BEACH PETROLEUM N.L.

REFLECTION SEISMIC SURVEY of THE DAKOTA BORE AREA SIMPSON DESERT, O.F. 57 N.T.

by
A. Yakunin
Geoseismic (Australia) Pty. Ltd.

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REPORT ON A REFLECTION SEISMIC SURVEY

of

THE DAKOTA BORE AREA

SIMPSON DESERT

O.P. 57 NORTHERN TERRITORY

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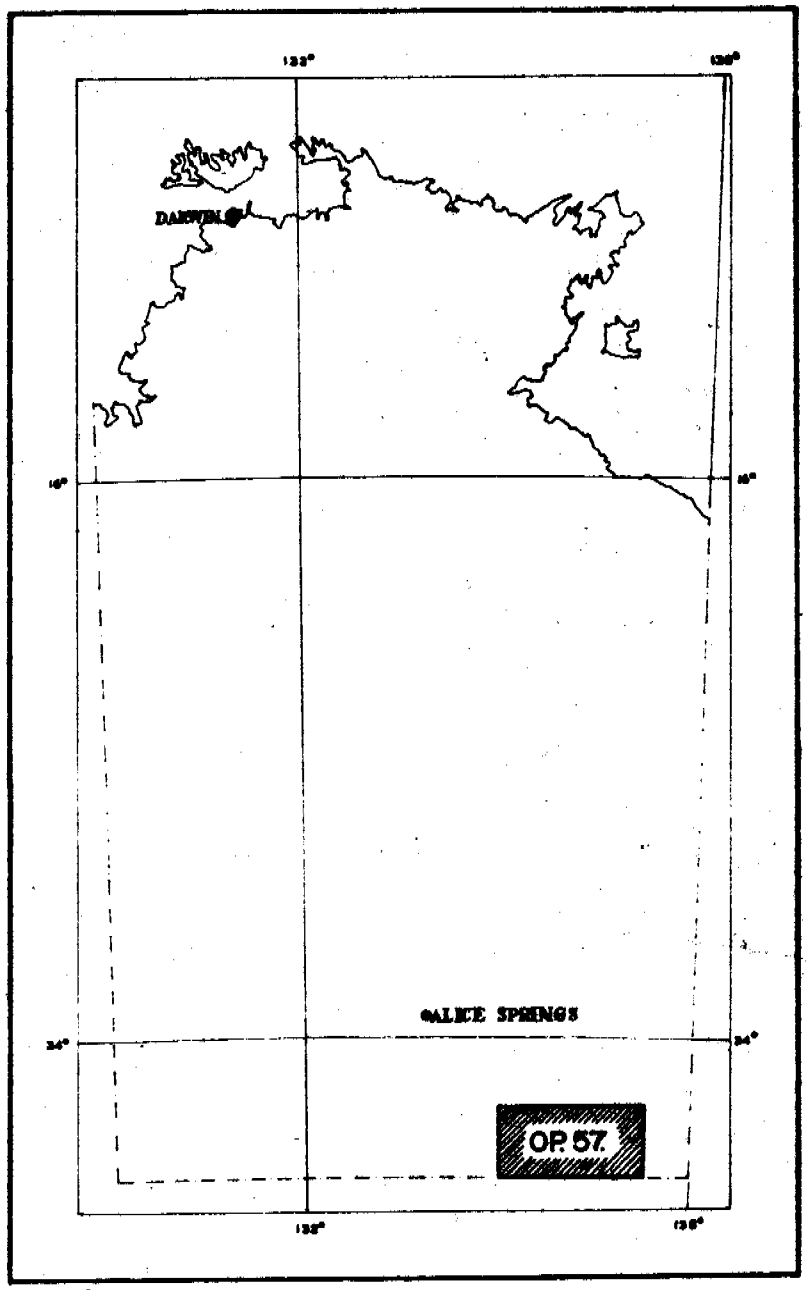

INDEX & LOCATION MAP
NORTHERN TERRITORY
AUSTRALIA
SIMPSON DESERT AREA
FOR
BEACH PETROLEM NL.
SCALE
100 50 0 100 200 300 MILES

BP 158.

GEOSEISMIC (AUST) LTD

ABSTRACT

A three month reflection seismic survey was completed in the central Simpson Desert region. The survey linked and extended pre-existing surveys in the Hale River Floodout and the Anacoora-Andado areas. The survey outlined in broad detail the previously located McDills gravity maxima and demonstrated Permian "drape" section to be thickening continuously to eastward over deeper plunging anticlinal structure. Structural "closure" along the axis of the McDills anticline was proven within the Permian.

I. INTRODUCTION.

A reflection seismic survey was conducted in a portion of O.P. 57 Northern Territory for Beach Petroleum N.L. by Geoseismic (Australia) Pty. Ltd. during August and September, 1964. The area lies between two surveys previously carried out in the area, namely, (a) the Hale River Floodout area and (b) the Anacoora-Andado area. The inter-relationships of the survey area are indicated on the shot point location map (BP.173D).

Results of the three surveys have been incorporated on all horizon maps. This has been necessary to prove structural "closure" and in the carrying of horizons across the various areas.

The survey was designed to investigate predicted structural "closure" on the intersection of the AB and D lines. The Permian section above the "P" reflector was to be examined for thickening "down-structure", in particular on the principal fold limbs and along anticlinal pitch. Several long lines were extended south to provide some indication of possible structural anomalies suggested by previous gravity results.

II GEOLOGY AND GEOPHYSICS.

1. GEOLOGY.

The area covered by the survey is located in the central Simpson Desert. This is an area completely masked by Quaternary deposits. Sand dunes extend throughout the area and prove a major impediment to vehicular movement. The dunes form long parallel dune systems varying in height to eighty feet and are of the "fixed" variety, covered with clumps of spinifex and with avalanche faces to the east. They trend N.N.W. with an average frequency of five per mile. The Simpson Desert and its environs have been adequately covered by R.C. Sprigg, (1963).

Of recent date new geological information has been provided by two stratigraphic wells drilled by French Petroleum south of the Northern Territory - South Australian border, fifty to sixty miles south of the present prospect area.

Witcherrie No. 1 well, located 35 miles south of Anacoora Bore, intersected Permian sediments beneath Mesozoic from 1817 to 2150 feet. These were underlain by the Finke River Series to 3838 feet and the bore then penetrated ?Ordovician quartzite to T.D. of 4803 feet. Purni No. 1 well, located 35 miles southeast of Anacoora Bore, east of the Finke River, intersected Permian below Mesozoic from 4650 feet to 5860 feet, where Precambrian bedrock was intersected. These results indicate a thickening of Mesozoic and particularly of Permian in a general north-easterly direction in this area. In O.P. 57 N.T., both gravity and seismic results have indicated an increase of section to the east. It is expected that the Permian section in the Dakota Bore area will be deeper and thicker than this section intersected in these wells.

Information as to the nature of the ?Mid-Lower Palaeozoic section beneath the Permian of the assignment area is uncertain.

2. PREVIOUS GEOPHYSICS.

An aeromagnetic survey was completed over the concession area in 1962 by the Bureau of Mineral Resources. The anomalous area of interest revealed on the McDills sheet, is predicted to correspond to a large intra-basement east-west trending anomaly. A northeast trending secondary feature is also present, displaced to the east at its intersection with the large east-west anomaly. This has the effect of distorting the structural trend reflected in the sediments.

Bouguer gravity data is reproduced on map BP.142G. This data indicates a long anomalous trend extending northeast, which could fit the trend of the secondary features of the aeromagnetic anomaly

previously referred to. The gravity trend is not displaced at its centre as suggested by the aeromagnetic data.

Comparison of the gravity against magnetic data reveals a general dissimilarity which suggests that the gravity pattern is more prominently influenced by the sedimentary overmass. Several other anomalous gravity features of interest in exploration are revealed on the gravity map, but these were not subject to coverage by the present seismic survey.

3. SEISMIC INVESTIGATIONS.

Two limited seismic surveys have been completed in this portion of the Simpson Desert. An additional survey has been completed to the south outside the lease area by French Petroleum Co. Pty. Ltd. in the Pedirka area. The work by French Petroleum Co. is referred to in relation to reflecting horizons carried from the Purni Stratigraphic well, and in a section drawn by correlation from this well to Malcolms Bore in the north (see accompanying plan BP.174).

The foregoing survey areas lie to the northeast and southwest of the present area at the extremities of a large asymmetical seismic anomaly extending away from a situation north of Mt. Etingambra. This anomaly is broadly compatible with earlier gravity results which closely approximates this strong (McDills) anticlinal trend. Comparison of the axis of the anticlinal trends indicates that axial shift is minor, since the principal gravity density contrast appears at the base of the Permian section. The previously disclosed and relatively steep dip on the northern flank is still present along the anticlinal trend, but limb dips lessen as the trend plunges and broadens to the northeast.

The indication of a shift or variation in northeast trend upon crossing the large aeromagnetic anomaly is substantiated on the seismic map by the local curving of the structural axis.

Seismic lines which were extended south to the vicinity of the Pedirka area were not, however, tied to the French Petroleum Company survey, so that a more complete integration was not possible. Correlation at the level of the "P" reflector was possible throughout the areas because of the strong and characteristic energy return of this reflection.

III FIELD PROCEDURES.

The area of the survey lies in a major desert area, and presents problems peculiar to this type of terrain.

The weather, an important factor affecting field work conditions and general efficiency, was milder, corresponding to the spring season of the year. Lower temperatures generally prevailed with averages in the 70 to 80°F range.

Ground transport presented a major problem, principally because of the persistant, long and parallel sand dunes which demanded considerable planning in order to maintain the survey on schedule. A TD14 tractor was used practically continually for clearing track and in hauling heavy equipment across the dunes. The steeper "avalanche" sides of the dunes face easterly and resulted in relatively easier movement in that direction. This factor necessitated the shooting of the area from west to east.

The difficulty of movement also presented a problem in the form of increased drive-time. In order to reduce the drive to the work sites, a central camp was established on the intersection of the J and AB lines. Access was available to the camp from the outside in either direction, namely along the J line to the north linking through Andado Station to Finke township and to the south along the Finke River linking to Mr. Dare Homestead. As the drive-time became excessive, fly camps were established away from the main camp. Numerous such camps were maintained on the eastern side of the prospect.

Drilling in the area was not a problem because of the ability to obtain seismic records with shallow holes. The usual hole depth was within the 40 to 50 foot range and the holes were preloaded when completed. Air with water injection was used in areas of loose sands. The long water haul, approximately 50 miles, prohibited the use of water as the principal drilling fluid.

The recording crew experienced the usual desert problems of battery charging and that of dust penetration into much of the electronic equipment. This dust problem was finally overcome by slip covers over the instruments when not in use, and the batteries presented less problem because they remained at a full charge longer in the cool weather. The ability to obtain reasonable records allowed the shooting to proceed at a fast rate. Three hole "inline" patterns, however, were used as a standard throughout the area. Deeper single holes were tried on some shot points on the long southern lines, but it was found better results were obtained using the shallow multiple holes. The three hole patterns were spaced at 15 feet intervals to reduce the ground roll.

The surface topographic survey was carried throughout the area using a theodolite and/or transit. Traverses were carried along the interdune corridors and these survey levels were tied into the gravity permanent markers. Lines extending beyond the gravity network were double run and locked back to the nearest available gravity survey permanent station marker.

Horizontal control was carried from "S" line in the Hale River Floodout area west to the "K" line in the Anacoora Bore vicinity. The Hale River Floodout area is tied to astrofix NMA-G-141. In order to fix the western end of the traverse, a control line was tied to the triangulation station at Mt. Etingambra from the end of the "D" line. Correction for horizontal control involved a minor re-adjustment of the AB line on its southwestern end. A check was also run on the "G" line where a discrepancy was located and corrected on the earlier completed seismic maps.

Experimentation was limited to hole depths and record quality improvement since all the standards had been set in the adjoining areas. Hole depths and multiple hole patterns were varied on occasions in areas of deteriorating record quality. Various filter settings were tried, but the standard 30-64 filter was used throughout the area on at least one playback. Several offset velocity shots were also taken in the area in an effort to obtain identification of the Permian unconformity. A breakover velocity was obtained, but the identification by velocity suggests penetration to an earlier Palaeozoic refractor was not obtained. (See accompanying plans.)

Corrections used on the records were based on a straight line ray path calculation for the centre and outside traces using a replacement velocity of 6000 feet per second to a datum of 300 feet. The weathering correction used was based on the intercept method obtained from the refraction plots. The theory of the corrections are the same as described in any geophysical text (Dobrin P69 to 77).

Several migrated sections have been plotted. These are based on the resolved time method. The horizontal velocity used was 6000 feet per second, which is equivalent to the refractor velocity below the weathering.

The computed weathering appeared to increase to the south of the structure reaching a maximum of 172 feet on shot point J-1.

IV RESULTS.

The record quality throughout the Dakota area was fair to good. Two horizon maps were compiled from the records and an isopach map computed. The maps are presented in the accompanying plans and are referred to as

"C" Horizon - Tentative Blythesdale
"P" Horizon - Tentative Permian
Time Interval Map "C" to "P"

The information on the maps are incorporated with that of previous surveys carried out over immediately adjoining areas. This permits more

satisfactory inter-relationship of the geological and geophysical results.

A deeper horizon map was attempted, but the information proved too parchy for useful presentation. This deeper horizon appears on several sections.

Depths to the principal reflector horizons have been computed by TΔT analysis, the moveouts compiled statistically from the records, a curve computed of the results. These results were incorporated with TΔT curves computed for the adjoining areas, then additional integration was undertaken in the shallower section, namely from the Blythesdale horizon to the surface by reference to South Australian Mines Department information as published in the Australian Oil and Gas Journal (October, 1962). A time-depth curve is presented for the area. The equation expressing the velocity function is $Va = 4700 + .5Z$. Depths estimated from this curve have been placed opposite the appropriate time-markers on the maps.

A series of VDF sections are included in the text of the report. These sections have been reduced to be compatible with sections produced in the adjoining area across the border in South Australia. This enabled a correlation to be carried from the area of the French Petroleum Co. Purni No. 1 well, located approximately 15 miles to the south of "J" line termination. This correlation section is presented as a Generalized Cross Section along a line of seismic shot points and gravity traverse information spanning approximately sixty miles from F.P.C. Purni No. 1 well to Malcolms Bore beyond the northern border of O.P. 57 Northern Territory.

The VDF record sections are reduced horizontally by a factor of ½ the vertical scale. This in effect exaggerates the dip, but does not detract from the proper record times. Migrated sections have been produced along selected interdune traverses where structural dip off the northern edge of the McDills Anticline is excessive. These are produced for the C, CD, M, O and Q lines.

Weathering control carried on the records is plotted on the tops of the VDF sections. Weathering depth generally increased to the south off the structure.

Experimentation was carried out in the area in the way of three refraction offsets. These are detailed in the accompanying plans. On the refraction offsets, it was found that the reflector could be followed into the wipeout area in the vicinity of the critical angle. The plot of the first arrivals beyond this point identified the refractor. Observation of the plots of the offset shootings shows that the highest refractor velocity obtained was in the 12,000 feet per second range, suggesting penetration was not obtained to the base of the Permian. Larger offsets were curtailed by the poor quality of the results beyond a distance of one and one half miles.

Gravity results for the area are reproduced on the Bouguer gravity map included in the accompanying plans. This map is included for comparison, since most of the programme has been assigned on the basis of the gravity map.

V. INTERPRETATION.

The structure maps presented are considered to be based on reliable reflections. The first leg of the reflectors have been used to avoid lags due to phasing. The quality of the reflections varies throughout the range. The "P" reflector is by far the strongest, and most characteristic. Correlations carried from the area to the adjoining lines have been based principally on the "P" reflector, and upon time interval separations from it.

The picture contained on both horizon maps are similar, the strong McDills anticline continues across the map without significant structural interruption.

The northern flank of the asymmetrical McDills anticlinal structure is the steeper dipping. Along the M line the "C" horizon dips are 150 feet per mile and dip increases with depth to 400 feet per mile at the "P"

horizon level. The structure plunges to the northeast at the rate of 51 feet per mile on the "C" (shallow) horizon and at 87 feet per mile on the "P" horizon.

Thinning of sedimentary section is considered to be particularly important within the Permian, in view of developments of comparable nature at Gidgealpa. Porous sands increase in proportion over the crest of these structures, and stratigraphic traps well suited to hydrocarbon accumulation occur in flank (onlap) situation. Considerable thinning occurs over the McDills anticline as revealed on the isochron map. The locus of thinning is seen to correspond with the structural "closure" contoured on the "P" horizon map at the intersection of the "D" and "AB" lines. Approximately fifty milliseconds or 150 feet of closure is calculated by TΔT at the "P" horizon level.

Of particular interest is the marked thinning below and within the "P" horizon across the crest of the structure as seen most advantageously on the "O" line. A considerable sedimentary wedging and/or stratigraphic onlap appears to be present. There is also indication of a seismic diffraction pattern from within Permian on the north flank.

An additional point of interest is the fault indicated lying south of the principal structure at shot point 0-49. This fault exhibits approximately 100 feet of southerly throw. The fault is not readily apparent on either of the other two long southern lines ("J" and "V"). More information would be required in this area to assess the strike of the fault and its relation to the main structure.

Good examples of sedimentary wedging onto the main anticlinal structure is seen on its northern edge, both above and below the "P" reflector. Unfortunately, the seismic diffraction patterns have had a masking effect in this critical region. Suggested line-ups of reflectors up to one second (return time) below the "P" reflector, if legitimate, would suggest that the structure becomes more "monoclinal" at depth.

Comparison of the seismic contour maps with the Bouguer Gravity Map reveals broad similarity over the McDills anticline and to the north along the long "J", "O" and "V" line. The smaller positive anomaly build-up suggested on the gravity to the south, however, is not substantiated. Instead, the seismic data suggests a more gradual build-up beyond the gravity anomaly to a structural "high" lying further south across the South Australian border. The aeromagnetic data suggests that in this situation a basement anomaly could be responsible, the axis of which extends south of the border into the Purni area. Between these two seismic anomalies a structurally low area trends southeast into the very deep basin region as shown in the Bureau of Mineral Resources 1962 aeromagnetic survey interpretation.

Energy below the "P" can be better observed on the VDF sections where partial reflections suggest a thickness of section at least 600 seconds below the intermediate horizon. Many of the line-ups in this zone are considered reliable. Diffraction patterns that are noticeable on the northern flank of the McDills structure on the interdune lines in the Anacoora area, are present also in the interdune lines in the Dakota area. Projection of the diffraction patterns back to "point source" suggest they may emanate from within the Permian. The patterns appear to originate from the pronounced stratigraphic thinning in this section, as observed on previously completed lines. This does not preclude the definite possibility that the diffractions originate from faulting along the northern side of the McDills anticline.

Relation of the seismic data to the geological formations known or believed to be present locally, suggest a gradual thinning and changing of section particularly within the Permian to the south along the "J" line. At the southern extremity of this line the otherwise prominent "P" reflector becomes much more subdued, and a lower reflector approaches the strength of the shallower "P" reflector.

Comparison with the gravity contours favours the view that there is

very little "axial" displacement from the gravity anomaly to that of seismic "high". This is somewhat unexpected in view of the extreme sedimentary thickening on the northern flank of the anticline. This may suggest that a considerable thickness of sediments is still present below the Permian, and the previously mentioned thickening of section is negligible in the overall sedimentary section.

VI CONCLUSIONS.

The Dakota Bore seismic survey has successfully linked two previously completed surveys. The major McDills asymmetrical anticline is shown to be continuous across the prospect. There is now evidence of secondary closures at or above the Permian "P" horizon levels as may be referred from Bouguer gravity data. Correlation of seismic contours with gravity data suggests that east-west gravity gradients are present in the area relating to events below the Permian level.

A notable thickening of sedimentary section is observed off structure especially within the Permian. The "CD" line has proven small structural closure on the overall anticlinal structure at the Permian level, presenting a favourable location for a first stratigraphic well. Sufficient survey has been completed in order to justify a combination structure and stratigraphic test in this area.

A. Yakunin

AY/be
23/2/65

APPENDIX I

STATISTICS

General

Commencement Date of Survey	4th August, 1964
Completion Date of Survey	24th September, 1964
Miles Traversed	121.5 miles
Number of Positions shot	486

Recording

Average depth of the best shot	40 feet
Number of field recording hours	540 hours
Number of hours drive	116 hours

Amount of Explosives used:

Geophex used - 5 lb. sticks	1,848 lbs.
Ammonium Nitrate - prills	15,000 lbs.
Detonators 60 foot leads	1,387
Usual size of shot	3 holes @ 5 lbs.

Drilling.

Number of drills used	2 drills
Number of hours drilling	590 hours
Number of hours drive time	113 hours
Total footage drilled	49,000 feet
Average rate of drilling	83 feet per hour
Types of bits	Skidmore Crooks
Size	4¼ inch
Number of bits	12 bits
Lost time	Nil
Casing used	Nil

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APPENDIX II

EQUIPMENT

Seismograph.

Make of Seismograph	S.I.E.
Number of Channels	24
Type of Camera	FRO-11
Type of Amplifier	F-11
Type of Geophones	EVS - 2
Frequency	20 cycles
Geophones per trace	Variable
Connection	Series parallel not to exceed 20% of 500 ohms impedance
Spacing in Group	10 feet (dependent upon noise analysis)
Spread Length	1,320 feet
Geophone Interval	110 feet
Shot Point to near Geophones	110 feet
End Trace Geophones	At interlocking shot points
Number of Cables	3

Magnetic Recorder

Make of Magnetic Recorder	Electro-Tech
Type	DS-7 Direct Recorder
Number of Traces	27 (including 3 information traces)

Equipped with movable heads and velocity cams if required.

Drilling

1 Mayhew 1000 drilling rig equipped with 10 foot Kelly, air and water drilling (Gardner Denver 4½" x 6" pump and WCG 427 cubic foot air compressor) mounted on a 1961 Bedford 4 x 4 truck and complete with 250 feet of drill stem, plus drilling accessories.

1 - Mayhew 1000 drill rig equipped with 15 foot Kelly, air and water combination (Gardner Denver 5" x 6" pump and WCG 480 cubic foot air compressor) mounted on 4 x 6 1961 International with size 1700 tyres in addition 300 feet 2⅞" OD drill stem and all drilling accessories.

2 - 1000 gallon tankers with built in gear pumps mounted on four wheel drive Bedfords.

Shooting.

1 - Bedford mounted with 600 gallon Griffin tank and related shooting accessories.

1 - 4000 lb. licensed dynamite storage equipped as per explosive regulations.

1 - Complete set of shooting equipment with two multihole blasters.

Surveying.

1 - Toyota (4 x 4) Landcruiser

1 - Wild T1 Theodolite

1 - Stadia Rod

Transport.

1 - Landrover (4 x 4) Personnel carrier.

1 - Toyota (4 x 4) Landcruiser office and scouting vehicle.

1 - Ford F600 supply truck.

Recording.

1 - International 120 (4 x 4) fitted with recording cab.

1 - Toyota (4 x 4) Landcruiser fitted as cable and geophone laying unit.

Office.

1 - 20 foot Carapark Caravan modified as Mobile Office, complete with office equipment.

Camp

a. Tents with stretchers, blankets and sheets.

b. 1 - Kitchen caravan fitted with gas stoves and electric freezer.

c. 1 - Dining marquee.

d. 1 - Shower caravan fitted with pressure pumps, lockers and washing facilities.

e. 1 - Lighting plant - 6 KVA Dunlite and accessory cables.

f. 1 - Mobile workshop with welder, mounted on (4 x 4) Ford Blitz.

APPENDIX III

PERSONNEL

Party Chief	A. Yakunin
Party Manager	J. Hastie
Seismologist	A. Moore
Chief Computer	R. Mather
Draftsman	M. Upton
Observer	D. McNutt
Junior Observer	R. Hasee
Shooter	J. Owens 3 helpers
Surveyor	T. Campion 1 rodman
Drillers	C. Grigor T. Quarry 2 helpers
Mechanic	D. Howell
Cook	R. Sampson
Second Cook	D. Millbrook
Supply Truck Driver	T. Howard