COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM SEARCH SUBSIDY ACTS

Publication No. 36

BLUE HILLS-LOGUE SEISMIC SURVEY, WESTERN AUSTRALIA, 1959-1960

BY

WEST AUSTRALIAN PETROLEUM PTY LIMITED

Issued under the Authority of Senator the Hon. W. H. Spooner,
Minister for National Development
1962

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

Minister: SENATOR THE HON. W. H. SPOONER, M.M.

Secretary: H. G. RAGGATT, C.B.E.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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FOREWORD

In 1959 the Commonwealth Government enacted the Petroleum Search Subsidy Act 1959. This Act enables companies that drill for new stratigraphic information, or carry out geophysical or bore-hole surveys in search of petroleum, to be subsidized for the cost of the operation, provided the operation is approved by the Minister for National Development.

The Bureau of Mineral Resources, Geology and Geophysics is required, on behalf of the Department of National Development, to examine the applications, maintain surveillance of the operations and in due course publish the results.

A reflection seismic survey was carried out under the Petroleum Search Subsidy Act 1959 in the Mt Anderson area of the Canning Basin in Western Australia by West Australian Petroleum Pty Limited. This Publication deals with that survey and contains the information furnished by West Australian Petroleum Pty Limited.

The final report was submitted in two parts: (i) a geological report and review of the interpretation by D.N. Smith, Geologist-Geophysicist of West Australian Petroleum Pty Limited, and (ii) a general report by A. Sabitay, Party Chief of Geophysical Service International, S.A.

These reports were collated and edited in the Geophysical Branch of the Bureau of Mineral Resources.

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ILLUSTRATIONS

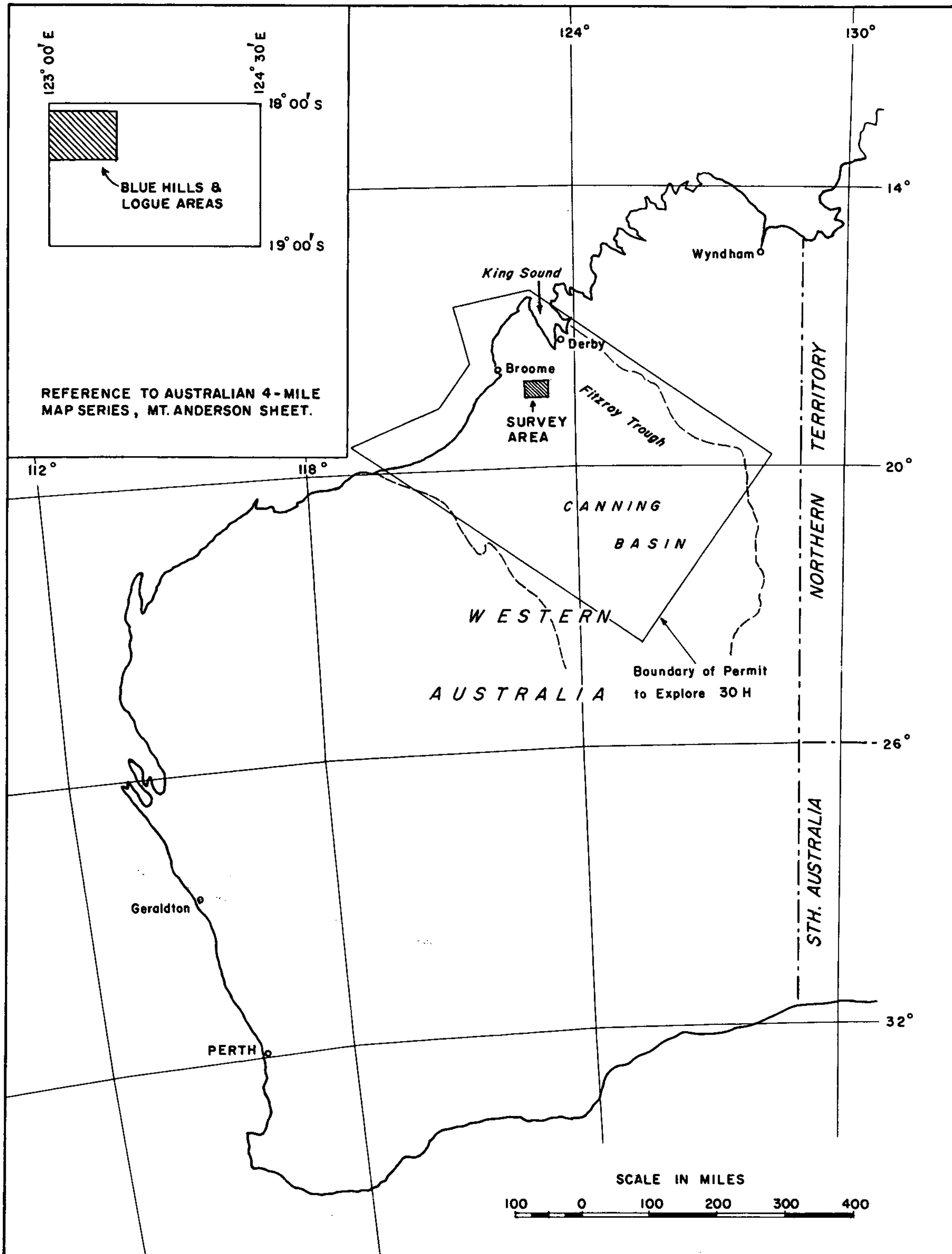


Fig. 1. LOCALITY MAP

ABSTRACT

A reflection seismic survey was conducted in 1959-1960 by Geophysical Service International, S.A. for West Australian Petroleum Pty Limited. The survey took place within the Canning Basin in Western Australia. The purpose of the survey was to investigate certain anomalies which had been indicated by a previous refraction seismic survey. The reflection seismic survey consisted of 63 miles of continuous profiles, and the interpretation of the results obtained over part of the prospect was controlled by three closed loops.

Four anticlinal structures were located in an area where the thickness of pre-Permian sediments is believed to be between 4000 feet and 5000 feet. One of these structures is in the form of an anticlinal nose plunging to the south-west with the open end facing north-east. The other three structures are anticlinal structures closed by faults.

1. INTRODUCTION

A reflection seismic survey was conducted in 1959-1960 by Geophysical Service International, S.A., for West Australian Petroleum Pty Limited (WAPET). The survey area (see Figure 1) is located 70 miles east of Broome, and lies within the Mt Anderson "4-mile" area. The area is covered by Permit to Explore 30H of the Canning Basin, Western Australia.

The field work was done during September and October, 1959, and additional work was carried out in April, 1960. A total of 63 miles of reflection traverses were shot. These lines are identified as Dampier Downs Line A to Line Z, Dampier Downs Line AA, Dampier Downs Line AB, etc.

It is the policy of WAPET to refer to all reflection seismic lines which fall on a one-mile map sheet by the name of a prominent geographical feature within the sheet. If a line passes onto a neighbouring sheet, its name and identifying letter change at the sheet boundary. Hence all reflection lines on Mt Anderson Sheet 1 are referred to as "Dampier Downs Line - " whereas those on Mt Anderson Sheet 2 are referred to as "Jurgurra Creek Line - ". WAPET's one-mile sheets are bounded by parallels of latitude, half a degree apart, and by lines of longitude, half a degree apart.

The sheet boundaries are placed on the degree and half degree lines to conform to the Australian National Mapping grid. Hence each WAPET one-mile map is equivalent to two one-mile maps of the Army series. It should be noted here that long refraction lines that are part of regional refraction reconnaissance programmes retain their name throughout their length regardless of the map sheets they traverse (e.g. Fenton Line C).

A previous refraction seismic survey had indicated several areas of positive basement relief located in the central portion of the Jurgurra Terrace in the Canning Basin. These areas are known as the Blue Hills and Logue structural anomalies. The purpose of the survey described in this report was to investigate these anomalies.

2. GEOLOGY

The Canning Basin (see Figure 1) is bounded on the west by the coastline between Port Hedland and King Sound and it extends eastwards almost to the Northern Territory border.

Near the north-eastern margin of the basin, and parallel to the strong Proterozoic lineament which controls this margin of the basin, is an elongated area of deep sedimentation - the Fitzroy Trough. This is separated from the broad, shallow, southern portion of the Canning Basin by the Jurgurra Terrace.

A large part of the surface of the Fitzroy Trough is covered by Permian and Triassic sediments with outcrops of Jurassic and Lower Cretaceous sediments in the north-west. Drilling and geological mapping have proved the existence of marine Ordovician, Devonian, Carboniferous, Permian, Triassic, Jurassic, and Cretaceous sediments whose aggregate thickness exceeds 30,000 feet.

In the desert country to the south of the Dampier Fault, which marks the northern limit of the shallow sedimentary basin to the south of the Fitzroy Trough, rock exposures are poor and subsurface information from drilling is meagre. However, it is apparent that this part of the Canning Basin has had a distinctly different depositional history from the Fitzroy Trough. The thick Carboniferous to Triassic sequence which is a feature of the Fitzroy Trough is absent. The known thickness of Ordovician, possible Devonian, Permian, Jurassic, and Lower Cretaceous rocks does not exceed 6000 feet.

Between the Dampier Fault which marks the northern boundary of the more stable southern part of the Canning Basin, and the Fenton Fault which marks the southern boundary of the deep Fitzroy Trough, there is a buried shelf known as the Jurgurra Terrace, where the depth to basement varies between 7000 and 11,000 feet.

The surface of the Blue Hills and Logue areas of the Jurgurra Terrace consists entirely of sandy soil derived from the underlying Mesozoic formations. These occur in outcrops in the Edgar Range to the south, where a thickness of about 500 feet of Jurassic and Lower Cretaceous rocks is exposed.

3. PREVIOUS GEOPHYSICAL SURVEYS

Reconnaissance Surveys

Up to 1958, several main structural provinces had been defined in the Canning Basin by the geological and geophysical reconnaissance carried out by WAPET. Reconnaissance seismograph refraction work was then intensified in the most promising area, the Jurgurra Terrace, and several possible structures were localized. This work is described by C. J. Blum and D. N. Smith in an unpublished report "Refraction Surveys of the Fenton Project" (West Australian Petroleum Pty Limited, 1959).

These refraction surveys mapped a 19,600 ft/sec refractor as basement at an average depth of 9000 feet below sea level. Thickness of the pre-Permian rocks was estimated at between 5000 and 6000 feet. This work was followed up by reflection seismic work [(1)], and Frome Rocks No. 1 and No. 2 Wells were drilled.

Extrapolation of the data from Frome Rocks No. 2, Dampier Downs No. 1, and Goldwyer No. 1 Wells showed that the pre-Permian rocks overlying the basement would be predominantly Devonian. Ordovician rocks might occur between the basement and the Devonian rocks. This thickness of 5000 feet or more of sediments may contain petroleum source and reservoir beds.

Attention was focussed on the Fenton refraction anomalies in the central part of the Jurgurra Terrace, i.e., west of Frome Rocks, and seismic reflection projects were initiated to map the sedimentary rocks.

The Blue Hills Project was designed to check a basement anticlinal anomaly found on Fenton Refraction Lines A and P. Information was needed to determine whether the

(1) Footnote by the Bureau of Mineral Resources:

The reflection seismic work referred to was carried out by WAPET to the south-east of the Blue Hills-Logue area. A full description of the survey is given in "Dampier Fault Seismic Survey, W.A. 1960". (West Australian Petroleum Pty Limited, (in preparation) .

pre-Permian sediments, believed to be 5000 feet thick in this locality, were similarly folded. Sufficient detail to locate a drilling site was desired.

The objectives in the Logue Project were to investigate two basement anticlinal anomalies in the Manguel area and to attempt to establish the presence or absence of intrusive salt in the younger prospective sediments. In Frome Rocks No. 1 Well, piercement salt was discovered to be associated with the Frome Rocks "basement" anomalies. Thus the similar refraction structures at Manguel were also suspected of being associated with injected salt, but positive reflection evidence was a pre-requisite to the condemnation of the area.

Plates 1, 2 and 3 include data from the Dampier Fault Seismic Survey. The reflection lines of this project were shot concurrently with those of the Blue Hills and Logue Projects and in some cases the one line is associated with each of the three projects. The data from the Dampier Fault Seismic Survey are not discussed in this report apart from that of Dampier Downs Line R, which closes loops at Blue Hills.

Gravity results coincident with the basement anomalies did not suggest any particular solutions to the types of structures which might occur at these three localities. The resolving capabilities of the seismic reflection method were needed to help integrate all data in the project areas.

Refraction and Reflection Data Portions of a number of Fenton Refraction Lines, both broadside and in-line, traverse the Blue Hills and Logue areas. A wide range of refractors was recorded by the in-line shooting but the most important for stratigraphic purposes were those recorded by two "all refractor" profiles shot on Fenton Line C. These profiles are centred at Fenton Shot-points 401 Line C and 489 Line C, which are near the Blue Hills and Logue Projects, respectively.

The refractors recorded are listed below together with the average depth and general geological correlation:-

TABLE I

REFRACTION DATA - FENTON LINE C

Fenton Refraction Shot-point 401 Line C (Blue Hills area).	Fenton Refraction Shot-point 489 Line C (Logue area)	Correlation
	10,700ft/sec. -1,400 feet 13,500ft/sec. -2,800 feet	Permian
16,400ft/sec. - 5,000 feet 18,000ft/sec. - 8,000 feet 19,600ft/sec. - 10,300 feet	18,000ft/sec. -7,000 feet 19,600ft/sec. -8,000 feet	pre-Permian

Throughout the subject reflection survey, one persistent angular unconformity was mapped between -3300 and -5000 feet. The comparison of Fenton Line A and Dampier Downs Line B suggests that the 16,400 ft/sec interface and this reflection unconformity are closely related. The assumption that the reflection unconformity (Phantom Horizon "B") is the Permian and pre-Permian interface is therefore considered reliable.

The 19,600 ft/sec (basement) refractor varies between -7000 and -11,000 feet in depth in the area; therefore a thickness of 5000 to 6000 feet of overlying pre-Permian rocks can be predicted in the area of Blue Hills and Logue. The age and lithology of these rocks can only be extrapolated from the data from the nearest wells.

Well Data Stratigraphic control on the Jurgurra Terrace is limited to Frome Rocks Nos. 1 and 2 Wells, which are 30 miles to the south-east of the project area. Full descriptions of the information obtained from Frome Rocks Nos. 1 and 2 are given in P.S.S.A. Pub. No. 8 (West Australian Petroleum Pty Limited, (in press)). The nearest stratigraphic test was Dampier Downs No. 1 Well, which is south of the Dampier Fault, i.e. on the Broome Platform. The depths of the formation tops encountered in the Frome Rocks Nos. 1 and 2 Wells are listed below.

TABLE II

DEPTHS BELOW SEA LEVEL OF FORMATIONS ENCOUNTERED IN WELLS ON THE JURGURRA TERRACE

Age	Formation	Frome Rocks No. 1	Frome Rocks No. 2
RECENT	Sands	+ 221	+ 287
JURASSIC (Upper)	Jarlemai Siltstone	+ 190	
	Alexander Formation	- 77	
	Wallal Sandstone	- 317	+ 266
PERMIAN	Liveringa Formation		+ 90
	Noonkanbah Formation		- 139
	Poole Sandstone		-1150
	Nura Nura Member		-1788
	Grant Formation	- 504(Dolomite breccia)	-1813
DEVONIAN	Upper unit		-3261
	Lower unit	-2026(Rock salt)	-5968
	TOTAL DEPTH	-3773	-7208

The Upper Devonian rocks at Frome Rocks No. 2 consisted of 4000 feet of limestones, calcarenites, shales, siltstones, and sandstones. The upper 2700 feet showed some visible oil and persistent staining in ostracod-rich limestone beds. Signs of oil were also apparent in the 1800 feet of Ordovician rocks penetrated in Goldwyer No. 1 Well. It is clear, then, that the 5000 to 6000 feet of pre-Permian rocks in the central part of the Jurgurra Terrace, which embraces the Blue Hills and Logue areas, will be predominantly Devonian with some underlying Ordovician rocks, and that both these sequences will be stratigraphically prospective.

4. FIELD PROCEDURES

Conditions

The topography of the area covered by the survey is gently rolling, and rising gradually northward. The surface is covered with sand and sandy soil which supports sparse spinifex and stunted trees. Climatic conditions were hot and dry; no rain fell during the period of the survey.

Drilling and drinking water was drawn from Nillibubacca Well on the main Broome-Derby road, and Clanmeyer Pool on Jurgurra Creek. McHugh Well was contaminated and therefore could only be used to provide water for drilling purposes. Two Caterpillar D-6 contract bulldozers were used to cut all patterns and lines for the survey. Access trails from the main Broome-Derby road were limited to lines bulldozed for various geophysical purposes. Commonly used access of this type was maintained, when necessary, with a WAPET grader.

Surveying

A plane table and telescopic alidade were used for all field surveying. Horizontal and vertical control were based upon permanent survey markers set up previously by both Robert H. Ray (Australia) Pty Ltd and Geophysical Service International, S.A. A magnetic declination of 2^{o}E was used.

Drilling

Hawthorne 4 3/4-in. kelly bits and 4 1/4-in. follower bits were used. Air-drilling was preferable in this area, and was used most of the time because of the distance water had to be hauled.

Sand, sandstone, and sandy clays were the most common deposits encountered in the shot-holes. Occasionally, in the deeper shot-holes (to 150 feet) on Line B, yellow, red, and white clays were penetrated and, in a few instances, the shot-holes were bottomed in harder blue clay.

Thirty-six hole patterns were drilled to kelly depth (20 feet). The depth of single holes for weathering control or production profiles varied from 40 to 155 feet. A deep hole for sub-weathering velocity information was drilled at Shot-point 68 Line G to 395 feet; it bottomed in sandstone.

Shooting

At first a single-hole shooting technique was used but three-hole and seven-hole in-line patterns became the normal practice early in the programme.

Experimentation on Line G indicated that a 36 shallow hole areal pattern was the optimum shot arrangement. This technique was employed for most of the subsequent programme.

"Geophex" was the explosive used on Lines B through F. "Nitrex" (ammonium nitrate) mixed with dieselene and primed with ten percent "Plastergel" was used in dry shallow shot-holes on subsequent lines. Much of the "Nitrex" had hardened to varying degrees in the drums and extra man-hours were required to repulverize it before it could be used.

Recording

Continuous split-spread recording was used on all project lines. Spread length used on Line B was 1760-0-1760 feet; the remainder of the project lines were shot with a 1320-0-1320 foot spread. The normal step-out of the longer spread was believed to be excessive at the shallowest mapping depths for optimum identification of reflection continuity in this area of fair-to-poor quality records. Occasionally, longer or shorter spreads were necessary to obtain a common shot-point at line intersections, or to avoid placing a shot-point at a poor drilling location.

Multiple geophone arrays were used to improve the signal-to-noise ratio. Eighteen geophones per group were generally used.

A summary of recording, drilling and shooting data used for production profiles is set out in Table III. (See page 8).

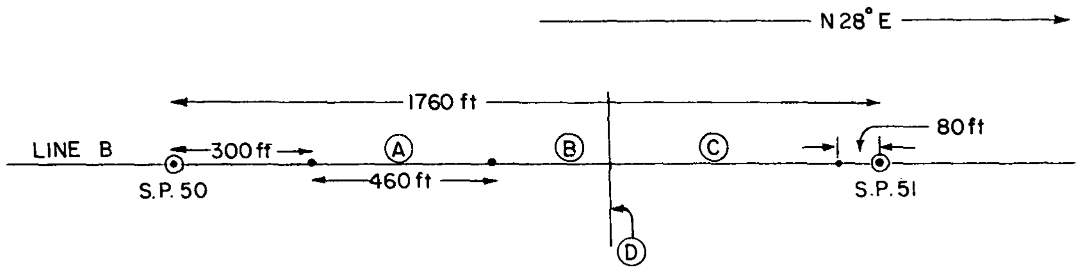
All recordings were obtained using Texas Instruments 7000KB 24-channel amplifiers. Wide-band data were recorded on both Magne DISC and monitor paper seismogram using a 120KK-18K filter. Field playbacks were subsequently obtained using a 75KK - 24K filter. Compositing was not used.

TABLE III

SUMMARY OF TECHNIQUES

Dampier Downs Line	Spread Length (feet)	Groups	Group Interval (feet)	Geophones per Group	Geophone Spacing (feet)	Shooting Patterns	Average Depth (feet)	Average Charge lb.	Explosive
B	split 3520	24	147	12	18	single holes	100-150 80	30 60	Geophex
C	split 2640	24	110	12	18	single holes	155	30	Geophex
D	split 2640	24	110	12	18	single holes	155	30	Geophex
E	split 2640	24	110	12	18	single holes	155	30	Geophex
F	split 2640	24	110	12	18	single holes	155	30	Geophex
G	split 2640	24	110	18	12	seven holes 36 holes	80 20	230& 260 360& 520	Geophex Nitrex
H	split 2640	24	110	18	12	36 holes	20	520	Nitrex
J	split 2640	24	110	18	12	36 holes	20	520	Nitrex
K	split 2640	24	110	18	12	36 holes	20	520	Nitrex
L	split 2640	24	110	18	12	36 holes	20	520	Nitrex
M	split 2640	24	110	18	12	five holes seven holes 36 holes	80 80 20	520 520 520	Nitrex Nitrex Nitrex
N	split 2640	24	110	18	12	36 holes	20	520	Nitrex
P	split 2640	24	110	18	12	36 holes	20	360 520	Nitrex Nitrex
Q	split 2640	24	110	18	12	16 holes 36 holes	20 20	160 320 360 520	Nitrex Nitrex
S	split 2640	24	110	18	12	16 holes	20	300-360	Nitrex
AB	split 2640	24	110	18	12	16 holes 36 holes	20 20	300-360	Nitrex

LAYOUT



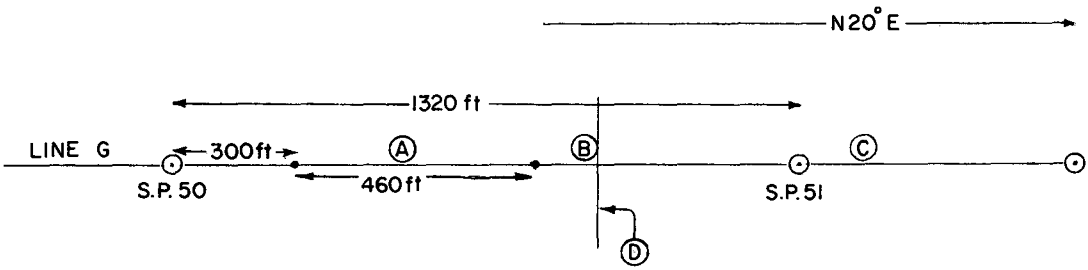
NOISE CHARACTERISTICS

TYPE	VELOCITY	FREQUENCY	WAVE-LENGTH
A	1375 ft/sec	10 c/s	138 feet
B	1450 ft/sec	12 c/s	120 teet
C	1770 ft/sec	16 c/s	110 feet
D	2690 ft/sec	33 c/s	81 feet

NOISE ANALYSIS — DAMPIER DOWNS LINE B. SHOT-POINT 50

Fig. 2

LAYOUT



NOISE CHARACTERISTICS

TYPE	VELOCITY	FREQUENCY	WAVE-LENGTH
A	2960 ft/sec	33 c/s	90 feet
B	2450 ft/sec	30 c/s	82 feet
C	2160 ft/sec	25* c/s	86 feet
D	1980 ft/sec	40(?)* c/s	50 feet

* These frequencies were measured on KK 75-24 K playback of noise shot.

NOISE ANALYSIS — DAMPIER DOWNS LINE G. SHOT-POINT 50

Fig. 3

5. FIELD EXPERIMENTS

by A. Sabitay

It was difficult to obtain good quality records in the Blue Hills-Logue area. Two semi-detailed experiments were conducted to study requirements for optimum record quality within limitations governed by the purpose of the project, equipment available, and costs.

Noise Analysis at Shot-point 50, Line B

Field Method - On the first day of the Blue Hills Project, 7th September 1959, a noise analysis was conducted at Shot-point 50, Line B. Four recording microspreads were shot each consisting of 24 groups at 20-foot intervals. The layout is shown in Figure 2.

A single S-19 geophone was used at each group location. Twenty pound charges in a single hole were shot successively into each spread (A through D) with charge tops ranging from 75 to 100 feet deep. Three adjacent in-line spreads (A through C) were used to determine velocity, frequency, and wave-length of noise-trains and change of these quantitative measurements with distance. The cross spread (D) was used to measure the component of the noise-trains perpendicular to the in-line spreads.

Results - The organized noise wave trains were of four types; these are tabulated in Figure 2.

The predominant frequencies of types A, C, and D would be adequately attenuated by the S-32 geophones with a natural frequency of 20 c/s (these are the geophones used by the party in normal reflection work), and also be electrical filtering (a 75KK-21K filter is commonly used).

In the design of multiple geophone groups to act as a wave-filter, it is necessary to have a spacing that is less than the shortest expected noise wave-length, and the total group length should be as long as the longest expected noise wave-length. Whereas only the observed frequencies are tabulated, consideration was also given to component frequencies to be expected from wave spectrum theory; using the limits of a 75-21 cut-off filter, the shortest and longest wave-lengths that were considered are the 75-c/s component of type A, which would be 18 feet, and a 21-c/s component to type D, which would be 128 feet.

The group design that evolved from this noise study was 18 geophones in-line per group, with a geophone interval of 12 feet and a total group length of 204 feet. This design provided good attenuation of the predominant frequency of noise wave type D (33 c/s and wave-length of 81 feet), as the group length covers 2 1/2 wave-lengths of this noise wave. An in-line group design (as opposed to an area design) was adequate because of the cross spread (D) indicated there were no significant components of the noise trains perpendicular to the in-line spreads.

Noise Analysis at Shot-point 50, Line G

Field Method - An identical field procedure was used as in the forementioned experiment. The analysis was conducted on 14th September 1959. The layout is shown in
i-2 Figure 3.

Results - Using the limits of a 75-21 cut-off filter, the shortest and longest noise waves to be expected from wave spectrum theory are 26 feet for a 75 c/s component of noise type D, and 141 feet for a 21 c/s component of type A.

The group design derived from these experimental data was 12 geophones per group at an interval of 18 feet, with a total group length of 198 feet. The strongest noise waves are the predominant frequencies of types A and B, which have wave-lengths of 90 and 82 feet respectively. The group design covers more than two wave-lengths of the predominant organized noises and should yield adequate attenuation.

Other Field Experiments

Comparisons were made at Shot-point 50, Line B, of various shooting depths in a single shot-hole. At the resulting optimum depth a single shot-hole was subsequently compared with a three-hole in-line pattern. The conclusion was that a single hole was adequate and Lines B through F were shot with this technique.

On Line G, the significant problem was the initiation of sufficient seismic energy. For this reason, seven-hole in-line patterns were compared with 36-hole areal patterns. The former proved better on the southern portion of the line, and the latter better on the northern portion.

An abbreviated noise analysis at Shot-point 68, Line G, showed high random noise. Further experiments were attempted at Shot-point 74, Line G. These compared 16 hole areal patterns with an 11-hole in-line pattern. Previously recorded shots using 36-hole patterns proved best; therefore, a 36-hole shooting pattern was used on Line G through L.

When record quality improved to good on Line Q, 36 and 16-hole patterns were tried in an attempt to decrease the amount of explosives used. The results indicated that 36-hole patterns were optimum as a standard technique throughout the area.

6. COMPUTING METHODS

by A. Sabitay.

Presentation of Results

The results of the survey are shown on Plates 1, 2 and 3 as contour plans of three phantom horizons. These are :

Phantom Horizon	Geological Identification	Depth below Sea Level
Phantom Horizon "A"	Top of the Grant Formation - Permian	1300 feet
Phantom Horizon "B"	Permian - pre-Permian Unconformity	4200 feet
Phantom Horizon "C"	pre-Permian (probably Devonian)	5600 feet

The following additional information has been filed in the Bureau of Mineral Resources and is available for future reference:-

(i) a complete set of shot-hole drill logs,
(ii) a complete set of surveyor's and observer's data sheets,
(iii) a complete set of record sections,
(iv) a complete set of plotted cross-sections,
(v) a map showing weathering depths,
(vi) a shot-point location and elevation map,
(vii) two graphs showing details of noise analysis.

Velocity Function

The Canning Basin Composite Velocity Function, $V_a = 6700 + 0.57Z$, was used throughout this survey. This function is the best visual fit to all available Canning Basin velocity information. Included in the study from which the function was obtained were results from:

Roebuck Bay No. 1 Velocity Survey
Dampier Downs No. 1 Velocity Survey
Jurgurra Creek tΔt Analysis
Samphire Marsh tΔt Analysis
La Grange Refraction Profile D
Samphire Marsh Refraction Profile A
Roebuck Bay Refraction Profile A
Roebuck Bay East Refraction Profile A
Jurgurra Creek Refraction Profile CC

Weathering Calculations

The up-hole method of correcting reflection times was used for single-hole and in-line pattern profiles. For shallow-hole areal patterns on lines up to and including Line P, short refraction data were utilized. On Lines Q, R, and J extension, a single relatively deep hole was shot at each shot-point, in addition to the shallow-hole areal patterns, and records were corrected by the up-hole method with data derived from the shot below the weathered layer. A sea level reference plane was used with a sub-weathering velocity of 6,500 ft/sec. This replacement velocity was derived during previous work in the area from up-hole velocity surveys, and the evaluation of short refraction data plotted at each spread location during the course of this survey confirmed the validity of this vertical velocity for the area.

Cross-section

First of all, the times of the reflections and correlations were analysed on the work-sections. Migrated depth sections were subsequently prepared using a straight ray method which approximates the curved ray path; the plotting arm was calibrated with the Canning Basin Composite Velocity Function.

The Gaby double-letter grading system (Gaby, 1947) was used in conjunction with a plotted reflection line-grade, as follows:

GG, GF FG, & FF, FP, PF, PP, & GP RP

Refraction first arrivals were plotted at the bottom of the section for each profile. Up-hole time or refraction intercept time, depth of shot and calculated depth of weathering were noted directly below the first-break plots.

Mapping

Both progress maps and final maps were prepared at a scale of 1 in. = 1 mile. All base maps were supplied by WAPET from Perth. The contour interval on structural maps was 100 feet.

Data for structural contour maps were generally obtained from phantom horizons. Phantom "A" was, however, often coincident with continuous reflection energy. All mapping values were taken from the migrated cross-sections.

Three phantom horizons were carried - one near the top of the Permian Grant Formation, one at the unconformity between the Permian and pre-Permian sediments, and one within the upper part of the pre-Permian strata. Wherever possible, phantom horizons were carried on a prominent reflection band. When this was not possible, reliable reflection data closest to the depth of the phantom horizon were followed when constructing the phantom. Naturally, more weight was given to reflections with high grade than to low grade reflections. The dips obtained from centre-to-centre correlation on adjacent or nearby records were considered more accurate than the dip across a single reflection, and the dip of a half reflection was considered to be the least accurate.

Neither a distinctive reflection character nor reflection continuity is associated with any of the mapping horizons.

7. DISCUSSION OF RESULTS

by A. Sabitay.

On most lines the quality of reflection data was fair, with a few good lines and fewer poor lines to, and including, the Permian - pre-Permian unconformity (phantom horizon "B"), which is at an average depth below sea level of 4000 feet. Excellent records were obtained on Lines P, M, Q, and R for the greater part of their coverage in the Permain and younger rocks. In a few localities, and at varying levels, reliable phantoms could be carried within the pre-Permian rocks but generally the data for pre-Permian interpretation are poor.

Reliable mapping horizons were derived on all lines for phantom horizons "A" and "B" with the exception of the following portions of lines:

Shot-points 57 - 60, Line G - possible fault

Shot-points 63 - 68, Line G - deep weathering

Shot-points 32 - 35, Line Q - possible fault

Shot-points 74 - 78, Line Q - possible fault.

Reflection Anomaly B coincides with the Fenton Line A basement refraction anomaly and also a small positive residual gravity anomaly.

(2) Logue

The quality of the reflection data up to the depth of the Permian - pre-Permian unconformity was very fair. In the vicinity of the Fenton Fault pattern, especially at phantom horizon "B" depth, data are insufficient to determine whether or not normal movement along the fault planes (C, D, and E) continued into the early Permian rocks. The data from the pre-Permian were generally poor, and insufficient to carry a reliable phantom horizon. Structural contours on the phantom horizon "C" map are based upon dip vectors only. Depth values have been arbitrarily based on the interval between phantom horizons "B" and "C" in the Blue Hills area. Similarly, fault displacements are arbitrary values based partially on the amount of relief indicated by the deeper reflections. Although the anticlinal reversals controlling Anomalies C and D are considered to be accurate at all depths, the reliability of the three structural interpretation maps decreased rapidly with the depth.

Reflection Anomalies C and D overlie the complex basement anomalies mapped by the Fenton Refraction data and are also associated with two strong positive observed and residual gravity trends. Individually, each is coincident with a residual maximum.

Phantom Horizon "C" - Within the pre-Permian (probably Devonian) strata (Plate 3).

(1) Blue Hills Phantom horizon "C" was carried on the cross-sections using fair to poor, discontinuous data at an average depth of -6000 feet.

The area of interest is limited in the south by the arcuate Dampier Fault, which is down-thrown on the north side. The Dampier Fault was located on Lines M, Q, and AB. On Lines M and Q, the phantom horizon "C" layer was lost against the fault plane, but on Line AB it is truncated by the overlying Permian - pre-Permian unconformity. Contouring to the south of the Dampier Fault is based on reflections from Ordovician strata - refer to Dampier Downs No. 1 Well (West Australian Petroleum Pty Limited, (in press)) drilled at Shot-point 40 on Dampier Downs Line A.

Phantom horizon "C" at Blue Hills has an over-all northerly dip of 4000 feet away from the Dampier Fault. The main structural trend consists of a number of parallel, faulted, north-westerly plunging anticlines and synclines, the axes of which when projected to the south-east intersect the Dampier Fault at a shallow angle. It is assumed that their formation was associated with movement along the Dampier Fault plane that occurred after the deposition of the reflecting surface, which is mapped as phantom horizon "C". The two main anticlinal axes are referred to as Anomalies A and B respectively.

Anomaly A plunges north-west and is defined by 370 feet of reversal along Line B. There is no south-easterly dip to effect vertical closure, but a maximum of 200 feet may occur against Fault B.

Anomaly B is defined by reversals of 1020 feet (faulted), 120 feet, 190 feet, and 380 feet (faulted) on Lines B, P, M, and AB respectively. The fourth reversal is axially faulted by Fault A. This fault effects a vertical closure of 300 feet on the up-thrown block for Anomaly B.

Faults A and B are "en echelon" and are probably associated with the changing direction of the Dampier Fault. Fault A dies out to the south-east and does not intersect the Dampier Fault. A maximum displacement of 800 feet is interpreted for Fault B on Line R.

Anomaly E has 800 feet of north-westerly dip and is closed against the Dampier Fault and Fault G. This anomaly is discussed in detail in the Dampier Fault Seismic Survey (West Australian Petroleum Pty Limited, (in preparation)).

(2) Logue Reflection data beneath the unconformity (phantom horizon "B") in the Logue area are sporadic and discontinuous but imply that the Devonian folding is complex and associated with strong faulting of unknown displacement. It was not possible to carry a reliable phantom within the pre-Permian rocks, but structure contours have been drawn to dip vectors plotted along each reflection line. The contour values at Logue are estimates based on the average interval between phantom horizon "B" and phantom horizon "C" in the Blue Hills area.

The Logue structural trend is south-west and north-east and is controlled by a fault pattern comprising three faults. They are:-

Fault C : normal, down-to-the-north, through Shot-points 76 Line Q, 35 Line J and 80 Line G.

Fault D : normal, down-to-the-north, through Shot-point 67 Line G.

Fault E : normal, down-to-the-east, through Shot-point 49 Line J.

Faults C and D are "en echelon" and joined by the oblique cross fault - Fault E.

Fault D appears to be the north-western extension of the Fenton Fault previously mapped at Frome Rocks and is shown to die out within the Logue area. Fault C, however, commences within the Logue area to the north of D and continues "en echelon" to the north-west. It is therefore considered to be part of the Fenton Fault system, which will include the third fault - Fault E. An alternative pattern showing the Fenton Fault as one continuous fault could be interpreted as passing through the following:- Shot-points 76 Line Q, 35 Line J, 49 Line J, 72 Line G and 57 Line J. However, cross-section evidence for faulting at Shot-point 72 Line G comparable to that illustrated at Shot-points 76 Line Q and 49 Line J is weak and, therefore, the "en echelon" system is preferred.

The displacement along Faults C, D and E is unknown but, considering the amount of structural relief on phantom horizon "C", the throw is unlikely to be less than 1500 feet. This figure was arbitrarily applied to the three faults (see Plate 3). Contour values are not shown on the down-thrown blocks because the time of faulting and the amount of displacement are uncertain.

It is shown later that the main movement on the Fenton Fault at Logue is thought to be normal and probably post-Devonian. Reverse movement is evident in the late Permian but it is uncertain whether any of the initial normal movement continued during the deposition of the Lower Permian sediments. If this was so, then it is quite possible that the contours on the down-thrown side of the three faults represent Permian structure.

On the up-thrown side of Faults C, D and E there are two areas of structural interest occurring at the depth of phanton horizon "C"; they are Anomalies C and D (see Plate 3).

Anomaly C is a south-westerly plunging anticlinal nose controlled by a 600 feet reversal on Line G.

Anomaly D is a narrow, sharp anticline bounded to the north by Fault C and to the south by Fault E. The structure is therefore essentially a horst. Faults E and D form a small graben which separates Anomalies C and D.

Closed contours are inferred at Anomaly D. These are influenced by reversals as follows:-

Shot-point 75, Line Q, 900 feet (northern flank 3900 feet)

Shot-point 38, Line J, 200 feet

Shot-point 76, Line G, 400 feet

Total fault and dip closure is more than 600 feet. The large reversal at Shot-point 75 on Line Q, however, coincides with and is therefore directly attributable to Fault C - the Fenton Fault. Fault C may continue to the north-west through reflection Fault F or through a down-to-the-north normal fault at stake 387 on Fenton Line A.

The complex folding and faulting in association with the Fenton Fault resembles the seismic interpretation in the vicinity of Frome Rocks No. 1 Well which was carried out before the well was drilled. This well penetrated piercement salt at 2026 feet below sea level, beneath 1500 feet of pre-Mesozoic dolomite breccia. The presence of piercement salt in the Logue area is therefore a strong possibility.

Phanton Horizon "B": Permian - pre-Permian Unconformity (Plate 2)

Phantom "B" was controlled on all the reflection cross-sections by a number of isolated but well defined and correlatable discordances. These were especially evident on the dip lines such as Dampier Downs Lines B, M, Q, and G. Phanton "B" was projected through these discordances and generally controlled by the immediately overlying continuous reflection data.

(1) Blue Hills Plate 2 shows that the general dip is north to north-west away from the Dampier Fault. Superimposed on this dip are two north-westerly plunging anticlinal structures, the axes of which are practically coincidental with the direction of the axis of the phantom horizon "C". Minor reversals along the northern axis are implied but the resultant culminations have less than 100 feet of closure. Anomalies A and B are essentially two north-westerly plunging noses. The unconformity surface at Blue Hills is unfaulted except along the plane of the Dampier Fault on Lines M and A. The throw is a questionable 150 feet on Line M and 900 feet on Line A.

(2) Logue Although the reflection lines at Logue are not tied directly to those at Blue Hills, the unconformity is readily recognizable in a sufficient number of places to provide control for phantom horizon "B". The structural contours show that a deep synclinal structure separates the Blue Hills and Logue structures. The axis of this depression continues north-east to separate Logue Anomalies C and D, which are sharp anticlines plunging west to south-west.

Anomaly C rises to 3000 feet below sea level at Shot-point 58 Line G where the maximum reversal is 270 feet. The structure is open to the east.

Anomaly D is a sharp anticlinal structure which has a maximum reversal of 900 feet on Line Q. Minor culminations of not more than 100 feet occur along the axis, which bifurcates into two small structures controlled by Line G. The northern flank of Anomaly D has 2800 feet of dip, i.e., 800 feet per mile.

The structural contours of phantom horizon "B" in the Logue area are unbroken by the Fenton Fault system (see phantom horizon "C" Faults C, D, and E). The reflection data controlling phantom horizon "B" in the vicinity of Faults C, D, and E are fairly continuous (except perhaps on Line Q at Fault C), thereby implying that normal movement on the Fenton Fault ceased before Permian deposition commenced. However, as positive evidence of this does not exist on all reflection lines, there remains the possibility that some normal movement did occur after Permian deposition commenced; this possibility is not suggested by Plate 2.

Phantom Horizon "A" - Top of the Grant Formation (Plate 1)

(1) Blue Hills The structure reflected from the top of the Permian Grant Formation is a subdued representation of the underlying Devonian phantom horizon "C" and the Permian - pre-Permian unconformity phantom horizon "B". Both Anomalies A and B appear as small reversals on the well-defined north-westerly plunging anticlinal axes. Phantom horizon "A" at Blue Hills is unfaulted, but up-warping in the upper part of the Permian rocks, e.g., on Dampier Downs Line M, indicates that reverse movement may have taken place along the Dampier Fault during late Permian times.

(2) Logue Phantom horizon "A" contouring conforms generally with phantom horizons "B" and "C" structures but with less relief. The anticlinal axes associated with Anomalies C and D are strongly developed.

Anomaly C rises to approximately 1000 feet below sea level on Line G.

Anomaly D rises to a minimum of 600 feet below sea level on Line J. Although it is defined by 380 feet of reversal on Line G and 530 feet on Line Q, areal closure is limited to 300 feet because of insufficient control. Phantom horizon "A" is unfaulted, but down-warping in the upper part of the Permian rocks, over the plane of the buried Fenton Fault on Dampier Downs Line Q, indicates that, as at Blue Hills, reverse movement has taken place during the late Permian.

Origin of the Blue Hills and Logue Structures

The two main types of structure developed in the central part of the Jurgurra Terrace are:-

(1) Simple anticlinal noses along the southern margin of the Terrace plunging north and away from the associated Dampier Fault, e.g., the Blue Hills structures; and

(2) Complex, narrow, faulted anticlines along the northern margin of the Jurgurra Terrace immediately south of the Fenton Fault Trend, e.g., the Logue structures.

Blue Hills Structures: The reflection seismic cross-section of Dampier Downs Line M illustrates the probable times of movement of the Dampier Fault. The first movement appears to have been down-to-the-north and occurred after the deposition of the reflecting surface, which is mapped as phantom horizon "C". The movement was probably post-Devonian since there is no sign that the pre-Permian rocks above or below phantom horizon "C" thin on to the Precambrian scarp of the Dampier Fault. This would imply contemporaneous deposition and movement. The attitude of the Lower Permian rocks, as indicated by Line M, also clearly shows that reverse movement has occurred along the fault plane during this time or later.

It is considered that the pre-Permian structure at Blue Hills is tectonically associated with this down-to-the-north movement of the Dampier Fault.

Logue Structures: The reflection seismic cross-sections across the Fenton Fault in the Logue area suggest a history of fault movement similar to that of the Dampier Fault, but the evidence for any normal movement continuing into the Permian is weak.

The complex structure at Logue may be directly associated with the movement along the Fenton Fault zone of faulting, but the similarity between Frome Rocks and Logue both of which are near the northern margin of the Jurgurra Terrace, strongly suggests that they are at least partially due to diapiric salt piercement.

It is believed that the salt at Frome Rocks originated from pre-Permian sediments in the Fitzroy Trough, which means that its emplacement via the Fenton Fault, and the formation of the Logue structures are therefore restricted to post-Carboniferous times.

9. CONCLUSIONS

by D.N. Smith

The Blue Hills and Logue Reflection Projects were initiated to investigate the significance of the basement leads in the central part of the Jurgurra Terrace. The former Project area is on the southern margin of the Jurgurra Terrace north of the Dampier Fault and the latter is on the northern margin near the Fenton Fault.

The basic structure in the Blue Hills area consists of relatively simple, sometimes faulted, anticlinal noses plunging away from the arcuate Dampier Fault. This structure had normal down-to-the-north movements during the late pre-Permian and early Permian times but reversed movement in later Permian times. The two strongest anticlinal noses in the pre-Permian are referred to as Anomalies A and B. These show a possible 200 to 300 feet of vertical closure.

Permian structure in general conforms with the underlying pre-Permian rocks but with less relief. Small reversals on the axes of Anomalies A and B result in unfaulted closures of 100 to 200 feet.

The basic structure in the Logue area consists of narrow complex anticlines closely associated with the Fenton Fault. The Fenton Fault is displaced "en echelon" to the north across the area. The history of movement of this fault appears to be similar to that of the Dampier Fault except that evidence for any normal movement in the Permian rocks is weak.

Structural Anomalies C and D are evident in both the Permian and pre-Permian rocks but only the pre-Permian rocks are displaced by the Fenton Fault. Anomaly D has a pre-Permian faulted closure of 400+ feet and a Permian unfaulted closure of 300 feet. This structure has more closure in the Permian than any other known structure on the Jurgurra Terrace.

The similarity between the deeper structures at Logue and at Frome Rocks suggests that the former are at least partially due to diapiric salt piercement.

REFERENCES

GABY, P.P	1947	Grading system for seismic reflections and correlations Geophysics 12. 590-617
WEST AUSTRALIAN PETROLEUM PTY LIMITED		Dampier Fault seismic survey, Western Australia, 1960. (In preparation).
WEST AUSTRALIAN PETROLEUM PTY LIMITED	1962	Frome Rocks No. 1 and No. 2 Wells, Western Australia. P.S.S.A. Pub. No. 8 (In press).

APPENDIX I

FIELD PROCEDURE

Description of Spread

Total number of geophones	288 or 432
Number of geophone groups	24
Geophones per Group	12 or 18
Normal distance between groups	110 ft
Distance to centre of first group	110 ft
Distance between geophones within group	18 or 12 ft
Normal distance between shot-points	1320 ft

Instrumental Details

Amplifier type	7000KB
Magnetic recording	Magne DISC
Camera type	RS8U
Circuit used	Straight
Recording filter	12OKK-18K
Playback filter	75KK-24K
Recording AGC	Medium
Playback AGC	Off

APPENDIX 2

KEY PERSONNEL

Party Chiefs	...	C.J. Blum*
		A. Sabitay
Computers	...	J.L. Harris
		P.M. James
Party Manager	...	R.J. Danks
Observer	...	V.J. Amiot
Surveyor	...	M.O. Stickel

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* transferred on 28th October, 1959.

APPENDIX 3

MOBILE EQUIPMENT

Party Chief	. . .	Land Rover
Party Manager	. . .	Land Rover
Surveyor	. . .	Land Rover and two D-6 Bulldozers
Recorder	. . .	R-160 International 4 x 4
Cable Truck	. . .	Land Rover
Shooter	. . .	R-160 International 4 x 4
Supply	. . .	R-160 International 4 x 4
Mechanic	. . .	R-160 International 4 x 4
Drills	. . .	Three R-190 Internationals with Mayhew 1000 air-water rigs
Water Trucks	. . .	Three R-190 International 6 x 6 with 1250 gal tanks
Kitchen Caravan	. . .	Four-wheel trailer with two kerosene refrigerators, butane stove, and deep freeze
Shower	. . .	Four-wheel trailer with 400 gal water tank
Light Plant	. . .	Two-wheel trailer with diesel driven AC generator
Kitchen Water	. . .	Two-wheel trailer with 200 gal tank

Along cross Lines C, K, and N poor results were recorded; however, reflection continuity and conformable dips permit reliable phantoming on these lines.

The few areas where reliable phantom horizons could be carried within the pre-Permian reflecting strata are in the vicinity of:

(1) Lines D, E, and F to -6,000 feet,

(2) Lines M and P at phantom horizon "C" level (-5,000 feet) and at about -9,000 feet,

(3) Line Q to -10,000 feet, south-west of Shot-point 63 and to -9,000 feet, north-east of the Fenton Fault,

(4) Line R to about -7,000 feet.

The comparatively poor quality of the data available for pre-Permian interpretation may be because of:

(a) Strong faulting

(b) Sequence of rocks affording few density contrasts for reflection interfaces

(c) Possible rapid facies changes, especially in Devonian rocks which may be shoreline or near-shore sediments on the Jurgurra Terrace.

In general, problems of poor quality records in these projects stem from the poor surface and near-surface recording and shooting media. Multiple geophone arrays and multiple hole pattern shots are techniques normally required to obtain usable data in the area.

8. INTERPRETATION

by D. N. Smith.

Quality of Data and Map Reliability

(1) Blue Hills

The quality of the reflection data was very fair up to a depth of 4000 feet, which is the average depth of the Permian - pre-Permian unconformity. Pre-Permian reflections were mostly poor, but sporadic fair quality data permitted the carrying of phantom horizon "C" on all lines.

The interpretations shown on the structural maps of phantom horizons "A", "B", and "C" are controlled by three closed loops comprising Lines B, P, M, R, S, and AB. They are therefore regarded as reliable. It should be pointed out, however, that the interpretation of phantom horizon "C" (possibly Devonian) depends on the presence of Faults A and B, the gradings of which include loop misclosure as a criterion.

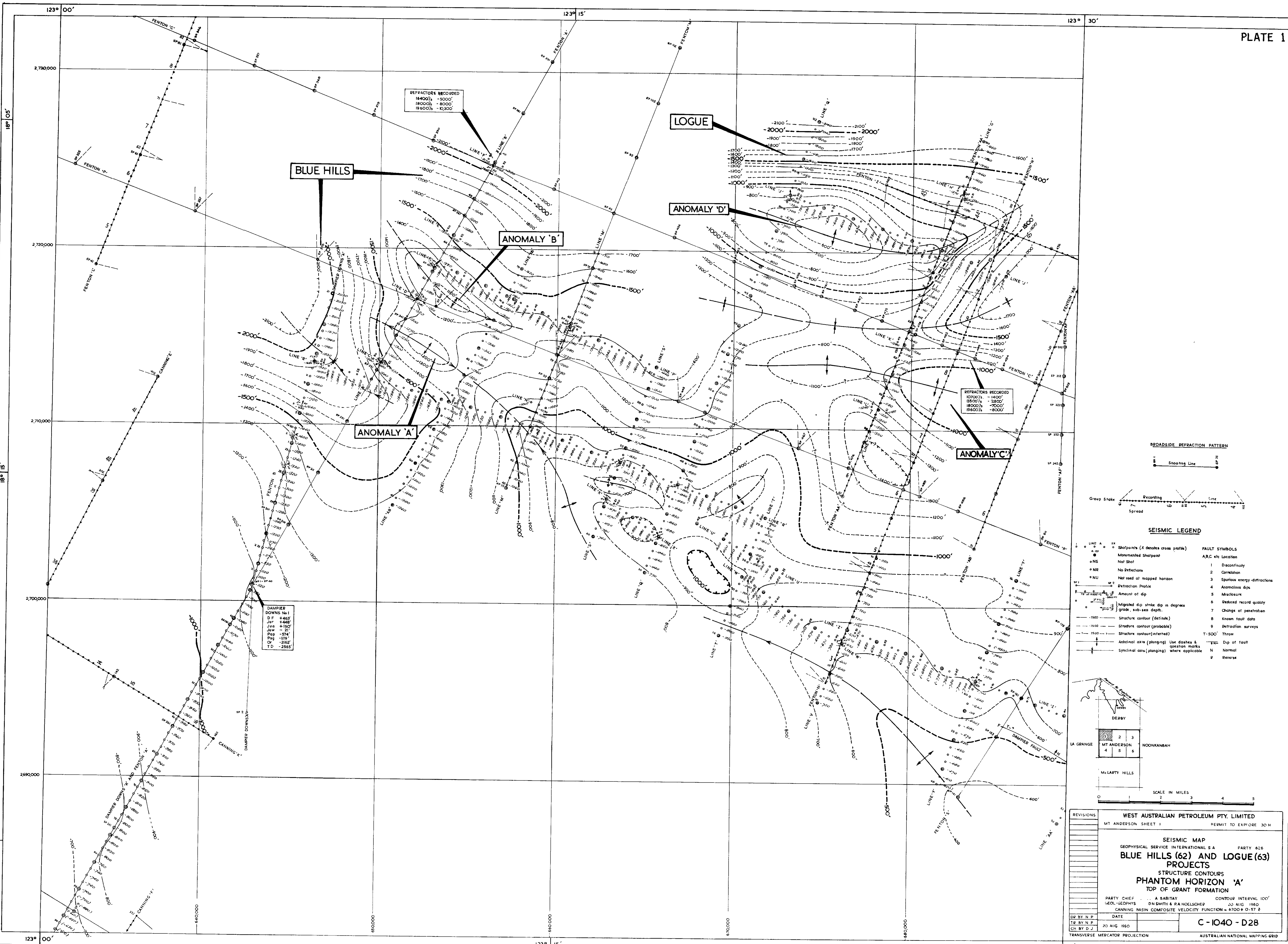

PLATE 1
BLUE HILLS
LOGUE
ANOMALY 'A'
ANOMALY 'B'
ANOMALY 'C'
ANOMALY 'D'
REFRACTORS RECORDED
16400'/s -5000'
18000'/s -8000'
19600'/s -10,300'
REFRACTORS RECORDED
10700'/s -1400'
13500'/s -2800'
18000'/s -7000'
19600'/s -8000'
DAMPIER DOWNS No 1
D F +463'
Jur +448'
Jua +160'
Juw - 21'
Pap -574'
Psg -1119'
Or -2162'
TD -2565'
BROADSIDE REFRACTION PATTERN
Shooting Line
Group Stake
Recording
Line
Spread
SEISMIC LEGEND
Shotpoints (X denotes cross profile)
Monumented Shotpoint
NS Not Shot
NR No Reflections
NU Not used at mapped horizon
Refraction Profile
Amount of dip
Migrated dip strike dip in degrees grade, sub-sea depth.
Structure contour (definite)
Structure contour (probable)
Structure contour (inferred)
Anticlinal axis (plunging)
Synclinal axis (plunging)
Use dashes & question marks where applicable
FAULT SYMBOLS
A,B,C etc Location
1 Discontinuity
2 Correlation
3 Spurious energy-diffractions
4 Anomalous dips
5 Misclosure
6 Reduced record quality
7 Change of penetration
8 Known fault data
9 Refraction surveys
T-500' Throw
Dip of fault
N Normal
R Reverse
DERBY
LA GRANGE
MT ANDERSON
NOONKANBAH
McLARTY HILLS
SCALE IN MILES
DAMPIER FAULT
DAMPIER DOWNS
FENTON 'C'
FENTON 'P'
CANNING 'E'
CANNING 'K'
WEST AUSTRALIAN PETROLEUM PTY. LIMITED
MT ANDERSON SHEET 1
PERMIT TO EXPLORE 30 H
SEISMIC MAP
GEOPHYSICAL SERVICE INTERNATIONAL S A
PARTY 626
BLUE HILLS (62) AND LOGUE (63)
PROJECTS
STRUCTURE CONTOURS
PHANTOM HORIZON 'A'
TOP OF GRANT FORMATION
PARTY CHIEF A BABITAY
CONTOUR INTERVAL 100'
GEOL-GEOPHYS D N SMITH & P.A HOELSCHER
20 AUG 1960
CANNING BASIN COMPOSITE VELOCITY FUNCTION = 6700 + 0.57 Z
REVISIONS
DATE
20 AUG 1960
C-1040-D28
TRANSVERSE MERCATOR PROJECTION
AUSTRALIAN NATIONAL MAPPING GRID

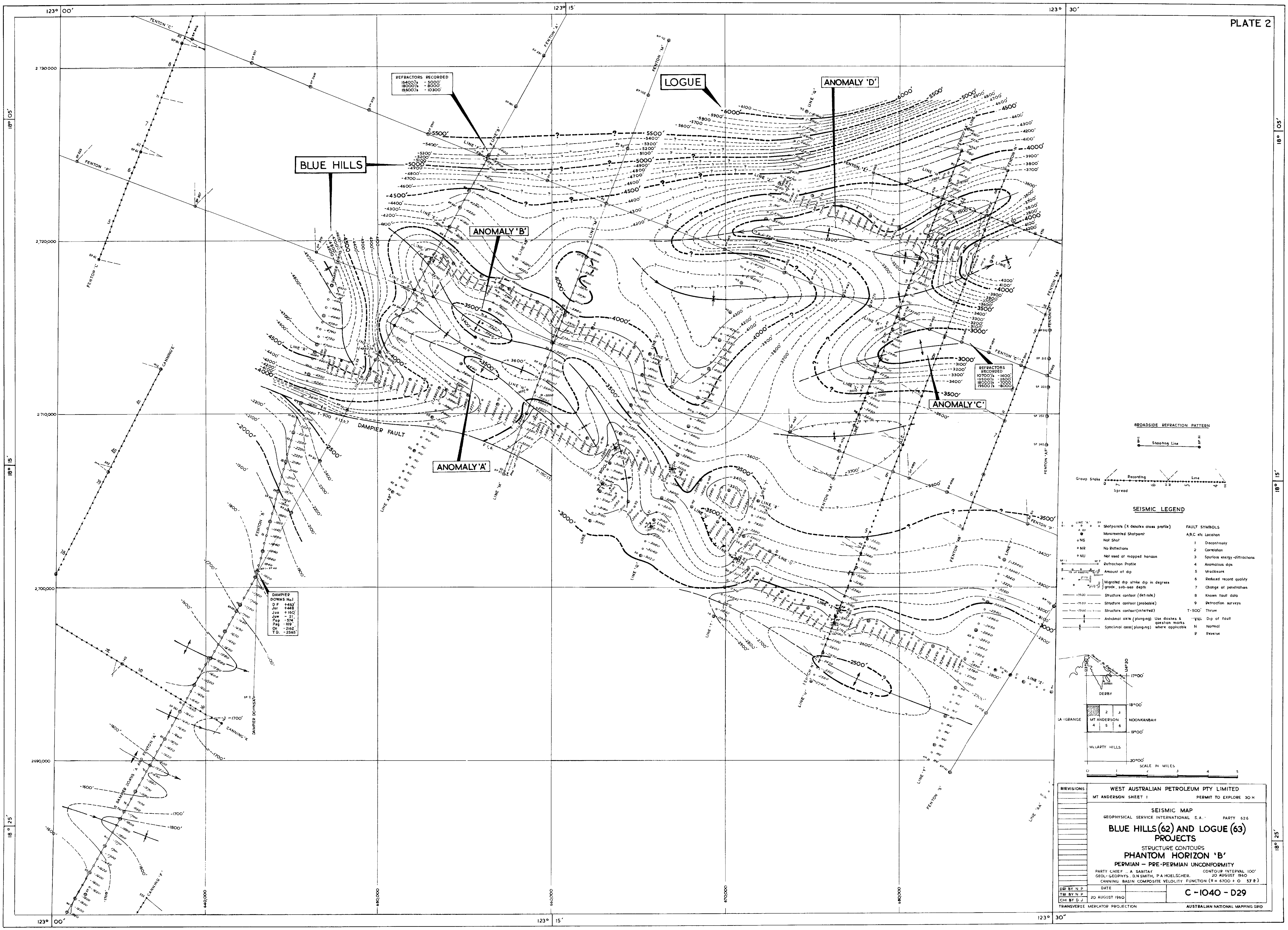
PLATE 2
LOGUE
ANOMALY 'D'
BLUE HILLS
ANOMALY 'B'
ANOMALY 'A'
ANOMALY 'C'
DAMPIER FAULT
BROADSIDE REFRACTION PATTERN
SEISMIC LEGEND
FAULT SYMBOLS
SCALE IN MILES
WEST AUSTRALIAN PETROLEUM PTY LIMITED
MT ANDERSON SHEET 1
PERMIT TO EXPLORE 30 H
SEISMIC MAP
GEOPHYSICAL SERVICE INTERNATIONAL S.A.
PARTY 626
BLUE HILLS (62) AND LOGUE (63) PROJECTS
STRUCTURE CONTOURS
PHANTOM HORIZON 'B'
PERMIAN – PRE-PERMIAN UNCONFORMITY
PARTY CHIEF .. A SABITAY
CONTOUR INTERVAL 100'
GEOL-GEOPHYS. D.N SMITH, P.A HOELSCHER.
20 AUGUST 1960
CANNING BASIN COMPOSITE VELOCITY FUNCTION
DR BY N P
TR BY N P
CH BY D J
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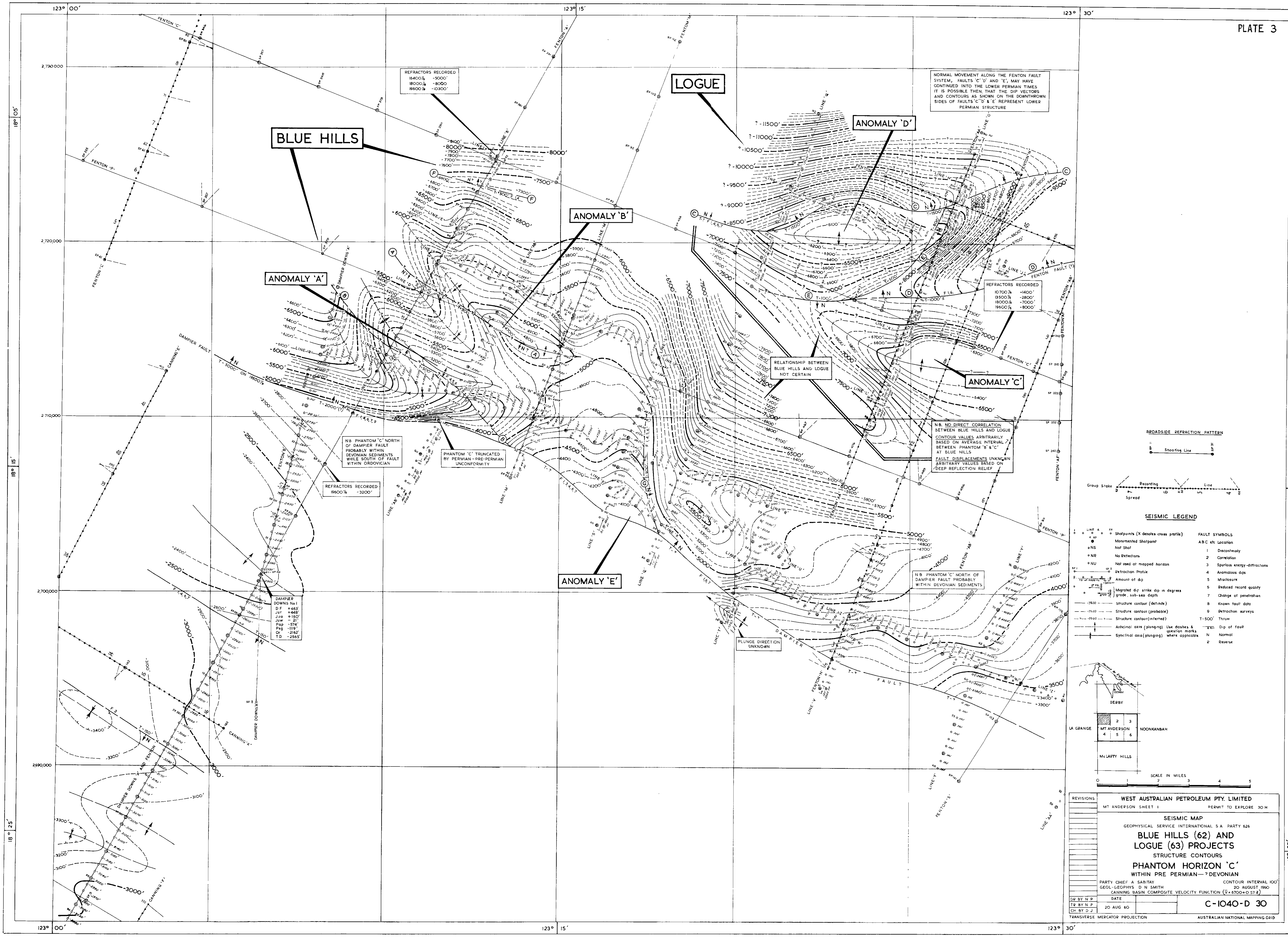
PLATE 3
BLUE HILLS
LOGUE
ANOMALY 'A'
ANOMALY 'B'
ANOMALY 'C'
ANOMALY 'D'
ANOMALY 'E'
REFRACTORS RECORDED
REFRACTORS RECORDED 19600 ⁄s -3200'
NORMAL MOVEMENT ALONG THE FENTON FAULT SYSTEM, FAULTS 'C' 'D' AND 'E', MAY HAVE CONTINUED INTO THE LOWER PERMIAN TIMES IT IS POSSIBLE THEN, THAT THE DIP VECTORS AND CONTOURS AS SHOWN ON THE DOWNTHROWN SIDES OF FAULTS 'C' 'D' & 'E' REPRESENT LOWER PERMIAN STRUCTURE
RELATIONSHIP BETWEEN BLUE HILLS AND LOGUE NOT CERTAIN
N.B. NO DIRECT CORRELATION BETWEEN BLUE HILLS AND LOGUE
CONTOUR VALUES ARBITRARILY BASED ON AVERAGE INTERVAL BETWEEN PHANTOM 'B' & 'C' AT BLUE HILLS
FAULT DISPLACEMENTS UNKNOWN ARBITRARY VALUES BASED ON DEEP REFLECTION RELIEF
NB PHANTOM 'C' NORTH OF DAMPIER FAULT PROBABLY WITHIN DEVONIAN SEDIMENTS WHILE SOUTH OF FAULT WITHIN ORDOVICIAN
PHANTOM 'C' TRUNCATED BY PERMIAN - PRE-PERMIAN UNCONFORMITY
N.B. PHANTOM 'C' NORTH OF DAMPIER FAULT PROBABLY WITHIN DEVONIAN SEDIMENTS
PLUNGE DIRECTION UNKNOWN
DAMPIER FAULT
BROADSIDE REFRACTION PATTERN
Group Stake Recording Line Spread
SEISMIC LEGEND
Shotpoints (X denotes cross profile)
Monumented Shotpoint
NS Not Shot
NR No Reflections
NU Not used at mapped horizon
Refraction Profile
Amount of dip
Migrated dip strike dip in degrees grade, sub-sea depth
Structure contour (definite)
Structure contour (probable)
Structure contour (inferred)
Anticlinal axis (plunging)
Synclinal axis (plunging)
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FAULT SYMBOLS
A B C etc Location
1 Discontinuity
2 Correlation
3 Spurious energy-diffractions
4 Anomalous dips
5 Misclosure
6 Reduced record quality
7 Change of penetration
8 Known fault data
9 Refraction surveys
T-500' Throw
Dip of fault
N Normal
R Reverse
DERBY
LA GRANGE
MT ANDERSON
NOONKANBAH
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SCALE IN MILES
REVISIONS
WEST AUSTRALIAN PETROLEUM PTY. LIMITED
MT ANDERSON SHEET 1
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BLUE HILLS (62) AND LOGUE (63) PROJECTS
STRUCTURE CONTOURS
PHANTOM HORIZON 'C'
WITHIN PRE PERMIAN—? DEVONIAN
PARTY CHIEF A SABITAY
GEOL-GEOPHYS D N SMITH
CONTOUR INTERVAL 100'
20 AUGUST 1960
CANNING BASIN COMPOSITE VELOCITY FUNCTION
DR BY N P
TR BY N P
CH BY D J
DATE 20 AUG 60
C-1040-D 30
TRANSVERSE MERCATOR PROJECTION
AUSTRALIAN NATIONAL MAPPING GRID