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OR-442D

BARRAMUNDI PROSPECT

AVO REPORT

BLOCK T27P
BASS BASIN AUSTRALIA

Presented to:

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CONCLUSIONS

- There are normal incidence and AVO anomalies over the Barramundi Prospect which represent fault bounded reservoirs
- Estimates of reservoir thickness range upwards from one hundred eighteen feet, to as much as 300 feet.
- These Reservoirs cover an area of some fourteen thousand acres.
- They are likely filled with oil and dissolved gas whose GOR ranges from 1700 to greater than 4500 : 1.
- Potential Reserves are estimated to be 420 Million barrels of oil.
- There are additional anomalies among the coaly portion of the EVCM, which are not included in this analysis.

Overview and Results

Normal Incidence Investigation

During the early stages of Barrimundi structural interpretation, an obvious amplitude anomaly was observed covering the Barramundi structure. It was realized that this anomaly was very likely a Direct Hydrocarbon Indicator (DHI). This investigation was initiated to determine if this anomaly could be supported by an in depth examination.

A Normal Incidence interpretation of this DHI anomaly in the Barramundi prospect indicated that it was similar to the anomaly observed in seismic over Yolla field. These anomalies are characterized by:

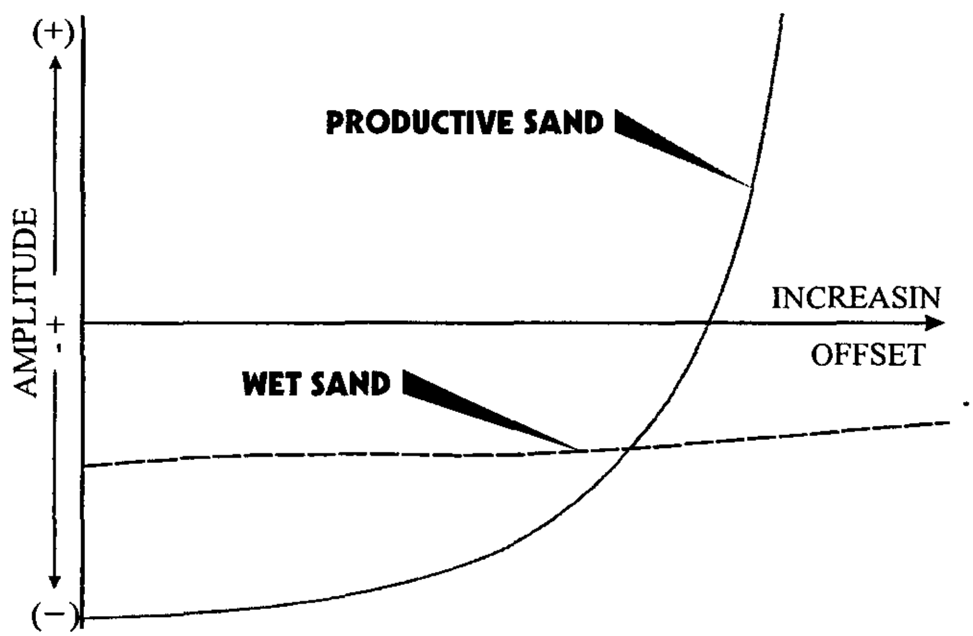
- Seismic trough representing the top Eastern View pay sand
- Trough increased in amplitude on structure;
- Time thickness (side peak to side peak) of trough increases up dip;
- Trough dims in amplitude downdip at a common record section time.

The depth of the trough is interpreted as relating to the relative increase in hydrocarbon saturation of the reservoir. Likewise, the increasing isochron thickness of the anomaly is related to the relative reduction in the interval transit time due to hydrocarbons replacing formation water. The simultaneous termination of these characteristics at a common downdip seismic record section time, is interpreted to signify a common downdip water level in the reservoir.

By overlaying the anomaly isochron map on the AVO anomaly outline map, it appears that twenty-six milliseconds is the downdip limit of the normal incidence anomaly. If this represents the water leg of the reservoir, then using values for porosity and matrix velocity seen in the Cormorant, then the calculated thickness of the sand is 118 feet. Utilizing the same parameters, and holding sand thickness constant, then isochron thickness greater than thirty feet are hydrocarbon productive with increasing GOR with larger isochron values. This translates into an oil productive area of about 10,000 acres and a high condensate yield a productive area of about 2500 acres. These thickness do not include the main body of the sand seen the cormorant well, but are simply for the uppermost EVCM sand, which is also the cleanest sand. The reservoirs below exhibit anomalous characteristics, but are more difficult to analyze because of their variable porosity and the presence of coals.

Amplitude vs. Offset Investigation

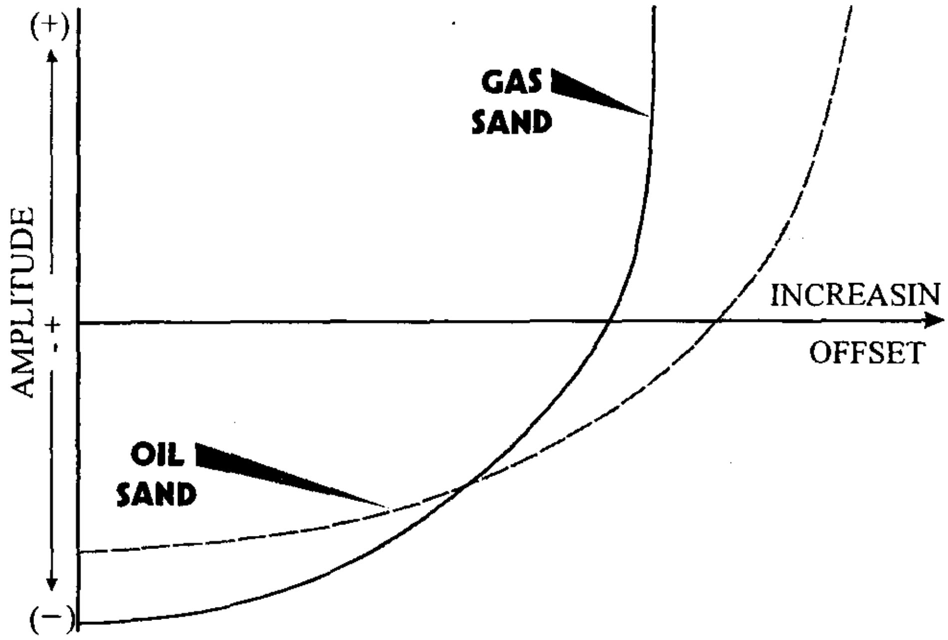
In the seismic offset domain, synthetic models generated from well logs, and actual seismic well ties, indicate that pay sands in the Yolla Field display a negative normal incidence intercept (trough) and a positive amplitude gradient. A similar pattern is observed over the Barramundi prospect which transitions into a flat gradient and shallow intercept time at a common downdip seismic record section time. This latter pattern is characteristic of water bearing sands, as seen in the Cormorant well tie. These responses are illustrated below:



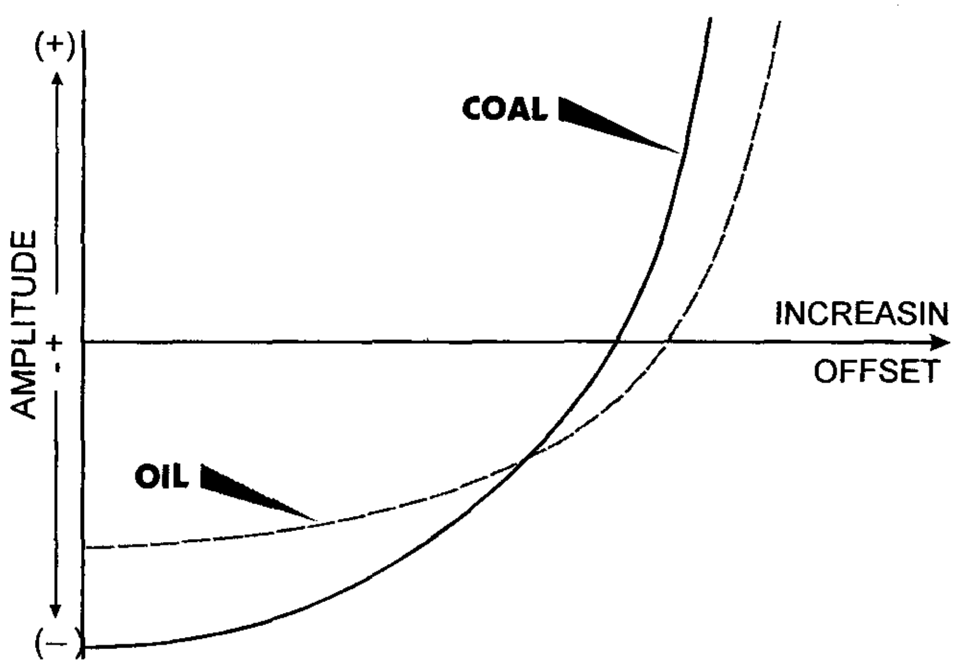
The Barramundi Prospect AVO anomaly:

- Is coincident with the area of the Normal Incidence anomaly
- Fits the structural interpretation
- Is similar to the anomaly seen over Yolla Field
- Third term curvature increases along the pattern of the NI isochron

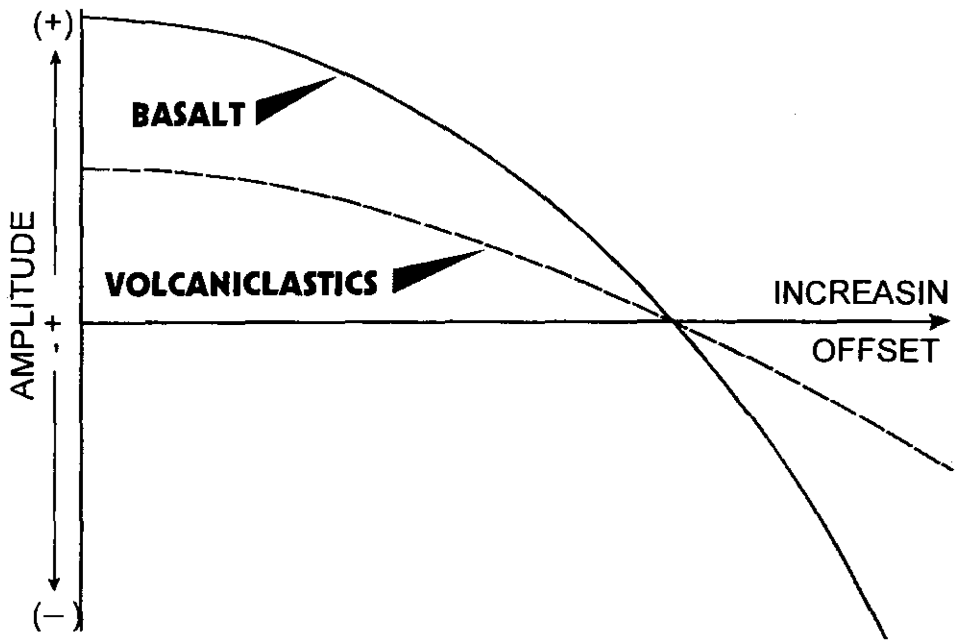
Oil is distinguished from gas by greater AVO curvature and deeper negative intercept value. It must be said however that increasing reservoir porosity can produce this same effect. However given the same porosity, the effect produced by the difference in pore fluids is illustrated below:



Interpretation of AVO responses in the Bass Basin is complicated by the presence of coals and igneous materials in the prospective section as well as interfering multiples in the middle and lower EVCM. These responses are shown in the following figures:



The response of igneous bodies is distinctly different from that of prospective reservoirs, as illustrated below:



Clearly, basalts and volcaniclastics are easily distinguishable from other lithologies. However, separating coals from productive sands is more difficult, in that the normal incidence intercept is negative and the amplitude gradient is positive for both.

Spatial Mapping

Since the target of this project , hydrocarbon filled reservoirs, and coals have the same general offset response, they must be identified by other means. By mapping the spatial distribution of the anomaly in question, and comparing its behavior with structural position, we were able to distinguish coal from hydrocarbon filled reservoirs. Because its environment of deposition controls the distribution of coal, there is no reason for coal to conform to the present day structure trap, as does the Barramundi anomaly.

Spatial mapping of the following Normal Incidence and AVO hydrocarbon indicators was done, and these maps are attached to this report in the AVO Interpretation Map Atlas:

- RMS Amplitude
- Anomaly Isochron
- Product Gradient
- AVO Anomaly Extents
- Instantaneous Amplitude

From the **RMS amplitude map**, it is evident that line to line amplitudes ties need to be adjusted through Line Tie and Grid Balance processes. Future work on this project needs to incorporate this step. In general, a qualitative relationship between depth of trough amplitude and structural position is apparent, supporting the hydrocarbon filled reservoir interpretation.

The **Anomaly Isochron map** is contoured on the anomaly's side lobe to side lobe time thickness. This map shows an apparent time thickness increase from the flanks of the structure to the crest of almost 40%. It is very suggestive that the isochron fits the time structure map. By comparing the isochron to structure, it appears that an isochron time thickness of 0.027 seconds represents the spill point of the structure, and probably the downdip limit of producable hydrocarbons. This conclusion is supported by the limits of hydrocarbon response shown on the AVO Anomaly Extents map. The magnitude of isochron thickness increase is interpreted as a strong hydrocarbon indicator, which we believe is related to increasing amounts of dissolved gas in the reservoir as one moves up dip.

Because of the amplitude grid not being balanced, the product gradients do not tie from line to line on the **Product Gradient map**. There is however, a strong relationship between higher structural position and increasing negative product gradient, which is another indication of hydrocarbons.

The **AVO Anomaly Extents map** portrays the downdip limit of AVO Hydrocarbon Response, connected from line to line to indicate the overall shape of the anomaly. This Outline, when compared to anomaly time structure, follows the general shape of the time structure.

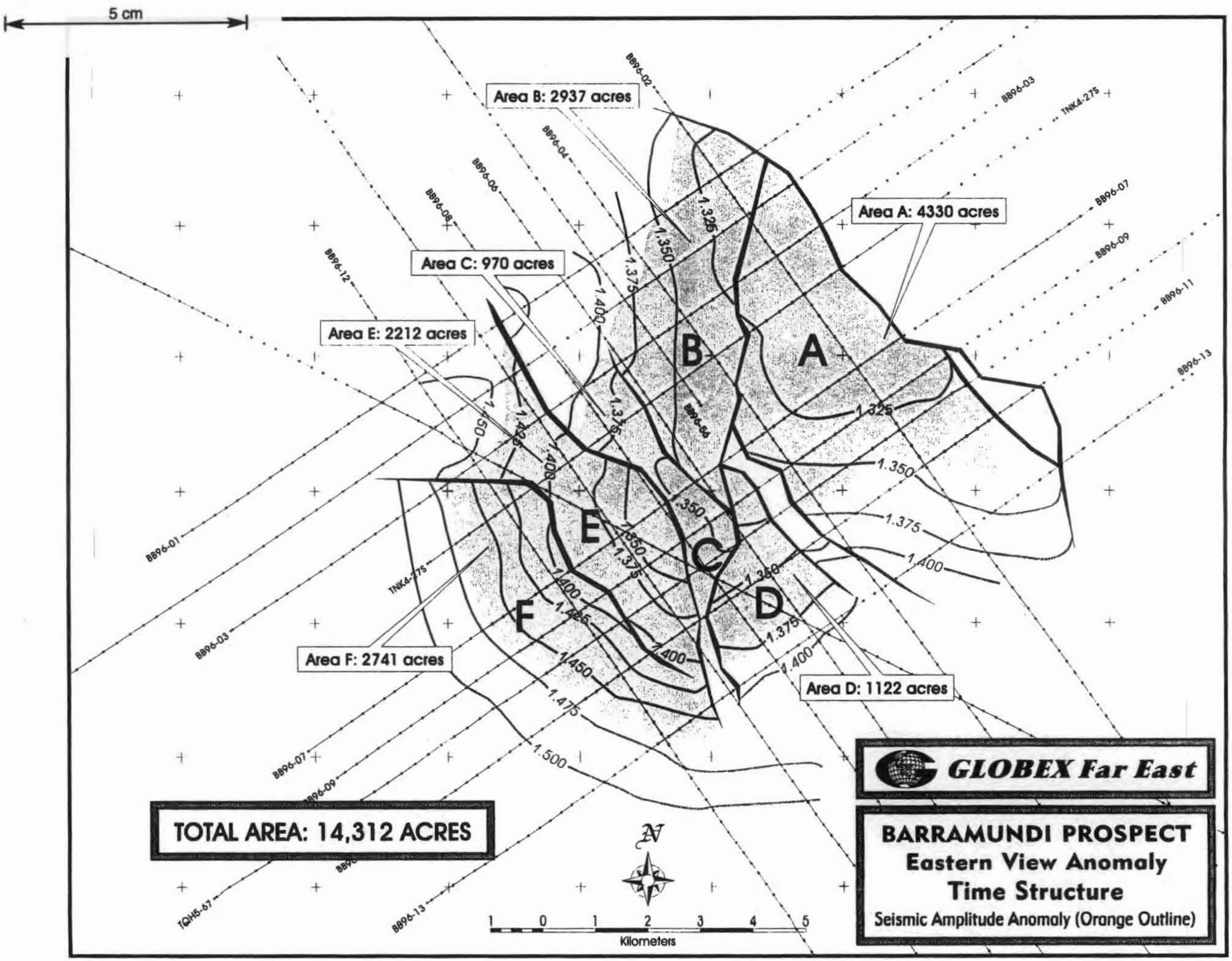
Mapping Conclusions

It was admitted from the outset, that on an individual normal incidence or AVO profile, we would be unable to distinguish between coal and hydrocarbon saturated reservoirs. By analyzing the spatial patterns of these responses, we are able to eliminate coal as an interpretative choice, since we find no reason to explain why coal should:

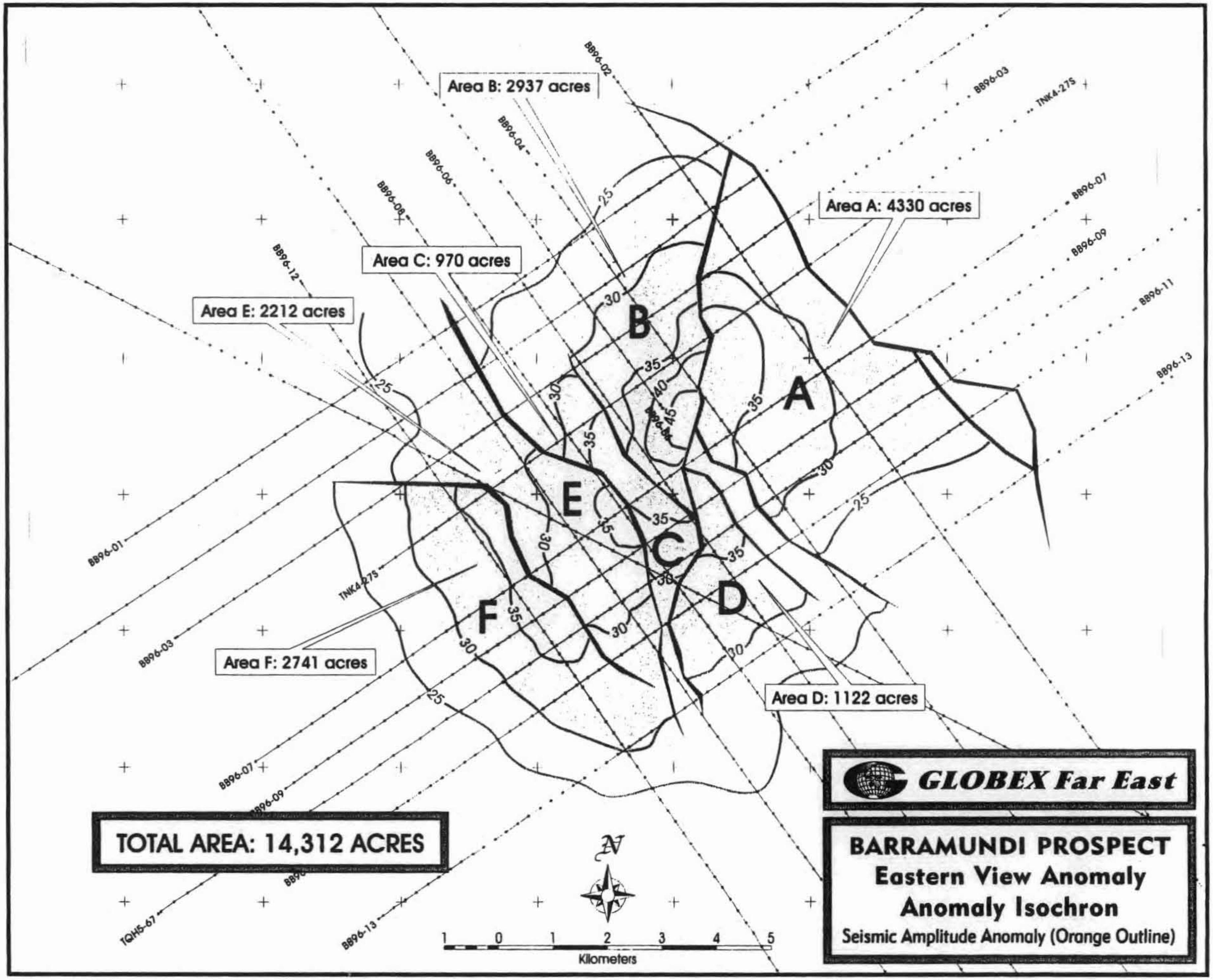
- Thicken over the present day structure.
- Truncate downdip at a common structural point.
- Appear in a stratigraphic section relatively free of coal in the Cormorant

However, all of these characteristics are typical of hydrocarbon filled reservoirs.

Individually, each of these observations is suggestive of a hydrocarbon filled reservoir. However, it is the combined weight of each of these mapped indicators overlain and compared to one another, and to the Barramundi


5 cm
Area B: 2937 acres
Area A: 4330 acres
Area C: 970 acres
Area E: 2212 acres
Area F: 2741 acres
Area D: 1122 acres
A
B
C
D
E
F
BB96-01
BB96-02
BB96-03
BB96-04
BB96-06
BB96-07
BB96-08
BB96-09
BB96-11
BB96-12
BB96-13
TNK4-275
TQH5-67
1.325
1.350
1.375
1.400
1.425
1.450
1.475
1.500
TOTAL AREA: 14,312 ACRES
N
1 0 1 2 3 4 5
Kilometers
GLOBEX Far East
BARRAMUNDI PROSPECT
Eastern View Anomaly
Time Structure
Seismic Amplitude Anomaly (Orange Outline)

561C09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Kilometers
GLOBEX Far East
BARRAMUNDI PROSPECT
Eastern View Anomaly
Anomaly Isochron
Seismic Amplitude Anomaly (Orange Outline)

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structure, leads to the conclusion that the observed Barramundi anomaly is a valid hydrocarbon indicator, similar to that producing in the Yolla Field. Further indications are that reservoir porosity, areal extent and thickness are greater at Barramundi than at Yolla, an indication supported by the quality of Upper EVCM sands seen at Cormorant.

Reservoir Thickness Calculation

Since the absolute thickness of reservoir sandstone was unknown, we assumed the trough to peak time interval represented the time thickness of the reservoir. Utilizing matrix velocities from the Cormorant this resulted in a thickness of 118 feet. We also assumed that this thickness remained constant over the Barramundi structure, which necessitated varying the reservoir GOR to explain the isochron thickening up dip. These assumptions also result in a water level at approximately the 0.027 sec isochron.

While we believe this assumptions to be reasonable, and consistent with the data, there are other assumptions that could be made. For example, the change in isochron thickness can be explained by varying the porosity and pay thickness. The strong relationship of isochron thickness to structural position compelled us to explain this behavior by varying the GOR between 1700 and 4500:1

Given the amount of seismic waveform tuning in response to this stratigraphic section, and the sand thickness in the Cormorant well, it is entirely possible that the base of the sand is masked and is actually much thicker. Possible thicknesses range up to a half wavelength or more, in the order of 250 to 300 feet.

Estimated Reserves

The AVO anomaly covers more than 14,000 acres, in six fault bounded compartments. Using a recovery factor of 250 barrels oil per acre-foot and an average pay thickness of 120 feet:

14,000 ac ft x 250 bbs / ac ft x 120 ft = **420 million barrels oil**

Setting and Background

Geological Overview

Globex Far East is Operator of permit T 27/P, a 1.8 million acre exploration permit located in 70 meter water depths of the Bass Basin of Australia. The Bass Basin is a Late Mesozoic-Cenozoic intracratonic basin trending northwest to southeast between Victoria and Northern Tasmania with an area of approximately 65,000 sq. kilometers. It is separated from the Otway Basin to the west and northwest by the King Island-Mornington Peninsula Rise and from the Gippsland Basin to the east by the Paleozoic rocks of the Bassian Rise.

The overall structural evolution of the Bass Basin is generally extensional, following a thermal sag phase associated with the successful separation of Australia and Antarctica beginning in the earliest Cretaceous and persisting through the Eocene. Mild wrenching as a result of Tertiary transpression has helped to form many of the prospects mapped in the T 27/P permit and is clearly evident on the seismic data.

The main stratigraphic units of interest for petroleum exploration in the Bass Basin are the Otway Group (Upper Jurassic-Lower Cretaceous), the siliclastic Furneaux Group (Upper Cretaceous-Paleocene), the siliclastic coal bearing Bass Group (Eocene), and the Torquay Group (Oligocene).

The primary exploration target within the Bass Basin is the Eastern View - Coal Measures petroleum system, which is comprised of reservoir and source sequences within the Bass and Furneaux Groups. This proven petroleum system is well documented at the Yolla Field. Discovered by Amoco in 1985 and located 9.5 kilometers west of the T 27/P permit boundary, Yolla Field produces from deltaic and shoreline sandstones of the Eastern View. These sands are on average 15 meters thick, but have been observed as thick as 100 meters, with porosity ranging between 15 and 20 percent. Production rates as high as 11.8 mmcf of gas per day and 892 barrels of condensate have been reported from the Yolla wells. Subsequent drilling and testing of oil reservoirs in the Yolla-1, Tilana-1 and the Pelican-5 wells, illustrates that these Middle and Late Eocene sandstones maintain good reservoir characteristics (porosity and permeability) at depths exceeding 3,000 meters.

Source rocks within these sections are equivalent to the Latrobe Group in the Gippsland Basin which are proven to have generated over millions of barrels of crude. Geochemical analysis of hydrocarbons produced at the Yolla #1 indicate Type II kerogens in the lower Eocene (which is generating the majority of the oil in the field), and a mixture of Type II and Type III kerogens in the Upper Paleocene section. A secondary petroleum system within the Upper Cretaceous

Otway Group is also recognized to contain source rocks, possible reservoirs and suitable sealing units, although very limited data are available to detail this system.

Geophysical Overview

In June of 1996, Exploration Consultants began a seismic interpretation on newly acquired seismic data located in Permit T /27P of the Bass Basin in southern Australia. Utilizing existing seismic control, Globex had previously identified several prospects within the block and had undertaken a large 2-D seismic program to verify the structural closure on these prospects prior to drilling wildcat wells. The largest of these prospects, Barrimundi, was assigned top priority for mapping.

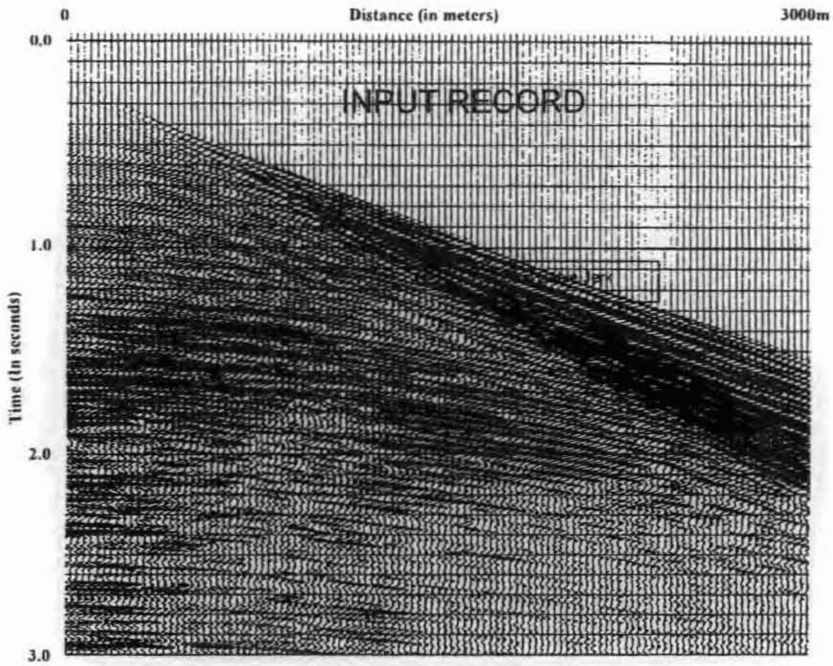
The newly acquired BB96 survey exhibited excellent internal reflection ties, but tied the TNK and TQH surveys with a shifts varying from twenty six to thirty eight milliseconds. Both older surveys were acquired with the same boat and streamer cable but required datum shifts to tie one another in some areas indicating that substantial shot point location errors must be involved.

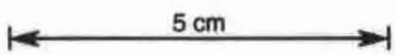
DHI Investigation

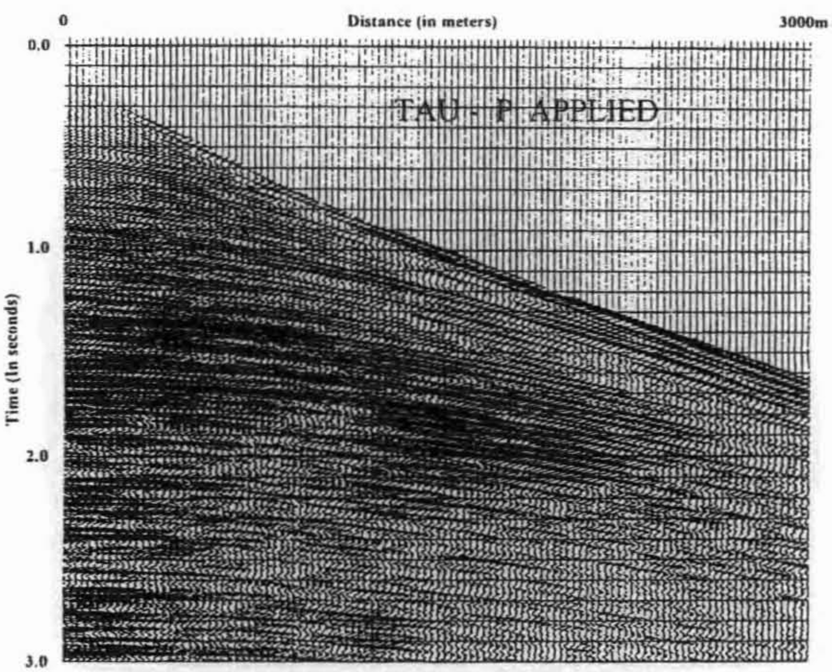
Seismic Processing

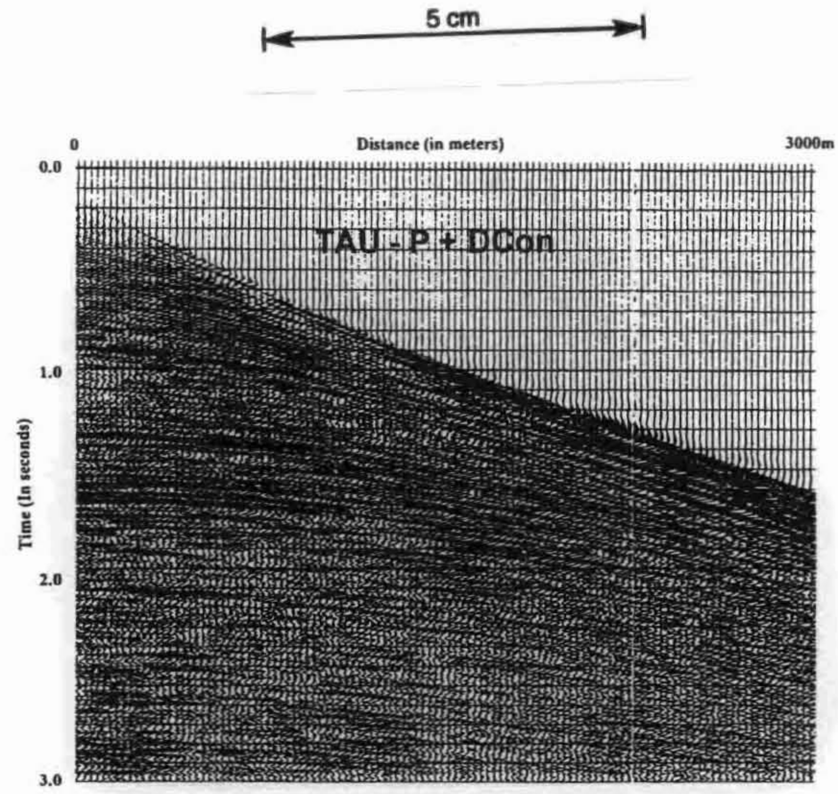
During the acquisition of the current data set, five foot seas and more were typical, which is characteristic for the Bass Straight. Some fifteen lines had to be re-shot because of noise problems, mostly in the form of cable jerk. This noise is widely separated from reflected arrivals and a simple K - F filter was found to be extremely effective in dealing with this problem. Another problem, associated with the sea conditions was the variation in air gun depth. This caused a variable source pulse and source strength. Shot consistent amplitude recovery was found to be necessary to balance amplitude from one shot to the next

Among the EVCM sands and shales, are interbedded basalts, coals and other volcanic products, which are strong seismic markers, particularly in the middle and lower EVCM. Also in the Miocene volcanic interval above the Demon's Bluff, there are some strong seismic contrasts. These markers set up a system of interbed multiples which is too complex for deconvolution to handle effectively. By picking closely spaced panels and inputing them into a tightly constrained Tau - P process, followed by deconvolution, we were able to dramatically improve the reflection to multiple amplitudes as is shown in the following examples


0
Distance (in meters)
3000m
0.0
1.0
2.0
3.0
Time (In seconds)
INPUT RECORD


5 cm


0
Distance (in meters)
3000m
0.0
1.0
2.0
3.0
Time (In seconds)
TAU - P APPLIED



Supergather Signal enhancement

Through comparison of noise reduction achieved from three on one to five on one, it was found that the three on one supergather was sufficient to suppress random noise without enhancing the multiple content. This also acted to moderate some of the shot to shot amplitude variations, in addition to the one second window in which shot wise amplitude balancing was run.

After preprocessing, the data were processed for AVO interpretation and analysis. AVO Attributes Calculated for each line and are found in the Seismic Atlas appended to this report. A brief discussion of the interpretative significance of these attributes is given in the interpretation section. The attributes generated were:

- Normal Incidence Stack
- Instantaneous Amp
- Instantaneous Phase
- Instantaneous Frequency
- Product Gradient

Well Log Models

The lithology of the EVCM contains some prominent seismic markers. The extremes range from high seismic impedance lithologies such as basalts to low impedance lithologies such as coals. Three wells were modeled to determine the Normal Incidence and AVO Response, these were:

- AMOCO #1 Tilana
- AMOCO #1 Yolla
- ESSO #1 Cormorant

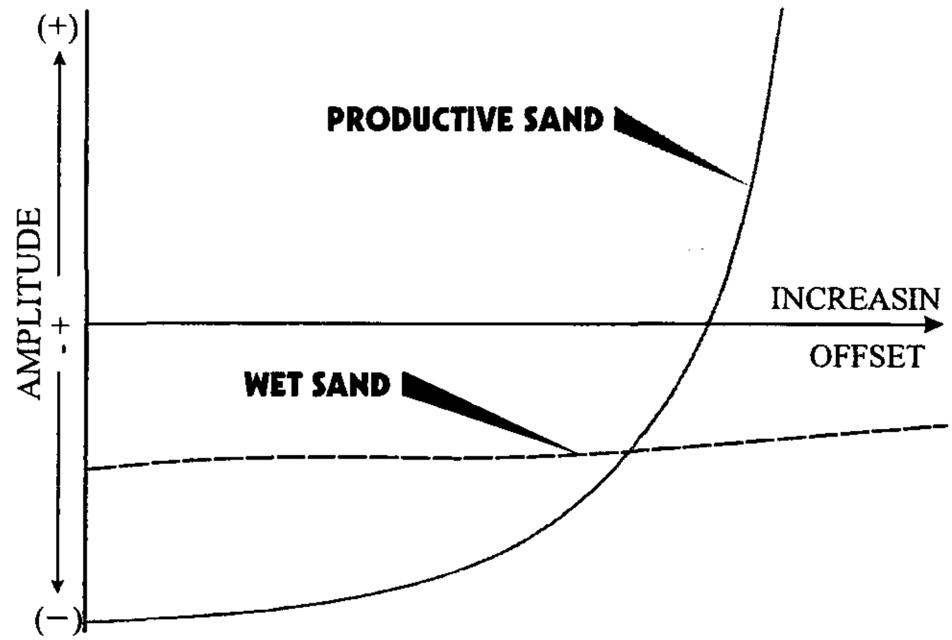
These models were generated using GMA software. In each model, Normal Incidence traces were derived using a wavelet whose frequency content matched that of the data. Offset traces were then calculated to determine the AVO response for the zone of interest. Values for formation density and compresional velocity were taken from density and sonic curves furnished in the digital well log suite. Default values were used for Poisson's ratio, except for coals, which were taken from published values for Permian coals in southeast Australia. In the study wells, the opportunity was present to model the following lithologies:

- coal
- basalt
- volcaniclastics
- wet reservoir sands
- oil bearing reservoir sands

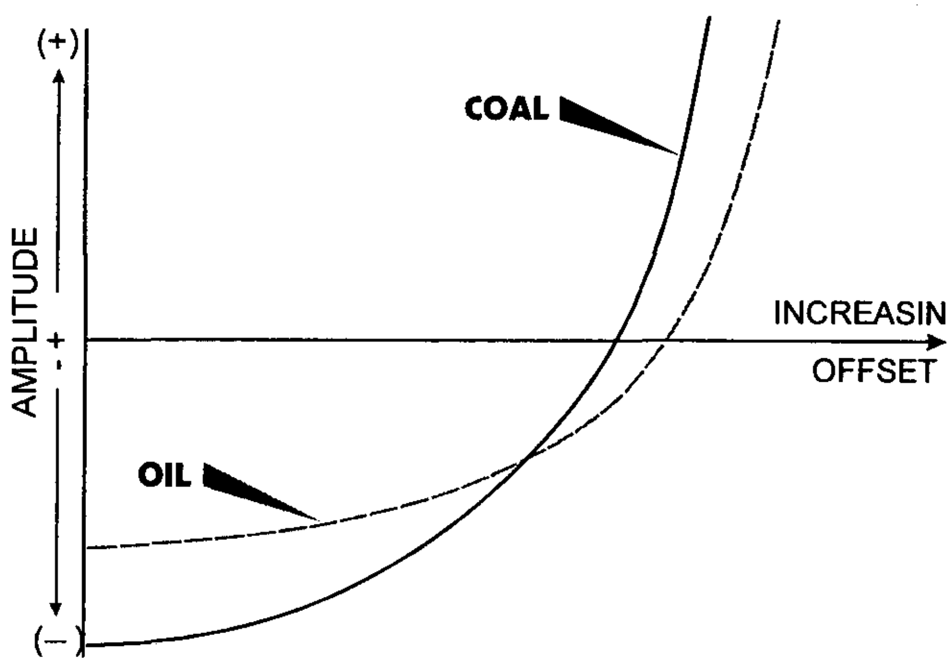
These lithologies are identified in the lithology column of the models attached in APPENDIX III. By varying the thickness of one of these lithologies, it was possible not only to model the seismic response to the actual thickness found in the well, but determine the response of the end members as has been done for pay and coal thickness presented in APENDIX III

From these models, it was determined that:

- Eastern View pay sands will be displayed on the BB96 data as a trough
- Wet sands are shown as a weak normal incidence trough and flat offset gradient as is shown in the figure below:

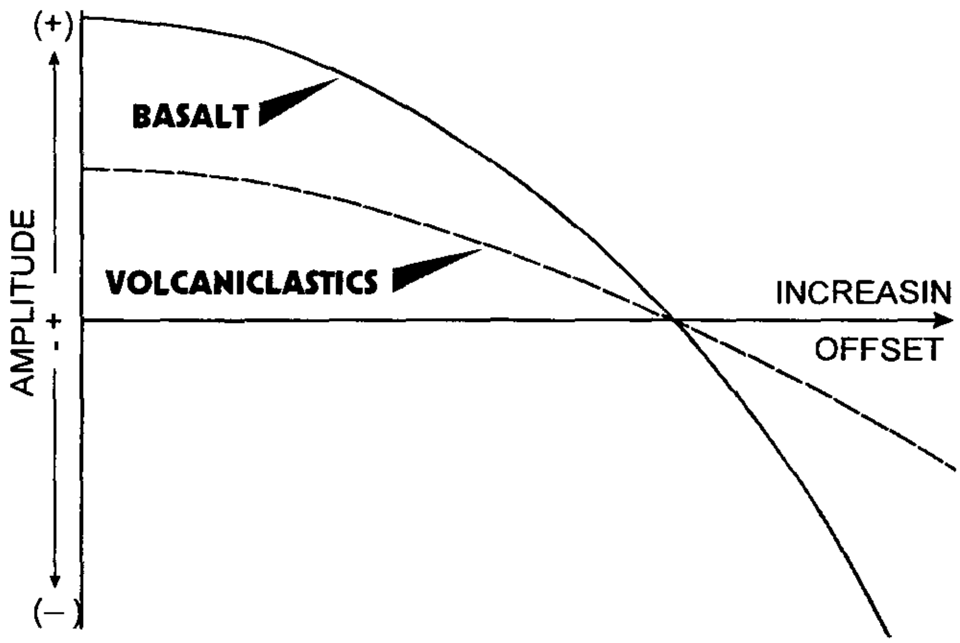


- Hydrocarbon bearing sands are displayed as a larger negative trough at normal incidence. The AVO response of hydrocarbon sands is a positive gradient with strong curvature beyond reflection angles of 27° as shown in the figure above.



- The AVO response of coal in the Eastern View is similar to that of an oil pay sand. This is not surprising since coal has high porosity and high hydrocarbon saturation as is shown in the figure above.

- There is little or no distinction between oil pay sands and coals, in the normal incidence domain. We will have to rely on the fact that oil filled reservoir sands will conform to the structural trap and coals will not.



- Basalts have a distinctive Normal Incidence and AVO signature. Starting with a strong positive reflection coefficient at zero offset, the amplitudes response is flat out to a reflection angle of about 26°, where the reflectivity rapidly diminishes to zero at about 35°, as seen in the illustration below:

- Volcaniclastics show a wide variation of both normal incidence and AVO behaviors. Typically these are seen as positive reflections with flat to slightly negative offset amplitude gradients as is depicted in the illustration below.

Cormorant Well Model

The normal incidence model indicates weak negative reflections for the wet sands in the upper most EVCM between depth1 and depth2. Similarly, the AVO response for these sands is flat to slightly negative. Below these sands are a series of strong negative reflectors with positive AVO gradients associated with the coal series.

For the thickest of these sands, marked as S_2 on the model, a Gassmann substitution of the pore fluids was made from water bearing to high GOR oil. Note the significantly deeper trough and strongly positive (less negative) amplitude with offset gradient. It is this sand interval which correlates with the Normal Incidence and AVO anomaly seen at Barrimundi. The modeled anomaly is very similar to the anomaly over the Barramundi Prospect, an example of which is shown in the AVO Interpretation section of this report.

About a thousand feet below the Top of EVCM there are a series of thin coals (three to six feet), which due to their spacing set up a tuning effect that results in a bright banded set of reflectors. These reflectors can be traced from the line BB96-50 tie to the Cormorant well, across to the Barrimundi Prospect. This band of reflectors largely prevented us from being able to evaluate potential deeper anomalies.

Yolla Well Model

Of primary interest in this well is the productive zones. The forty-foot thick oil pay zone at about 6000 feet, immediately below the Top of EVCM, is expressed as a seismic trough. Several tests were taken in this zone resulting in flow rates from 1198 BO and 2.2 MMCF to 892 BO and 11.8 MMCF. This results in calculated GOR's from 1836:1 to 3377:1, depending on the zone tested. This variable GOR, from what has to be the same reservoir, is in our view due to permeability variations within the zone tested. Since gas is about 100 times more permeable than oil, we believe the lower figure more accurately represents reservoir gas saturation. Seismically, this sand is characterized by a larger negative trough at normal incidence, than wet sands, and in the offset domain shows a positive gradient with strong curvature beyond reflection angles of 27° .

A significant amount of dry gas, up to 15 MMCF was tested in a lower zone below 9000 feet, but this sand appears to be relatively tight from well logs, and it is problematical that this zone could sustain these rates. Since the vertical separation between these two zones is insufficient to explain this dramatic difference in GOR, and the fact that most of the source rocks in this portion of the basin are still within the oil generation phase, we also assume this is related to reservoir permeability. This zone models with much the same response as the oil zone above, which may be further evidence that ratio of dissolved gas is much lower than indicated by the production test. The fact that the Normal Incidence and AVO response is much weaker than that of the shallower zone, when in fact gas should give a stronger response, is also taken to mean this interval is lower in porosity.

Also of interest is the response of the three hundred-foot thick Igneous layer around 8500 feet. The seismic response of this layer is totally unlike any of the other lithologies modeled in this well. Starting with a strong positive reflection coefficient at zero offset, the amplitudes response is flat out to a reflection angle of about 26°, where the reflectivity rapidly diminishes to zero at about 35°.

Tilana Well Model

This well was chosen to model because of the relatively thick volcaniclastic and igneous layers within the EVCM. The nearly homogenous igneous body at approximately 6700 feet exhibits minor internal reflectivity, while the volcaniclastics layer from 10,000 feet to TD is seismically active with strong internal reflectors, related to variety of textures, densities and matrix velocities typical of these types of rocks.

Predictive Analysis

Limiting Factors

As in every DHI investigation, there are limiting factors affecting NI and AVO Interpretation. Below are factors, which were weighed during the investigation, along with our assessment of the impact each factor has in contributing to the overall accuracy of our predictions:

- *Lack of shear wave information from any wells in this basin* required us to use default values for shear velocities. The greatest cause of concern was the values to be used for coal. There is an extremely wide range of possible values for coal depending on the type of coal, depth of burial, hydrocarbon saturation etc. For this study, values used were taken from published values given for Permian coals in Southeast Australia. These values, if in error probably de-emphasize the effect of coal.

- *Less than optimum cable lengths* were used in all of the seismic data acquired in this area. Since the AVO effect of pay sands is most prominent beyond reflection angles of 27°, a streamer length of 15,000 feet would have been desirable. This longer cable would also magnify the cable jerk noise problems discussed earlier.

- *Inadequate source input.* On the weaker shot records it was apparent that there was a loss of reflection amplitude simply due to spherical spreading on all events, not just the event under discussion. It is our view that these records represent a small sample of the overall database. In addition, the effect of the three on one supergather was to minimize this effect.

- *Inconsistent source input.* Due to wave action, the air guns were firing at varying water depths affecting source strength and signal. Again the effects of the supergather helped mitigate this problem.

- *Noisy input records.* In an effort to reduce noise, seismic processing was necessary which had the potential of disturbing the amplitude relationships we were trying to measure. Every possible precaution was taken to ensure that this didn't happen.

- *Lack of amplitude tie.* Due to the problems discussed above, and software limitations, it was not possible to deal with this problem effectively. Consequently were reluctant to make quantitative judgments, regarding bed thickness involving tuning.

- *Amount of faulting in reservoir.* The segmented reservoir in this case meant that in any segment, there were a limited number of common downdip terminations with which pinpoint water levels.

Conclusions

- There are normal incidence and AVO anomalies over the Barramundi Prospect which represent fault bounded reservoirs

- Estimates of reservoir thickness range upwards from one hundred eighteen feet, to as much as 300 feet.

- These Reservoirs cover an area of some fourteen thousand acres.

- They are likely filled with oil and dissolved gas whose GOR ranges from 1700 to greater than 4500: 1.

- Potential Reserves are estimated to be 420 Million barrels of oil.

- There are additional anomalies among the coaly portion of the EVCM, which are not included in this analysis.

Future Work

A great deal more analytical interpretative work could be done on this data set to enhance its predictive results. There are several important preconditions to initiating an extended study. These are:

- Gaining a better well tie within the anomaly area
- Obtaining pertinent shear wave data
- Grid balance and amplitude tie data set

Meeting these requirements would enable us to perform an AVO inversion which, would greatly enhance our ability to predict:

- Sand thickness
- Reservoir porosity
- Reservoir fluids and GOR
- Enable to look for pays in the lithologically more complex Middle EVCM

APPENDIX I: TRACE AMPLITUDES

Trace Amplitudes: (Gray Scale)
These are the migrated time sections on which the structural horizons were picked. They have been played out at the same scale as the attribute section for easy reference and comparison.

APENDIX II: ATLAS OF SEISMIC ATTRIBUTES

Seismic Trace Attributes were generated for each line in the study, and are here presented with the study horizon shown in red. A listing and brief description of each attribute as well identifying color scheme is given below.

Normal Incidence: (Red / Blue Display)
This display reflects stacked trace amplitudes with range offset effects removed and is the best display to analyze the normal incidence anomaly and anomaly isochron.

Product Gradient: (Red / Black Display)
The product gradient is the algebraic product of the normal incidence intercept (amplitude value where X = 0, and the slope of the amplitude increase (decrease) with offset. It is designed to emphasize certain amplitude with offset behaviors. For instance, pay sands in the EVCM show a negative intercept and a positive gradient, resulting in a negative Product Gradient. The same sand in a water bearing state will demonstrate a slightly negative gradient, resulting in a positive Product Gradient, completely different in sign than that of a pay sand.

Instantaneous Frequency: (Red / Green Display)
This attribute is calculated from the trace amplitudes using certain assumptions, such as constant phase of frequency components of the signal and uniform spacing of the reflection series. Changes in rates of curvature of the seismic signal are then seen as changes in "frequency". Rapid changes amplitude slope are seen as high frequencies. As an amplitude trough becomes deeper, its sides become steeper and are "higher in frequency". Consequently, amplitude troughs, representing sands show increasing frequency with increasing hydrocarbon saturation.

APPENDIX III: AVO Modeling Study

APPENDIX IV: AVO Interpretation Map Atlas