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FINAL REPORT

CENTRAL AMADEUS SEISMIC SURVEY

1973 - 1974

C.P. 175 AND 178

AMADEUS BASIN
NORTHERN TERRITORY

FOR

MAGELLAN PETROLEUM AUSTRALIA LTD.

BY

MANDREL INDUSTRIES INC.
FINAL REPORT
CENTRAL AMADEUS SEISMIC SURVEY
1973 - 74
O.P. 175 and 178
AMADEUS BASIN
NORTHERN TERRITORY
FOR
MAGELLAN PETROLEUM (N.T.) PTY. LTD.
BY
MANDREL INDUSTRIES INC.

AREA MANAGER
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ABSTRACT

A digital Common Depth Point seismic survey has been conducted for Magellan Petroleum (N.T.) Pty. Ltd. by Mandrel Industries, Inc. in blocks O.P. 175 & 178 of the Amadeus Basin located south and west of Alice Springs, Northern Territory.

The "Geograph" weight dropping technique was used in conjunction with a Sum-It digital field recorder to obtain 895.24 kilometers of 1200% coverage.

All data were processed in Alice Springs by the ComMand on-site digital processing center. Operations were commenced on July 3rd, 1973 and were completed on April 27th, 1974.

Mr. S. Wood of Mandrel Industries, Inc. was in charge of both the field crew and the ComMand processing center while client representation was provided by Mr. L.W. Pfitzner for Magellan Petroleum (N.T.) Pty. Ltd.
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INTRODUCTION

A digital Common Depth Point reflection survey has been carried out by Mandrel Industries, Inc. for Magellan Petroleum (N.T.) Pty. Ltd. in blocks O.P. 175 & 178 located in the Amadeus Basin, south and west of Alice Springs.

The program was divided into four basic areas entitled Ooraminna, Waterhouse, Palm Valley, and Mereenie (Figure 1).

The objective of the survey was to detail and confirm, if possible, anomalies which had been indicated by previous reconnaissance seismic, gravity, and drilling surveys.

A surface source method, the "Geograph", was employed throughout the survey to provide 1200% coverage. The data were recorded on a Sum-It Floating Point recorder. A total of 895.24 kilometers of coverage were recorded in 2692.85 hours of operation.

Data were processed in Alice Springs at the ComMand digital processing center. Reprocessing of single fold data which had been shot during earlier survey was also carried out in an effort to improve the signal to noise ratio.

Field operations were initiated on July 3rd, 1973 and were concluded April 27th, 1974.
OBJECTIVES

The program is divided into four basic blocks with several prospects contained in each block.

Mereenie

It was desired to investigate both flanks of the Mereenie and Glen Edith anticlines in an attempt to confirm suspected closures.

Along the southwestern flanks of the anticlines the possibility of closure exists along the footwall side of a northeasterly dipping thrust fault. Confirmation was desired of this closure by additional seismic work.

Previous seismic and gravity surveys have indicated an anomalous trend along the northeastern flank with possible faulting. It was desired to further delineate this trend and to confirm, if possible, the existence of faulting.

Further to the north the Gardiner Range anticline is intersected by the Carmichael - Deering structures. Single fold recording methods have previously yielded poor results and it was desired to obtain additional information on the suspected highly complex structural conditions through the use of 1200% C.D.P. recording.
Palm Valley

Five lines were dropped in the Palm Valley area in an attempt to further delineate the structure. Four of these lines were off the northern flank of the surface anticline while the fifth linked the Palm Valley No. 2 well with Palm Valley No. 3 across the top of the anticline.

PV1 line was dropped along the crest of the surface anticline to provide a seismic tie between the two aforementioned wells and to prove or disprove stratigraphic continuity.

Lines PV2, PV3 and PV4 were placed parallel to the northern flank of the Palm Valley surface anticline in an effort to determine if nosing exists.

Waterhouse

The southern flank of the Waterhouse Ranges is of interest due to the possibility of entrapments having been created beneath the northward dipping Waterhouse thrust fault.

To the south of the program area lie the James Ranges. A possible anomalous structure just off the northern flank of these ranges had been indicated by earlier single fold surveys but data quality was poor.

Program was designed to cover both the southern flank of the Waterhouse Ranges and the northern flank of the James Ranges.

Ooraminna

This area is considered prospective due to results of two early test wells. Additional program was deemed necessary in order to obtain data in previous "no record" zones.

Previous work had also indicated apparent differences between gravity and seismic profiles and it was desired to resolve these differences if possible.
LOGISTICS

Bases of Operations

The crew office consisting of the Party Chief, Seismologist, and the Computer plus the ComMand processing center were established in office space made available by Magellan Petroleum (N.T.) Pty. Ltd.

The field crew's operations were conducted from tent camps located near the center of the program areas.

Access to the prospects was good during dry periods via station and wellsites roads.

Terrain

Most of the prospects consisted of relatively open spinifex covered land intersected by occasional bands of scrub timber.

Topography ranged from anticlinal outcroppings such as the James, Gardiner, and Waterhouse Ranges, to gently rolling sand country. Sand dunes were encountered often in the Mereenie prospect.
Dozing

Line clearance was initially provided by a D-5 Dozer. In order to increase the production of line mileage this was replaced by a D-6 dozer and a Cat-12 grader. No problem was incurred in providing sufficient mileage for the recording crew with this combination. The Cat-12 grader was also used to create access roads wherever required.

Weather

Weather was unusually bad with an abnormal amount of rainfall incurred. A total of 594 hours of time was lost due to inclement weather.
SURVEYING

A K & E transit and a Wild T-2 theodolite were used for the survey. Wherever possible loops were closed and all hanging lines were double run. Elevations and horizontal control were taken from previous surveys, existing triangulation stations, bench marks, and well sites.

Permanent markers were established at intersections and ends of lines. Markers were also established at periodic intervals along the longer lines and at turning points in the line bearing. These markers consist of 5'6" star pickets with aluminum tags bearing line and station number attached. Appendix II lists all permanent markers and locations.

Vertical and Horizontal Loop Closure maps are included with this report.
EQUIPMENT

Vehicular

The crew was equipped with the following vehicles.

One (1) Party Manager's Toyota
One (1) Observing crew's Toyota
One (1) Surveyor's Toyota
Four (4) Geophone crew's Toyotas
One (1) Bedford - Cable Truck
Two (2) Acco Internationals - Water and Supply Trucks
One (1) R-190 International with recording hut
Two (2) Internationals with Longreach weight dropping units mounted
One (1) International with W/shop mounted
One (1) D-7 Caterpillar bulldozer
One (1) Tractor and float for moving dozer
One (1) Caterpillar-12 grader

Cables and Geophones

Twelve (12) CDP cables: 2000' length, medium duty, road type. Four reflection takeouts per cable spaced at 500' intervals. Beside each reflection takeout is located one refraction takeout and one spare takeout.

Geophones: 3360 EV-2A - 14 Hz, mounted 12 to a string.
INSTRUMENTATION

Sum-It Field Recorder

Data were recorded on a 24 channel floating point Sum-It (serial number 24). The output tape consists of a summation of 16 drops in an EPR, mpx 32, format. This tape is 9-track, $\frac{1}{2}$ inch, IBM compatible with a packing density of 800 bpi and is 2400' long. Recording was done for 4 seconds at a 2 millisecond sample rate.

SDA-1 Amplifiers

Minimum fixed gain allowable was 30db. Over this amount another 90 db of binary gain ranging was permitted in six db steps.

A low cut filter of 12Hz (12db) was utilized in conjunction with an aliasing filter of $62\frac{1}{2}$ Hz (80db).

SDW-300 Camera

A SDW-300, dry process, camera was used to display the recorded data.
FIELD OPERATIONS

Waterhouse

On July 3rd a noise analysis was conducted along the southern end of line 73-3-L6 (Figure 5). This was done in order to check the validity of the proposed field technique which had been designed from the analysis of noise parameters taken from data recorded further to the west near Gosses Bluff.

Examination of this noise analysis revealed that the major noise problem associated with the area was not high velocity boundary waves as indicated near Gosses Bluff, but multiple refractions of the Meissner type. The velocity of these multiples was approximately 1950 meters per second which corresponded to the velocity of the boundary waves measured near Gosses Bluff. Due to this coincidence the proposed field technique was valid even though the type of noise was different.

A center weighted 48 geophone array with a total length of 136 meters was employed (Figure 4).

To complement the spatial filter created by the combination of the source and geophone arrays, an electrical filter was used in the recording truck. This filter was a 12 Hz (12db) low cut.

A station interval of 140 meters was selected as it not only allowed sufficient offset when used in a split spread configuration but also permitted efficient usage of the desired geophone and source arrays.
A split spread field technique consisting of a \(2\frac{1}{2}\) station offset to the near trace was chosen. Offsets were 1890-350-0-350-1890 meters (Figure 2).

The above combination of electrical and spatial filters allowed a theoretical reflection recording band of 12 Hz to 70 Hz with an even attenuation of all coherent noise within this frequency range assuming a horizontal velocity of 2000 meters per second.

Lines 73-3-3.2 and 73-3-3.2 ext. were recorded using 100 meter station intervals and a 150 meter drop segment in an effort to improve data quality over a suspected near surface anticline (Figure 3).

Upholes were drilled throughout most of the area as a check on near surface conditions.
Palm Valley

After completion of the original Waterhouse program the recording crew moved onto the Palm Valley program. Operations were initiated using the same recording parameters as had been utilized in Waterhouse. Field data did not exhibit any severe noise characteristics and it was decided that no changes were required in the field technique.

One line, 73-3-PV1, was placed along the crest of the surface anticline. Access was difficult to this line and it was necessary to bend this line several times as it followed surface contours between the two wells it linked.

Upholes were also drilled along the lines in case additional weathering control was needed.

Mereenie.

Again the same field technique was employed. Little disturbance was noted from either boundary waves or multiple refractions; but, strong interference was noted in the areas of near surface or surface anticlines. It is thought that this interference may emanate from the surface of these anticlines in the form of near surface diffractions.

Again the up hole rig was employed to obtain near surface information.
Ooraminna

After initiation of operations in the Ooraminna area two problems were incurred. Multiple refractions were destroying shallow data on the longer offsets in some parts of the program area and a deep weathering channel ran through the northern half of the area causing a marked deterioration of data quality.

On two lines, 73-3-2.2 and 73-3-1.9 ext. station interval was reduced to 100 meters with the drop segment being reduced to 150 meters in length Figure (3). This was done in order to permit a higher effective stack without including refraction damaged data.

No upholes were drilled in this area. In the areas of near surface channelling the weathering appeared to be several hundred meters deep making uphole drilling impractical.
FIELD OPERATION SUMMARY AND RECOMMENDATIONS

Waterhouse, Palm Valley, and Mereenie

Data were of good quality except where program approached or transversed surface anticlines formed by Hermannsburg or Mereenie Sandstones. Data deteriorated drastically in these areas with quality ranging from poor to "no record".

Examination of data recorded in the vicinity of such anticlines revealed a high degree of coherent horizontal energy ranging from 5000 meters per second to 200 meters per second. This noise was of such high velocity that no attenuation was inflicted by the geophone and source arrays over the reflection bandwidth thereby preventing the recovery of signal.

One explanation for the proliferation of horizontal noise in the anticlinal areas is to theorize a high degree of minor fracturing in the Hermannsburg and Mereenie Sandstones which would act as point sources for near surface diffractions which are propagated horizontally.

It is suggested that long source and geophone arrays be employed with a split spread technique using a station interval of 50 meters. Offset would be 625-75-0-75-625 meters. Arrays should be of sufficient length to attenuate the high velocity horizontal interference which was prevalent in the anticlinal areas. This would necessitate severe ground mixing of arrays due to the short station increment but no harm should result.
Qoraminna

This area differs considerably in nature from the others. Two problems, probably interrelated, were encountered which caused a marked reduction in data quality.

A major weathering channel and its associated tributaries crossed the northern half of the program area. Due to this, an abrupt change of statics is required if proper datum corrections are to be made. Using first breaks taken from the field records it was estimated that this channelling could approach 700 meters in depth as compared with a normal thickness of weathering of 50-70 meters.

Within the area of deep weathering multiple refractions of high intensity disrupted data with a resulting deterioration in quality. In an effort to increase the effective stack before having to remove refraction interfered data by muting during processing, it was decided to reduce the station interval to 100 meters in order to decrease the total offset. This produced an offset of 1250-150-0-150-1250 meters. Both shallow and deep reflections were improved with this spread when employed on lines 73-3-1.9 ext. and 73-3-2.2.

This area is interesting both geologically and geophysically and two recommendations are made for any future seismic surveys. A dynamite refraction crew should be utilized to obtain static corrections, particularly for all work done north of the Alice Springs No. 1 well.

Station interval should be reduced to a maximum of 100 meters and preferably to 70 meters. Source and geophone arrays should be increased in length to attenuate the multiple refractions. This would create considerable ground mixing of arrays but should greatly enhance data quality.
PROCESSING

Introduction

All data, including the presentation of a provisional final section were processed and displayed on the ComMand on-site digital processing center.

The system is fully integrated and stand-alone in its capabilities. Basically, it is comprised of a RAYTHEON 704 computer, two AMPEX ½ inch nine track magnetic tape drives, fixed head disc, teletype input, and a GOULD electrostatic printer. A comprehensive software package is provided for use in diagnostic, analytical, bulk processing and display modes.

The ComMand enables rapid inspection of data with preliminary or 'brute' stacks available only a few hours after reception of tapes from the field recorder. Minimum turnaround with maximum effort is a feature of the ComMand with co-operation and supervision by the interpretation team encouraged at all stages of the operations.

Data Quality

Processed data were generally good to excellent in the Waterhouse and Palm Valley prospects with marked deterioration encountered in areas of rugged surface terrain and outcroppings.

In the Mereenie and Alice Springs prospects, record quality ranged from excellent across synclinal troughs and anticlinal flanks to poor over the associated anticlinal crests and inferred structural disturbances.

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Processing Parameters

Processing parameters employed were subject to extensive pre-use scrutiny and testing, both before and after stacking. A generalised processing flow chart is enclosed (Figure 6).

After reformat of the field tape, a double action amplitude recovery routine was applied consisting of a synthetic amplitude recovery and digital AGC. The output was subjected to a series of frequency analyses both in the time and frequency domains utilising autocorrelogram plots and power spectra. From these investigations a pre-stack deconvolution pass was determined and applied using a 0.160 sec (later increased to 0.200 sec) operator in the frequency domain. This process was designed both to 'whiten' the frequency spectrum over the expected signal range and to attenuate any short period reverberations in the data originating in the low velocity surface layers.

Following deconvolution, a bandpass filter was applied with the purpose of band limiting the frequency spectrum to the desired range determined by examination of computed SIGNAL/NOISE ratios.

Normally the next stage consisted of producing a 'brute' stack enabling preliminary interpretation to begin. Following the presentation of a preliminary stack analytical work was carried out in an effort to achieve optimum NMO determination with emphasis placed on velocity control over structural highs. Tools employed consisted largely of VELSTACK (a constant velocity stack program) and CDS/CVS (common distance traces output with a suite of constant velocities). Reliability is considered good with acceptable ties effected to available well logs. Velocities are generally high with near surface velocities ranging from 3000 to 4000 metres/sec.
Following velocity determination, a series of corrected gathers were run in order to design an effective trace suppression or muting function to remove unwanted head waves, refracted energy and first break noise ahead of the true reflected signal.

Application of an automatic residual statics routine (statcor) followed which served to further refine the stacked output.

Post-stack processing included the extensive utilisation of long period time domain predictive deconvolution using operator lengths determined after examination of sectional autocorrelograms (SAC) while a final digital filter was applied after careful examination of Multiple Filter Scans and Signal Power Spectra (AUTOFILT) to achieve optimum resolution and continuity.

Sections were produced at each stage of processing with a provisional final section presented soon after completion of each line.

Periodically copies of final processed data for completed lines were shipped to Houston where migration, if required, and final filming of each line was completed.

Experimentation

Apart from analytical experimentation during normal production processing, certain items of interest were selected for special studies. These items included examination of production source and receiver array responses using a range of horizontal velocities encountered throughout the area as well as the effect of field filters on the recorded signal.
Conversion of section stacking velocities to interval velocities, true average velocities and implied depths, particularly on lines adjacent to the Mereenie anticline, gave valuable additional data to aid interpretation of structurally complex crestal lines.

Additional experimentation specifically directed at these complex lines included UP-DIP and DOWN-DIP stack comparisons and in certain cases running a suite of stacks of decreasing CDP multiplicity (by progressively discarding long distance traces) to investigate the effect of depth point dispersion in regions of strong dip (Figure 7).

Another interesting piece of experimentation involved the processing of seismic data recorded to 13 seconds duration in an attempt to record the Mohorovicic Discontinuity. A copy of the report is included (Appendix III).
Reprocessing

A number of previously recorded and processed analog lines were reprocessed concurrently with production processing utilising techniques developed on intersecting lines of the present survey.

Format conversion from the original analog tapes to digital format was already completed with the data in an otherwise raw state. The processing sequence was generally similar to that described for the present survey with the exceptions that static corrections as originally computed were used; and, since each line was recorded in single-fold configuration, a residual static correction pass was unnecessary.

In order to retain similar character between these older lines and the present survey, post-stack parameters were chosen to aid correlation of reflected events throughout the area.

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The Amadeus Basin is a westerly trending intracratonic depression within the Central Australian Shield (Southern Northern Territory). Present day margins narrow toward eastern and western extremities. The basin is approximately 800 Km by 320Km covering an area of 150,000 square Km (Figure 1).

Since its inception in the Early Proterozoic the Amadeus Basin has received in excess of 9,000 M of sediments. The sedimentary section comprises unmetamorphosed marine sediments laid down in the interval between Early Proterozoic and Ordovician times. Subsequent sediments being principally continental deposits; Recent sediments being comparatively thin occur now as outliers. The sedimentary section overlies igneous and metamorphosed basement rocks, which have surface expression as the Arunta Complex along the northern margin of the basin and the Misgrave Complex along the southern margin (Figure 8).

The earliest sediments in the Amadeus Basin probably extended well beyond present margins. These Proterozoic sediments were deposited as a continuous sheet in a shallow stable, marine environment (Heavitree Quartzite). The development of barred basins and lagoonal environments is inferred from the presence of evaporites and carbonate rocks of the Bitter Springs Formation (Figure 9a, 9b).
Diastrophism of the Areyonga Movement was accompanied by the development of a 'basinal' province in the southern area of the Amadeus Basin separated from a shelf province to the north, by a medial westerly trending hinge line (Wells et al, 1970). This movement and the South Range Movement in the Late Proterozoic uplifted areas to the south which then became the provenances for the subsiding areas.

Sedimentation continued with little tectonic disturbance during the Late Proterozoic, retaining the two distinct environments. The Areyonga and Pertatataka Formations, deposited at this time, have similar lithology, facies distribution and environmental conditions. Two stages of glaciation have been identified in this time, the earlier of the two covering the entire shelf and the later episode being confined to a small subsidiary basin in the northeast. The Petermann Ranges Orogeny re-configured the basin, shifting the axis of deposition to the north. The shelf province appears to have been little disturbed by these intense movements which were localized in the south west of the basin.

The 'basinal' sediments were uplifted as isoclinal and recumbent folds developed and Proterozoic sediments were infolded with basement complex, during Late Proterozoic to Early Cambrian times. Overthrusting of the young Proterozoic sediments was accomplished by utilizing the more competent Bitter Springs Formation as a decollement. This movement provided a southern provenance for Cambrian deposition. The Cambrian Pertaoorta Group, unconformably overlying the Proterozoic rocks, comprises marine sands and silts, including an evaporatic member (Chandler Limestone). Carbonate and evaporitic deposition predominated in the northeast and clastics in the remainder of the basin grade coarse to fine from the west to the south east.

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Sedimentation during this time shows evidence of a facies change across a median ridge subdivisions varying from continental to deltaic in the west to marine carbonates and shale in the east.

The Larapinta Group (Figure 9) was laid down from the Late Cambrian to Ordovician, conformably overlying the Pertaoorta Group and the Proterozoic rocks to the south. The depositional pattern indicates a series of transgressions and regressions in an epeiric sea which probably extended beyond the present basin margins.

These shallow marine Ordovician rocks comprise sandstones, siltstones and shales which show true depositional thinning to the south. Ordovician sedimentation was brought to a close by the Rodingan Movement (Silurian?), the ensuing environment being principally continental. Desert erosion provided sediments of the Mereenie Formation which is partly shallow marine, partly fluviatile and aeolian. An apron of coarse conglomerates developed at the foothills of the Central MacDonnell Ranges. The Mereenie Formation unconformably overlies the earlier rocks, the majority of sediments probably being deposited during the Devonian.

This phase of deposition was interrupted by the Pertnjara Movement (Late Devonian) which uplifted sediments on the northern margin. Molasse deposits of the Pertnjara Group followed this movement, the sediments accumulating at the base, on the southern flank of the newly formed mountains. The Finke Group was deposited contemporaneously within the basin.
The Alice Springs Orogeny (Foreman et al., 1965) is evidenced by folding overthrusting and the formation of nappes, along the northern margin of the basin. This Mid to Late Palaeozoic cycle may have started near the end of the Ordovician and shows increased intensity in the Devonian, activity persisting into the Carboniferous. The two major occurrences of evaporites appear to have provided shearing planes of weakness with detachment of sediments occurring angularly between these planes as sediments were overthrust (Foreman and Milligan, 1965).

Huge blocks of allochthonous sediments provide evidence of gravity sliding in response to uplifting and overthrusting. The sediments of the Late Palaeozoic depression do not show signs of activity as intense, as that evidenced in the basement complexes to the north. Many of the structures of the depression display an origin in the Palaeozoic and some diapirs and thrusts may have been initiated as early as the Petermann Ranges Orogeny. The Amadeus area stabilized after the deposition of the Pertnjara Group to serve as provenance for the Permian to Cretaceous sediments of the Simpson and Gibson deserts.

Middle Tertiary fluvial and lacustrine sediments were deposited in ancestral river valleys as the climate became wetter. Tilting and minor faulting accompanied the downwarping of the Lake Eyre area, establishing the present system of internal drainage.
INTERPRETATION

The surveyed areas have been presented as four subregions designated as Mereenie, Palm Valley, Waterhouse and Ooraminna from west to east respectively. All areas encompass a belt of intrabasinal thrusts and folds adjacent to the northern margin of the Amadeus Basin.

Three horizons and two isopachs have been mapped for each subregion. In general seismic data quality is very good. 'No record' areas are consistently related to anticlinal features, usually where outcropping sandstone rocks may be observed. Where possible the survey data were tied into maps prepared by Krieg (1967), and in most cases ties were very good with few of the old lines requiring repicking or adjustment. The bed thickness of most Palaeozoic sediments is remarkably uniform and little related to structural movements, except in the Ooraminna area.

Gross structure may be viewed as two layers above a crystalline basement with anatexis probably merging the lower layer into the basement. These layers are separated by an incompetent 'plane' comprising the Bitter Springs Formation. Two major diastrophic events have been recognised in the area giving complex relationships between thrust faulting and fold development. The earlier, the Petermann Ranges Orogeny (Late Proterozoic), was localised along the southern border, sediments being overthrust from the south. The later, the Alice Springs Orogeny was localised along the northern border and over thrust from the north.
Mereenie

The Mereenie map covers several distinct prospects, interrelated by thrust and fold trends. Two parallel thrust lineaments oriented northwest to southeast (Glen Edith Hills and Gardiner Range), intersect a third lineament oriented approximately east-west. The resulting faults, folds and intersections of these lineaments provide potential traps for hydrocarbon accumulation.

Horizons were chosen to tie with previous work on old Line BN shotpoint 83. Preliminary mapping revealed some misties in the area, particularly to the northwest. Hence the horizons to be mapped were chosen so that fair ties throughout the area could be attained and also, so that reflection character could be identified in different areas. Three horizons A, B and C-2 have been mapped. For timing, the onset of the reflection below the coloured line has been mapped. Horizon A is the lower leg of the very strong reflection band estimated to be approximately the top of the Mereenie Formation, possibly an unconformity. It has been mapped to assist ties to outcrop geology. Horizon B does not possess a strong reflection character but has been mapped because of its proximity to the prospective Pacoosta Sandstone. A good character correlated tie to Line 73-1-M2 places Horizon B in the Lower Stairway Sandstone and Horizon C-2 has been mapped as the lower leg of a strong reflection band in the vicinity of the C-2 mapped by Krieg (1967).

Correlation throughout the Mereenie area is good. Horizon A is always very strong except when it is high in the section, where the combined effects of deep weathering and muting during processing would alter the character. Horizon B shows an increase in strength to the west. This may indicate an east-west stratigraphic variation. Horizon C-2 also shows a slight variation in character in this dimension. Coherent energy content deteriorates in regions of thrusting (anticlines), however relative character of reflections seems constant.

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The Mereenie maps show horizons and isopachs which give fairly reliable view of the area. However, as it combines data from various sources some caution is necessary in the interpretation of anomalies. The 1973 seismic work has been mapped from migrated sections. All previous lines used were not migrated and have differing static corrections at tie points. Hence anomalous areas on the boundaries between old and new data have to be viewed with caution. The reliability of Horizons A and C-2 are considered 'very good'. Horizon B however, because of possible stratigraphic and observed character variation is 'fairly' reliable. The area to the north of the Gardiner Ranges (Lines 73-1-GA3, GA3 EXT and GA4) has been tied to the previous maps of the Palm Valley area. These 1973 lines are not physically tied to the Mereenie area which forms an interconnected network independently. Character correlation is difficult between the two areas and the time difference (1.0 sec.) is very large. However, such a depth (in time) is also observed north of the Glen Edith Hills in a similar structural environment. This situation leaves a break in the correlation of horizons between the two sub-regions. Subsequently the horizons mapped in each area, although close, cannot uncategorically be designated as the same units.

The isopachs show little variation along all of the 1973 data. A slight thickening along the flanks of synclinal areas may be attributed to the parallel folding of beds which when mapped are represented by a vertical time difference and not one normal to the 'bedding' planes. This phenomenon may also be observed in the Waterhouse area.
Seven wells have been drilled on the Mereenie Anticline consisting of four shut-in gas condensate wells, one shut-in oil well and two non-economic shut-in wells. The gas and oil producer is the Upper Pacoota Sandstone (Cambrian), and abnormal gas pressures have been observed in the Stairway Sandstones (Ordovician). The Pacoota Sandstones have a high residual hydrocarbon content and evidence of euxinic conditions, indicating that they are probably both source and reservoir rocks. The Upper Pacoota Sandstone is capped by the Ordovician Horn Valley Siltstones and shales which exhibit suitable characteristics to be a source rock. Porosity is extremely low in these silts and sands providing a good cap rock. Permeability and porosity are not exceptionally good in the Upper Pacoota Sandstones although some stringers show a slight improvement. This situation has led to the conclusion that fracture porosity and permeability are of major importance in locating suitable traps.

In the region of the Mereenie Anticline seismic results have provided a good tie to well information along Line 73-1-M2. The best record quality crossing the anticline transversely is found on Line 73-1-4.5. This Line indicates an overthrust with a steeply dipping décollement which maintains this attitude from south of Mereenie No. 1 to the termination of the structure. Lines 73-1-4.7 Ext and 73-1-4.8 indicate an apparent syndcline on the southern forefront which seems to consist of horizons which dip northwards under the overthrust segment. The décollement becomes shallower in dip to the west which may be noted by comparing Lines 73-1-4.8 and 7.5. This area then is the most likely site of large throw overthrusting (Glen Edith Hills).
The western half of Mereenie anticline is an arcuate structure, perhaps due to differential overthrusting. A stratigraphic closure to Mereenie Anticline has been postulated between West Mereenie No. 1 and N.W. Mereenie No. 1 (WCR, N.W. Mereenie No. 1).

The Mereenie Anticline is part of a northwest to southeast fold belt which includes Glen Edith Hills and Walker Creek Anticlines. Structurally, this belt consists of a thrust fault. The thrusting is greatest and the thrust plane shallowest in the Glen Edith Hills area. The thrust plane deepens to near normal along the southern flanks of Mereenie Anticline (Lines 73-1-4.6 to 4.8), and then undergoes a transition to a fold - West Walker Creek Anticline. This is in accord with fault to fold transitions as modelled by Gardner and Spang (1973). Line WW-2 of Gardiner Range Gravity Survey, 1973 does not indicate a fault of great magnitude on the northern flank of West Walker Creek Anticline. Hence the fault observed on Mereenie Anticline may be related to thrusting and is presumed, on the model basis, to terminate between the abovementioned anticlines. The Glen Edith Hills intersect an east-west fault zone (thrust?) which may be observed on the western end of Line 73-1-GA1 near stations 410,420. The Glen Edith Hills are interpreted as being further overthrust than Mereenie Anticline and hence more complex geologically, giving poorer seismic records on the anticline (see Lines 73-1-6.5, F, 7.5 and GE). In this area Horizon A shows variance to the relief of underlying horizons as fault zones are approached. This variance is attributed to continental apron deposits, being laid down towards the end of Mereenie Sandstone deposition or early during Pernjara Group deposition. These apron deposits are thought to be contemporaneous with the overthrusting of the Alice Springs Orogeny (Wells, et al, 1965). These phenomena may be observed on Lines 73-1-GA1 (W) and GE.
This northwestern area has two intersecting thrusts with the synclinal sediments on the southern forefront of each being deeply buried and thrust under the overlying sediments. This severe overthrusting may be attributed to the nearby intrusion of Arunta Basement Complex resulting in effective constriction of the basin. Near to the intersection of these major thrusts, sediments have a 'triangular' closure: i.e. two intersecting fault planes flanking a syncline, which is truncated by them and plunging away from the intersection. Such a trap may exist at the northwest extremity of the Glen Edith Hills and certainly does exist at the northwestern extremity of Gardiner Range as defined by Lines 73-1-GA4 and GA3X. The northern flank of the Glen Edith Hills provides a prospective area for future exploration. The critical factor for the location of seismic lines in this area is the location of fault and fracture zones. An improved field technique as suggested on page 13 could yield information on prospective arched and faulted sediments on the northern side of Glen Edith Hills and also on possible fault traps under the southern flank.

The interpretation plate of combined gravity and seismic results for Line 73-1-4.5 indicates a fault with a large throw on the northern flank of the Mereenie Anticline (Gardiner Range Gravity Survey, 1973). The extension of this fault at least west to N.W. Mereenie No. 1 may be inferred from gravity data (Adastra, 1962 and Century, 1961). The eastern extension is less tenuous. This fault on the southern flank of Wild Eagle Syncline is a very favourable prospect for a hydrocarbon trap. The upturning sediments of the syncline terminate against the fault and they may be expected to deepen in sympathy with the eastern nose of the Mereenie Anticline.
Western closure is difficult to discern; however, two possibilities exist. The stratigraphic (?) closure between W. Mereenie No. 1 and N.W. Mereenie No. 1 could credibly be expected to extend into the synclinal area. The Mereenie Anticline does not show a structural growth extending back to the Ordovician, the time of deposition of the productive Pacoota Sandstones as Isopachs covering rocks of this time show little variance in this area. Hence the depositional environment is not expected to differ between the crest and flank for the Pacoota Sandstone. The stratigraphic closure would then be valid for a trap within the syncline. The second closure possibility is the slight down turn observed in reflections on Line 73-1-M1. A third, but as yet unobserved, possibility exists for tear faults crossing the anticline transversely, providing closure.

The proximity of such a large structural trap to the Mereenie Anticline, which has proven reserves of oil and gas, makes this an attractive prospect. The source of hydrocarbons seems to be the reservoir rocks and possibly the overlying Horn Valley Siltstone. As outlined above, the depositional environment is expected to be fairly constant so that a suitable source may be postulated. One of the most important aspects of defining suitable traps is the presence of good fracture porosity. A fracture analysis of the Palm Valley - Gardiner Ranges - James Ranges Anticlines by Thigpen in 1973 concluded that fracture density was high along the crests and lower flanks of anticlines. Only in the case of narrow anticlines with high curvature was the crestal fracture density expected to exceed that on the flanks. The Mereenie Anticline is certainly not as narrow as the Gardiner Range which was cited as an example of a narrow anticline. Hence good fracture porosity may be anticipated on the flank of Mereenie Anticline.
The trap outlined above needs careful definition by mapping the fault plane trace to determine its longitudinal extent, and then the horizons abutting this major feature need to be mapped. If this feature proves to be productive, a similar structure may be investigated on the southern flank of Middle Range Syncline. Delineation of this feature could be achieved by seismic surveying.

A continuous thrust zone oriented approximately east-west has been mapped joining the northwestern tips of Glen Edith Hills and Gardiner Range in accord with Krieg (1967). The continuity of these thrusts may not extend across the area, but may be a series of en echelon features which is difficult to assess from seismic data. Antithetic faults from this major trend dissect the northwestern nose of Gardiner Range to form potential traps. A gravity high in the Mt. Solitary area reinforces the possible fault mapped crossing Line 73-1-BN. This fault would give a prospective closed structure along Line 73-1-GA2X. Such a feature could be repeated to the west of Mt. Solitary, the decisive factor again being fault closure. The southern flank of Gardiner Range Anticline also provides an interesting prospect. The region lacking seismic and gravity coverage between Line 73-1-4.5 and 4.5 EXT is anomalous topographically, gravimetrically, and acoustically (See Interpretation Figure Line 73-1-4.5). The northern flank of the Gardiner Range Anticline has near surface salt intruded along the fault zone (Wells and Kennewell, 1972). The salt intrusion as suggested by the Gardiner Range Gravity Report, 1973 provides a prospective area for the upturning and closure of sediments. A gravity profile along the southern flank of the topographic high between Lines 73-1-4.5 and 4.5 EXT would assist in locating isolated salt intrusions.
Two distinct phases of overthrusting have occurred in the Amadeus Basin. The earlier, the Petermann Ranges Orogeny was largely confined to the lower plate (below the Bitter Springs Formation). The second is readily evident in the overlying sediments (Alice Springs Orogeny). A simplified sequence of events for the development of the Mereenie Anticline may be postulated from the seismic results and is shown in Figures 14 a,b,c. The east-west thrusting appears to be related to basement intrusion and overthrusting along the northern margin, whereas the northwest-southeast thrusts and folds appear to have developed along linear fracture planes originating in the lower plate. Apron deposits imply an onset of thrusting from the north during the Carboniferous as the upper Carboniferous sediments or early Pernjara Group were being laid down.
Palm Valley

All the Palm Valley lines produced very good data with the exception of 73-3-PV1. This line, connecting Palm Valley Wells Nos 2 and 3 showed little of the crestal configuration.

Horizons were chosen to tie with previous mapping and as such although close to similarly named horizons in adjacent subregions, they are not the same continuous horizon. In contrast to the Mereenie area Horizon B shows stronger reflection character whereas Horizon C-2 shows poorer character. Horizon D-1 is approximately two legs below the D-1 mapped in the west of the Waterhouse area. Correlation of reflections away from the crest of the anticline is very good. Continuity of mapped horizons along Line 73-3-PV1 is doubtful and minor faults may be present that cannot be discerned on the seismic section. Coherent energy content of reflections improves away from the anticline so that 73-3-PV5 gives the best correlation to the Waterhouse area.

The Maps show an 'elbow' shape for Palm Valley Anticline in all horizons. This 'elbow' may be observed as a high on Line 73-3-PV3. The isopachs also reflect this feature as a slight thinning (see Isopach C2/D1). A closed nose has been mapped to the eastern end of Palm Valley structure. Closure however could be effected by tear (?) faults cutting the anticline transversely. All horizons in this area are reliable away from the crest of the anticlines.
The western end of 73-3-Pv3 shows a slight turnover which increases with depth (See Horizon C-2). A northern extension of this feature is not observed on 73-3-PV5. The lines did show a continuous anticline structure in accord with previous mapping of the Palm Valley area. There is the possibility that a fault oriented east-west and located between the Lines 73-3-PV3 and PV1 could give closure for a fault on the northern flank of the anticline. Such a trap could be considered a good prospect as fracture analysis favours the crests and lower flanks of anticlines (Thigpen, 1973). Ties to the wells are very difficult to make confidently. They appear to be in fairly close agreement with the ties for Mereenie. Horizon B again correlates to the Stairway Sandstone.

The Palm Valley Anticline is an arcuate anticline which terminates towards the Gardiner and James Ranges. The northern flanks of both ranges are fault bounded, being overthrust from the south. In accord with the modelling of fault to fold transitions (Gardiner and Spang, 1973), this lineament maintains continuity as an anticline which is flanked by Palm Valley syncline to the north. The Palm Valley anticline seems to be an independant fold in response to southerly directed basement overthrusting which may postdate the first phase (Figure II). The evolution of the anticline is then due to the differential absorption of movement, along the thrust planes by faulting, and by folding to the north of the Gardiner Range anticline which was transformed from the collinear thrusts. The apparent independence from the Waterhouse thrusts implies that old North-South (?) fault lineaments may segment the basin from east to west and wrench faulting could be expected along these lineament.
Waterhouse

The Waterhouse area conforms to previous mapping in overall relief. The most prospective area surveyed during 1973 is located in the James Ranges around the Hugh River.

Three horizons (C-1, C-2 and D-1) and two isopachs have been presented. All horizons were initially tied to old work along Lines 73-1-1.5 and 1.6. Horizon C-2 has very strong character and may be readily recognized throughout the area. Horizon C-1 is an enigmatic reflector usually located two or three legs above C-2. Horizon D-1 is also enigmatic but located one leg above a strong reflector. Difficulty was experienced in tying migrated lines to the unmigrated 73-1-AEX. However by utilising ties on the same lines but unmigrated, adjusted values have been plotted on the maps for AEX. Ties throughout the area were good. Misties with the old work may be attributed to different statics corrections which may differ by as much as 40 msec. The greatest mistie observed (~60 msec) was in the northwest near Line 73-1-3.6. The old values in the area have been adjusted - the old sections have not been re-picked. Hence the western edge of the Waterhouse map does not match the eastern edge of the Palm Valley map for Horizon D-1. The reliability of all horizons mapped in the Waterhouse area is very good. Isopachs show a slight thickening on the margins of synclines which, as in the Mereenie area, may be attributed to parallel folding.
Fault traps under the thrusts forming the Waterhouse Ranges are difficult to assess. The difficulty arises in trying to estimate how far the underthrust sediments project beneath the range. The migration of reflections on Lines 73-3-3.3S and 3.3N tends to overlie deep reflections of very steep dip which plunge in opposite directions. Since the migrated reflections have coherency it would seem that the complication may be due to reflected refractions at depth beneath the zone of overthrusting. Although this is a problem in itself, the prerequisite nose necessary for east-west closure on the southern flank of the anticline has not been observed. Such a nose may exist along the northern flank but this is doubted as horizons in the area are very regular in relief.

Line 73-3-3.6 illustrates the tapering out of overthrusting into a conical fold at the western terminus of the anticline. This feature is offset from the main anticline and tear faults between West Waterhouse No. 1 and the main anticline could be postulated for closure. Highs observed on the southern ends of Lines 73-3-1.5 and 1.6 are the western nose of the Orange No. 1 structure. The highs on the northern ends of these lines may have closure against the thrust plane on the southern flank of the anticline and present a drillable prospect. Fracture porosity in the Pacoota Sandstones would be necessary for hydrocarbon accumulation. The Pacoota Sandstones, however do not seem to have as high an organic content in this eastern part of the basin. Hence the Jay Creek Limestone may be an alternative prospect (See Alice No. 1 WCR, 1963). The High River area viewed optimistically in Figure 16 has two potential structures. A southerly dipping thrust fault has been inferred on Line 73-3-3.2 and extended through to Line 73-3-2.2 Horizons on the overthrust block have been positioned by correlation of reflection character and geological outcrop. Reflection character is poor, probably due to fracturing.
The Waterhouse Ranges appear to be flanked on the north and south by underthrust sediments. Décollement planes within the Bitter Springs Formation are manifested as tight isoclinal folds (See Line 73-3-3.3S), and intrusive thickening on the flanks of the synclines. The Waterhouse Ranges seem to be the cap of a 'mushroom' development of near symmetrical underthrusting (See Figure 15). The western extension of the thrust lineament does not seem to have any of the structures associated with fault to fold transitions as is found in the Mereenie and Palm Valley areas. The eastern extension disappears in the Ooraminna area (See page 39 ).
Ooraminna

The Ooraminna map covers a structurally complex area where the Waterhouse thrust trend and nearby basement intrusion may be observed. Fair ties to the 1967 work (Krieg) enabled the merging of old and new data.

Mapping around Alice No. 1 well was complicated by poor records to the north, and severe faulting on most lines. The character of reflections in the Ooraminna area is essentially the same as for the Waterhouse area. C-2 is a consistently strong reflector while B and D-1 are not as well defined. Consequently, Horizon C-2 is the most reliable. However reliability diminishes north of Alice No. 1. Correlation by character is good from the west of the Waterhouse area across to Ooraminna. The horizons mapped in the Waterhouse area have been carried throughout Ooraminna. The maps indicate strong relief in all horizons due to intense faulting. The thickness of beds mapped is slightly greater than equivalent beds in the Waterhouse area. This may be largely attributed to the curvature effects of parallel folding as in the Waterhouse and Mereenie areas. Two legs below Horizon D-1, distinct variations in thickness may be observed. A bank of two strong reflections develops into three with an increase in thickness over anticlines (See Line 73-4-1.1). This may also be observed on Lines 73-4-1.6 and 1.6. On line 73-4-2.4 the situation changes and thinning occurs on the extension of Ooraminna Anticline (subsurface). This difference to the other areas is in keeping with the structural disposition of this anticline. It may be noted that Ooraminna Anticline transects faults (outcrop geology), which does not appear to happen for the subsurface structures in the vicinity of Alice No. 1. This difference in thickening suggests that the anticline may have evolved in response to tectonic forces that were different either in time or direction to those responsible for the structures in the north.

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This variable band is approximately located at the top of the Arumbera Sandstone, which suggests that it could be the Chandler Formation -- which has been documented as containing evaporites and related to shearing in response to thrust faulting (Forman et al., 1966). The thinning of this formation may explain its absence in the outcrop sequence of Ooraminna Anticline. In contrast, the thickening over anticlines in the vicinity of Alice No. 1 may explain the presence of salt in formations above the Chandler Formation which was encountered while drilling Alice No. 1 (WCR, 1963).

The geological history of the northeastern portion of the basin has shown a variance to the rest of the basin as far back as the Proterozoic (Wells, et al., 1965). Generally, the area has been more mobile with restricted environments ideal palaeoenvironments for the preservation of organic detritus. The Waterhouse overthrust is a prominent structural feature in the west of the area and may be observed on the northern end of Line 73-4-1.5. This pronounced linear trend, however, cannot be observed extending through the vicinity of Alice No. 1. Overthrusting may be observed on Lines 73-4-1.7, 2.1 and 2.2 but correlation with the Waterhouse trend is not apparent. The complexity of fold and faults and their interrelationship to the east of Alice No. 1 is not observed in the Waterhouse area. The Alice area therefore is the confluence of strong fault trends which is evidenced in surface fault and fold orientations. The disposition of these faults and folds suggests folding along sheared fault planes. Such shear faulting could be a concomitant part of variable overthrusting of basement rocks which are much closer to the north of this area than Waterhouse, Palm Valley or Mereenie (Figure 13).
The north-south fault postulated in Figure 13 has expression in the vicinity of Alice No. 1 and crosses the nose of Ooraminna Anticline to continue south at least as far as Mt. Brunonia. It may however, curve in a manner similar to the trend observed to the east, (See Ooraminna maps). Here in the James Ranges an offset in outcrop due to transcurrent (?) movement may be observed in outcrop geology and the disposition of the ranges. The absence of the Ordovician suite on crossing this fault suggests that a vertical displacement accompanied shearing; the eastern block being slightly uplifted. Stratigraphic inference from the seismic sections (73-4-2.3, 2.4, 1.6) suggests a late Cambrian movement or epeirogeny as confirmed by Brunschwiler's outcrop studies (1959). This shear lineament probably represents a very ancient suture which may extend deep into basement rocks, having undergone rejuvenation with each period of diastrophism. The trend is paralleled to the east and probably has morphological expression as the gaps in the McDonnell Ranges, well known to tourists. This interpretation is speculative but it does account for the observed phenomena.

Alice No. 1 may have been drilled on the flank of westerly plunging anticline and has been mapped as such. This anticline may be an overthrust feature, or alternatively, Alice No. 1 may have been positioned on the crest. Closure for Alice No. 1 is uncertain to the northwest and the southeast directions. A fault closure has been postulated in both directions on the basis of seismic record (Line 3.02 and 73-4-1.9X) and surface geology. No new prospects have been defined in the vicinity of Alice No. 1, however several leads are indicated nearby. Turnover is indicated on Line 73-4-1.7 about stations 210 - 220 a seismic line across this could reveal a closed structure.
Two anticlinal trends may be postulated flanking the surface syncline to the east, that has expression on Line 73-4-1.7 about station 200. A possible northwest trending nose transverse to this trend is apparent in surface geology. East-west closure may also be augmented by possible north-south faulting either normal, transcurrent, or a combination of the two.

The mapped horizons (C-1, C-2 and D-1) were chosen to tie with the previous work. However Lines 73-4-1.6, 2.3 and 2.4 show a thinning of sediments above Horizon C-1 (Pacoota Sandstone). This thinning is so pronounced that the Pacoota Sandstone could pinchout on approaching Mt. Ooraminna. An isopach is presented in Figure 17 showing the thickness of all sediments between the top (?) of the Pacoota Sandstone and the base of the Mereenie Sandstone (?). All intervening formations are absent in outcrop near Mt. Ooraminna. Seismic record indicates a small basin (e.g. see Horizon C-1) and as Horizon C-1 does not have a strong character the possibility of pinchout cannot be overlooked. Pinchout of the Pacoota Sandstone appears possible anywhere after the 200 msec. isopach line on Figure 17 (based on reflection character continuity). The pinchout of the Horn Valley Siltstone with a combined facies change makes assessment of a caprock a new problem. Several closure possibilities exist: There may be completely closed stratigraphic traps encircling the small basin; although, this is unlikely as the postulated shear fault seems to dissect these small basins. The fault does however appear to have some vertical displacement which could provide closure prospects. The indications are that the Ooraminna Anticline started growing in the Ordovician and as such, probably predates the Alice Springs Orogeny - hence...

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its 'continuity' across the postulated shear fault when compared to the smaller drag folds which emanate from faults.

A careful assessment of changes in thickness of the Pacoota Sandstone and adjacent outcropping beds would shed more light on stratigraphic variation in the area. This may enable estimation of sites of increased porosity due to facies changes near pinchouts. A careful evaluation of the organic content of these rocks indicates an alternative source rock to the Pacoota Sandstone is the Jay Creek Limestone. This is the formation which contained high oil saturations when penetrated in Alice No. 1. Outcrop studies have shown that algal bioherms are present in the formation which have a petroliferous smell when hammered. The low porosity of these sediments requires the presence of fracturing at potential trap sites.

The geological history of this northeastern area indicates that stratigraphic traps may be present in Cambrian or later Palaeozoic rocks. Hence more seismic surveying of the areas to the north and south of Ooraminna Anticline could reveal stratigraphic traps.
Relationship of Seismic Record Quality to Structural Features

In some areas within the Amadeus Basin seismic records are excellent where in 'normal' geological situations a very poor record would be expected. Two notable examples of this occur in the Waterhouse and Mereenie areas (Line 73-3-AEX) and (73-1-GA4).

A geomorphological feature as striking as the Waterhouse Ranges might expectedly be flanked by normal faults. Consequently a seismic line along the flank would yield data obscured by diffractions and refractions. In the case of a fairly shallow thrust plane, as proposed in this interpretation, good reflections may be expected from a line along the forefront of overthrusting (See Figure 18). This situation may be observed on all lines abutting the Waterhouse Ranges on both flanks. In the Mereenie area, good records were obtained on the northern side of the Gardiner Range (Line 73-4-GA4), and the southern forefront to the Mereenie overthrust (Lines 73-4-4.5, 6.5, 7.5 and GE). Poor records have consistently been related to anticlines, on outcropping sandstones with one exception: Line 73-1-E which is located on the southern flank of Gardiner Range Anticline.

The poor data is then attributed to positioning over a near normal fault plane. In accord with the gravity low in this area, salt intruded along the fault plane would contribute to noise and "no record" problems.
CONCLUSIONS AND RECOMMENDATIONS

All four subregions contain prospects and leads which may be developed. The Mereenie area contains the most favourable prospects owing to the proximity to known hydrocarbon accumulations.

A better understanding of this area should now enable planning of more seismic work to detail further prospects. Although several leads and prospects have been outlined in all areas, closure confirmation rests on the delineation of faults. In some cases gravity data have yielded information on the presence of faults, difficult to validate with seismic information. The cheapest and quickest available method that could yield valuable information on faults and fractures would be remote sensing using a variety of windows. Little information for immediate drilling has been revealed in most areas. The only exception to this is the trap on the southeastern edge of the Waterhouse Ranges where further exploration would provide little more evidence for closure. The Pacoota Sandstone does not seem to have had as restricted an environment here as in areas to the west, so that target horizons below this need to be considered. The Ooraminna area has potential stratigraphic and structural traps which need definition by seismic surveying. This is an area of variable relief where the mapping of subsurface horizons may yield prospects. All areas surveyed to the west have a relatively uniform subsurface configuration and potential traps require definition of fault traces and their continuity for closure confirmation.
All areas contain prospects or leads requiring definition by seismic surveying. The potential of the area for hydrocarbon accumulations has been proven, so that further exploration is a favourable proposition.

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Area Manager.

William Killeen
Stephen Wood
Party Chief.

Scott McTaggart
Scott McTaggart
Interpretation.
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APPENDIX I

STATISTICAL DATA

(All Areas)

Totals for Field Crew:

Last Day 27th April, 1974.
Days in Period 293 days.
Total hours (excluding down time) 2692.85
Record Hours 1631.75
Travel Hours 317.60
Camp Move Hours 109.5
Holidays (Not worked) 40.0
Weather 594.0
Down 319.75
Profiles 6482
Km's coverage 895.24

Totals for Command Processing Center:
Current Seismic Processing (Hours) 1277:20
Reprocessing of older work (Hours) 131:50
Uphole Drill
Total Footage: 5801 (From Nov)
Total Hours : 273
Number of bits consumed: 82 sets of blades
5 Rock bits
3 Starter blades
Dynamite Used: 425 lbs.
Caps Used : 978
### Waterhouse

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### Palm Valley

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<td>Down hours</td>
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<td>Km's coverage</td>
<td>74.90</td>
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### Mereenie

<table>
<thead>
<tr>
<th>First Day</th>
<th>September 15th</th>
<th>February 15th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Day</td>
<td>November 28th</td>
<td>April 17th</td>
</tr>
<tr>
<td>Days worked</td>
<td>136</td>
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</tr>
<tr>
<td>Total Hours (excluding down time)</td>
<td>1167.75</td>
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<td>Record Hours</td>
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<tr>
<td>Travel Hours</td>
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<td>Camp Move hours</td>
<td>70</td>
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<tr>
<td>Weather hours</td>
<td>280</td>
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<tr>
<td>Holiday hours</td>
<td>-</td>
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</tr>
<tr>
<td>Down hours</td>
<td>262.5</td>
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### Ooraminna

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<tr>
<th>First Day</th>
<th>December 2nd</th>
<th>April 18th</th>
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<tbody>
<tr>
<td>Last Day</td>
<td>February 14th</td>
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<tr>
<td>Days worked</td>
<td>76</td>
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<tr>
<td>Total hours (excluding down time)</td>
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<td>Record Hours</td>
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<td>Down hours</td>
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<tr>
<td>Profiles</td>
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# APPENDIX II

## MERRENEI

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<th>LINE</th>
<th>STATION</th>
<th>ELEVATION</th>
<th>LATITUDE</th>
<th>DEPARTURE</th>
<th>LOCATION OF P.M.</th>
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<tbody>
<tr>
<td>73-1-4.5</td>
<td>100</td>
<td>738.46</td>
<td>7337781</td>
<td>745769</td>
<td>on rocky outcrop.</td>
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<tr>
<td>73-1-JC</td>
<td>193</td>
<td>735.48</td>
<td>7334289</td>
<td>754027</td>
<td>at base of sandhill.</td>
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<td>73-1-JC</td>
<td>261</td>
<td>723.86</td>
<td>7338916</td>
<td>745628</td>
<td>840 m along line from I/S with road.</td>
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<td>73-1-JC</td>
<td>99</td>
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<td>7327915</td>
<td>765573</td>
<td>80 m from creek.</td>
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<td>73-1-JC</td>
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<td>761777</td>
<td>I/S with 73-1-4.8.</td>
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<td>73-1-4.7</td>
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<td>771183</td>
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<td>777.90</td>
<td>7340983</td>
<td>765369</td>
<td>4.6 km from E. Mer.(\times) 2</td>
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<td>73-1-M2</td>
<td>182</td>
<td>699.34</td>
<td>7334449</td>
<td>774803</td>
<td>7.1 km from E. Mer.(\times) 1</td>
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<tr>
<td>73-1-F</td>
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<td>745677</td>
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<td>73-1-E</td>
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<td>761655</td>
<td>897 m from I/S with 73-1-BN</td>
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<td>7363899</td>
<td>768880</td>
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<td>73-1-4.8</td>
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<td>7332139</td>
<td>773410</td>
<td>990 m from creek.</td>
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<td>776225</td>
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<td>717016</td>
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<td>73-1-GE</td>
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<td>741302</td>
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<td>757.21</td>
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<td>781209</td>
<td>at 7° bend in line.</td>
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<td>73-1-GA1</td>
<td>203</td>
<td>755.74</td>
<td>7364140</td>
<td>762746</td>
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<td>DEPARTURE</td>
<td>LOCATION OF P.M.</td>
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<td>73-1-GA3</td>
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<td>7360814</td>
<td>795696</td>
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<td>7363850</td>
<td>790983</td>
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<td>7364380</td>
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<td>73-1-F</td>
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<td>299</td>
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<td>752.05</td>
<td>7347356</td>
<td>760485</td>
<td>at foot of range.</td>
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<td>73-1-4.9</td>
<td>133</td>
<td>773.29</td>
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<td>758292</td>
<td>in heavy scrub.</td>
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<td>73-1-5.5</td>
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<td>at foot of ranges.</td>
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<td>73-1-GA1</td>
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<td>7387108</td>
<td>728227</td>
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<td>7369432</td>
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<td>near I/S with 73-1-GA2</td>
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<td>73-1-4.9</td>
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<td>763.69</td>
<td>7343857</td>
<td>760758</td>
<td>near rocky ridge.</td>
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<tr>
<td>73-1-M1</td>
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<td>7347254</td>
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<td>E.O.L. near large sand dune.</td>
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<td>DEPARTURE</td>
<td>LOCATION OF P.M.</td>
</tr>
<tr>
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<tr>
<td>73-1-4.7 ext 195</td>
<td>778.43</td>
<td>7329192</td>
<td>761105</td>
<td>260 from flat rocky outcrop.</td>
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<tr>
<td>73-1-4.7 ext 141</td>
<td>792.47</td>
<td>7335070</td>
<td>765854</td>
<td>near range.</td>
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| 73-1-4.5 | 191 | 782.90 | 7346192 | 755259 | near Mereenie
| 73-1-4.5 | 107 | 728.72 | 7338430 | 746503 | I/S with 73-1-JC
| 73-1-F | 400 | 750.16 | 7333127 | 717487 | 280 m from rocky outcrop. |
| 73-1-M1 | 100 | 705.70 | 7367871 | 738071 | 0.8 km from I/6 with 73-1-6.5
| 73-1-6.5 | 100 | 739.71 | 7338787 | 713417 | E.O.L. |
| 73-1-7.5 | 201 | 665.23 | 7363784 | 723308 | E.O.L. |

**PAWM VALLEY**

<table>
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<tr>
<th>LINE</th>
<th>STATION</th>
<th>ELEVATION</th>
<th>LATITUDE</th>
<th>DEPARTURE</th>
<th>LOCATION OF P.M.</th>
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<td>73-3-PV5</td>
<td>100</td>
<td>585.37</td>
<td>7352077</td>
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<td>2.1 km east of Hermannsberg airport.</td>
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<td>73-3-PV5</td>
<td>170</td>
<td>576.86</td>
<td>7351612</td>
<td>270059</td>
<td>5 km from Hermannsberg on north bank Finke River.</td>
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<tr>
<td>73-3-PV4</td>
<td>100</td>
<td>604.83</td>
<td>7336564</td>
<td>291375</td>
<td>1.2 km north of James Range.</td>
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<td>73-3-PV4/3 I/S</td>
<td>598.41</td>
<td>7348582</td>
<td>277057</td>
<td>2 km south from 1st grid on Hermannsberg to Alice Spring</td>
<td></td>
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<td>73-3-PV 3/2 I/S</td>
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<td>7350275</td>
<td>257673</td>
<td>4 km west of road to Pv I/6</td>
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<tr>
<td>73-3-PV2</td>
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<td>7348571</td>
<td>245535</td>
<td>1.5 km north of ranges.</td>
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<td>73-3-PV1</td>
<td>100</td>
<td>891.48</td>
<td>7342753</td>
<td>266221</td>
<td>19 km west of road to Pv I/1 in rocky outcrop.</td>
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<td>73-3-PV1</td>
<td>176</td>
<td>935.57</td>
<td>7342140</td>
<td>256833</td>
<td>5.2 km east of PV I/2</td>
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0.5 km west of PV I/3
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<th>LATITUDE</th>
<th>DEPARTURE</th>
<th>LOCATION OF P.M.</th>
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<tbody>
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<td>73-1-1.7 ext 140</td>
<td>527</td>
<td>7312585</td>
<td>354004</td>
<td>2 km from track</td>
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<tr>
<td>73-3-3.3N 250</td>
<td>582</td>
<td>7343211</td>
<td>340613</td>
<td>at foot of range</td>
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<tr>
<td>73-3-3.3N 1</td>
<td>576.07</td>
<td>7347128</td>
<td>340981</td>
<td>350 m from river</td>
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<td>73-3-3.3N I/S</td>
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<td>7355485</td>
<td>340040</td>
<td>I/S with 3-3NXB old line</td>
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<td>7355934</td>
<td>339973</td>
<td>E.O.L.</td>
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<td>358078</td>
<td>E.O.L.</td>
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<td>7339880</td>
<td>346011</td>
<td>I/S with 73-3-2.3</td>
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<td>7340860</td>
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<td>I/S with 73-3-1.6</td>
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<td>337577</td>
<td>I/S with 73-3-3.3S</td>
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<td>73-3-AEX 200</td>
<td>619.06</td>
<td>7340739</td>
<td>323289</td>
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<td>73-3-AEX 155</td>
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<td>7343802</td>
<td>309743</td>
<td>I/S with 73-3-3.6</td>
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<td>7345015</td>
<td>304434</td>
<td>E.O.L.</td>
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<td>73-3-3.6 100</td>
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<td>306703</td>
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<td>73-3-3.6 240</td>
<td>654.43</td>
<td>7354735</td>
<td>314438</td>
<td>E.O.L. at foot of hills</td>
<td></td>
</tr>
<tr>
<td>73-3-1.5 195</td>
<td>605.14</td>
<td>7344807</td>
<td>361510</td>
<td>120 km from New South Road</td>
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<tr>
<td>73-3-1.5 100</td>
<td>568.07</td>
<td>7334222</td>
<td>369166</td>
<td>12.04 km from Main Road</td>
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</tr>
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<td>73-3-1.6 163</td>
<td>630.85</td>
<td>7341523</td>
<td>358883</td>
<td>2.52 km from Old South Road</td>
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</tr>
<tr>
<td>73-3-1.6 100</td>
<td>559.81</td>
<td>4333179</td>
<td>358016</td>
<td>5.4 km from New South Road</td>
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<td>73-3-2.2 221</td>
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<td>7326039</td>
<td>347022</td>
<td>560 m from Main Road</td>
<td></td>
</tr>
<tr>
<td>73-3-2.2 153/168</td>
<td>530.80</td>
<td>7319602</td>
<td>343362</td>
<td>140 m from Old South Road</td>
<td></td>
</tr>
<tr>
<td>73-3-2.2 93</td>
<td>510.45</td>
<td>7312912</td>
<td>338609</td>
<td>2.94 km from South Road</td>
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</tr>
<tr>
<td>73-3-2.3 105</td>
<td>569.53</td>
<td>7318328</td>
<td>346207</td>
<td>1.12 km from fence on South Road 71 km from Alice Springs.</td>
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## WATERHOUSE (2)

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<tr>
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<th>DEPARTURE</th>
<th>LOCATION OF P.M.</th>
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<td>73-3-2.3</td>
<td>265</td>
<td>577.50</td>
<td>7340720</td>
<td>346008</td>
<td>At foot of Waterhouse Range</td>
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<tr>
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<td>100</td>
<td>562.03</td>
<td>7326882</td>
<td>323209</td>
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<tr>
<td>73-3-3.2S</td>
<td>153</td>
<td>512.99</td>
<td>7321351</td>
<td>334880</td>
<td>At foot of James Range</td>
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<td>73-3-3.2</td>
<td>152</td>
<td>518.18</td>
<td>7322356</td>
<td>335557</td>
<td>At end of a ridge</td>
</tr>
<tr>
<td>73-3-3.2</td>
<td>133</td>
<td>514.48</td>
<td>7323925</td>
<td>336635</td>
<td>Near I/S with 3.3S</td>
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<tr>
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<td>184</td>
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<td>7318432</td>
<td>333572</td>
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## OGRAMINNA

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<th>DEPARTURE</th>
<th>LOCATION OF P.M.</th>
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<td>73-4-1.1</td>
<td>100</td>
<td>517.03</td>
<td>7370936</td>
<td>405798</td>
<td>8 miles from Emily Gap near Ross Road.</td>
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<td>390843</td>
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<td>133</td>
<td>522.82</td>
<td>7361957</td>
<td>393918</td>
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<td>503.79</td>
<td>7352923</td>
<td>406263</td>
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<td>DEPARTURE</td>
<td>LOCATION OF P.M.</td>
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<td>526.10</td>
<td>7355358</td>
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<tr>
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<td>391614</td>
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<td>394838</td>
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<td>400481</td>
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<td>403904</td>
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<td>389022</td>
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<td>73-4-1.6</td>
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<td>545.06</td>
<td>7332680</td>
<td>394234</td>
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<td>E.O.L. on Sand dune</td>
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<td>375136</td>
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<td>394869</td>
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<td>571.01</td>
<td>7342209</td>
<td>385157</td>
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<td>73-4-1.6</td>
<td>257</td>
<td>530.25</td>
<td>7328828</td>
<td>397893</td>
<td>40 m from fence.</td>
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</table>
APPENDIX III

INVESTIGATION INTO THE PRESENCE OF THE MOHOROVICIC DISCONTINUITY USING SEISMIC REFLECTION DATA
RECORDED TO 13 SECONDS IN LENGTH

An attempt to record, process, and display reflected energy from the Mohorovicic discontinuity was made, utilising normal procedures carried out for line 73-3-1.7.

Certain limitations, however, both in the recording and processing systems resulted in minor modifications to the original plan.

The field recorder has a maximum recording cycle time of 13 seconds, sampled at 0.002 sec. intervals giving 6500 output digitised samples for processing.

Reformatting of the field tape to ComMand MPX-1 format followed, with resampling to 4 msec. rate, giving 3250 output samples. Because of software restrictions, normal binary gain-recovery was not available, and a digital AGC pass was made with further resampling to 8 msec. rate.

ComMand routine software allows for a total 1500 sample data trace for such programs as CDP stacking and filtering, with the result that the maximum data length allowed was further restricted to 12 seconds, or 1500 samples at 8 msec. rate.

The next stage of processing involved removal of NMO, application of static corrections, and CDP stacking.
Finally the assumption was made that only lower frequency energy would be returned from such extreme depths expected to reveal the 'Moho' and that any high frequency energy present was probably ambient in nature such as random wind, mechanical, or electrical interference or reverberated energy from near-surface events. To discriminate against these 'noise' frequencies, an arbitrarily determined high cut filter of 30Hz was applied to the data to pass the expected signal and enhance the appearance of the deep section.

The filtered output was then displayed on the 'GOULD' electrostatic printer.

No prominent reflections were detected below the near surface sedimentary sequences although certain weak line-ups of energy could be inferred below 9 seconds.

.../60
APPENDIX IV

PERSONNEL

Party Chief
Seismologist
ComMand Operator
Computer
Electronic Supervisor
Party Manager
Observer
Junior Observer
Junior Observer
Mechanic
Mechanic
Shooter
Weight Truck Operator
Weight Truck Operator
Surveyor
Surveyor
Rodmen
Cook
Field Assistants

S. Wood
S. McTaggart
R. Lambert
P. Lock
B. Easterling
G. Devlin / E. McLachlan
T. Smith
D. Beeston
R. Morgan
R. Buckmaster
P. Stark
W. Berg
L. Coombs
P. Murphy
B. Hedditch
F. Carlson
(2)
(1)
(15)
FIELD TECHNIQUE - 12 CDP

STATION INTERVAL: 140 m.
GEOPHONE ARRAY LENGTH: 136 m.
DROP SEGMENT: 16 drops / 175 m.

INITIAL OFFSET: 350 m.
FAR OFFSET: 1890 m.
FIELD TECHNIQUE - 12 CDP

STATION INTERVAL: 100m.
GEOPHONE ARRAY LENGTH: 136 m.
DROP SEGMENT: 16 drops/150 m.

INITIAL OFFSET: 150 m.
FAR OFFSET: 1250 m.
GEOPHONE and SOURCE ARRAYS

GEOPHONE ARRAY IS CENTERED ON STATION
DROP PATTERN IS CENTERED BETWEEN STATIONS
NOISE STUDY
LINE 73-3-1.6
WATERHOUSE

PODS 1 & 2 CONSIST OF 12 GEOPHONES EACH.

PATCHES 1 & 2 ARE 48 GEOPHONE ARRAYS AS SHOWN IN FIGURE 4.

THE WEIGHT TRUCK STARTED AT POD 1 AND MADE ONE DROP PER 10 m. INTERVAL
UNTIL POD 2 WAS REACHED—A TOTAL OF 201 DROPS.
ANALYSIS MAIN LINE DISPLAYS

PROGRAMS

AMPLITUDE ANALYSIS

FIELD DATA

FIELD MONITORS

FREQUENCY ANALYSIS

REFORMAT AND AMPLITUDE RECOVERY

MONITOR OF RECORDS (Trace editing)

PRE-STACK DECONVOLUTION AND FILTERING

MONITOR OF RECORDS (Final editing)

VELOCITY ANALYSIS

CDP GATHER

BRUTE STACK

Veilstack

CDS/CVS

FREQUENCY ANALYSIS

FINAL STACK WITH AUTOMATIC RESIDUAL STATICS

FINAL STACK

FINAL STACK DECONVOLUTION AND FILTERING

FINAL SECTION

DATA SENT TO HOUSTON FOR MIGRATION & FILMING

FIGURE 6
The greater the offset, the greater the dispersion & displacement. The greater the depth, the greater the displacement — the less the dispersion.

Structural relationships can thus be grossly misrepresented in the time section, and in certain cases trends reversed. In the case of a high angle normal fault occurring in a section of strong dip, the time section can distort the pattern sufficiently to yield a high angle reverse fault.
AMADEUS BASIN
REGIONAL GEOLOGY
N.T. AUSTRALIA

OIL PERMIT NO. 175

OIL PERMIT NO. 178

GOSSES SLUFF

PALMYRA VALLEY

ALICE SPRINGS

MOUNT RENNIE

MOUNT LIEBIG

AYER'S ROCK

GAWLER RISE

MURRUAH COMPLEX

BARBARAIO COMPLEX

0 25 50 75 KM. 1967

FIGURE 8

AMADEUS BASIN
BOUNDARY MAGNETICALLY INFERRED.
SEDIMENTARY - CRYSTALLINE ROCK CONTACT.
POST PALEOZOIC TO RECENT.
LOWER PALEOZOIC.
UPPER PALEOZOIC.
LOWER PRECAMBRIAN.
UPPER PRECAMBRIAN.

N.T. AUSTRALIA

120° E

130° E

131° E

132° E

133° E

134° E

2° S

14° S

15° S

16° S

17° S

18° S

19° S

20° S
### Table 1: Summary of Formations, Northern Amadeus Basin, Australia

<table>
<thead>
<tr>
<th>AGE</th>
<th>ORIGIN</th>
<th>FORMATION AND PREDOMINANT LITHOLOGY (WEST)</th>
<th>THICKNESS (M)</th>
<th>AVERAGE MEASURED DENSITY (G/M)</th>
<th>AVERAGE VOLUME OF FORMATION (HRU)</th>
<th>REMARKS</th>
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</thead>
<tbody>
<tr>
<td>TERTIARY TO RECENT</td>
<td>CONTINENTAL</td>
<td>Deception Range, Homer, Loom, etc., Homer, Vale, etc.</td>
<td>0-900</td>
<td>2.10</td>
<td>90.20</td>
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<td>DEVONIAN TO PEARL</td>
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<td>0-200</td>
<td>6.90</td>
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<td>LATE UNCAERIEN</td>
<td>DINOSAURIC</td>
<td>DEEP CREEK, PRESIDENT, Htt.</td>
<td>0</td>
<td>30.90</td>
<td>90.20</td>
<td></td>
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</tbody>
</table>

**FIGURE 9b**
1. OVERTHRUSTING FROM THE SOUTH

2 DEPOSITION

3. OVERTHRUSTING FROM THE NORTH

Isoclinal folding and intrusion of Bitter Springs Formation.

Assimilation and metamorphism of lower plate(?).

MEREENIE: POSTULATED DEVELOPMENT OF ANTICLINES

FIGURE 14
POor seismic record.

(a)

Good seismic record.

(b)

FIGURES: 18 a, b

SEISMIC RECORD & STRUCTURE

WATERHOUSE: 'MUSHROOM' STRUCTURE