

AVO Review of Near Top Eastern View

A review of the AVO characteristics
of the Near Top Upper Eastern View
Group

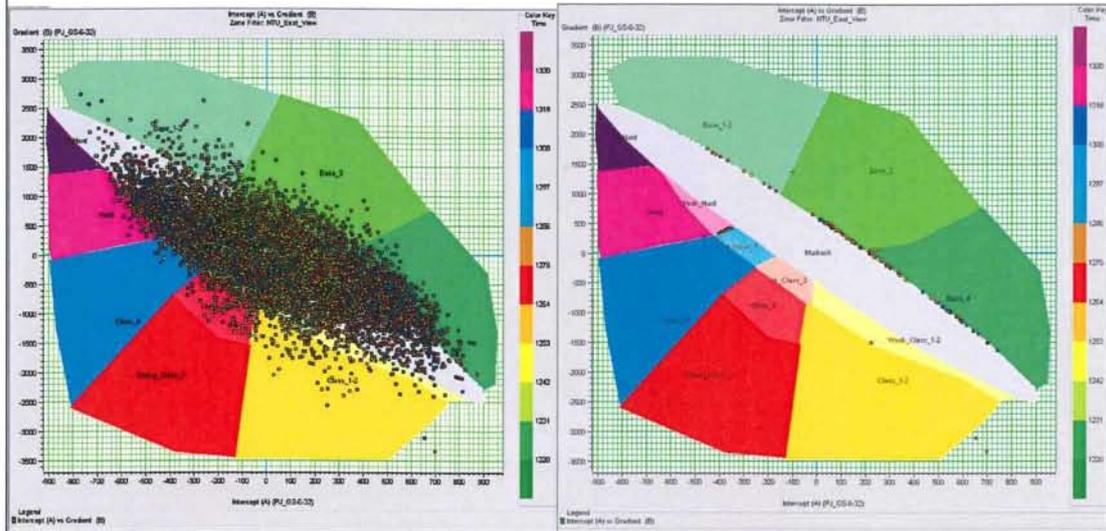


Makaira Geotechnical P/L

While the phase of this initial work hasn't been calibrated by well tie, the data is presenting as a minimum phase dataset with some similarities to a delayed SEG zero phase wavelet with more energy in the leading trough.

Initially a very near offset stack was performed to review potential energy losses due to shallow volcanics, and then the AVO characteristics of the supplied "Near Top Eastern View Group" horizon were examined.

The following Intercept Gradient Cross-Plot analysis shows this horizon to present as a soft sand w.r.t. the adjacent shales and showing a high degree of rotation of the mudrock line - presumably due to high porosity.

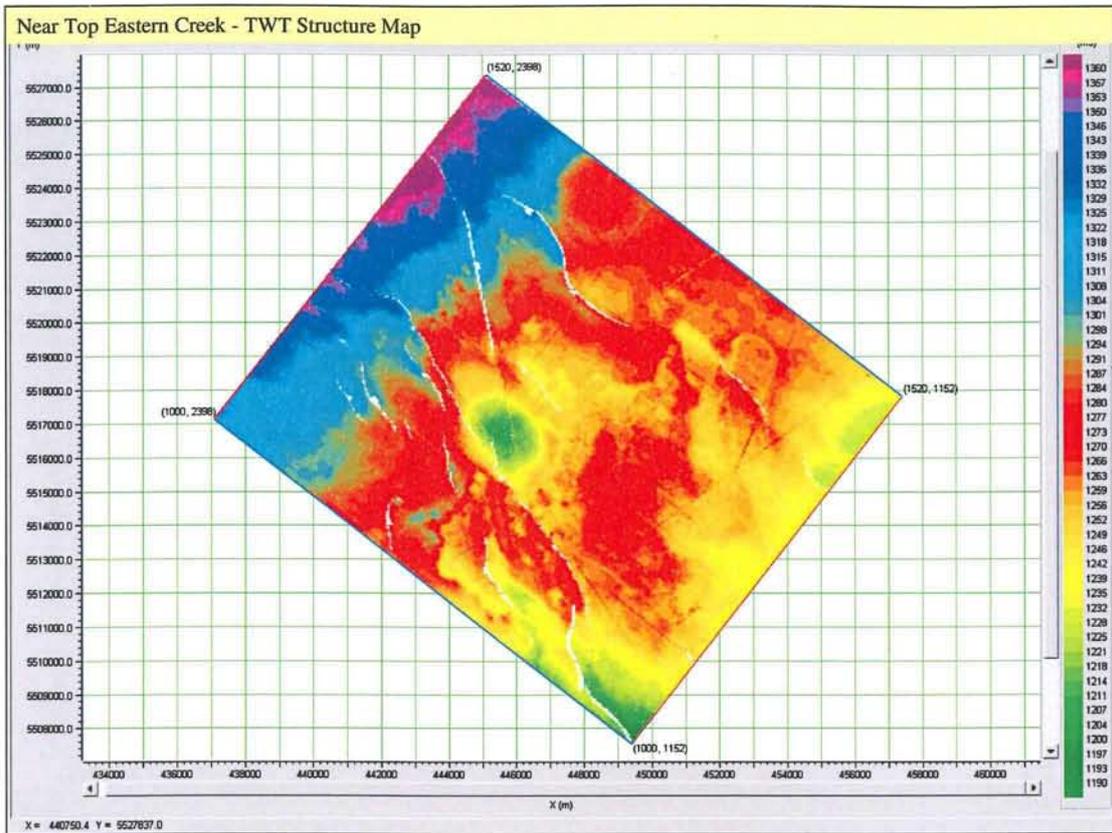


Here's the largest "leap of faith" in this work, that the phase and polarity of the data has been properly maintained in processing and the data is really "undisturbed" polarity. This is impossible to calibrate properly without a good well tie. We are reliant on PGS processing report to be a correct and complete summary of the processing applied to the data w.r.t. polarity and phase.

If that is the case and the data is really Minimum phase and the cable and source ghosts are still in the data - then we can progress in confidence.

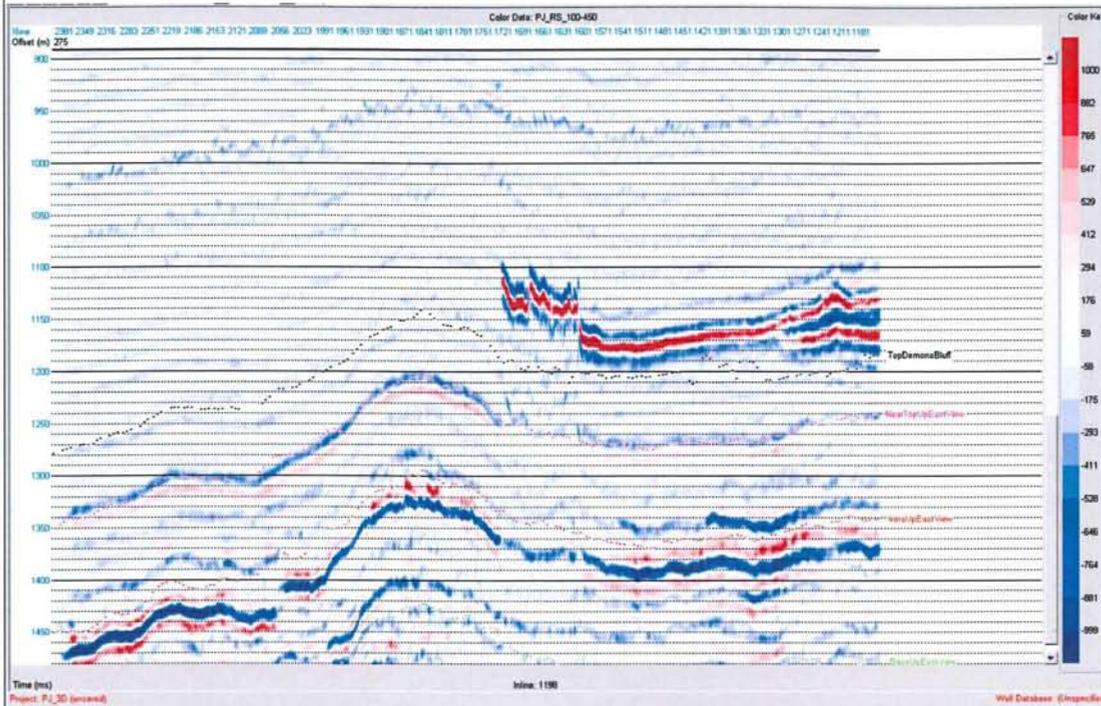
This colour scheme and the underlying concept of Intercept vs Gradient cross plot is important in AVO work. Given SEG polarity standards (and using the USA polarity convention) that would result from PGS processing flow, an analysis of the change of amplitude at a given time along a NMO'd gather allows us to calculate the Gradient (rate of change of amplitude with offset) and Intercept (Amplitude at the given time at zero offset).

If the lithology and seismic remain constant at a boundary interface, a change in fluid type from Brine to Oil or Gas (or other fluid combination with reduced bulk modulus and Density) would result in a negative shift in both Intercept and Gradient at the resulting reflection event that results from the top interface of the layer being analysed and positive change at the base (although this boundary may not be so sharp - depending in the character of the transition between fluids).



This is the “event of interest” as provided by Benaris interpreters.

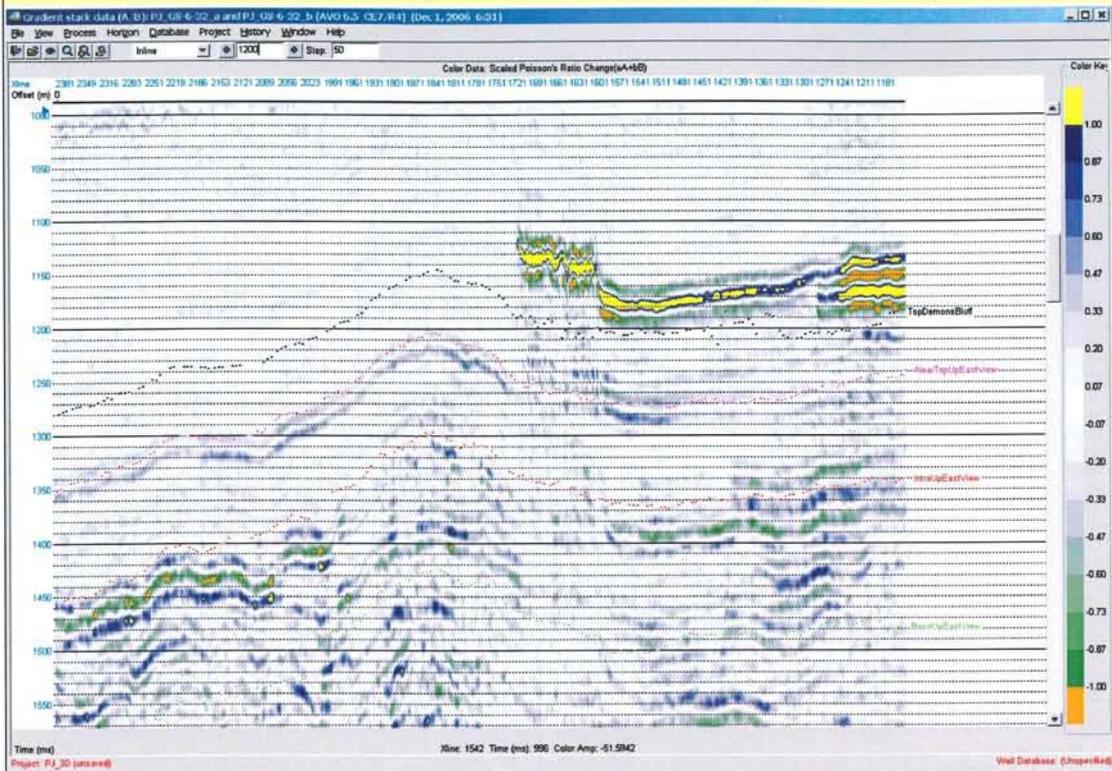
Near Offset Stack of Raw Gathers - near 450m offsets only



This is a simple stack of the Nearest offsets that could be stacked with confidence that the gathers are flat, based on QC of the gathers as part of this analysis. The near 450 metres are very flat and as a fixed offset range are a good “relative true amplitude” product.

The stacked line in question is Inline 1200.

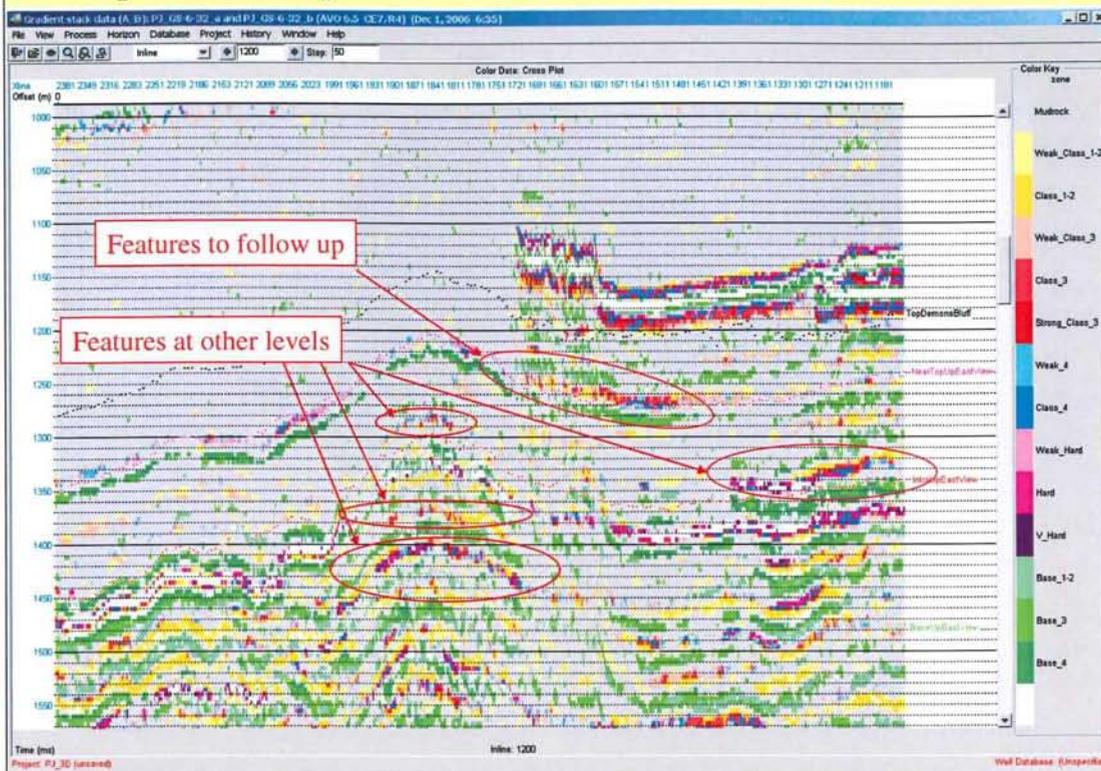
Scaled Poisson Ratio Change of Raw Gathers - angle 8-34 deg



The “SPRC” (Scaled Poisson Ratio Change) section is a simple proportionally added Intercept and Gradient, i.e. $SPRC = A * Gradient + B * Intercept$ where A and B are positive scalars designed to optimise the sum to show fluid changes. Another term for this is the delta-Rp.

In this plot, negative numbers are good. The very strong positive SPRC amplitude event at the volcanics layer is indicative that the assumed polarity is correct.

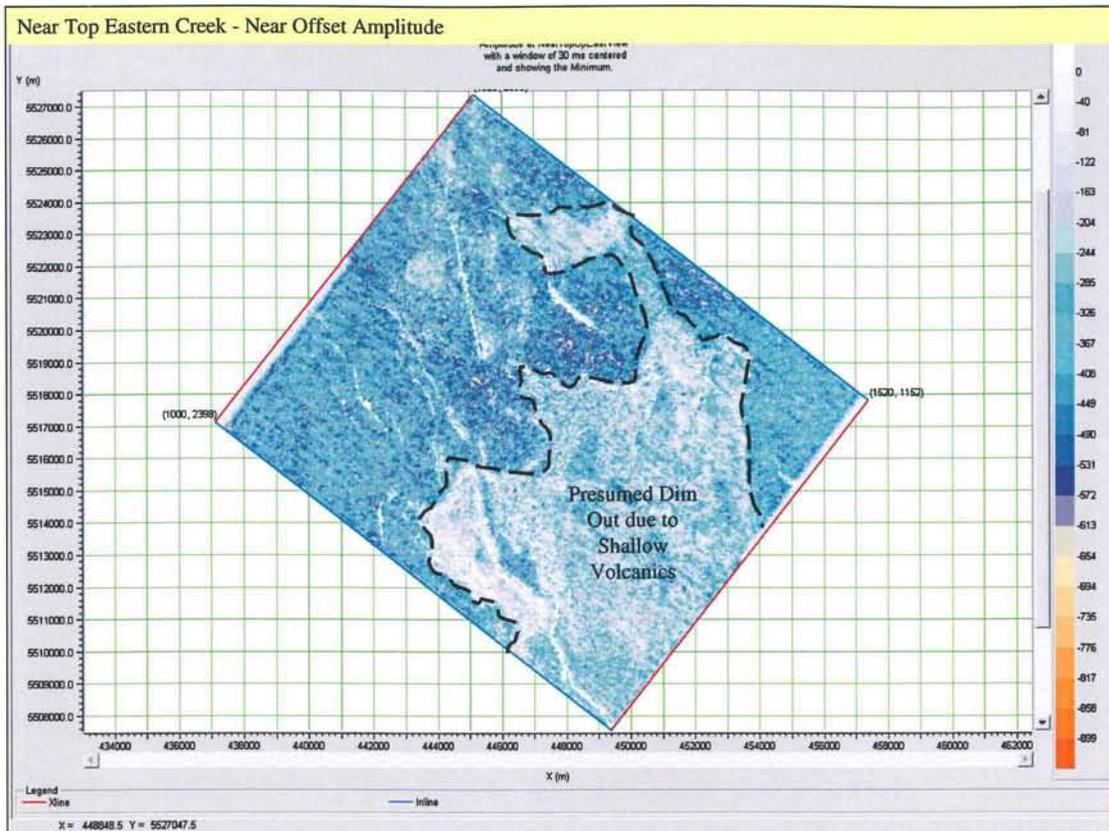
Intercept Gradient Xplot of Raw Gathers -



Here we see the Intercept vs Gradient Cross plot colour scheme being used. The intercept and Gradient at each point of the section is analysed and a colour applied to that sample accordingly.

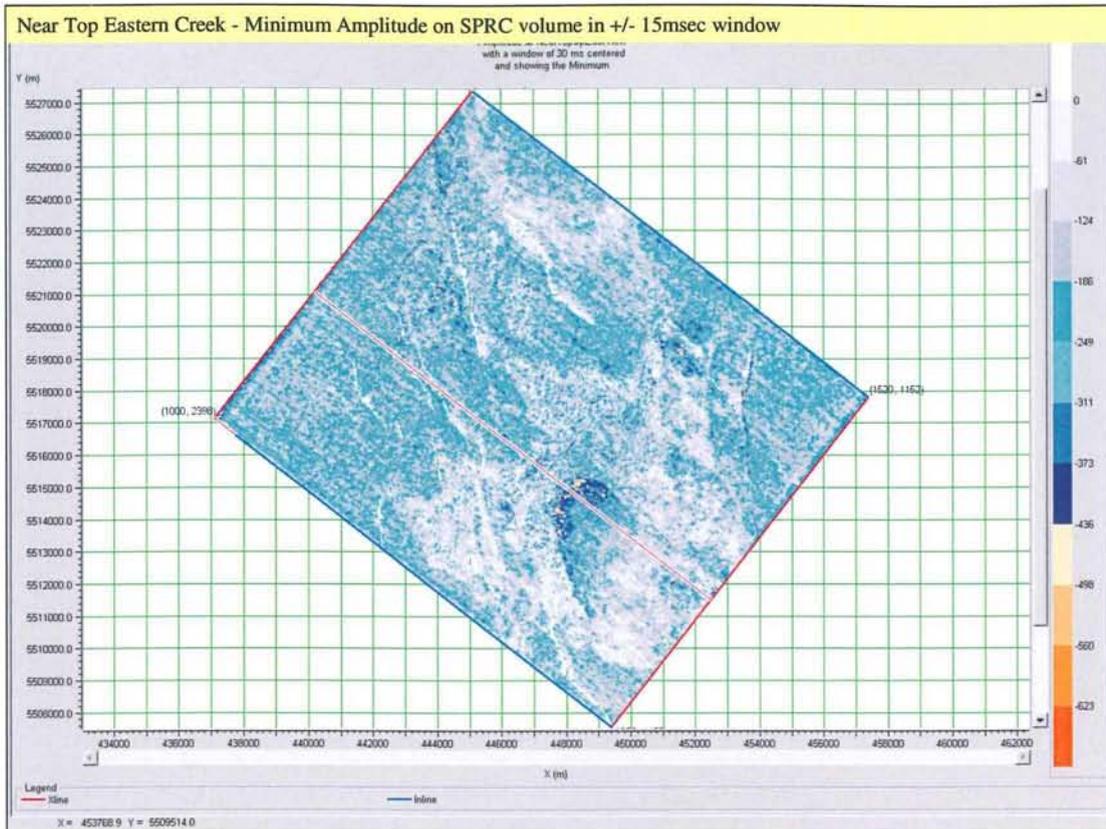
A hard boundary is green (or white if off the scale of the colour plot). An ideal hydrocarbon response would be Orange/Red/Blue layer immediately over a Green. This would be the Top and Base reflection from a single sand with hydrocarbons in, if the sand itself was a reduced or non-reflection event.

Remember that every reflection will have some characteristic colour scheme, and what we'd like to see is the change of that reflection character in such a way as to indicate change in fluid composition. We're looking in change in character of a reflection event. A simple red over green could result from a soft sand encased in shale, with any fluid in the pore space. We're looking for changes in the reflection character.



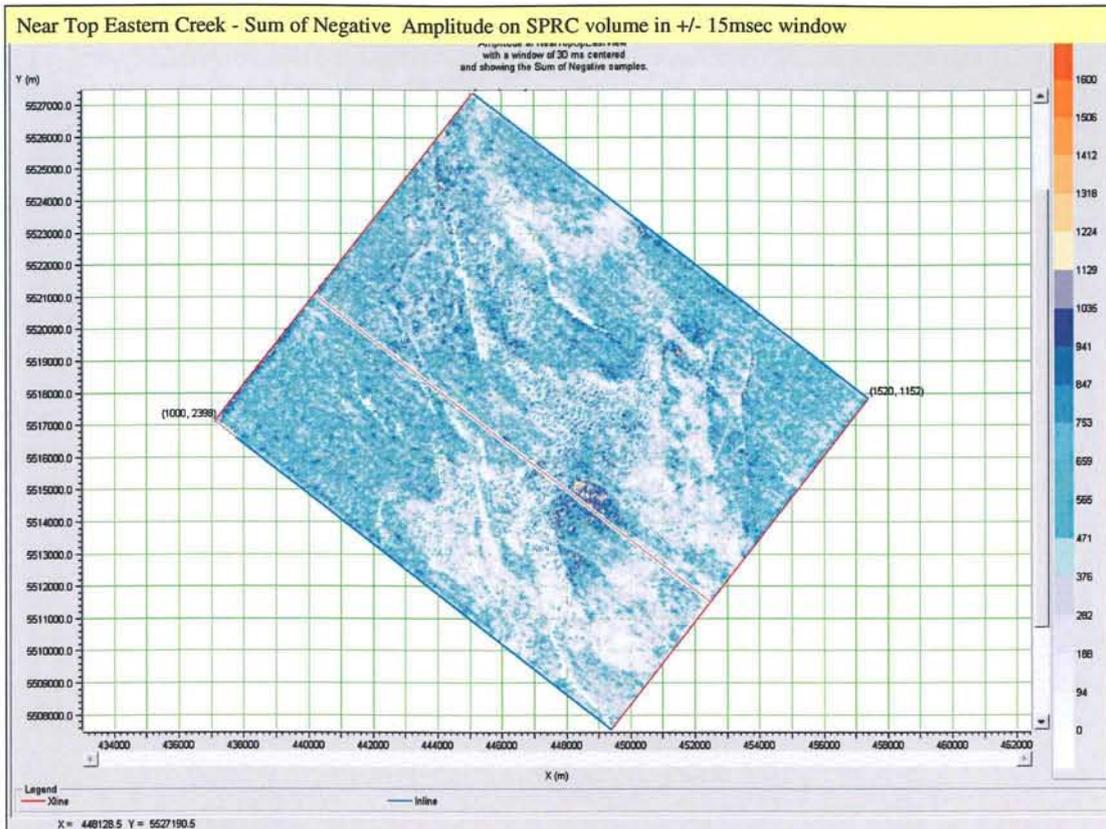
How does the presence of the volcanics affect the seismic.? It can be clearly seen to be suppressing the amplitudes of deeper reflections.

Attempting to correct for this effect in a True amplitude way will be difficult, at this stage we will be content to progress the analysis while being aware of this potential problem.

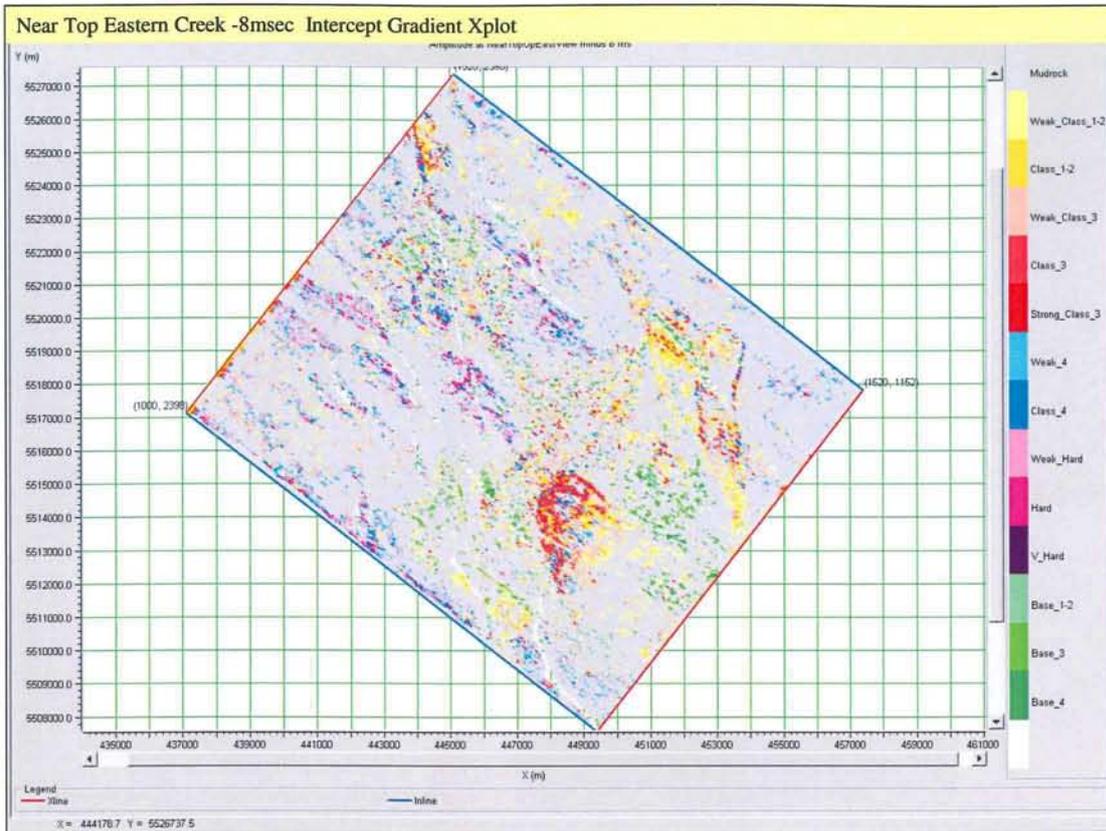


Looking at the key reflection event, the strongest SPRC anomaly can be seen underneath the volcanics and no SPRC anomaly can be seen in this time window at Pee-Jay.

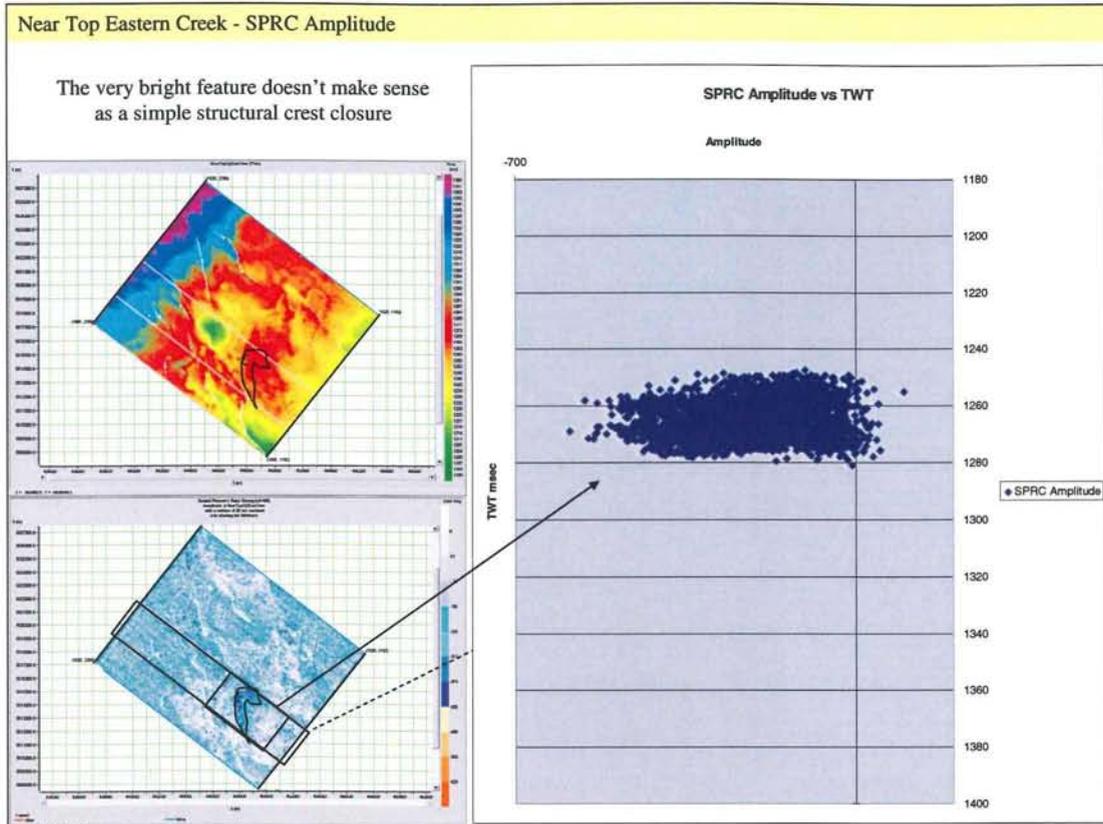
This is taken from the SPRC by extracting the “maximum negative” amplitude in a 30msec window centered around the interpreted Near Top Eastern Creek event.



A similar view - this time summing the amplitudes - not just looking at the peak amplitude - should be less subject to noise and may be enhanced by Low frequency contributions sometimes seen in Gas accumulations.



Looking at the AVO characteristic - we have a Class 3 AVO anomaly in the data, but not at Pee Jay. Also of interest should be the two other areas with class 2/3 AVO reflection character.

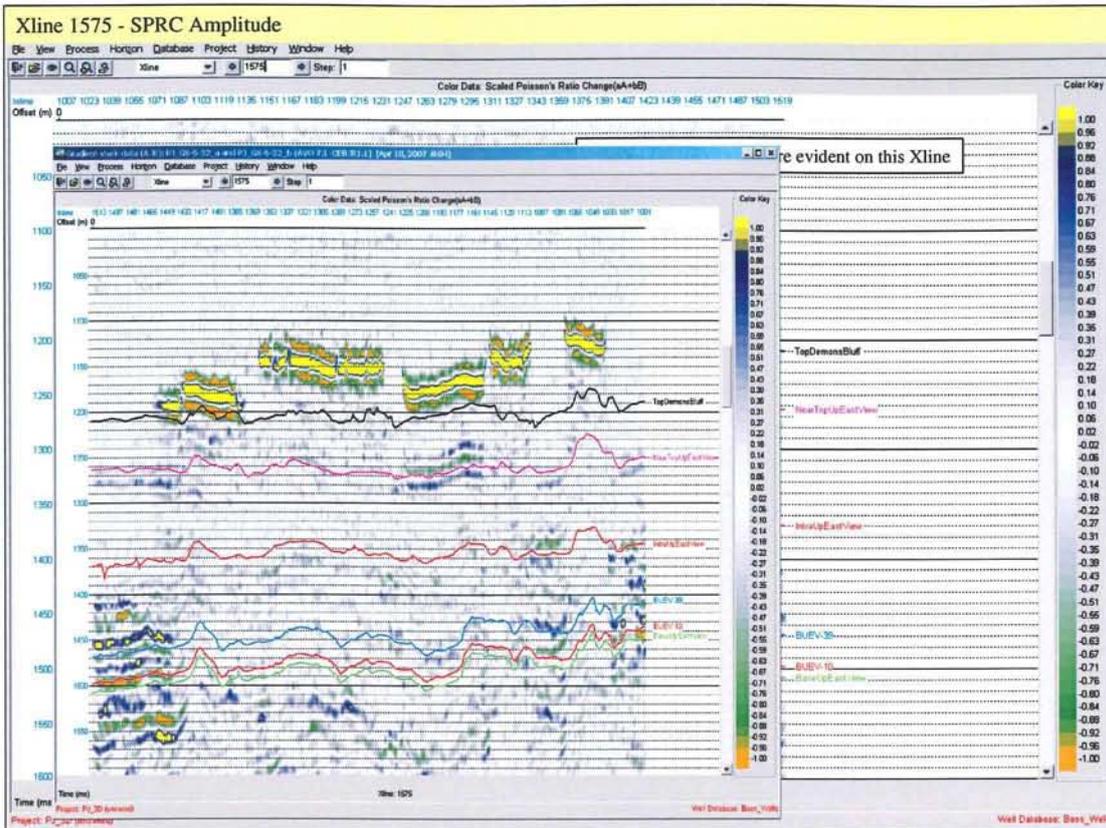


Looking at the magnitude of the amplitude from the reflection event of interest - it is clearly anomalous by any comparison with the “mean result”.

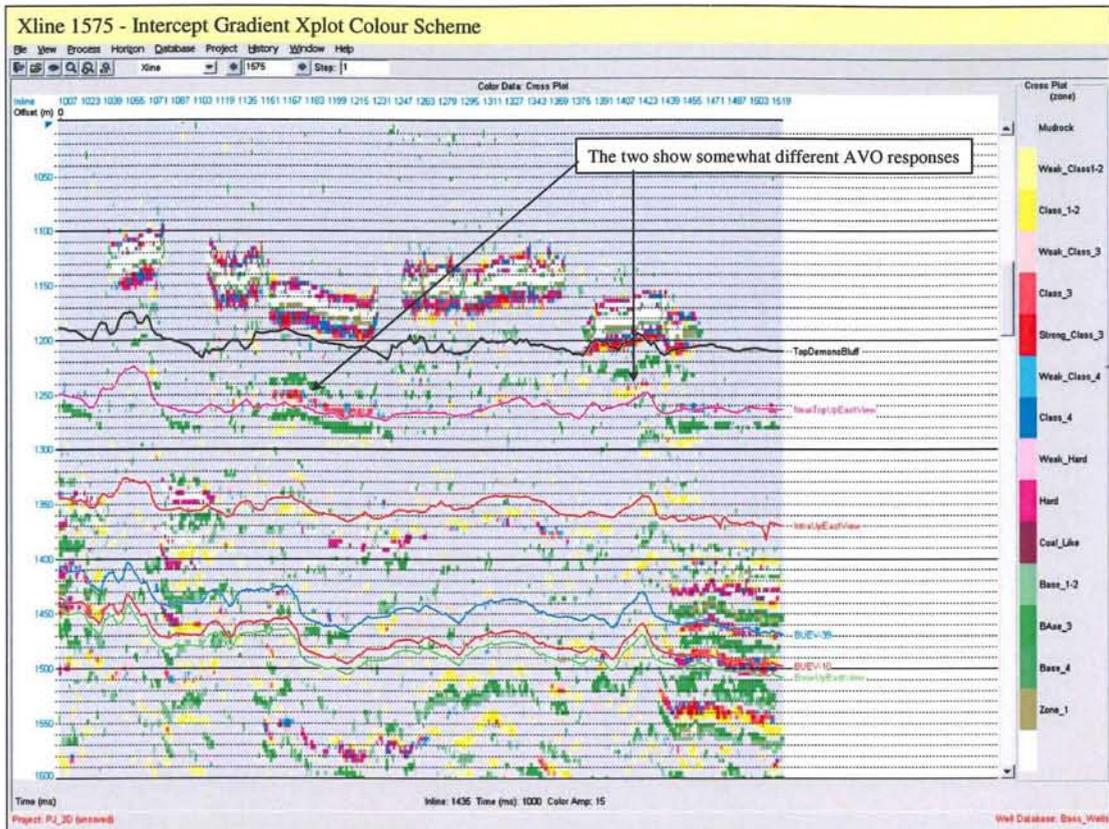
Looking at the same reflection event in other parts of the 3D we build up a background PDF (Probability Distribution Function) of the event. In the anomalous area there are amplitudes outside the normal PDF range of the background.

Why is this event in a relative structural low? - good question and prompts the belief that it is likely to be a lithological feature.

This slide needs to be seen in Slide Show mode.



Xline 1575 runs through the bright anomaly and extends to the North East.



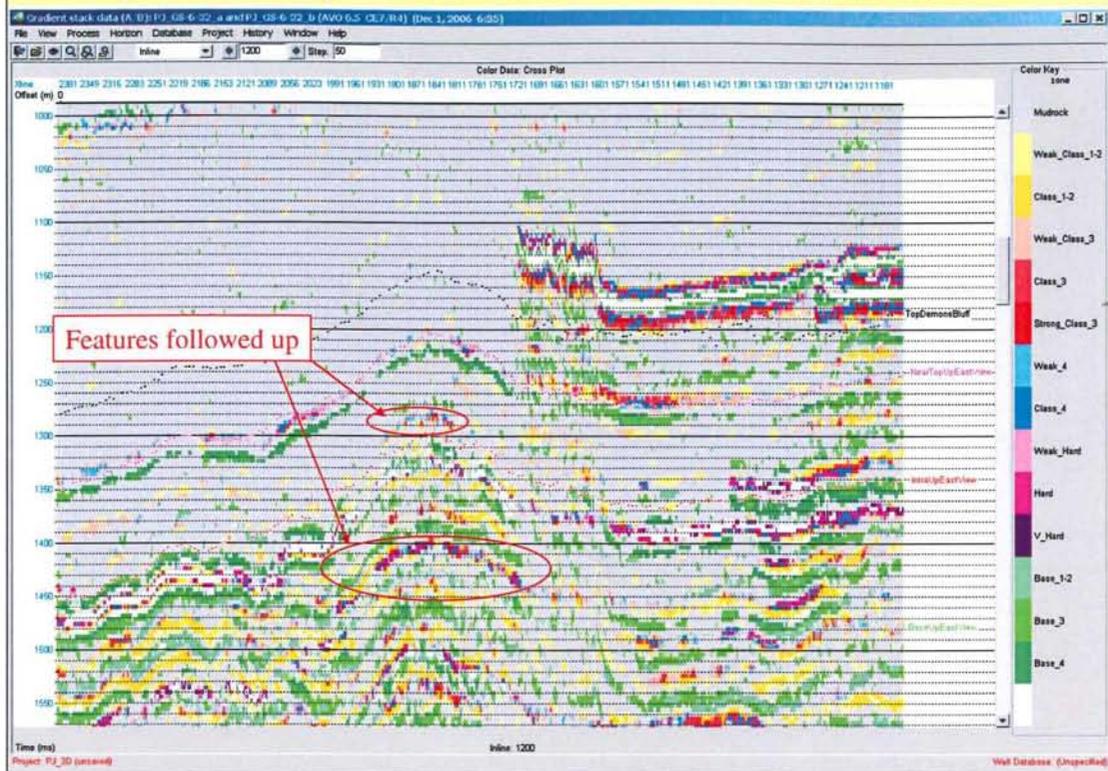
Xline 1575 runs from the bright anomaly in the low to another anomaly, albeit weaker, in the north. This feature is also under the volcanics and it is difficult to quantify reliably how much amplitude loss is associated with the volcanics. As the far offsets would be reduced more than near offsets, it is anticipated that the AVO products would be more affected than the stack amplitude.

Intra and Near Base Upper Eastern View

Attempts to see if the anomalies seen on Inline 1200 are related to structure or show significant AVO at the crest of Pee Jay.

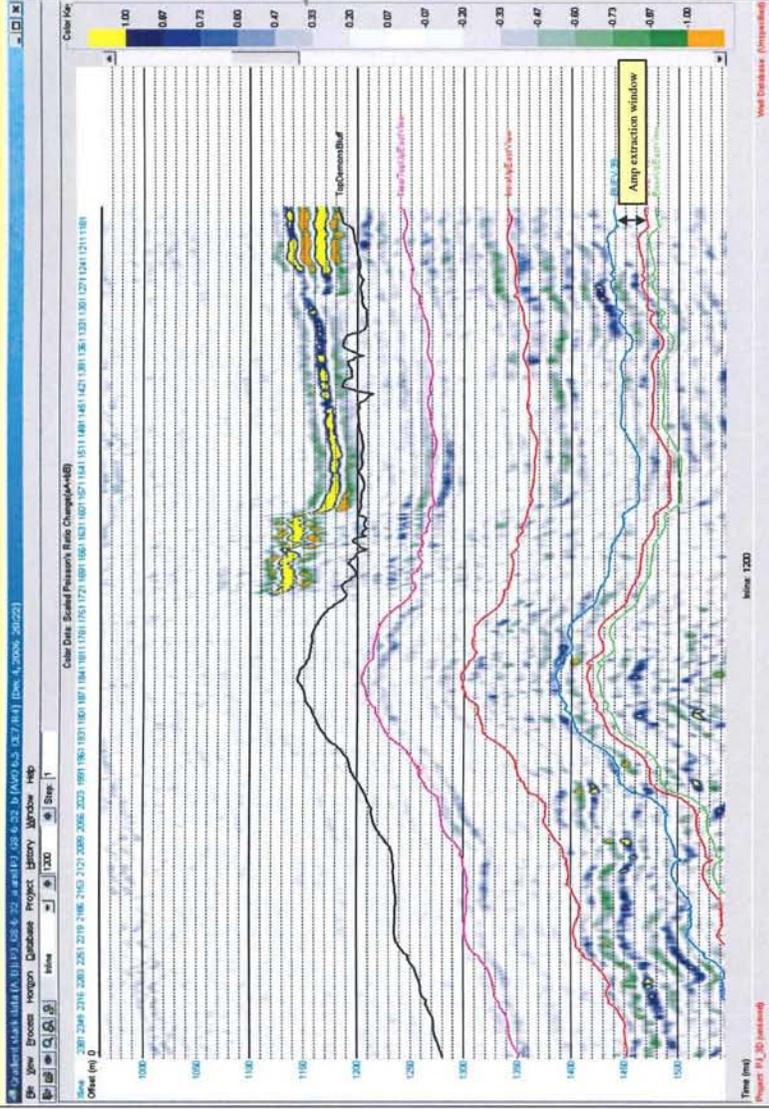
This Power point will review the weaker anomalies seen on Inline 1200, in particular over Pee Jay

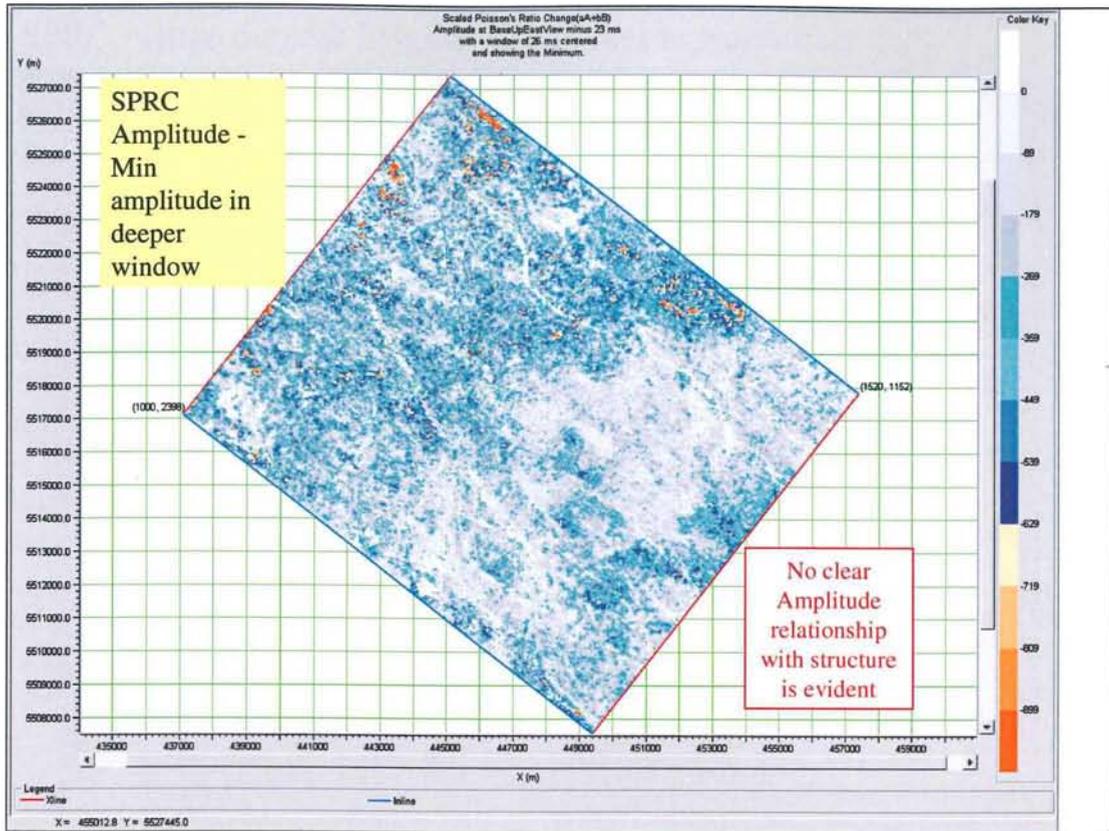
Intercept Gradient Xplot of Raw Gathers - Features of Interest



Using the "AVO" characterising colour scheme described in Near Top Eastern View Group

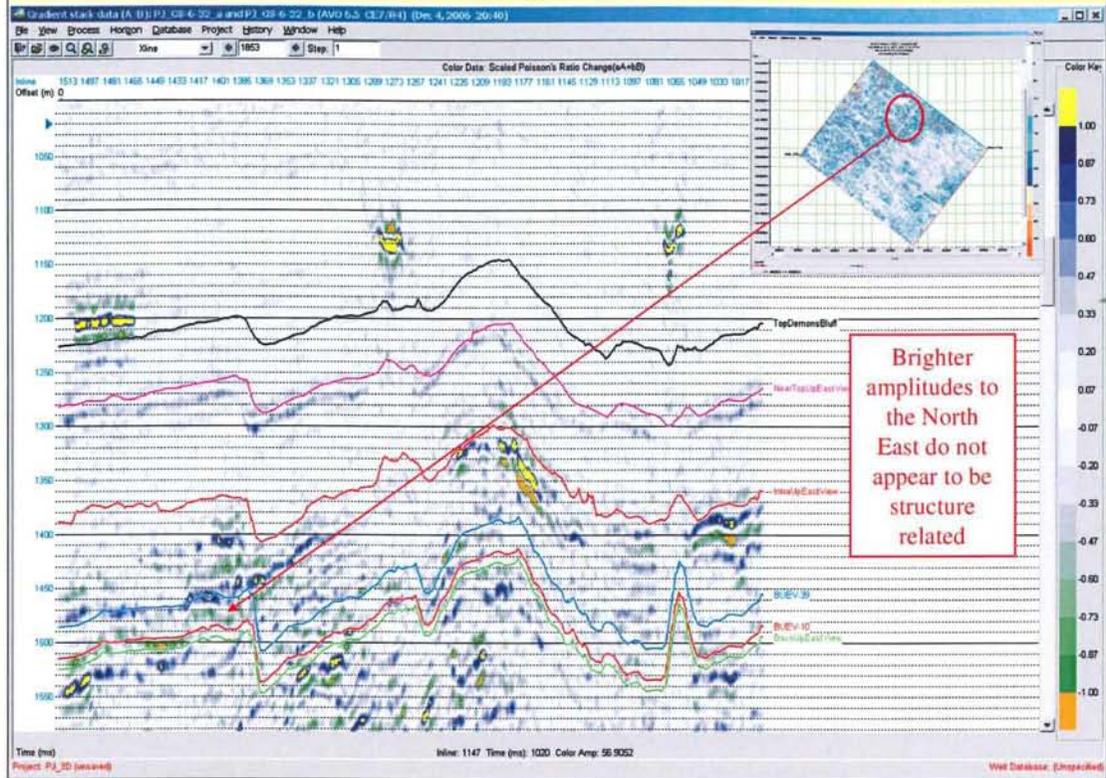
SPRC - Deeper Feature showing Amplitude Extraction Window

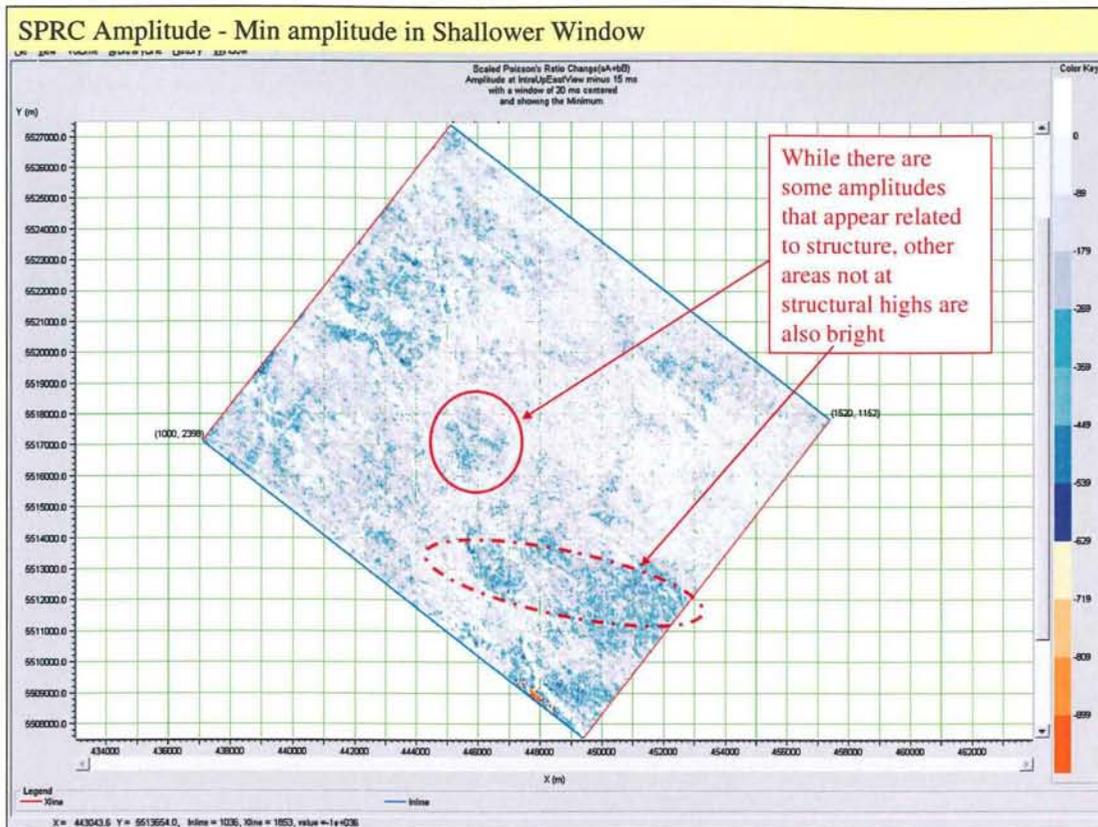




The SPRC or "Poisson Ratio Change" is another term for the

SPRC - Xline through Brighter amplitudes to North East

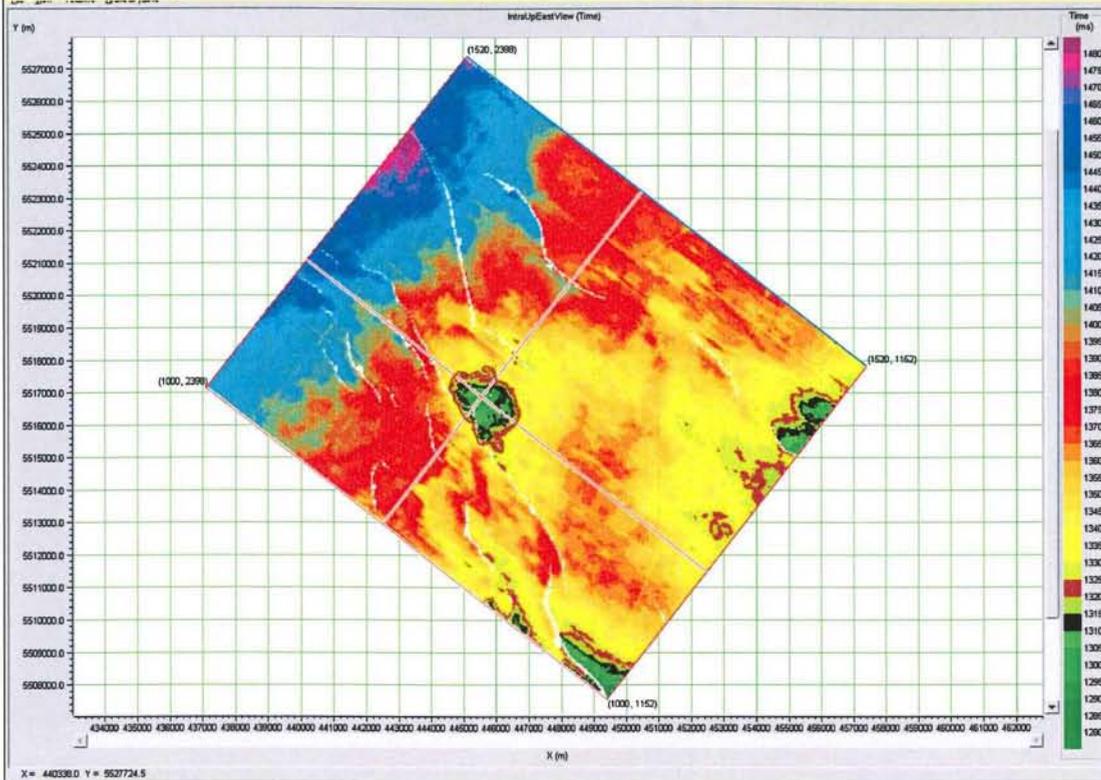




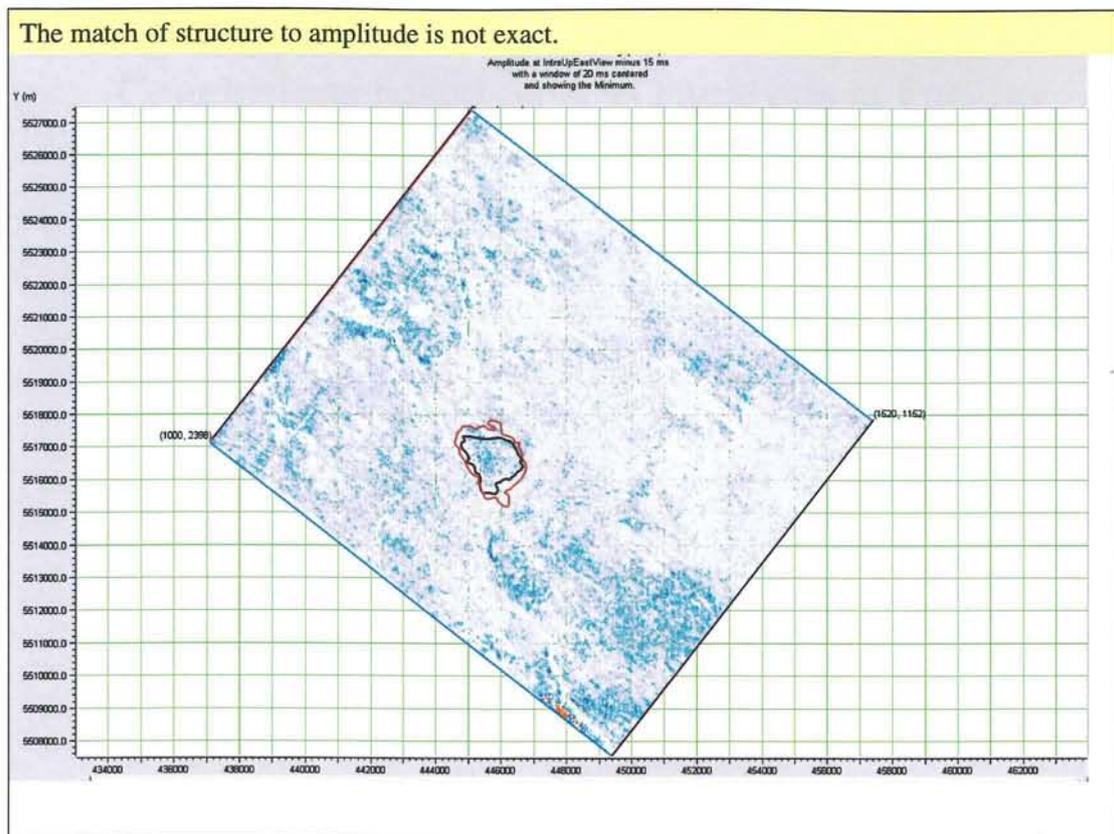
There is some weak “possible” conformance to structure of the SPRC amplitude at the shallower level. However this amplitude is less than that seen at the same level away from structure.

We can either conclude that there is lithological variation throughout the 3D area that explains the amplitudes, or that there would have to be common liquid variation. This would appear unlikely unless there was a potential trapping mechanism in the southern area. The third possibility is that both liquids and lithology are changing. To differentiate the two with some certainty would need a careful quantitative assessment with suitable V_p and V_s data to allow either simultaneous inversion or other quantitative inversion e.g. Bayesian Stochastic inversion. Both of these really need well control to validate quantitative assessment and calibrate the wavelet amplitude and phase.

A careful comparison of Structure and amplitude is warranted



In this TWY horizon map certain TWT levels are highlighted to show common TWTs. Polygons of these layers have been extracted and superimposed upon the SPRC extraction map to see if a relationship between structure and AVO anomaly area exists.



It is interesting to note that while the very crest of Pee-Jay at this level has a weak anomaly associated with it, the anomaly does not extent to the limit of mapped closure.

There could be a variety of possible interpretations of this.

- 1 There is a small amount of gas or oil at the crest of the structure.
- 2 There is gas at the crest and a “dead” oil downdip - geologically implausible
- 3 The shallow nature of the crest is affecting the rock physics and seismic response at the crest. The effect is lithological, associated with depth.
- 4 There is amplitude boost at the crest associated with focussed imaging.
- 5 The steep flanks at Pee-Jay have lost some reflection energy and the anomaly should extend down the flanks. This is a product of the migration and acquisition geometry and failure to capture all ray paths.

There are larger amplitudes away from the crest that are likely to be lithological, the interpretation of these amplitudes is ambiguous.

Conclusions based on AVO analysis at Pee-Jay

On first review, there is no obvious AVO anomaly that indicates that gas is present in high porosity sands over the Pee Jay structure.

A weak conformance of structure to amplitude is present just above the Intra Upper Eastern View horizon, but these same magnitude of amplitudes are seen in other locations which are not at structural crests.

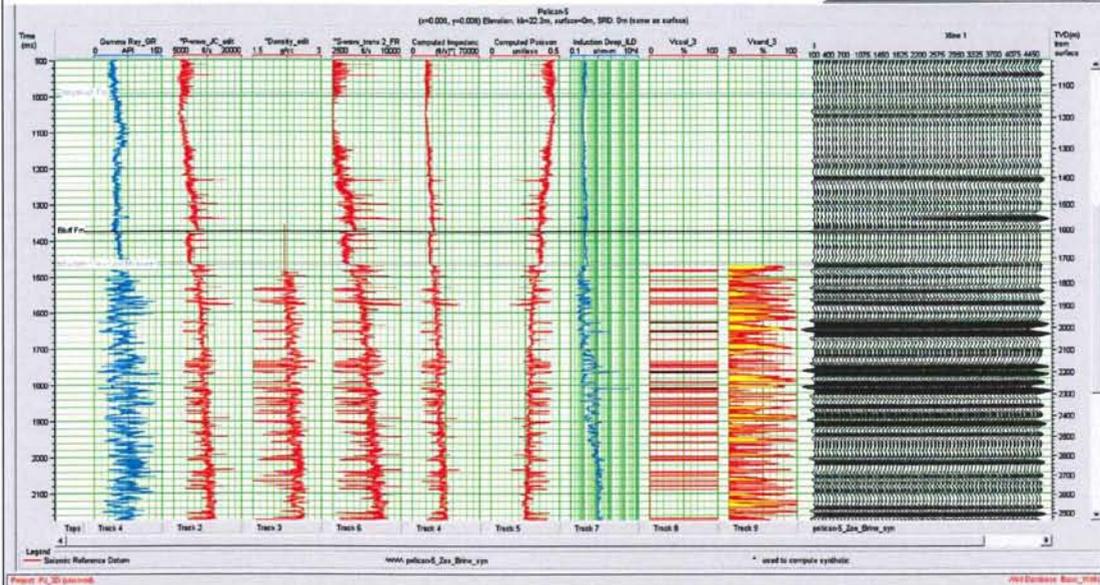
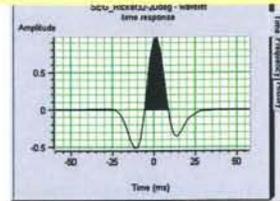
Well Modelling

An attempt was made to predict the magnitude of AVO response that would be expected in the Eastern View Coal Measures.

Looking at the seismic is important, but some well calibration would be useful

Pelican-5 - Synthetic Gather - Modelled using Zoeppritz Approximation

Pelican-5 was the only available well with Sonic and Density Logs. Shear logs were predicted using Greenberg-Castagna based on Vshale from GR only and Coal prediction from Density logs



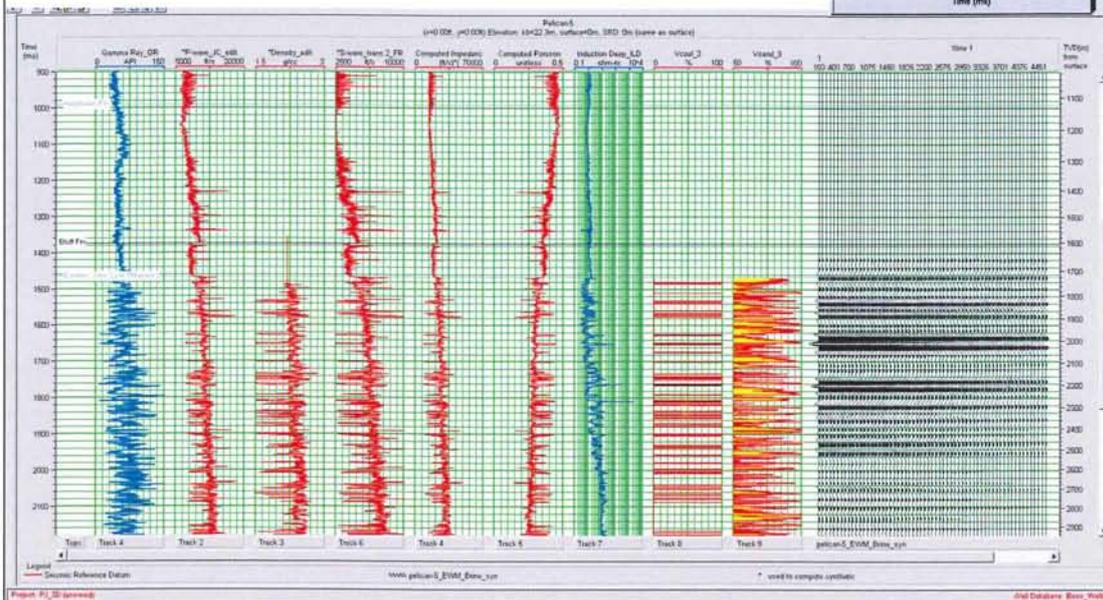
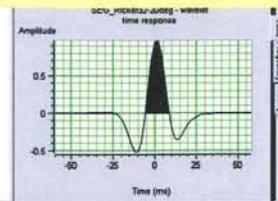
Firstly,

I'm not happy about the Shear wave prediction among all these coals, I believe the synthetic is altogether too bland, and more work should be conducted if this is to make more sense.

That said the magnitude of the AVO character change is likely to be useful, but Zoeppritz modelling isn't the way to go in this situation.

Pelican-5 - Synthetic Gather - Modelled using Elastic Wave Modelling

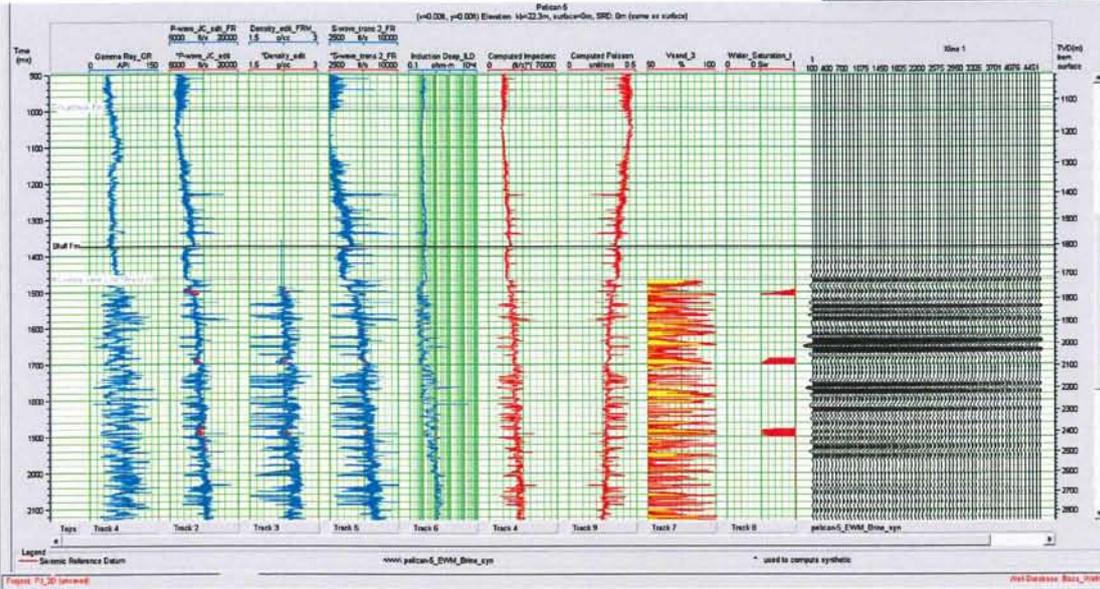
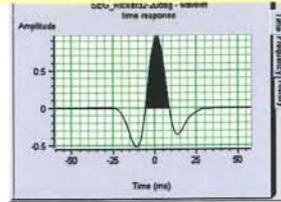
The wavelet used was predicted from the processing sequence. Elastic Wave modelling was preferred to Zoeppritz modelling to ensure thin beds were better handled.



The elastic wave modelling is showing up the typical Greenberg Castagna overly washed out look when a comprehensive log analysis isn't performed. The coal parameters were estimated and may have been too conservative.

Pelican-5 - Synthetic Gather - BRINE Response

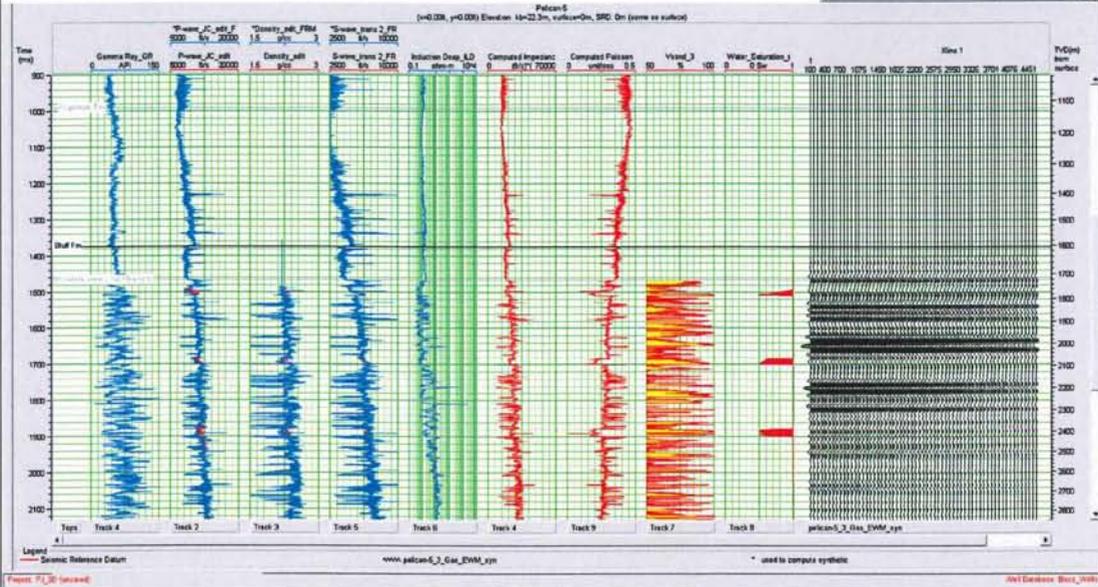
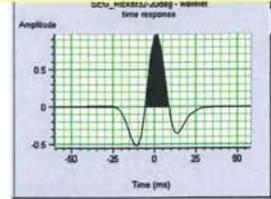
Brine, Gas and Oil were modelled in each of three sands in the Eastern View Group to provide an indicative response of the affect of hydrocarbons.



The same plot as previous - just showing where the three substituted sands are and set at the same scale as the next few plots.

Pelican-5 - Synthetic Gather - GAS Response

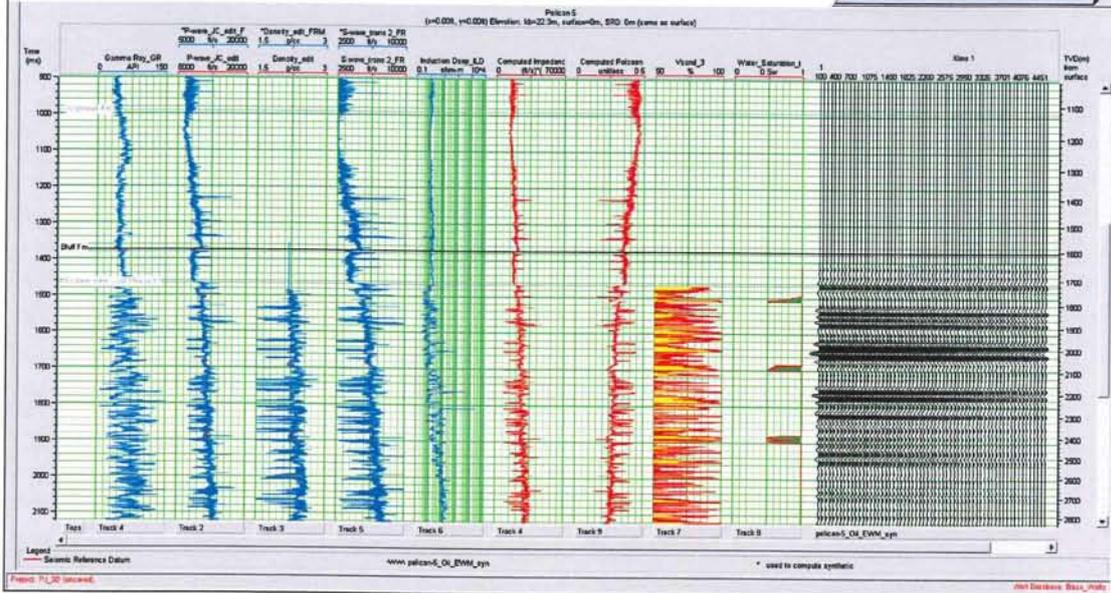
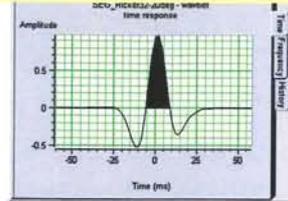
This is the modelled GAS response - i.e. the predicted AVO response of the Eastern View Group with three gas sands.



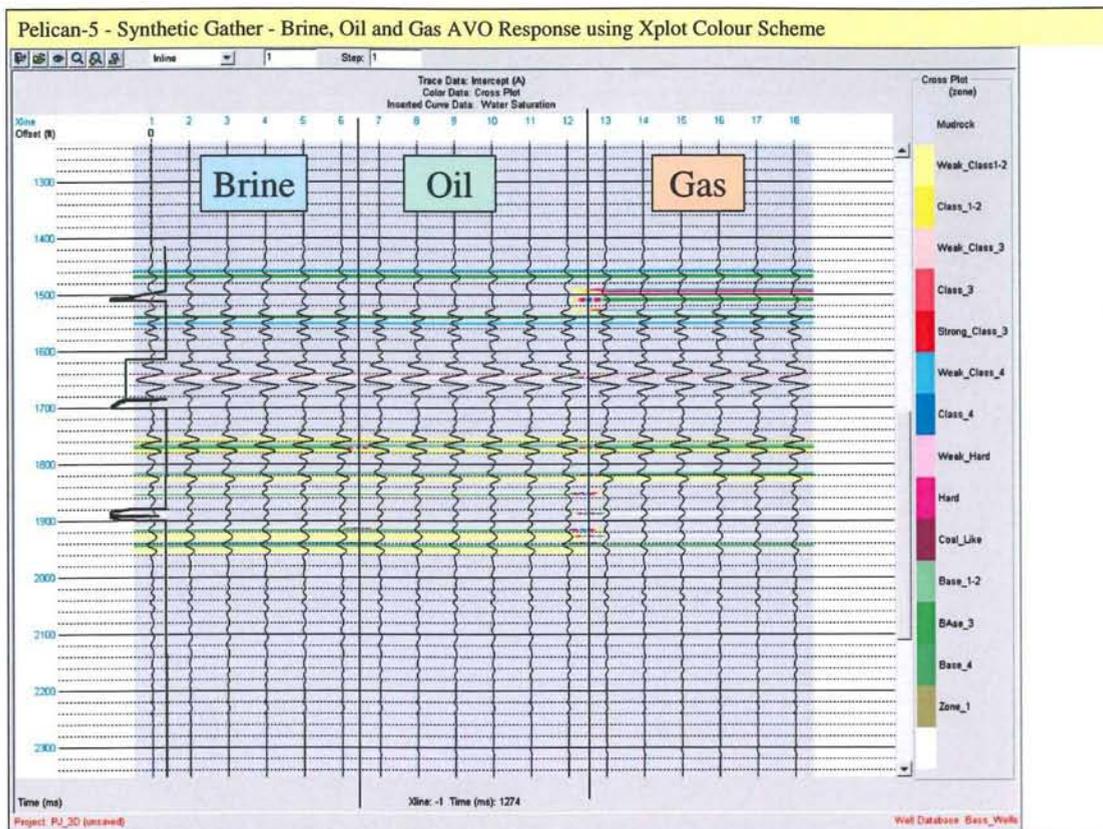
This is a very important plot - there is a Poisson Ratio (PR) shift due to the GAS, but the synthetic isn't moving much at all. Stack amplitudes would be hard pressed to see this difference.

Pelican-5 - Synthetic Gather - Oil Response

This is the modelled Oil response - the Oil used was 38 API with a small amount of dissolved gas (in this case 80 l/l)



The Oil response with little Gas was virtually indistinguishable from the Brine. Based on that the “Dead Oil” case wasn’t modelled

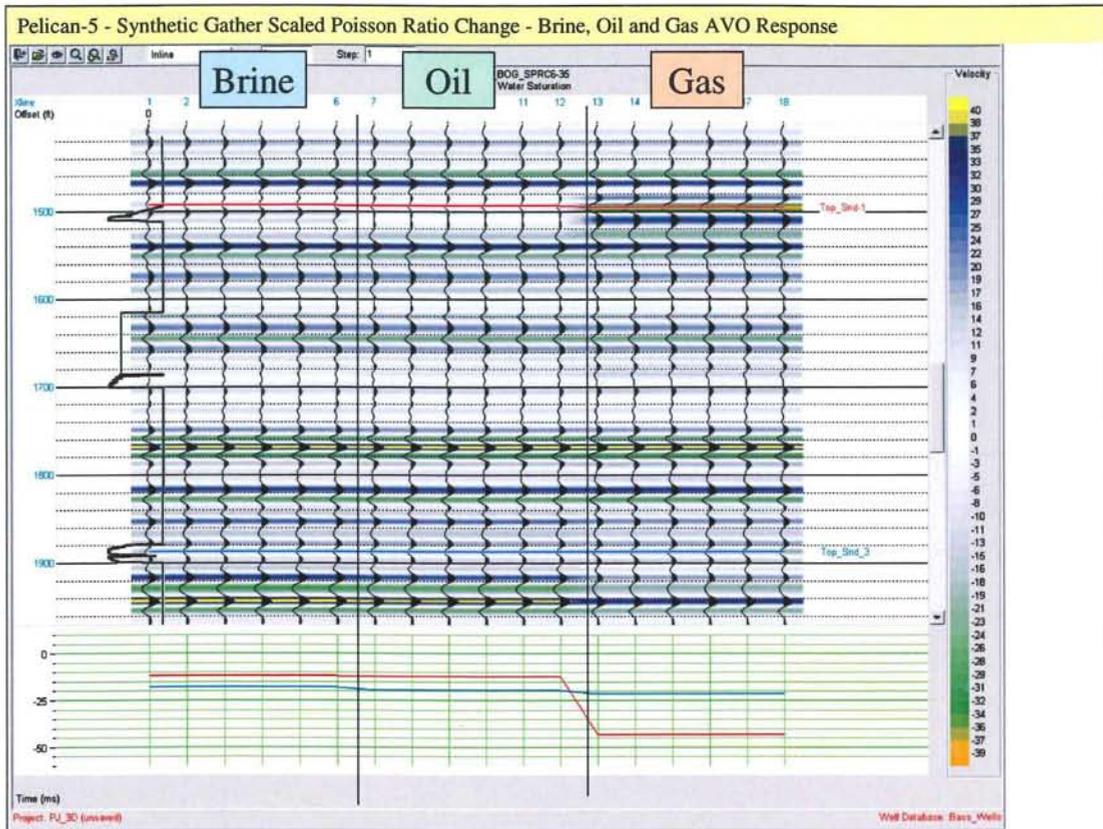


Now I've used the same colour scheme for the AVO sections on the synthetics for the wells after suitable scaling, and the shallow gas is seen, although the deeper sands appear as a weakened or non-existent response.

In this plot the Intercept and Gradient for each of the three cases was determined, and the traces concatenated and duplicated 6 times to show the differences.

The Water Saturation plot (with a strange square bump near the middle sand) is shown as a single curve on the left to show where the sands of interest were.

I believe this work could be re-done better with a more comprehensive petrophysical analysis with multiple mineralogies.



Here is the SPRC amplitude of the synthetic gathers.

While the fluid related amplitude change isn't obvious from colour plotting, it does show that a small change in this AVO measure is expected. It is unlikely that the fluid related amplitude changes in the second or third sand would be visible in the presence of noise or variable geology and seismic, but certainly the gas affect of the shallow sand should be evident.

Conclusion

With the high reflectivity of the coals a weak hydrocarbon signature is likely to be hidden. The shallow (and higher porosity) sand is likely to have an AVO signature if gas filled, but it is still weak, fluid content at deeper levels will be hard to see.

You should see shallow gas, but deeper gas and log GOR Oil will be a battle within these coals.