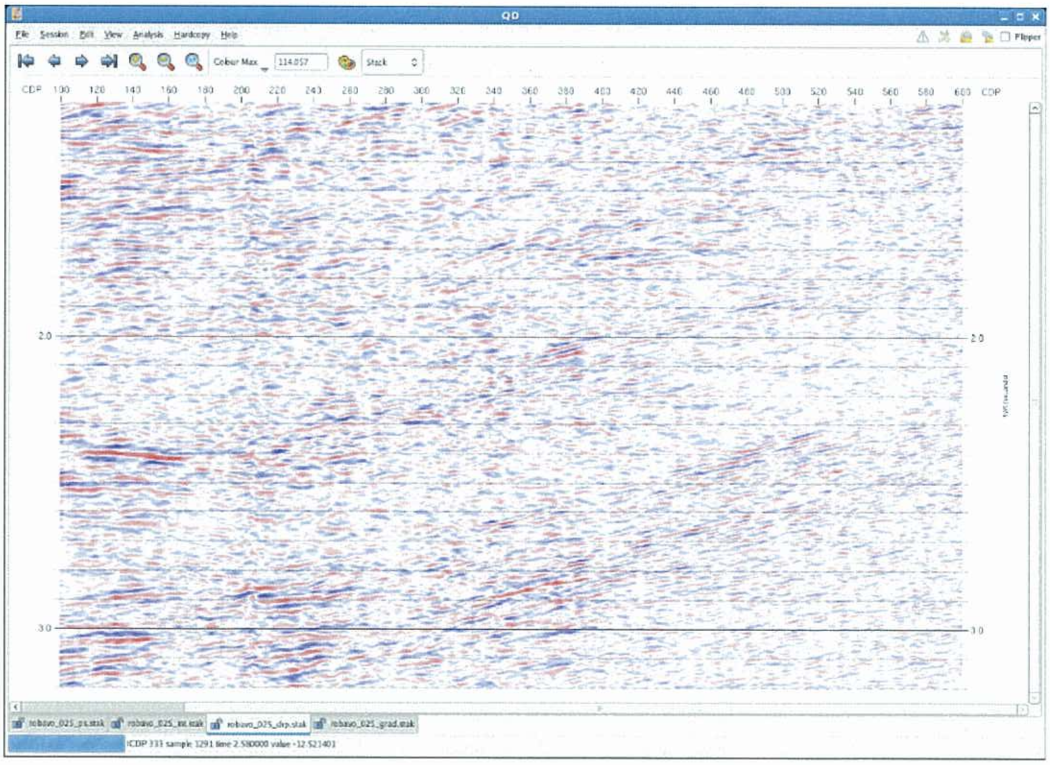


Figure 9 : Line TB01-TD Delta Rp stack.

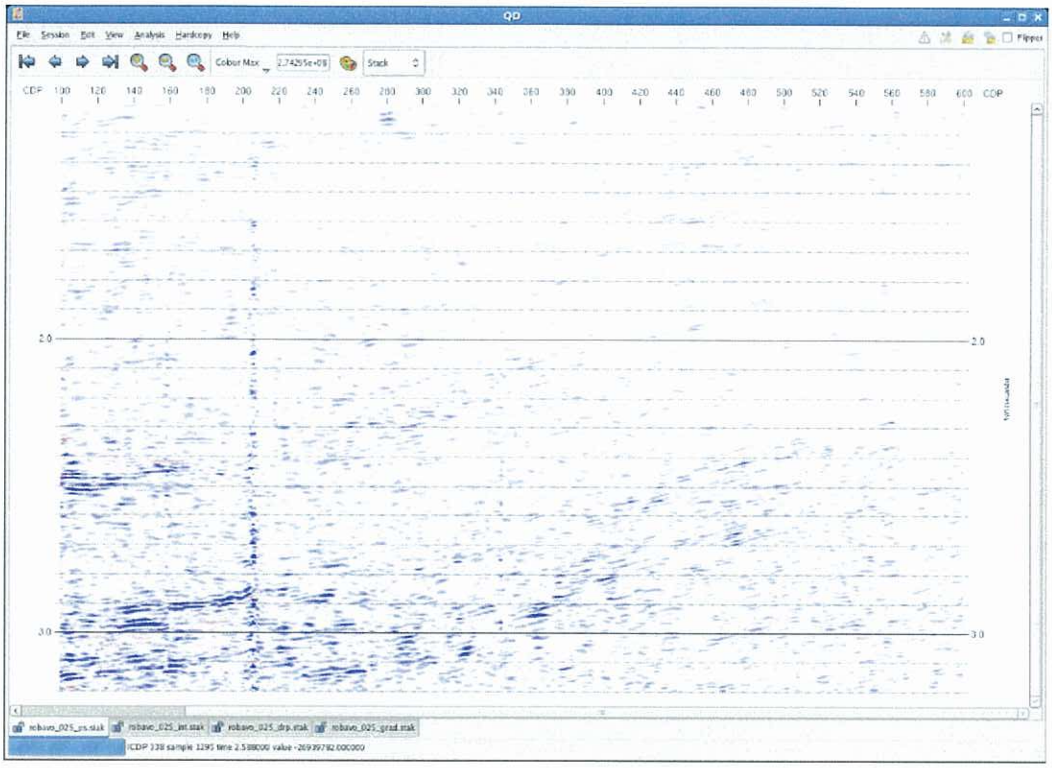


Figure 10 : Line TB01-TD Product stack.

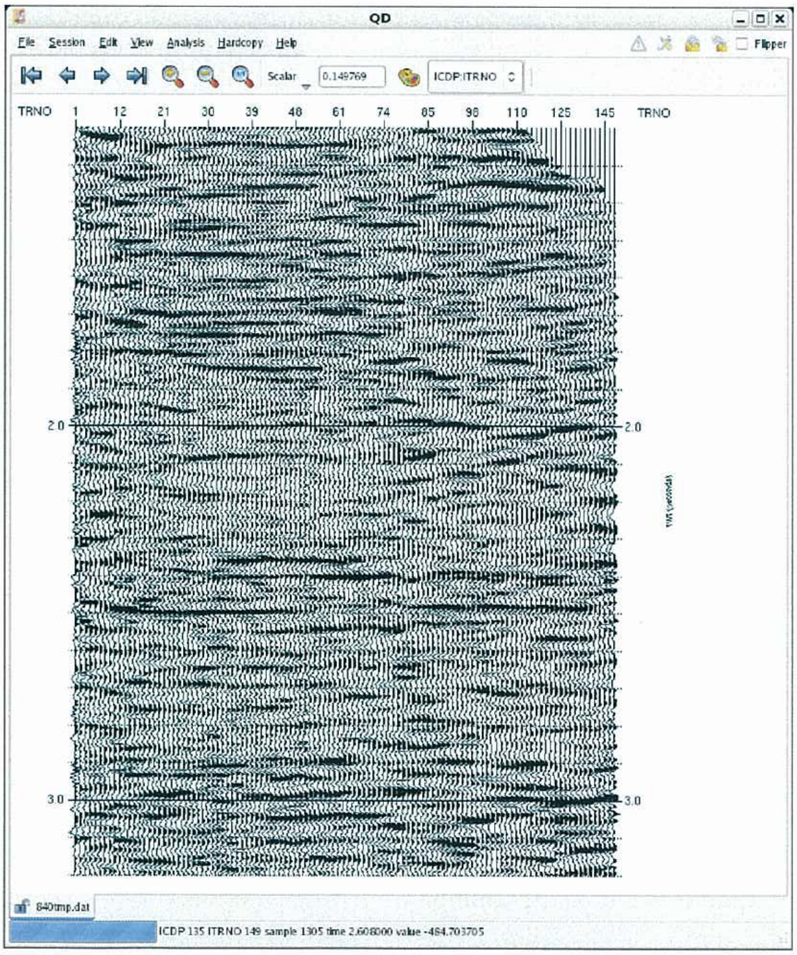


Figure 11 : Line TB01-TD CDP gather 135.

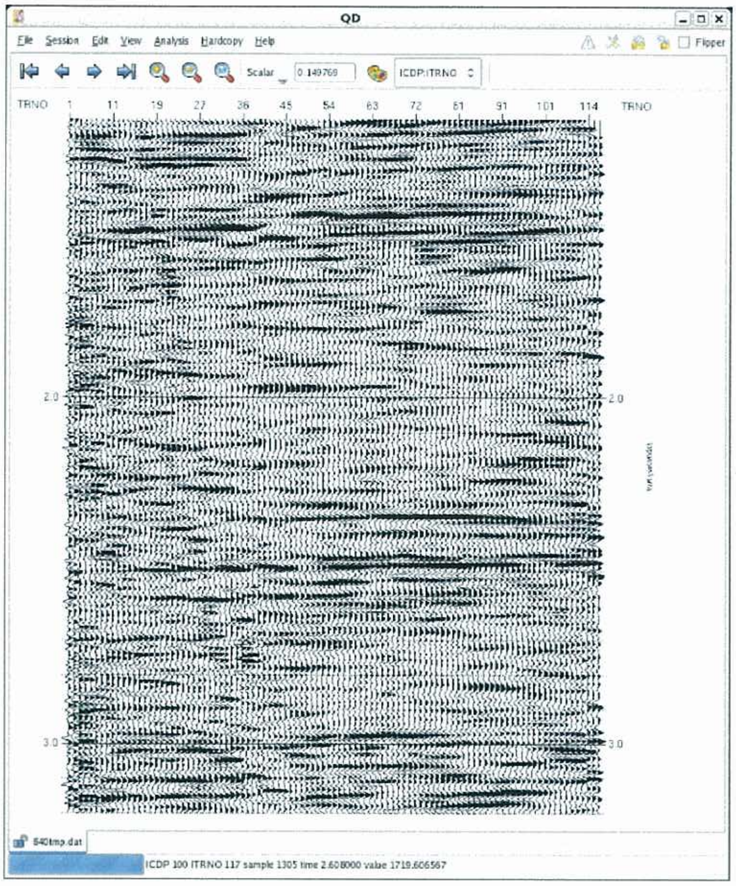


Figure 12 : Line TB01-TD CDP gather 100.

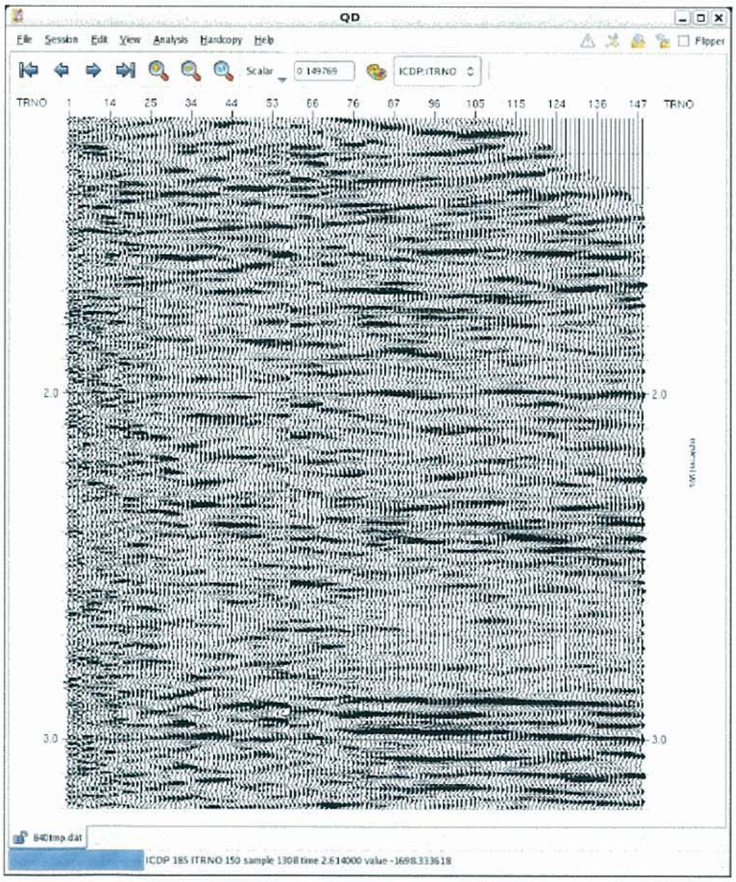


Figure 13 : Line TB01-TD CDP gather 185.

Line TB02-BA:

The gradient stack below suggests some minor local anomalies around the top of the main structure at about 1100 ms. In particular at CDP 2560 1070 ms there is a Gradient and Product stack anomaly which corresponds to an event on the CDP gather displaying a minor amplitude effect. The Delta Rp is effectively silent and the Product stack shows the same response as on the other lines.

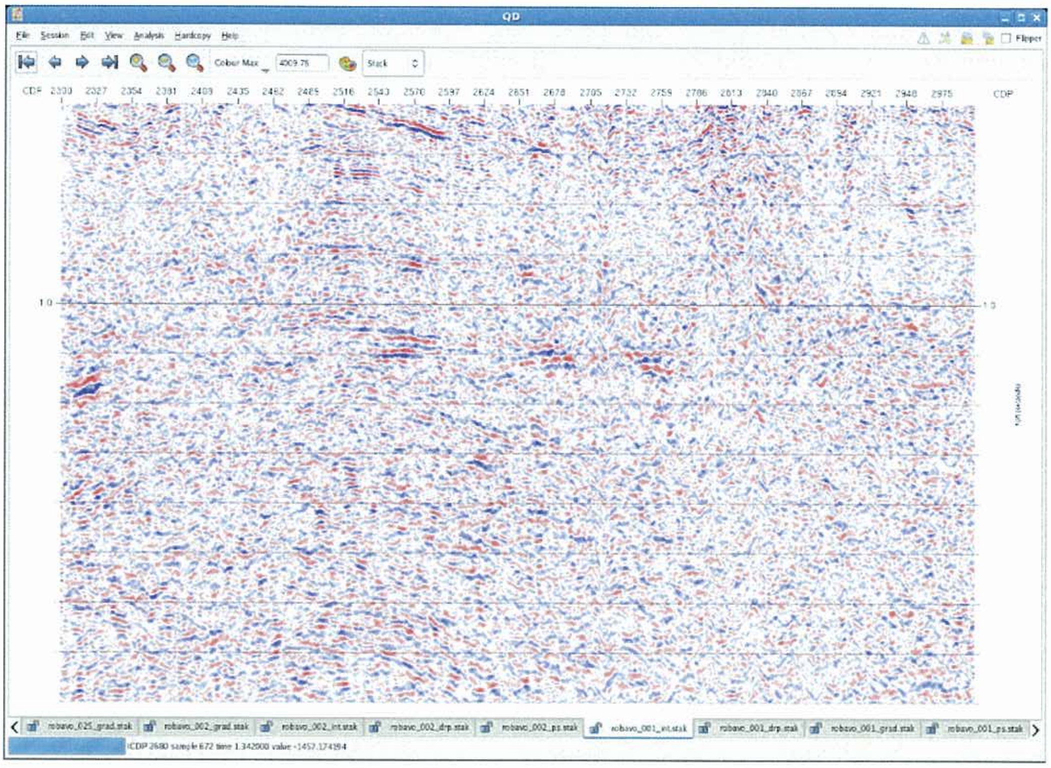


Figure 14 : Line TB02-BA Intercept stack.

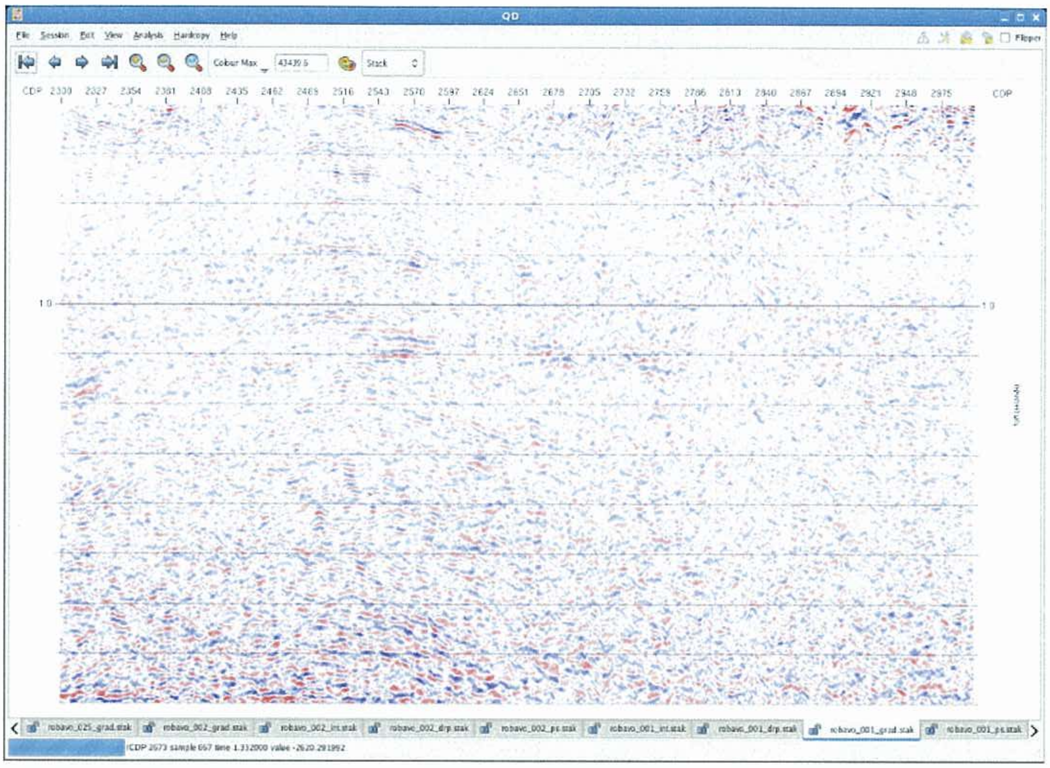


Figure 15 : Line TB02-BA Gradient stack.

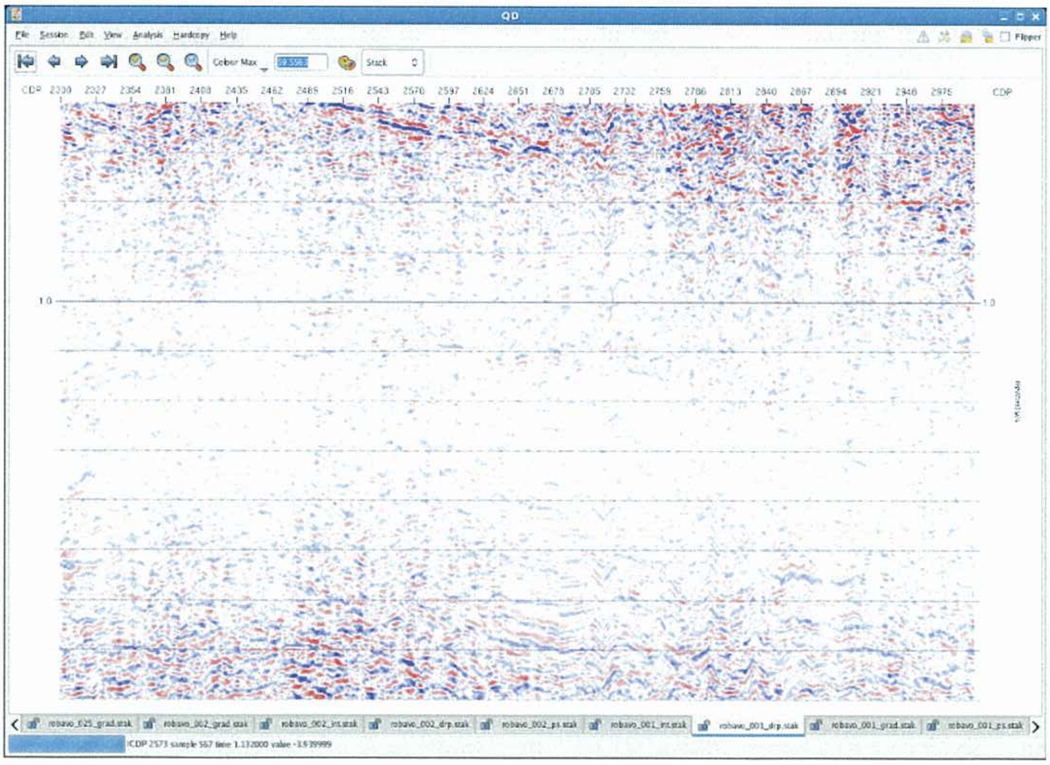


Figure 16 : Line TB02-BA Delta Rp stack.

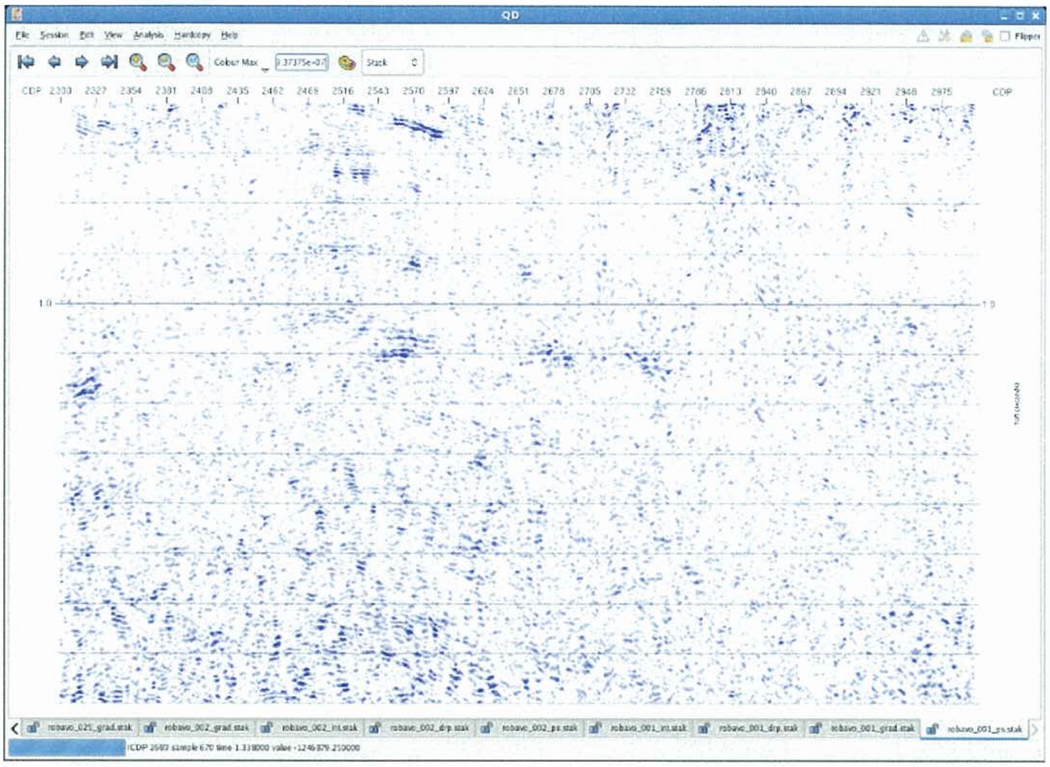


Figure 17 : Line TB02-BA Product stack.

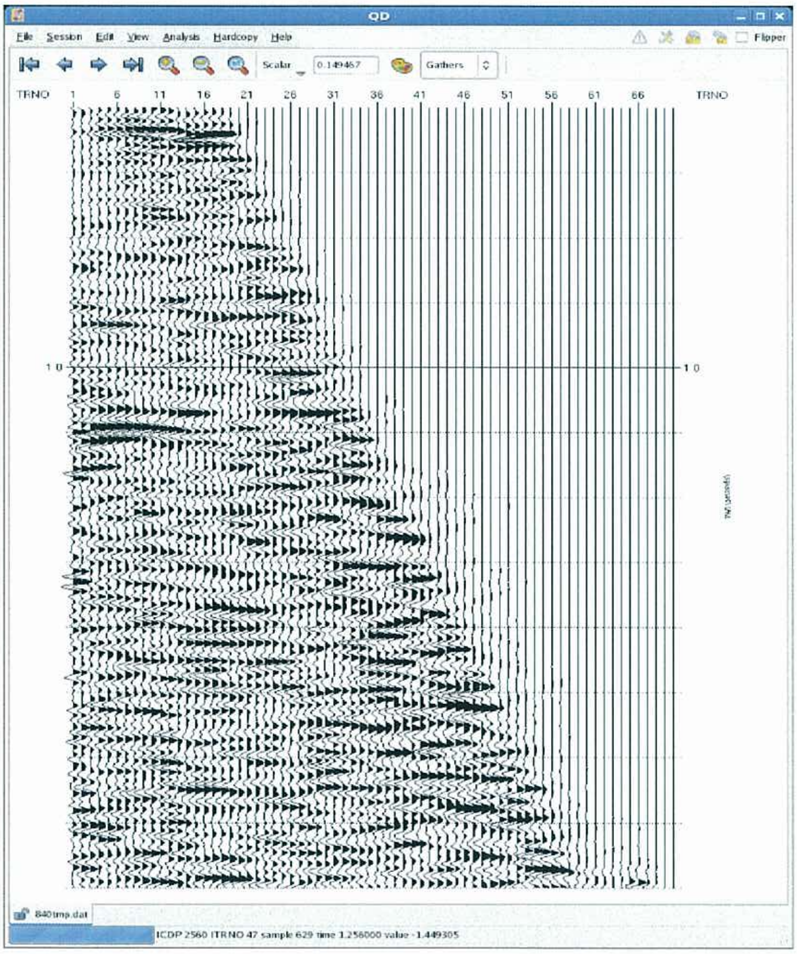


Figure 18 : Line TB02-BA CDP gather 2560.

6 COMMENTS

As we are dealing with pre-stack data we must do without the noise attenuating power of the stack, along with any post-stack noise attenuation. As the input gathers have only DMO applied we must also make do without the focusing of energy via migration. The CDP gather conditioning prior to AVO analysis is essentially designed to address some of these concerns by improving the signal-to-noise ratio.

Due to the lack of well information:

1) we cannot confirm the polarity of the data.
2) we cannot determine the expected AVO response (ie. calibrate the AVO).

Note that the timing (TWT) on all displays assume the time of first sample is 0 ms. Dependng on which line is being considered this might compare to -500ms (TB02-BA) or -700 ms (TB01-PB,TD).

The gradient stack has been the most useful attribute for highlighting anomalous zones. However, it cannot be used in isolation. It has been shown on gathers that sometimes the reason for the high gradient is not valid. When considered in combination with the other attributes and gathers more credibility can be asigned to the anomaly. The product stack did not provide any typical low impedance gas sand anomalies. But then this is a limestone reserevoir, overlain by sandstone and siltstone. Without any well log data it is difficult to ascertain for sure, but the reservoir is perhaps more likely to be high impedance (hard sand). In this case the product stack is not indicative. The Delta Rp stack has supported other attributes and provided alternative anomalies.

While the AVO analysis has highlighted some anomalous areas not a great deal can be concluded about the nature of these anomalies. With so little detailed geological information available it is impossible to determine the expected response from a particular horizon and very difficult to reliably interpret any results. I suggest that any future AVO analysis needs to be more targeted and involve logged well data.

7 APPENDIX I – DELTA Rp

AN AVO INTERPRETATION PROCESS BASED ON Rp AND GRADIENT CROSSPLOTS

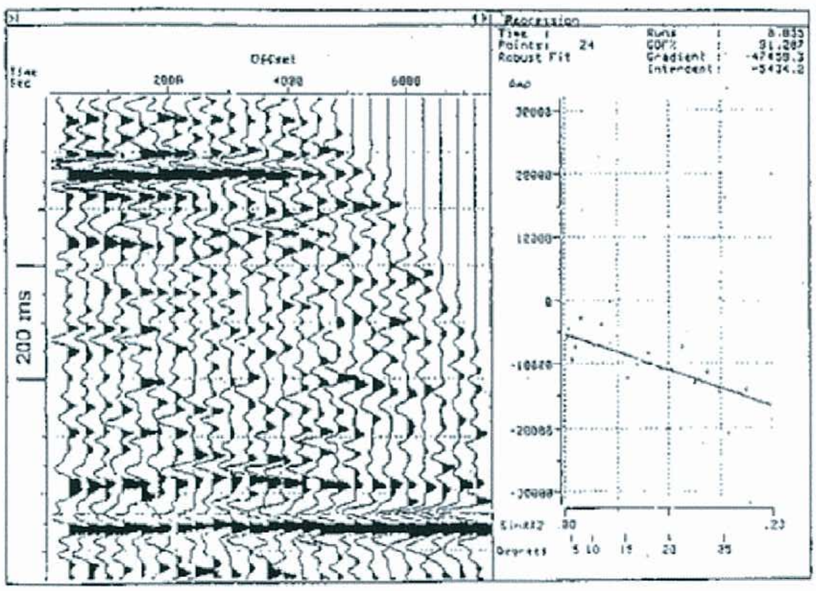
THE CONCEPT

F.S.I. has developed a method of AVO Analysis that is based on the concept of crossplotting AVO measurements. Data input to the cross plot are Rp (often called intercept) and the Gradient measurement from seismic gathers. The F.S.I. algorithm calculates a lithological trend from the Rp and Gradient data. This trend is the response of brine-filled rocks in the analysis window. Unusual rocks, like gas-filled sands are displaced from this wet trend. The ΔRp calculation is the reflectivity separation between a data point with anomalous reflectivity and the trend.

With calibration the method serves to identify lithology or fluid content.

THE MEASUREMENT

F.S.I. has designed a seismic processing flow to optimize the quality of gathers input to AVO analysis. This processing flow includes pre-stack migration. The Rp (intercept) and Gradient are calculated for each time sample using F.S.I.'s Robust Least Squares fitting technique. This allows statistical control in the measurement. The procedure is based on the Shuey hypothesis.



amplitude (theta) = Rp + gradient sin ^2(theta)

intercept = Rp

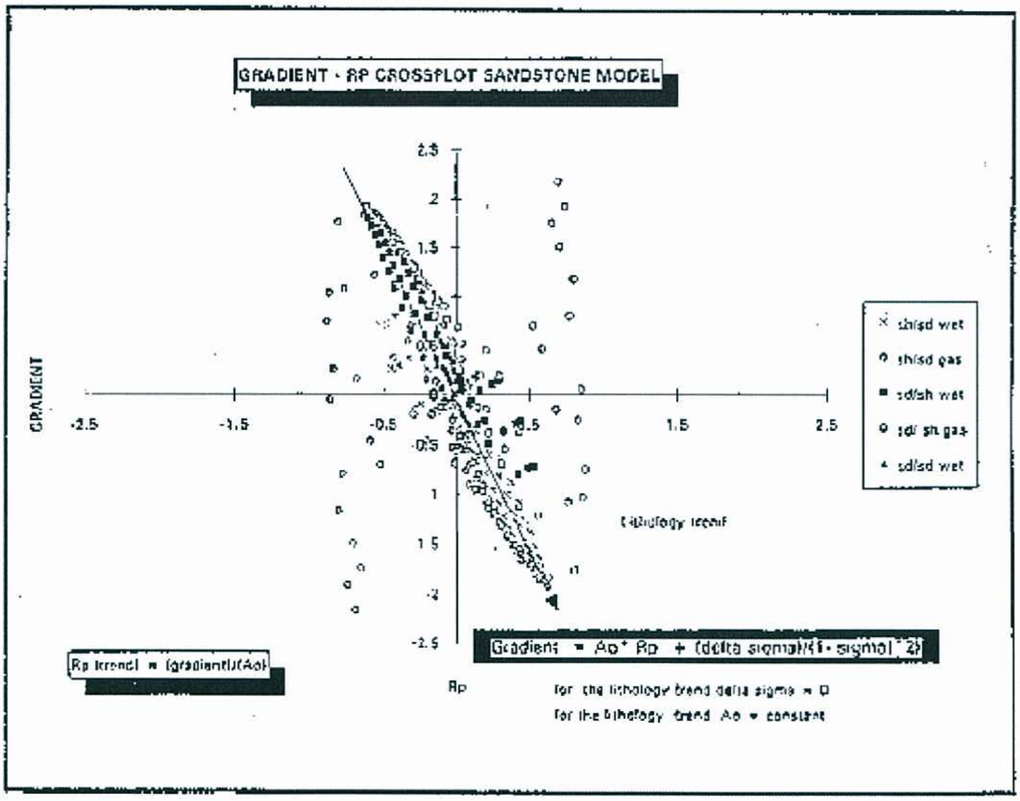
slope = gradient

ROCK PROPERTIES – THE BRINE-FILLED LITHOLOGICAL TREND

Analysis of crossplots of Rp and Gradient from seismic traces, well logs and theoretical data reveal a trend in the data points. A crossplot based on a model of sandstone encased in shale serves to illustrate this idea. The shales range from 5,000 to 12,000 ft/sec, brine and gas sands range between 3 and 40% porosity. This model is supplemented by brine-sand to brine-sand interfaces with a 3% porosity contrast. The crossplot of this model exhibits a negative trend for the brine-sands that is similar to that of logs and seismic traces. This lithological trend supplies a relationship between brine-filled Rp and Gradient that is useful for AVO studies.

The lithological trend of brine-filled rocks in a study interval is related to the gradient defined in the AVO equations. The average change in Poisson's ratio for the brine-filled lithologic trend is zero, while the (Ao) term of the Shuey gradient expression is a constant. The ΔRp measurement is based on the derivation of this brine-filled lithologic trend.

The F.S.I. AVO algorithm calculates the brine-filled lithologic trend for each seismic trace within design gates that vary spatially and in time. ΔRp is the difference in amplitude between the actual reflectivity and the brine-filled lithological trend. The model data crossplot illustrates the natural separation of gas and brine-filled sands.



8 APPENDIX II – AVO CLASSIFICATIONS