DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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POOLE RANGE SEISMIC SURVEY 1962

Volume 1. Text plates 1 to 4 and 21 to 33

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BUREAU OF MINERAL RESOURCES

POOLE RANGE SEISMIC SURVEY

1962

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SUMMARY

A four and a half month seismic survey has been carried out in the Poole Range area of the Fitzroy Basin by C.G.G. where both the reflection and refraction methods have been tested.

Reflection experiments lead to a high multiplication of geophones and shot-holes patterns. However, tests were too limited and too scattered to allow for definite conclusions regarding the best recording procedure.

The refraction method has been used to provide information regarding the extension at depth of Poole Range surface anticline. The same method was used for a reconnaissance survey on the regional gravity anomaly 16 A. Besides shallow markers, two and sometimes three deep markers were followed simultaneously.

The results obtained during the survey indicate that:

- Poole Range surface structure has no extension at depth;
- Two high zones, separated by a narrow trough appear to correspond to the gravity anomaly 16 A. The eastern high zone is a wide dome with a closure of about 4,000 ft at the level of the deeper marker. The western high zone corresponds to a shelf-like area of the deeper marker. It is overlain by sedimentary formations where facies changes are suggested by rapid variations of the marker's velocities. This is the shallowest area of the survey with a 15,000 ft/sec marker at a depth of less than 10,000 ft.

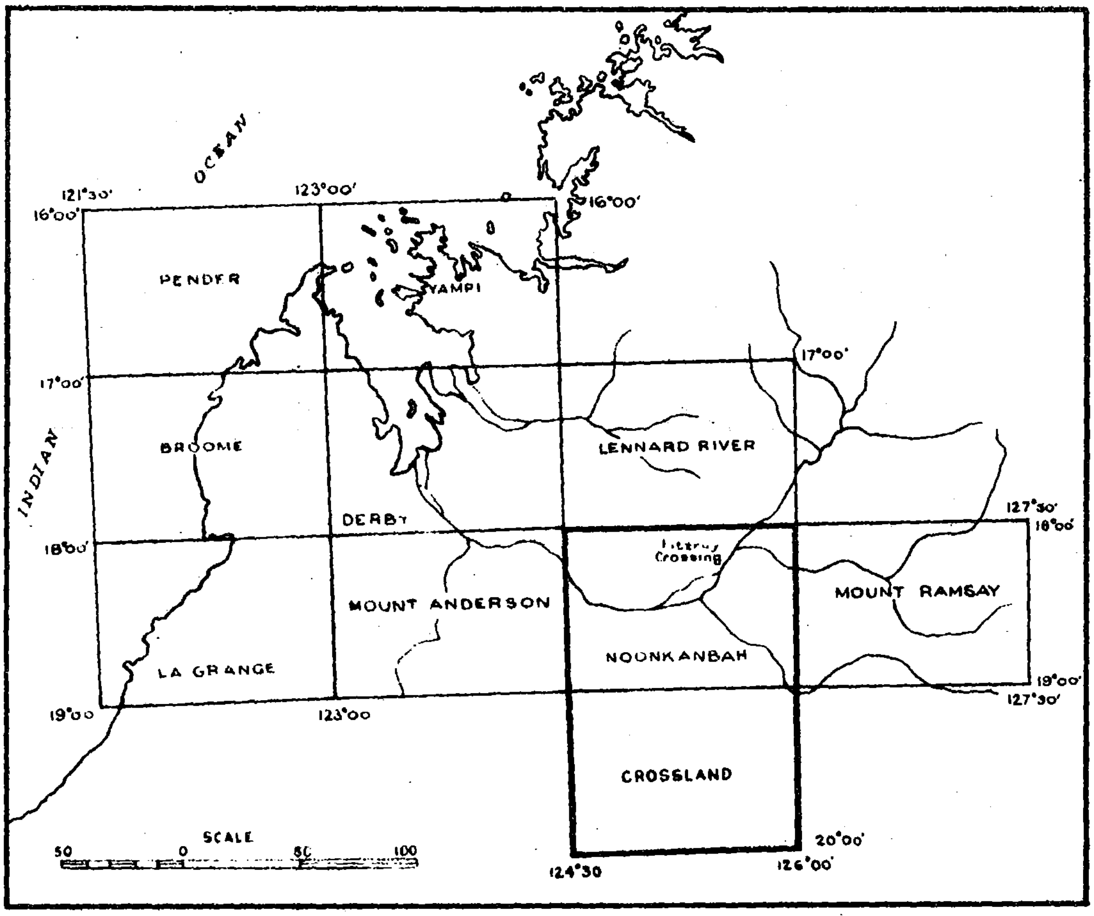
Delimination of the most interesting structural locations would require the carrying out of supplementary traverses.

A tentative interpretation makes the deeper marker a

probable Proterozoic level with depths ranging from 15,000 feet to 30,000 feet. The two others might represent Devonian and Ordovician formations.

POOLE RANGE SEISMIC SURVEY 1962

Fig. 1



CHAPTER I

INTRODUCTION

Following a call for tender by the Government of Australia, Department of National Development, the Compagnie Generale de Geophysique provided a seismic party to carry out a survey in the Poole Range area of the Fitzroy Basin in Western Australia. This area is located in a permit granted to West Australian Petroleum Pty. Ltd. as Authority to Prospect for oil No. 30H.

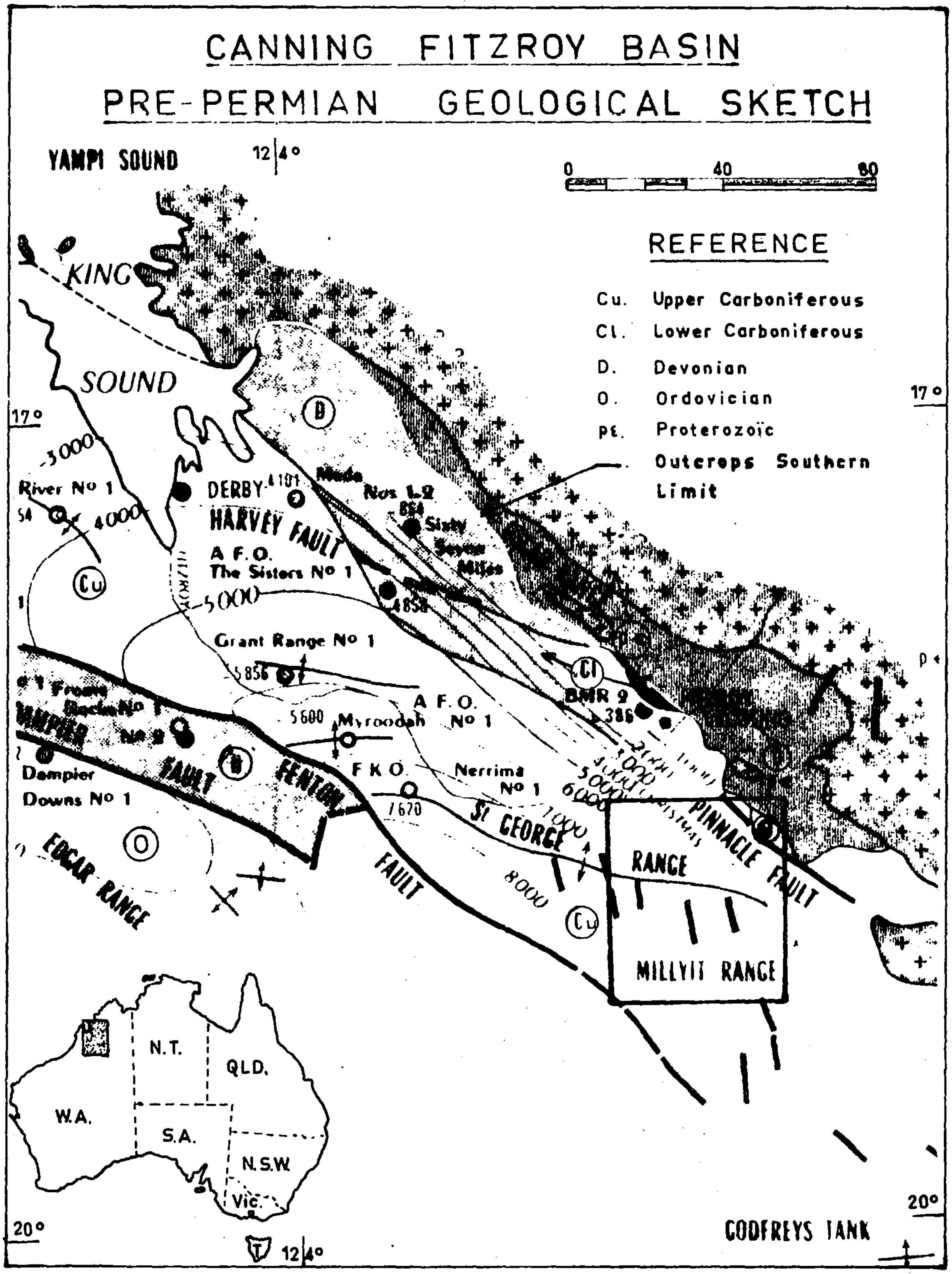
The party was capable of operating either with the refraction or the reflection methods as specified in the Agreement which indicated that this work was to end no later than six months after the commencement of the survey.

The first hole was drilled on the 15th of June 1962, and the last one on October 31st, 1962. The first shot was fired on the 16th of June and the last shot on the 2nd of November 1962.

Various reflection experiments, a ten miles long reflection traverse, a refraction sounding and 174,46 miles of refraction traverses were carried out during the survey.

The party included 35 men (5 key men being from France) and was headed by Mr M. LAVIEUVILLE, Geophysicist.

Fig. 2


CANNING FITZROY BASIN
PRE-PERMIAN GEOLOGICAL SKETCH
YAMPI SOUND
124°
0
40
80
REFERENCE
Cu. Upper Carboniferous
Cl. Lower Carboniferous
D. Devonian
O. Ordovician
pε. Proterozoic
Outcrops Southern Limit
KING
SOUND
17°
DERBY
HARVEY FAULT
A.F.O.
The Sisters No 1
Sixty Seven Miles
Grant Range No 1
A.F.O.
No 1
Myroodah
F.K.O.
Nerrima
No 1
BMR 9
DAMPIER
FAULT
FENTON
FAULT
Dampier
Downs No 1
EDGAR RANGE
ST GEORGE
RANGE
PINNACLE FAULT
MILLYIT RANGE
N.T.
QLD.
W.A.
S.A.
N.S.W.
Vic.
20°
GODFREYS TANK

CHAPTER II

GEOLOGY

1. GENERAL INFORMATION

The Canning Fitzroy Basin, bounded by metamorphic and folded Proterozoic rocks, contains units of Paleozoic and Mesozoic sediments.

The Fitzroy Trough where the survey has been carried out represents the north eastern part of the Basin. It is an elongated north-west-southeast feature, limited to the northeast by the Lennard Shelf. To the southwest, it is bounded by a system of northwest southeast faults defining the Jurgurra Terrace, between the deepest part of the Trough and the Broome Swell, where the basement is considered much shallower.

The major geological features are indicated on figure 2.

2. STRATIGRAPHY

2.1. Ordovician sediments.

The Ordovician rocks are the oldest sediments known in the Basin where they crop out in a very restricted area near Price's Creek. They are also found in several wells in the south west part of the Canning Basin. But the Ordovician sediments are missing in outcrops and bores along the north eastern edge of the Fitzroy Basin (Meda and 67th mile wells).

In the Fitzroy Basin, the lower Ordovician consists mainly

of compact limestones and dolomites which can nevertheless be expected to have some reservoir possibilities.
No information is available regarding the possible existence of Ordovocian rocks in the Fitzroy Trough as well as on the Jurgurra Terrace, since none of the wells penetrated sediments older than Devonian.
Consequently nothing is known of the facies in the deep parts of the Fitzroy Trough.

2.2. Devonian sediments.

The Devonian rocks are known in large outcrops on the Lennard Shelf where they overlay, with an angular unconformity, Proterozoic and igneous rocks. They were encountered in wells on the edge of the Fitzroy Trough and on the Jurgurra Terrace but they were absent to the southwest. The Devonian rocks consist of a calcareous reef complex composed mainly of algal limestone. In places the reef is cut by conglomeratic deposits or covered by calcareous beds containing significant marl intercalations. Though such reservoir appears variable in character and distribution, with a rather poor cap-rock the Devonian formation still is one of the best objectives in the search for petroleum accumulations. The Devonian has not been reached in the deeper part of the Fitzroy Trough and consequently no information is available regarding its possible existence and facies under Poole Range.

2.3. Lower Carboniferous

Little is known from the outcrops, but Lower Carboniferous was encountered in wells on the northern edge of the Fitzroy Trough.
Consisting of siltstones, limestones and sandstones and appearing to grade without a break from the Devonian, its oil possibilities are associated with those of the Devonian (Oil show at Meda 1).

2.4. Other Formations

The other overlaying Paleozoic and Mesozoic sediments are considered to have no petroleum potential.

3. POOLE RANGE GEOLOGICAL PROBLEM

In its evaluation of the petroleum prospects in Australia, the I. F. P. indicated what appears to be the most attractive objectives in the search for oil over this area.

Besides the first obvious objectives represented by the shallow Devonian reefs and associated traps on the Lennard Shelf, presently investigated by WAPET, some geophysical work was recommended in the deep part of the Fitzroy Trough.

The oil possibilities are restricted over the whole Canning-Fitzroy Basin to the Ordovician and Devonian - Lower Carboniferous formations. But in the Fitzroy Trough, nothing is known of the facies, location and distributions of these sediments, though the thickness of the barren beds can be over 13,000 ft (Grant Range No. 1.) Hence, it seems preferable to consider studying the extension at depth of the large and well developed surface anticlines. The Poole Range structure was recommended as first step in this work.

The Poole Range structure is situated at the south-eastern end of the Nerrima-St. George-Poole Range trend. It is a west-north-west elongated and faulted dome with a definite closure to the east and an indication of closure to the west if Mt. Hutton is considered as part of the Poole Range Dome. The oldest rock formation exposed is of permian age (Grant formation surrounded by successive rings of Poole sandstones, Noonkanbah and Liveringa formations).

The selection by the I.F.P., of the Poole Range structure is based on the two following reasons:

1/ Out of all the major surface structures known in the Fitzroy Trough, it is the nearest one to both the Ordovician sequence and Devonian reefs. The Ordovician limestones known at the outcrop near Price's Creek give a faint smell when broken and traces of oil have been reported in three of the old bores. The outcrops of Devonian reef limestones are only 15 miles away, separated from the Poole Range structure only by the Talbot syncline and the Pinnacle fault.

2/ The Poole Range structure is interpreted as being located within the Fitzroy Trough in a position relatively close to the northeastern shelf, at a difference of the Grant Range structure. Consequently, some thinning of the non prospective Upper Carboniferous was expected which would be sufficient to make of Poole Range a structurally favorable area where Ordovician and Devonian formations may lie at shallower depth.

CHAPTER III

GEOPHYSICS

The oil possibilities in the Fitzroy Basin were first recognized in 1919 when traces of oil were reported from the Price's Creek area. Subsequently, the search for oil included the drilling of several wells and the regional and/or detailed geological mapping both by the Commonwealth and private Companies.

But it was not before 1952 that, following suggestions made by W. F. Schneeberger, geophysical investigation made its first appearance in this area. Several geophysical surveys have since been carried out, including aeromagnetic, gravity and seismic methods of exploration.

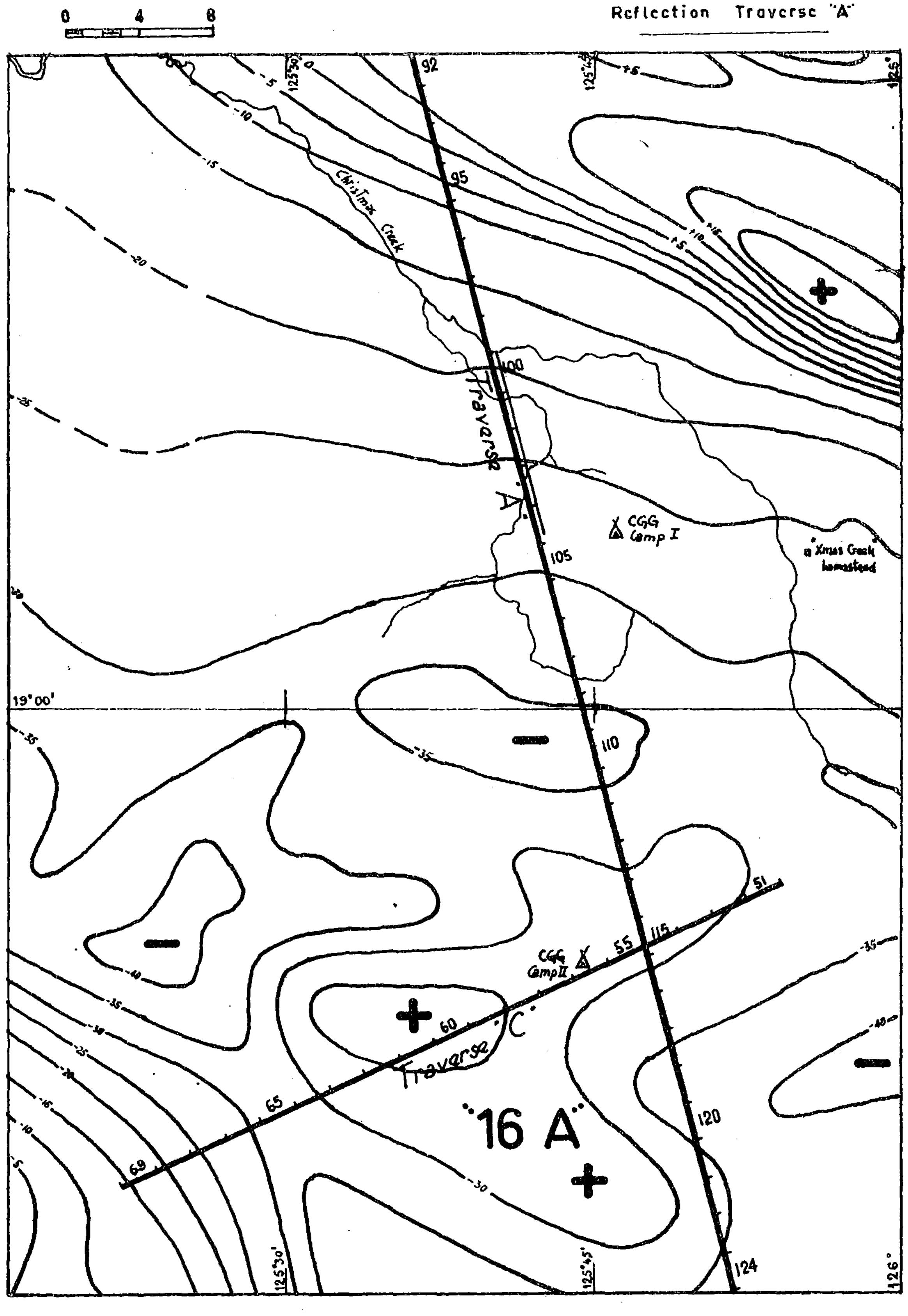
Without going into a detailed analysis of all the geophysical surveys, we shall summarize briefly the contribution of the geophysical work to the knowledge of the Poole Range area.

1. AEROMAGNETIC AND GRAVITY SURVEYS.

In 1954 an aeromagnetic reconnaissance survey, made by the B. M. R. included 14 north-east lines of flight, widely spaced across the Fitzroy Basin, two of which are located in the vicinity of Poole Range. In 1953 a ground gravity survey was conducted by the B. M. R. on the Poole Range structure and complementary readings have been later added by ground work in 1954 and helicopter work in

Fig. 3

BOUGUER ANOMALY 1960 and SEISMIC SURVEY 1962



1960. Because of the absence of sufficient control such surveys contributed very little, if anything, to the detailed knowledge of the Poole Range structure itself. It can be seen, as well on the magnetic total intensity map as on the gravity Bouguer map, that there is no pronounced anomaly associated with the Poole Range structure (see fig 3).

Both surveys suggest that the Poole Range structure is in a deep trough environment, i.e. the Fitzroy Trough between the Lennard Shelf limited to the south by the Pinnacle Fault, and the Broome Swell limited to the north by the Fenton Fault. The gravity interpretation shows, better than the aeromagnetic work, indications of the persistence of such features, at least to some degree, into the northeast Canning. The geophysical results can be furthermore interpreted as indicating that the presence of a shallow basement core in the Poole Range structure appears unlikely.

No information is gained regarding the evolution of the above features to the south-east, but the positive Bouguer anomalies in the Dummer Range and Gregory Salt Lake areas may be interpreted as indicating the south-eastern end of the Fitzroy Trough.

2. REFLECTION SEISMIC SURVEYS.

The geophysical investigation of the Poole Range structure with the seismic reflection method was started by the B.M.R. in 1953 and was followed by a second B.M.R. survey in 1954.

Probably due to the strong limitations introduced by a non satisfactory equipment and for the absence of sufficient elaborate techniques, the 1953 survey did not obtain any reflected events, outside of the Talbot syncline, on the Poole Range structure.

The 1954 survey had for objectives a study of the eastern, southern and western flanks of the Poole Range dome. Though the recording equipment and technique used during this survey proved to give data of acceptable quality in other areas of the Fitzroy Basin, the results obtained over Poole Range were very scarce and of poor quality. The area where some reflected events were obtained is restricted to the south-eastern flank of the structure on isolated sections of the traverses representing less than 40% of the total length of traverse surveyed. No information could be obtained in the other areas.

We would like to note, however, that a study of the character of the records suggests the possibility of improving the quality of the seismic data in the Christmas Creek area by the use of elaborate recording techniques.

The scattered and poor events recorded during these surveys have been interpreted by the B. M. R. as indicating the persistence of the Poole Range structure to a depth of at least 16,000 ft in a conformable section of 20,000 feet of sediments. It would be remembered, however, that the available data is such as to make rather hazardous any definite conclusions on the faulting, thickness or attitude of the sedimentary section.

3. REFRACTION SEISMIC SURVEYS

The B. M. R. made use of the refraction seismic method during two surveys conducted in 1953 and 1955 in the Talbot Syncline and Price's Creek area, both located north-east of the Poole Range structure.

Generally speaking, the refraction surveys carried out in the Fitzroy Basin appear rather unsatisfactory. By using somewhat inadequate recording equipment and/or techniques, full advantage was not taken of all the possibilities of the refraction method.
One result of the application of elementary techniques was to restrict the interpretation to the study of the velocity parameter at the exclusion of all others. Experience in other parts of the world has shown that such methods are very often not sufficient for the definition of a marker and its specific character.
Consequently, not only does the method prevent correlations but its limitations may also explain the difficulties encountered in the identification of the markers in places such as A. F. O. Nerrima No. 1 and WAPET Grant Range No. 1 where a well had been drilled into the Upper Carboniferous.

However, these 1953 and 1955 surveys provided some information relative to the velocities of a few markers existing at relatively shallow depths in the surveyed areas. One interesting result was obtained, north of the Pinnacle Fault, where the Ordivician outcrops appear with a velocity of about 13,000 ft/sec underlain by a formation showing a high velocity of about 19,000 feet/sec which was later identified in B.M.R. bore No. 3 at Price's Creek as Precambrian rocks.

In 1956, WAPET carried out another refraction traverse on the south-eastern flank of the Poole Range structure, along a line parallel to the alleged axis of the dome. The work conducted by WAPET, including very little double coverage, was not complete. Furthermore, the interpretation was made difficult, especially in the picking of second arrivals by the presence of interfering signal phases on numerous records. Consequently, the results are somewhat ambiguous. However, it can be interpreted as indicating that a high velocity marker, i.e. above 17,000 ft/sec is unlikely to exist at depths shallower than approximately 12,000 ft.

CHAPTER IV

OBJECTIVES and PROGRAMMES

1.1. DEFINITION OF THE OBJECTIVES.

1.1. Geology

The geological setting of the Poole Range problem has been previously described in chapter II, paragraph 3.

The primary objective of the seismic work at Poole Range was the determination of a structural location suitable for a drilling target.

On the basis of the information available prior to the start of the survey, it was thought that structural information at depth below 13,000 feet was necessary.

1.2. Geophysics

The first two months were used to test the applicability of both seismic reflection and refraction methods. The effectiveness of a method can be judged only on its ability to provide satisfactory structural information.

In this respect the reflection method is considered satisfactory if and when capable of recording in continuous profiling reflecting horizons at 2.5 or 3 second.

Previous refraction surveys suggested that the presence of a high velocity refractor was unlikely at depths shallower than 12,000 feet. In case this situation is confirmed, the refraction method is considered satisfactory if capable of recording refractor with velocities higher than 16,000 feet/sec.

1.3. Modification of the objectives

At the end of the first two months, besides selection of one geophysical method, the B. M. R. decided to interrupt the study of the Poole Range structure.

Instead the objectives were defined as follows:
"To define by refraction work the structural attitude of the formations north of the Christmas Creek.
"To attempt to follow the markers detected at Poole Range towards the south and across the regional gravity anomaly 16 A."
"To test the applicability of the reflection method in the area of anomaly 16 A.

One month later, the first of the above objectives was abandoned before completion following a B. M. R. decision to concentrate all efforts on other objectives.

1.4. Comments

It appears necessary, at this point, to stress the limitations inherent to the geophysical method of investigation.

1.4.1. it is likely that the seismic work cannot indicate whether or not Ordovician and Devonian sediments are present beneath Poole Range since the age of the formations is not a parameter directly recorded by any geophysical method.

1.4.2. it is further expected that subsequent attempts to stratigraphic correlations of the results with the formations known in other places would be highly hazardous for the following reasons:

The seismic parameters of well identified and dated formations have only been sampled in very few locations, widely scattered in the Fitzroy Basin. In several instances, the correlations are not very positive and the conclusion of the study of such parameters remains somewhat ambiguous.

The prospective formations appear, where they were seismically sampled, with different facies either in bores or in outcrops. Thus the Ordovician was recorded by the B. M. R. at Price's Creek with a velocity of less than 14,000 feet/sec, while the Ordovician and Devonian, further west at Roebuck Bay, were recorded by WAPET with velocities of over 17,000 feet/sec. Furthermore, since no information is available on the eventual evolution of such facies towards the deep parts of the Fitzroy Trough, it is not unlikely that the facies of the Ordovician and Devonian rocks, as known outside of the Trough, might be different under the Poole Range Dome.

2. PROGRAMMES

2.1. First programme

In order to meet the objectives of the first two months the following programme was considered:

Reflection. To carry out experimental work along the central part of traverse A south of the Christmas Creek (see location map, Plate PL 1). It was expected that heavy patterns of holes and geophones might be required in order to obtain satisfactory data quality.

Refraction. To carry out a complete refraction sounding along the same area of traverse A. It was expected that long distance shots might be necessary in order to detect and sample the existing refractors.

2.2. Subsequent programmes

The reflection results being of poor quality, the B. M. R. selected the refraction method to carry out the subsequent programme.

In order to meet the new objectives (see 1.3. above) the following programme was decided:

"To extend traverse A to the north and to the south.

"To deviate and to carry out traverse C to the west across the anomaly 16 A up to the Fenton Fault (if present).

2.3. Realization of the programmes

The programme indicated here were carried out, with the exception of the northern extension of traverse A which was interrupted following a B. M. R. decision as previously mentioned.

For both traverses, exploitation diagrams with shot distances from 40,000 to 130,000 feet were used. These heavy diagrams (6 shots per base) allowed the continuous following of at least two markers and more often three. But they led to a slower progression along the traverses since multiple coverage was required.

Fig. 4

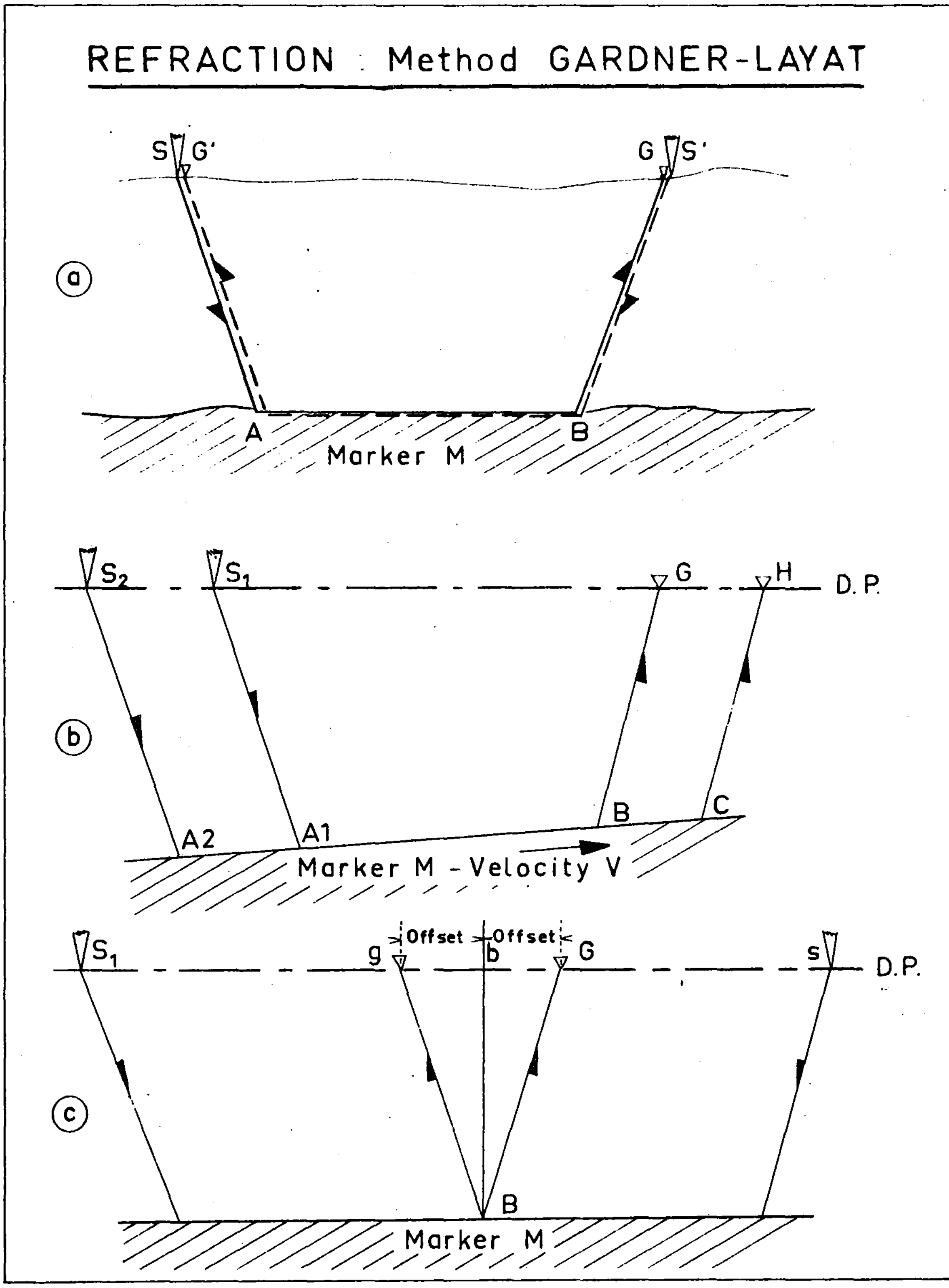
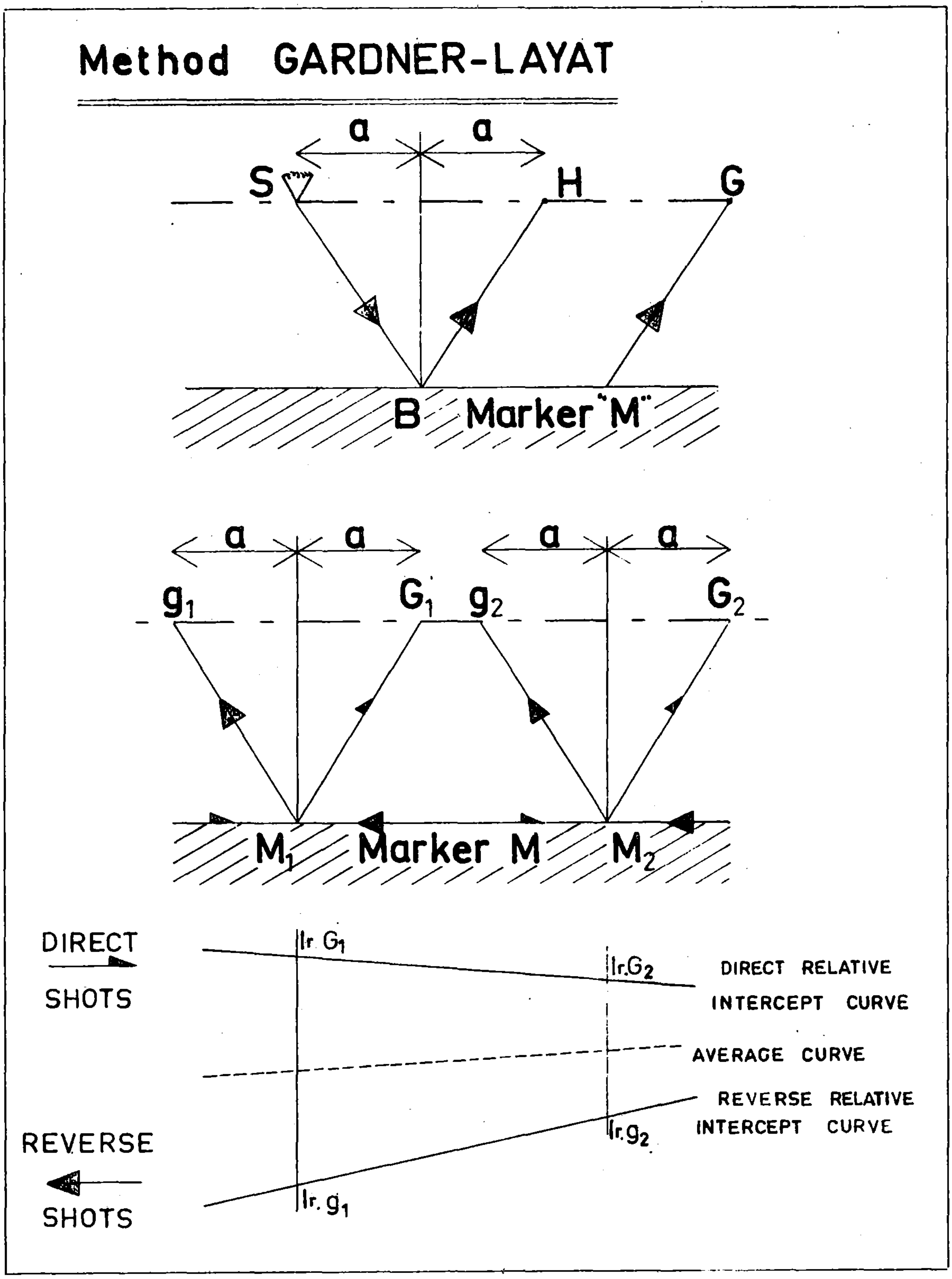

REFRACTION : Method GARDNER-LAYAT
S
G'
G
S'
a
A
B
Marker M
S2
S1
G
H
D. P.
b
A2
A1
B
C
Marker M - Velocity V
S1
g
Offset
b
Offset
G
s
D.P.
c
B
Marker M

Fig. 4 bis



Method GARDNER-LAYAT
a
a
S
H
G
B
Marker "M"
a
a
a
a
g_1
G_1
g_2
G_2
M_1
Marker M
M_2
DIRECT
SHOTS
Ir. G_1
Ir. G_2
DIRECT RELATIVE
INTERCEPT CURVE
AVERAGE CURVE
REVERSE RELATIVE
INTERCEPT CURVE
REVERSE
SHOTS
Ir. g_2
Ir. g_1

CHAPTER V

TECHNIQUES and OPERATIONS

1. TECHNIQUES

The reflection method used during the first part of the survey, besides the experimental work, is the convential continuous split-spread recording. Twenty four recording traces were laid out and the shot was fired mid-way between traces 12 and 13.

The refraction technique is the Gardner-Layat method of continuous profiling which has been used by C.G.G. since 1952, modified and adopted from L.W. GARDNER. "An areal plan of mapping subsurface structure by refraction shooting"(Geophysics 1947, vol XII, page 221).

A special technique was used for surveying the shallow markers. The principle of the method called "constant distance correlations" was published by Clement et Layat from C.G.G. in Geophysical Prospecting 1961, vol IX, page 296.

The Gardner-Layat method is schematically represented on figure No. 4 and 4 bis. This technique is analysed in detail in appendix 5 under the heading "TECHNIQUE".

2. OPERATIONS

The area is generally presenting a poor accessibility and the spinifex cover makes all travels rough and time consuming. The accessibility has been schematically pictured on plate PL 4.

The weather was generally hot during day time (100^{o} to $108^{o}F$) with warm nights since September. During most of the survey windy conditions were prevalent and a few storms occurred around mid October.

The area of the survey appears rather isolated and the nearest agglomeration Fitzroy Crossing (approximately 30 residents) is only connected by a regular airline twice a week. This isolation and the absence of a crossing on the Christmas Creek created difficult problems of logistics. A service had to be organized with the Party vehicles for the transportation of supplies (food, fuel, lubricants, explosives etc...) to the camp.

To the Party, initially composed of 25 men, were added by agreement with the B. M. R. one clerk and one mechanic assistant. For the refraction operations 7 other men were added, hence bringing the total staff to 34. Two surveyors in training on the Party are not included in this figure.

The field operations are broken down in various steps which are examined in detail in Appendix 6.

The Party equipment included 14 vehicles in reflection but one extra vehicle was added for the refraction operations.

The surveying operations were conducted either with a WILD TO or a KERN DK 1 theodolite and the work was tied with Army trigonometrical stations.

The drilling was done mainly by air with two Mayhew 1000, air-water combination drills mounted on

International trucks R-190 assisted by three Bedford tankers (600 gallons).

The recording operations were carried out using a reflection spread with 24 geophone groups spaced 150 feet apart and 24 geophones per group laid out parallel to the traverse with 15 feet spacing. Several high multiplication geophone and holes patterns were experimented. In refraction work 24 traces were also recorded with 900 feet spacing and one single geophone per group.

The recording equipment is a pulse width modulation magnetic assembly associated with CGG-59 amplifiers, equipped with a simultaneous SIE/PRO-11 Galvanometric monitor and with a Teledelto sequential play-back Electro Tech MTD-I.

CHAPTER VI

RESULTS

1. REFLECTION WORKS

From the results obtained in a simplified sampling of the organized noise velocities at shot-point 100 X on traverse A, it was decided to use 24 geophones with 15 feet spacing at each geophone group. This spread was used for recording 10 miles of continuous profile starting at shot point 101 and extending south across the alleged axis of the Poole Range surface structure (see plate PL 1).

The reflection cross section is presented in variable area and variable density on plates PL16(A and B) and PL 17 (A and B). The static corrections (elevation, weathered zone) were made with a datum plane at 450 feet above sea level, at the play back center. At the same time, the data was corrected for the "move-out" corresponding to the velocity function:

V = 12,000 + .5 D (where D is the depth in feet below the datum plane) as derived from the velocity survey available at Grange Range No. 1.

The results mainly indicate two areas where good quality events are pickable down to two seconds. But no horizon can be drawn in continuity from one end to the other of the cross section.

Various experiments were carried out all along the traverse, regarding shot point patterns and geophones lay-out. These experiments were made at scattered locations and do not allow for indisputable conclusions.

However, it appeared that a high multiplication of geophones and a large pattern of shot holes led to better results.

2. REFRACTION WORK

The refraction work started with a "sounding" on Traverse A at the same location as the reflection work. It was subsequently integrated in the continuous profiling carried out on Traverse A. The two traverses shot during the survey, covering approximately 175 miles in double coverage are indicated on plates P L 1,2, 3.

The final results are represented as depth curves for each traverse on plates 27A and Pl 27B. The interpretation was carried out on the monitor records and all corrections made with a reference plane at 450 feet above sea level. The static corrections (elevation, weathered zone) were computed with a weathered zone velocity of 3,500 feet/sec overlaying a formation showing a velocity of 8,000 feet/sec.

Difficulties were encountered in the interpretation as a result of the absence of a reliable velocity information. Consequently, several hypothesis had to be made regarding this parameter for the establishment of the depth curves, as indicated on the plates.

Two or three deep seismic refractors and two shallow ones were followed on both traverses but it should be kept in mind that they could correspond to several different geological formations.

2.1. Traverse A

The results obtained on traverse A indicate the existence of three distinct areas:

"First, on the north an area on the upthrown side of Fault F1 (estimated throw 7,500 feet) which might present a culmination at 12,000 feet on the 17,500 feet/sec marker.

"Second, a central part down the fault F1 which is the deepest section of Traverse A and shows practically no expression at depth of the axis of the Poole Range Surface structure.

"Third, to the south a large culmination is well delineated by both deep markers although it is hardly reflected on the shallow 10,000 ft/sec marker. The top of this dome appears on bases 113-114 at 15,000 feet and 19,000 feet on the two deep markers. The suggested closure on the deeper refractor appears to be at least 4,000 feet.

The quality of the data is generally good although unpredictable variations of the velocities and dips of the refractors made exploitation and interpretation often difficult.

2.2. Traverse C

The results obtained on traverse C suggest the existence of a syncline both sides of which might present structural interest. The deepest part located on bases 58-59 reaches 23,500 feet.

To the east, the culmination revealed on traverse A has its west closure ensured by fault F 3, with an estimated throw of about 4,000 feet.

To the west, all markers are raising to shallower depths and, above the shelf-like deepest marker, a culmination is suggested at base 63 which is reflected in the shallow 10,350 ft/sec marker. The deeper refractor raises to a depth of 15,500 feet while the marker above appears shallower than 10,000 feet.

The data is generally of better quality than on traverse A and the interpretation appears easier.

3. COMMENTS ON THE RESULTS

The picture given above is certainly a reliable description of the general attitude of the seismic refractor.

But it must be stressed that, besides the impossibility to identify the markers in terms of geological age, the assumptions made on the velocities have a vital importance and small deviations might cause important changes to the depth picture which has been discussed.

The discussion of the results is the object of the next chapter.

CHAPTER VII

DISCUSSION OF RESULTS AND INTERPRETATION

FIRST PART : REFLECTION RESULTS

It appears that traverse A shot with 24 geophones per trace with deep holes, does not allow the continuous following of an horizon across the Poole Range structure. Furthermore, this procedure gives very poor information at 2.5 seconds and below (see plates Pl 16 and 17). Good results are obtained between shot points 106 and 110, 120 and 123. They are poor below one second between shot points 103 and 106, 110 and 113, 117 and 120, 123 and 128. No continuous horizon appears from shot points 101 to 103, 113 to 117 and 128 to 130. Finally, 27% of the shot points give "pickable" reflections down to 2 sec., 27% allow to "pick" shallow reflections and 46% give no appreciable results.

So, a better procedure is still to be found if a reflection survey is to be attempted. There is an indication that larger geophones and holes patterns are necessary. It is not very clear whether a smaller number of deep holes or a bigger number of shallow holes should be used. Additional experimentation is necessary and this involves a considerable footage to be drilled.

In conclusion, the scattered results obtained on the reflection traverse A have a variable quality which was considered inadequate for solving the Poole Range problem.

SECOND PART : REFRACTION RESULTS

1. INTERPRETATIVE DOCUMENTS

The basic information is taken from the monitor record on which 24 traces and the time break are recorded. From thereon, a number of documents is established for the elaboration of the interpretation. In order to make our discussion possible, a certain number of plates shall be only briefly presented here, since full details are given in Appendix 7.

On the diagrams "Exploitation" all spreads recorded are visualized for each traverse - direct shots above and reverse shots below the line representing the traverse. The slant lines intersect the traverse at the shot point considered and the spreads are projected on the slant lines, perpendicularly to the traverse. The vertical scale indicates the shooting distances in feet. The breaks between successive markers, the faults, the areas of interference and some particularities, such as faster or slower events close to the picked arrivals, are represented on these diagrams.

Most of the discussion of the results proper shall be carried out on the "Exploitation plate" of each marker where the corrections, the intercept curves in geophone and marker position, the deviation curve - used for computing the actual horizontal velocity of the marker, and the delay curve are plotted.

The transformation of the delay curves into depth curves is made in reference to the "Depth curve" plates where the assumed average velocities and the actual horizontal marker velocities are represented.

Naturally, the play-back records of the magnetic tapes, after treatment on the play-back center, could be used for a complete interpretation. However, these documents were not used here but they are listed and presented with full detail in Appendix 7.

2. RECORDS CHARACTERISTICS

Records are of good quality on traverse C but appear occasionally poor on traverse A. When they are good, "picking" the first burst of energy is very easy. When they are poor, it is estimated that a 5 to 10 milli-seconds error can affect the arrival time of the first break. Several cross controls carried out on the reciprocal times and the overlapping due to the shooting technique contribute to reduce this "picking" error. We endeavoured to pick first events only, although, in a few places, second events had to be used.

3. SIGNAL FREQUENCY

The records show that the energy arrivals from the deeper marker have an apparent period of 60 to 80 milli-sec. whereas the others have a period of 60 to 70 milli-seconds. A cycle correction of 70 millisec. has been applied to the deeper marker and a 60 millisec. cycle correction has been used for the others. Second arrivals excepted, the first top after the onset has been marked. This is an attempt to bring the timing as close as possible to the arrival of the refracted energy.

It must also be noted that the shallow markers recorded on the centre shots have a cycle correction of 24 milliseconds only.

4. SHALLOW REFRACTORS INTERPRETATION

The shallow refractors were interpreted by the "Constant distance correlation method". When one uses this method, the interpretation is conducted on one trace per record, selecting the one located at a distance close to the double offset distance from the shot point. It is not a continuous control and the accuracy of the interpretation depends largely on the precision of the corrections. In the area under survey, the surface is nearly flat and the weathered zone looks very uniform - so that surface corrections are not a problem. The deviation of the plotted depth points is in the range of 10 millisec. in delay or half intercept time, so corresponding to a maximum 20 millisec. dispersion of travel times.

The curves representing the 10,000 and 12,000 ft/sec markers have been smoothed out. The velocity determinations along the markers are not accurate. They result from a study of the time-distance curves and from an interpretation with two different shooting distances. This last procedure theoretically allows to check velocity variations in the range of 200 ft/sec but this was done only for the 10,000 ft/sec marker and for the 12,000 ft/sec marker of traverse C. The two markers seem to be quite parallel and the 10,000 ft/sec marker is close to the base of the weathered zone (200 to 400 ft below).

5. DEEP REFRACTORS GENERALITIES

5.1. COMPUTATION VELOCITIES : all intercept times were computed with a 20,000 ft/sec velocity for the deeper marker and with 17,500 ft/sec for the others.

5.2. OFFSET DISTANCES : the lack of information concerning the repartition of the markers and of the vertical velocity did not allow us to compute the values of the different offsets. When such is the case, the offset is determined by comparing the relative direct and reverse curves. By shifting the curves horizontally there is one position which leads to their best parallelism, and this position corresponds to the actual offset (see Appendix 5 for details). This process gave us an offset of 21,600 feet for the deeper marker and values ranging from 10,800 to 18,000 feet for the other markers.

6. ACCURACY OF THE GARDNER-LAYAT METHOD

The accuracy of the Gardner-Layat method depends on a number of parameters and namely:

- the surveying accuracy and precision in placement of the stakes;
- the accuracy of the corrections;
- the geophone group spacing and shot point spacing;
- the accuracy of the velocity function adopted;
- the tectonic conditions.

We shall now review these different parameters.

6.1. SURVEYING ACCURACY : the traverses must be straight lines and distances have to be accurate. On a refraction party, surveyors are given special directions.

For instance, the maximum permissible change of direction along a traverse is 2 degrees.

Distance measurements have been determined by the Stadia method, with an average shooting distance of 450 feet, i.e. half the interval between geophone traces. For such shooting distances and equipment, experience proves that the error averages .2%. It was probably smaller at Poole Range where traverses lay in a flat area.

For the average exploitation distance of 108,000 ft used for the depper marker, the maximum distance error might be : 108,000 . 0.2% = 216 ft. The corresponding intercept error is $\frac{216}{V} = \frac{216}{20} = 11$ milli-seconds, which leads to a delay error of 5.5 millisec. According to delay variations from 550 to 950 millisec. (deeper marker), the relative accuracy averages 1%. This figure is in very good agreement with the margin of error normally admitted.

6.2. ACCURACY OF CORRECTIONS : for accurate corrections a special investigation must be carried upon the first layers. This leads to increasing the number of weathering shots and to differentiate several layers if necessary. Such an investigation is out of size with a reconnaissance survey such as the one under review. Corrections computed assuming one constant velocity weathered layer and derived from special shots, made approximately every second mile, can probably be up to 10 milliseconds off. Local anomalies less than 2 miles long can be overlooked. However, the Gardner-Layat

method quite often succeeds in detecting them because a very shallow anomaly reflects upon the same geophone locations in direct and reverse shooting. Hence it can be detected by examining the relative curves before offsetting them: the anomaly is the same on both intercept curves and shows at the same geophone position.
Such anomalies show along traverse C on the relative curves of both markers (see Pl. 24B and 25B). The amount of correction added is represented by a dark area.

6.3. GEOPHONE GROUP AND SHOT POINT SPACINGS: the interval between traces depends upon the objective of the survey. The big 900 ft interval used here is normally used for wide reconnaissance of deep and thick markers.

In the course of the interpretation, it was occasionally difficult to follow the 17,500 ft/sec marker. The spacing is too big for this marker from which the energy arrivals show frequent variations and appear on a short length only in each travel time curve. This last condition was met on the 17,200 ft/sec segment on traverse C (bases 56 to 60 in direct shooting and 52 to 55 in reverse shooting). This brings in the problem of the spacing between successive shots: when the arrivals from a marker are recorded between distances D and D+X, the spacing between shot points should be shorter than X.
During the present survey, shots were fired every second mile. This makes it theoretically impossible to map a marker appearing on less than 2 miles or 12 traces on the time-distance plot.

As a conclusion of the above remarks, we may say that the marker for which the interpretation is the more ascertained over the whole study is the deeper marker. For this marker, the overlap of first arrivals from successive shot points was sufficient.

6.4. ACCURACY OF THE VELOCITY FUNCTION ADOPTED : it has already been reported that no accurate data concerning the vertical velocities is available. The same applies to the relationship between refraction markers and geological formations. Besides, a parameter very important to know for applying the Gardner-Layat method is the offset relative to each marker.

To figure out an offset, the theoretical seismic wave path have to be plotted, taking into account all the velocities as well as the anisotropy factor of each individual section travelled across. In the present case, this plot is not possible and an offset can be determined only be comparing the two relative intercept curves as explained above (5-2). The resulting value of the offset is only an approximation. Moreover, along a traverse and a given marker, the offset varies with dips and depths.

It is conceivable to interpret a refraction survey in two steps:

- in a first step, the offset is approximated as we have said. This leads to approximations of the marker velocity, of the shape of the average relative curve and the delay curve, of the time reference for this last curve;

- in a second step, after a bore hole has been drilled and logged for velocities and anisotropy, the offset at the bore hole is computed. It can then be varied along the other parts of the survey, using the changes of depth and dip derived from the first step interpretation.

It can be derived from the above considerations that a refraction survey must not be considered as yielding definitive results. Starting with the same basic data and recordings, successive interpretations get closer and closer to the reality as and when experimentally determined factors take the place of hypothesis used in the course of the first computation.

Along the two traverses surveyed, the correlation between relative curves is generally quite good. However the offsets used can be 40% off at places. This figure may look extremely high. Actually, the accuracy with which the offset is known affects only slightly the final results. To give a figure, let us say that along traverse C, for both markers (17,500 and 20,000 ft/sec), variations of the offset of 30% lead to velocity variations of 3% and delay variations of 5%, at some places only.

6.5. THE TECTONIC CONDITIONS: the refraction method used does not allow for an accurate calculation of the most general case where markers have any shapes and dips. In that case, the refraction wave paths do not follow any longer the interfaces and their angle with the normal to the refracting surface differs from the critical angle (arc sin V_{n-1}/V_n). Hence both the field technique and the interpretation become more elaborate due to important variations in the shooting distances and the offsets.

All along the present interpretation, possible variations of the offset along the marker have not been considered. The dips have been assumed to be small enough for allowing the approximations :

$\cos \theta = 1$ and $\sin \theta = \theta = \mathrm{tg}\ \theta$, where θ is the dip of the refracting interface.

Most often, such an approximation is good enough. The error is still smaller than 10% when $\theta = 25^{\circ}$ and such dips have not been encountered at Poole Range. The dip of the deeper marker on the lower side of fault F1 (traverse A, base 97), looks close to 15°.

A geological limit may exist on the west of traverse C along the best part of which the 17,200 ft/sec marker of bases 52 to 56 could not be interpreted. It may be that its apparent velocity becomes very close to that of the deeper marker, so that both energy arrivals cannot be clearly dissociated.

7. DELAY CURVES - TRAVERSE A (Pl. 23A, 24A, 25A and 26A)

The "Exploitation diagram" (Pl. 23A), shows that the suitable distances for following the main markers vary considerably. For instance, the minimum shooting distance for the deeper marker to be a first event varies from 65,000 to 130,000 ft. These unpredictable variations are due to changes of the velocities, dips of the various markers or unconformities between refractors which is the most important factor.

A dotted line delimits the areas of two main markers. The deeper is always more energetic and the rate of decrease of the refracted energy with the distance is very small. Picking the shallower marker is sometimes difficult because of the low energetic level. Furthermore, the first event is often interfered by the deeper marker arrivals when the shooting distance increases. The apparent velocities of events corresponding to a third marker are indicated on the slant lines of the refraction sounding shot points. Such events appear also on the direct records, bases 93 to 96, with a higher frequency: 20 cps instead of about 15.

By superposing the relative direct and reverse curves, we chose 1.5 base = 16,200 ft. as the offset of the "17,500" marker and 2 bases = 21,600 ft as the offset of the "20,000" marker.

7.1. MARKER "20,000": several possible faults are seen on the records, particularly on reverse shot records. All faults are identified on the interpretative documents. The probability of the phenomenon is greater when a block letter F is used instead of f. It must be noticed that a fault is scarcely visible on both direct and reverse shots because of its dissymetry. When it happens, it is obviously a means of getting an estimation of the offset value. The location of small faults is approximate as it depends on the value adopted for the offset. The throw is not always well determined since the arrivals are disturbed in tectonic areas, for instance by diffraction patterns and/or refracted paths along the faults.

F 1 is the most important fault and appears very clearly on the reverse-shot records. On direct-shot records it corresponds to a steep break line (rapid variation of the critical distance), as it may be seen on Plate 23A. Near F 1, there is a wide zone of interfered records. The character of F 1 is the same on "17,500" marker events. The small faults f1 to f4 might correspond to irregularities like a sudden change of dip. It is probably so even with F2, seen on both direct and reverse-shot monitors.

7.2. MARKER "17,500" : at both extremities of this traverse the velocity is actually of 17,500 ft/sec; elsewhere it is ranging from 16,300 to 17,000 ft/sec but the determinations are satisfactory (see Pl. 24A).

The dome of the northern end of the traverse is not quite assured but on base 92 we have two calculated delays and the direct relative curve, both showing a northward dip.

The small fault f6 is visible on reverse-shot records. A shortage of records in this zone makes it impossible to connect the 17,000 ft/sec with the 16,500 ft/sec marker. The same is true for the segments of 16,500 ft/sec and 16,300 ft/sec velocity refractors. It is not excluded to have a velocity slightly higher than 16,300 ft/sec on the top bases 111 to 114.

We did not notice any change of the record character suggesting a change of the velocity on base 118.

The fault f8 is not clear: having only the reverse intercept curve southward, we drew the delay curve assuming an unchanged velocity.

7.3. GENERAL COMMENTS : from a structural point of view it is interesting to note the very high position of the markers at the northern end of the traverse;

- the closure of over 140 millisec. of the wide dome stretching from base 109 to base 119, at the deeper marker level. It is not unlikely that an increase of the marker velocity is present south of fault f4. In such a case the delay curve would be lowered and the closure increased.

These main features seem to affect all the formations since they are visible on the shallowest 10,000 and 12,000 ft/sec markers. It must be kept in mind that these are seismic markers and it is possible to follow a continuous seismic marker which corresponds, in fact, to different geological formations. It is not sure, for instance, that the deeper 18,500 ft/sec and 19,300 ft/sec markers belong to the same geological formation. The same applies to the 17,500 and 17,000 ft/sec segments of the shallower marker.

8. DELAY CURVES - TRAVERSE C (Pl. 23B, 24B, 25B and 26B)

The shooting distance for each marker does not vary much. The first event from the deeper marker takes place at an average distance of 72,000 ft. This distance increases only for the most eastern direct shots and there, for the first time, a faster event is seen on the same records.

Between the areas of the deeper and shallower markers there is an area which can be interpreted as a third refractor zone. This is true for the shot points 45 to 55 (direct shooting), but, afterwards, the break with the deeper marker vanishes and the events appear to be interfered : large periods, abnormally energetic traces. We considered this area as an interfered area between the two main markers (Pl. 23B).

The records are generally of better quality than on traverse A and the "picking" is easier and more reliable especially for the shallower marker.

8.1. MARKER "20,000" : as for traverse A we considered an offset of 21,600 feet. It gives the best fit of the relative intercept curves.

Fault F3 is corroborated by a change of the marker velocity (Pl. 24B). The other faults F4 and F5 are close by and possibly belong to the same system. Westwards we have a segment of reverse intercept curve but the impossibility of determining the actual velocity allows only assumptions about the dip values. In case of unchanged velocity, the 18,500 ft/sec refractor is merely horizontal. In case of increased velocity, the marker is climbing westwards (Pl. 24B).

The determinations of the actual velocities are satisfactory but nothing can be seen on records explaining the change arising on base 61 where the velocity varies from 18,500 to 20,000 ft/sec.

8.2. MARKER "17,500" : two different refractors have to be considered:

- a 17,200 ft/sec marker whose offset is close to 18,000 ft.
- a shallower marker with a chosen offset of 10,800 ft.

Both relative curves of the 17,200 ft/sec marker show a westward climb on base 56 but we cannot ascertain this form because of the interferences with the deeper marker and the shortness of the events (see Pl. 23B). East of the light fault f5 we have at our disposal solely the direct curve and calculated delays so that the dip on base 52 is not ensured.

Changes of dip of the deviation curve concerning the shallower marker do not allow for good determination of the true velocity. It is ranging from 14,900 to 17,100 ft/sec. One interruption of the marker is visible on records, it is fault F6 bounding westwards the short segment of the 14,900 ft/sec marker. As nothing appears on the deeper marker in this area, it is possibly caused by a lateral facies change of the "17,500" marker. Anyway, it is quite sure that there is a culmination area between bases 62 and 64.

8.3. GENERAL COMMENTS : the examination of plate Pl. 26B "Delay curves" suggests the following remarks:

- two high situated areas are delimited by the synclinal zone of bases 57 to 61;
- the eastern one corresponds to the wide dome of traverse A, nearby the traverses intersection.

Consequently, only the eastward dip is not assured, it is but alleged by the 17,200 ft/sec marker's eastward dip;

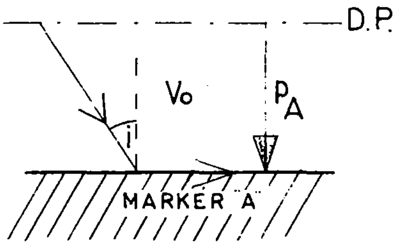
- at the other end of traverse C, all markers have their highest position, but there is a shortage of basic information between faults F4-F5 and the near located Fenton fault (perhaps on base 69 ?);
- there is a possible facies change affecting all markers around base 60: velocities variations, and another one regarding mainly the "17,500" marker between bases 62 and 64 and east of the fault F3: start of the 17,200 ft/sec marker;
-unconformities between the shallow surface formations: 10,000 and 12,000 ft/sec markers and the "17,500" marker are present as well as between this one and the deeper refractor. Although the two markers were not followed on both sides of fault F3, we suppose the main unconformity to be between the 17,200 ft/sec and the deeper markers, rather than between the former and the 15,900 ft/sec markers.

8.4. INTERSECTION OF TRAVERSES A AND C: delays and velocities are approximately the same at the deeper marker level : 690 millisec. and 18,700 ft/sec on traverse A, 680 millisec. and 18,900 ft/sec on traverse C. Such slight differences are admissible.

The corresponding values for the shallower marker are: 435 millisec. and 16,300 ft/sec, 480 millisec. and 17,200 ft/sec. The intercepts of both traverses were computed with an X/V velocity of 17,500 ft/sec. After calculation of the true marker velocity, a correction of the delay times is to be considered (see Appendix V -3-2).

Fig. 5

DEPTH COMPUTING



1/MARKER A

DELAY : d_A

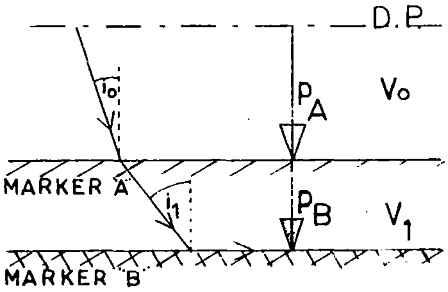
HORIZONTAL VELOCITY : V_A

DEPTH : p_A

OVERBURDEN VELOCITY : Vo

$\sin i = \frac{V_o}{V_A}$

$$① \quad p_A = \frac{V_o \cdot d_A}{\cos i} \quad \text{(without anisotropy)}$$



2/MARKER B

VERTICAL VELOCITY between A and B : V_1

DELAY : d_B

HORIZONTAL VELOCITY : V_B

DEPTH : $p = p_A + p_B$

$\frac{\sin i_o}{V_o} = \frac{\sin i_1}{V_1} = \frac{1}{V_B}$

$$d_B = \frac{p_A \cdot \cos . i_o}{V_o} + \frac{p_B \cdot \cos . i_1}{V_1} = d_A \cdot \frac{\cos . i_o}{\cos . i} + p_B \cdot \frac{\cos . i_1}{V_1}$$

$$② \quad p_B = \left(d_B - d_A \frac{\cos . i_o}{\cos . i} \right) \cdot \frac{V_1}{\cos . i_1}$$

$$p = ① + ②$$

This correction is of (-21) millisec. for the 17,200 ft/sec marker and (-63) millisec. for the 16,300 ft/sec. marker. This means that if the markers had the same horizontal velocity of 17,500 ft/sec., the delays would have been : 480 + 21 = 501 millisec. on traverse C and 435 + 63 = 498 millisec on traverse A. Consequently, the same marker was followed on both traverses. The delay and velocity differences may be caused by the different offsets chosen: 16,200 and 18,000 feet, and/or by the shorter exploitation distance used on traverse A, leading to a slight shallower and slower refractor.

9. DEPTH CURVES (Pl. 27A and 27B)

The method of depth computing and the formulae used are indicated on Fig. 5. The Gardner-Layat method gives us the delay and the actual horizontal marker velocity. We assumed the anisotropy of formations negligible, the overburden velocity V_o constant as long as the marker velocity remains constant and this parameter varying according to the depth and the marker velocity, as indicated on the plates 27A and 27B.

The assumed values of V_o range from 15,000 to 15,800 ft/sec on traverse A. North of fault F1 it is likely having greater overburden velocity because of the thinning of slow subsurface formations. For the higher located "17,500" marker of traverse C, V_o is supposed to vary from 13,600 to 15,400 ft/sec.

After computing the depth of the first marker, we computed the thickness between the two markers, as shown on Fig. 5. We admitted that the interval velocity between the markers does not vary very much. On traverse A this velocity is of 17,000 ft/sec. except northwards fault F1 where the markers are nearer to each other (V_1 = 16,500 ft/sec.). On traverse C, because of the smaller depth, the interval velocity varies between 16,000 and 16,800 ft/sec. The interval depth being known, the deeper marker depth is the sum of the two above calculated depths.

It must be kept in mind that we have no data concerning the overburden velocity and that tiny variations of V_o lead to great depth variations: the closer the velocities V_o and V (actual marker velocity), the greater the depth variations. For instance, on traverse A, the 16,300 ft/sec marker's top is at 15,000 ft assuming a 15,000 ft/sec overburden velocity. A 2% increase of this figure: 15,000 to 15,300 ft/sec overburden velocity, leads to a depth increase of 15% : 17,300 ft deep marker instead of 15,000 ft.

10. COMPARISON OF THE DELAY AND DEPTH CURVES

A comparison of these curves shows that:

- the markers "17,500" and "20,000" are closer to each other than it appears on the delay curves;
- the fault F1 with its very great throw of about 7,500 ft might correspond to the Pinnacle Fault or to one of its components;
- the method used for the depth computing lowers the middle part of traverse C. However, it can be checked

that the average vertical velocity between the Datum plane and the deeper marker from base 56 to base 62 is near 15,400 ft/ sec., in spite of the different velocities V_0 and V_1 distributions;

- the fault F3 with a downthrown to the west of near 4,000 ft could correspond to fault f4 of traverse A, which has a southward downthrown of about 2,000 ft, although the velocities are different in the downthrown sides on each traverse.

THIRD PART : ACHIEVEMENT OF OBJECTIVES

1. GEOLOGY

Following the assumptions made on the velocities, the structural information concerns markers ranging from 7,000 to 30,000 ft deep. Indications of structural locations suitable for a drilling target are suggested as follows:

- the possible anticline at the northern extremity of traverse A;
- the dome near the crossing of traverses A and C. It has a great extension in the north-south direction. Westwards, its closure is insured by the faulted zone F3. This is the best looking structure encountered during this survey;
- the high zone to the west of traverse C. At depth, it is looking like a shelf and the structural interest seems to be limited to the shallower marker. However, the velocity variations complicate their exploitation by refraction method.

Anyhow, these locations could not be considered for drilling site without complementary studies of the suggested features.

2. GEOPHYSICS

The reflection experiments led to geophones and holes patterns with which a 10 miles long traverse was carried out. Yet, no continuous deep horizon could be followed and it appears that complementary experimentation is necessary before starting a new reflection survey.

In refraction, two markers were followed continuously on the Poole Range area and across the gravity anomaly 16A. The actual velocity of the deeper one varies from 18,500 to 20,000 ft/sec. The velocity of the other ranges from 14,900 to 17,500 ft/sec. Besides, two shallow formations were followed using the centre shots.

The results indicate that the Poole Range surface anticline seems to have a very restricted development at depth since it does not appear clearly on the delay curves. There is a small structure on base 103 of traverse A but it concerns only the deeper marker. At any rate, this area is too deep to present any immediate interest.

Over the gravity anomaly 16A the results indicate the possible existence of two high zones separated by a narrow trough. Comments about these high points are given above in paragraphs 7-3 and 8-3.

3. TENTATIVE OF GEOLOGICAL INTERPRETATION

The deeper marker has the character of a very thick and old refractor: very slow decrease of the energy level with the shooting distance, presence of many faults, lack of continuous faster events. Therefore it may be assumed that this marker is a Proterozoic refractor with depth varying between 15,500 and 30,500 ft - assuming our hypothesis on the vertical velocities are right.

If the presence of thick Devonian and Ordovician formations is confirmed in the Fitzroy Trough, the "17,500" markers could represent them. The marker of traverse A with actual velocity ranging from 16,300 to 17,500 ft/sec. might belong to an Ordovician sequence, as the 17,200 ft/sec segment on the eastern part of traverse C. Westward fault F3 the marker might represent a more recent formation, possibly Devonian, with velocity ranging from 14,900 to 17,500 ft/sec.

The shallow markers 10,000 and 12,000 ft/sec. and events happening at shooting distances smaller than 70,000 ft on traverse A (shot points 97, 99, 106 and 108) might represent Permian and Carboniferous layers.

FOURTH PART : COMPARISON WITH FORMER GEOPHYSICAL RESULTS

1. GRAVITY (Pl. 27A, 27B, Fig.3)

The intersection values of the Bouguer anomaly curves (Surveys 1956-1960) with traverses A and C are plotted on the depth curves plates. It is doubtless that similar features appear between the gravity and the refraction results:

- the fault F1 is suggested by the steep slope of the anomaly curve on base 95;
- no important relief is revealed by the gravity between the Pinnacle Fault and anomaly 16A; this is confirmed by the refraction survey;

- anomaly 16A involves two refraction high zones, corresponding well (traverse A), or approximately (traverse C), with it;
- the suggested fault alignment, from F3 on traverse A to f4 on traverse C, would correspond to the saddle of the (-30) curve (see Fig. 3) followed towards the southeast by a change of direction of the contours. However, there is no seismic evidence that F3 and f4 are one same feature.

2. REFRACTION

We shall try a brief comparison between our results and those obtained by WAPET in 1956;

- in the Poole Range area, on bases 100 to 105 of traverse A, the 18,000 ft/sec layer seen as a late arrival on the records in 1956, might be our 16,500 ft/sec marker. As a matter of fact, the first break of this marker is seen at shooting distances from 54,000 to 70,000 ft (see Pl. 23A). The shooting distances used in the 1956 survey, smaller than 54,000 ft, hence did not allow the "picking" of this marker as first event.
- the offset of 15,800 ft given for the marker in 1956 is quite close to the offset of 16,200 ft that we have chosen for the 16,500 ft/sec marker;
- nothing can be deduced from the velocity difference because 18,000 ft/sec is an apparent velocity;
- concerning the depth, it was considered that the 18,000 ft/sec layer was deeper than 13,000 ft. The depth of our 16,500 ft/sec refractor is about 18,000 ft;
- the second layer given with a 15,750 ft/sec velocity might correspond to the "17,500" marker followed on the west part

of traverse C. On traverse A it has not been followed because of the lack of records. The offset we adopted is 10,800 ft, almost the same as indicated in the WAPET 1956 report : 12,200 ft.

CHAPTER VIII
CONCLUSIONS

The various reflection tests were so limited and scattered on isolated locations that definite conclusions regarding the best recording procedure are not possible at this stage. The 10 miles experimental traverse did not allow to follow continuously an horizon across the Poole Range surface structure. Additional experimentation is necessary if a reflection survey is to be attempted.

Two shallow formations, probably of Permian age followed as refraction markers appear to reflect the Tectonic features revealed at depth.

These features appear as culminations affecting all deep markers in three different areas of the prospect: northern extremity of traverse A, eastern and western parts of the gravity anomaly 16 A. Within the formations where these tectonic features take place, the two seismic refractors might be interpreted as levels respectively of Devonian - Ordovician and Proterozoic age.

Furthermore, the survey suggests that the surface anticline of Poole Range has no extension at depth. The results also indicate that the Poole Range area lies much deeper than the northern end of traverse A or the area of gravity anomaly 16 A.

The work was too limited for a drilling site to be reliably located. Further seismic work is recommended in order to delineate the interesting tectonic features detected during this present survey.

CHAPTER IX

RECOMMENDATIONS

The survey carried out shows the applicability of the refraction method to solving a certain number of problems in the Fitzroy Trough. It is a reconnaissance method allowing to point out the main structural features of a given area rapidly.

The applicability of the reflection method has not been completely evaluated, and, if a further survey is to be attempted, a similar party capable of operating both reflection and refraction methods can be used again.

We indicated in Chapter VIII "Conclusions" that three different areas present structural interest : northern extremity of traverse A, eastern and western parts of traverse C. The reflection method could be tested in the north of traverse A, much shallower than the Poole Range area. At any rate, if there is a closure, a large structure is not likely to occur in this zone.

The structure on the eastern part of traverse C looks very wide. Besides, good results are obtained at the deepest marker level. An area of about 200 square miles could be detailed by shooting refraction traverses, parallel to traverses A and C in the northern part. In the southern part the direction of the traverses should be modified to bring them perpendicular to and to check the possibility of an important northwest - southeast fault connecting F3 and F4.

The deeper marker can be followed continuously with a shooting distance from 95,000 to 117,000 ft, which means that only one direct and one reverse shot on each base are enough. Experience has shown that arrivals at distances smaller than 95,000 feet result into interferences from several markers and are difficult to use. Variations in the recording distances relative to each marker make it difficult to forecast a shooting program. On the other hand, comparatively easier travelling conditions make it possible to contemplate a survey in two phases with laying out the spread again. So, the shooting program could start with shooting for the deeper marker at distances where no interference is expected. Every 4 or 5 shot points, additional recordings on closer spreads would supply complete time distance curves where the different break points can be noted. This already constitutes a sort of qualitative information about the intermediate markers. From this information, the best shooting distances can be selected and complementary exploitation diagram can be planned depending on the markers to be mapped. Then the traverse would be shot again with this new shooting programme.

The western part of traverse C is a dune area where accessibility is poor. But the difficulties to be expected are technical too. The present survey indicates that the intermediate 17,500 ft/sec markers should be the objectives. Along the east-west direction of traverse C, they are recorded on short extents only and this makes them very difficult to interpret. A northwest - southeast direction, more or less parallel to the known trend of the Pinnacle and the possible trend of an F 3 f4 faults, could lead to a better continuity and longer recordings from a same marker.

If continuity is not better in this direction than along traverse C, the interpretation would remain very difficult. In any case, it is improbable that a same marker can be followed all along a loop unless an unreasonably dense network of traverses are shot.

Reflection seismic accommodates the surveying of discontinuous horizons much better. The very short test made on the last day of the field operations indicates that the method would meet difficulties too. But it might be worth making a more complete test before attempting a detailed survey of this area.

Concerning the equipment of the party, the following suggestions should be made:

- The party must be provided with a large number of geophones in order to allow for a complete reflection experimentation.

- The means of transportation of a refraction party have to be determined carefully in order to avoid loss of time when providing the fly camp and the crews with explosives and other consumable stores.

- In any case, a dozer is necessary to improve the generally bad travelling conditions.

BRISBANE THIS 19th DAY OF JANUARY 1963

For Compagnie Generale de Geophysique

The Area Manager

Pieuchot

M. Pieuchot

REFERENCES

L. W. GARDNER — "An areal plan of mapping subsurface structure by refraction shooting" (Geophysics 1947, vol. XII, p. 221)

CLEMENT et LAYAT — "Constant distance correlation" (Geophysical Prospecting 1961, vol. IX, p. 296)

DOCUMENTS KEPT BY THE PARTY

1. AIR PHOTOS

1.1 - Noonkanbah

Run	Number	Run	Number
14A	A 5306-5310	9A	C 5173-5191
14	5387-5410	9	5000-5003
13	5246-5268		5990-5999
12	5222-5244	8A	5320-5336
	5245, 5744	8	5932-5957
11A	C 5137-5160	7	5740-5761
11	5165-5189	6A	5096-5113
10	5144-5150		
	5152-5164		

1.2 - Crossland

Run	Number	Run	Number
E/K	5015-5016	4	5187-5189
7	5083-5085	3	5037-5039
6	5093-5095	2	5049-5051
5	5175-5177		

2. AIR PHOTO MOSAICS

2.1 - 4 Miles/Inch	Mt. Anderson	Dummer
	Crossland	Cornish
	Mt. Bannerman	Lucas
	Billiluna	Noonkanbah
2.2 - 1 Mile/Inch	Dukes Dome	Christmas Creek
	Brunton Hill	Bohemia Downs
	Mt. Fairbairn	187/Zone 3
	Bucknall	

3. SURVEYING DOCUMENTS

Noonkanbah -Sheet 2,2 Miles/Inch

-Army Survey Corps, preliminary and unpublished

Trigonometrical stations

-R.010 -R.073 - NM/F/39, with computation formulae for changing datum.

-Stations are part of a compensated network based on astrofix.

Poole Range area - Gravity

-Location map of gravity stations.

-2 miles/Inch.

-with triangulation points, part of a compensated network different from with above system.

Location maps - Seismic

-Seismic survey 1954 Donkey Gorge, 1 mile/inch.

-Seismic survey 1954 Christmas Creek, 1 mile/inch.

-Seismic survey 1953 Poole Range-Price's Creek, 1 mile/inch.

Elevations

-Gravity stations : list of corrected elevations.

-Seismic stations : list of NOT corrected elevations.

4. GEOLOGICAL DOCUMENTS

-Western Australia	40 miles/inch Geology - coloured by hand.
-Fitzroy Basin	8 miles/inch Solid geology.
-Noonkanbah	4 miles/inch with explanatory Note.
-Poole Range	I. F. P. Photogeology- Sheets I to VI Transparency
-I. F. P. Aus/5414	Petroleum Prospects in Australia, by D. Trumpy et al. 1 - in English 1 - in French (text and plates).
-Bulletin No. 60	Geology of the Canning Basin. W.A., by J.J. Veevers and A.J. Wells.
-B. M. R. -Records 1952/1959	Review of the petroleum prospects of the N. W. and Fitzroy Basin of W.A. and suggestions for a future exploration programme by W. F. Schneeberger.

5. GEOPHYSICAL DOCUMENTS

5.1 - Gravity

Noonkanbah 4 miles/inch Bouguer Anomaly (1952/1957)

Fitzroy-Canning 40 miles/inch Bouguer Anomaly (1952/1960)

a) without province boundaries,

b) with province boundaries.

4 miles/inch reduced to 1/500,000 :

Anketell	La Grange	Mt. Bannerman
Billiluna	Lennard River	Mt. Ramsay
Broome	Mandora	Munro
Crossland	Mc Larty Hills	Noonkanbah
Derby	Mt. Anderson	Yampi
Gordon Downs		

5.2 - Seismic

Grant Range No. 1	Seismic well survey, information and plate.
Nerrima A.F.O. No. 1	Seismic well survey, B.M.R. Record 1962 No. 65 (complete)

Fitzroy Basin velocities - T/ Δ T analyses - Plate.

6. GEOPHYSICAL RECORDS

B.M.R. 1953	W.Z. Records
B.M.R. 1954	Reflection records
WAPET 1956	Refraction records.

7. GEOPHYSICAL REPORTS

B. M. R. Records 1955 No. 35	Seismic Survey of the Poole Range-Price's Creek area, by E. R. Smith.
B. M. R. Records 1956 No. 66	Seismic Reflection Survey in the Poole Range Christmas Creek area, by L. W. Williams.
B. M. R. Records 1957 No. 37	Seismic Refraction Traverse in the Christmas Creek area, by E. R. Smith.
B. M. R. Records 1962 No. 91	Poole Range Gravity Survey 1953, by I. B. Everingham.
B. M. R. Records 1962 No. 105	Reconnaissance Gravity Survey 1952-60, Canning Basin and Fitzroy Basin, W. A., by A. J. Flavelle and M. J. Goodspeed.
WAPET Canning Basin 1956	Poole Range refraction Profile "A", by Shaller & Hoelscher (6 plates).