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Pacific Oil & Gas Pty. Limited

GEOPHYSICAL INTERPRETATION OF NORTHERN BEETALOO SUB-BASIN

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Date: 13 April 1994

PR94/18 A

VOL 1

Submitted to: K.D. Tuckwell

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CRAE Report No. **305020**

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1 SUMMARY AND RECOMMENDATIONS

The seismic data in the Northern Beetaloo Sub-basin was re-interpreted incorporating gravity and TEM data. For time interpretation, Schlumberger's CHARISMA interactive interpretation system was used in a bureau basis. The interpretation on the CHARISMA system confirmed the previous "colour pencil interpretation" to be reasonable. Only minor adjustments were made to the previous interpretation, where seismic data alone is available.

Time interpretation, however, was improved in the Chanin area by referencing to the thickness trend of the base of Cambrian basalt inferred by gravity interpretation.

The resultant depth maps of the "Jamison Sandstone" and "Moroak Sandstone" in the Chanin area bear more confidence than previous ones, because a complete gravity, TEM and seismic data set is available. A statistical analysis of the data shows little improvement can be achieved in other areas where the data set is incomplete.

While gravity and TEM interpretation helps improving depth conversion of seismic data, its data density, every 500 metres, is not comparable with that of seismic data, typically 125 metres sampling interval supported by 20 times data redundancy (6.25 metres CDP interval).

In summarising the conclusions:

1) interpretation on a workstation is fast and increases reliability by frequent/concurrent monitoring, but the results is only marginally different from manual interpretation.

2) with the amount of the constraining data, the Chanin structure cannot be conclusively determine its closure; it still presents a very long narrow "nose" which the pre-drill geological inference stated a strong possibility of a closure. The drilling location is the crestal position within the available dataset.

3) the Ronald structure was remapped with seismic and well data alone, and presents a closure at the "Jamison Sandstone" level, but somewhat weak closure at the "Moroak Sandstone" level.

4) All the leads previously mapped are still present in the current maps. However these leads are supported by a small number of seismic data points.

To improve the quality of depth structure mapping, it is recommended, without economic consideration:

1) to acquire better seismic data with a closer group interval, say five metres as suggested by Mitchell (1993).

2) to process the seismic data with a particular attention to shallower horizons and static correction; "manual statics" (NEDO, 1994) and "dynamic correction" (Digicon) may help.

3) to increase data density of gravity and TEM by at least four times to make it comparable with that of seismic data.

It is also recommended to improve data flow to ensure timely delivery of maps.

2 INTRODUCTION

Approximately 2700 kilometres of seismic data was recorded in the Beetaloo Sub-basin between 1989 and 1992, of which about 2000 kilometres are in the current northern exploration acreages of EP18, EP23 and EP24 (PetNTcw9555A).

The general poor quality of the seismic data and particular uncertainty in velocity estimation make the depth mapping by seismic data alone very difficult. With help from the gravity data in controlling the effect of the anomalous thickness variation of the Cambrian basalt, the depth of the "Jamison Sandstone" was successfully predicted at the **Chanin 1** well (Menpes, 1993). Other wells, without the gravity data, presented up to nine per cent error in depth prediction of the same horizon. This is still within the range of the world standard of depth estimation error in wildcat areas, however, further improvement was urged.

An interactive seismic interpretation workstation was used for the first time with the McArthur Basin data to improve accuracy and speed. The ability of changing scales and flattening a horizon during interpretation is the main aid in picking horizons. Displaying tie points on cross-lines helped check misties and cycle jumps which may occur between control points. The system displays horizon time in map form as it is interpreted. This enables quick check and iteration of horizon time pick.

In late 1993, additional gravity, ground magnetic and TEM surveys were carried out in the northern Beetaloo Sub-basin. The dataset obtained from the surveys provided a valuable information to depth conversion of interpreted seismic data. In the present work, the velocity derived from seismic velocity analysis is not used for depth conversion, but the well velocity survey is used as the main source of velocity information supported by sonic log data.

A new method was designed to incorporate the gravity and TEM data into seismic depth conversion. The scope was first to estimate the depth of base of Cambrian, or base of basalt, from the gravity and TEM data tied to wells, then to calculate the depth of underlying horizons by successive "layer-cake" method using time differences between seismic horizons and corresponding interval velocities from well velocity surveys and sonic logs.

The wells drilled in 1993 on the prospects identified by the seismic interpretation did not show significant hydrocarbons. The structural validity of those prospects is questioned. The present report includes the structural maps of those prospects generated by re-interpretation incorporating the additional data.

3 DATA DESCRIPTION

3.1 Seismic Data

Almost 2,700 kilometres of seismic data was collected in Beetaloo Sub-basin between 1989 and 1992 (Suto, 1993), of which about 2,000 kilometres lies in the current exploration acreages EP18, 23, 24 and 33.

The data quality is poor owing to difficulty in signal penetration, mode-converted waves and abundance of secondary noise sources (Kennett, 1993; Mitchell, 1993; Muedter; 1993). The inconsistent near surface layers add difficulty in static correction while general high velocity of Proterozoic sediments reduces resolution of seismic data. Consequently the velocity analysis is extremely difficult.

Depth conversion using seismic velocity resulted in errors up to nine percent at wells. The NMO velocity to stack the data set is much slower than the usual range of deviation from the average velocity.

The variable near surface condition presents a difficulty in static correction of the seismic data. The data corrected with refraction statics tied to upholes does not solve the statics problem sufficiently because anomalous irregular variation of interval velocity of Cambrian limestone extends to lower than the seismic reference datum (SRD). Three layer refraction statics method was employed to correct it.

While this method improves the stacking of the data, it causes difficulty in tying the velocity survey. The static correction values derived from the three layer refraction statics includes correction under the SRD, and are considerably different from the velocity survey data measured at SRD at wells.

Every field effort was made to improve the data quality: the multiplicity was increased to as high as 275-fold; the VP interval and receiver group interval were reduced to as low as 10 metres in a part of the 1992 survey. Even with this intense field effort, the data quality is not high standard particularly in shallow reflectors. It was also noted that the production rate at these parameters was economically unattractive, and the group interval was reverted to 12.5 metres.

3.2 TEM Data

The TEM surveys were carried out in three phases: on experimental survey in 1991; in a part of the Jamison grid in 1992 and in the Chanin area in 1993. Details of these surveys and interpretation are given in Isaev (1991), Isaev (1992), Surkov et al (1992), Lane (1992) and Lane (1994).

The TEM data is particularly useful in estimating the depth of the base of high-conductivity basalt and in finding high-resistivity anomaly in sandstones which may be caused by hydrocarbon.

All the seismic lines in the Chanin area were covered by the TEM survey, while selected lines were surveyed in the Jamison grid and only five soundings each were recorded near **Ronald 1** and **Burdo 1** wells.

3.3 Gravity Data

The published BMR gravity map is from their survey of 1965 and is based on a coarse regional irregular grid approximately 10 kilometres apart on average between stations (BMR, 1967).

Additional gravity data was collected by Pardi Pty Ltd in 1989 along the Carpentaria Highway and the fence lines now near the **Chanin 1** well. After drilling **Chanin 1**, more gravity data was collected along the seismic lines covering entire Chanin grid and parts of the Ronald and Burdo areas at 500 metre station interval. No gravity work was carried out over the Jamison Grid.

The gravity data defines the Beetaloo Sub-basin well in the regional sense. When the regional basin trend is removed the residual gravity anomaly mainly represents the depth and thickness of the Cambrian basalt.

3.4 Well Log Data

Three wells were drilled in EP24 in 1989: **Altree 2**; **McManus 1** and **Walton 2**. Between 1990 and 1992 four wells were drilled in the southern EP18 (**Jamison 1**, **Mason 1**, **Balmain 1** and **Shortland 1**) and two wells in 1993 in the northern EP18 (**Chanin 1** and **Ronald 1**). In EP23, **Burdo 1** was drilled in 1993.

All the EP18 and 23 wells intersected the Cambrian basalt, "Hayfield Mudstone", "Jamison Sandstone" and Kyalla Member. **Jamison 1**, **Chanin 1**, **Chanin 1**, **Ronald 1** and **Burdo 1** reached Moroak Sandstone. Cambrian Sandstone (Bukalara equivalent?) was intersected in all the southern EP18 wells except **Mason 1**.

Until 1993, the wells were drilled with no return through the Cambrian limestone and basalt sections, and were cased as soon as the base of basalt was reached in order to avoid collapsing. No wireline logs were recorded in this interval. The only available information in the interval is rate of penetration and occasional cuttings, upon which the depth and thickness of the basalt was estimated.

In 1993, the casing was set within the basalt and the lower part of the basalt could be logged for the first time in **Chanin 1** then in **Ronald 1** and **Burdo 1**. Sonic interval transit time data over the part of the basalt is available in these three wells. Yet estimation of the depth of the top of basalt still relies heavily on rate of penetration.

3.5 Well Velocity Survey Data

Checkshot surveys were carried out in all the wells. Most wells show fair to good quality data. However the shallower part of the wells does not give good quality data because of the casing. This presents a problem in establishing ties to the seismic reference datum.

4 PRESENT INTERPRETATION

4.1 Seismic Time Interpretation

An interactive seismic interpretation system, CHARISMA, was used for time interpretation.

The previous interpretation of top of "Jamison Sandstone" and Moroak Sandstone was transferred from Encom's file, which had been interpreted on paper sections in early 1993 and digitised. These two horizons were reinterpreted on CHARISMA using old interpretation as a guide. This led to an occasional minor refinement of the horizon time interpretation correcting small excursion of the interpreted horizons from a consistent part of the seismic signature. In most of the area, this refinement is small, considering the contour interval of final time map of 10 milliseconds, and the change is thought to be negligible. However some significant refinement was applied to the areas near **Chanin 1** where the gravity data indicated some inconsistency in terms of the thickness of the Cambrian basalt (See 5.2).

Three additional horizons were interpreted: base of "Jamison Sandstone" and top and base of Cambrian basalt.

The base of "Jamison Sandstone" is observed as an unconformity most convincingly on the northern part of the line MD92-251. The capability of horizontal squeeze of the interactive system assists this recognition. In other areas, the unconformity is occasionally recognised, but is not definite as the high level of cross cutting noise often resembles termination of reflectors under an angular unconformity.

A special study was carried out at the National Centre for Petroleum Geology and Geophysics (NCPGG) to interpret top and base of the Cambrian basalt (Donley, 1993). The study only interpreted the horizons on the seismic lines with wells. The results of the study was transferred onto the CHARISMA system. On examination, considerable errors in interpretation were found in well-ties and intersection ties. Consequently, this interpretation had to be totally revised. This indicates ambiguity of the data and difficulty in interpretation of these shallow horizons.

Time maps of the "Jamison Sandstone" and "Moroak Sandstone" are presented at 1:100,000 regional scale (PetNTcw9638, 9639, 9644 and 9645), and each prospect and lead is plotted at 1:50,000 (PetNTcw9636, 9637, 9633, 9628, 9635, 9627, 9634, 9629, 9631, 9670, 9626 and 9632).

4.2 Gravity and TEM Interpretation

The interpretation of gravity and TEM data was carried out using GEOSOFT, GLENDL and UBC inversion softwares (Lane, 1994).

The depth of the base of the Cambrian basalt was calculated at every station tying to the well data. The depth profiles were manually smoothed between the stations.

4.3 Incorporating the Airborne Magnetic Data

As stated in 4.1 and 5.1, seismic interpretation of the shallow horizons is extremely difficult due to low signal/noise ratio partly resulting from low fold.

To aid the seismic interpretation of the Cambrian basalt, the aeromagnetic data was used. The aeromagnetic data with modern image processing shows a characteristic signature of the basalt. Observing this, it is possible to identify the extent of the basalt along the seismic lines. They were plotted on the seismic sections to indicate truncation edges of the Cambrian basalt. The time interpretation was carried out in accordance of the truncation edges. (PetNTcw9466, 9467, 9468, 9469, 9470, 9471, 9472, 9473, 9474, 9475 and 9476).

5 DEPTH CONVERSION

5.1 Depth Conversion Method

The depth estimation of the top of "Jamison Sandstone" and Moroak Sandstone was planned to deploy "hybrid layer-cake method". With this method, the depth of the base of the Cambrian basalt is first estimated by the gravity and TEM methods. The thickness of the subsequent stratigraphic units are calculated from seismic interval travel time and interval velocities from the well velocity survey, then added to the depth of the base of Cambrian basalt to reach the target sandstone horizons.

This method is chosen because:

a) the gravity and TEM claim the ability of estimating the depth of the Cambrian basalt with reasonable confidence, where seismic method cannot; and

b) the velocity information from the well velocity surveys and sonic logs shows fairly stable interval velocity, while velocities from seismic velocity analysis are considered unreliable.

The method requires:

a) accurate depth estimation of the base of the Cambrian basalt;

b) accurate time interpretation of the *same* horizon;

c) accurate time interpretation of top and base of the "Jamison Sandstone" and top of the Moroak Sandstone; and

d) accurate interval velocity of the "Hayfield Mudstone", "Jamison Sandstone" and Kyalla Member.

To fulfil the above requirements, seismic horizons were tied to the wells at the time indicated by the velocity survey rather than seismic characters (PetNTcw9557, 9558, 9559, 9560, 9561, 9562, 9563, 9564, 9565 and 9566).

The "hybrid layer-cake" method was applied to the Chanin area where the gravity/TEM/seismic dataset is complete (see 6.1).

In the Ronald area and the Jamison grid, the gravity and TEM data are not available on all the seismic lines. For this area, it was hoped that an average velocity trend to the base of basalt could be established from the areas where the dataset is complete, and that the trend could be applied to the areas where seismic data alone is available. In other words, if the depth of the base of the Cambrian basalt estimated by the gravity and TEM data had a strong correlation with any aspect of the seismic time horizons, then that correlation could be used to estimate the depth of the base of the Cambrian basalt where seismic is the only data available. As a result of data analysis such a correlation could not be found (see 6.2) and the conventional "layer-cake" method was applied to the Ronald area (see 7).

5.2 Monitoring Interpretation

The initial interpretation of seismic horizon time was displayed with gravity and TEM data at a consistent horizontal scale (PetNTcw9581, 9582, 9583, 9584, 9585, 9586 and 9587). The time interpretation of the top and base of the basalt was checked against the other geophysical data for consistency.

A particular attention was paid to agreement between thickness of the basalt and the gravity profile. If the gravity decreases where seismic interpretation shows increase of thickness of basalt, then a suspicion on the validity of the interpretation is cast. Usually, the cause of such an inconsistency is the ambiguity of the seismic data, and a possibility of alternative interpretation is sought.

Examples of alteration are shown in PetNTcw9696, 9697, 9698, 9699, 9700, 9701, 9702, and 9703. In each case, the time interpretation of the base of the Cambrian basalt is altered to make consistent with the gravity profile. All the alterations are in the Chanin area where precise gravity data is available.

In some of the cases, the original seismic interpretation seems correct by its own right. On line SH90-103 for example (PetNTcw9698 and 9699) the seismic data shows a feature which appears channel-fill of basalt with apparent velocity pull-up in the lower horizons. The original interpretation was, thus, justified. However, the gravity profile shows no appreciable thickening of basalt, and the time interpretation was modified accordingly.

The seismic data in this area is known to be noisy and is particularly ambiguous in shallow horizons. Thus the gravity data was honoured to correct seismic interpretation. But there is no means of checking the quality of gravity data except for its internal consistency.

6 DEPTH CONVERSION IN THE CHANIN AREA

The seismic time interpretation in the Chanin area was converted to depth by the method described in 5.2.

The depth profiles of the horizons are presented in PetNTcw9652, 9653, 9654, 9655 and 9656. The depth maps of the Chanin area are PetNTcw9704, 9705 and 9706.

6.1 Depth Maps

The depth structure map of the base of Cambrian basalt was produced from TEM interpretation (PetNTcw9674). This shows a prominent trough over the **Chanin 1** drilling location. This trough is filled with the Cambrian basalt, which may cause a velocity pull-up to the lower seismic horizons. The velocity anomaly caused by the thickness variation of the basalt is not easily estimated (see 6.2).

The depth structure maps of the top of "Jamison Sandstone" was drawn by adding the thickness of "Hayfield Sandstone" calculated by multiplying the internal travel time with the interval velocity.

The interval velocities of the Proterozoic lithological units from the velocity survey of **Chanin 1** are shown in Table 1 below.

UNIT	INTERVAL VELOCITY
"Hayfield Mudstone"	3910 m/sec
"Jamison Sandstone"	4350 m/sec
Kyalla Member	3830 m/sec

Table 1: Formation Interval Velocity - Chanin 1

The depth map of the top of the "Jamison Sandstone" is on PetNTcw9704. The map shows the long high "nose" extending from northwest. There is an option in contouring whether or not to close the Chanin structure. There is not enough data to constrain the contouring. The pre-drill geological interpretation was that presence of such a thin ridge not forming a closure is geologically improsible. It is noted that the pre-drill map predicted the depth of the top of "Jamison Sandstone" exactly (Menpes, 1993).

The Moroak Sandstone depth map (PetNTcw9706) also shows a "nose" from northwest. But the relief over the Chanin structure is somewhat smaller.

The feature that the lower horizon has less relief than the upper horizon was often questioned for its geological validity. Lister (1993, *pers. comm.*) explained this as a result of "stress guide" (see Memo PET-67-2.10; 25 November 1993, in Appendix II) whereby a competent layer, thick Moroak Sandstone in this case, takes most of stress and deforms most.

6.2 Search for Velocity Trend

To examine the relationship between the seismic horizon time and depth of the base of the Cambrian basalt, a series of graphs were plotted. The purpose of this exercise is to find a relationship useful in depth conversion in the areas where only seismic data is available. So these plots are an effort to find a velocity or velocity trend which can be related to seismic horizon times.

First of all, the seismic two-way time to the base of the Cambrian basalt is plotted against the depth derived from gravity and TEM interpretation (PetNTcw9693 and 9692). If the average velocity to the base of the Cambrian basalt is constant, the points will fall on a straight line with its slope being the average velocity, then that average velocity can be applied to other areas where gravity and TEM data are absent.

The plots show a positive correlation between the depth and seismic two-way time of the base of Cambrian, and the correlation was slightly improved by the revision of interpretation from 0.79 to 0.81. However the graphs show that at any two-way time the corresponding depths range 50 to 150 metres.

This is clearer in the second set of graphs on which the average velocity to the base of Cambrian is plotted against the two-way time (PetNTcw9676 and 9691). At any two-way time, the corresponding average velocity can be anything between 3000 and 4500 m/sec. This shows the average velocity of the overlying material is independent of its burial depth or thickness.

The geology between the seismic reference datum and the base of Cambrian consists of Tindall Limestone and Antrim Plateau Volcanics (Cambrian basalt). The seismic velocity of these rocks are in contrast: around 4000-4500 m/sec for the limestone and 5500-6000 m/sec for the basalt. It was expected that the variation in average velocity is related to the variation of the composition of the rocks.

As the third attempt, the average velocity to base of the Cambrian basalt was plotted against seismic two-way interval travel time through the basalt (PetNTcw9677 and 9678). The plots show a considerable scatter, i.e. the correlation in each case is low.

The plot from the original interpretation (PetNTcw9677) shows a weak negative correlation between the two variables. This is inconsistent with the consideration of interval velocity. After the revision (PetNTcw9678), the correlation coefficient turned positive, albeit the absolute value is small (0.28). This change gives some confidence in the revised interpretation. Yet the correlation is not sufficient to derive a function to determine average velocity from the two-way interval travel time of the basalt. The range in the average velocity is 1500 m/sec regardless of the thickness of the basalt.

Finally, the proportional composition of basalt and limestone is taken into consideration of average velocity. Graphs in PetNTcw9687 and 9688 show the average velocity plotted against the ratio of seismic two-way travel time of basalt to that of total Cambrian formations. These graphs again fail to show any definite relationship between the proportional composition of basalt and the average velocity. It is noted that the correlation coefficient between these parameters turned from negative to positive after the revision of the interpretation. Although the absolute value is small this is consistent with geological expectation.

The graphs PetNTcw9683 and 9684 are average velocity to base of Cambrian basalt plotted against proportional composition of the limestone, which are reciprocal of PetNTcw9687 and 9688.

7 DEPTH CONVERSION OF OTHER AREAS

7.1 Jamison Area

A statistical analysis identical to what applied in the Chanin area was carried out over the whole area where the depth of base of the Cambrian basalt was estimated by TEM, before and after the revision of time interpretation in the Chanin area (PetNTcw9695, 9689, 9679, 9685 and 1682; PetNTcw9694, 9690, 9680, 9686 and 9681).

Hardly any correlation can be observed between the average velocity to the base of the Cambrian basalt and any of the parameters plotted. Also the average velocity ranges by more than 1500 m/sec at any value of the parameters considered. Therefore this statistical analysis shows that the average velocity to the base of the basalt cannot be confidently determined by any of the seismic parameters considered.

In other words, the depth of the base of the Cambrian basalt cannot be confidently estimated from the seismic time interpretation where the TEM data is absent. As the depth conversion of the lower horizons depend on the depth estimation of the base of the Cambrian basalt, the "hybrid layer-cake method" cannot be used in this circumstance.

As the time interpretation did not change significantly (see 4.1), and no additional information is present, no further attempt in depth conversion in the Jamison grid is performed. The previous maps (PetNTcw9210, 9211, 9219, 9220) cannot be improved by this different method of depth conversion.

7.2 Ronald Area

A small amount of gravity and TEM surveys were carried out near **Ronald 1** and **Burdo 1** in 1993. An extensive, but not on all the seismic lines, TEM survey was carried out in the Jamison grid in southern EP18 in 1992.

Depth of the base of the Cambrian basalt was estimated using GRENDL software on these lines. Examples of the depth profiles are on PetNTcw9667 and 9668.

Comparing the gravity profile with the time interpretation of top and base of the Cambrian basalt, the consistency between them is considered good (PetNTcw9650, 9660, 9661 and 9662).

However the gravity and TEM data coverage in the Ronald area is scarce, and the "hybrid layer-cake" method cannot be applied.

Here an additional information of the **Ronald 1** well is now available. Using the interval velocities derived from the velocity survey (Hibbird, 1993) the conventional "layer-cake" method is applied to the area. The interval velocities are assumed constant over this relatively small area (Table 2).

UNIT	INTERVAL VELOCITY
Undifferentiated	2533 m/sec
Cambrian Basalt	5594 m/sec
"Hayfield Mudstone"	3981 m/sec
"Jamison Sandstone"	4125 m/sec
Kyalla Member	3758 m/sec

Table 2: Formation Interval Velocity - Ronald 1

The depth maps of "Jamison Sandstone" and Moroak Sandstone) PetNTcw9707 and 9708) were produced by this "layer-cake" method. These maps are subject to refinement when more TEM data becomes available therefore "Preliminary" is attached to the title, but they represent the best attempt with the available data.

The "Jamison Sandstone" structure map shows a closure with the crest at the drilling location. The map of Moroak Sandstone structure also shows a closure but it can be easily open by recontouring.

8 DISCUSSION AND CONCLUSION

The "hybrid layer-cake" method of depth conversion was applied to the Chanin area, where the complete gravity/TEM/seismic dataset is available. The TEM interpretation provided the depth of the base of the Cambrian basalt and depth of the underlying horizons were calculated by "hanging down" from the base of basalt using seismic horizon times and interval velocities from the well velocity survey.

The difference is data density between the gravity/TEM data (every 500m) and the seismic data (every 6.25m resampled at every 125m) may affect the horizontal resolution of the depth maps. The scarcity of the gravity/TEM data acts as a spatial high-cut filter in depth conversion. In order to achieve a horizontal resolution comparable to that of the seismic data, a denser gravity/TEM survey is necessary. It is expected that the data density should be at least the same as resampling density of seismic time interpretation, every 125m or ten VPs.

However, due to the nature of gravity and TEM data, which integrates effects from a considerable volume of the earth, it may not be possible to achieve such a horizontal resolution; a theoretical calculation to establish an appropriate data density is necessary.

The statistical analysis performed on the depth and seismic time of the base of the Cambrian basalt showed that the depth cannot be confidently estimated from the seismic data alone. It shows that either or both of TEM and seismic data are reliable. The seismic data at this shallow level is known to be unreliable. The TEM interpretation tied the wells with a reasonable confidence. As with all the remote geophysical data, persistence of accuracy of TEM data away from the wells cannot be checked until another well is drilled in this area.

In this exercise, the Chanin structure was re-mapped with an increased confidence. The structure at the "Jamison Sandstone" has "weakness" in closure to the northwest: a long "nose" may open to that direction. This is the case at the pre-drill time. The additional constraint to the data by TEM and gravity does not conclusively determine the presence or absence of the closure, as the data coverage is not sufficient. Only geological inference that "presence of such a long narrow nose without a closure is geologically improsible" presents an argument for the structural closure of the Chanin prospect.

A conventional "layer-cake" method is applied to the Ronald area using the interval velocities from the **Ronald 1** well velocity survey. The Ronald prospect shows a depth closure at the "Jamison Sandstone" and the Moroak Sandstone levels but the closure of the latter is weak. The map can be refined with TEM data.

Both Chanin and Ronald structures show more relief on "Jamison Sandstone" than on Moroak Sandstone. The feature that the lower horizon has less relief than the upper horizon was often questioned for its geological validity. Lister (1993, *pers. comm.*) explained this as a result of "stress guide" (see Memo PET-67-2.10; 25 November 1993, in Appendix II) whereby a competent layer, "Jamison Sandstone" in this case, takes most of stress and deforms most.

The previously recognised undrilled leads, South Ronald (PetNTcw9636 and 9637) and East Jamison (PetNTcw9628 and 9633), were mapped in seismic time only. These leads are still present in the new interpretation. However they are defined by small portions of seismic data and further seismic/gravity/TEM surveys are required to work up to prospect status.

The quality of seismic data can be improved by more intense filed effort and more precise static correction. Both of them are labour-intensive, time-consuming, hence expensive.

Mitchell (1993) recommended a short group interval/shot interval (5m) while maintaining the high fold (275-fold).

Recent development of static correction algorithm of "manual statics" (NEDO, 1994) and "dynamic correction" (Digicon) may be worth a try. In whichever the case, spatial sampling interval and effect of smoothing must be closely monitored.

Finally, it is noted that the data flow of this work suffered from time to time and an improvement in the system is strongly recommended (Appendix I).

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LOCALITY

Tanumbirini (SE53-D)

KEYWORDS

Geophys-seismic; Geophys-gravity; Geophys-TEM; Geophys-electromagnetic; McArthur Basin; Northern Territory; Depth Conversion; **Chanin 1**; **Ronald 1**.

APPENDIX I

CHRONOLOGY OF THE PROJECT

1993	
October 4	Seismic data were forwarded to Schlumberger for loading on to Charisma system.
October 11	Interactive seismic interpretation started.
October 26	Deadline for delivery of interpretation of shallow horizons from NCPGG, not met.
November 1	Gravity/TEM surveys were completed.
November 10	Seismic interpretation of three Proterozoic horizons completed.
November 30	EP18 TCM - "Preliminary" depth conversion using the seismic velocities was presented because the depth and time data of the base of the Cambrian basalt was not yet available.
	Deadline for gravity/TEM depth estimate, not met.
December 8	Interpretation of Cambrian horizons from NCPGG was delivered (deadline October 26).
December 10	The above file was loaded on Charisma and checked.
	Errors in well ties and intersection ties became evident and total reinterpretation was necessary.
December 13	Errors were corrected and interpretation was extended to the lines not done by NCPGG.
December 29	Gravity profiles were plotted with seismic time interpretation.
December 23 - January 9	No progress in interactive interpretation as the Schlumberger staff had leave.
1994	
January 8 - 26	KS had leave.
January 28	Depth estimate by gravity and TEM was done by RJLL (deadline November 30).
February 1	Original statistical analysis.
February 2- 10	Schlumberger system not available.
February 11	Revision of interpretation.
February 16 - 25	CRAE, ASEG Conferences; Schlumberger system was also away.
March 4	Revised statistical analysis.
March 28	Depth map of "Jamison Sandstone", by RJLL.
April 11	NCPGG report not yet delivered.

③ PET-67-2.10

① **MEMO TO:** I. M. Clementson

② **COPY TO:** KDT/SAH/SAM/KPL/JT/RJLL

FROM: K. Suto

DATE: 25 November 1993

RE: **Stress Guide - Discussion with Prof. Lister**

On the evening of 23 November 1993, I visited Prof. Gordon Lister of Monash University at his home. We discussed the structure style of the McArthur Basin observed in the seismic sections: the structure of the Jamison Sandstone has relief variation with higher spatial frequency and amplitude than that of the underlying Moroak Sandstone.

Prof. Lister suggested a phenomenon called "stress guide", (I cannot find this term in the index of structural geology textbooks at hand; perhaps it is an engineering term). When layers of rocks with different strength are compressed, the strong (competent) layer takes most stress and results in folds with higher spatial frequency and amplitude. This phenomenon is not uncommon and occurs in any scale, microscopic, hand specimen, structural construction such as a dam, sedimentary basin or plate. The spatial frequency of the fold is closely related with the thickness of the strong layer: the thinner the layer the higher the frequency becomes.

The thickness-frequency relationship of the Jamison Sandstone structure is not yet checked.

Prof. Lister also mentioned that the orientation of fabrics in core samples may confirm the phenomenon. So far this sort of analysis is not carried out in our McArthur acreages.

K. SUTO

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